

**COMMONWEALTH OF VIRGINIA
DEPARTMENT OF ENVIRONMENTAL QUALITY**

**Virginia Stormwater Management Handbook
Technical Review Committee (TRC) Meeting #8
Thursday June 25, 2026**

Draft Agenda

Meeting Location:

Department of Environmental Quality
Bank of America, 3rd Floor Conference Room
1111 East Main Street
Richmond, VA 23219

Start – 9:30 AM

Welcome	DEQ Staff
<ul style="list-style-type: none">▪ Sign-In▪ FOIA Information▪ Past Meeting Minutes	
Updates	All
<ul style="list-style-type: none">▪ TRC #7 Follow Up Topics (P-FIL, Timber Mats for CE and CRS, etc.)	
Specifications Review	All
<ul style="list-style-type: none">▪ P-FIL-06 Bioretention▪ Appendix F	
Lunch Break – 12:00 pm	All
Draft Specification Review	All
<ul style="list-style-type: none">▪ Flocculant Specification – Follow Up▪ All CMAC Materials – Follow Up▪ Permanent Linear Utility Access Roads - New	
Public Forum	All
Next Steps	DEQ Staff
<ul style="list-style-type: none">▪ Stormwater Capture and Reuse	
Wrap Up	DEQ Staff

P-FIL-05 Bioretention

1.0 Definition

Bioretention is a method of treating stormwater by pooling water on the surface of a vegetated media system and allowing filtering and settling of suspended solids and sediment at the top mulch layer, prior to infiltrating and passing through the underlying biofiltration media, so that further pollutant removal via a range of biogeochemical processes occurs. As such, bioretention areas are shallow stormwater basins or landscaped areas that utilize engineered soil media and vegetation to retain and sequentially treat stormwater runoff via a combination of mechanisms ([e.g., infiltration, filtration, evapotranspiration, plant uptake, etc.](#)) before its discharge to local surfacewater or groundwater.

2.0 Purpose and Applicability of Best Management Practice

Bioretention can be used harmoniously with any land use. Bioretention offers many different design alternatives that make it a versatile practice for use within various locations in the development site. Typical locations for bioretention include the following:

- **Parking lot islands.** The parking lot grading is designed for sheet flow towards linear landscaping areas and parking islands between rows of spaces. Curb-less pavement edges can be used to convey water into a depressed island landscaping area. Curb cuts can also be used for this purpose.
- **Parking lot edge.** Small parking lots can be graded so that flows reach a curb-less pavement edge or curb cut before reaching catch basins or storm drain inlets. The turfgrass at the edge of the parking lot functions as a filter strip to provide pre-treatment for the bioretention practice. The depression for bioretention is in the pervious area adjacent to the parking lot.
- **Road medians, roundabouts, interchanges, and cul-de-sacs.** The road cross-section is designed to slope towards the center median or center island rather than the outer edge, using a curb-less edge.
- **Right-of-way or commercial setback.** A linear configuration can be used to convey runoff in sheet flow from the roadway. Runoff can also be conveyed by way of a grass channel or pipe to the bioretention practice.
- **Courtyards.** Runoff collected in a storm drain system or roof leaders can be directed to courtyards or other pervious areas on site where bioretention can be installed.
- **Dry Extended Detention (ED) basin.** A bioretention practice can be located on an upper shelf of an extended detention basin, after the sediment forebay, to boost treatment. Depending on the ED basin design, the designer may choose to locate the bioretention practice in the bottom of the basin.
- **Tree Planters and Other Local Landscape Planting Structures.** Tree planting pits or other urban landscape planting structures (e.g. rain gardens) can be designed to accept local curb or sheet flow from roadways, sidewalks, roofs, or other adjacent surfaces with a designed bioretention soil media. This and other urban retention applications of varying scales are described in more detail in [9.0 Appendix A Micro-bioretention](#) and [10.0 Appendix B Ultra-Urban Bioretention](#).

3.0 Planning and Considerations

Bioretention facilities can receive stormwater from impervious and non-impervious drainage areas. [Some key feasibility issues for bioretentions include those identified in table P-FIL-05-1.](#)

Table P-FIL-05-2 Bioretention Feasibility Criteria	
Criteria	Details
Available Space	Sizing is based on treatment volume (Tv) and the dimensions of the bioretention.

<u>Site Topography</u>	Steeper slopes adjacent to and upstream of the bioretention can generate rapid runoff velocities into the facility that may carry a high sediment loading (refer to pre-treatment criteria in <u>Section 5.1.1</u>). Refer to Section 5.11.1 for steep slope considerations.
<u>Contributing Drainage Area</u>	There is no maximum CDA to the bioretention as long as it is designed according to the specification.
<u>Available Hydraulic Head</u>	Bioretention facilities are fundamentally constrained by the invert elevation of the downstream conveyance system to which the practice discharges (i.e., the bottom elevation needed to tie the underdrain from the bioretention into the storm drain system). In general, 4 to 5 feet of elevation above this outlet invert, is needed to create the hydraulic head needed to drive stormwater through the proposed filter bed. Less hydraulic head is needed if the underlying soils are permeable enough to dispense with the underdrain.
<u>Depth to Water Table</u>	Designers should ensure that the bottom of the bioretention facility is separated from the seasonally high groundwater table, with 2 feet of separation for a level 1 facility and 3 feet of separation for a level 2 facility, to ensure that groundwater does not intersect the filter bed because this could lead to groundwater contamination or facility failure.
<u>Depth to Bedrock</u>	2 feet vertical separation.
<u>Soils</u>	Soil conditions do not constrain the use of bioretention facilities, although they normally determine whether an underdrain is needed for Level 1 bioretention facilities. Low-permeability soils with an infiltration rate of less than 0.5 inch per hour will require an underdrain for a Level 1 bioretention facility. Designers must verify site-specific soil permeability at the proposed location using the methods for on-site soil investigation presented in Appendix C Soil Characterization and Infiltration Testing in order to eliminate the requirements for an underdrain.
<u>Utilities</u>	Interference with underground utilities should be avoided, particularly water and sewer lines. Designers should consult local utility design guidance for the horizontal and vertical clearance between utilities and the bioretention. Likewise, the routing of other utilities (such as phone, cable, electric) through bioretention facilities should be avoided in order to minimize disturbance of the utilities or the bioretention during the maintenance of either.
<u>Avoidance of Irrigation or Baseflow</u>	Bioretention facilities should be located to avoid inputs of springs, irrigation systems, chlorinated wash water, or other dry weather flows.
<u>Setbacks</u>	<p>If an impermeable liner and an underdrain are used, no setback is needed from the building. Otherwise, the standard 10-foot down-gradient setback applies.</p> <p>Expected effluent concentrations of typical urban runoff (total phosphorus [TP], total nitrogen [TN], metals) from bioretention facilities are reported by the International BMP Database and are considered to be acceptable in terms of groundwater impacts provided that the feasibility factors of water table, hot spot land uses, and karst (Section 5.11) are met. However, if groundwater contamination is a concern, groundwater mapping is recommended to determine possible connections to adjacent groundwater wells.</p>

Commented [MC1]: Table 6-19

Commented [MC2]: Per Table 6-19

Commented [MC3]: Per Table 6-19

Commented [MC4]: Requesting Arcadis input

Feature	Recommended Offset	Notes
<u>Existing buildings, retaining walls, bridge supports, and other such structures.</u>	<u>1H:1V zone of influence</u>	<u>Closer offsets may be considered on a case-by- case basis where impermeable liners are specified by the designer.</u>
<u>Sewer mains</u>	<u>2V:1H zone of influence</u>	
<u>Sewer laterals</u>	<u>5 feet horizontal, 12 to 18 inches vertical</u>	
<u>Water mains</u>	<u>5 feet horizontal</u>	
<u>Large utilities</u>	<u>10 feet horizontal, 18 inches vertical</u>	<u>Includes water transmission mains, high-pressure gas mains, large conduits.</u>
<u>Utility lines, service lines (not otherwise specified above)</u>	<u>3 feet horizontal, 12 to 18 inches vertical</u>	<u>Coordination with utilities required where offsets cannot be achieved.</u>
<u>Existing inlets</u>	<u>5 feet horizontal</u>	<u>Closer offsets may be considered on a case-by- case basis.</u>
<u>Telephone poles, utility poles, traffic signals, or comparable</u>	<u>5 feet horizontal</u>	

Concern	Details
<u>Hot Spot Land Use</u>	<u>Runoff from hot spot land uses should not be treated with infiltrating bioretention facilities (i.e., constructed without an underdrain). For a list of potential stormwater hot spots, please consult P-FIL-04 Infiltration Practices. An impermeable liner should be used for filtration of hot spot runoff.</u>
<u>Community Acceptance</u>	<u>Common community concerns with bioretention facilities include the continued ability to mow grass, landscape preferences, weeds, standing water, and mosquitoes. Bioretention facilities are a positive stormwater management alternative because these concerns can be fully addressed through the design process and proper ongoing operation and routine maintenance. If bioretention facilities are installed on private lots, homeowners will need to be educated on their routine maintenance needs, must understand the long-term maintenance plan, and may be subject to a legally binding Maintenance Agreement (see Section 7.8). The local government may require placement of bioretention facilities in a drainage or maintenance easement in order to ensure long-term maintenance.</u>

With bioretention practices, surface runoff is directed into a shallow landscaped depression that incorporates volume reduction and a range of pollutant removal mechanisms. Bioretention facilities are composed of three main components:

1. Surface ponding area,
2. Soil filter media, and
3. Gravel layer and drainage [\(Figure P-FIL-05-1 and Figure P-FIL-05-2\)](#).

3.1 Ponding Area

The ponding area is a depression that temporarily stores the stormwater as it enters the practice, allows for some sediment to settle out, and facilitates infiltration into the soil filter media and underlying native soil (depending on design options).

3.2 Soil Filter Media

The soil filter media is comprised of an engineered soil media, which filters stormwater, facilitates nutrient removal processes, and supports the rooted vegetation growing in the bioretention practice.

3.3 Gravel Layer and Drainage

The gravel layer is comprised of stone located between the soil filter media and the native soil. This layer protects the engineered soil media from the native soil and stores water until it exfiltrates into the surrounding soil or exits via an underdrain, i.e., a perforated pipe laid within the gravel layer that conveys treated water away from the practice.

3.4 Types of Bioretention

Bioretention installations can be divided into different categories. The choice of which specification to use is based on the size of the contributing drainage area and the site's available space. The three main types of bioretention are summarized in [Table P-FIL-02-4](#) [Table P-FIL-02-1](#), below.

Table P-FIL-05-4 Summary of the Three Main Types of Bioretention

Type	Details
Bioretention	Focuses on general bioretention practices that are used to treat parking lots and/or commercial rooftops, usually in commercial or institutional areas. Inflow can be either sheet flow or concentrated flow. Bioretention practices may also be distributed throughout a residential subdivision, but ideally, they should be in a common area or within drainage easements to treat a combination of roadway and lot runoff (Figure P-FIL-05-3).
Micro-bioretention (a.k.a. Rain Gardens)	Small, distributed practices designed to treat runoff from small areas, such as individual rooftops, driveways, and other on-lot features in detached, single-family residential developments. Inflow is typically sheet flow or can be concentrated flow with energy dissipation when located at downspouts. Please refer to Appendix A Micro-bioretention for design criteria for Micro-bioretention (Figure P-FIL-05-4).
Ultra Urban Bioretention	Structures such as expanded tree pit planters, curb extensions, and foundation planters located in ultra-urban developed areas such as city streetscapes. Please refer to Appendix B Ultra-Urban Bioretention for design criteria for Urban Bioretention (Figure P-FIL-05-5).

Figure P-FIL-05-1 Image of typical bioretention practice



Figure P-FIL-05-2 Image of typical bioretention practice



Figure P-FIL-05-3 Image of bioretention cell receiving stormwater runoff from multiple input points (3) in a mixed-use development in Blacksburg, VA



Figure P-FIL-05-4 Image of a micro-bioretention/rain garden cell receiving direct roof downspout input in Blacksburg Virginia



Figure P-FIL-05-5 Image of Ultra-urban bioretention/tree planter cell receiving curb/road drainage in Fairfax VA



The bioretention design level, drainage area size, and the land use composition influence the space required. A designer will not know the dimensions of the bioretention practice until the treatment volume is determined from the [VRRM](#). In addition to the footprint of the surface ponding area, space will be needed for pre-treatment measures and access for maintenance. A general guideline for preliminary surface area sizing is 3 to 10 percent of the contributing drainage area.

4.0 Stormwater Performance Summary

Bioretention configurations can vary based on the amount of nutrient load reduction required, the site's available space, the underlying native soil's hydraulic conductivity, and/or the ability to daylight an underdrain if used. The design configurations are split into two categories (Level 1 and Level 2) to help the designer determine which configuration is best suited for a particular set of needs. These two levels have specific design requirements and receive different removal performance credits.

4.1 Design Levels

The major design goal for bioretention is to maximize runoff volume reduction and nutrient removal. To this end, designers may choose to go with the traditional baseline design (Level 1) or choose an enhanced design (Level 2) that maximizes nutrient and runoff reduction. Level 1 installations are exclusively designed for retention and treatment in the bioretention media, whereas Level 2 installations include infiltration into the surrounding underlying native soil as a part of the treatment process. The decision to choose Level 1 or Level 2 design will depend on the hydraulic conductivity of the underlying native soil and the amount of total phosphorus (TP) reduction needed. For Level 1 designs, the assigned performance credit is based on the practice's void storage, assumed soil media filtration, plant N and P uptake, and other removal processes that occur within the confines of the bioretention unit. For Level 2, the performance credit is based on the same processes as in Level 1 and the ability of the native soils to accept the water leaving the bioretention practice.

4.2 Performance

The Virginia Runoff Reduction Method ([VRRM](#)) provides performance credits for TP removal. Performance credits are composed of two processes, namely runoff reduction (RR) and pollutant removal (PR). The RR credit is based on volume loss, and the PR credit is based on combined physical, chemical, and biological

processes. The overall removal credit is based on an annual mass load reduction, which combines the RR and PR. The assigned credit is greater for Level 2 than for Level 1 because of the design enhancements of Level 2 plus the infiltration of the stormwater into underlying native soils (see [Table P-FIL-05-5](#) [Table P-FIL-02-2](#)).

Table P-FIL-05-25 Summary of Stormwater Treatment Functions Provided by Bioretention

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Reduction Volume	40%	80%
Total Phosphorus EMC Reduction ¹ by BMP Treatment Process	25%	50%
Total Phosphorus Mass Load Removal	55%	90%
Total Nitrogen EMC Reduction ¹ by BMP Treatment Process	40%	60%
Total Nitrogen Mass Load Removal	64%	90%

Notes:

Source: Hirschman et al 2009.

1. Change in event mean concentration (EMC) through the best management practice (BMP).

5.0 Design Criteria

A summary of the design elements for bioretention are provided in [Table P-FIL-02-3](#) [Table P-FIL-05-6](#). The table includes references to other sections and tables within this specification and appendices. The differences in the two levels of design that enable bioretention systems to maximize nutrient reduction are detailed in [Table P-FIL-02-3-05-6](#) below.

Table P-FIL-05-63 Bioretention Design Primary Criteria

Level 1 Design	Level 2 Design
Surface Area: $T_v \text{ (cu ft)} \dagger = [(1.0)(R_v)(A)] / 12 - \text{the volume reduced by an upstream BMP}$	Surface Area: $T_v \text{ (cu ft)} \dagger = [1.25(R_v)(A)] / 12 - \text{the volume reduced by an upstream BMP}$
Perform soil test if no underdrain	Soil Test must be performed
Hydraulic conductivity (Ksat): Min > 0.5 in./hr. to remove the underdrain requirement Max < 10 in./hr. without underdrain*	Hydraulic Conductivity (Ksat): Min > 0.25 in./hr. Min > 0.5 in./hr. to remove the underdrain requirement Max < 10 in./hr.*
<u>Drain Time:</u> Ponding Volume ≤ 48 hrs. Design Volume ≤ 48 hrs. (with underdrain) Design Volume ≤ 72 hrs. (if no underdrain)	<u>Drain Time:</u> Ponding Volume ≤ 48 hrs. Design Volume ≤ 72 hrs.

Notes:

* The native soil may be amended to lower the hydraulic conductivity below 10 inches per hour (see [Appendix F](#)).

† If part of a treatment train, the treatment volume calculated by the VRRM spreadsheet includes the remaining volume from an upstream practice(s).

‡ Ponding depths between 6-12 inches need to incorporate plants that tolerate widely fluctuating water levels.

§ Additional depth can be added to the filter media and/or gravel layer/sump to help meet water quantity requirements. This additional depth is not used for surface area sizing calculations. See Section 5.2.

**When used in tree planter applications, at least 36" of suitable rooting depth must be maintained. For example, if filter media depth is 24", at least 12" of non-compacted suitable soil that meets overall media [Ksat](#) criteria should be employed between the media and the underdrain or soil infiltration zone.

Commented [MC5]: Discuss" add cross sections from design spec No. 9 such as

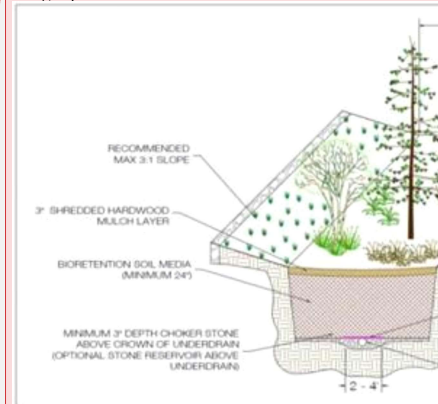


Figure 9.4a: Typical Bioretention

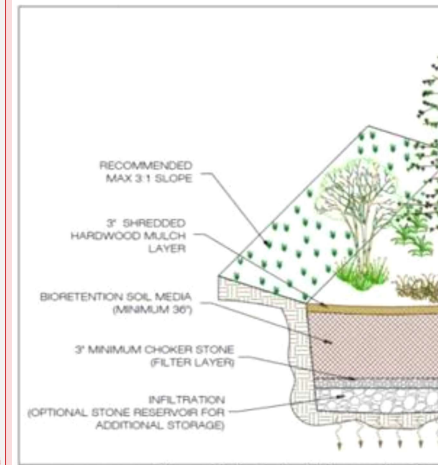


Figure 9.4b: Typical Bioretention Bas

Commented [MC6]: Discussion: specify to use "Larger of Volumetric Approach and Flow-rate Approach (see Section 5.1)" here? Ask Arcadis

Commented [MC7]: Discuss: Should we specify a required # of tests to determine [Ksat](#) here?

Appendix F Table F-1 references:
([VDOT](#)) × Virginia Department of Environmental Quality (VDEQ) 2021 VTM-134, or procedures in [Appendix C](#) Infiltration Practices.
[VDOT Virginia Test Methods](#)

Table P-FIL-05-63 Bioretention Design Primary Criteria

Level 1 Design	Level 2 Design
<p>Stormwater quantity: Design extra storage (optional; as needed) on the surface, in the engineered soil matrix, and in the gravel layer/sump to accommodate a larger storm. OR Use the VRRM Compliance Spreadsheet to calculate the Curve Number (CN) Adjustment</p>	
<p>Pond Depth: Minimum 6 inches and maximum of 12 inches‡</p>	
<p>Side Slopes: 3H:1V or flatter</p>	
<p>Surface Cover: 2-3 inches of mulch or alternative, such as managed approved vegetation</p>	
<p>Planting Plan: A planting template to include turfgrass, herbaceous vegetation, shrubs, and/or trees to cover at least 75% of surface area in 2 years.</p>	<p>Planting Plan: A planting template to include turfgrass, herbaceous vegetation, shrubs, and/or trees to cover at least 90% of surface area in 2 years. Turfgrass must be combined with shrubs and/or trees.</p>
<p>Filter Media Depth: Min: 24 inches Max: 48 inches§ Min: 36 inches rooting depth for trees**</p>	<p>Filter Media Depth: Min: 36 inches Max: 48 inches§ Min: 36 inches rooting depth for trees**</p>
<p>Filter Media: Supplied and certified by vendor per criteria provided in Appendix F.</p>	
<p>Gravel Layer: Min choker stone layer: 3 in. Min gravel layer with no underdrain: 0 in. Min gravel layer with underdrain: 9 in. Max gravel layer: 12 in.§</p>	<p>Gravel Layer: Min choker stone layer: 3 in. Min sump depth with underdrain: 9 in. Max sump depth: 12 in.§</p>
<p>Underdrain: Schedule 40 PVC or equivalent with clean-outs. Use slotted pipe under the filter bed and closed pipe elsewhere.</p>	
<p>Observation Wells: Schedule 40 PVC or equivalent closed pipe, <u>perforated in reservoir layer only per Figure P-FIL-05-6. An Internal Water Storage (IWS) zone in the bottom of the stone reservoir layer can enhance peak flow attenuation, infiltration, and pollutant removal, see Section 5.6.4 below for additional details. Storage volume estimates should be checked based on the design criteria in this specification (NC DEQ, 2024).</u></p>	
<p>Conveyance and Overflow: Off-line/On-line option</p>	
<p>Geometry: Concentrated flow: Locate inlets and outlets as far apart as possible. Non-concentrated flow: Distribute inflow evenly across filter surface area.</p>	
<p>Maintenance: Deeded Maintenance Agreement See Sections 7.11 and 7.12 for routine and non-routine maintenance requirements as well as a maintenance checklist.</p>	
<p>Notes:</p> <p>* The native soil may be amended to lower the hydraulic conductivity below 10 inches per hour (see Appendix F).</p> <p>† If part of a treatment train, the treatment volume calculated by the VRRM spreadsheet includes the remaining volume from an upstream practice(s).</p> <p>‡ Ponding depths between 6-12 inches need to incorporate plants that tolerate widely fluctuating water levels.</p> <p>§ Additional depth can be added to the filter media and/or gravel layer/sump to help meet water quantity requirements. This additional depth is not used for surface area sizing calculations. See Section 5.2.</p>	

**When used in tree planter applications, at least 36" of suitable rooting depth must be maintained. For example, if filter media depth is 24", at least 12" of non-compacted suitable soil that meets overall media Ksat criteria should be employed between the media and the underdrain or soil infiltration zone.

5.1 BMP Sizing

To function as designed, a bioretention practice must be sized based on the design criteria in [Table P-FIL-052-36](#). An example of initial sizing calculations is given in [Appendix F](#). The final footprint of the bioretention practice will consist of the pre-treatment area and the surface ponding area. The size of the practice is determined by the design level (Level 1 or 2), which will depend on the amount of P to be removed, the hydraulic conductivity (K_{sat}) of the underlying native soils, and whether an underdrain can be daylighted. The size of the practice could also be influenced by storage added to meet water quantity requirements. This section provides the means to properly size a bioretention practice to capture the BMP design treatment volume (T_{VBMP}) and any additional volume to help manage water quantity.

5.1.1 Pre-treatment

Provide pre-treatment for bioretention. Pre-treatment should dissipate and disperse concentrated flows entering the practice, as well as trap sediment and trash that clog the bioretention media. Refer to Support Component: Pre-treatment P-SUP-06 for design details and specifications for applicable pre-treatment options.

5.1.2 Component Depths

The various layers of the bioretention practice are referred to as components. A bioretention practice must contain a ponding area and soil filter media. A gravel layer can also be added, and designers can choose from different options for the gravel layer. The gravel layer is called a “sump” for Level 2 designs because the underdrain is located at the top of the gravel. Each component has established minimum and maximum depths ([Table P-FIL-052-36](#)). The depths of the selected components are used in the computation for the surface area of the practice.

5.1.3 Surface Area Sizing

Surface Area Sizing for Stormwater Quality. Proper sizing of the surface area is important for bioretention for three main reasons:

1. The first is to ensure that the surface area size is not too small to accommodate the expected design volume of flow. If the practice is too small, a portion of the treatment volume will bypass the practice. ~~As an example, runoff volume bypass could occur at 0.7 inches of rainfall or greater depending on rainfall intensity. Local topography and the hydraulic conductivity (K_{sat}) of the soil media or native soil, whichever is the limiting K_{sat} value.~~
2. The second reason is to confirm that the design storage volume passes through and exfiltrates from the practice within specified drain times. Drain times aim to ensure storage is available within the practice between storm events and to prevent the soil media from being saturated for an extended period.
3. The third reason involves the land use designation within the VRRM spreadsheet. Provided the bioretention practice is designed and maintained as directed in this specification, the surface area is counted as forest and mixed open space in the VRRM spreadsheet (DEQ VRRM User Guide).

The surface area size for any practice will be based on the comparison of two equations. One equation is based on the volumetric requirements of the practice (Volumetric method) and the other is based on the interaction of the practice with its surrounding soil environment (Flow-rate method). Both equations require knowing T_{VBMP} , which is the treatment volume based on the runoff generated from the 1-inch storm event, and includes runoff from impervious surfaces and managed turf within the contributing drainage area to the BMP plus any remaining runoff volume from upstream runoff reduction practices. Any forest area included within the contributing drainage area is not part of the T_{VBMP} . The T_{VBMP} for Level 1 designs can be obtained from the VRRM spreadsheet. For Level 2 designs, use Equation P-FIL-05-1 to calculate the T_{VBMP} :

Equation P-FIL-05-1: Treatment Volume Calculation.

$$T_{VBMP} = (C_{Level} \times R_v \times A) / 12$$

Where:

C_{Level} = factor that is set to 1 in. (for Level 1 designs) or 1.25 in. (for Level 2 designs)

Commented [MC8]: Discussion: Specify to use the larger of the two results
Ask Arcadis

R_v = composite volumetric runoff coefficient, which comes from the VRRM Drainage Area (DA)

Tab. A = drainage area to BMP (sq. ft.)

Volumetric Approach: The required surface area (SA; in square feet) is computed as the T_{VBMP} (in cubic

feet) divided by the equivalent storage depth, ESD (in feet; Equation P-FIL-05-2). The equivalent storage depth represents the void space available for water storage within the surface ponding area, soil media, and gravel layer (if needed) of the bioretention practice. The equivalent storage depth is computed as the sum of the depths (in feet) of the utilized components multiplied by their respective accepted porosity (Table P-FIL-05-4). Therefore, the selection of the component depths (within the required minimums and maximums of Table P-FIL-5-3) will influence the size of the surface area.

Equation P-FIL-05-2 Bioretention Surface Area Using Volumetric Approach.

$$SA = T_{VBMP} / ESD$$

Where:

SA = surface area (sq. ft.)

T_{VBMP} = BMP treatment volume (cu. ft.)

= Level 1 BMP design treatment volume (cu. ft.) = [(1.0 in.)(R_v)(A) / 12];

= Level 2 BMP design treatment volume (cu. ft.) = 1.25[(1.0 in.)(R_v)(A) / 12]

R_v = Composite volumetric runoff coefficient from the VRRM Compliance Spreadsheet or User Guide

A = drainage area to BMP (sq. ft.)

ESD = equivalent storage depth (ft.)

$$= (d_{ponding} \times \eta_{ponding}) + (d_{media} \times \eta_{media}) + (d_{gravel} \times \eta_{gravel})$$

d = depth of the respective layer (ponding, media, or gravel; ft.)

η = available porosity of the respective layer (ponding, media or gravel; Table P-FIL-05-4)

Table P-FIL-05-47 Estimated Porosity for Each Bioretention Component

Bioretention Component	Available Porosity (η)
Ponding Area	1.0
Soil Media	0.25 *
Gravel Layer	0.40

Note:

*Estimated value assuming full media dry-down.

Flow-rate Approach: In addition to utilizing the T_{VBMP} and the depths for the ponding area and soil filter media, this method also includes drain time K_{sat} (Claytor and Schueler 1996). The selected K_{sat} will either be that of the soil filter media or native soil, depending on the design level of the practice and the results of the soil test for the native soil. This approach also provides a level of insurance that the practice will drain within the two-day specified time.

Equation P-FIL-05-3 Bioretention Surface Area Using Darcy's Law Flow Rate Approach.

$$SA = (12 \times T_{VBMP} \times d_{media}) / (td \times K_{sat} \times (d_{ponding} + d_{media}))$$

Where:

SA = surface area of bioretention practice (ft.²)

T_{vBMP} = treatment volume of the BMP (cu. ft.)

d_{media} = depth of soil filter media (ft.)

t_d = required drain time (hr.); maximum is 48 hours for ponding volume

K_{sat} = hydraulic conductivity (in./hr.);

if Level 1 with an underdrain, use the K_{sat} of the soil filter media;

if Level 2 or Level 1 without an underdrain, use the K_{sat} of the most restrictive layer (soil filter media, native soil)

d_{ponding} = depth of ponding area (ft.) ~~213~~

Surface Area Sizing for Stormwater Quantity. The credit from RR can be used to reduce the stormwater volume that discharges from the site. The reduction of the stormwater volume can therefore be applied to meet both water quality and water quantity requirements. The VRRM spreadsheet calculates the RR credit for water quality and applies the credit to the water quantity volumes. This reduced runoff volume is shown on the Runoff Volume and Curve Number Calculations Tab. Detailed information on this process can be found in DEQ VRRM User Guide.

Designers may be able to create additional surface storage by expanding the surface ponding footprint to accommodate a greater quantity credit for channel and/or flood protection. This surface ponding expansion can be accomplished without necessarily increasing the soil media footprint. In other words, the engineered soil media would only underlie part of the surface area of the bioretention. In this regard, the ponding footprint can be increased as follows to allow for additional storage:

- 50% surface area increase if the ponding depth is 6 inches.
- 25% surface area increase if the ponding depth is between 6 and 12 inches.

Both Level 1 and Level 2 designs are limited by the percentage surface ponding expansion described above. For Level 1 practices with an underdrain, the added volume of storage for channel and flood protection is also limited by the ponding volume drain time of 48 hours. For Level 2 practices or Level 1 without an underdrain, the storage volume for channel and flood protection must drain within 72 hours (See Section 5.1.3 on Drain Times).

Note: Any depths used to increase storage for additional quantity credit are not to be used in the surface area equations (Equations P-FIL-05-2 and 05-3).

5.1.34 Drain Times

The drain time is defined as the time it takes for a storage volume to exit either the entire practice or a component of the practice, e.g., ponding area, soil media, sump. The drain time is important for two reasons:

1. To ensure void storage is available for successive storm events, and
2. To prevent anaerobic conditions within the soil media that can cause the release and transport of nutrients and metals.

A predetermined drain time ([Table P-FIL-05-58](#)) has been assigned for a given storage volume. The storage volumes of interest are the volume of water contained in the ponding area (PV) and the design volume (DV). The DV, at a minimal, will equal T_{vBMP}. The maximum DV is composed of the T_{vBMP} and the water

quantity volume that can be applied toward meeting channel/flood protection requirements (QV).

Table P-FIL-05-58 Design Parameters for Drain Time Calculations

Bioretention Component	Unit	Design Criteria
Treatment volume of BMP (T _{vBMP})	ft. ³	Obtain from VRRM spreadsheet*

Table P-FIL-05-58 Design Parameters for Drain Time Calculations

Bioretention Component	Unit	Design Criteria
Ponding volume (PV)	ft. ³	Total volume of water in ponding area
Water quantity volume (QV)	ft. ³	Volume applied for channel/flood protection
Design volume (DV)	ft. ³	Total volume of water that drains within the established drain time (48 or 72 hours) DV = TvBMP + QV
Hydraulic conductivity of soil filter media (media Ksat)	in./hr.	Supplied by vendor or use 0.5
Hydraulic conductivity of native soil (soil Ksat)	No underdrain: ≥ 0.5 and < 10 in./hr. Level 2 with sump or internal water storage: ≥ 0.25	
Maximum drain time of ponding volume	hrs.	48
Maximum drain time of practice	hrs.	72 (or 48 hours if Level 1 with an underdrain)

Note:

* For Level 2 practices, multiply TvBMP from VRRM spreadsheet by 1.25.

Drain time of the surface ponding area: The maximum drain time of the ponding volume is 48 hours. If the two-day limit is exceeded, adjust the sizing of the practice or alter the landcover to reduce the volume to the facility.

Equation P-FIL-05-4 Drain Time of the Surface Ponding Area.

$$td-PV = 12 \times PV / (K_{sat} \times SA)$$

Where

$td-PV$ = drain time of the ponding volume (hours)

PV = ponding volume (ft.³)

K_{sat} = hydraulic conductivity of the soil filter media (in./hr.)

SA = surface area of soil filter media (ft.²)

Drain time of the practice: Use the drain time of the practice to ensure that the treatment volume exfiltrates within 48 hours for Level 1 designs with an underdrain and within 72 hours for Level 1 designs without an underdrain and for Level 2 designs (Equation P-FIL-05-35). If the limit is exceeded, make sizing adjustments for the practice or alter the landcover to reduce the volume to the facility.

Equation P-FIL-05-5 Drain Time of the Treatment Volume.

$$td-TV = 12 \times TVBMP / (K_{sat} \times SA)$$

$td-TV$ = drain time of the treatment volume (hours)

$TVBMP$ = treatment volume of BMP (cu. ft.)

K_{sat} = hydraulic conductivity of the most restrictive layer (in./hr.)

- Level 1 with underdrain, use K_{sat} of soil filter media
- Level 1 without underdrain, use limiting K_{sat} of soil filter media or native soil.

- Level 2, use limiting K_{sat} of soil filter media or native soil

SA = surface area of soil filter media (sq. ft.)

This calculation determines the additional storage that can be added for channel and flood protection. The volume available for channel and flood protection is the difference between the T_{VBMP} that drains within 72 hours (or 48 hours if Level 1 with an underdrain) and any remaining volume that would drain within that drain time limit. If storage is to be used for channel and flood protection, use the following equation to determine the volume available:

Equation P-FIL-05-6: Volume Available for Quantity Requirements.

$$QV = (K_{sat} \times SA \times td-TV / 12) - T_{VBMP}$$

Where:

QV = Volume available for channel/flood protection (cu. ft.)

K_{sat} = hydraulic conductivity of the most restrictive layer (soil filter media, native soil) (in./hr.)

SA = surface area of soil filter media (sq. ft.)

$td-TV$ = drain time of the treatment volume (hours); maximum = 72 hours (or 48 hours if Level 1 with an underdrain)

T_{VBMP} = Treatment volume of the practice (cu. ft.)

5.1.54 Storage Volume

The designer should calculate the total storage volume located within the surface ponding area, soil media, and gravel layer to determine the actual storage volume that the practice contains. The volume of the ponding area needs to account for the side slopes of 3H:1V or flatter. Because of the side slopes, the actual storage volume will be larger than the design volume. However, only the design volume is required to drain within 72 hours (or 48 hours if Level 1 with an underdrain).

Equation P-FIL-05-7: Total Storage Volume of the Practice.

$$SV_{practice} = [(SA_{avg-ponding} \times d_{ponding}) + (SA_{media} \times d_{media} \times \eta_{media}) + (SA_{gravel} \times d_{gravel} \times \eta_{gravel})]$$

Where:

$SV_{practice}$ = storage volume of the practice (ft.³)

$SA_{avg-ponding}$ = the average area of the ponding layer (ft.²)

= $0.5 \times [(surface\ area\ at\ the\ top\ of\ the\ layer) + (surface\ area\ at\ the\ bottom\ of\ the\ layer)]$

d = depth of the respective layer (ponding, media, or gravel; ft.)

SA = surface area of the respective layer (media or gravel; ft.²)

η = porosity of the respective layer (media or gravel; $\eta_{ponding} = 1$; see Table P-FIL-05-4)

If the media and/or gravel layers have side slopes, use the equation above and replace SA_{media} with $SA_{avg-media}$ and/or replace SA_{gravel} with $SA_{avg-gravel}$ (as needed). The symbols for $SA_{avg-media}$ and $SA_{avg-gravel}$ refer to the following:

SA_{avg} = the average area of the respective layer (media or gravel; ft.²)

= $0.5 \times [(surface\ area\ at\ the\ top\ of\ the\ layer) + (surface\ area\ at\ the\ bottom\ of\ the\ layer)]$

Note: The surface area computed using Equation P-FIL-05-2 and 05-3 must not use component depths added for the purpose of water quantity volume.

Note: The VRRM spreadsheet computes the treatment volume that is used to size the practice. This treatment volume represents the largest storage volume that the practice contains based on the bioretention specifications for water quality management and is the only volume recognized by the VRRM spreadsheet.

5.2 Surface Ponding Area

The surface ponding area includes the portion of the bioretention practice located between the top of the filter media and the top of the ponded water surface.

The minimum surface storage requirements are based on the need to capture the T_{vBMP} from a full range of expected storm intensities. Rainfall distribution in the mid-Atlantic includes both short intense storms, as well as long, steady, low-intensity rain events. During high intensity storm events, the bioretention practice may fill up faster than the collected stormwater is able to filter through the soil media. In addition, the hydraulic conductivity of the surface layer of mulch and the soil media will vary over the maintenance life cycle of the practice.

Therefore, an adequate ponding volume is necessary to allow the runoff to begin to filter into the soil media before the runoff bypasses or overflows the surface storage. The method provided in determining the surface ponding area is an attempt to capture and treat the majority of the T_{vBMP} for most storm events.

The surface ponding area must be primarily covered with vegetation and includes planting zones on the bottom and sides of the ponded area. Design elements for the surface ponding area include the ponding depth, side slopes, surface cover, and planting plan.

5.2.1 Depth

The surface ponding area of a bioretention practice must have a minimum ponding depth of 6 inches and a maximum ponding depth of 12 inches. A ponding depth of 6 inches is preferred unless site constraints mandate the deeper ponding depth.

5.2.2 Side Slopes

Side slopes of the ponding area are required to be 3H:1V or flatter.

5.2.3 Surface Cover



*A residential bioretention used to manage upgradient street runoff that was formerly causing nuisance flooding downstream
Photo Credit: Hirschman Water & Environment, LLC.*

- ~~Mulch. Include a 2- to 3-inch layer of mulch on the surface of the filter bed unless managed grass cover is utilized with a high K_{sat} establishment soil cover. Shredded, aged hardwood bark (aged at least 6 months) makes a very good mulch surface cover, as it may retain some pollutants and typically will not float away. The maximum depth of the mulch layer is 3 inches.~~

The surface cover is the layer of materials located on the top of the soil filter media. The purpose of the cover is to enhance plant survival, suppress weed growth, and pre-treat runoff before it reaches the soil filter media. The choice of surface cover will also influence the maintenance activities of the soil filter media and plantings (see Section 7.0 Maintenance). This layer is not included in the sizing calculations. The surface cover options are listed below.

- ~~Mulch. Include a 2- to 3-inch layer of mulch on the surface of the filter bed unless managed grass cover is utilized with a high K_{sat} establishment soil cover. Shredded, aged hardwood bark (aged at least 6 months) makes a very good mulch surface cover, as it may retain some pollutants and typically will not float away. The maximum depth of the mulch layer is 3 inches.~~

Formatted: Font: (Default) Arial, Font color: Black, Strikethrough

Formatted: List Paragraph, Line spacing: Exactly 13.4 pt, Bulleted + Level: 1 + Aligned at: 0.35" + Indent at: 0.6"

Formatted: Font: (Default) Arial, Font color: Black, Strikethrough

Formatted: Font: (Default) Arial, Bold, Font color: Black, Strikethrough

- **Managed grass or non-leguminous herbaceous cover.** Managed grass is defined as grassy areas that are not used for food or fodder and have a minimum maintenance of at least two mowing events per year. Any perennial grass mixture or monostand that covers the soil well (at least 70% living cover) will protect soil and allow infiltration. Species that will persist the best (i.e., cover the soil) at the location should be used. Grass performance and persistence is very much dependent on the geography, characteristics and intended maintenance of the site. Native species should be specified over non-native species where possible to meet design expectations.
 - The following sources and others provide more information:
 - "Virginia Turfgrass Variety Recommendations" by Virginia Cooperative Extension
 - "Virginia Department of Transportation Specifications for Standard and Non-Standard Seed" (e.g., Green Tag list) by Virginia Department of Transportation
 - Virginia Department of Transportation Road and Bridge Specifications Section 603 Seeding

Formatted: Font: (Default) Arial, Font color: Black

Formatted: List Paragraph, Bulleted + Level: 1 +
Aligned at: 0.35" + Indent at: 0.6"

Alternative Vegetative Covers and/or Zones. In some situations, designers may consider alternative surface covers such as native groundcover, erosion control matting (coir or jute matting), river stone, or pea gravel. Native groundcover serves a dual role, as both surface cover and vegetation (see Section 5.3.4). Stone or gravel are not recommended in parking lot applications because they increase soil temperature and have low water holding capacity. Furthermore, the use of stone or gravel disqualifies the surface area of the bioretention from being counted as forest and mixed open space in the VRRM spreadsheet. For most up-to-date list of native species, please see the DCR Virginia Native Plant Finder (<https://www.dcr.virginia.gov/natural-heritage/native-plants-finder>).

5.2.4 Planting Plan

A planting plan must be developed for the intended vegetated zones in each bioretention area. The primary objective of the planting plan is to cover as much of the surface area of the filter bed as quickly as possible to provide some level of vegetative resistance to water flow and enhance evapotranspiration and nutrient uptake (see [Table P-FIL-05-6](#)). The planting plan should be prepared by a landscape or revegetation/restoration professional to tailor it to the site-specific conditions. Minimum plan elements shall include the following:

- Delineation of planting area into moisture zones,
- Template,
- Vegetation Plan, and
- Installation and Maintenance Plan.

Delineation of Planting Area. The planting area needs to be sectioned into different moisture and/or plant type (e.g., grass, shrub, tree) zones. Delineate the low, medium, and high moisture zones of the practice. In the lowest area, plant facultative species that tolerate frequently wet conditions, and in the highest areas, plant species that do well under drier conditions. Also indicate the location of inlets, outlets, underdrains and any utilities that cross the bioretention practice to ensure that the vegetation planted in these areas is appropriate given assumed wetness gradients and constraints.

Planting Options/Templates. The planting template for a given site BMP describes the types of vegetation to be planted within the bioretention practice, e.g., herbaceous vegetation, shrubs, and/or trees. The choice of which planting template to use depends on the scale of bioretention, the context of the site in the urban environment, the filter depth, the desired landscape amenities, and the owner's capability to maintain the landscape. Six potential bioretention vegetation options/templates are summarized in [Table P-FIL-05-69](#).

Table P-FIL-05-69 Bioretention Vegetation Options and Templates
Vegetation Component Options

Managed Grass

This option serves as both vegetation and surface cover (see Section 5.2.3). For Level 1 practices, managed grass is all that is needed. For Level 2 practices, managed grass must be combined with shrubs and/or trees. Use grass species that have dense cover, are relatively slow growing, and require limited mowing (see Table P-FIL-05-7).

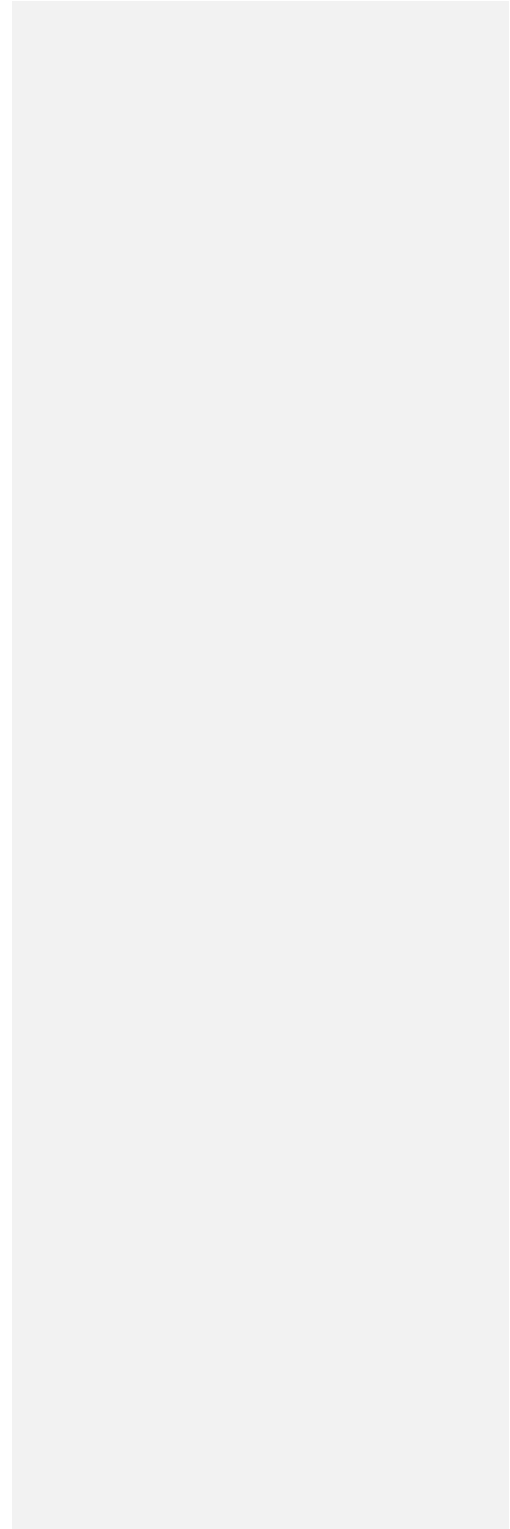


Table P-FIL-05-69 Bioretention Vegetation Options and Templates

Vegetation Component	Options
Perennial Garden	This option uses herbaceous plants and native grasses to create a garden effect with seasonal cover. This option is attractive, but it requires diligent maintenance in the form of weeding. Use of pollinator-friendly mixes is encouraged.
Perennial garden with shrubs	This option mixes native shrubs and perennials together in the bioretention area. This option is frequently used when the soil filter media is too shallow to support tree roots (which have a minimum effective rooting depth of 36 inches).
Tree, shrub and herbaceous plants	This template is the traditional landscaping option for bioretention and is highly recommended. The landscape goal is to simulate the structure and function of a native early successional forest plant community.
Managed grassland and trees	This option is a lower maintenance version of the tree-shrub-herbaceous option. Trees are planted within larger mulched islands to prevent damage during mowing operations.
Herbaceous meadow	This approach focuses on the herbaceous layer and may resemble a wildflower meadow or roadside vegetated area (e.g., with Joe-pye-weed, New York Ironweed, sedges, grasses, etc.). The goal is to establish a natural look that may be appropriate if the practice is located in a lower maintenance area (e.g., further from buildings and parking lots). Shrubs and trees may be incorporated around the perimeter.

Vegetation Plan. The vegetation plan includes the number and list of plants to be planted, recommended spacing, and size of planting stock. Some popular native species that work well in bioretention areas and are commercially available can also be found in [Table P-FIL-05-710](#). Commonly used ornamental nonnative (non-invasive and/or problematic) are also provided in [Table P-FIL-05-710](#). Internet links to more detailed bioretention plant lists developed in Piedmont and Coastal Plain communities of the Chesapeake Bay region are provided in Section 5.3.

Consider the following when selecting vegetation for a bioretention practice:

- Native plant species should be specified over non-native species where possible to meet design expectations, but some ornamental and non-native species may be used for landscaping effect if they are not aggressive or invasive.

Use of pollinator friendly species is encouraged where compatible with design expectations.

- Plants should be selected based on a specified zone of hydric tolerance and must be capable of surviving both wet and dry conditions. Care is needed in selecting vegetation for facilities with ponding depths greater than 6 inches.
- Use turfgrass, perennials or shrubs instead of trees in practices with shallower filter beds (e.g. where 36" of effective rooting depth cannot be assured).

If trees are used, plant shade-tolerant ground covers within the drip line.

- Tree species should be those that tolerate expected non-pristine air and water inputs from the urban landscape.

Maintenance is an important consideration in selecting plant species. Plant selection differs if the area will be frequently mowed, pruned, and weeded, in contrast to a site that will receive minimum annual maintenance.

- If the bioretention area is to be used for snow storage or is to accept snowmelt runoff, it should be planted with salt-tolerant, herbaceous perennials and shrubs.

This list is not exclusive and additional sources of information are given in below the table. Use of native species adapted to fluctuating wetness (redox) conditions is encouraged over the use of non-native ornamental species for direct planting into bioretention media zones. Drier mesic species are best utilized around bioretention margins, berms and conveyances.

For most up-to-date list of native species, please see the DCR Virginia Native Plant Finder

(<https://www.dcr.virginia.gov/natural-heritage/native-plants-finder>).

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Shrubs							
American Beauty-berry, French-mulberry	<i>Callicarpa americana</i>	4-6 ft	4-6 ft	Clay soil, cold, drought	Mesic to wet	Seed, plugs, cuttings	Zones 6-12. Full sun to part shade. Attractive purple seeds. Conspicuous flowers. Attracts birds and butterflies.
Coastal White-alder, Sweet Pepperbush	<i>Clethra alnifolia</i>	3-6 ft	3-8 ft	Wet soil, acid soil, sands and clays, salt spray, heavy shade	Mesic to wet	Potted plants	Fragrant, showy flowers. Fall color. Attracts birds, bees, and butterflies. Part shade to full shade. Zones 3-9.
Buttonbush	<i>Cephalanthus occidentalis</i>	4-8 ft	5-12 ft	Erosion, wet soil, shallow standing water	Mesic to wet	Potted plants, bareroot seedlings	Zones 5-9. Full sun to part shade. Attracts pollinators. Does not tolerate dry soils

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Silky dogwood	<i>Swida amomum</i>	6-12 ft	6-12 ft	Deer, erosion, wet soil, black walnut, shade	Mesic to wet	Potted plants	Zones 5-8. Full sun to part shade. Attracts pollinators. Prefers rich, acidic soils. Can spread via rhizomes.
Gray dogwood	<i>Swida racemosa</i>	10-15 ft	10-15 ft	Deer, wet soil, somewhat dry soil, air pollution	Mesic	Potted plants	Zones 4-8. Full sun to part shade. Attracts pollinators. Tolerates many soil types. Can spread via rhizomes.
Winterberry	<i>Ilex verticillata</i>	2.5-3 ft	6-10 ft	Erosion, clay soil, wet soil, air pollution	Mesic to wet	Potted plants	Full to part shade. Zones 3-9. Need 1 male per 9-10 females to produce berries.
Virginia-willow, Virginia Sweetspire	<i>Itea virginica</i>	3-5 ft	3-5 ft	Deer, heavy shade, wet soil, erosion	Mesic to wet	Potted plants	Full sun to part shade. Zones 5-9. Prefers high OM soils.
Inkberry	<i>Ilex glabra</i>	3-4 ft	3-4 ft	Rabbit, deer, erosion, wet soil, air pollution	Mesic to wet	Potted plants	Full sun to part shade. Zones 4-9. Prefers high OM, acidic soils. Evergreen

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Wax Myrtle, Southern Bayberry	<i>Morella cerifera</i>	10-15 ft	6-15 ft (can reach a max of 25 ft)	Clay soil. Saline soils. Flood and drought when established. Deer and rabbit resistant	Mesic to wet	Potted plants	Evergreen. Zones 7-10. Needs constant moisture to establish (drought and flood tolerant once established). Sun to part shade. Fragrant.
Common Ninebark, Eastern Ninebark	<i>Physocarpus opulifolius</i> var. <i>opulifolius</i>	4-6 ft	5-8 ft	Drought, erosion, clay soil, dry soil, wet soil, shallow-rocky soil, black walnut	Dry to mesic – well drained	Potted plants, bare roots	Zones 2-8. Full sun to part shade. Struggles with heat and humidity. Needs pruning after flowering.
Common Elderberry	<i>Sambucus canadensis</i>	5-12 ft	5-12 ft	Erosion, clay soil, wet soil.	Mesic to wet	Potted plants	Zones 3-9. Full sun to part shade. Showy, fragrant flowers that attract pollinators. Edible berries attract birds. Grows best in humic soils. Spreads by suckers.

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Arrow-wood	<i>Viburnum dentatum</i>	6-10 ft	6-10 ft	Black walnut, var. soil types	Mesic – well drained	Potted plants	Zones 2-8. Full sun to part shade. Showy flowers, fall foliage. Blue Muffin cultivar ~ half size. Prefers moist loams, tolerates many soils.
Black Haw	<i>Viburnum prunifolium</i>	6-12 ft	12-15 ft	Drought, clay soil, black walnut, air pollution	Dry to mesic-well drained	Potted plants, bare root	Zones 3-9. Full sun to part shade. Attracts pollinators. Showy flowers, fruits, fall foliage. Can be pruned to grow as a small tree (30'). Edible fruits.
Grasses and Herbaceous Perennials							
Big Bluestem, Turkeyfoot	<i>Andropogon gerardii</i>	2-3 ft	4-6 ft	Deer, Drought, Erosion, Dry Soil, Black Walnut, Air Pollution	Dry to mesic	Seeds, potted plants	Full sun. Zones 4-9.
Swamp Milkweed	<i>Asclepias incarnata var. pulchra</i>	2-3 ft	2-5 ft	Heavy clay, wet soil, high deer resistance	Mesic to wet	Potted plants	Zones 3-8. Full sun to part shade. Attracts pollinators. Pink flowers. Toxic to pets and livestock in large quantities.

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Pennsylvania sedge	<i>Carex pensylvanica</i>	6-12 in	6-12 in	Heavy shade, wet soil	Dry to mesic – well drained.	Plugs, small pots, seeds	Part to full shade. Zones 3-8. Prefers loose soils.
Riveroats	<i>Chasmanthium latifolium</i>	1-2.5 ft	2-5 ft	Poor soils, black walnut.	Mesic to wet	Seed, potted plants	Zones 3-8. Full sun to part shade. Spreads via seeds
Virginia Dayflower	<i>Commelina virginica</i>	1.5-3 ft	1.5-3 ft	Wet soil	Mesic to wet	Small pots	Hardiness zones 5/6-9. Small blue flowers. Sun to shade
Hollow Joe-pye-weed	<i>Eutrochium fistulosum</i>	2-4 ft	2-7 ft	Wet soil, deer and rabbit resistant	Mesic to wet	Seed, potted plants	Shrubby perennial. Zones 4-10. Full sun to part shade. Showy flowers. Attracts pollinators
Swamp Rose-mallow, Eastern Rose-mallow, Crimson-eyed Rose-mallow	<i>Hibiscus moscheutos</i>	2-4 ft	3-7 ft	Wet soil, some light shade, heat and humidity	Mesic to wet	Seeds, plants	Zones 5-9. Full sun. Prefers high OM soils, does not tolerate dry soils. Showy flowers, attracts pollinators.
Virginia Blue Flag, Southern Blue Flag	<i>Iris virginica</i> soil	1-3 ft	1-3 ft	Deer, wet	Mesic to wet	Seeds, potted plants	Zone 5-9. Full sun. Prefers wet, boggy, acidic, sandy soils. Does not tolerate dry soil.

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Common Rush, Soft Rush	<i>Juncus effusus ssp. solutus</i>	1-4 ft	1-4 ft	Clay soil, deer	Mesic to wet	Seeds, potted plants	Full to part sun. Zone 4-9
Cardinal flower	<i>Lobelia cardinalis</i>	1-2 ft	2-4 ft	Rabbit, deer, wet soil, brief flooding	Mesic to wet	Seeds, plants	Zones 3-9. Full sun to part shade. Showy flowers, attract pollinators. Prefers rich soils. Does not tolerate dry soils.
Scarlet Beebalm, Oswego Tea	<i>Monarda didyma</i>	2-3 ft	2-4 ft	Rabbit, deer, clay soil, wet soil, black walnut	Mesic to wet	Seeds, plants	Zones 4-9. Full sun to part shade. Fragrant, showy flowers, attracts pollinators. Best in rich, moisture-retentive soils; does not tolerate dry soils.
Wild Bergamot	<i>Monarda fistulosa</i>	2-3 ft	2-4 ft	Deer, drought, clay soil, shallow-rocky soil, black walnut	Dry to mesic	Seeds, plants	Zones 3-9. Full sun to part shade. Fragrant, showy flowers, attracts pollinators.

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Switchgrass; Blunt Switchgrass	<i>Panicum virgatum</i> var. <i>virgatum</i> ; var. <i>cupense</i>	2-3 ft	3-6 ft	Drought, pollution, deer resistant, black walnut	Mesic (well drained)	Potted plants	Controls erosion (roots can reach depths of 10 feet). Food source and cover for birds. Sun to partial shade (best in full sun). Zones 3-9
Black-eyed Susan	<i>Rudbeckia hirta</i>	1-2 ft	1-3.5 ft	Heat, drought, clay soil. Slightly deer resistant	Dry to mesic	Seeds, small pots	Hardiness zones 3-7. Dislikes poorly drained, wet soils (side-slope species). Sun to partial shade. Free seeding. Showy flowers. Attracts pollinators
Little Bluestem	<i>Schizachyrium scoparium</i> var. <i>scoparium</i>	1.5-2 ft	2-4 ft	Deer, drought, erosion, black walnut, air pollution, occasional inundation	Dry to mesic	Seeds, potted plants	Many cultivars. Zones 3-9. Full sun (tolerates part shade),

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Sweet Goldenrod, Anise-scented Goldenrod	<i>Solidago odora</i>	1-2 ft	2-5 ft	Deer, drought, clay soil	Dry to mesic	Seed, potted plants	Zone 4-9. Conspicuous yellow flowers. Attracts pollinators. Full sun
Trees							
Downy Serviceberry	<i>Amelanchier arborea</i>	15-25 ft	15-25 ft	Tolerant of wide range of soils	Mesic	Potted trees	Zones 4-9. Full sun to part shade. Shrubby habit if root suckers unpruned.
Red maple	<i>Acer rubrum</i>	30-50 ft	40-80 ft	Wide range of soil, air pollution. Moderately deer resistant	Mesic to wet by variety	Potted trees	Showy fall color. Fast growing. Sun to partial shade. Zones 3-9
Pawpaw	<i>Asimina triloba</i>	15-30 ft	15-30 ft	Wet soil, black walnut, deer	Mesic to wet- well drained	Potted trees	Zones 5-9. Full sun to part shade (more fruit production in full sun). Prefers moist, acidic, fertile soils. Showy fall foliage. Spreads by suckers.
River Birch, Red Birch	<i>Betula nigra</i>	40-60 ft	40-70 ft	Deer, drought, heat, wet soil, black walnut, air pollution	Mesic to wet	Potted trees, burlapped trees	Full sun to part shade. Zones 4-9. Prefers acidic, fertile soils.

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Common Hackberry, Northern Hackberry <i>Celtis occidentalis</i>	40-60 ft	40-60 ft	Drought, clay soil, wet soil, dry soil, air pollution, poor soils	Mesic to wet – well drained	Potted trees, burlapped trees	Full sun to part shade. Zones 2-9. Attracts birds and butterflies. Edible fruits.
Common Persimmon, American Persimmon <i>Diospyros virginiana</i>	25-35 ft	35-60 ft	Drought, clay soil, dry soil, shallow-rocky soil, black walnut, air pollution	Dry to mesic	Potted trees	Full sun to part shade. Zones 4-9. Prefers moist, sandy soils.
Sweetgum <i>Liquidambar styraciflua</i>	50-75 ft	60-90 ft	Clay, short duration flooding, rabbits	Mesic to wet	Potted trees	Does not tolerate alkaline soil. Not deer tolerant. Attracts wildlife. Sun to partial shade. Zones 5b-9. Showy fall color
Sweetbay, Sweetbay Magnolia, Swamp Magnolia <i>Magnolia virginiana var. virginiana</i>	12-30 ft	12-30 ft	Clay soils, wet soils, shade, flooding, air pollution, salt spray	Mesic to wet	Potted trees	Fragrant white-cream blooms. Attracts birds and wildlife. Sun to partial shade. Zones 5-10.
Water-tupelo <i>Nyssa aquatica</i>	25-50 ft	50-80 ft	Poorly drained soils, standing water	Mesic to wet	Potted trees	Full sun to part shade. Zones 6-9. Prefers moist, acidic soils.

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Black Gum, Sour Gum	<i>Nyssa sylvatica</i>	20-30 ft	30-50 ft	Wet soil, some standing water, dry soil, black walnut,	Mesic to wet	Potted trees, possibly burlapped trees	Full sun to part shade, Zones 3-9. Prefers moist, acidic soils.
American Sycamore	<i>Platanus occidentalis</i>	60-100 ft	75-100 ft	Deer, wet soil, air pollution	Mesic to wet	Potted trees, burlapped trees	Zones 4-9. Full sun. Large tree – best for large areas. Tolerates light shade. Prefers rich, humic, moist soils.
Black Cherry, Wild Black Cherry	<i>Prunus serotina var. serotina</i>	30-60 ft	50-80 ft	Drought, salt spray, black walnut	Dry to mesic	Potted trees	Showy, white flowers. Susceptible to diseases. Not deer tolerant. All parts except fruit are toxic. Attracts pollinators. Zones 3-9
<i>Quercus</i> Swamp White Oak <i>bicolor</i>		50-60 ft	50-60 ft	Wet soil, drought,	Mesic to wet	Potted trees, burlapped trees	Zones 3-8. Full sun. Prefers acidic soil. Showy fall foliage.
Swamp Chestnut Oak, Basket Oak	<i>Quercus michauxii</i>	30-50 ft	40-60 ft	Erosion, wet soil, part shade, occasional flooding	Mesic to wet	Potted trees, burlapped trees	Zones 5-9. Full sun. Showy fall foliage. Grows best in acidic, moist loams and sandy soils.

Table P-FIL-05-7-10 Suggested Native Plants for Use in Bioretention Applications

Common name	Botanical Name	Spread	Height	Tolerances	Soil moisture	Availability (e.g., seeds, plants)	Other notes
Pin Oak	<i>Quercus palustris</i>	40-60 ft	50-70 ft	Wet soils, some flooding	Mesic to wet.	Potted trees, burlapped trees	Full sun. Zones 4-8. Does not tolerate very poorly drained soils. Prefers acidic soils.
Willow Oak	<i>Quercus phellos</i>	25-50 ft	40-75 ft	Wet soils, clay soil, air pollution, light shade.	Mesic to wet	Potted trees, burlapped trees	Full sun. Zones 5-9. Tolerates some poor drainage.
Shumard Oak	<i>Quercus shumardii</i>	30-40 ft	40-60 ft	Drought, dry soils, wet soil, air pollution	Dry to mesic – well drained soils	Potted trees, burlapped trees	Full sun. Zones 5-9. Prefers mesic, acidic soils. Moderately fast growing but a smaller oak. Showy fall foliage.
Black Willow	<i>Salix nigra</i>	30-60 ft	30-60 ft	Erosion, flooding	Mesic to wet	Potted trees	Zone 4-9. Full sun to part shade. Shallow roots stabilize soil. Intolerant of dry soil and full shade.
Baldcypress	<i>Taxodium distichum</i>	20-45 ft	50-70 ft	Deer, clay soil, wet soil, air pollution, compacted soils.	Mesic to wet	Potted trees, burlapped trees	Full sun. Zones 4-9. Prefers moist, acidic, sandy soils but can tolerate many soils as well as dry soils to standing water. Only native in Coastal Plain of VA.

5.3 Links for Stormwater BMP and Native Plant Publications

The resources identified in this subsection are listed alphabetically by organization and title.

Chesapeake Bay Landscape Professional (CBLP)

- CBLP Sustainable Landscapes Maintenance Manual – <https://certified.cblpro.org/product-category/manuals/>
- Native Plants for Stormwater Best Management Practices – <https://certified.cblpro.org/product-category/manuals/>

Cornell University, School of Integrative Plant Science

- Woody Shrubs for Stormwater Retention Practices: Northeast and Mid-Atlantic Regions – http://www.hort.cornell.edu/uhi/outreach/pdfs/woody_shrubs_stormwater_hi_res.pdf

U.S. Fish and Wildlife Service

- Native Plant Center (interactive online version) – <http://www.nativeplantcenter.net/>
- Native Plants for Wildlife Habitat and Conservation Landscaping: Chesapeake Bay Watershed. (available at <https://dnr.maryland.gov/criticalarea/Documents/chesapeakekenatives.pdf>)

Virginia Botanical Associates

- Digital Atlas of the Virginia Flora – <http://vaplantatlas.org/>

Virginia Department of Conservation and Recreation

- Fact Sheets and Brochures: Native Plants for Conservation, Restoration and Landscaping (Coastal Plain, Piedmont Plateau, Mountains, Riparian Forest Buffers, Grasslands) – <https://www.dcr.virginia.gov/natural-heritage/factsheets>
- Flora of Virginia – <http://www.dcr.virginia.gov/natural-heritage/vaflora> (describes nearly 3,200 plant species native to or naturalized in Virginia)
 - Flora of Virginia – App – <https://floraofvirginia.org/>
 - Native Plants – <http://www.dcr.virginia.gov/natural-heritage/nativeplants>
 - Native Plant Finder – <http://www.dcr.virginia.gov/natural-heritage/native-plants-finder>

Virginia Department of Forestry

- Common Native Shrubs and Woody Vines of Virginia Identification Guide Book – 2022 – (ID: P00027) – https://dof.virginia.gov/wp-content/uploads/Common-Native-Shrubs-and-Woody-Vines-ID_pub.pdf~~http://www.dof.virginia.gov/edu/index.htm or https://dof.virginia.gov/wp-content/uploads/Common-Native-Shrubs-and-Woody-Vines-ID_pub.pdf~~
- Common Native Trees of Virginia Identification Guide Book – 2022 – (ID: P00026) – https://dof.virginia.gov/wp-content/uploads/Common-Native-Trees-ID_pub.pdf~~http://www.dof.virginia.gov/edu/index.htm or https://dof.virginia.gov/wp-content/uploads/Common-Native-Trees-ID_pub.pdf~~

Virginia Native Plant Society – <https://vnps.org/>

- Virginia Native Plant Guides – <https://vnps.org/virginia-native-plant-guides/>
 - Regional native plant guides: Accomack and Northampton, Central Rappahannock, Northern Neck, Northern Virginia, Virginia's Capital Region, and Southeast Virginia
 - Piedmont Native Plants: A Guide for Landscapes and Gardens
- Interactive Plant Selectors – <https://vnps.org/interactive-plant-finders/>

Virginia Tech Extension Publications - www.pubs.ext.vt.edu

- Rain Garden Plants - https://www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/426/426-043/SPES-57.pdf
www.pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/SPES-57

5.3.1 Links to Invasive Plant Publications

The resources identified in this subsection contain information about plants to avoid and are listed alphabetically by organization and title.

- U.S. Forest Service
Nonnative Invasive Plants of Southern Forests: A Field Guide for Identification and Control – https://www.srs.fs.usda.gov/pubs/gtr/gtr_srs062/

Virginia Department of Conservation and Recreation

- Invasive Plant Factsheets – <https://www.dcr.virginia.gov/natural-heritage/invspfactsheets>
- Virginia Invasive Plant Early Detection Species – <https://www.dcr.virginia.gov/natural-heritage/invsp-earlydetection>

Virginia Invasive Plant Species List – <https://www.dcr.virginia.gov/natural-heritage/invspdflist>

Virginia Native Plant Society – <https://vnps.org/>

- ~~Plant Invaders of Mid-Atlantic~~ Natural Areas Field Guide – <https://vnps.org/product/plant-invaders-of-mid-atlantic-natural-areas-field-guide/>

5.4 Installation and Maintenance Plan

Describe the planting sequence, post-nursery care, and initial maintenance requirements in the planting plan. Consider the following recommendations when planting and caring for newly planted vegetation:

- Plant “wet tolerant” (facultative or hydrophytic/obligate) species near the center of the practice and facultative to upland species near the perimeter.
- Plant woody vegetation away from points of inflow.
- Planting densities should be 1 to 1.5 feet on-center for herbaceous vegetation, 5 to 10 feet on-center for shrubs, and 15 feet on-center for trees (or one tree per 250 sq. ft.).
Trees should not be planted directly above underdrains but instead should be located closer to the perimeter.
- Planting holes for trees should be at least 3 feet deep to provide enough soil volume for the root structure of mature trees. This recommendation applies even if the remaining filter media layer is shallower than 3 feet.
- Temporary or supplemental irrigation may be needed for bioretention plantings in order for plant installers to provide a warranty regarding plant material survival.

Supplemental irrigation by a rain tank system is recommended (see [P-BAS-04](#) Rainwater Harvesting).

5.5 Filter Media

The filter media will be supplied by a vendor and must meet the criteria and test methods in [Appendix F.](#) The specification is written for the vendor and is **NOT** intended for contractors to construct this filter media mix on-site unless materials are stockpiled on site and tested before utilization.

- **Soil Filter Media Depth.** The maximum and minimum depths are provided in [Table P-FIL-05-3](#) for receiving the assigned RR and PR credits. If trees are included in the bioretention planting plan, tree planting holes in the filter bed must be at least 2 feet above the seasonal high-water table or extended water table mound to provide sufficient soil volume and support for the root structure of mature trees. The exception would be Coastal Plain zones where facultative wet, or wetland obligate species are planted.

5.6 Gravel Layer/Sump

See [Figure P-FIL-05-11](#) for more information.

5.6.1 Choker Layer

Lay a 2- to 4-inch layer of medium-to-coarse sand over a minimum 3-inch layer of choker stone (typically [VDOT #8](#) or [#89](#) gravel). The choker layer is placed beneath the filter media and at the top of the gravel layer, if needed. The choker layer does not count towards TVBMP storage calculations.

5.6.2 Underdrain ~~(Optional)~~

When the K_{sat} of the native soils is less than 0.5 in./hr., an underdrain is required for a Level 1 practice. The underdrain is a perforated pipe laid below the choker layer and is located within the gravel layer. The underdrain conveys water to either the existing storm drain or daylights into an above ground swale, woodland, or stream.

The underdrain should be a minimum 6-inch perforated schedule 40 PVC pipe (or equivalent corrugated HDPE) with 3/8-inch perforations at 6 inches on center. The professional will determine the diameter of the underdrain. Once the slotted portion of the underdrain runs beyond the surface dimensions of the bioretention soil filter media, it transitions to a solid-wall pipe. The underdrain should be sized so that the ponding area and soil media storage fully drain within 48 hours. Multiple underdrains may be necessary for bioretention areas wider than 40 feet, and each underdrain is recommended to be located no more than 20 feet from the next pipe or the edge of the bioretention.

The underdrain is encased in a layer of clean, ASTM D448 No. 57 stone (VDOT #57) that does not extend beyond the surface dimensions of the bioretention filter media. The underdrain pipe should have at least 3 inches of stone above it and at least 6 inches of stone below it, and be sloped at ~~0.001-2%~~ $\#/\#$ within the practice. The minimum depth of the gravel layer is 9 inches. This gravel layer may count towards the TV_{BMP} storage calculations using a void ratio of 0.4 to calculate storage volume (see Section 5.1).

5.6.3 Underdrain with Liner

An impermeable liner can only be used for Level 1 designs with an underdrain. The liner is used in the following situations:

-
- Hotspots
- Karst topography
- High groundwater table or bedrock
- Near building foundations, or
Where deemed necessary by a geotechnical investigation

Impermeable liners may be either clay or geomembrane.

Clay liners shall meet the specifications in [P-SUP-01](#). The clay liner shall have a minimum thickness of 12 inches.

- If a geomembrane liner is used, it shall have a minimum thickness of 40 mils, be ultraviolet resistant, and comply with the specifications in [P-SUP-01](#).

5.6.4 Underdrain with Optional Infiltration Sump/Internal Water Storage ~~(optional)~~

Design configurations with an infiltration sump or internal water storage (IWS) are for the Level 2 designs and require K_{sat} testing at the location of the practice ([Table P-FIL-02-3](#)). The bottom of the infiltration sump or IWS must be at least 2 feet above the seasonally high-water table or projected water mound (if applicable). For sites located on fill or other highly disturbed/compacted soils, geotechnical investigations are required to determine if the use of an infiltration sump or IWS is permissible.

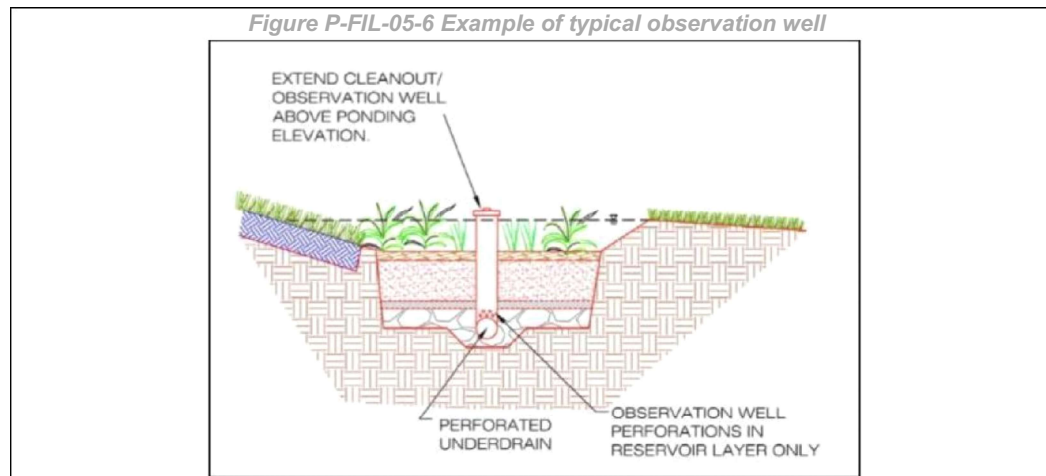
- *Sump*: The infiltration sump is a gravel area located below the underdrain that provides a storage area so the water can exfiltrate into the native soils without impeding drainage from the upper layers. The sump

- can provide storage to meet T_{VBMP} requirements and help meet channel and flood protection technical criteria.
- Internal Water Storage (IWS):* As an alternative to the sump, the underdrain can have an “upturned elbow” configuration, also referred to as an internal water storage (IWS) zone. This configuration places the perforated underdrain at the bottom of the stone reservoir layer, with the outlet elevated to the same elevation as the top of the sump. The IWS can be used where limited head is a site constraint (e.g., relatively flat sites). IWS can enhance peak flow attenuation, infiltration, and pollutant removal.

5.7 Observation Wells

All bioretention practices should include at least one observation well. Observation wells extend from above the highest elevation of the ponding area, where it is protected with a vented cap, to the bottom of the gravel layer. The observation well consists of a well-anchored, 4- to 6-inch diameter, rigid schedule-40 PVC pipe, with 3/8-inch perforations at 6 inches on center within the gravel layer and no perforations above the gravel layer ([Figure P-FIL-05-6](#)).

For bioretention practices that have an underdrain system, an observation well should be tied into any of the T or Y connections in the underdrain system and must extend upward above the ponding level. These observation wells can also double as cleanouts.



5.8 Conveyance and Overflow

There are two basic design approaches for conveying runoff into, through, and around bioretention practices:

- Off-line: Flow is split or diverted so that only the BMP treatment volume or design flow enters the bioretention area. Larger flows bypass the bioretention treatment.
- On-line: All runoff from the contributing drainage area flows into the practice. Flows that exceed the design capacity exit the practice via an overflow structure or weir.

5.8.1 Off-line Bioretention

Off-line designs are preferred. If runoff is delivered by a storm drainpipe or is along the main conveyance system, the bioretention area should be designed off-line so that flows do not overwhelm or damage the practice. To determine the discharge that the practice will receive, the T_{VBMP} will need to be converted. The method to convert the volume to a flow is provided in [Appendix F](#).

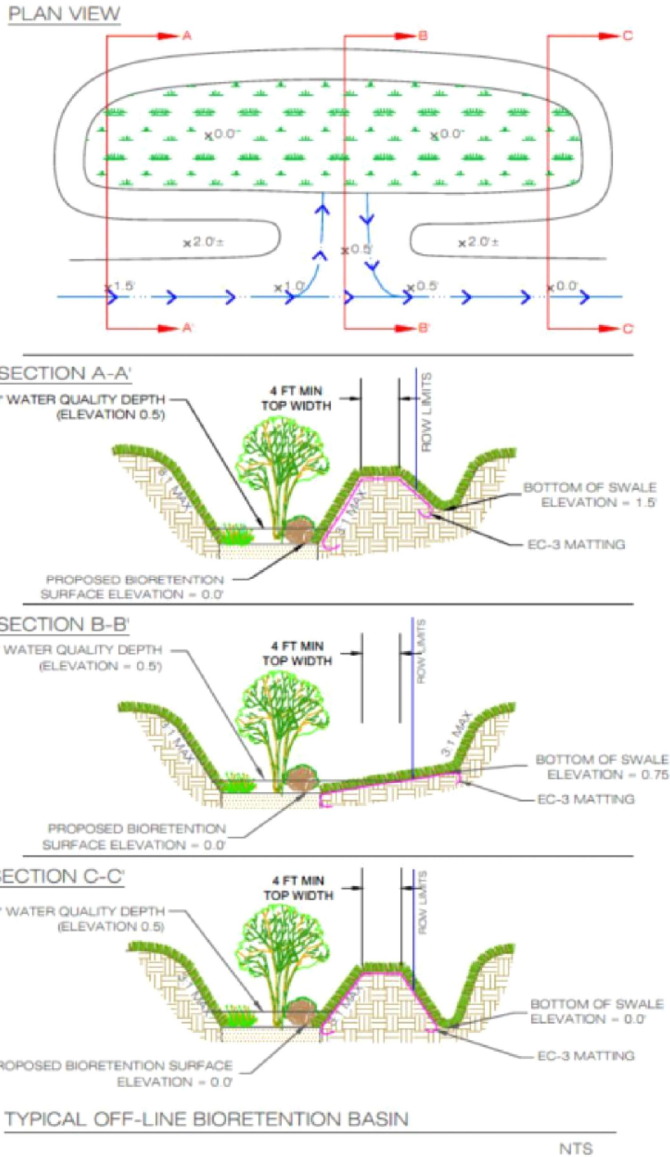
Table P-FIL-05-8-11 Advantages and Disadvantages of Offline Bioretention

Advantages	Disadvantages
The practice receives, at most, the T_v BMP so there may be no need for an overflow device.	Needs a diversion structure to split the
All runoff that reaches the practice is treated.	Requires more space to handle diverted flows.
When designed properly, runoff enters under non-erosive conditions resulting in fewer issues with erosion within the practice.	

Two options for creating off-line bioretention facilities are provided below.

- Create an alternate flow path at the inflow point into the structure such that when the maximum ponding depth is reached, the incoming flow is diverted past the practice ([Figure P-FIL-05-7](#)). In this case, the higher flows do not pass over the filter bed and through the practice, and additional flow is able to enter as the ponding water infiltrates through the soil filter media.
- Utilize a low-flow diversion, such as a weir, curb opening, or a flow splitter placed at the inlet that allows only the T_v BMP to enter the practice. A bypass channel is needed to handle the remaining flow.

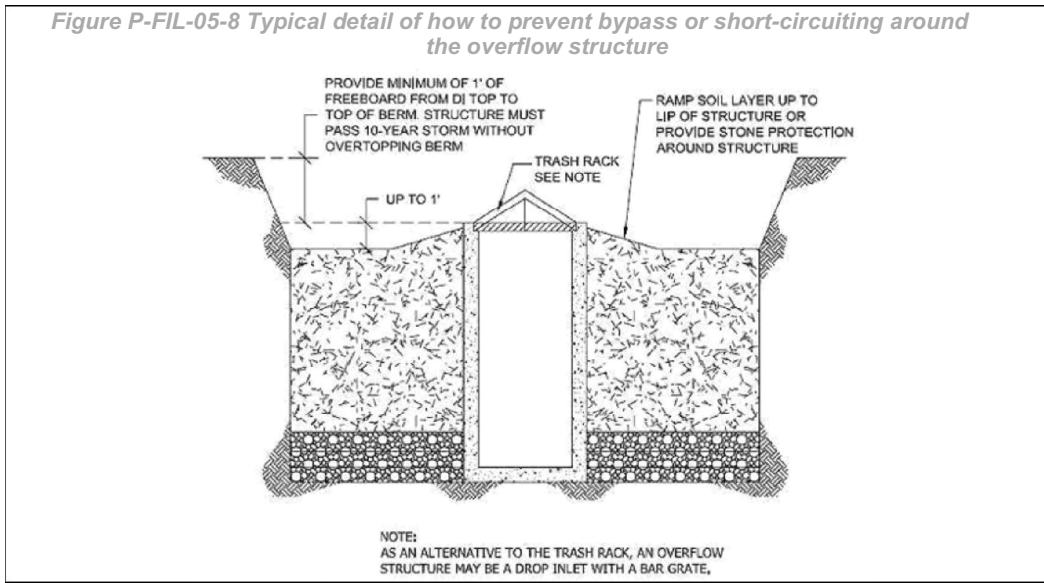
Figure P-FIL-05-7 Typical details for off-line bioretention



5.8.2 On-line Bioretention

All the discharge from the drainage area flows into the practice. On-line designs require attention to safely convey larger flows in adequate conveyances and with adequate freeboard. At no time during a storm event can the maximum head over the design underdrain or soil infiltration depth be more than 4 - 5 ft. Drainage designs should be based on expected peak discharges assuming that upstream practices may fail and/or provide marginal storage during larger events.

Flows that exceed the water quality design capacity exit the practice via an overflow structure. Field experience has shown that soil media immediately around an overflow structure is prone to scouring and erosion and, thus, short circuiting of the treatment mechanism. For example, water can flow straight down through scour holes or sinkholes to the underdrain system (Hirschman et al. 2009). Design options should be used to prevent this type of scouring. One example is shown in [Figure P-FIL-05-8](#).



The following criteria apply to overflow structures:

- Inlet velocities for higher return periods need to be quantified in order to prevent erosion and scour from occurring within the practice.
 - The ponding surface area should generally be flat so the bioretention area fills up like a bathtub.
 - Design the overflow system to control flows associated with the 2- and 10-year design storms so that velocities are non-erosive at the outlet point (i.e., to prevent downstream erosion).
 - Common overflow systems within bioretention practices consist of an inlet structure, where the top of the structure is placed at the maximum water surface elevation of the bioretention area, typically 6 to 12 inches above the surface of the filter bed (6 inches is the preferred ponding depth).
 - The outlet device should be designed to pass flows greater than the TvBMP discharge and or equal to the 100-year storm event. The outlet structure may be a landscape grate inlet or a commercial-type structure.
- At least 6 inches of freeboard must be provided between the top of the overflow device and the top of the bioretention area to ensure that nuisance flooding will not occur.

5.9 BMP Geometry

BMP geometry guidelines for bioretention can be found in [Table P-FIL-05-912](#) below.

Table P-FIL-05-9-12 Geometry Guidelines for Bioretention Practices	
Geometry	Guidelines
Flow Path	Design internal flow path such that the treatment mechanisms provided by the bioretention are not bypassed or short-circuited

Table P-FIL-05-912 Geometry Guidelines for Bioretention Practices

Geometry	Guidelines
Inlet flow energy attenuation	Additional emphasis needs to be placed on the peak runoff rate and energy of the inflow when the drainage area has an asymmetric shape or is larger than 2.5 acres
Travel Time for concentrated flows	Flows must have an acceptable internal geometry such that the "travel time" from each inlet to the outlet should be maximized by locating the inlets and outlets as far apart as possible
Travel Time for non-concentrated/sheet flows	Design the practice so that inflows are distributed as evenly as possible across the entire filter surface area.

5.10 Signage

Bioretention units in highly visible areas (e.g., schools, parks, urban settings, government buildings) should be stenciled or otherwise permanently marked to designate it as a stormwater management practice. The stencil or plaque should indicate (1) its water quality purpose, (2) that it may pond briefly after a storm, and (3) that it is not to be disturbed except for required maintenance.

5.11 Regional and Special Design Adaptations

Design criteria for regional and special design adaptation can be found in [Table P-FIL-05-1013](#).

Table P-FIL-05-1013 Regional and Special Design Adaptations and Considerations

Regional/Special Item	Consideration and Adaptation
Karst Terrain	Karst regions are found in much of the Ridge and Valley province of Virginia and limited areas of the Coastal Plain, which complicates both land development and stormwater design. Thus, a geotechnical investigation is needed in areas with karst terrain. A geotechnical investigation may not be necessary for a Level 1 practice with a liner and an underdrain. Building setback recommendations should be part of the investigation. For further guidance, please see Appendix E .

Notes:

* Although these design criteria permit bioretention to be used on a wider range of Coastal Plain sites, it is important to evaluate the specific constraints represented by the site and avoid using bioretention on marginal sites that directly impact the pollutant removal and volume reduction pathways. Other stormwater practices, such as wet swales, ditch wetland restoration, and smaller linear wetlands, are often preferred alternatives for Coastal Plain sites. Earlier restrictions for high K_{sat} (> 10 in/hr) soils from [HSG A](#) mapping units should also be addressed.

Refer to additional discussion regarding steep slope suitability for bioretention following this table.

Table P-FIL-05-10-13

Regional and Special Design Adaptations and Considerations

Regional/Special Item	Consideration and Adaptation
Coastal Plain *	<p>The flat terrain, low hydraulic head, and high-water table of many Coastal Plain sites can constrain the application of deeper bioretention areas (particularly Level 2 designs). In such settings, the following design adaptations may be helpful:</p> <p>A linear approach to bioretention, using multiple cells leading to the ditch system, helps conserve hydraulic head.</p> <p>The minimum depth of the soil filter media for a Level 1 design may be relaxed to 18 to 24 inches. It is also useful to limit surface ponding to 6 to 9 inches and avoid the need for additional depth by establishing a turfgrass cover rather than using mulch. The shallower media depth and the turfgrass cover generally comply with the Dry Swale specification, and therefore will be credited with a slightly lower pollutant removal (See BMP P-CNV-02 Dry Swales).</p> <p>The minimum depth to the seasonally high-water table or mound from the invert of the system can be 1 foot for a Level 1 design, if the bioretention area is equipped with a large-diameter underdrain (e.g., 6 inches or larger). Maintain at least 0.3% slope in the underdrain to ensure positive drainage. The underdrain should be tied into the ditch or conveyance system. The mix of plant species selected should reflect Coastal Plain plant communities and should be more wet footed and salt tolerant than those used in typical Piedmont applications.</p>
Steep Terrain	<p>Land with a slope of up to 10 to 20% may drain to a bioretention area if a two-cell design is used to dissipate erosive energy prior to filtering. The first cell, between the slope and the filter media, functions as a forebay to dissipate energy and settle any sediment that migrates down the slope. Designers may also want to terrace a series of bioretention cells to manage runoff across or down a slope. The drop in slope between cells should be limited to 1 foot and should be armored with river stone or a suitable equivalent. See Figure P-FIL-05-11.</p>

Notes:

* Although these design criteria permit bioretention to be used on a wider range of Coastal Plain sites, it is important to evaluate the specific constraints represented by the site and avoid using bioretention on marginal sites that directly impact the pollutant removal and volume reduction pathways. Other stormwater practices, such as wet swales, ditch wetland restoration, and smaller linear wetlands, are often preferred alternatives for Coastal Plain sites. Earlier restrictions for high K_{sat} (> 10 in/hr) soils from [HSG](#) A mapping units should also be addressed.

Refer to additional discussion regarding steep slope suitability for bioretention following this table.

Commented [MC9]: Discuss: VWRRC suggestion to add: "An impermeable or very low permeability geomembrane must be used against the gabions or similar retaining structure to prevent flow from leaving the treatment unit through that surface. An underdrain could be placed at the low point of the filter if the native soil will not provide adequate infiltration capacity."

Table P-FIL-05-10_13 Regional and Special Design Adaptations and Considerations

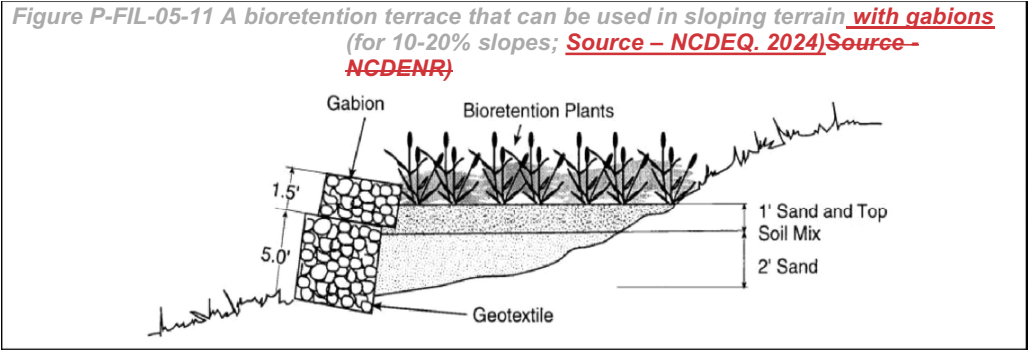
Regional/Special Item	Consideration and Adaptation
Cold Climate and Winter Performance	<p>Bioretention areas may be used for snow storage if an overflow is provided and salt-tolerant, non-woody plant species are used. Tree and shrub locations should not conflict with plowing and piling of snow into storage areas.</p> <p>It should be noted that even though salt-tolerant plants are recommended, chlorides from road salts (and other deicers as may be found on parking lots and sidewalks), have been found to contribute to the export of nutrient washouts from bioretention in following precipitation events. It is recommended that the use of NaCl deicers be limited to prevent long-term nutrient export.</p> <p>Although several studies have shown that bioretention facilities operate effectively in Pennsylvania and West Virginia winters, extend the filter bed and underdrain pipe below the frost line and/or oversize the underdrain by one pipe size to reduce the freezing potential.</p>
Linear Highway Sites	<p>Bioretention is a preferred practice for constrained highway right of ways when designed as a series of individual on-line or off-line cells. In these situations, the final design closely resembles that of dry swales. Salt tolerant species should be selected if salt compounds will be used to de-ice the contributing roadway in the winter.</p>

Notes:

* Although these design criteria permit bioretention to be used on a wider range of Coastal Plain sites, it is important to evaluate the specific constraints represented by the site and avoid using bioretention on marginal sites that directly impact the pollutant removal and volume reduction pathways. Other stormwater practices, such as wet swales, ditch wetland restoration, and smaller linear wetlands, are often preferred alternatives for Coastal Plain sites. Earlier restrictions for high K_{sat} (> 10 in/hr) soils from [HSG A](#) mapping units should also be addressed.

Refer to additional discussion regarding steep slope suitability for bioretention following this table.

5.11.1 Steep Terrain – Additional Consideration and Schematic



Commented [MC10]: Arcadis: Revise figure to remove sand and soil mix

An impermeable or very low permeability geomembrane must be used against the gabions or similar retaining structure to prevent flow from leaving the treatment unit through that surface. An underdrain could be placed at the low point of the filter if the native soil that the unit is built against will not provide adequate infiltration capacity.

Formatted: Indent Left: 0.13"

6.0 Construction Specifications

The basic material specifications for Bioretention are outlined in Table P-FIL-05-144.

Table P-FIL-05-144 Bioretention Materials Specifications

Material	Specification	Notes
Filter Media Composition (Appendix F)	Filter Media to contain: 80% - 90% sand 10% - 20% soil fines 3% - 5% organic matter	The volume of filter media based on 110% of the plan volume, to account for settling or compaction. See Appendix F.
Filter Media Testing	See Appendix F for criteria	The media should be certified by the supplier.
Mulch Layer	Use aged (at least 6 months), double-shredded hardwood bark mulch.	Lay a 2- to 3-inch layer on the surface of the filter bed.
Alternative Surface Cover	Use river stone or pea gravel, coir and jute matting, or turfgrass cover.	Lay a 2- to 3-inch layer to suppress weed growth.
Topsoil For Manage Grass Cover or other intensive vegetation management	Loamy sand or sandy loam texture, with less than 5% clay content; pH corrected to between 6 and 7; and an organic matter content of at least 2%.	3-inch surface depth. Must meet minimum Ksat requirements of underlying media.
Geotextile/Liner	Use a non-woven geotextile fabric with a flow rate of > 110 gal./min./sq. ft. (e.g., Geotex 351 or equivalent)	Apply only to the sides and directly above the underdrain. For hotspots and certain karst sites only, use the appropriate liner on the bottom.
Choking Layer	Lay 2- to 4-inch layer of sand over 3-inch layer of VDOT #8 or #89 washed gravel	
Stone Underdrain and/or Storage Layer	VDOT #57 stone	9 inches for the underdrain; Up to 12 inches for the stone storage layer, if needed; Double washed and clean and free of all fines Use aggregate stone with <1.5% dust of fracture (DoF), consistent with VDOT
Underdrains and Cleanouts	Use 6-inch rigid schedule 40 PVC pipe (or equivalent corrugated HDPE for micro-bioretention), with 3/8-inch perforations at 6 inches on center; position each underdrain on a 1% or 2% slope located no more than 20 feet from the next pipe.	Lay the perforated pipe under the length of the bioretention cell, and install non-perforated pipe as needed to connect with the storm drain system. Install T's and Y's as needed, depending on the underdrain configuration. Extend cleanout pipes to the surface with vented caps at the Ts and Ys.
Observation Wells	Use 4- to 6- inch rigid schedule 40 PVC pipe (or equivalent corrugated HDPE for micro-bioretention), with 3/8-inch perforations at 6 inches on center within the gravel layer	Use a closed wall pipe above the gravel layer. Extend observation well pipes to the surface with vented caps
Plant Materials	See Section 5.2 and Table P-FIL-05-7	Establish plant materials as specified in the landscaping plan and the recommended plant list.

Commented [MC11]: For discussion: "It would difficult to meet that requirement, which will result in a "sand" USDA soil class most likely if the Clay is < 5%; To have a loamy sand with < 5% clay would be rare and difficult to create."

Commented [AK12R11]: Kateri - Luckstone

Formatted Table

Commented [MC13]: Per Luck Stone " VDOT compliant aggregate requires stone to be processed as needed to remove deleterious material. For crushed aggregate, the % deleterious material is considered the dust of fracture (DoF) and is required to be < 1.5% for VDOT coarse aggregate. If the DoF is > 1.5%, the aggregate must be washed sufficiently to achieve this requirement. A VDOT aggregate submittal will include a Customer Gradation Report, which shows the DoF as determined by laboratory testing. Every crushed stone facility has different washing requirements primarily based on the characteristics of the parent rock material and how much dust is produced when crushed. Thus, the best objective requirement for "clean aggregate" is to comply with the VDOT requirement for DoF to be < 1.5%. The number of times an aggregate is washed is not a reliable way to predict cleanliness."

6.1 Construction Stage Erosion and Sediment Controls

Bioretention areas should be fully protected by silt fence or construction fencing, particularly if they will rely on infiltration (i.e., have no underdrains). Ideally, bioretention should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment. Bioretention basin locations may be used as small sediment traps or basins during construction. However, these locations must be accompanied by notes and graphic details on the [ESC](#) plan specifying:

1. The maximum excavation depth at the construction stage must be at least 1 foot above the post-construction maximum excavation,
2. The practice must contain an underdrain, and
3. The plan must also show the proper procedures for converting the temporary sediment control practice to a permanent bioretention practice, including dewatering, cleanout and stabilization.

6.2 Bioretention Installation

The following is a typical construction sequence to properly install a bioretention basin. The installation of a bioretention basin will include intermediate inspections at critical stages of construction with inspector sign-off that the elements of the bioretention are constructed according to the approved plans and specifications. As an alternative, if allowed by the [VSMP](#) Authority, the contractor may rely on the engineer of record or other qualified individual to conduct the intermediate inspections and certifications of compliance. The construction sequence for micro-bioretention is more simplified. These steps may be modified to reflect different bioretention applications or expected site conditions:

Step 1. Construction of the bioretention area may only begin after the entire contributing drainage area has been stabilized with vegetation. It may be necessary to block certain curb or other inlets while the bioretention area is being constructed. The proposed site should be checked for existing utilities prior to any excavation.

Step 2. The designer and the installer should have a preconstruction meeting, checking the boundaries of the contributing drainage area and the actual inlet elevations to ensure they conform to the original design. Since other contractors may be responsible for constructing portions of the site, it is quite common to find subtle differences in site grading, drainage and paving elevations that can produce hydraulically important differences for the proposed bioretention area. The designer should clearly communicate, in writing, any project changes determined during the preconstruction meeting to the installer and the plan review/inspection authority.

Step 3. Temporary erosion and sediment controls are needed during construction of the bioretention area to divert stormwater away from the bioretention area until it is completed. Special protection measures such as erosion control fabrics may be needed to protect vulnerable side slopes from erosion during the construction process.

Step 4. Any pre-treatment cells should be excavated first and then sealed to trap sediments.

Step 5. Excavators or backhoes should work from the sides to excavate the bioretention area to its appropriate design depth and dimensions. Excavating equipment should have scoops with adequate reach so they do not have to sit inside the footprint of the bioretention area. Contractors should use a cell construction approach in larger bioretention basins, whereby the basin is split into 500 to 1,000 sq. ft. temporary cells with a 10- to 15-foot earth bridge in between, so that cells can be excavated from the side.

Step 6. It may be necessary to rip the bottom soils to a depth of 6 to 12 inches to promote greater infiltration if required K_{sat} testing and/or onsite soil investigation indicates limitations.

Step 7. Place geotextile fabric [directly above the underdrain and](#) on the sides of the bioretention area with a 6-inch overlap on the sides. If a stone storage layer will be used, place the appropriate depth of #57 stone on the bottom, install the perforated underdrain pipe, pack #57 stone to 3 inches above the underdrain pipe, and add approximately 3 inches of choker stone/pea gravel as a filter between the underdrain and the soil media layer. If no stone storage layer is used, start with 6 inches of #57 stone on the bottom, and proceed with the layering as described above.

Step 8. Obtain filter media from a qualified vendor and store it on an adjacent impervious area or plastic sheeting. After confirming that the media meets the specifications, apply the media in 6 to 12-inch lifts until the desired top elevation of the bioretention area is achieved. Add sufficient clean water to facilitate settling (or

evaluate after a significant rainfall event) to check for settlement, and add additional media, as needed, to achieve the design elevation. Taking and maintaining an archived air-dried composite sample of the media and mulch materials for at least one year following installation is recommended in case of apparent internal drainage failures.

Step 9. Prepare planting holes for any trees and shrubs. If coir or jute matting will be used, install it prior to planting and cut holes or slits in it to install the plants.

Step 10. Install plant materials as shown in the planting plan, and place the surface cover (e.g., mulch, river stone or managed grass), depending on the design.

Step 11. Install any temporary irrigation, and water plants initially as required for establishment

~~Prepare planting holes for any trees and shrubs, install the vegetation, and water accordingly. Install any temporary irrigation.~~

Step 120. Place the surface cover in both cells (e.g., mulch, river stone or managed grass), depending on the design. If coir or jute matting will be used in lieu of mulch, the matting will need to be installed prior to planting (Step 9), and holes or slits will have to be cut in the matting to install the plants.

Step 134. Install the plant materials as shown in the landscaping plan, and water them initially as required for establishment, particularly if weeks of no rain occur between March and November.

Step 142. Install appropriate signage and/or perimeter fencing as/if required.

7.0 Operations and Maintenance Considerations

7.1 Construction Inspections

Inspections during and immediately after construction are needed to ensure that all the elements of bioretention basins are built in accordance with these specifications. Use a detailed inspection checklist that requires signoffs by qualified individuals at critical stages of construction and to ensure that the contractor's interpretation of the plan is consistent with the designer's intent. The following identifies the critical stages of construction where an intermediate inspection and signoff by a qualified individual is recommended since the items can't be verified after

- construction is completed. A construction inspection checklist that includes certifications of inspection at critical stages is provided in Section 7.2.
- The following represents items that are frequently overlooked during construction inspection but represent important elements for ensuring the success of the bioretention practice during the initial break-in period.

Verify the proper coverage and depth of mulch, vegetation, or soil matting has been achieved following construction, both on the filter bed and the side-slopes.

Inspect the pre-treatment forebays and filter strips to verify that they are properly installed, stabilized, and working effectively ~~before~~ opening the practice to runoff.

Check that outfall protection/energy dissipation measures at concentrated inflow and outflow points are stable.

Upon final acceptance of the practice, log the practice's GPS coordinates and submit them for entry into the [VESMP](#) Authority's [BMP](#) maintenance tracking database.

Formatted: Bottom: 1.38"

Commented [MC14]: Discuss: Additional text suggested by VWRRC

Figure P-FIL-05-12 An older bioretention area with mature tree growth and shaded areas. Adaptive management is required in areas such as these for continued performance.



Photo Credit: Hirschman Water & Environment, LLC

7.2 Sample Construction Inspection Checklist for Bioretention Practices

The checklist for construction inspection of bioretention practices is found along with those for other BMPs in [Appendix H](#) and provides a basic outline of the anticipated items for the construction inspection of bioretention practices. This checklist does not necessarily distinguish between all the design variations and differences in construction between the family of practices: bioretention basins, micro-bioretention, urban bioretention, and ultra-urban bioretention. Similarly, the use of an infiltration sump below an underdrain, or an infiltration sump with an “upturned elbow,” and other variations between Level 1 and Level 2 bioretention may not be clearly identified in this checklist. Inspectors should review the plans carefully and adjust these items and the timing of inspection verification as needed to ensure the intent of the design is met. Finally, users of this information may wish to incorporate these items into a VESMP Authority Construction Checklist format consistent with the format used for erosion and sediment control and BMP construction inspections.

7.3 Pre-Construction Meeting

- Pre-construction meeting with the contractor designated to install the bioretention practice has been conducted.
- Identify the tentative schedule for construction and verify the requirements and schedule for interim inspections and sign-off.
- Subsurface investigation and soils report supports the placement of a bioretention practice in the proposed location.
- Impervious cover has been constructed/installed and area is free of construction equipment, vehicles, material storage, etc.
- All pervious areas of the contributing drainage areas have been adequately stabilized with a thick layer of vegetation and erosion control measures have been removed.
- Area of bioretention practice has not been impacted during construction.
- Stormwater has been diverted around the area of the bioretention practice and perimeter erosion control measures to protect the practice during construction have been installed.

7.4 Excavation

- Compare the bioretention surface and invert design elevations with the actual constructed elevations of the inflow and outlet inverts and adjust design elevations as needed.
 - Area of bioretention excavation is marked, and the size and location conform to plan.
 - If the excavation area has been used as a sediment trap: verify that the bottom elevation of the proposed stone reservoir is lower than the bottom elevation of the existing trap.
 - For Level 2 bioretention, ensure the bottom of the excavation is scarified prior to placement of stone.
 - Subgrade surface is free of rocks and roots, and large voids. Any voids should be refilled with the base aggregate to create a level surface for the placement of aggregates and underdrain (if required).
 - No groundwater seepage or standing water is present. Any standing water is dewatered to an acceptable dewatering device.
 - Excavation of the bioretention practice has achieved proper grades and the required geometry and elevations without compacting the bottom of the excavation.
- Certification of Excavation Inspection:** Inspector certifies the successful completion of the excavation steps listed above.

7.5 Choker Layer, Underdrain, and Stone Reservoir Placement

- All aggregates, including, as required, the choker layer, the stone reservoir layer or infiltration sump conform to specifications as certified by quarry.
 - Underdrain size and perforations meet the specifications.
 - For Level 2 installations: placement of choker layer and initial lift of stone reservoir layer aggregates with underdrain or infiltration sump, spread (not dumped) to avoid aggregate segregation; or
 - Impermeable liner, when required, meets project specifications, and is placed in accordance with manufacturers specifications.
 - Sides of excavation covered with geotextile, when required, prior to placing stone reservoir aggregate; no tears or holes, or excessive wrinkles are present.
 - Placement of underdrain, observation wells, and underdrain fittings (45-degree wyes, cap at the upstream end, etc.) are in accordance with the approved plans.
 - Elevations of underdrain and outlet structure are in accordance with approved plans, or as adjusted to meet field conditions.
- Placement of remaining lift of stone reservoir layer as needed to achieve the required reservoir depth.
- Certification of Choker Layer and Underdrain Placement Inspection:** Inspector certifies the successful completion of the choker layer and underdrain placement steps listed above.

7.6 Bioretention Soil Media Placement

- Soil media is certified by supplier or contractor as meeting the project specifications per [Appendix F](#) and provides confirmation testing data.
 - Soil media is placed in 6- to 12-inch lifts to the design top elevation of the bioretention area. Elevation has been verified after settlement (2 to 4 days after initial placement assuming rain or an initial watering in event).
 - Side slopes of ponding area are feathered back at the required slope (no steeper than 3H:1V).
- Certification of Soil Media Placement Inspection:** Inspector certifies the successful completion of the soil media steps listed above.

7.7 Pre-treatment and Plant Installation

- Placement of energy dissipators and pre-treatment practices (forebays, gravel diaphragms, etc.) are installed in accordance with the approved plans.
- Riser, overflow weir, or other outflow structure is set to the proper elevation and functional; or

- External bypass structure is built in accordance with the approved plans.
- Appropriate number and spacing of plants are installed in accordance with the approved plans.
- All erosion and sediment control practices have been removed.
- Follow-up inspection and as-built survey/certification has been scheduled.
- GPS coordinates have been documented for all bioretention practice installations on the parcel.

7.8 Maintenance Agreements

The Virginia Erosion and Stormwater Management Regulation (9 [VAC](#) 875) specifies the circumstances under which a maintenance agreement must be executed between the owner and the VESMP Authority, and sets forth inspection requirements, compliance procedures if maintenance is neglected, notification of the local program upon transfer of ownership, and right-of-entry for local program personnel.

All bioretention practices must include a long-term maintenance agreement consistent with the provisions of the VSMP regulations and must include the recommended maintenance tasks and a copy of an annual inspection checklist.

- When micro-bioretention practices are applied on private residential lots, homeowners should be educated regarding their routine maintenance needs by being provided a simple document that explains their purpose and routine maintenance needs.
- A deed restriction, drainage easement or other mechanism enforceable by the VSMP Authority must be in place to help ensure that rain gardens and bioretention filters are maintained and not converted or disturbed, as well as to pass the knowledge along to any subsequent owners.
- The mechanism should, if possible, grant authority for the VSMP Authority to access the property for inspection or corrective action.

7.9 First Year Maintenance Operations

Successful establishment of bioretention areas requires that the tasks outlined below be undertaken in the first year following installation.

Table P-FIL-05-125 Summary of Essential First-Year Maintenance Operations

Activity	Timing
Initial Inspections	For the first 6 months following construction, the site should be inspected at least twice after storm events that exceed 0.5 inch of rainfall.
Spot Reseeding	Inspectors should look for bare or eroding areas in the contributing drainage area or around the bioretention area, and make sure they are immediately stabilized with grass cover.
Fertilization	One-time, spot fertilization may be needed for initial plantings. Slow-release nitrogen sources should be utilized whenever possible.
Watering	Watering is needed once a week during the first 2 months, and then as needed during the first growing season (March/April-October), depending on rainfall.
Remove and replace dead plants	Since significant amounts of the initial planting stock may not survive in the first year, construction contracts should include a care-and-replacement warranty to ensure that vegetation is properly established and survives during the first growing season following construction. The typical thresholds below which replacement is required are 85% survival of intended/seeded herbaceous plant material and 100% survival of shrubs and trees. <u>During replacement, be sure to maintain the integrity of the bioretention media mix.</u>

Formatted: Space After: 0 pt

Formatted Table

7.10 Maintenance Inspections

It is highly recommended that a spring maintenance inspection and cleanup be conducted at each bioretention area. The following is a list of some key maintenance inspection items:

- Check to see if 75% to 90% cover (mulch plus vegetative cover) has been achieved in the bed and measure the depth of the remaining mulch.
- Check for sediment buildup at curb cuts, gravel diaphragms or pavement edges that prevents flow from getting into the bed, and check for other signs of bypassing.
- Check for any winter- or salt-killed vegetation and replace it with hardier species.
- Note presence of accumulated sand, sediment and trash in the pre-treatment cell or filter beds and remove it.
- Inspect bioretention side slopes and grass filter strips for evidence of any rill or gully erosion and repair it.
- Check the bioretention bed for evidence of mulch flotation, excessive ponding, dead plants, or concentrated flows, and take appropriate remedial action.
- Check inflow points for clogging and remove any sediment.
- Look for any bare soil or sediment sources in the contributing drainage area and stabilize them immediately.
- Check for clogged or slow-draining soil media, a crust formed on the top layer, inappropriate soil media, excessive plugging by sediments, or other causes of insufficient filtering time, and restore proper filtration characteristics.

Example maintenance inspection checklists for bioretention areas can be accessed in [Appendix H](#).

Formatted: Right: 0.69"

7.11 Routine Maintenance Tasks

Maintenance of bioretention areas should be integrated into routine landscape maintenance tasks. If landscaping contractors will be expected to perform maintenance, their contracts should contain specifics on unique bioretention landscaping needs, such as maintaining elevation differences needed for ponding, proper mulching, sediment and trash removal, and limited use of fertilizers and pesticides. A customized maintenance schedule must be prepared for each bioretention practice, since the maintenance tasks will differ depending on the scale of bioretention, the landscaping template chosen, and the type of surface cover. A generalized summary of common maintenance tasks and their frequency is provided in [Table P-FIL-05-136](#).

Table P-FIL-05-136 Routine Maintenance Tasks

Maintenance Tasks	Frequency
Mow grass filter strips and bioretention turfgrass cover.	At least 4 times per year
Perform spot weeding, erosion repair, trash removal, and mulch raking.	Monthly
Add reinforcement planting to maintain desired vegetation density. Remove invasive plants using recommended control methods. Stabilize the contributing drainage area to prevent erosion.	As needed
Perform spring inspection and cleanup. Supplement mulch to maintain a 2 to 3-inch layer. Prune trees and shrubs.	Annually as/if needed
Remove sediment in pre-treatment cells and inflow points.	At least 4 times per year
Replace the mulch layer.	Every 2-3 years or if in poor condition
Reevaluate Ksat via appropriate method for both primary media filter layer and underlying and/or lateral soil infiltration zone (if utilized).	Every 5 years

7.12 Non-Routine Maintenance Tasks

The most common non-routine maintenance problem involves standing water (e.g., insufficient drainage). If water remains on the surface for more than 48 hours after a storm, adjustments to the grading may be needed or underdrain repairs may be needed. The surface of the filter bed should also be checked for accumulated sediment or a fine crust that builds up after the first several storm events. There are several methods that can be used to rehabilitate the filter (try the easiest things first, as listed below):

- Open the underdrain observation well or cleanout and pour in water to verify that the underdrains are functioning and not clogged or otherwise in need of repair. The purpose of this check is to see if there is standing water all the way down through the soil. If there is standing water on top, but not in the underdrain, then there is a clogged soil layer. If the underdrain and standpipe indicate standing water, then the underdrain must be clogged and will need to be snaked.
- Remove accumulated sediment and till 2 to 3 inches of sand into the upper 8 to 12 inches of the underlying mineral soil or filter media. Do not simply add sand to the overlying mulch layer.
- Install sand wicks from 3 inches below the surface to the underdrain layer. Sand wicks can be installed by excavating or using an auger (a tree auger or similar soil boring tool) down to the gravel storage zone to create vertical columns that are then filled with a clean open-graded coarse sand material (coarse sand mix like the gradation used for the soil media). Enough wick drains of sufficient dimension should be installed to meet the design dewatering time for the practice. However, this assumes that the underlying zone remains unsaturated and can receive the water.
- Final Measures - remove and replace some or all of the soil media and reconfirm overall filter permeability and underdrain to outlet head drop.

8.0 References

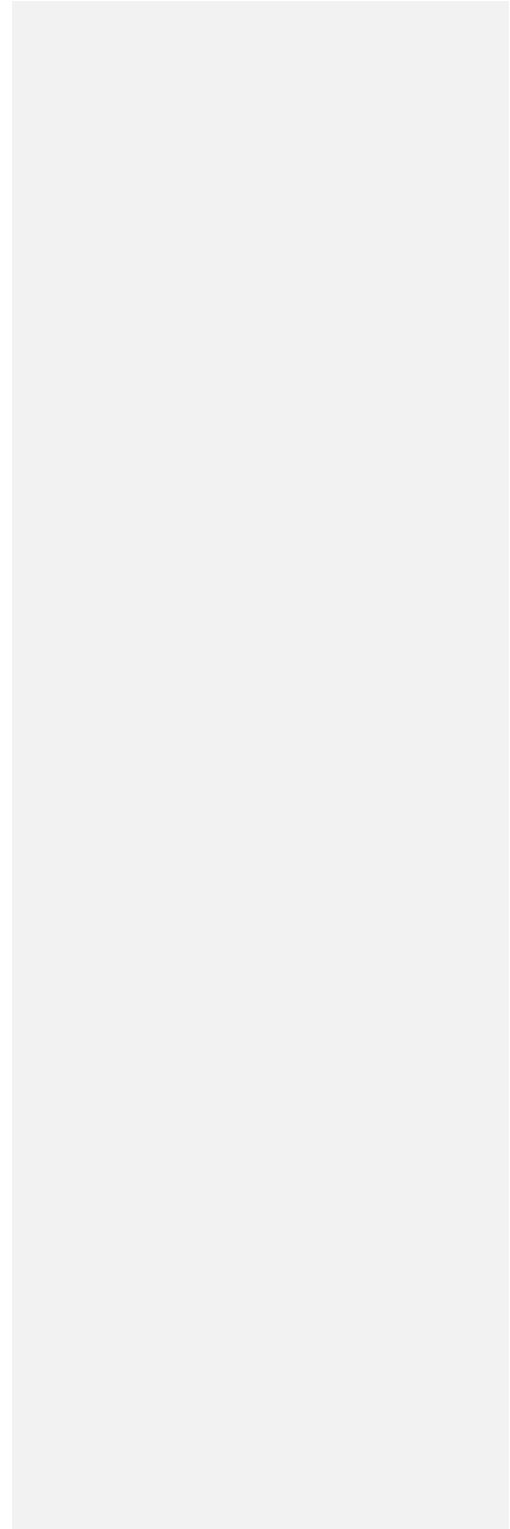
- Claytor, R.A. and T. R. Schueler. 1996. Design of Stormwater Filtering Systems. The Center for Watershed Protection, Ellicott City, MD. <https://owl.cwp.org>.
- Hirschman, D., L. Woodworth and S. Drescher. 2009. Technical Report: Stormwater BMPs in Virginia's James River Basin – An Assessment of Field Conditions and Programs. Center for Watershed Protection. Ellicott City, MD. It is available at: https://owl.cwp.org/mdocs-posts/hirschmand-sw_bmps_va_james_river_basin/
- Minnesota Stormwater Steering Committee (MSSC). 2005. The Minnesota Stormwater Manual. <http://www.pca.state.mn.us/water/stormwater/stormwater-manual.html>.
- Natural Resources Conservation Service (NRCS). 1986. Urban Hydrology for Small Watersheds: TR-55. 210-VI-TR-55, Second Ed., June 1986. Conservation Engineering Division, Natural Resources Conservation Service, United States Department of Agriculture (USDA).
- ~~North Carolina Department of Environmental Quality (NC DEQ), 2024. "C-2. Bioretention Cell." NCDEQ Stormwater BMP Manual. 2024. <https://www.deq.nc.gov/energy-mineral-and-land-resources/stormwater/bmp-manual/c-2-bioretention-cell/download?attachment>~~
- ~~North Carolina Department of Environmental and Natural Resources (NCDENR). "12. Bioretention." NCDENR Stormwater BMP Manual. 2012.~~
- Virginia Department of Environmental Quality (VDEQ). 2013. Virginia Stormwater Management Handbook. 2nd Edition.
- Virginia Department of Environmental Quality (VDEQ). 2016. Guidance Memo No. 16-2001 - Updated Virginia Runoff Reduction Method Compliance Spreadsheets - Version 3.0. May 2, 2016.

9.0 Appendix A Micro-bioretention

Definition

Micro-bioretention practices, commonly referred to as rain gardens, are designed to treat runoff from small areas, such as individual rooftops, lawns and other commercial or residential on-lot features. Micro-bioretention differs from bioretention primarily in scale, with the micro-bioretention practice receiving stormwater from a much smaller drainage area.

See Table P-FIL-05 A-1 and [Table P-FIL-05 A-2](#) for other differences.



Purpose and Applicability of Best Management Practice

The purpose of the micro-bioretenion practice is the same as that for general bioretention. Micro-bioretenion is typically applicable for treating runoff from small areas, such as sidewalks, driveways, and other on-lot features. Micro-bioretenion treats stormwater runoff by simulating native landscape processes and filtering runoff and pollutants via soil biogeochemical processes and plant uptake. Bioretention works by collecting stormwater runoff from a roof, sidewalk, driveway, or other impervious areas that would otherwise go directly to local street or storm drainage. The water temporarily ponds on the surface of the feature and then slowly filters down through the underlying soil media and/or is taken up by plants.

Inflow is typically sheet flow from a nearby sidewalk/driveway or lawn, or can be concentrated flow with energy dissipation, when receiving roof flow from downspouts or other directed drainage. It can be used in both commercial and residential developments.

More than one micro-bioretenion practice can be used on a site. For example, they can be used at different points along the runoff pathway, in different pathways, or at different downspouts. Sometimes two or more small micro-bioretenion practices are connected and used instead of one large one because of design or space considerations.

Micro-bioretenion, as defined here, is also commonly referred to as "rain gardens" and several example configurations are given below in [Figure P-FIL-05 A-1](#) and [Figure P-FIL-05 A-2](#). A list of alternative designs provided by various localities is provided at the end of this Appendix.

Planning and Considerations

Feasibility

Micro-bioretenion can be located anywhere along the natural runoff pathway. Runoff can also be directed into a micro-bioretenion practice through pipes or swales. Micro-bioretenion practices can be in sun or shade and should be located at least 10 feet away from building foundations, not on steep slopes, not over underground utilities, or a septic field, and not where the water table is high (≤ 24 in). Refer to [Table P-FIL-052-3](#) and others in the primary bioretention specification for feasibility, site selection criteria and regional and special case design adaptations.

Commented [MC15]: Refer to feasibility table (P-FIL-05-1) upon finalization

Stormwater Performance Summary

The typical stormwater functions of an micro-bioretenion area with respect to runoff reduction (RR) and pollutant removal (PR) are described in [Table P-FIL-05 A-1](#).

Table P-FIL-05 A-1 Micro-Bioretenion Design Level Performance

Pollutant Constituents	Design Level 1	Design Level 2
Total Phosphorus Removal Credit	40% RR	80% RR
	25% PR	50% PR
	55% Mass Load*	90% Mass Load*
Total Nitrogen Removal Credit	40% PR	60% PR
	64% Mass Load*	90% Mass Load*

Notes:

RR = runoff reduction; PR = pollutant removal

*Mass Load Reduction = combined functions of runoff reduction and pollutant removal. Pollutant removal refers to the change in event mean concentration (EMC) as it flows through the practice and is subjected to treatment processes, as reported in Hirschman et al. (2009).

Design Criteria

A summary of the design elements for micro-bioretenion is provided in [Table P-FIL-05 A-2](#). Note certain minor variations for this application vs. [Table P-FIL-052-3](#) in the primary text for general bioretention (e.g.

Commented [MC16]: Refer to feasibility table (P-FIL-05-1) upon finalization

higher minimum K_{sat} for Level 1). [Utilize an Internal Water Storage \(IWS\) when possible, see Section 5.6.4 above for details.](#)

Table P-FIL-05 A-2 Summary of Design Elements

Design Element	Level 1 (RR: 40; TP: 25)	Level 2 (RR: 80; TP: 50)
Site Selection	Refer to criteria in Section 2.2. Additional criteria may apply depending on the region of the state (see Section 6 Regional and Special Case Design Adaptations).	
Area	Contributing Drainage Maximum = 0.5 acres with up to 25% Impervious Cover*	
Soil Testing	Perform soil test if no underdrain	One soil test per practice
Hydraulic Conductivity of Native Soils	Min > 1 in./hr. to remove the underdrain requirement	Min > 0.25 in./hr.
	Max < 10 in./hr.†	Min > 1 in./hr. to remove the underdrain requirement Max < 10 in./hr.‡
Surface Area	$TVBMP$ (cu. ft.) / ESD (ft.) Where: $TVBMP$ (cu. ft.) = (1.0 in.)(R_v)(A)/12	$TVBMP$ (cu. ft.) / ESD (ft.) Where: $TVBMP$ (cu. ft.) = (1.25 in.)(R_v)(A)/12
	NA	Ponding Volume ≤ 48 hrs. Design Volume ≤ 72 hrs.
Stormwater Quantity	Design extra storage (optional; as needed) on the surface, in the engineered soil matrix, and in the gravel layer/sump to accommodate a larger storm. OR Use the Virginia Runoff Reduction Method (VRRM) Compliance Spreadsheet to calculate the Curve Number (CN) Adjustment	
Ponding Depth	Maximum: 6 inches‡	
Side Slopes	Ponding Storage Area: 3H:1V or flatter	
Surface Cover	2 to 3 inches of mulch or alternative, such as managed approved vegetation in soil media meeting general bioretention media criteria.	

Notes:

RR = runoff reduction (%); TP = total phosphorus reduction (%); NA = not applicable.

* Micro-bioretention can be located at individual downspout locations to treat up to 1,000 sq. ft. of impervious cover (100% IC).

† The native soil must be amended to lower the hydraulic conductivity below 10 inches per hour. See [Appendix C](#).

‡ Incorporate plants that tolerate fluctuating water levels.

§ Additional depth can be added to the filter media and/or gravel layer/sump to help meet water quantity requirements. This additional depth is not used for surface area sizing calculations. See Section 5.1.

**When used in tree planter holes, at least 36" of suitable rooting depth must be maintained. For example, if filter media depth is 24", at least 12" of non-compacted suitable soil that meets overall media K_{sat} criteria should be employed between the media and the underdrain or soil infiltration zone.

|| Media mix tested for an acceptable hydraulic conductivity (or permeability) and phosphorus content.

Table P-FIL-05 A-2 Summary of Design Elements

Design Element	Level 1 (RR: 40; TP: 25)	Level 2 (RR: 80; TP: 50)
Planting Plan	A planting template to include managed turfgrass, herbaceous vegetation, and/or shrubs (min = 1 out of those 3 choices) to cover at least 75% surface area in 2 years.	A planting template to include managed turfgrass, herbaceous vegetation, shrubs, and/or trees (min = 2 out of those 4 choices) to cover at least 90% of the infiltration surface area in 2 years. Turfgrass must be combined with herbaceous perennials, shrubs and/or trees.
Filter Media Depth	Min: 18 inches Max: 36 inches§	Min: 24 inches Max: 36 inches§ Min: 36 inches rooting depth for trees**
Filter Media	Mixed on-site or supplied by vendor	Supplied and certified by vendor per criteria in Appendix F .
Gravel Layer/Sump	Min choker stone layer: 3 in. Min gravel layer with no underdrain: 0 in. Min gravel layer with underdrain: 9 in. Max gravel layer: 12 in.‡	Min choker stone layer: 3 in. Min sump depth with underdrain: 9 in. Max sump depth: 12 in.‡
Underdrain	HDPE or equivalent; Clean-outs are not necessary. Use slotted pipe under the filter bed and closed pipe elsewhere.	
Observation Wells	Schedule 40 PVC or equivalent closed pipe.	
Pre-treatment	External (leaf screens, grass filter strip, External plus a grass filter strip energy dissipater, etc.).	
Conveyance and Overflow	Off-line/On-line option	
Geometry	Concentrated flow: Locate inlets and outlets as far apart as possible. Non-concentrated flow: Distribute inflow evenly across filter surface area.	
Maintenance	Deeded Maintenance Agreement See Section 7 for routine and non-routine maintenance requirements.	

Notes:

RR = runoff reduction (%); TP = total phosphorus reduction (%); NA = not applicable.

* Micro-bioretenion can be located at individual downspout locations to treat up to 1,000 sq. ft. of impervious cover (100% IC).

† The native soil must be amended to lower the hydraulic conductivity below 10 inches per hour. See [Appendix C](#).

‡ Incorporate plants that tolerate fluctuating water levels.

§ Additional depth can be added to the filter media and/or gravel layer/sump to help meet water quantity requirements. This additional depth is not used for surface area sizing calculations. See Section 5.1.

**When used in tree planter holes, at least 36" of suitable rooting depth must be maintained. For example, if filter media depth is 24", at least 12" of non-compacted suitable soil that meets overall media k_{sat} criteria should be employed between the media and the underdrain or soil infiltration zone.

|| Media mix tested for an acceptable hydraulic conductivity (or permeability) and phosphorus content.

Figure P-FIL-05 A-1 Micro-bioretention with (a) simple disconnection to downstream practice and/or (b) alternate practice of compost amended filter path

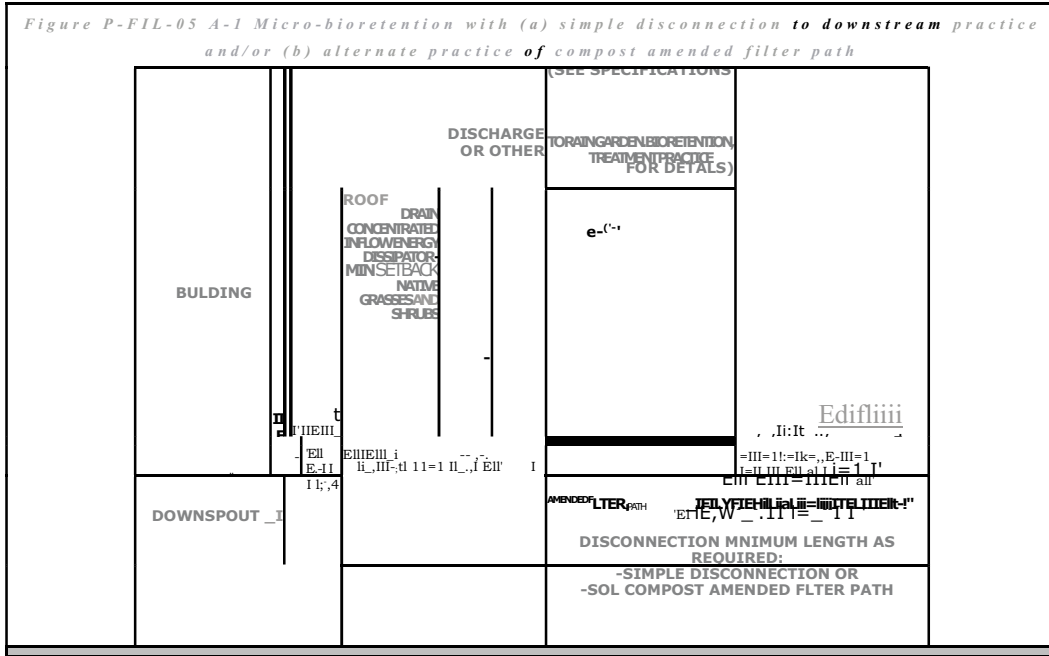
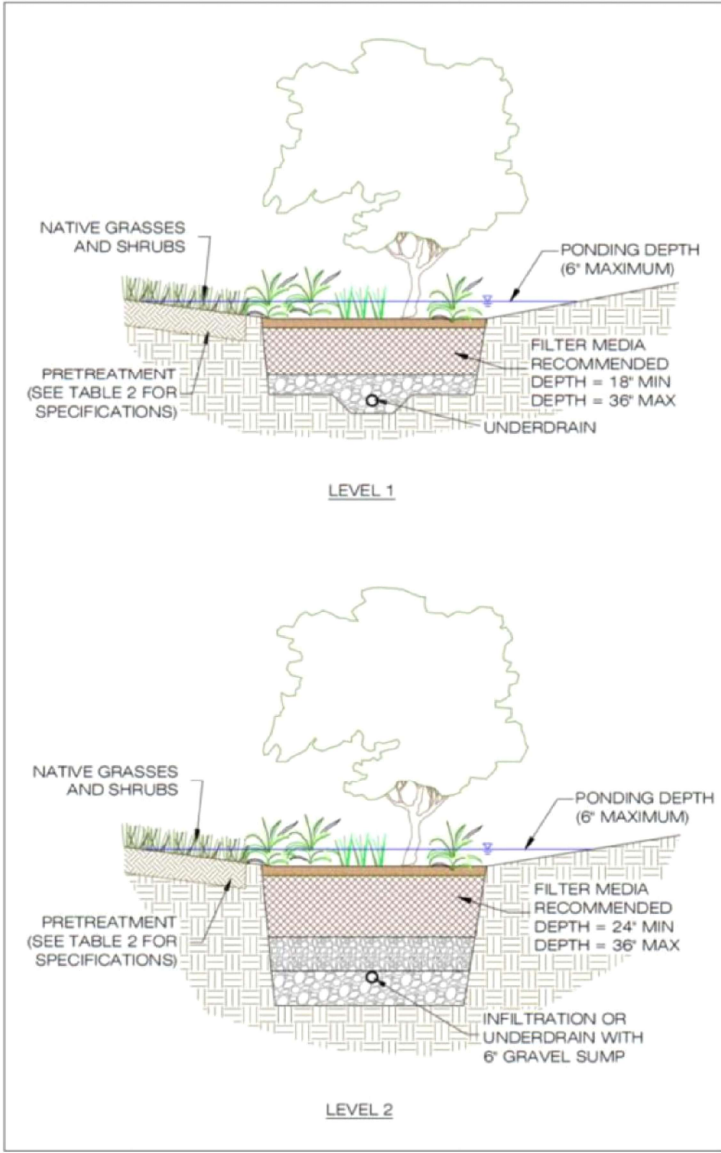


Figure P-FIL-05 A-2 Typical Micro-bioretention basis with Level 1 vs. Level 2 design



Guidance and References on Micro-bioretention (a.k.a Rain Gardens)

Chesapeake Stormwater Network (CSN). 2014. Homeowner Guide for a More Bay-Friendly Property. Chesapeake Stormwater Network. Timonium, MD. <https://chesapeakestormwater.net/resource/homeowner-guide-for-a-more-bay-friendly-property/> (accessed April 19, 2023).

Hirschman, D., L. Woodworth and S. Drescher. 2009. Technical Report: Stormwater [BMPs](#) in Virginia's James River Basin – An Assessment of Field Conditions and Programs. Center for Watershed Protection. Ellicott City, MD. It is available at: https://owl.cwp.org/mdocs-posts/hirschmand-sw_bmps_va_james_river_basin/

Fairfax County. 2009. Rain Garden Design and Construction: A Northern Virginia Homeowner's Guide. Fairfax County Park Authority and the Northern Virginia Soil & Water Conservation District. Fairfax County Publication 4/09. Fairfax, VA. <https://www.fairfaxcounty.gov/soil-water-conservation/rain-garden> (accessed April 19, 2023).

Fox, L.J., D.J. Robinson, and D.J. Sample. 2018. Stormwater Management for Homeowners Fact Sheet 5: Rain Gardens. Publication SPES-13P, Virginia Cooperative Extension. Virginia Tech. <https://www.pubs.ext.vt.edu/SPES/SPES-13/SPES-13.html> (accessed April 19, 2023).

Golon, S.K. and J. Okay. 2014. Rain Gardens: Technical Guide. VDOF P00127, Virginia Department of Forestry. Charlottesville, VA. https://dof.virginia.gov/wp-content/uploads/Rain-Gardens-Technical-Guide_pub.pdf (accessed April 19, 2023).

Montgomery County, Maryland. 2020. *RainScapes Planting Designs for Rain Gardens*. RainScapes Program of the Department of Environmental Protection, Montgomery County, Maryland. About RainScapes | Department of Environmental Protection, Montgomery County, MD (montgomerycountymd.gov) Accessed August 26, 2023).

[North Carolina Department of Environmental Quality \(NC DEQ\), 2024. "C-2. Bioretention Cell." NCDEQ Stormwater BMP Manual. 2024. https://www.deq.nc.gov/energy-mineral-and-land-resources/stormwater/bmp-manual/c-2-bioretenion-cell/download?attachment](https://www.deq.nc.gov/energy-mineral-and-land-resources/stormwater/bmp-manual/c-2-bioretenion-cell/download?attachment)

Virginia Association of Soil & Water Conservation Districts. 2023. Virginia Conservation Assistance Program (VCAP) Implementation and Design Manual. 8th edition. <https://vaswcd.org/vcap/> (accessed April 19, 2023).

10.0 Appendix B Ultra-Urban Bioretention

General Description



Stormwater Planters



Expanded Tree Pits

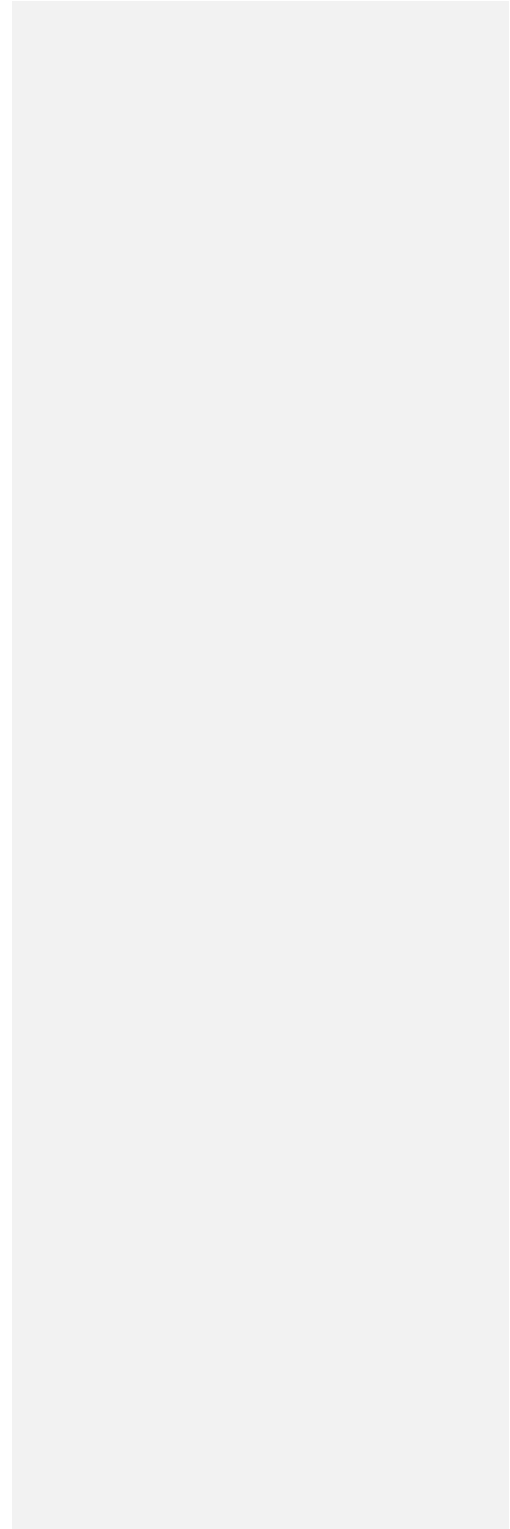


Stormwater Curb Extensions

Ultra-urban bioretention practices are similar in function to regular bioretention practices except they are adapted to fit into "containers" or other relatively small, engineered enclosures within urban landscapes. This practice does not include simple "tree planter holes" in urban landscapes that do not contain specified soil media and drainage.

Typically, ultra-urban bioretention is installed within an urban streetscape or city street right-of-way, urban landscaping beds, tree pits and plazas, or other features within an ultra-urban area. Ultra-urban bioretention is not intended for large commercial areas, nor should it be used to treat small sub-areas of a large drainage area such as a parking lot. Rather, ultra-urban bioretention is intended to be a containerized practice incorporated into small, fragmented drainage areas such as shopping or pedestrian plazas within a larger urban development.

Ultra-urban bioretention features hard edges, often with vertical concrete sides, as contrasted with the earthen slopes of regular bioretention. These practices may be open-bottomed to allow some infiltration of runoff into the sub-grade, but they generally are served by an underdrain.



There are three variants of the ultra-urban bioretention practice: stormwater planters, expanded tree pits, and stormwater curb extensions. Each ultra-urban bioretention variant is planted with a mix of trees, shrubs, and grasses as appropriate for its size and landscaping context.

Stormwater planters (also known as vegetative box filters or foundation planters) take advantage of limited space available for stormwater treatment by placing soil media in a container located above ground or at grade in landscaping areas between buildings and roadways ([Figure P-FIL-05 B-1](#)). The small footprint of foundation planters is typically contained in a precast or cast-in-place concrete vault. Other materials may include molded polypropylene cells and precast modular block systems.

Expanded tree pits are installed in the sidewalk zone near the street where urban street trees are normally installed ([Figure P-FIL-05 B-2](#)). The treatment area is increased by using a series of connected tree plantings in a row. The surface of the enlarged planting area may be mulch, grates, permeable pavers, or conventional pavement. The large and shared rooting space and a reliable water supply increase the growth and survival rates in this otherwise harsh planting environment.

Figure P-FIL-05 B-1 Stormwater planters



Figure P-FIL-05 B-2 Expanded tree pits



Stormwater curb extensions (also known as parallel bioretention) are installed in the road right-of-way either in the sidewalk area or in the road itself. In many cases, curb extensions serve as a traffic-calming or street-parking control device. The basic design adaptation is to move the raised concrete curb closer to the street or in the street, and then create inlets or curb cuts that divert street runoff into depressed vegetated areas within the expanded right-of-way ([Figure P-FIL-05 B-3](#)).

Figure P-FIL-05 B-3 Stormwater curb extensions



Performance

The typical stormwater functions of an ultra-urban bioretention area are described in [Table P-FIL-05 B-1](#).

Table P-FIL-05 B-1 Summary of Stormwater Functions Provided by Ultra-urban Bioretention Areas

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	40%	NA
Total Phosphorus (TP) EMC Reduction ¹ by BMP Treatment Process 25%		NA
Total Phosphorus (TP) Mass Load Removal	55%	NA
Total Nitrogen (TN) EMC Reduction ¹ by BMP Treatment Process	40%	NA
Total Nitrogen (TN) Mass Load Removal	64%	NA

Use the Virginia Runoff Reduction Method ([VRRM](#)) Compliance Spreadsheet to calculate the Curve Number (CN) Adjustment
OR

Channel and Flood Protection

Design extra storage (optional; as needed) on the surface, in the engineered soil matrix, and in the stone/underdrain layer to accommodate a larger storm and use [NRCS](#) TR-55 Runoff Equations ² to compute the CN Adjustment.

Notes:

Sources: [CWP](#) and CSN (2008) and CWP (2007)

1. Change in the event mean concentration (EMC) through the practice. The actual nutrient mass load removed is the product of the removal rate and the runoff reduction rate (see Table 1 in the Introduction to the New Virginia Stormwater Design Specifications).
2. NRCS TR-55 Runoff Equations 2-1 thru 2-5 and Figure 2-1 can be used to compute a curve number (CN) adjustment for larger storm events based on the retention storage provided by the practice(s)

Design Table

Table P-FIL-05 B-2 Ultra-Urban Bioretention Design Criteria

Level 1 Design Only (RR: 40; TP: 25)

Maximum Drainage Area = 2,500 sq. ft.¹ (100% impervious)

Sub-soil testing (Refer to the Primary Bioretention Design Specification)

Sizing :

$$T_v \text{ BMP} = [(1)(R_v)(A) / 12]$$

Maximum Ponding Depth = 6 to 12 inches²

Filter media depth minimum = 18 inches; recommended maximum = 48 inches

Media and Surface Cover

(Refer to the Primary Bioretention Design Specification)

Underdrain = Schedule 40 PVC with clean-outs

(Refer to the Primary Bioretention Design Specification)

Building setbacks (Refer to [Figure P-FIL-05 B-5](#) below)

Inflow = sheetflow (e.g., curb cuts); concentrated flow (e.g., trench drains, roof drains)

Deeded maintenance O&M plan (Refer to the Primary Bioretention Design Specification)

Notes:

1. Larger drainage areas may be allowed with sufficient flow controls and other mechanisms to ensure proper function, safety, and community acceptance; however, the urban bioretention filter must then be designed in accordance with the Level 1 bioretention criteria ([Table P-FIL-025-3](#)).
2. Ponding depth above 6 inches will require a specific planting plan to ensure appropriate plants (Refer to the Primary Bioretention Design Specification).

2-3. Utilize an Internal Water Storage (IWS) zone when possible, see Section 5.6.4 above for details.

Formatted: Bottom: 2.81"

Commented [MC17]: Refer to feasibility table (P-FIL-05-1) upon finalization

Formatted: List Paragraph, Left, Indent: Left: 0", First line: 0", Right: 0.25", Space Before: 0.05 pt, After: 6.35 pt, Line spacing: Exactly 12.7 pt, Tab stops: Not at

Formatted: Font: (Default) Arial, Underline, Font color: Black

Commented [MC18]: FIGURE: Arcadis
Please improve quality of words for readability and integrate '18" MIN'

Typical Details

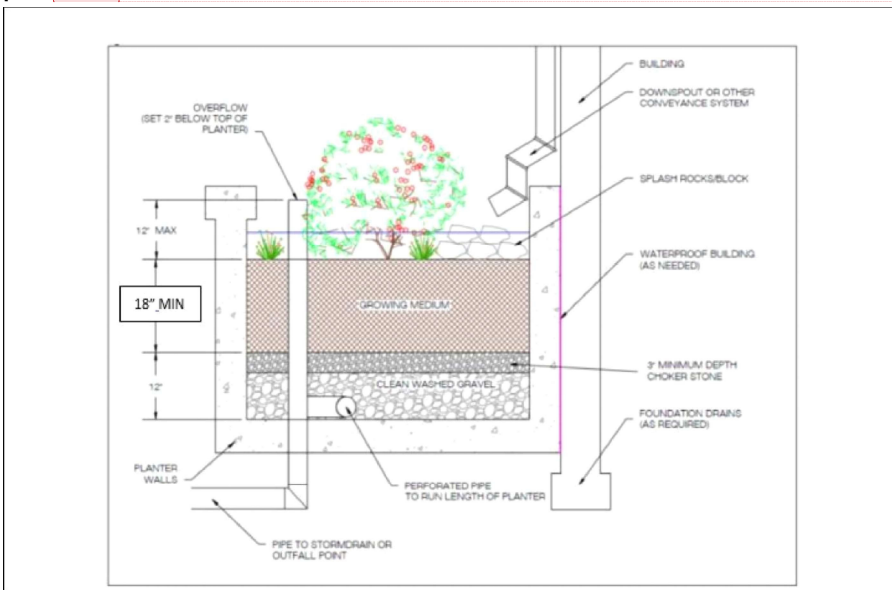
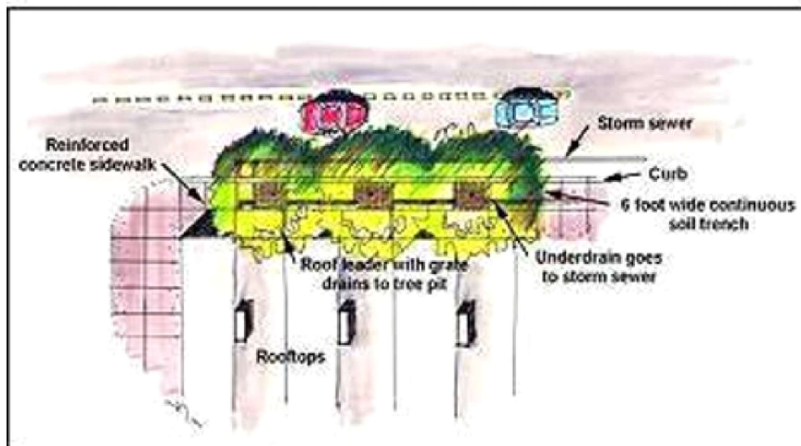
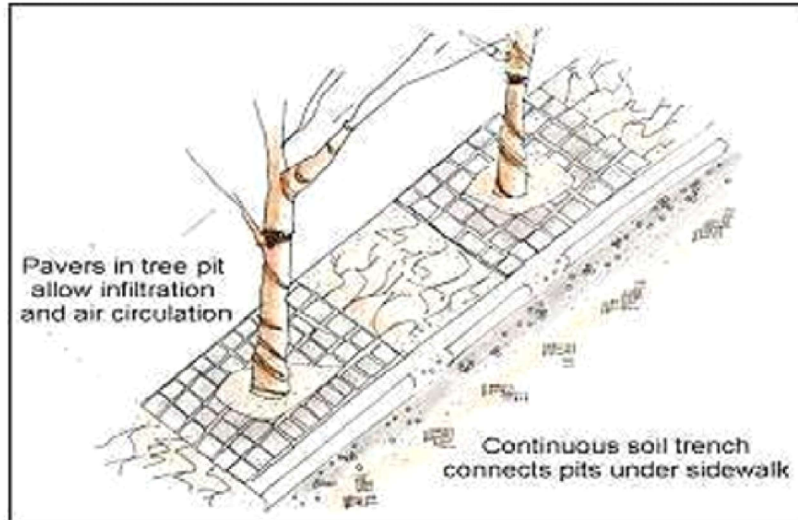


Figure P-FIL-05 B-5 Expanded tree pit details



Physical Feasibility & Design Applications

In general, ultra-urban bioretention has the same constraints as regular bioretention, along with a few additional constraints as noted below:

Contributing Drainage Area. Ultra-urban bioretention is limited to 2,500 sq. ft. of drainage area to each unit, and the contributing drainage area is considered to be 100% impervious. Larger drainage areas may be allowed with sufficient flow controls and other mechanisms to ensure proper function, safety, and community acceptance.

Adequate Drainage. Ultra-urban bioretention practice elevations must allow the untreated stormwater runoff to be discharged at the surface of the filter bed and ultimately connect to the local storm drain system.

Available Hydraulic Head. In general, 3 to 5 feet of elevation difference is needed between the downstream storm drain invert and the inflow point of the ultra-urban bioretention practice. This is generally not

a constraint, due to the standard depth of most storm drains systems.

Setbacks from Buildings or Roads. If an impermeable liner and an underdrain are used, no setback is needed from the building. Otherwise, the standard 10 foot down-gradient setback applies.

Proximity to Underground Utilities. Ultra-urban bioretention practices frequently compete for space with a variety of utilities. Since they are often located parallel to the road right-of-way, care should be taken to provide utility-specific horizontal and vertical setbacks. However, conflicts with water and sewer laterals (e.g., house connections) may be unavoidable, and the construction sequence must be altered, as necessary, to avoid impacts to existing service.

Overhead Wires. Designers should also check whether future tree canopy heights achieved in conjunction with ultra-urban bioretention practices will interfere with existing overhead telephone, cable communications and power lines.

Minimizing External Impacts. Because ultra-urban bioretention practices are installed in a highly urban settings, individual units may be subject to higher public visibility, greater trash loads, pedestrian use traffic, vandalism, and even vehicular loads. Designers should design these practices in ways that prevent, or at least minimize, such impacts. In addition, designers should clearly recognize the need to perform frequent landscaping maintenance to remove trash, check for clogging, and maintain vigorous vegetation. The urban landscape context may feature naturalized landscaping or a more formal design. When ultra-urban bioretention is used in sidewalk areas of high foot traffic, designers should not impede pedestrian movement or create a safety hazard. Designers may also install low fences, grates or other measures to prevent damage from pedestrian short-cutting across the practices.

Design Criteria

Ultra-urban bioretention practices are similar in function to regular bioretention practices except they are adapted to fit into “containers” within urban landscapes. Therefore, special sizing accommodations are made to allow these practices to fit in very constrained areas where other surface practices may not be feasible.

Sizing of Ultra-urban Bioretention

The requirements for sizing an ultra-urban bioretention filter are the same as that of bioretention and micro-bioretention described in the Primary design specification.

General Design Criteria for Ultra-urban Bioretention

Design of ultra-urban bioretention should follow the general guidance presented in the main part of this bioretention design specification. The actual geometric design of ultra-urban bioretention is usually dictated by other landscape elements such as buildings, sidewalk widths, utility corridors, retaining walls, etc. Designers can divert fractions of the runoff volume from small impervious surfaces into micro-bioretention units that are integrated with the overall landscape design. Inlets and outlets should be located as far apart as possible. The following is additional design guidance that applies to all variations of ultra-urban bioretention:

- The ground surface of the ultra-urban bioretention cell should slope 1% towards the outlet, unless a stormwater planter is used.
- The soil media depth should be a minimum of 18 inches.

If large trees and shrubs are to be installed, soil media depths should be a minimum of 4 feet.

Each individual ultra-urban bioretention unit should be stenciled or otherwise permanently marked to designate it as a stormwater management facility. The stencil or plaque should indicate (1) its water quality purpose, (2)

- that it may pond briefly after a storm, and (3) that it is not to be disturbed except for required maintenance.
- All ultra-urban bioretention practices should be designed to fully drain within 24 hours.
- Any grates used above ultra-urban bioretention areas must be removable to allow maintenance access.

The inlet(s) to ultra-urban bioretention should be stabilized using [VDOT #3](#) stone, splash block, river stone or other acceptable energy dissipation measures. The following forms of inlet stabilization are recommended:

- Downspouts to stone energy dissipators.
- Sheet flow over a depressed curb with a 3-inch drop.
- Curb cuts allowing runoff into the bioretention area.
- Covered drains that convey flows across sidewalks from the curb or downspouts.
 - Grates or trench drains that capture runoff from the sidewalk or plaza area.
- Pre-treatment options overlap with those of regular bioretention practices. However, the materials used may be chosen based on their aesthetic qualities in addition to their functional properties. For example, river rock may be used in lieu of rip rap. Other pre-treatment options may include one of the following:
 - A trash rack between the pre-treatment cell and the main filter bed. This will allow trash to be collected from one location.
 - A trash rack across curb cuts. While this trash rack may clog occasionally, it keeps trash in the gutter, where it can be picked up by street sweeping equipment.
 - A pre-treatment area above ground or a manhole or grate directly over the pre-treatment area.
- Overflows can either be diverted from entering the bioretention cell or dealt with via an overflow inlet. Optional methods include the following:
 - Size curb openings to capture only the Treatment Volume and bypass higher flows through the existing gutter.
 - Use landscaping type inlets or standpipes with trash guards as overflow devices. Use
 - a pre-treatment chamber with a weir design that limits flow to the filter bed area.

Specific Design Issues for Stormwater Planters

Since stormwater planters are often located near building foundations, waterproofing by using a watertight concrete shell or an impermeable liner is required to prevent seepage.

Specific Design Issues for Expanded Tree Pits

The bottom of the soil layer must be a minimum of 4 inches below the root ball of plants to be installed.

Extended tree pits designs sometimes cover portions of the filter media with pervious pavers or cantilevered sidewalks. In these situations, it is important that the filter media is connected beneath the surface so that stormwater and tree roots can share this space.

- Installing a tree pit grate over filter bed media is one possible solution to prevent pedestrian traffic and trash accumulation.
- Low, wrought iron fences can help restrict pedestrian traffic across the tree pit bed and serve as a protective barrier if there is a drop-off from the pavement to the micro-bioretention cell.
- A removable grate capable of supporting typical H-20 axle loads may be used to allow the tree to grow through it.

Each tree needs a minimum of 400 cubic feet of shared root space.

Specific Design Issues for Stormwater Curb Extensions

Roadway stability can be a design issue where stormwater curb extensions are installed. Consult design standards pertaining to roadway drainage. It may be necessary to provide a barrier to keep water from saturating the road's sub-base and demonstrate it is capable of supporting H-20 axle loads.

Planting and Landscaping Considerations

The degree of landscape maintenance that can be provided will determine some of the planting choices for ultra-urban bioretention areas. The planting cells can be formal gardens or naturalized landscapes.

In areas where less maintenance will be provided and where trash accumulation in shrubbery or herbaceous

flowering plants can be included. This may be attractive at a community entrance location.

Native trees or shrubs are preferred for ultra-urban bioretention areas, although some ornamental species may be used. Selected perennials, shrubs, and trees must be tolerant of salt, drought, and inundation. Additionally, tree species should be those that are known to survive well in the compacted soils and polluted air and water of an urban landscape.

Ultra-Urban Bioretention Material Specifications

Please consult the primary design specification ([Table P-FIL-052-3](#)) for the typical materials needed for filter media, stone, mulch and other bioretention features. The unique components for ultra-urban bioretention may include the inlet control device, a concrete box or other containing shell, protective grates, and an underdrain that daylight to another stormwater practice or connects to the storm drain system. The underdrain should:

Commented [MC19]: Refer to feasibility table P-FIL-05-1 upon finalization

- Consist of slotted pipe greater than or equal to 4 inches in diameter, placed in a layer of washed (less than 1% passing a #200 sieve) VDOT #57 stone.
- Have a minimum of 2 inches of gravel laid above and below the pipe.
- Be laid at a minimum slope of 0.5 %.
- Extend the length of the box filter from one wall to within 6 inches of the opposite wall and may be either centered in the box or offset to one side.
- Be separated from the soil media by non-woven, geotextile fabric or a 2-to-3-inch layer of either washed VDOT #8 stone or 1/8 to 3/8 inch pea gravel. Note that the fabric should not cover the entire area of separation between soil media and gravel, but rather be placed just above the perforated underdrain system and extend laterally up to from the centerline of the pipe.

Construction

The construction sequence and inspection requirements for ultra-urban bioretention are generally the same as micro-bioretention practices. Consult the construction sequence and inspection guidance provided in the primary design specification. In cases where ultra-urban bioretention is constructed in the road or right-of-way, the construction sequence may need to be adjusted to account for traffic control, pedestrian access, and utility notification.

Ultra-urban bioretention areas should only be constructed after the drainage area to the facility is completely stabilized. The specified growth media should be placed and spread by hand with minimal compaction, to avoid compaction and maintain the porosity of the media. The media should be placed in 6-to-12-inch lifts with no machinery allowed directly on the media during or after construction. The media should be overfilled above the proposed surface elevation, as needed, to allow for natural settling. Lifts may be lightly watered to encourage settling. After the final lift is placed, the media should be raked (to level it), saturated, and allowed to settle for at least one week prior to installation of plant materials.

Maintenance

Routine operation and maintenance are essential to gain public acceptance of highly visible ultra-urban bioretention areas. Weeding, pruning, and trash removal should be done as needed to maintain the aesthetics necessary for community acceptance. During drought conditions, it may be necessary to water the plants, as would be necessary for any landscaped area.

To ensure proper performance, inspectors should check that stormwater infiltrates properly into the soil within 24 hours after a storm. If excessive surface ponding is observed, corrective measures include inspection for soil compaction and underdrain clogging. Consult the maintenance guidance outlined in the main part of this design specification (Section 7).

Design References

Center for Watershed Protection. 2006. *Urban Watershed Forestry Manual*. [Part 2: Conserving and Planting Trees at Development Sites](#). Ellicott City, MD. Available online at: <https://owl.cwp.org/mdocs-posts/urban-watershed-forestry-manual-part-2/>

City of Portland. Bureau of Environmental Services. (Portland BES). 2004. *Portland Stormwater Management Manual*. Portland, OR. <http://www.portlandonline.com/bes/index.cfm?c=dfbcc>

Credit Valley Conservation. 2008. *Credit River Stormwater Management Manual*. Mississauga, Ontario.
[North Carolina Department of Environmental Quality \(NC DEQ\), 2024. "C-2. Bioretention Cell." NCDEQ Stormwater BMP Manual, 2024. https://www.deq.nc.gov/energy-mineral-and-land-resources/stormwater/bmp-manual/c-2-bioretenion-cell/download?attachment](https://www.deq.nc.gov/energy-mineral-and-land-resources/stormwater/bmp-manual/c-2-bioretenion-cell/download?attachment)

Northern Virginia Regional Commission. 2007. *Low Impact Development Supplement to the Northern Virginia BMP Handbook*. Fairfax, Virginia

Saxton, K.E., W.J. Rawls, J.S. Romberger, and R.I. Papendick. 1986. "Estimating generalized soil-water characteristics from texture." *Soil Sci. Soc. Am. J.* 50(4):1031-1036.

Schueler, T., D. Hirschman, M. Novotney and J. Zielinski. 2007. *Urban stormwater retrofit practices*. Manual 3 in the Urban Subwatershed Restoration Manual Series. Center for Watershed Protection, Ellicott City, MD.

APPENDIX F BIORETENTION DESIGN – BACKGROUND INFORMATION

Contents:

[F.1 Guidance for Amending Soils with High Hydraulic Conductivity](#)

[F.1.1 Amended from 2020 Minnesota Stormwater Manual](#)

[F.1.2 Soil Amendment Approaches](#)

[F.1.3 Complications](#)

[F.1.4 Guide to Developing a Soil Amendment Plan](#)

[F.2 References](#)

[F.3 Filter Media](#)

[F.3.1 Filter Media Criteria and Testing for Bioretention](#)

[F.3.2 General Composition](#)

[F.4 Calculating Treatment Volume Peak Discharge](#)

[F.4.1 Introduction](#)

[F.4.2 Modified Curve Number Method](#)

[F.5 References](#)

F.1 Guidance for Amending Soils with High Hydraulic Conductivity

F.1.1 Amended from 2020 Minnesota Stormwater Manual

The primary concern raised by the Minnesota criteria described here are with high rates of internal hydraulic conductivity above ~ 8 inches per hour and include: (1) a diminished ability to attenuate pollutants due to the relatively short contact time between the soil and infiltrating stormwater and (2) a higher potential for rapid contaminant transport to local groundwater or other receiving surface water systems (e.g., in the event of chemical spills).

Similar concerns could occur under Virginia conditions for certain soils with: (a) no underlying clay + iron enriched Bt or Bw horizon (e.g., Entisols) in combination with (b) a seasonal high water table or mound that exceeds a two foot standoff criteria. In Virginia, it is unlikely that these soil conditions would be encountered in most upland soil landscapes as long as appropriate setbacks from jurisdictional wetlands and ephemeral drains are maintained coupled with the minimum two-foot standoff criteria above the seasonal high water table or mound. However, this combination of soil properties is possible in certain soil landscapes in Virginia, particularly in the lower Coastal Plain and Eastern Shore. Therefore, the procedures recommended below could potentially be utilized to decrease K_{sat} of the receiving base elevation soil. Therefore, this overall best management practice ([BMP](#)) sets a maximum soil infiltration zone K_{sat} of 10 inches/hour under the assumptions outlined above.

F.1.2 Soil Amendment Approaches

Amending soils with high hydraulic conductivity typically involves either physically decreasing the hydraulic conductivity or increasing the pollutant attenuation capacity.

- **Physically decreasing hydraulic conductivity:** This approach involves designing the soil matrix to achieve a specific permeability that both reduces the speed at which stormwater runoff reaches the groundwater and increases contact time with the soil.
- **Increasing pollutant attenuation:** This approach does not specifically link to a target hydraulic conductivity.

Rather, the soil is amended to meet a threshold, such as organic matter content, that satisfies permit requirements. Compost or other adsorptive materials such as biochar or alum sludge are commonly used to achieve higher pollutant attenuation capacity.

Note: Because of the site-specific nature for amending soils, this document offers general guidance on amending soils rather than a specific approach and was not developed for Virginia conditions per se.

F.1.3 Complications

One of the most common complications of amending soil is decreasing the hydraulic conductivity so much that it becomes unacceptably slow. This is often caused by the introduction of fine-grained materials, which become clogged in the native soil. Subsequent consequences of clogging the soil may include failure to meet 48-hour drain time requirements and killing vegetation that was not intended for prolonged inundation. Another complication is the potential for the soil amendment to serve as a pollutant source. For example, certain amendment media such as compost can export soluble phosphorus in higher concentrations than the incoming stormwater runoff, thus contributing to increased phosphorus loading.

F.1.4 Guide to Developing a Soil Amendment Plan

Designers developing a soil amendment plan to slow the hydraulic conductivity below 10 inches per hour should seek to physically decrease the hydraulic conductivity or to increase pollutant attenuation capacity while taking steps to prevent common complications.

Step 1 – Determine soil conditions.

The first step in developing a soil amendment plan involves understanding the baseline conditions of the native soils in which the amendment will be performed including:

- **Hydraulic conductivity:** Measure hydraulic conductivity using appropriate methods and number of measurements.
- **Soil gradation (grain-size distribution):** Grain-size (particle-size) distribution provides an indication of the presence of fine-grained material (e.g., clay) which can slow infiltration and attenuate pollutants. Samples for grain size analysis are typically collected with soil borings. Sieve analysis is commonly used to determine grain size distribution, although other methods (e.g., hydrometer) are available.
- **Soil type:** This can be determined from published soil survey maps, Natural Resources Conservation Service ([NRCS](#)) Web Soil Survey, or preferably via on-site investigation coupled with lab data once the overall soil horizonation (e.g., A-B-C) and grain-size distribution is known.
- **Organic matter content:** Soil organic matter (or organic carbon) affects both soil hydraulic conductivity and attenuation of many potential pollutants in stormwater runoff (e.g., metals, organic chemicals, certain forms of nitrogen and phosphorus, bacteria).
- **Degree of compaction:** Compacted soils will have reduced hydraulic conductivity. Similarly, hydraulic conductivity in uncompacted soils can be decreased by compacting soils to some extent, but this is highly dependent upon moisture content at the time of operations. Several methods are available to evaluate soil compaction, including penetration tests (with moisture content adjustment) and preferably measuring soil bulk density via core-ring sampling, neutron scattering, or other approved methods.

Soil samples should be taken in close proximity to the infiltration test locations.

Step 2 – Develop site plan and select amendment application option(s).

Depending on the site-specific conditions determined from the first step, the soil amendment plan should define one or more of the following.

- Areas where native soil will be retained in place due to sufficient hydraulic conductivity.
- Areas where native topsoil or subsoil will be amended in place.
- Areas where native topsoil will be stripped and stockpiled prior to grading for reapplication.

Step 3 – Identify available material source.

Compost and topsoil are the most used soil amendment media.

Step 4 – Calculate amendment volume.

When calculating the volume of soil amendment material needed, the following should be taken into consideration.

- Desired hydraulic conductivity (K_{sat}) of the amended soil;
- Desired pollutant attenuation capacity based on texture or cation exchange capacity ([CEC](#)) or other appropriate indices;
- Amendment material characteristics (e.g., density, gradation, organic matter);
- Desired depth of amendment; and
- Degree to which native soil will be mixed with amendment material.

Step 5 – Specify construction procedures.

Implementation of the soil amendment construction procedure needs to ensure the appropriate volume of amendment is used and that the mixing process results in a consistent, homogeneous media across the entire site to the desired depth (usually 10 to 12 inches). The mixing process can be accomplished by either

- Blending the native and amendment materials in place with tilling equipment such as a multiple shank ripper or chisel plow followed by disking, or
- Excavating the native soil, mixing with the amendment material, and reapplying the mixture to achieve the desired depth and gradation.

The specified construction procedure must also ensure that common complications are prevented and may include the following.

- Avoid layering – creating two or more soil layers with an abrupt linear contact that are significantly different in K_{sat} that can lead to: (a) perching of saturated conditions above the dissimilar contact or (b) enhanced lateral flow downgradient.
- When leaching of nutrients could be harmful to a receiving water, the combined influence of the compost source on extractable P (see Table F1) should be taken into consideration.

Step 6 – Specify final inspection procedures.

The soil amendment plan should specify post-soil amendment infiltration testing, which is critical to ensuring the amended soil performs as expected (that the new hydraulic conductivity is not too high, too low, or uneven throughout the site).

What rate should I use if I follow the procedure?

If the above procedure is followed, we recommend one of the following:

- Set a minimum target rate that is clearly lower than the stated K_{sat} level of concern (e.g., 10 in/hr.).
- Conduct field tests to determine the hydraulic conductivity (K_{sat}).

F.2 References

US Army Corps of Engineers. EM 1110-2-2300. 2004. General Design and Construction Considerations for Rock-Fill Dams – Appendix B.

US Army Corps of Engineers. EM 1110-2-1901. 1986. Seepage Analysis and Control for Dams – Appendix D. 1986.

F.3 Filter Media

The filter media of a bioretention practice consists of an engineered soil mixture that has been carefully blended to create a filter media that maintains long-term permeability while holding and providing sufficient nutrients to support plant growth. The final filter media shall consist of a well-blended mixture of medium to coarse sand, loamy native soil mineral components, and an organic amendment (compost). The sand maintains the desired permeability of the media while the limited amount of silt + clay particles and compost amendment help support initial plant growth and provide for pollutant adsorption, particularly for P. It is anticipated that the gradual increase of organic matter through natural processes of root dieback, surface litter additions and mixing by the soil biota will continue to support plant growth without the need to add fertilizer beyond establishment, and the root structure of maturing plants along with biological activity of the media and accumulating organic matter will lead to aggregation to help maintain medium to long-term permeability.

F.3.1 Filter Media Criteria and Testing for Bioretention

The criteria listed in Table F-1 below are key factors to consider in determining an acceptable filter media mixture and are required to be certified by the media blender or supplier. While the ability to maintain effective infiltration rates along with minimum internal media permeability (Ksat) minimum Ksat over time is an overriding consideration, all components of the criteria should be adhered to. Furthermore,

it is particularly important for vendors to keep plant available P levels within the prescribed range and carefully screen large rock fragments out of native soil components before blending. Depending on the source of compost or other suitable organic amendment utilized, vendors may need to design for the lower acceptable range of total organic matter (3%) in the fine earth (< 2mm ground) fraction.

It is important to understand the differences between field infiltration and internal permeability rates. Surface infiltration rates are not constant and usually decrease with time as the surface void space becomes saturated and media components (humus and clays) swell. However, once the receiving surface and underlying soil media become saturated, the infiltration rate approaches and is controlled by the permeability (K_{sat}) of the underlying media. See Appendix C for more details and appropriate methods for testing.

Table F-1 Filter Media Criteria and Testing for Bioretention

Filter Media Criterion	Description	Standard(s)	Testing Method
General Composition	Filter media must have the proper proportions sand, fines, and organic matter to promote plant growth, drain at the proper rate over time, and filter pollutants, particularly P.	80%–90% sand; 10%–20% soil fines (silt+clay); maximum clay content:10% 3%–5% organic matter content by weight	Particle size analysis via Soil Survey Staff (2014) on mineral blend only or following organic matter removal; Grind sample to < 2.0 mm for organic matter via Loss on Ignition (LOI) or Walkley-Black. Nelson & Sommers (1982). Also in Sparks et al. 2020.
Sand Component	Medium to coarse aggregate natural mineral source or quartz substitute. Do not use ground concrete, aggregate, bottom ash, or other similar materials.	(< 2.0 to 0.05 mm); Mica <5%. ≥0.05 mm and < 2 mm; 50% between 0.5 mm and 2 mm by USDA/NRCS criteria	Standard dry sieve analysis. ASTM C33/VDOT Grade A acceptable as long as overall coarse fragment (> 2mm) criteria for whole media blend as stated below (< 25%) is met.
Topsoil	Loamy sand, Sandy Loam, or Loam Based on U.S. Department of Agriculture (USDA) Textural Triangle	NRCS texture class based on < 2mm. For whole sample, no more than 20% total > 2.0 mm; all must pass 9.5 mm.	PSA via Soil Survey Staff (2014)
Organic Amendment	Stable, well-aged, clean compost from leaf litter, humus, peat moss or other suitable organic source(s)	See P-FIL-08 Soil Compost Amendment for criteria for suitable organic materials.	See the following for methods: Compost Research & Education Foundation: https://compostfoundation.org

Recommended Analytical Methods:

CEC, Organic Matter, Extractable P and other Chemical Methods: Sparks, D.L., Page, A.L., Helmke, P.A, and R.H. Loeppert. 2020. Methods of Soil Analysis, Part 3: Chemical Methods, Soil Science Soc. Amer., Madison WI. Methods of Soil Analysis, Part 3: Chemical Methods | Wiley (accessed August 26, 2023).

Compost Quality and Tests: Stehouwer, R., L. Cooperband, and R. Rynk. 2022. Compost characteristics and quality. In R. Rynk et al. (Eds.) Chapt. 15, Pp. 737- 775. The Composting Handbook. Academic Press. London, UK.

Particle Size Analysis, CEC and Organic Matter: Soil Survey Staff. 2014. Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 51, Version 2.0. R. Burt and Soil Survey Staff (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service. NRCS Publications - Item Detail (usda.gov) (accessed August 26, 2023).

pH and Soluble Salts: Soil Survey Staff 2014 or Sparks et al. 2020. See above.

Formatted: Right: 0.02", Line spacing: single

Commented [MC1]: Revised to reflect consistency with 2021 VDEQ x VDOT document (page 14 of 41)

Commented [MC2]: Below, Extractable P revised to reflect above document (more consistent with material available for industry)

Table F-1 Filter Media Criteria and Testing for Bioretention

Filter Media Criterion	Description	Standard(s)	Testing Method
Cation Exchange Capacity (CEC)	CEC measures soil reactivity and ability to retain ions against leaching. CEC generally increases with OM and clay content and pH.	CEC: > 5.0 milliequivalents per 100 grams (or cmolc per kg) via pH 7 NH4OAc method.	Soil Survey Staff 2014. Based on Sumner & Miller (1996) or other similar unbuffered salt methods. Also in Sparks et al. (2020).
Permeability (Ksat)	Refers to the hydraulic conductance (Ksat) of the filter media.	Ksat = 1 to 2 inches/hour. Rates will most likely be higher. Initial rates < 10 inches/hour acceptable	Virginia Department of Transportation (VDOT) × Virginia Department of Environmental Quality (VDEQ) 2021 VTM-134, or procedures in Appendix C Infiltration Practices . See guidance in F 3.2 below . VDOT Virginia Test Methods
Extractable P	Filter media with high P levels will export P through the media and potentially to downstream conveyances or receiving waters.	Mehlich I 5-3245 mg/kg or Mehlich III 48-4010-78 mg/kg	Mehlich I or Mehlich III extraction of < 2mm ground whole media sample.
pH	Soil pH influences plant nutrient availability, microbial populations and net soil charge/reactivity.	Between 5.5 and 7.5	1:1, 1:2 soil:water or saturated paste soil extract. Soil Survey Staff (2014)
Soluble Salts	Filter media with high levels of soluble salts can injure or kill plants and can clog the filter media	Less than 4.0 mmhos/cm	Saturated paste soil extract. Soil Survey Staff (2014)

Formatted Table

Recommended Analytical Methods:

CEC, Organic Matter, Extractable P and other Chemical Methods: Sparks, D.L., Page, A.L., Helmke, P.A. and R.H. Loeppert. 2020. Methods of Soil Analysis, Part 3: Chemical Methods, Soil Science Soc. Amer., Madison WI. Methods of Soil Analysis, Part 3: Chemical Methods | Wiley (accessed August 26, 2023).

Compost Quality and Tests: Stehouwer, R., L. Cooperband, and R. Rynk. 2022. Compost characteristics and quality. In R. Rynk et al. (Eds.) Chapt. 15, Pp. 737- 775. The Composting Handbook. Academic Press. London, UK.

Particle Size Analysis, CEC and Organic Matter: Soil Survey Staff. 2014. Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 51, Version 2.0. R. Burt and Soil Survey Staff (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service. NRCS Publications - Item Detail ([usda.gov](https://www.nrcs.usda.gov)) (accessed August 26, 2023).

pH and Soluble Salts: Soil Survey Staff 2014 or Sparks et al. 2020. See above.

F.3.2 General Composition

The ultimate performance goal of the filter media is to achieve a verified soil permeability or hydraulic conductivity (Ksat) of 1 to 2 inches per hour (or 60 to 120 cm/day). Initially, the Ksat will be higher. The recommended maximum initial Ksat should not exceed 10 inches per hour and that value will be expected to decline as the media settles and larger compost fragments decompose. Permeability (Ksat) measurement on pre-installation media mixes should be provided by the vendor at levels of compaction and moisture similar to expected installed field conditions. Alternatively, the permeability of the media may be determined via an approved and appropriate field infiltration test run immediately after installation. See Appendix C for more details.

In order to achieve recommended Ksat, the bioretention soil mixture must be classified as a sand, loamy sand for the fine earth fraction (< 2 mm) on the USDA NRCS Texture Triangle, with the following composition:

- 80%–90% sand;
- 10%–20% silt+clay; maximum clay content: 10%;
- 3%–5% organic matter content; and
- USDA NRCS coarse/rock fragment fraction (> 2mm) must be < 20% for the entire media blend for all mineral/soil fragments including the sand and topsoil blended materials.

Additionally, the sand utilized in the mineral blend must meet the grain size distribution indicated in Table F-2. The final combined particle size analysis must be conducted on the mineral fraction only or follow appropriate treatments to remove organic matter (e.g., 30% H2O2 oxidation) before particle size analysis.

Table F-2 Sand Grain Size Distribution

Sieve	Size	% Passing
3/8 in	9.50 mm	100
No. 4	4.75 mm	95 to 100
No. 8	2.36 mm	80 to 100
No. 16	1.18 mm	45 to 85
No. 30	0.6 mm	15 to 60
No. 50	0.3 mm	3 to 15
No. 100	0.15 mm	0 to 4

- The following is the recommended composition of the three media ingredients:

Sand. Sand shall consist of alumino-silica-based native sands, rock fines or coarse aggregate that is angular or round in shape and meets the mixture grain size distribution above. No substitutions of alternate materials such as diabase, calcium carbonate, rock dust or dolomitic sands are accepted. In particular, the material shall contain less than 5% mica by weight when tested with ASTM C295.

ASTM C-33, Standard Specification for Concrete Aggregates, concrete sand will typically meet the requirements for the sand to be used in filter media. However, some samples of ASTM C-33 sand may have too high a fraction of fine sand and silt- and clay-sized particles to meet the final filter media particle size distribution requirements. In general, coarser gradations of ASTM C-33 will better meet the filter media particle size distribution and hydraulic conductivity requirements. Do not use ground concrete, aggregate or bottom ash due to concerns over high pH influences.

Topsoil. Topsoil is generally defined as the A + E horizons of the native soil profile which contains a combination of sand (2 to 0.5 mm), silt (0.05 to 0.002 mm) and clay (< 0.002 mm) sized mineral particles. Native topsoils usually also contain 0.5 to 5% finely divided organic matter (humus) by weight, but that is not considered

Commented [MC3]: For discussion: DEQ is participating in new research study with VTRC - addressing appropriate method for estimating permeability of media with goal of new hybrid lab method that would be feasible for a standard geotech lab with appropriate guidance on column diameter, packing density, whether or not concentrated road salt does is required.

Study not complete. Potential for incorporation once sufficient data is acquired

in assignment of USDA NRCS mineral soil texture classes. Since the objective of the specification is to carefully establish the proper blend of these ingredients in the final filter media, the vendor

must carefully select the topsoil source material to meet the overall final topsoil+sand blend criteria of no more than 20% silt+clay, and no more than 10% clay.

Generally, the use of a topsoil defined as a loamy sand, sandy loam, or loam (per the USDA Textural Triangle) will be an acceptable ingredient and in combination with the other ingredients meet the overall performance goal of the soil media. However, it is important to note the following:

1. USDA NRCS soil texture is determined on the < 2mm fraction only. Organic matter should be removed for all source topsoil with more than 5% OM via the H₂O₂ oxidation pre-treatment method.
 2. For the purpose of this specification, the topsoil component utilized shall not contain > ~~20~~25% coarse/rock fragments > 2.0 mm and no particles may be > ~~9.5-12~~ mm (~~3/8-1/2~~ inch). This will provide a final sand+topsoil mineral component blend that limits the total > 2mm fraction to < ~~20~~25%.
- **Organic Matter.** Organic matter shall consist of stable, well-composted, natural, carbon-containing organic materials such as leaf mulch, peat moss, humus, or yard waste (consistent with the material specifications found in [P-FIL-04](#) Soil Compost Amendment and/or the Compost Research & Education Foundation). The material shall be free of debris such as plastics, metal, concrete, stones larger than 0.5 inch, larger branches and roots, and wood chips over 1 inch in length or diameter. The organic matter content of the final media blend must be determined on the appropriate size fraction with one of the methods ([LOI](#) or Walkley-Black) specified in Table F-1.
 - **Other organic (e.g., biochar, stable sludges) or inorganic residuals or additives (e.g., alum sludge, steel slag, recycled glass)** may be considered to meet or enhance [Table F-1](#) requirements for mineral texture, [CEC](#), P, or organic matter levels, but must be approved by VDEQ or Virginia Department of Agriculture and Consumer Services ([VDACS](#)) for such application and approved on a case-by-case basis.

In order to achieve a proper mix of these three ingredients, start with an open-graded coarse sand material and proportionately mix in the topsoil materials that may contain anywhere from 10% to 20% soil fines (sandy loam, loamy sand, loam) to achieve the desired ratio of sand and fines. Sufficient suitable organic amendments (e.g., stable compost) can then be added to achieve the 3% to 5% soil organic matter target. The exact composition of organic matter and topsoil material will vary, making the exact particle size distribution of the final total soil media mixture difficult to define in advance of evaluating available materials.

Plant Available Phosphorus (P) content. The filter media should contain sufficient plant-available P to support initial plant establishment and plant growth, but it should not serve as a significant source of P for longterm leaching losses. This range should be between ~~5~~ to ~~45-32~~ mg/kg P for the Mehlich I extraction procedure or ~~48~~ to ~~40~~~~10-78~~ mg/kg P for the Mehlich III extraction procedure. The Virginia and/or NRCS P-Index is not applicable to biofiltration media per se.

Cation Exchange Capacity (CEC). The minimum CEC of a bioretention soil media mix for pollutant removal is 5.0 (meq/100 g or cmol_c/kg) or greater. The filter media CEC should be determined by the Unbuffered Salt, Ammonium Acetate, Summation of Cations or Effective CEC techniques (Sumner and Miller 1996) or similar methods that do not utilize strongly acidic extracting solutions. Methods used by USA Soil Taxonomy that employ the BaCl₂-TEA extract to estimate exchangeable acidity (H⁺) may not be used.

Hydraulic Conductivity (K_{sat}). The bioretention soil media should have a minimum saturated hydraulic conductivity of 1 to 2 inches per hour (or 60 to 120 cm/day) and an initial K_{sat} of no more than 10 inches per hour before settling following initial wetting events.

pH. The pH of bulk media should be in the range of 5.5-7.5.

Soluble Salts. The specific conductance of a saturated paste extract of the bulk media should never exceed 4 mmhos/cm (or dS/m) and should be below 2 mmhos/cm unless salt tolerant plant species are used.

Commented [MC4]: Extractable P revised to reflect above document (more consistent with material available for industry) (Consistent w/ revisions to table F-1)

Formatted: Subscript

Formatted: Subscript

F.4 Calculating Treatment Volume Peak Discharge

F.4.1 Introduction

The water quality treatment volume (T_{vBMP}) is defined as the amount of runoff from a contributing drainage area generated by the rainfall from the 90th percentile storm event, which has been established as the 1-inch storm for Virginia. In order to properly size water quality BMPs, the water quality treatment volume must be calculated using the Virginia Runoff Reduction Method (VRRM). This treatment volume can then be converted into peak discharge ($qpTv$) in order to ensure non-erosive conditions and BMP flow capacity. The peak discharge is further needed for the design and sizing of pretreatment cells, level spreaders, by-pass diversion structures, overflow riser structures, grass swales, water quality swale geometry, and manufactured treatment devices (MTDs).

The VDEQ has reviewed several methods for calculating peak discharge. The Modified Curve Number Method is VDEQ's preferred way to calculate the peak discharge for the water quality treatment volume associated with the BMP drainage area. The method is based on the Small Storm Hydrology Method (Pitt 1999) and NRCS Graphical Peak Discharge Method in Technical Release 55 (TR-55; USDA 1986).

The equation used for the Modified Curve Number Method is provided below.

$$qpTv = q_u \times A \times Q_a$$

Equation 11.12 in VDEQ, 2013 (Modified NRCS TR-55 Eq. 4-1)

Where:

$qpTv$ = treatment volume peak discharge (cfs)

q_u = unit peak discharge (cfs/mi²/in)

A = BMP drainage area (mi²)

Q_a = runoff volume (watershed inches = T_{vBMP}/BMP drainage area)

F.4.2 Modified Curve Number Method

Follow the steps below to use the Modified Curve Number Method to compute the peak discharge of the BMP's treatment volume ($qpTv$).

Step 1: Calculate the BMP treatment volume (T_{vBMP}) using the VRRM .

The VRRM spreadsheets for new development and redevelopment are available at <https://www.deq.virginia.gov/water/stormwater/stormwater-construction/guidance-vrrm>. The T_{vBMP} is expressed in the VRRM spreadsheets in cubic feet (ft³). The T_{vBMP} is used to compute the runoff volume (Q_a).

Note: When using a treatment train, the designer should consult the VRRM spreadsheet to determine the total treatment volume from both the immediate contributing drainage area and any additional volume remaining from the upstream BMP.

Step 2: Calculate the modified curve number (CN) for the BMP contributing drainage area.

The CN is needed to compute the initial abstraction (I_a), which is used to determine the unit peak discharge (q_u) (Step 4).

The following equation is derived from the NRCS Curve Number Method, which is described in detail in Chapter 2 (Estimating Runoff) of TR-55 (USDA 1986):

Equation: Derivation of NRCS Curve Number and Runoff Equation

$$CN = \frac{1000}{[10 + 5P + 10Q_a - 10(Q_a^2 + 1.25Q_aP)^{0.5}]}$$

Where:

CN = modified curve number

P = rainfall (inches), equal to 1.0 inch in Virginia

Q_a = runoff volume (watershed inches), equal to T_vBMP ÷ BMP drainage area

Note: When using a hydrologic/hydraulic model for sizing a runoff reduction BMP or calculating q_{pTv} , designers must use this modified curve number for the drainage area to generate runoff equal to the T_vBMP .

Step 3: Compute the time of concentration (T_c) for the site or drainage area.

T_c influences the shape and peak of the runoff hydrograph. Chapter 3 of TR-55 (Time of Concentration and Travel Time; USDA 1986) provides detailed procedures for computing the T_c .

Step 4: Determine the unit peak discharge (q_u).

The unit peak discharge (q_u) is described in Chapter 4 of TR-55 (Graphical Peak Discharge Method; USDA 1986).

Note: The Virginia Stormwater Management Program ([VSMP](#)) regulations require that designers use updated rainfall data based upon the National Oceanic and Atmospheric Administration ([NOAA](#)) Atlas 14 publication for stormwater management computations and modeling.

Note: Exhibit 4-II in TR-55 reports q_u in units of csm/in, which equals cubic feet per second (cfs) per square mile (mi²) of drainage area per inch of runoff (cfs/mi²/in).

Formatted: Superscript

Step 5: Calculate the water quality treatment volume's peak discharge (q_{pTv}).

The q_{pTv} is computed using equation 11.12 in VDEQ's Draft 2013 Virginia Stormwater Management Handbook and is shown in the Introduction section of this document. The equation is a modified version of equation 4-1 in TR-55 (Chapter 4: Graphical Peak Discharge Method; USDA 1986).

F.5 References

- [NOAA](#). 2023. Atlas 14 Point Precipitation Frequency Estimates for Virginia. Available at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=va (accessed June 12, 2018).
- Pitt, R. 1999. "Small Storm Hydrology and Why it is Important for the Design of Stormwater Control Practices." In: Advances in Modeling the Management of Stormwater Impacts, Volume 7. (Edited by W. James). Computational Hydraulics International, Guelph, Ontario and Lewis Publishers/CRC Press.
- United States Department of Agriculture ([USDA](#)). 1986. Urban Hydrology for Small Watersheds: TR-55. 210-VI-TR-55, Second Ed., June 1986. Natural Resources Conservation Service, Conservation Engineering Division.
- VDEQ. 2013. Draft 2013 Virginia Stormwater Management Handbook, Second Ed. Available at <https://www.swbmp.vwrrc.vt.edu/references-tools/> (accessed July 5, 2018).



1 **C-SCM-14 Flocculant Chemical Additives**

2 Final Draft — incorporating Arcadis redlines and TRC Meeting #6 (April 16, 2026) and #7 (May 28, 2026)
3 comments

4 **1.0 Definition**

5 Flocculants are chemical additives used to enhance the coagulation and removal of suspended sediment from
6 construction stormwater runoff. This aggregation process, called flocculation, makes the particles heavy enough
7 to settle out of the water, which reduces turbidity and prevents soil erosion from leaving a disturbed area. Applied
8 to construction stormwater using passive or active delivery systems, they work by neutralizing the electrical
9 charges that keep particles separated and are often used in conjunction with other erosion control measures like
10 sediment basins or wattles.

11 **2.0 Purpose and Applicability of Best Management Practice**

12 Only products listed on the Virginia DEQ Approved Flocculant Product List may be used. (List will be maintained
13 as a live link on the DEQ webpage, like the Manufactured Treatment Device list.)

14 The purpose of flocculants is to complement, not replace, construction BMPs. They are used to maximize
15 sediment removal and water quality but do not provide pollutant load reduction credit for water quality compliance
16 purposes.

17 When flocculants are used, other construction BMPs must be placed downstream of the flocculant application
18 point to capture treated runoff. Direct application to bare or disturbed soil for temporary stabilization or dust
19 control is permitted under this specification.

20 At this time, cationic flocculants are excluded from this specification due to their high toxicity to gilled organisms.

21 **3.0 Planning and Considerations**

22 Use flocculants in combination with other construction BMPs in the Handbook, never as a stand-alone
23 construction BMP for a drainage area.

24 Provide clear, site-specific justification for flocculant use, describing the unique sediment control challenges
25 present and how the use of flocculants in conjunction with other construction BMPs will provide the preferred
26 solution. Also provide a map showing: locations where flocculant will be applied and stored on site, points of
27 discharge, and soil types.

28 Select flocculant products based on site-specific soil conditions and water characteristics. Conduct performance
29 testing (e.g., jar testing) and consult manufacturer recommendations to ensure compatibility and effectiveness.
30 Conduct all construction and installation activities in accordance with the SWPPP and manufacturer's guidelines.

31 A qualified manufacturer representative or stormwater professional shall assist with site-specific soil and water
32 testing and product selection, including flocculant type, dose, and application method, to ensure effective
33 sediment control and regulatory compliance.

34 Prior to flocculant application, confirm compatibility with all applicable Virginia Pollutant Discharge Elimination
35 System (VPDES) and Virginia Water Protection (VWP) permits, and any local regulatory requirements.

36 **4.0 Stormwater Performance Summary**

37 Sediment Removal Efficiency: High

38 Erosion Control Efficiency: Low

39

Commented [KA1]: SWPPPs are not "approved" like plans..

40 The use of flocculants is intended to improve the effectiveness of sediment and erosion control measures at
41 construction sites, particularly in conditions where conventional BMPs may not sufficiently control fine or colloidal
42 sediment (e.g., colloidal clays that can pass through silt fence or remain suspended in sediment basins even
43 when properly designed and installed).

44 **5.0 Design Criteria**

45 Only products listed on the Virginia DEQ Approved Flocculant Product List (live link on DEQ webpage) may be
46 used.

47 Both active (metered dosing) and passive (blocks, logs, soil/matting applications) dosing systems are permitted.

48 Introduce flocculants at points of high turbulence (e.g., basin inlets, slope drains) to ensure thorough mixing and
49 maximize sediment removal. Flocculants may also be applied directly to disturbed soils as part of stabilization,
50 dust control, or treatment train applications.

51 Apply flocculant products according to manufacturer guidance, DEQ-approved limits, and site-specific jar testing
52 results. Adjust dosing as needed based on performance and monitoring outcomes. For Polyacrylamide (PAM),
53 use site-specific jar testing to determine optimal dosage, typically within the range of 1–5 mg/L.

54 Conduct jar testing as the primary method for evaluating flocculant performance and determining appropriate
55 dosing. Repeat jar tests whenever soil conditions or application configurations change. Follow manufacturer
56 guidance and EPA-recommended protocols for performance evaluation.

57 Evaluate treated water for sediment and turbidity using visual indicators such as color and opacity. Consult the
58 manufacturer to adjust application rates, methods, or product selection within manufacturer-recommended and
59 DEQ-approved ranges based on field observations. Document all adjustments and rationale in the project
60 SWPPP for review.

61 Evaluate field turbidity immediately following cessation of a measurable storm event using a clear turbidity tube
62 (minimum 60 cm in length) with a Secchi pattern or similar visual threshold, supplemented with handheld turbidity
63 meters or other approved methods as needed. Record observations in the project SWPPP and use them to guide
64 corrective actions. If water clarity does not meet visual or instrument-based standards, consult the manufacturer
65 and/or local authority to adjust BMPs or flocculant application accordingly, and update the SWPPP to reflect the
66 changes.

67 **Flocculant Use Pathways:**

68 Flocculants may be incorporated into a project in one of two ways:

- 69 1. Specified on Design Plans: Flocculant use is identified during the design phase, included in the Erosion
70 and Sediment Control (ESC) Plan and SWPPP, with product selection, dosing approach, and application
71 locations documented prior to construction.
- 72 2. Field Revision: If turbidity issues are identified after construction begins, flocculant use may be added via
73 a field revision to the ESC Plan or SWPPP. A modification should be made to the approved plans for
74 those disturbances less than 1 acre that do not have an SWPPP in place. All required documentation
75 (site-specific justification, map, product selection, jar test results) must be submitted and approved by the
76 VESMP/VSMP authority prior to use.

77

78 **6.0 Construction Specifications**

79 Install and maintain dosing systems per manufacturer instructions.

Commented [KA2]: Is this the right nomenclature? Maybe "products"? Dosing is used in utilities, don't think it is used in construction.

80 Conduct routine inspection of products and equipment during use and after each measurable storm event; repair
81 or remove malfunctioning equipment immediately.

82 For passive devices, ensure they are securely anchored in the flow path and not buried or bypassed by runoff.
83 Replace or reposition passive flocculant devices that become ineffective due to coating, drying, or displacement.

84 Do not over-apply flocculants; excessive dosages may reduce effectiveness and increase environmental risk.

85 Flocculants, when used as part of a sediment-control treatment train, are to be applied upstream of a final
86 Perimeter Control Measure (PCM) or Sediment Control Measure (SCM). Ensure that stormwater is treated
87 through a PCM or SCM prior to discharge. This approach maximizes sediment removal and prevents untreated
88 releases to the stormwater system.

89 Conduct all construction and installation activities in accordance with the approved SWPPP and manufacturer's
90 guidelines. Perform jar tests, or other approved means, at each site to verify the effectiveness and safety of the
91 selected flocculant under site-specific conditions. Demonstrate sediment removal performance and confirm that
92 no adverse chemical or toxicity impacts occur to receiving waters.

93 Document all jar tests, operational procedures, treatment application rates, and schedules. Make these records
94 available for DEQ review upon request.

95 **7.0 Operations and Maintenance Considerations**

96 Train all appropriate site personnel in flocculant handling, dosing, and spill response.

97 Store flocculant products to prevent contact with stormwater prior to application. Clean up any spills immediately.

98 Inspect application systems and sediment removal BMPs routinely, especially after rainfall events.

99 Conduct visual turbidity evaluations for influent and effluent during chemical treatment, following the
100 manufacturer's recommendations. Visual inspection is for observable field conditions (e.g., turbidity, evidence of
101 fish kills or aquatic stress) and does not require water quality sampling. If visual inspection indicates inadequate
102 sediment control, contact the manufacturer to adjust the application rate, method, or product selection as needed
103 and update the SWPPP to reflect the changes. Maintain a log of daily visual inspections in the SWPPP.

104 Keep detailed records in the project SWPPP of chemical use, equipment maintenance, monitoring results, and
105 any unforeseen incidents.

106 If any fish kills, unexplained aquatic toxicity, or violations of water quality standards are observed, immediately
107 suspend flocculant use and notify DEQ. All chemical treatment must be suspended until corrective actions are
108 reviewed and approved by DEQ.

109 Sediment recovered from flocculant treatment is not classified as hazardous waste solely because of flocculant
110 use. Dewatered sediment may be reused as fill or land-applied, provided it meets applicable federal, state, and
111 local standards for stability and environmental safety.

112

113 **8.0 References**

- 114 ● Applied Polymer Solutions. 2024. Technical Bulletin 2: Anionic Polyacrylamide (PAM) Guidance for
115 Erosion and Sediment Control in Construction Stormwater. APS, Greensboro, NC.
- 116 ● Maryland Department of the Environment. Standards for Use of Chemical Additives for Sediment Control.
- 117 ● North Carolina Department of Environmental Quality. Construction Stormwater Flocculant Guidance.

Commented [KA3]: Not sure we can specify a "daily" inspection more stringent than CGP. Maybe "observe".

- 118
- Minnesota Pollution Control Agency. Polyacrylamide (PAM) for Construction Stormwater.
- 119
- U.S. Environmental Protection Agency. 2019. Use of Treatment Chemicals for Particulate Removal from Construction Stormwater. EPA-832-F-19-001.
- 120
- 121
- Washington Department of Ecology. Stormwater Management Manual for Western Washington, Appendix III-D.
- 122

123

124 **Appendix A: Flocculant Approval Process:**

125 Manufacturers or applicants may propose new products for inclusion on the Approved Flocculant List by
126 submitting required data and an application to DEQ. Information includes but is not limited to:

- 127
- Product chemistry data
- 128
- EPA/DEQ protocol toxicity data
- 129
- Site-specific risk assessment, including consideration of aquatic resources (e.g., known sensitive species, designated use waters) downstream of the proposed application area
- 130
- Proposed monitoring and an adverse-event contingency plan
- 131
- 132



1 **C-SCM-14 Flocculant Chemical Additives**

2 Final Revised Draft — incorporating Arcadis redlines and TRC Meeting #6 (April 16, 2026) and #7 (mMay 28,
3 2026) comments

4 **1.0 Definition**

5 Flocculants are chemical additives used to enhance the coagulation and removal of suspended sediment from
6 construction stormwater runoff. This aggregation process, called flocculation, makes the particles heavy enough
7 to settle out of the water, which reduces turbidity and prevents soil erosion from leaving a disturbed area. Applied
8 to construction stormwater using passive or active delivery systems, they work by neutralizing the electrical
9 charges that keep particles separated and are often used in conjunction with other erosion control measures like
10 sediment basins or wattles.

11 **2.0 Purpose and Applicability of Best Management Practice**

12 Only products listed on the Virginia DEQ Approved Flocculant Product List may be used. (List will be maintained
13 as a live link on the DEQ webpage, like the Manufactured Treatment Device list.)

14 The purpose of flocculants is to complement, not replace, construction BMPs. They are used to maximize
15 sediment removal and water quality but do not provide pollutant load reduction credit for water quality compliance
16 purposes.

17

18 When flocculants are used, other construction BMPs must be placed downstream of the flocculant application
19 point to capture treated runoff. Direct application to bare or disturbed soil for temporary stabilization or dust
20 control is permitted under this specification.

21 Flocculants shall be used as part of a sediment control treatment train with other construction BMPs. Direct
22 application to bare or disturbed soil for temporary stabilization or dust control is also permitted under this
23 specification, provided a downstream perimeter or sediment control measure is in place to capture treated runoff.

24 Only products listed on the Virginia DEQ Approved Flocculant Product List may be used. (List will be maintained
25 as a live link on the DEQ webpage, like the Manufactured Treatment Device list.)

26 The purpose of flocculants is to complement, not replace, construction BMPs. They are used to maximize
27 sediment removal and water quality but do not provide pollutant load reduction credit for water quality compliance
28 purposes.

29 Use of cationic flocculants, water-soluble polymers, or other chemical additives that possess a net positive
30 (cationic) charge is permitted only with prior written DEQ approval. See Section 6.0 for the approval process and
31 required submittals

32 At this time, cationic flocculants are excluded from this specification due to their high toxicity to gilled organisms.

33 τ

34 **3.0 Planning and Considerations**

35 Use flocculants in combination with other construction BMPs in the Handbook, never as a stand-alone
36 construction BMP for a drainage area.

37 Provide clear, site-specific justification for flocculant use, describing the unique sediment control challenges
38 present and how the use of flocculants in conjunction with other construction BMPs will provide the preferred

39 solution. Also provide a map showing: locations where flocculant will be applied and stored on site, points of
40 discharge, and soil types.

41 Select flocculant products based on site-specific soil conditions and water characteristics. Conduct performance
42 testing (e.g., jar testing) and consult manufacturer recommendations to ensure compatibility and effectiveness.

43 Conduct all construction and installation activities in accordance with the approved SWPPP and manufacturer's
44 guidelines.

Commented [KA1]: SWPPPs are not "approved" like plans.,

45 A qualified manufacturer representative or stormwater professional shall assist with site-specific soil and water
46 testing and product selection, including flocculant type, dose, and application method, to ensure effective
47 sediment control and regulatory compliance.

48 Prior to flocculant application, confirm compatibility with all applicable Virginia Pollutant Discharge Elimination
49 System (VPDES) and Virginia Water Protection (VWP) permits, and any local regulatory requirements.

50 **4.0 Stormwater Performance Summary**

51 Sediment Removal Efficiency: High

52 Erosion Control Efficiency: Low

53

54 The use of flocculants is intended to improve the effectiveness of sediment and erosion control measures at
55 construction sites, particularly in conditions where conventional BMPs may not sufficiently control fine or colloidal
56 sediment (e.g., colloidal clays that can pass through silt fence or remain suspended in sediment basins even
57 when properly designed and installed).

58 **5.0 Design Criteria**

59 Only products listed on the Virginia DEQ Approved Flocculant Product List (live link on DEQ webpage) may be
60 used.

61 Both active (metered dosing) and passive (blocks, logs, soil/matting applications) dosing systems are permitted.

62 Introduce flocculants at points of high turbulence (e.g., basin inlets, slope drains) to ensure thorough mixing and
63 maximize sediment removal. Flocculants may also be applied directly to disturbed soils as part of stabilization,
64 dust control, or treatment train applications.

65 Apply flocculant products according to manufacturer guidance, DEQ-approved limits, and site-specific jar testing
66 results. Adjust dosing as needed based on performance and monitoring outcomes. For Polyacrylamide (PAM),
67 use site-specific jar testing to determine optimal dosage, typically within the range of 1–5 mg/L.

68 Conduct jar testing as the primary method for evaluating flocculant performance and determining appropriate
69 dosing. Repeat jar tests whenever soil conditions or application configurations change. Follow manufacturer
70 guidance and EPA-recommended protocols for performance evaluation.

71 Evaluate ~~Monitor~~ treated water for sediment and turbidity using visual indicators such as color and opacity.

72 Consult the manufacturer to a Adjust application rates, methods, or product selection within manufacturer-
73 recommended and DEQ-approved ranges based on field observations. Document all adjustments and rationale in
74 the project SWPPP for review.

75 Evaluate ~~Monitor~~ field turbidity immediately following cessation of a rain event with a depth of greater than 0.1 inch
76 in 24 hours ~~measurable~~ measurable storm event using a clear turbidity tube (minimum 60 cm in length) with a

77 Secchi pattern or similar visual threshold, supplemented with handheld turbidity meters or other approved
78 methods as needed. Record observations in the project SWPPP and use them to guide corrective actions. If

79 water clarity does not meet visual or instrument-based standards, [consult the manufacturer and/or local authority](#)
80 [to adjust BMPs or flocculant application accordingly, and update the SWPPP to reflect the changes.](#)

82 Flocculant Use Pathways:

83 Flocculants may be incorporated into a project in one of two ways:

- 84 1. Specified on Design Plans: Flocculant use is identified during the design phase, included in the Erosion
85 and Sediment Control (ESC) Plan and SWPPP, with product selection, dosing approach, and application
86 locations documented prior to construction.
- 87 4. Field Revision: If turbidity issues are identified after construction begins, flocculant use may be added via
88 a field revision to the ESC Plan or SWPPP. [A modification should be made to the approved plans for](#)
89 [those disturbances less than 1 acre that do not have an approved SWPPP in place.](#) All required
90 documentation (site-specific justification, map, product selection, jar test results) must be submitted and
91 approved by the VESMP/VSMP authority prior to use.

94 6.0 Construction Specifications

95 Install and maintain [dosing](#) systems per manufacturer instructions.

96 [Conduct routine inspection of](#) ~~inspect dosing products and~~ equipment ~~daily during~~ use and after each ~~rain~~
97 ~~measurable~~ [measurable storm](#) event; repair or remove malfunctioning equipment immediately.

98 For passive devices, ensure they are securely anchored in the flow path and not buried or bypassed by runoff.
99 Replace or reposition passive flocculant devices that become ineffective due to coating, drying, or displacement.

100 Do not over-apply flocculants; excessive dosages may reduce effectiveness and increase environmental risk.

101 Flocculants, when used as part of a sediment-control treatment train, are to be applied upstream of a final
102 Perimeter Control Measure (PCM) or Sediment Control Measure (SCM). Ensure that stormwater is treated
103 through a PCM or SCM prior to discharge. ~~Do not discharge flocculant-treated water directly into an MS4.~~ This
104 approach maximizes sediment removal and prevents untreated releases to the stormwater system.

105 Conduct all construction and installation activities in accordance with the approved SWPPP and manufacturer's
106 guidelines. Perform jar tests, or other approved means, at each site to verify the effectiveness and safety of the
107 selected flocculant under site-specific conditions. Demonstrate sediment removal performance and confirm that
108 no adverse chemical or toxicity impacts occur to receiving waters.

109 Document all jar tests, operational procedures, treatment application rates, and schedules. Make these records
110 available for DEQ review upon request.

111 Cationic Flocculant Approval Process:

112 ~~Cationic flocculants may not be used without prior written DEQ approval. To request approval, the permittee shall~~
113 ~~submit the following to DEQ:~~

- 115 ● ~~Product chemistry data~~
- 116 ● ~~EPA/DEQ protocol toxicity data~~

Commented [KA2]: Is this the right nomenclature?
Maybe "products"?

Commented [KA3]: Not sure we can specify a "daily"
inspection more stringent than CGP. Maybe "observe".

117 • ~~Site-specific risk assessment, including consideration of aquatic resources (e.g., known sensitive species,~~
118 ~~designated use waters) downstream of the proposed application area~~

119 • ~~Justification for cationic use over anionic alternatives~~

120 • ~~Proposed monitoring and contingency plan~~

122 ~~DEQ may require additional construction stormwater BMPs, enhanced sediment basins, increased monitoring, or~~
123 ~~other site-specific controls to prevent water quality violations associated with cationic chemical discharge.~~

124 ~~Suspend use immediately and notify DEQ if aquatic toxicity or water quality violations are observed.~~

125 ~~Manufacturers or applicants may propose new products for inclusion on the Approved List by submitting required~~
126 ~~data to DEQ.~~

127 7.0 Operations and Maintenance Considerations

128 Train all appropriate site personnel in flocculant handling, dosing, and spill response.

129 Store flocculant products to prevent contact with stormwater prior to application. Clean up any spills immediately.

130 Inspect application systems and sediment removal BMPs routinely, especially after rainfall events.

131 Conduct visual turbidity evaluations monitoring for influent and effluent during chemical treatment, following the
132 manufacturer's recommendations. Visual inspection is for observable field conditions (e.g., turbidity, evidence of
133 fish kills or aquatic stress) and does not require water quality sampling. If visual inspection indicates inadequate
134 sediment control, contact the manufacturer to adjust the application rate, method, or product selection as needed
135 and update the SWPPP to reflect the changes. Maintain a log of daily visual inspections in the SWPPP.

138 Keep detailed records in the project SWPPP of chemical use, equipment maintenance, monitoring results, and
139 any unforeseen incidents.

140 If any fish kills, unexplained aquatic toxicity, or violations of water quality standards are observed, immediately
141 suspend flocculant use and notify DEQ. All chemical treatment must be suspended until corrective actions are
142 reviewed and approved by DEQ.

143 Sediment recovered from flocculant treatment is not classified as hazardous waste solely because of flocculant
144 use. Dewatered sediment may be reused as fill or land-applied, provided it meets applicable federal, state, and
145 local standards for stability and environmental safety.

147 8.0 References

- 148 • Applied Polymer Solutions. 2024. Technical Bulletin 2: Anionic Polyacrylamide (PAM) Guidance for
149 Erosion and Sediment Control in Construction Stormwater. APS, Greensboro, NC.
- 150 • Maryland Department of the Environment. Standards for Use of Chemical Additives for Sediment Control.
- 151 • North Carolina Department of Environmental Quality. Construction Stormwater Flocculant Guidance.
- 152 • Minnesota Pollution Control Agency. Polyacrylamide (PAM) for Construction Stormwater.

- 153 • U.S. Environmental Protection Agency. 2019. Use of Treatment Chemicals for Particulate Removal from
154 Construction Stormwater. EPA-832-F-19-001.
- 155 • Washington Department of Ecology. Stormwater Management Manual for Western Washington,
156 Appendix III-D.

157

158 **Appendix A: Cationic Flocculant Approval Process:**

159 ~~Cationic flocculants may not be used without prior written DEQ approval. To request approval, the permittee shall~~
160 ~~submit the following to DEQ:~~

161 ~~Manufacturers or applicants may propose new products for inclusion on the Approved Flocculant List by~~
162 ~~submitting required data and an application to DEQ. Information includes but is not limited to:~~

- 163 • ~~Product chemistry data~~
- 164 • ~~EPA/DEQ protocol toxicity data~~
- 165 • ~~Site-specific risk assessment, including consideration of aquatic resources (e.g., known sensitive species,~~
166 ~~designated use waters) downstream of the proposed application area~~
- 167 ~~Justification for cationic use over anionic alternatives~~
- 168 • ~~Proposed monitoring and adverse-event contingency plan~~

169 ~~DEQ may require additional construction stormwater BMPs, enhanced sediment basins, increased monitoring, or~~
170 ~~other site-specific controls to prevent water quality violations associated with cationic chemical discharge.~~
171 ~~Suspend use immediately and notify DEQ if aquatic toxicity or water quality violations are observed.~~

172 ~~Manufacturers or applicants may propose new products for inclusion on the Approved List by submitting required~~
173 ~~data to DEQ.~~

The following documents provided for the TRC's review include the Permanent Linear Utility Access Road specification (item #1 below) and additional materials intended to support the specification:

1. The Permanent Linear Utility Access Road specification with a placeholder for a calculation-based dimension matrix for one of the details
2. C-SCM-14 Plunge Pool Outlet
3. Access Road Plunge Pool Basis of Design
4. The House Bill from 2023 for reference
5. The Section of the VSMH that currently addresses the House Bill for reference. We are taking the information in this section and incorporating into a more detailed specification
6. Sections from other specifications that were used to compile this one for reference. For example, much of the information comes from NRCS and Forestry
7. The VDOT Table for Open-Graded Aggregate we reference in our draft spec

C-SCM-14 Permanent Linear Utility Access Road

1.0 Definition

A Permanent Linear Utility Access Road is the construction of a new permanent access road or the expansion and improvement of an existing impervious road for the operation and maintenance of a linear utility.

2.0 Purpose & Applicability of Best Management Practice

This specification applies to permanent access roads that are being developed to support the operation, construction, and/or maintenance of linear utility projects and support activities specifically associated with the linear utility under construction. This specification applies to development of new access roads on existing pervious surfaces, and the expansion or improvements of existing impervious roads. This specification does not supersede any restrictions or requirements for environmentally sensitive areas, including Resource Protection Areas (RPA).

This Best Management Practice (BMP) is used to:

1. Allow for permanent linear utility access roads that are designed and constructed such that they satisfy the water quantity requirements as outlined in this specification; however, water quality requirements must be addressed independently.- See Section 4.0 for additional information.

3.0 Planning and Considerations

Due to erosion and sedimentation concerns arising from access roads with a surface cover of exposed soil, this specification is written to address access roads constructed with an open graded gravel or stone surface. A properly maintained graveled or stone surface limits the potential for sediment-laden runoff, erosion and impacts to downstream properties.

Inadequately stabilized construction and maintenance of access roads are especially susceptible to erosion. The exposed soil surface is continually disturbed and recompacted with traffic, leaving little opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff along their surfaces. During wet weather, these exposed areas often become muddy and can generate significant quantities of sediment-laden runoff that may pollute downgradient streams or transport it offsite on the wheels of construction vehicles. Aggregate as a surface stabilization measure, when installed in accordance with this specification can promote infiltration and decrease runoff.

During construction and prior to restoration, areas within the limits of disturbance, including access roads, must be designed to meet DEQ requirements for erosion and sediment control established in 9VAC25-875-560. In circumstances where karst features are present, site-specific considerations including but not limited to an engineered design may be required.

To avoid erosion, compaction, and potential runoff issues when siting a permanent utility access road, follow the planning steps recommended below:

1. Recommend coordination with resources agencies (e.g., Virginia Department of Conservation and Recreation, Virginia Department of Wildlife Resources, Virginia Department of Historic Resources) to

Commented [KA1]: This applies to all linear utilities not just electric and note "utility" is not defined in VESMP regs.

Commented [KA1R2]: Closest is Utilities Act: [Utility Facilities Act](#), consider "public"

Commented [KA1R3]: § 56-265.1. Definitions
(b) "Public utility" means any company that owns or operates facilities within the Commonwealth of Virginia for the generation, transmission, or distribution of electric energy for sale, for the production, storage, transmission, or distribution, otherwise than in enclosed portable containers, of natural gas, or, if produced, stored, transmitted, or distributed by a natural gas utility as defined in § 56-265.4.6, supplemental or substitute forms of gas sources as defined in § 56-248.1, or geothermal resources for sale for heat, light or power, or for the furnishing of telephone service, sewerage facilities or water. A "public utility" may own a facility for the storage of electric energy for sale that includes one or more pumped hydroelectricity generation and storage facilities located in the coalfield region of Virginia as described in § 15.2-6002. However, the term "public utility" does not include any of the following: ...

- 37 determine the appropriate areas for access routes, taking into consideration aquatic resources and sensitive
38 areas including karst resources to minimize disruption.
- 39 2. Evaluate information from the Natural Resources Conservation Service (NRCS) Web Soil Survey,
40 U.S. Geological Survey, National Wetlands Inventory, and other available resources to determine the most
41 appropriate areas for access routes avoiding areas of highly erodible soils, karst topography, wet or rocky
42 areas, and areas with seasonally high-water tables to the maximum extent practicable, to avoid challenging
43 construction and maintenance.
- 44 3. Evaluate existing public and private roads, drives, and trails for possible project use (where feasible). If
45 existing roads are to be utilized, consider and evaluate the following:
- 46 a. Existing road infrastructure to confirm it is adequate for potential traffic conditions (turning radius,
47 width, structural stability, grade, etc.).
- 48 b. Existing culverts and ditch lines for function, sizing and stability.
- 49 c. Potential BMPs necessary for project use and compatibility with current private road use.
- 50 d. Existing land cover and potential changes that may occur during project use (short and long-term).
- 51 e. Potential landowner requests for any/all road improvements to remain following project completion.
- 52 4. Evaluate the site topography to locate natural benches and flatter slopes, use these areas for access routes.
53 Avoid long, steep road grades and narrow valleys.
- 54 5. Evaluate upslope watersheds that may contribute stormwater runoff onto the road surface which may warrant
55 design measures to address potential run-on and conveying through drainage.
- 56 6. Evaluate aquatic resources in the area to minimize stream and/or wetland crossings. Where crossings are
57 unavoidable, ensure appropriate permitting and consider the following:
- 58 a. Cross at right angles to minimize the length of the crossing.
- 59 b. Cross where the resource is narrowest and upland areas are most stable.
- 60 c. Minimize the number of crossings to the maximum extent practicable.
- 61 d. Span the resource without disturbing the bank on either side if possible, for example with a bridge.
- 62 e. Leave a buffer zone of undisturbed ground between the road and resource, where the road runs parallel
63 to the resource.
- 64 f. More stringent stream and wetland permit requirements supersede the considerations listed above.
- 65 7. Where possible, use switchbacks to lessen the road grade on steeper sloped areas.
- 66 8. Locate roads on stable geology that includes well-drained soils and rock formations that tend to dip into the
67 slope. Avoid slumps and slide-prone areas characterized by steep slopes, highly weathered bedrock, clay
68 beds, concave slopes, hummocky topography, or rock layers that dip parallel to the slope.
- 69 9. Ridge tops can be good places for roads if proper drainage can be constructed. Be aware that conditions may
70 change when constructing during the dry season. Be prepared to address stormwater concerns seasonally as
71 hidden springs, seeps and streams may be more evident in the winter and spring (See 9VAC25-875-560).
- 72 10. If possible, build roads on the drier south- or west-facing slopes.
- 73 11. Implementation of construction and restoration best management practices and operational controls should
74 be considered to mitigate fugitive dust emissions.
- 75 12. Roads often cross drainage patterns so controlling the flow and direction of runoff across the road is
76 paramount. Adequately sized and stabilized ditches to catch minor hillside runoff should be considered when
77 diffuse flow across roads or broad-based dips are not possible or create erosion or slope stability concerns.

78 The design goal is to maintain the existing hydrologic conditions and patterns to the maximum extent
79 practicable and disperse runoff such that erosion and downstream flooding does not result.

80 4.0 Stormwater Performance Summary

81 **MS-7: Cut and Fill Slopes** – Cut and fill slopes will be designed and constructed in a manner that will minimize
82 erosion. It is important that slopes are properly seeded and mulched to establish permanent vegetation so
83 erosion by concentrated flow does not occur. Roughening the surface and other soil bed preparation actions can
84 help decrease runoff by lowering the velocity of flow and increasing water retention, which leads to better seed
85 germination and root bed health.

86 **MS-19: Adequate Stormwater Conveyance to Adequate Stormwater Outfall** – Permanent access roads
87 designed and constructed in accordance with this specification that dissipate flow without concentrating it are
88 compliant with water quantity requirements; however, water quality requirements must be addressed
89 independently.

90 **9VAC25-875-560**

91 **Erosion Control Efficiency: MODERATE**

92 **Sediment Removal Efficiency: LOW**

93 **Water Quality Compliance:**

94 The Virginia Stormwater Management Program Regulation requires the use of the Virginia Runoff Reduction
95 Method (VRRM), or another equivalent methodology approved by DEQ, for compliance with the water quality
96 criteria, 9VAC25-875-580. The VRRM requires that the post-development landcover conditions of a site be
97 classified as one of four (4) landcover categories (i.e. Impervious, Managed Turf, Mixed/Open, or Forested) for
98 nutrient load reduction requirement calculations. Roads constructed in accordance with this specification shall be
99 counted as impervious for water quality calculation purposes as measures are being implemented to promote
100 infiltration and limit compaction as noted below:

- 101 • Infiltration will be promoted by using clean open-graded angular aggregate as defined in this specification.
- 102 • Compaction will be limited during construction through the use of low impact construction practices (i.e.
103 limited proof rolling, gravel topdressing, use of tracked equipment, etc.) when feasible. This segmentation
104 results in less vehicular traffic on a given access road and spreads the vehicular usage throughout the
105 project.
- 106 • Compaction will be limited post construction due to the infrequent vehicular traffic use. Maintenance and
107 inspection vehicular traffic is typically limited to routine inspections that generally occur twice a month or
108 less, with significantly less heavy equipment use, if at all, post construction.
- 109 • Roads will generally be allowed to naturally re-vegetate over time as they will be subject to standard
110 linear utility maintenance practices including limited bush hogging of less than four (4) times per year.
- 111 • Water quality will be addressed separately in accordance with the VRRM required nutrient reductions.

112 5.0 Design Criteria

113 The permanent linear utility access road design should follow the contour of the natural terrain and limit the
114 channelization of water to the maximum extent possible. Specifications have been provided below to encourage
115 the design in this manner, while providing additional options for site specific conditions as the need arises.
116 Virginia has unique physiography and characteristics change between the Appalachian Plateaus, Ridge and

117 Valley Province, Blue Ridge, Piedmont, and Coastal Plain which affect utility installation practices and design
 118 strategies that should be addressed to ensure compliance with this specification.

119 Table C-SCM-14-1. Design Criteria for Permanent Linear Utility Access Roads

Design Criteria for Permanent Linear Utility Access Roads	
Road Cross-Sections	<p>Five road cross-sections are typically used in road construction: (1) crowned fill; (2) crowned turnpike; (3) outslope; (4) inslope with ditch; and (5) crowned and ditched (Figure C-SCM-14-1).</p> <p>The choice of which cross-section to use depends on the drainage needed, soil stability, slope, and the expected volume of traffic on the road. The cross-sections can be used in combination as the terrain changes or as drainage issues are encountered.</p> <ul style="list-style-type: none"> • Crowned Fill Section: Use on flat ground where water standing on a road surface may be a problem. • Crowned Turnpike Section: Use on low ground roads where fill is not available. • Outslope: Use on moderate slopes for low-volume roads and stable soils. Outsloping can be more dangerous in wet and snowy weather. • Inslope with Ditch Section: Use on steep hills, areas with fine-textured soils, and where drainage is necessary to prevent erosion and ensure slope stability. • Crowned and Ditched Section: Use on high-volume roads on steep side hills.
Road Width	<p>Construct roadbeds to be a maximum of 14 feet wide and a maximum of 24 feet wide and 100 feet long for passing areas every 2000' or more on average as needed.</p>
Alignment (Natural Resources Conservation Service 2021)	<p>Adapt the gradient and horizontal alignment to reflect the intensity of use, the mode of travel, the type of equipment, loading, and the level of development. Frequent grade changes generally cause fewer erosion problems than long, continuous gradients. Design horizontal curves and switchbacks with sufficient radius for trucks and other large vehicles to negotiate easily. A radius of no less than 35 feet for standard vehicles and 50 feet for tractor-trailers is recommended unless site specific conditions demonstrate otherwise.</p> <p>Permanent linear utility access roads should not be constructed within sinkholes (as defined by a closed topographic depression) or over cave entrances.</p>
Road Grade	<p>Road grade is the single most important factor in planning a low-volume road. Where feasible, permanent linear utility access roads are intended to follow the contour of the existing terrain, keeping road grades to a minimum. If possible, do not exceed 10%. Exceeding these grades typically results in the transport of gravel from the roadbed and generally makes for poorly stabilized conditions on steeper road grades. Problematic conditions include ruts forming more easily and higher runoff velocities, which cause gullies and rill erosion along the roadbed and downstream areas. In conditions where gravel transport is possible, broad based dips or other means of collecting and directing surface water away from the roadbed to a stabilized area or flow dissipator (as necessary).</p>
Road Embankment Side Slopes (Pennsylvania Department of	<p>Construct all cuts and fills to be 2H:1V or flatter to the extent possible. Slopes 2H:1V or steeper shall use Soil Stabilization Blankets and Matting (BMP C-SSM-05) to ensure final stabilization, among</p>

Design Criteria for Permanent Linear Utility Access Roads

<p>Environmental Protection [PADEP] 2012)</p>	<p>any other applicable VSMH practices. Minimize cuts and fills where possible. Long and/or high cut/fill slopes are often difficult to stabilize. In soils with low shear strength, these slopes also pose an increased potential for slope failures. Stabilize cut and fill slopes as soon as possible, but no more than seven (7) calendar days, after reaching final grade in accordance with Permanent Seeding (BMP Specification C-SSM-10) and Soil Stabilization Blankets and Matting (BMP C-SSM-05).</p>
<p>Drainage Ditches</p>	<p>Permanent linear utility access road designs promote diffuse flow patterns and limit the channelization of water to the maximum extent practicable by utilizing open graded aggregate as defined in this specification. Where diffuse flow patterns cannot be achieved, drainage ditches may be needed. To minimize drainage areas and flows to each ditch, the maximum allowable depth shall be 1.5 feet. Drainage ditches may discharge through ditch turnouts, disconnects, plunge pools, and other approved energy dissipating devices to diffuse flows and promote infiltration. Drainage ditches that discharge concentrated flow to a channel <u>shall discharge to an adequate and stabilized outfall in accordance 9VAC25-875-600</u> and demonstrate compliance.</p>
<p>Stabilization</p>	<p>Stone: Apply a 6-inch course of clean open-graded angular aggregate, as defined in VDOT Road and Bridge Specifications, Section 203, Table II-3 with no component finer than the No. 16 Sieve or an equivalent mix, immediately after grading. A combination of these different stone classifications found in Table II-3 may be used to withstand loading conditions and prevent footprint migration if specified in the approved plans.</p> <p>A geotextile may be applied to the roadbed surface before coarse aggregate placement. Design specifications for geotextile are provided in Temporary Stone Construction Entrance (BMP-C-SCM-03). In "heavy duty" traffic situations, place stone at an 8- to 10-inch depth to avoid excessive migration or maintenance needs.</p> <p>If a geogrid system is to be used follow manufacturer's material installation specifications and/or the conditions in this specification, whichever is more stringent.</p>
	<p>Permanent Right -of-Way Diversions shall be constructed in accordance with specification C-ECM-07. The minimum height of permanent right-of-way diversions will be reduced to 12-inches from the temporary specification, to better accommodate operations and maintenance vehicle traffic.</p>
<p>Broad Based Dips (BBDs)</p>	<p>Broad based dips (BBDs) collect flowing water from the road surface and direct it across the road to a stable outlet on road grades less than 10%. <u>They are constructed as a gentle roll in the centerline profile of the road that is meant to be permanent as a self-maintaining water diversion structure with mild slopes that can be traversed by vehicles.</u> A BBD can prevent accelerated aggregate loss and sediment generation by stopping drainage from flowing a long distance in wheel tracks or ruts. BBD's are the preferred low impact method for conveying water across utility access roads on gentle grades and dispersing the flow.</p> <p>CONSTRUCTION CONSIDERATIONS</p>

Commented [KA2]: Consultant working on calculation matrix showing non-erosive velocities based on flow with plunge pool configuration. To be provided at meeting or as soon as available.

Commented [MC3]: Figure 3.35.3 specifies 8-10%. Revise either figure or language for consistency

Design Criteria for Permanent Linear Utility Access Roads

SPACING: Multiple BBDs can be used in sequence, to drain a long stretch of road. Suggested spacing is provided in Table C-SCM-14-4. Design spacing for BBDs depends on site-specific conditions including road slope, upslope drainage areas and flows, soil type and downstream conditions.

SIZE & SHAPE: Size determination for BBDs will vary depending on road slopes and anticipated traffic. BBDs on flat roads may be relatively small, with slight elevation changes and short fill transitions. Whereas dips installed on steeper sections of road will need to be larger and will require longer approaches to ease the transition into and out of the structure. Be sure to take anticipated traffic, including the type and amount, into account. A relatively wide channel in the dip bottom is recommended to disperse flows as well as easing vehicle transitions. The upslope end of the dip should be tied into the uphill bank to ensure water does not bypass the structure.

ANGLE: BBDs should be angled across the road at approximately 20-40 degrees and not placed perpendicular to the road like a speed bump. The angle will facilitate the flow of water across the road.

SLOPE: Similar to a cross pipe, the bottom of a BBD should have a continuous elevation drop towards the downstream end for positive drainage. The slope is usually dictated by the grade of the road and the angle of the dip but should be mild in nature to prevent erosive velocities.

DIP REINFORCEMENT: Because a BBD is designed to convey flow on the surface of the road, reinforcement of the BBD bottom is recommended, especially on steeper slopes. Open graded aggregate larger than the road surface can be used to reinforce the bottom of the dip to resist erosion if needed.

DIMENSIONS: See Figure C-SCM-14-X.

OUTLET REINFORCEMENT: BBDs should be constructed to discharge to a permanently stabilized, well-vegetated area. Runoff from the BBD shall not be immediately redirected back onto the road. BBDs and outlets shall be sited so that they do not discharge into sinkholes or other karst features, unless an enhanced engineering design is provided, prepared by a licensed professional with experience working in karst conditions. A minimum of 10' of 18" compost filter sock shall be installed on contour at the downslope end of the BBD with an additional 8' in a J-hook orientation to provide sediment capture until the contributing drainage area is permanently stabilized. Once the contributing drainage area is stabilized in accordance with MS-3, this filter sock shall be removed.

MAINTENANCE: A properly constructed BBD will function with minimal maintenance and shall not require perpetual maintenance agreements but will be inspected in accordance with required permits and for maintenance needs along with the utility line itself.

Commented [MC4]: Figure 3.35.3 specifies [SPACING = 400/% GRADE + 75]. Revise figure for consistency

Commented [MC5]: Revise figure to include 20-40 degree angle placement

Commented [MC6]: Update figure and table IDs upon finalizing

Turnouts and Ditch Disconnects
 Turnouts and ditch disconnects are broad flat swales that drain water away from roads or roadside ditches into well-vegetated areas. Turnouts are typically located along crowned roadways while ditch disconnects are located at the terminus of roadside ditches along in-slope or crowned with ditch roadways to return runoff to diffused flow

Design Criteria for Permanent Linear Utility Access Roads

	<p>where it may collect due to topography. Locate turnouts and ditch disconnects to take advantage of natural drainage courses or buffer areas where possible.</p> <p>Grade the approach to a turnout on a 2% to 3% slope to allow positive drainage. Ensure that the spoil from turnout construction is not allowed to form a dam at the end of the turnout. Do not discharge water from a turnout or ditch disconnect directly into a stream or waterbody.</p> <p>An excavated sump at the end of the feature can effectively pond and settle out sediment before discharging to a well vegetated, stabilized area.</p> <p>Where a suitable vegetative filter strip is not available to remove sediment, install a compost filter sock, rock filter or other sediment removal device found in the current VSMH at the outlet of the turnout. Design discharges from a turnout or ditch disconnect to minimize erosion by minimizing the contributing drainage area, breaking up long and/or steep slopes and minimizing or flattening slopes to reduce velocities.</p> <p>Stabilize outlet as soon as possible after grading in accordance with Permanent Seeding (Specification BMP-C-SSM-10) and Soil Stabilization Blankets and Matting (Specification BMP-C-SSM-05).</p>
Stream or Wetland Crossing	<p>Permanent stream and wetland crossings should be designed on a site-specific basis. Crossings should be designed as close to perpendicular as possible. Observe locality design requirements if more stringent. Ensure all applicable permits are in place prior to installation of stream and wetland crossings.</p>
French Mattress	<p>French mattresses are structures below a road consisting of clean coarse rock wrapped in geotextile fabric, which water can pass through freely. They maintain dispersed flow and allow for free movement of water through a road base. French mattresses may be used in extremely wet areas, such as areas where the road overlays soils with a high water table, to support the roadbed while allowing unrestricted water movement. They may be used to stabilize the road in areas where it could be weakened by water saturation. To avoid water ponding, the outlet should allow for free draining.</p> <p>French mattresses are not pipe replacements and should not be used for concentrated overland flow, such as small streams or channels, or overland stormwater drainage. Sediment load carried by storm flows would eventually clog the mattress.</p> <p>French mattresses should be designed according to Figure C-SCM-14-XX.</p>

Source: Technical Bulletin 2/2019, Broad Base Dips, Penn State Center for Dirt and Gravel Road Studies.

6.0 Construction Specifications

Experience has shown that proper installation is critical to effective operation and to limit the maintenance required of a utility access road.

6.1 Necessary Erosion and Sediment Controls

Commented [KA7]: This section needs work. We need to discuss how specific we want to be and do we want it as a numbered process like others.

- 126
- 127
- 128
- 129
- 130
- Before permanent access road construction, install the appropriate erosion and sediment controls downgradient of the construction activity in accordance with the approved plans. Measures may include Compost Filter Socks (BMP-C-PCM-05), Silt Fence (BMP-C-PCM-04), Temporary Sediment Trap (BMP-C-SCM-11), Temporary Sediment Basin (BMP-C-SCM-12), and other structures. Upland disturbance should only commence after proper installation of perimeter controls.
 - Utility access roads should be protected from sediment intrusion by silt fence or other perimeter control measures, particularly if they are to be constructed prior to upstream stabilization.
 - Permanent utility access roads that are also used for temporary construction access for construction of the utility should be restored prior to permanent conversion, as discussed below.
- 131
- 132
- 133
- 134

135 **6.2 Permanent Linear Utility Access Road Construction Sequence**

136 The following is a typical construction sequence to properly install utility access roads, which may need to
137 be modified depending on site specific conditions.

- 138
- 139
1. Construction of the permanent utility access road shall begin after the contributing drainage area has been stabilized.
 2. As noted above, temporary erosion and sediment controls may be needed during installation to divert stormwater away from the utility access road area until it is completed. Special protection measures such as erosion control fabrics may be needed to protect vulnerable side slopes from erosion during the excavation process. The proposed utility access road area must be kept free from sediment during the entire construction process. Construction materials that are contaminated by sediments must be removed and replaced with clean materials.
 3. Clear the roadbed of all vegetation, roots, and other objectionable material as necessary. The native soils along the bottom of the utility access road should be scarified or tilled, as needed, prior to the placement of the clean washed aggregate.
 4. Spread 6-inch lifts of the appropriate clean, washed stone aggregate and lightly compact it using a vibratory roller in static mode until there is no visible movement of the aggregate. Do not crush the aggregate with the roller. Do not install frozen aggregate materials.
 5. Upon completion of roadway grading, immediately stabilize cut and fill slopes.
- 140
- 141
- 142
- 143
- 144
- 145
- 146
- 147
- 148
- 149
- 150
- 151
- 152

153 **6.4 Construction Inspections**

154 Inspections before and during construction are needed to ensure that utility access roads are built in accordance
155 with these specifications. During routine project inspections, document that the contractor's interpretation of the
156 plan is consistent with the designer's intent and installation at a minimum meets the material, minimum depth, and
157 width requirements as detailed. For projects requiring a Construction General Permit (CGP), this information
158 should be documented in the project SWPPP.

159 The key elements of the utility access road inspections are provided below:

- 160
- 161
- 162
- 163
- 164
- 165
- 166
- 167
1. Before construction, the area upstream of the utility access road should be reviewed for potential sources of sediment and those areas should be stabilized prior to road installation. The utility access road area should be reviewed to ensure the soil upon which the access road will be installed is not compacted and will promote infiltration.
 2. During construction, the utility access road area should be monitored to ensure construction is being performed with materials in accordance with this specification and the approved design plan. The permanent utility access road area should be evaluated for inadvertent compaction caused by construction equipment.

168

169 **6.5 Temporary Construction Road Conversion to Permanent Linear Utility Access Road**

170 Construction methods, equipment selection, and other site-specific conditions may dictate the temporary use of
171 smaller sized aggregates as a surface for utility access roads. On roads constructed using only clean, open
172 graded aggregate, large, multi-axle construction vehicles may lose traction or become stuck. Where site
173 conditions require, a course of smaller aggregates such as VDOT 21A or B. crusher run, or other similar
174 aggregate sizes may be applied as a top lift to bind larger aggregates in the road surface and improve traction
175 and bearing capacity. Small aggregates used in this application shall be deemed temporary and will be removed
176 prior to the completion of construction and termination of permits. When the construction road restoration
177 sequence described below is completed, the remaining access road shall be found compliant with this
178 specification.

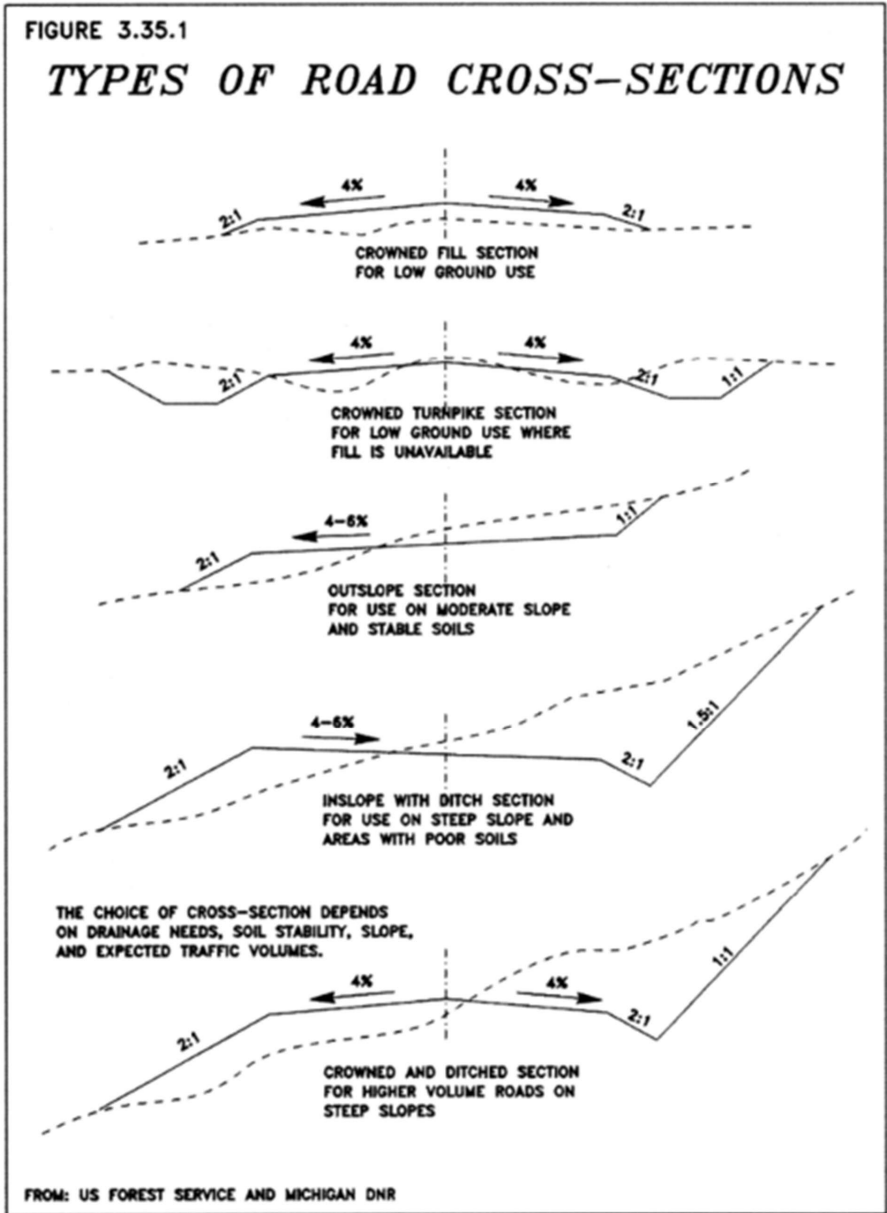
179 The following is a typical construction sequence to properly convert a temporary construction road to a permanent
180 linear utility access road.

- 181 1. All temporary materials including temporary stone aggregate shall be removed in shallow lifts. Upon the
182 removal of each lift, the roadbed should be inspected for the presence of fine aggregates and sediment.
183 Repeat until desired results are achieved.
- 184 2. Areas compacted during construction shall be restored to promote infiltration. This may include practices
185 such as ripping or discing to loosen the roadbed composition.
- 186 3. Once fine aggregates have been removed from the road surface, clean, open graded aggregate may be
187 installed in accordance with this specification and the approved plans to achieve the desired road depth
188 and result.

189

FIGURE 3.35.1

TYPES OF ROAD CROSS-SECTIONS



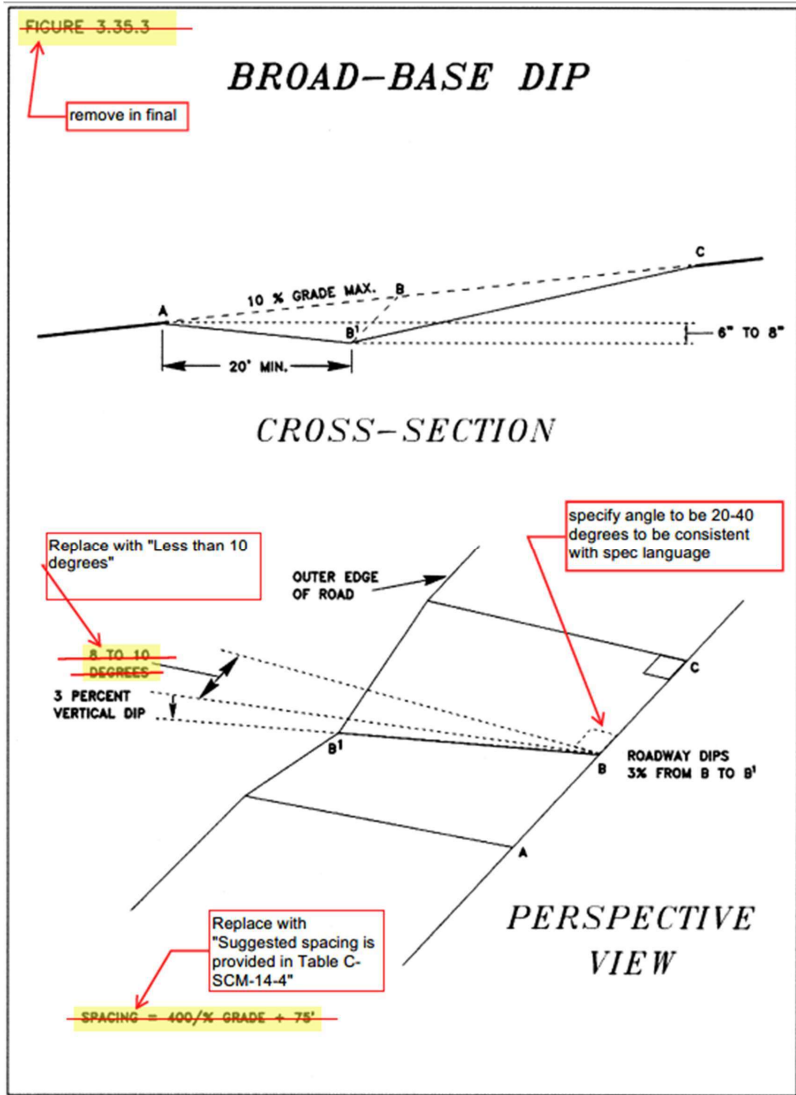
190
191 Figure C-SCM-14-2. Types of Cross Road Sections
192 West Virginia BMP 3.35 – Access Road/Low Volume Road/Driveway, p.3.35-9.

Commented [MC8]: Check numbering

193 INSERT FIGURES FOR BROAD BASED DIPS, USDA AND FOREST SERVICE EXAMPLES BELOW

194

195



196

197 Figure C-SCM-14-X – Broad Based Dip

198

Commented [MC9]: Figure: change name to "Broad Based Dip" to match language

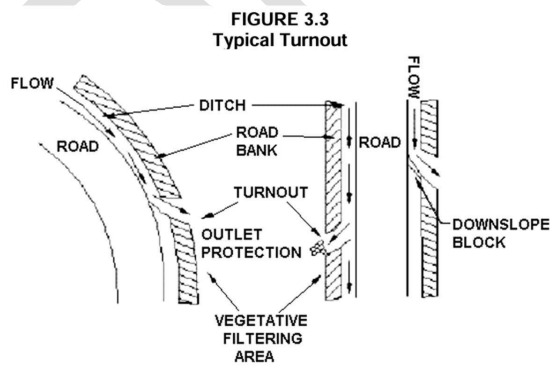
Commented [MC9R2]: REVISE TEXT THROUGHOUT TO REFLECT FIGURE TITLE

Suggested Spacing for Broad-Based Dips	
Road Grade (%)	Distance (ft.)
2	300
3	235
4	200
5	180
6	165
7	155
8	150
9	145
10	140
12	135

200

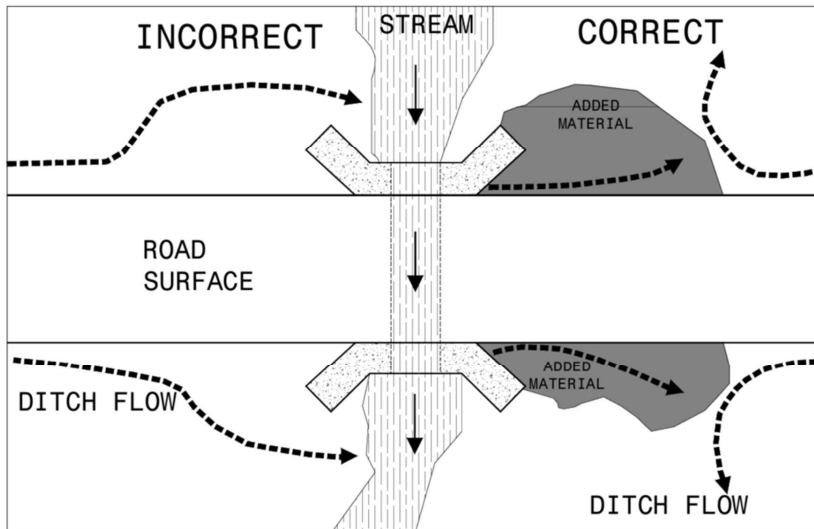
201 Source: Virginia's Forestry Best Management Practices for Water Quality Field Guide October 2019

202 [Figure C-SCM-14-XX](#) Ditch Turnout

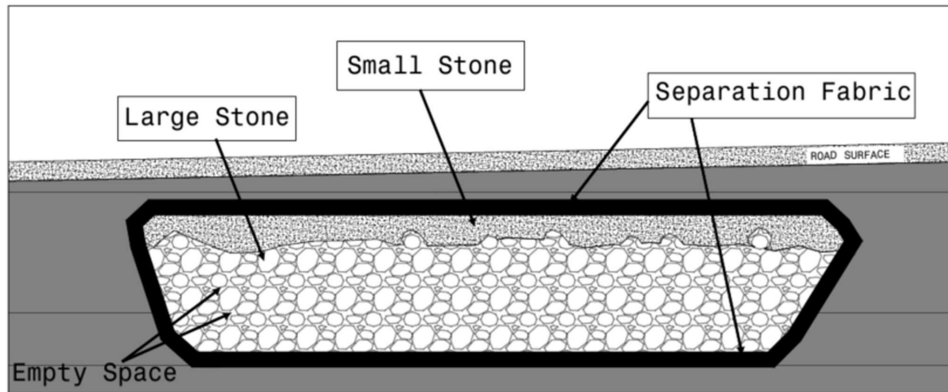


203

Disconnecting Ditches And Streams



* Aerial depiction of road-stream crossing. The left side of the diagram shows the traditional practice of discharging water to the stream. The right side of the diagram shows material added to redirect ditch flow and outlet water away from the stream.



Commented [KA10]: Should we provide more detail on materials? Specify an over lap on separation fabric and class? Class of stone?

213 **7.0 Operations and Maintenance Considerations**

214 At a minimum, inspections should occur in accordance with 9VAC25-880-70 Part II G or at a more stringent
215 frequency established by the authority, whichever is more restrictive.

216 Monitor roadways and cut/fill slopes for gully and rill erosion
217 and sloughing or scour in the ditches. Ensure that the
218 measures have been maintained and are sufficient to capture
219 road surface runoff. If runoff overruns these measures, repair
220 immediately. Inspect culverts, roadside ditches, and outlets
221 and restore flow capacity as needed. If erosion results,
222 additional measures or modifications may be necessary.



Example of Poorly Maintained Vehicular Route Stabilization

223 Ensure that the proper road cross-section is available, and
224 adjacent areas are adequately stabilized to receive runoff.
225 Repair or replace surface materials, including travel treads, as
226 needed in accordance with this specification to maintain runoff
227 characteristics.

228 Monitor roads and drainage structures to ensure that the measures do not become clogged with silt or other
229 debris. Remove accumulated debris as necessary to maintain flow capacity. Stabilize disturbed areas
230 immediately following maintenance activities in accordance with 9VAC-875 and VSMH Specifications.

231 Monitor seeded areas adjacent to the roads to ensure that vegetation is mature and maintained.

232 In certain situations (landowner or land management entity request, etc.), improvements made to pre-existing
233 access roads may be left as the permanent condition by complying with the road criteria in this specification, such
234 that the permanent condition is stable and not eroding. Note conversion from a temporary access road cross-
235 section to the permanent ones defined herein may be necessary.

236 After completion of construction and permanent stabilization of the disturbed area associated with the linear utility
237 access roads, the roads should function with minimal maintenance. During operation, the roads will be inspected
238 periodically along with typical maintenance and inspection of the utility. If a permanent BMP is not required to
239 meet the water quality or quantity standards per the VSMH then a permanent maintenance agreement is not
240 required.

241 **8.0 References**

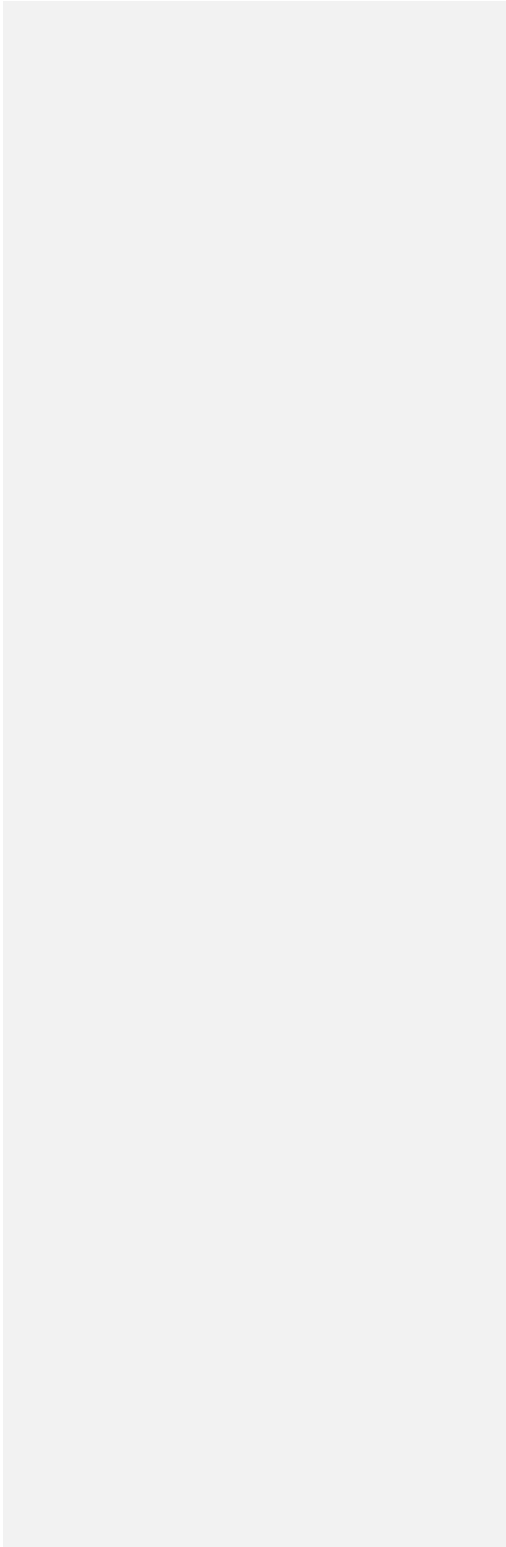
242 Dominion Energy. 2019. Erosion and Sedimentation Control and Stormwater Management Control Standards and
243 Specifications for Dominion Energy Electric Distribution. March. Available online at:
244 [https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/bmp-design-](https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/bmp-design-specifications)
245 [specifications](https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/bmp-design-specifications).

246 Natural Resources Conservation Service. 2020. Conservation Practice Standard: Access Road, Code 560.
247 National Standard 560-CPS-1. United States Department of Agriculture, Natural Resources Conservation
248 Service. September. Available online at: [https://www.nrcs.usda.gov/resources/guides-and-](https://www.nrcs.usda.gov/resources/guides-and-instructions/access-road-ft-560-conservation-practice-standard)
249 [instructions/access-road-ft-560-conservation-practice-standard](https://www.nrcs.usda.gov/resources/guides-and-instructions/access-road-ft-560-conservation-practice-standard).

250 PADEP. 2012. Erosion and Sediment Pollution Control Program Manual. Final. Technical Guidance Number 363-
251 2134-008. March. Available online at:
252 <http://www.depgreenport.state.pa.us/elibrary/GetFolder?FolderID=4680>.

253 Virginia Department of Environmental Quality. 1992. Virginia Erosion and Sediment Control Handbook. Third ed.
254 Available online at: [https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-
256 construction/handbooks](https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-
255 construction/handbooks).
257
256 Wetland Studies and Solutions, Inc. 2020. Erosion and Sediment Control Standards for Wetland and Stream
257 Bank Construction Projects. WSSI #21698.01. Revised September 17. Available online at:
258 [https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/bmp-design-
260 specifications](https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/bmp-design-
259 specifications).
260 Penn State Center for Dirt and Gravel Road Studies. 2019 Technical Bulletin, Broad Base Dips
261
262


DRAFT



Plunge Pool Outlets

Plunge Pool Outlets (PPOs) are one option for dissipating energy and diffusing flows to promote infiltration at the ends of drainage ditches and cross culverts. They include a sump where sediment can settle out and a level earthen lip that can act as a weir to ensure runoff is discharged evenly into the surrounding well stabilized area.

CONSTRUCTION CONSIDERATIONS

 SPACING: Cross culverts and ditch outlets to PPOs should be spaced based on the topography, land cover, and soil types within the contributing drainage area to limit peak flows from the **10-year storm** according to [Tables C-SCM-14-X through Y](#) based on the down-gradient condition (slope, soil type, etc.).

SIZE & SHAPE: PPOs should be sized based on the peak flows from the **10-year storm** according to [Tables C-SCM-14-X through Y](#) and [Figure C-SCM-14-X](#).

ANGLE: PPOs should be angled such that the width of the pool (B) is perpendicular to the direction of the pipe.

SLOPE: The earthen lip of the pool should be located opposite the culvert and must be flat across the entire length and width of the lip to ensure even distribution of flow. The earthen lip should be on contour with the existing grade.

OUTLET STABILIZATION: Place soil stabilization blanket (C-SSM-05, Treatment 1, aka EC-2) at the downgradient end of the plunge pool covering the earthen lip and extending a minimum distance equal to the length of the plunge pool downgradient. The blanket should extend at least 1 foot wider than the width of the plunge pool.

MINIMUM STONE SIZE: The minimum stone size depends on which variant is selected for the depth of the pool. A Type I pool will have a smaller footprint but require larger stones in the lining compared to a Type II pool. A Type II pool is twice as deep as a Type I pool. Use the following equations to determine the average stone size (d₅₀).

- Type I: $d_{50} = (0.0125d^2/T_w) \times (Q/d^{2.5})^{4/3}$
- Type II: $d_{50} = (0.0082d^2/T_w) \times (Q/d^{2.5})^{4/3}$

d₅₀ = the median stone size (feet), refer to Riprap ([C-ECM-13](#))

d = the culvert diameter or span (feet)

T_w = the tailwater depth (feet)

Q = the design flow for the culvert, minimum **10-year storm** (cfs)

MAINTENANCE: A properly constructed PPO will function with minimal maintenance and shall not require perpetual maintenance agreements. It shall be inspected in accordance with required permits and/or for maintenance needs along with the utility line itself. Any accumulated sediment shall be removed from the PPO when the depth (F) has been reduced by 50%.

**Maximum Allowable Discharges to Plunge Pools based on Pipe/Plunge Pool Size
for various Down-Gradient Slopes, Easily Erodeable Soils (K>0.35)**

<i>Permissible Velocity (fps):</i>				5	4	3	3	3	3
Type 1 Plunge Pool Dimensions				Maximum Peak Flows (cfs) for given down-gradient Slopes					
Pipe Dia (in)	Width B (ft)	Length C (ft)	Depth F (ft)	0-5% ①	5-10%	10-20%	20-33% ②	33-50% ②	50-100% ②
12.00	5.00	6.00	0.50	5.17	2.72	0.76	0.52	0.38	0.22
15.00	6.25	7.50	0.63	6.54	3.36	0.95	0.64	0.47	0.28
18.00	7.50	9.00	0.75	7.92	3.99	1.13	0.77	0.57	0.33
21.00	8.75	10.50	0.88	9.29	4.64	1.31	0.90	0.66	0.39
24.00	10.00	12.00	1.00	10.67	5.29	1.51	1.03	0.75	0.45
30.00	12.50	15.00	1.25	13.42	6.58	1.87	1.28	0.94	0.56
36.00	15.00	18.00	1.50	16.17	7.83	2.24	1.53	1.12	0.67
Type 2 Plunge Pool Dimensions				Maximum Peak Flows (cfs) for given down-gradient Slopes					
Pipe Dia (in)	Width B (ft)	Length C (ft)	Depth F (ft)	0-5% ①	5-10%	10-20%	20-33% ②	33-50% ②	50-100% ②
12.00	8.00	9.00	1.00	8.47	4.25	1.21	0.82	0.61	0.36
15.00	10.00	11.25	1.25	10.67	5.29	1.51	1.03	0.75	0.45
18.00	12.00	13.50	1.50	12.87	6.29	1.80	1.23	0.90	0.54
21.00	14.00	15.75	1.75	15.07	7.34	2.11	1.43	1.05	0.62
24.00	16.00	18.00	2.00	17.27	8.34	2.39	1.63	1.20	0.71
30.00	20.00	22.50	2.50	21.68	10.39	2.99	2.05	1.50	0.89
36.00	24.00	27.00	3.00	26.08	12.49	3.58	2.44	1.80	1.07

**Maximum Allowable Discharges to Plunge Pools based on Pipe/Plunge Pool Size
for various Down-Gradient Slopes, Erosion Resistant Soils (K<0.35)**

<i>Permissible Velocity (fps):</i>				7	6	5	5	5	5
Type 1 Plunge Pool Dimensions				Maximum Peak Flows (cfs) for given down-gradient Slopes					
Pipe Dia (in)	Width B (ft)	Length C (ft)	Depth F (ft)	0-5% ①	5-10%	10-20%	20-33% ②	33-50% ②	50-100% ②
12.00	5.00	6.00	0.50	5.17	7.31	2.79	1.87	1.37	0.81
15.00	6.25	7.50	0.63	6.54	9.25	3.46	2.33	1.71	1.01
18.00	7.50	9.00	0.75	7.92	11.19	4.13	2.78	2.05	1.21
21.00	8.75	10.50	0.88	9.29	13.11	4.78	3.24	2.38	1.41
24.00	10.00	12.00	1.00	10.67	14.86	5.45	3.69	2.72	1.61
30.00	12.50	15.00	1.25	13.42	18.40	6.80	4.60	3.39	2.00
36.00	15.00	18.00	1.50	16.17	21.93	8.13	5.52	4.06	2.40

Type 2 Plunge Pool Dimensions				Maximum Peak Flows (cfs) for given down-gradient Slopes					
Pipe Dia (in)	Width B (ft)	Length C (ft)	Depth F (ft)	0-5% ①	5-10%	10-20%	20-33% ②	33-50% ②	50-100% ②
12.00	8.00	9.00	1.00	8.47	11.97	4.38	2.96	2.18	1.29
15.00	10.00	11.25	1.25	10.67	14.86	5.45	3.69	2.72	1.61
18.00	12.00	13.50	1.50	12.87	17.69	6.52	4.42	3.25	1.93
21.00	14.00	15.75	1.75	15.07	20.55	7.58	5.15	3.79	2.24
24.00	16.00	18.00	2.00	17.27	23.37	8.67	5.88	4.33	2.56
30.00	20.00	22.50	2.50	21.68	28.97	10.78	7.32	5.41	3.20
36.00	24.00	27.00	3.00	26.08	34.66	12.92	8.80	6.49	3.85

Table Notes:

- ① Down-gradient flow depths capped at 0.25 ft (3") even though velocity is non-erosive
- ② Down-gradient flow depths < 0.1' if computed as channel flow, but velocities low (<1.5 cfs) if computed as sheetflow

General Notes:

- A) Type 1 Plunge Pools utilize larger stone and require less depth, decreasing the total pool footprint compared to Type 2 Pools, but also have lesser maximum peak flows than Type 2 Plunge Pools for the same diameter pipe
- B) Permissible Velocity Calculations assume the plunge pools discharge to well-vegetated areas such as grass pastures

Roughness Coefficient (Manning's n)

Channel Flow: 0.03 Floodplains; Pasture, no brush; Short grass (2.a.1.). Normal value
Source: VDOT Drainage Manual, App. 7D-1 (From VSMH section 5.3.2.3 Channel Protection Req.)
***For steep slopes (≥33%), depths <0.1 ft, therefore checked Manning's n for sheetflow too.*

Sheetflow calc shows 0.1 ft depth reached before velocity reached, therefore used channel flow max Q

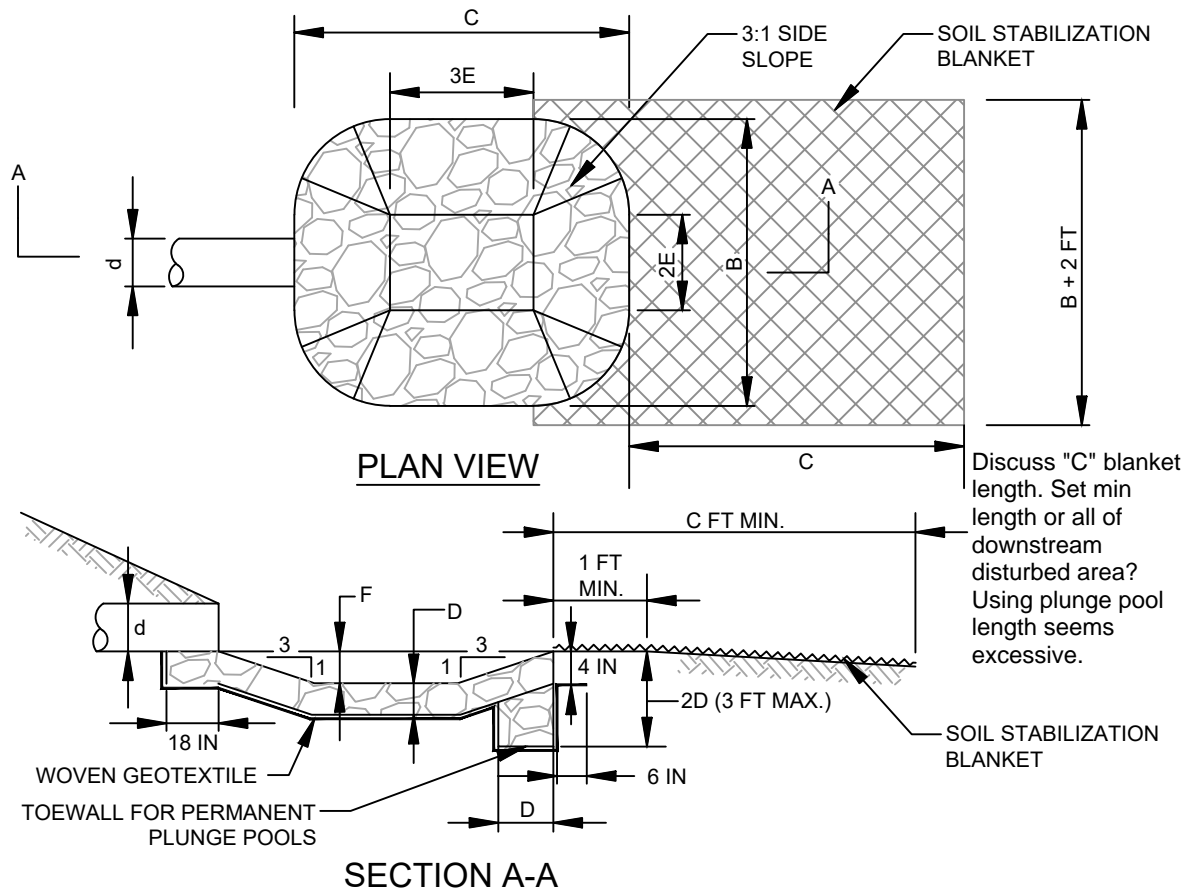
Sheet Flow: 0.24 Dense Grasses

Source: VSMH Table A-1 (NRCS National Engineering Handbook, Table 15-1)

Permissible Velocity:

See Rows 4 & 16 Erosion-Resistant Soils, Tall Fescue or Kentucky bluegrass

Source: VSMH Table A5



CONSTRUCTION SPECIFICATIONS

1. USE SPECIFIED CLASS OF RIPRAP.
2. USE WOVEN GEOTEXTILE AS SPECIFIED IN C-ECM-13, AND PROTECT FROM PUNCHING, CUTTING, OR TEARING. REPAIR ANY DAMAGE OTHER THAN AN OCCASIONAL SMALL HOLE BY PLACING ANOTHER PIECE OF GEOTEXTILE OVER THE DAMAGED PART OR BY COMPLETELY REPLACING THE GEOTEXTILE. PROVIDE A MINIMUM OF ONE FOOT OVERLAP FOR ALL REPAIRS AND FOR JOINING TWO PIECES OF GEOTEXTILE.
3. PREPARE THE SUBGRADE FOR THE PLUNGE POOL TO THE REQUIRED LINES AND GRADES. COMPACT ANY FILL REQUIRED IN THE SUBGRADE TO A DENSITY OF APPROXIMATELY THAT OF THE SURROUNDING UNDISTURBED MATERIAL.
4. EMBED THE GEOTEXTILE A MINIMUM OF 4 INCHES BELOW GRADE AND EXTEND THE GEOTEXTILE A MINIMUM OF 6 INCHES BEYOND THE EDGE OF THE SCOUR HOLE.
5. STONE FOR THE PLUNGE POOL MAY BE PLACED BY EQUIPMENT. CONSTRUCT TO THE FULL COURSE THICKNESS IN ONE OPERATION AND IN SUCH A MANNER AS TO AVOID DISPLACEMENT OF UNDERLYING MATERIALS. DELIVER AND PLACE THE STONE FOR THE PLUNGE POOL IN A MANNER THAT WILL ENSURE THAT IT IS REASONABLY HOMOGENEOUS WITH THE SMALLER STONES AND SPALLS FILLING THE VOIDS BETWEEN THE LARGER STONES. PLACE STONE FOR THE PLUNGE POOL IN A MANNER TO PREVENT DAMAGE TO THE GEOTEXTILE. HAND PLACE TO THE EXTENT NECESSARY.
6. AT THE PLUNGE POOL OUTLET, PLACE THE STONE SO THAT IT MEETS THE LEVEL EARTHEN LIP. EXTEND EARTHEN LIP A MINIMUM OF 1' AND GRADE A GENTLE SLOPE (3:1 MAX.) BACK TO EXISTING GRADE. PLACE SOIL STABILIZATION BLANKET DOWNGRADIENT OF OUTLET COVERING THE EARTHEN LIP AND EXTENDING DOWNSLOPE A MINIMUM DISTANCE EQUAL TO THE LENGTH, C, OF THE PLUNGE POOL OUTLET.
7. MAINTAIN LINE, GRADE, AND CROSS SECTION. KEEP OUTLET FREE OF EROSION. REMOVE ACCUMULATED SEDIMENT AND DEBRIS. AFTER HIGH FLOWS INSPECT FOR SCOUR AND DISLODGED RIPRAP. MAKE NECESSARY REPAIRS IMMEDIATELY.

Utility Access Road Plunge Pool Outlet Basis of Design

In mountainous terrain, it is often necessary to construct roadside ditches for safety and slope stability. Rather than conveying the runoff in the ditch all the way to the low point of the road, the cross-culverts discharge the runoff at regular intervals to maintain the pre-development drainage and flow patterns. In addition to mimicking these pre-development characteristics, the cross-culverts also reduce flow volumes, velocities, and depth in the roadside ditches. In this regard, they act in a similar manner to waterbars and slope interrupters on a utility right-of-way.

The Utility Access Road Plunge Pool Outlet is based on the plunge pool design from the outlet protection specification (C-ECM-15). It is intended to disperse flows from a cross-culvert across the width of the pool and discharge the runoff in a uniform manner at a non-erodible velocity. The practice is intended to be installed where a permanent level spreader is not practicable.

To ensure that the discharge from these plunge pools is non-erosive, the flows were modeled as a channel with vertical sidewalls and a bottom width that corresponds to the width of the plunge pool for various slope ranges to determine a maximum permissible discharge that remains non-erosive. The results of this modelling effort can be seen in the tables on the following pages for both erosion resistant (ER) and easily erodible (EE) soils. The tables show the pipe diameter and associated plunge pool characteristics on the left side of the chart (based on the previously approved outlet protection plunge pool) and the associated maximum peak flow from the pipe for a given slope range on the right. The calculations assume that the flows will be discharged to a well-vegetated (grass) area and flow in a uniform manner the width of the plunge pool. Although computed velocities are still non-erosive for flatter slopes at depths greater than 0.25' (3"), flows were constrained to this depth when computing maximum discharges. Also, flows were calculated as channel flow rather than sheet flow for all cases even though flow depths on steeper slopes are less than 0.1 feet of depth since the velocity is still non-erosive with the lower roughness coefficient of channel flow conditions.

**Maximum Allowable Discharges to Plunge Pools based on Pipe/Plunge Pool Size
for various Down-Gradient Slopes, Easily Eroible Soils (K>0.35)**

<i>Permissible Velocity (fps):</i>				5	4	3	3	3	3
Type 1 Plunge Pool Dimensions				Maximum Peak Flows (cfs) for given down-gradient Slopes					
Pipe Dia (in)	Width B (ft)	Length C (ft)	Depth F (ft)	0-5% ①	5-10%	10-20%	20-33% ②	33-50% ②	50-100% ②
12.00	5.00	6.00	0.50	5.17	2.72	0.76	0.52	0.38	0.22
15.00	6.25	7.50	0.63	6.54	3.36	0.95	0.64	0.47	0.28
18.00	7.50	9.00	0.75	7.92	3.99	1.13	0.77	0.57	0.33
21.00	8.75	10.50	0.88	9.29	4.64	1.31	0.90	0.66	0.39
24.00	10.00	12.00	1.00	10.67	5.29	1.51	1.03	0.75	0.45
30.00	12.50	15.00	1.25	13.42	6.58	1.87	1.28	0.94	0.56
36.00	15.00	18.00	1.50	16.17	7.83	2.24	1.53	1.12	0.67

<i>Permissible Velocity (fps):</i>				5	4	3	3	3	3
Type 2 Plunge Pool Dimensions				Maximum Peak Flows (cfs) for given down-gradient Slopes					
Pipe Dia (in)	Width B (ft)	Length C (ft)	Depth F (ft)	0-5% ①	5-10%	10-20%	20-33% ②	33-50% ②	50-100% ②
12.00	8.00	9.00	1.00	8.47	4.25	1.21	0.82	0.61	0.36
15.00	10.00	11.25	1.25	10.67	5.29	1.51	1.03	0.75	0.45
18.00	12.00	13.50	1.50	12.87	6.29	1.80	1.23	0.90	0.54
21.00	14.00	15.75	1.75	15.07	7.34	2.11	1.43	1.05	0.62
24.00	16.00	18.00	2.00	17.27	8.34	2.39	1.63	1.20	0.71
30.00	20.00	22.50	2.50	21.68	10.39	2.99	2.05	1.50	0.89
36.00	24.00	27.00	3.00	26.08	12.49	3.58	2.44	1.80	1.07

Table Notes:

- ① Down-gradient flow depths capped at 0.25 ft (3") even though velocity is non-erosive
- ② Down-gradient flow depths < 0.1' if computed as channel flow, but velocities low (<1.5 cfs) if computed as sheetflow

General Notes:

- A) Type 1 Plunge Pools utilize larger stone and require less depth, decreasing the total pool footprint compared to Type 2 Pools, but also have lesser maximum peak flows than Type 2 Plunge Pools for the same diameter pipe
- B) Permissible Velocity Calculations assume the plunge pools discharge to well-vegetated areas such as grass pastures

Roughness Coefficient (Manning's n)

Channel Flow: 0.03 Floodplains; Pasture, no brush; Short grass (2.a.1.). Normal value

Source: VDOT Drainage Manual, App. 7D-1 (From VSMH section 5.3.2.3 Channel Protection Req.)

***For steep slopes (≥ 33%), depths <0.1 ft, therefore checked Manning's n for sheetflow too.*

Sheetflow calc shows 0.1 ft depth reached before velocity reached, therefore used channel flow max Q

Sheet Flow: 0.24 Dense Grasses

Source: VSMH Table A-1 (NRCS National Engineering Handbook, Table 15-1)

Permissible Velocity:

See Rows 4 & 16 Easily Erodible Soils, Tall Fescue or Kentucky bluegrass

Source: VSMH Table A5

Kinematic (Channel) Calculations for Easily Erodeable (EE) Soils

$$V = 1.49/n * R^{(2/3)} * S^{(1/2)}$$

$$Q = 1.49/n * A * R^{(2/3)} * S^{(1/2)}$$

$$P = w + 2d \quad R = A / P$$

Blue Header (A:D): Input Data				Gray Header (E:I): Calculated Values					Permissible Velocities	
Width, w (ft)	Slope, S (ft/ft)	Roughness Coeff., n	Depth, d (ft)	Area, A (sf)	Wetted Perimeter, P (ft)	Hyd. Radius, R (ft)	Q (cfs)	V (fps)	Vmax (fps, Erosion Resistant)	Vmax (fps, Easily Erodeable)
5.00	5%	0.03	0.25	1.25	5.50	0.23	5.17	4.14	7	5
5.00	10%	0.03	0.14	0.68	5.27	0.13	2.72	4.00	6	4
5.00	20%	0.03	0.05	0.25	5.10	0.05	0.76	3.00	5	3
5.00	33%	0.03	0.03	0.17	5.07	0.03	0.52	3.00	5	3
5.00	50%	0.03	0.03	0.13	5.05	0.03	0.38	3.00	5	3
5.00	100%	0.03	0.01	0.07	5.03	0.01	0.22	3.00	5	3
6.25	5%	0.03	0.25	1.56	6.75	0.23	6.54	4.19	7	5
6.25	10%	0.03	0.13	0.84	6.52	0.13	3.36	4.00	6	4
6.25	20%	0.03	0.05	0.31	6.35	0.05	0.94	3.00	5	3
6.25	33%	0.03	0.03	0.21	6.32	0.03	0.64	3.00	5	3
6.25	50%	0.03	0.03	0.16	6.30	0.02	0.47	3.00	5	3
6.25	100%	0.03	0.01	0.09	6.28	0.01	0.28	3.00	5	3
7.50	5%	0.03	0.25	1.88	8.00	0.23	7.92	4.22	7	5
7.50	10%	0.03	0.13	1.00	7.77	0.13	3.99	4.00	6	4
7.50	20%	0.03	0.05	0.38	7.60	0.05	1.13	3.00	5	3
7.50	33%	0.03	0.03	0.26	7.57	0.03	0.77	3.00	5	3
7.50	50%	0.03	0.03	0.19	7.55	0.02	0.57	3.00	5	3
7.50	100%	0.03	0.01	0.11	7.53	0.01	0.34	3.00	5	3
8.75	5%	0.03	0.25	2.19	9.25	0.24	9.29	4.25	7	5
8.75	10%	0.03	0.13	1.16	9.01	0.13	4.63	4.00	6	4
8.75	20%	0.03	0.05	0.44	8.85	0.05	1.32	3.00	5	3
8.75	33%	0.03	0.03	0.30	8.82	0.03	0.89	3.00	5	3
8.75	50%	0.03	0.03	0.22	8.80	0.02	0.66	3.00	5	3
8.75	100%	0.03	0.01	0.13	8.78	0.01	0.39	3.00	5	3
10.00	5%	0.03	0.25	2.50	10.50	0.24	10.67	4.27	7	5
10.00	10%	0.03	0.13	1.32	10.26	0.13	5.28	4.00	6	4
10.00	20%	0.03	0.05	0.50	10.10	0.05	1.51	3.00	5	3
10.00	33%	0.03	0.03	0.34	10.07	0.03	1.02	3.00	5	3
10.00	50%	0.03	0.03	0.25	10.05	0.02	0.75	3.00	5	3
10.00	100%	0.03	0.01	0.15	10.03	0.01	0.44	3.00	5	3
12.50	5%	0.03	0.25	3.13	13.00	0.24	13.42	4.29	7	5
12.50	10%	0.03	0.13	1.64	12.76	0.13	6.55	4.00	6	4
12.50	20%	0.03	0.05	0.62	12.60	0.05	1.87	3.00	5	3
12.50	33%	0.03	0.03	0.43	12.57	0.03	1.28	3.00	5	3
12.50	50%	0.03	0.03	0.31	12.55	0.02	0.94	3.00	5	3
12.50	100%	0.03	0.01	0.19	12.53	0.01	0.56	3.00	5	3
15.00	5%	0.03	0.25	3.75	15.50	0.24	16.17	4.31	7	5
15.00	10%	0.03	0.13	1.96	15.26	0.13	7.83	4.00	6	4
15.00	20%	0.03	0.05	0.75	15.10	0.05	2.24	3.00	5	3
15.00	33%	0.03	0.03	0.51	15.07	0.03	1.53	3.00	5	3
15.00	50%	0.03	0.02	0.37	15.05	0.02	1.12	3.00	5	3
15.00	100%	0.03	0.01	0.22	15.03	0.01	0.67	3.00	5	3

Kinematic (Channel) Calculations for Easily Erodeable (EE) Soils

$$V = 1.49/n * R^{(2/3)} * S^{(1/2)}$$

$$Q = 1.49/n * A * R^{(2/3)} * S^{(1/2)}$$

$$P = w + 2d \quad R = A / P$$

Blue Header (A:D): Input Data				Gray Header (E:I): Calculated Values					Permissible Velocities	
Width, w (ft)	Slope, S (ft/ft)	Roughness Coeff., n	Depth, d (ft)	Area, A (sf)	Wetted Perimeter, P (ft)	Hyd. Radius, R (ft)	Q (cfs)	V (fps)	Vmax (fps, Erosion Resistant)	Vmax (fps, Easily Erodeable)
8.00	5%	0.03	0.25	2.00	8.50	0.24	8.47	4.23	7	5
8.00	10%	0.03	0.13	1.06	8.27	0.13	4.25	4.00	6	4
8.00	20%	0.03	0.05	0.40	8.10	0.05	1.21	3.00	5	3
8.00	33%	0.03	0.03	0.27	8.07	0.03	0.82	3.00	5	3
8.00	50%	0.03	0.03	0.20	8.05	0.02	0.60	3.00	5	3
8.00	100%	0.03	0.01	0.12	8.03	0.01	0.36	3.00	5	3
10.00	5%	0.03	0.25	2.50	10.50	0.24	10.67	4.27	7	5
10.00	10%	0.03	0.13	1.32	10.26	0.13	5.28	4.00	6	4
10.00	20%	0.03	0.05	0.50	10.10	0.05	1.51	3.00	5	3
10.00	33%	0.03	0.03	0.34	10.07	0.03	1.02	3.00	5	3
10.00	50%	0.03	0.03	0.25	10.05	0.02	0.75	3.00	5	3
10.00	100%	0.03	0.01	0.15	10.03	0.01	0.44	3.00	5	3
12.00	5%	0.03	0.25	3.00	12.50	0.24	12.87	4.29	7	5
12.00	10%	0.03	0.13	1.58	12.26	0.13	6.32	4.00	6	4
12.00	20%	0.03	0.05	0.60	12.10	0.05	1.80	3.00	5	3
12.00	33%	0.03	0.03	0.41	12.07	0.03	1.22	3.00	5	3
12.00	50%	0.03	0.03	0.30	12.05	0.02	0.90	3.00	5	3
12.00	100%	0.03	0.01	0.18	12.03	0.01	0.54	3.00	5	3
14.00	5%	0.03	0.25	3.50	14.50	0.24	15.07	4.31	7	5
14.00	10%	0.03	0.13	1.83	14.26	0.13	7.33	4.00	6	4
14.00	20%	0.03	0.05	0.70	14.10	0.05	2.09	3.00	5	3
14.00	33%	0.03	0.03	0.48	14.07	0.03	1.43	3.00	5	3
14.00	50%	0.03	0.03	0.35	14.05	0.02	1.05	3.00	5	3
14.00	100%	0.03	0.01	0.21	14.03	0.01	0.63	3.00	5	3
16.00	5%	0.03	0.25	4.00	16.50	0.24	17.27	4.32	7	5
16.00	10%	0.03	0.13	2.09	16.26	0.13	8.38	4.00	6	4
16.00	20%	0.03	0.05	0.80	16.10	0.05	2.41	3.00	5	3
16.00	33%	0.03	0.03	0.54	16.07	0.03	1.63	3.00	5	3
16.00	50%	0.03	0.03	0.40	16.05	0.02	1.20	3.00	5	3
16.00	100%	0.03	0.01	0.24	16.03	0.01	0.72	3.00	5	3
20.00	5%	0.03	0.25	5.00	20.50	0.24	21.68	4.34	7	5
20.00	10%	0.03	0.13	2.60	20.26	0.13	10.41	4.00	6	4
20.00	20%	0.03	0.05	1.00	20.10	0.05	2.98	3.00	5	3
20.00	33%	0.03	0.03	0.68	20.07	0.03	2.03	3.00	5	3
20.00	50%	0.03	0.03	0.50	20.05	0.03	1.51	3.00	5	3
20.00	100%	0.03	0.01	0.30	20.03	0.01	0.89	3.00	5	3
24.00	5%	0.03	0.25	6.00	24.50	0.24	26.08	4.35	7	5
24.00	10%	0.03	0.13	3.12	24.26	0.13	12.48	4.00	6	4
24.00	20%	0.03	0.05	1.19	24.10	0.05	3.58	3.00	5	3
24.00	33%	0.03	0.03	0.81	24.07	0.03	2.44	3.00	5	3
24.00	50%	0.03	0.03	0.60	24.05	0.02	1.80	3.00	5	3
24.00	100%	0.03	0.01	0.36	24.03	0.01	1.07	3.00	5	3

**Maximum Allowable Discharges to Plunge Pools based on Pipe/Plunge Pool Size
for various Down-Gradient Slopes, Erosion Resistant Soils (K<0.35)**

<i>Permissible Velocity (fps):</i>				7	6	5	5	5	5
Type 1 Plunge Pool Dimensions				Maximum Peak Flows (cfs) for given down-gradient Slopes					
Pipe Dia (in)	Width B (ft)	Length C (ft)	Depth F (ft)	0-5% ①	5-10%	10-20%	20-33% ②	33-50% ②	50-100% ②
12.00	5.00	6.00	0.50	5.17	7.31	2.79	1.87	1.37	0.81
15.00	6.25	7.50	0.63	6.54	9.25	3.46	2.33	1.71	1.01
18.00	7.50	9.00	0.75	7.92	11.19	4.13	2.78	2.05	1.21
21.00	8.75	10.50	0.88	9.29	13.11	4.78	3.24	2.38	1.41
24.00	10.00	12.00	1.00	10.67	14.86	5.45	3.69	2.72	1.61
30.00	12.50	15.00	1.25	13.42	18.40	6.80	4.60	3.39	2.00
36.00	15.00	18.00	1.50	16.17	21.93	8.13	5.52	4.06	2.40

<i>Permissible Velocity (fps):</i>				7	6	5	5	5	5
Type 2 Plunge Pool Dimensions				Maximum Peak Flows (cfs) for given down-gradient Slopes					
Pipe Dia (in)	Width B (ft)	Length C (ft)	Depth F (ft)	0-5% ①	5-10%	10-20%	20-33% ②	33-50% ②	50-100% ②
12.00	8.00	9.00	1.00	8.47	11.97	4.38	2.96	2.18	1.29
15.00	10.00	11.25	1.25	10.67	14.86	5.45	3.69	2.72	1.61
18.00	12.00	13.50	1.50	12.87	17.69	6.52	4.42	3.25	1.93
21.00	14.00	15.75	1.75	15.07	20.55	7.58	5.15	3.79	2.24
24.00	16.00	18.00	2.00	17.27	23.37	8.67	5.88	4.33	2.56
30.00	20.00	22.50	2.50	21.68	28.97	10.78	7.32	5.41	3.20
36.00	24.00	27.00	3.00	26.08	34.66	12.92	8.80	6.49	3.85

Table Notes:

- ① Down-gradient flow depths capped at 0.25 ft (3") even though velocity is non-erosive
- ② Down-gradient flow depths < 0.1' if computed as channel flow, but velocities low (<1.5 cfs) if computed as sheetflow

General Notes:

- A) Type 1 Plunge Pools utilize larger stone and require less depth, decreasing the total pool footprint compared to Type 2 Pools, but also have lesser maximum peak flows than Type 2 Plunge Pools for the same diameter pipe
- B) Permissible Velocity Calculations assume the plunge pools discharge to well-vegetated areas such as grass pastures

Roughness Coefficient (Manning's n)

Channel Flow: 0.03 Floodplains; Pasture, no brush; Short grass (2.a.1.). Normal value

Source: VDOT Drainage Manual, App. 7D-1 (From VSMH section 5.3.2.3 Channel Protection Req.)

***For steep slopes (≥ 33%), depths <0.1 ft, therefore checked Manning's n for sheetflow too.*

Sheetflow calc shows 0.1 ft depth reached before velocity reached, therefore used channel flow max Q

Sheet Flow: 0.24 Dense Grasses

Source: VSMH Table A-1 (NRCS National Engineering Handbook, Table 15-1)

Permissible Velocity:

See Rows 4 & 16 Erosion-Resistant Soils, Tall Fescue or Kentucky bluegrass

Source: VSMH Table A5

Kinematic (Channel) Calculations for Erosion Resistant (ER) Soils

$$V = 1.49/n * R^{(2/3)} * S^{(1/2)}$$

$$Q = 1.49/n * A * R^{(2/3)} * S^{(1/2)}$$

$$P = w + 2d \quad R = A / P$$

Blue Header (A:D): Input Data				Gray Header (E:I): Calculated Values					Permissible Velocities	
Width, w (ft)	Slope, S (ft/ft)	Roughness Coeff., n	Depth, d (ft)	Area, A (sf)	Wetted Perimeter, P (ft)	Hyd. Radius, R (ft)	Q (cfs)	V (fps)	Vmax (fps, Erosion Resistant)	Vmax (fps, Easily Erodible)
5.00	5%	0.03	0.25	1.25	5.50	0.23	5.17	4.14	7	5
5.00	10%	0.03	0.25	1.25	5.50	0.23	7.31	5.85	6	4
5.00	20%	0.03	0.11	0.56	5.22	0.11	2.78	5.00	5	3
5.00	33%	0.03	0.08	0.38	5.15	0.07	1.88	5.00	5	3
5.00	50%	0.03	0.05	0.27	5.11	0.05	1.37	5.00	5	3
5.00	100%	0.03	0.03	0.16	5.06	0.03	0.81	5.00	5	3
6.25	5%	0.03	0.25	1.56	6.75	0.23	6.54	4.19	7	5
6.25	10%	0.03	0.25	1.56	6.75	0.23	9.25	5.92	6	4
6.25	20%	0.03	0.11	0.69	6.47	0.11	3.46	5.00	5	3
6.25	33%	0.03	0.07	0.47	6.40	0.07	2.33	5.00	5	3
6.25	50%	0.03	0.05	0.34	6.36	0.05	1.71	5.00	5	3
6.25	100%	0.03	0.03	0.20	6.31	0.03	1.01	5.00	5	3
7.50	5%	0.03	0.25	1.88	8.00	0.23	7.92	4.22	7	5
7.50	10%	0.03	0.25	1.88	8.00	0.23	11.19	5.97	6	4
7.50	20%	0.03	0.11	0.82	7.72	0.11	4.12	5.00	5	3
7.50	33%	0.03	0.07	0.56	7.65	0.07	2.78	5.00	5	3
7.50	50%	0.03	0.05	0.41	7.61	0.05	2.04	5.00	5	3
7.50	100%	0.03	0.03	0.24	7.56	0.03	1.21	5.00	5	3
8.75	5%	0.03	0.25	2.19	9.25	0.24	9.29	4.25	7	5
8.75	10%	0.03	0.25	2.18	9.25	0.24	13.09	6.00	6	4
8.75	20%	0.03	0.11	0.96	8.97	0.11	4.80	5.00	5	3
8.75	33%	0.03	0.07	0.65	8.90	0.07	3.25	5.00	5	3
8.75	50%	0.03	0.05	0.48	8.86	0.05	2.38	5.00	5	3
8.75	100%	0.03	0.03	0.28	8.81	0.03	1.41	5.00	5	3
10.00	5%	0.03	0.25	2.50	10.50	0.24	10.67	4.27	7	5
10.00	10%	0.03	0.25	2.48	10.50	0.24	14.84	6.00	6	4
10.00	20%	0.03	0.11	1.09	10.22	0.11	5.47	5.00	5	3
10.00	33%	0.03	0.07	0.74	10.15	0.07	3.69	5.00	5	3
10.00	50%	0.03	0.05	0.54	10.11	0.05	2.71	5.00	5	3
10.00	100%	0.03	0.03	0.32	10.06	0.03	1.61	5.00	5	3
12.50	5%	0.03	0.25	3.13	13.00	0.24	13.42	4.29	7	5
12.50	10%	0.03	0.25	3.07	12.99	0.24	18.43	6.00	6	4
12.50	20%	0.03	0.11	1.36	12.72	0.11	6.80	5.00	5	3
12.50	33%	0.03	0.07	0.92	12.65	0.07	4.60	5.00	5	3
12.50	50%	0.03	0.05	0.68	12.61	0.05	3.39	5.00	5	3
12.50	100%	0.03	0.03	0.40	12.56	0.03	2.01	5.00	5	3
15.00	5%	0.03	0.25	3.75	15.50	0.24	16.17	4.31	7	5
15.00	10%	0.03	0.24	3.66	15.49	0.24	21.93	6.00	6	4
15.00	20%	0.03	0.11	1.63	15.22	0.11	8.14	5.00	5	3
15.00	33%	0.03	0.07	1.10	15.15	0.07	5.52	5.00	5	3
15.00	50%	0.03	0.05	0.81	15.11	0.05	4.05	5.00	5	3
15.00	100%	0.03	0.03	0.48	15.06	0.03	2.40	5.00	5	3

Kinematic (Channel) Calculations for Erosion Resistant (ER) Soils

$$V = 1.49/n * R^{(2/3)} * S^{(1/2)}$$

$$Q = 1.49/n * A * R^{(2/3)} * S^{(1/2)}$$

$$P = w + 2d \quad R = A / P$$

Blue Header (A:D): Input Data				Gray Header (E:I): Calculated Values					Permissible Velocities	
Width, w (ft)	Slope, S (ft/ft)	Roughness Coeff., n	Depth, d (ft)	Area, A (sf)	Wetted Perimeter, P (ft)	Hyd. Radius, R (ft)	Q (cfs)	V (fps)	Vmax (fps, Erosion Resistant)	Vmax (fps, Easily Erodible)
8.00	5%	0.03	0.25	2.00	8.50	0.24	8.47	4.23	7	5
8.00	10%	0.03	0.25	2.00	8.50	0.24	11.97	5.99	6	4
8.00	20%	0.03	0.11	0.88	8.22	0.11	4.39	5.00	5	3
8.00	33%	0.03	0.07	0.59	8.15	0.07	2.97	5.00	5	3
8.00	50%	0.03	0.05	0.44	8.11	0.05	2.17	5.00	5	3
8.00	100%	0.03	0.03	0.26	8.06	0.03	1.29	5.00	5	3
10.00	5%	0.03	0.25	2.50	10.50	0.24	10.67	4.27	7	5
10.00	10%	0.03	0.25	2.48	10.50	0.24	14.84	6.00	6	4
10.00	20%	0.03	0.11	1.09	10.22	0.11	5.47	5.00	5	3
10.00	33%	0.03	0.07	0.74	10.15	0.07	3.69	5.00	5	3
10.00	50%	0.03	0.05	0.54	10.11	0.05	2.71	5.00	5	3
10.00	100%	0.03	0.03	0.32	10.06	0.03	1.61	5.00	5	3
12.00	5%	0.03	0.25	3.00	12.50	0.24	12.87	4.29	7	5
12.00	10%	0.03	0.25	2.95	12.49	0.24	17.68	6.00	6	4
12.00	20%	0.03	0.11	1.31	12.22	0.11	6.54	5.00	5	3
12.00	33%	0.03	0.07	0.88	12.15	0.07	4.41	5.00	5	3
12.00	50%	0.03	0.05	0.65	12.11	0.05	3.25	5.00	5	3
12.00	100%	0.03	0.03	0.39	12.06	0.03	1.93	5.00	5	3
14.00	5%	0.03	0.25	3.50	14.50	0.24	15.07	4.31	7	5
14.00	10%	0.03	0.24	3.42	14.49	0.24	20.53	6.00	6	4
14.00	20%	0.03	0.11	1.52	14.22	0.11	7.61	5.00	5	3
14.00	33%	0.03	0.07	1.03	14.15	0.07	5.15	5.00	5	3
14.00	50%	0.03	0.05	0.76	14.11	0.05	3.79	5.00	5	3
14.00	100%	0.03	0.03	0.45	14.06	0.03	2.25	5.00	5	3
16.00	5%	0.03	0.25	4.00	16.50	0.24	17.27	4.32	7	5
16.00	10%	0.03	0.24	3.89	16.49	0.24	23.33	6.00	6	4
16.00	20%	0.03	0.11	1.73	16.22	0.11	8.68	5.00	5	3
16.00	33%	0.03	0.07	1.18	16.15	0.07	5.89	5.00	5	3
16.00	50%	0.03	0.05	0.87	16.11	0.05	4.33	5.00	5	3
16.00	100%	0.03	0.03	0.51	16.06	0.03	2.57	5.00	5	3
20.00	5%	0.03	0.25	5.00	20.50	0.24	21.68	4.34	7	5
20.00	10%	0.03	0.24	4.84	20.48	0.24	29.03	6.00	6	4
20.00	20%	0.03	0.11	2.16	20.22	0.11	10.82	5.00	5	3
20.00	33%	0.03	0.07	1.47	20.15	0.07	7.33	5.00	5	3
20.00	50%	0.03	0.05	1.08	20.11	0.05	5.40	5.00	5	3
20.00	100%	0.03	0.03	0.64	20.06	0.03	3.20	5.00	5	3
24.00	5%	0.03	0.25	6.00	24.50	0.24	26.08	4.35	7	5
24.00	10%	0.03	0.24	5.78	24.48	0.24	34.63	6.00	6	4
24.00	20%	0.03	0.11	2.58	24.22	0.11	12.91	5.00	5	3
24.00	33%	0.03	0.07	1.76	24.15	0.07	8.80	5.00	5	3
24.00	50%	0.03	0.05	1.29	24.11	0.05	6.47	5.00	5	3
24.00	100%	0.03	0.03	0.77	24.06	0.03	3.85	5.00	5	3

VIRGINIA ACTS OF ASSEMBLY -- 2023 SESSION

CHAPTER 196

An Act to direct the Department of Environmental Quality to include specifications relating to certain activities for stormwater management and erosion and sediment control related to the installation of permanent gravel access roads by an electric utility in the next publication of the Department of Environmental Quality's Virginia Stormwater Management Handbook.

[H 2126]

Approved March 22, 2023

Be it enacted by the General Assembly of Virginia:

1. § 1. *As used in this act, "electric utility" means any person that generates, transmits, or distributes electric energy for use by retail customers in the Commonwealth, including any investor-owned electric utility, cooperative electric utility, or electric utility owned or operated by a municipality.*

§ 2. *The Department of Environmental Quality (the Department) shall include specifications for stormwater management and erosion and sediment control for the installation of permanent gravel access roads by an electric utility for the purpose of construction and maintenance of electric transmission lines in the next publication of the Department's Virginia Stormwater Management Handbook (the Handbook). Such specifications shall be developed after seeking input from electric utility representatives. Any electric utility that complies with the Handbook's specifications for stormwater management and erosion and sediment control for the installation of a permanent gravel access road for the purpose of construction and maintenance of electric transmission lines shall be deemed to satisfy the water quantity technical criteria in the Stormwater Management Act pursuant to Article 2.3 (§ 62.1-44.15:24 et seq.) of Chapter 3.1 of Title 62.1 of the Code of Virginia.*

An electric utility may provide in its annual standards and specifications reasonable assurance that the specifications in the Handbook will be satisfied. The electric utility may achieve such reasonable assurance by incorporating the applicable specifications from the Handbook into a stormwater management plan and an erosion and sediment control plan developed for a project to install a permanent gravel access road under its annual standards and specifications.

§ 3. *Until the effective date of the next publication of the Handbook, any new permanent gravel access road associated with the construction and maintenance of electric transmission lines by an electric utility shall be deemed to have satisfied the required water quantity technical criteria if (i) the maximum width of the permanent gravel access road is no more than 14 feet with passing areas not more than 100 feet in length and 24 feet in width every 2,000 feet, on average; (ii) the permanent gravel access road follows the contour of the natural terrain to the extent possible and slopes should not exceed 10 percent; (iii) the permanent gravel access road is constructed using clean, open-graded, angular aggregate at a depth of no less than six inches; and (iv) the following conditions are met:*

1. *The project is managed so that during construction of the permanent gravel access road the area of land-disturbing activity is less than one acre;*

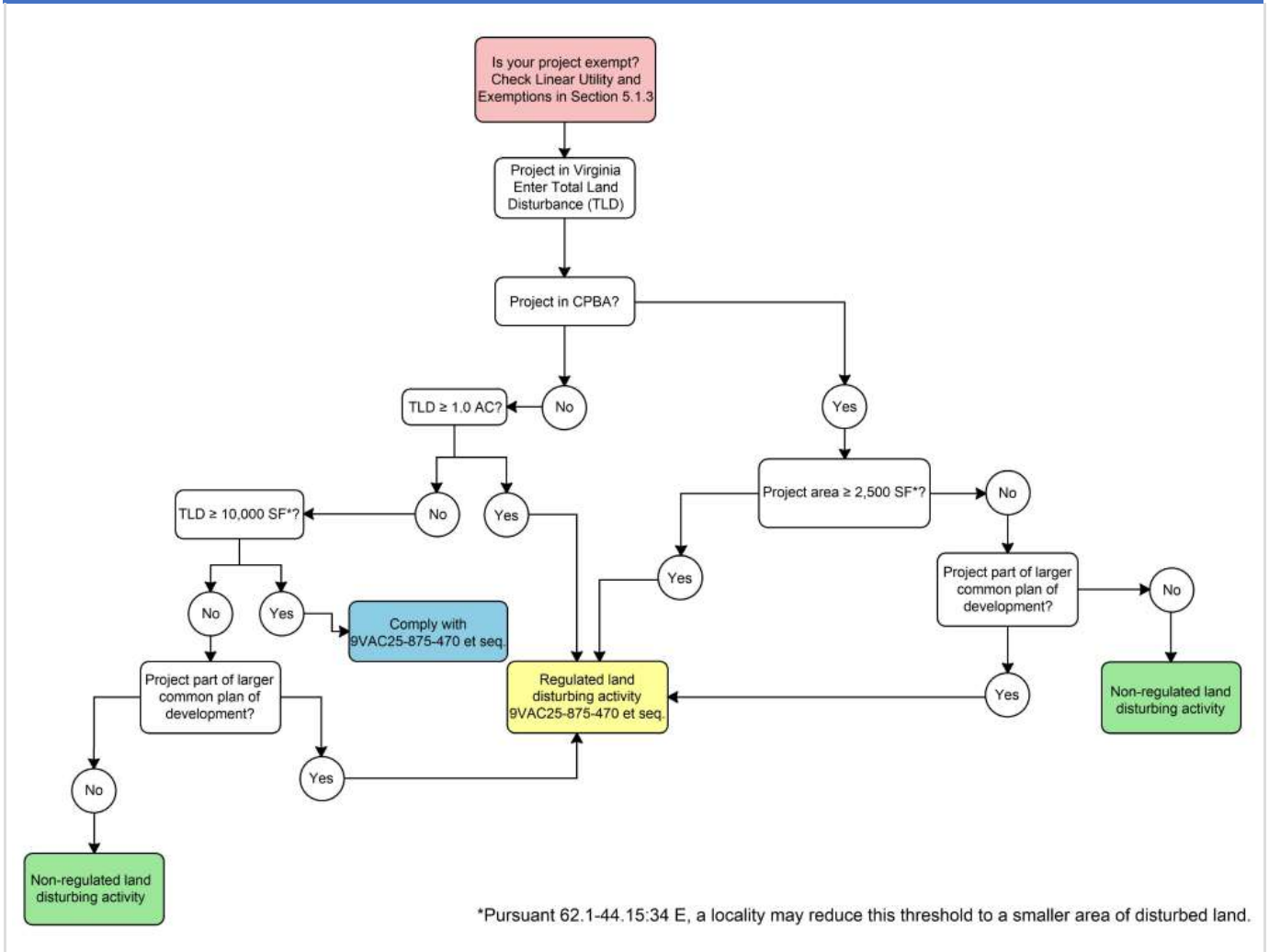
2. *The area where land-disturbing activity has been completed is adequately stabilized prior to initiating construction of the gravel access road on the next area subject to land-disturbing activity. "Adequately stabilized" means compliance with Standard and Specification 3.36 in the 1992 Virginia Erosion and Sediment Control Handbook;*

3. *The environment is protected from erosion and sedimentation damage associated with the land-disturbing activity; and*

4. *The project owner or construction activity operator designs, installs, implements, and maintains pollution prevention measures to (i) minimize the discharge of pollutants from equipment and vehicle wash water, wheel wash water, and other wash waters; (ii) minimize the exposure of building materials, building products, construction waste, trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste, and other materials present on site to precipitation and to stormwater; (iii) minimize the discharge of pollutants from spills and leaks and implement chemical spill and leak prevention and response procedures; (iv) prohibit the discharge of wastewater from the washout of concrete; (v) prohibit the discharge of wastewater from the washout and cleanout of stucco, paint, form release oils, curing compounds, and other construction materials; and (vi) prohibit the discharge of fuels, oils, or other pollutants used in vehicle and equipment operation and maintenance.*

The electric utility shall provide in its annual standards and specifications reasonable assurance that such conditions will be satisfied. The electric utility may achieve such reasonable assurance by incorporating the conditions of this section into an erosion and sediment control plan developed for the project under the utility's annual standards and specifications.

Figure 5-1 Applicability of Regulated Land Disturbance Requirements



5.1.2 Reserved

5.1.3 Linear Development Projects

Linear development projects are special projects sometimes handled somewhat differently under the Virginia laws and regulations than non-linear projects. A "linear development" project is an LDA that is linear in nature such as, but not limited to: (i) the construction of electric and telephone utility lines and natural gas pipelines; (ii) construction of tracks, rights-of-way, bridges, communication facilities, and other related structures of a railroad company; (iii) highway construction projects; (iv) construction of stormwater channels and stream restoration activities; and (v) water and sewer lines. Private subdivision roads or streets are not considered linear development projects. 9VAC25-875-20.

Linear development projects are required (9VAC25-875-640) to control post-development stormwater runoff in accordance with a site-specific stormwater management plan or a comprehensive watershed stormwater management plan developed in accordance with the Virginia Erosion and Stormwater Management Regulation (Regulation).

The Regulation does not distinguish among types of linear development projects such as aboveground or underground utilities, highway construction, rights-of-way, bridges, tracks, and related structures of a railroad company. VDEQ recognizes that the construction of aboveground or underground linear utilities may not result in changes to the pre-development runoff characteristics of the land surface after the completion of construction and final stabilization. Also, the application of the post-development water quantity and water quality controls to these types of projects and the preparation and implementation of a stormwater management plan may provide minimum water quality benefit. Examples of such projects include:

- The installation of underground utilities (e.g., waterlines, sewer lines, oil and gas distribution pipelines) beneath existing impervious cover (e.g., asphalt pavement, concrete pavement) that will be returned to its pre-development condition after the completion of construction and final stabilization;
- The installation of underground utilities (e.g., waterlines, sewer lines, oil, and gas distribution pipelines) beneath existing pervious cover (e.g., mixed open space, managed turf) that will be returned to its pre-development condition after the completion of construction and final stabilization; or
- The installation of aboveground (i.e., overhead) utility lines.

If the project will not result in changes to the pre-development runoff characteristics of the land surface after the completion of construction and final stabilization, then VDEQ or the local VESMP authority may waive the requirement for the preparation and implementation of a stormwater management plan. VDEQ recognizes that, on a site-specific basis, a stormwater management plan may be required, especially if the linear utility project will significantly alter the pre-development runoff characteristics of the land surface.

Installation of Permanent Gravel Access Roads for Construction and Maintenance of Electric Transmission Lines

An electric utility, defined in 2023 Acts of Assembly Chapters 196 (HB 2126) and 197 (SB1178) as, “any person that generates, transmits, or distributes electric energy for use by retail customers in the Commonwealth, including any investor-owned electric utility, cooperative electric utility, or electric utility owned or operated by a municipality,” may abide by the following criteria for the installation of new permanent gravel access roads for the construction and maintenance of electric transmission lines under DEQ-approved standards and specifications:

- (i) the maximum width of the permanent gravel access road is no more than 14 feet with passing areas not more than 100 feet in length and 24 feet in width every 2,000 feet, on average;
- (ii) the permanent gravel access road follows the contour of the natural terrain to the extent possible and slopes should not exceed 10 percent;
- (iii) the permanent gravel access road is constructed using clean, open-graded, angular aggregate at a depth of no less than six inches; and
- (iv) the following conditions are met:
 1. The project is managed so that during construction of the permanent gravel access road the area of land-disturbing activity is less than one acre;
 2. The area where land-disturbing activity has been completed is adequately stabilized prior to initiating construction of the gravel access road on the next area subject to land-disturbing activity. "Adequately stabilized" means compliance with [C-SSM-05](#), Soil Stabilization Blankets and Matting, in Chapter 7 of this Handbook;
 3. The environment is protected from erosion and sedimentation damage associated with the land-disturbing activity; and

4. The project owner or construction activity operator designs, installs, implements, and maintains pollution prevention measures to (i) minimize the discharge of pollutants from equipment and vehicle wash water, wheel wash water, and other wash waters; (ii) minimize the exposure of building materials, building products, construction waste, trash, landscape materials, fertilizers, pesticides, herbicides, detergents, sanitary waste, and other materials present on site to precipitation and to stormwater; (iii) minimize the discharge of pollutants from spills and leaks and implement chemical spill and leak prevention and response procedures; (iv) prohibit the discharge of wastewater from the washout of concrete; (v) prohibit the discharge of wastewater from the washout and cleanout of stucco, paint, form release oils, curing compounds, and other construction materials; and (vi) prohibit the discharge of fuels, oils, or other pollutants used in vehicle and equipment operation and maintenance.

An electric utility that complies with the criteria listed above, shall be deemed to satisfy the water quantity technical criteria in the Virginia Erosion and Stormwater Management Act, §§ 62.1-44.15:24 through 62.1-44.15:50 of the Code of Virginia (effective July 1, 2024, formerly the Stormwater Management Act). As required by the law, the electric utility must incorporate the applicable criteria from the Handbook (above) into a stormwater management plan and an erosion and sediment control plan developed for a project to install a permanent gravel access road under standards and specifications.

5.1.4 Exemptions

Certain activities are not required to comply with the VESMA and ESCL as outlined in the following section and in coordination with the local VESMP or VESCP authority. All the following activities are exempt from the ESCL and Regulation; however, these activities may be regulated by other agencies or regulations.

- Minor LDAs such as home gardens and individual home landscaping, repairs, and maintenance work;
- Installation, maintenance or repair of any individual service connection;
- Installation, maintenance, or repair of any underground utility line when such activity occurs on an existing hard-surfaced road, street, or sidewalk, provided the LDA is confined to the area of the road, street, or sidewalk that is hard surfaced;
- Installation, maintenance, or repair of any septic tank line or drainage field unless included in an overall plan for LDA relating to construction of the building to be served by the septic tank system;
- Permitted surface or deep mining operations and projects, or oil and gas operations and projects conducted pursuant to Title 45.2 of the Code of Virginia;
- Clearing of lands specifically for bona fide agricultural purposes; the management, tilling, planting, or harvesting of agricultural, horticultural, or forest crops; livestock feedlot operations; agricultural engineering operations, including construction of terraces, terrace outlets, check dams, desilting basins, dikes, ponds, ditches, strip cropping, lister furrowing, contour cultivating, contour furrowing, land drainage, and land irrigation. However, this exception shall not apply to harvesting of forest crops unless the area on which harvesting occurs is reforested artificially or naturally in accordance with the provisions of Chapter 11 (§ 10.1-1100 et seq.) of Title 10.1 of the Code of Virginia or is converted to bona fide agricultural or improved pasture use as described in subsection B of § 10.1-1163;
- Repair or rebuilding of the tracks, rights-of-way, bridges, communication facilities, and other related structures and facilities of a railroad company.
- Installation of fence and signposts or telephone and electric poles and other kinds of posts or poles;

Disconnecting Ditches and Streams. Ditch lines that drain directly to the stream are hydrologically connected to the stream and become efficient conduits of sediment to the stream channel. Environmentally sensitive maintenance practices identify opportunities to reduce sediment delivery and restore more natural hydrologic conditions by decreasing ditch connectivity and encouraging infiltration.

Criteria for disconnecting ditches and streams

- Roads with through cuts at the approach to stream crossing.
- Insloped roads on gentle or rolling ground with no signs of intercepting subsurface flows.
- Ditch lines with a large contributing area.

How to disconnect ditches from streams

- Eliminate ditches where possible through berm removal and filling the road profile.
- Locate drainage outlets away from streams and into vegetation when possible.
- Regrade ditches in wide flood plains to drain away from stream crossings.
- Construct broad-based dips to disperse surface and ditch flows before stream crossings.
- Outslope the road before stream crossings to disperse surface flows.

Benefits of disconnecting ditches and streams

- Reduces discharge of sediment to the stream.
- Reduces pulse flow of stormwater to stream system (lessens flood flows).
- Encourages infiltration and sediment filtration.
- Simple, effective, and inexpensive.



Figure 4.19—Unstable ditch. This ditch presents a safety, maintenance, and environmental concern. It is too deep, too wide, unvegetated, and can route sediment to the stream.



Figure 4.20—Traditional urban stormwater approaches collect and convey ditches directly to streams, as pictured above. Modern rural stormwater management should disconnect the road and stream by avoiding concentrated discharges to streams and encourage drainage dispersal.

Reprofiling Ditches at Stream Crossings

In broader valleys or relatively flat landscapes, it is often possible to make road ditches flow away from the stream crossing. To accomplish this, fill material is added to the area around the crossing to raise the grade. The ditch is regraded to force water to flow away from the stream crossing into stable vegetated outlets.

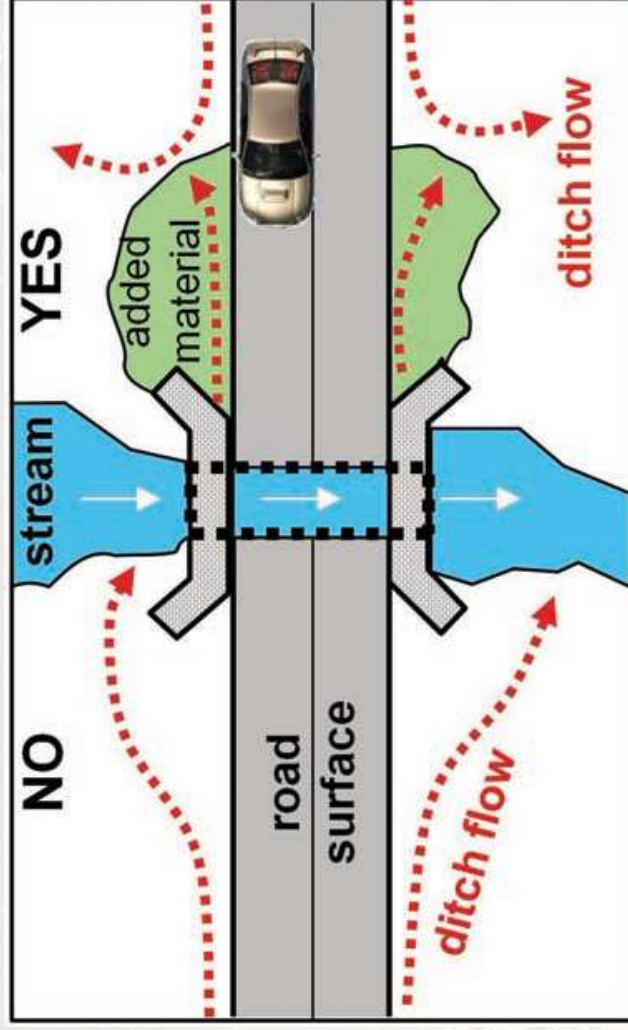


Figure 4.21—Aerial depiction of road-stream crossing. The left side of the diagram shows the traditional practice of discharging water to the stream. The right side of the diagram shows material added to redirect ditch flow and outlet water away from the stream.

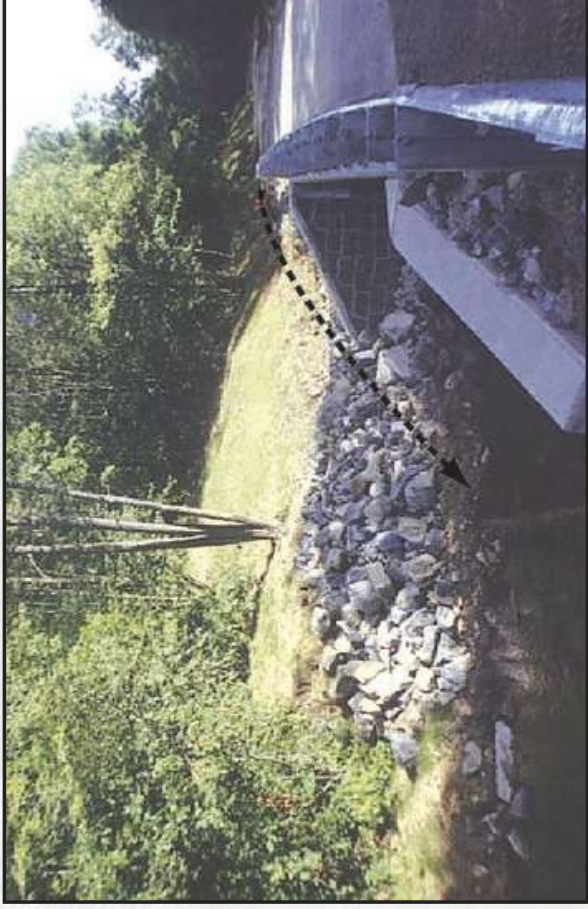


Figure 4.22a—**Before:** A typical crossing with ditches armored with rock and draining directly into the stream.

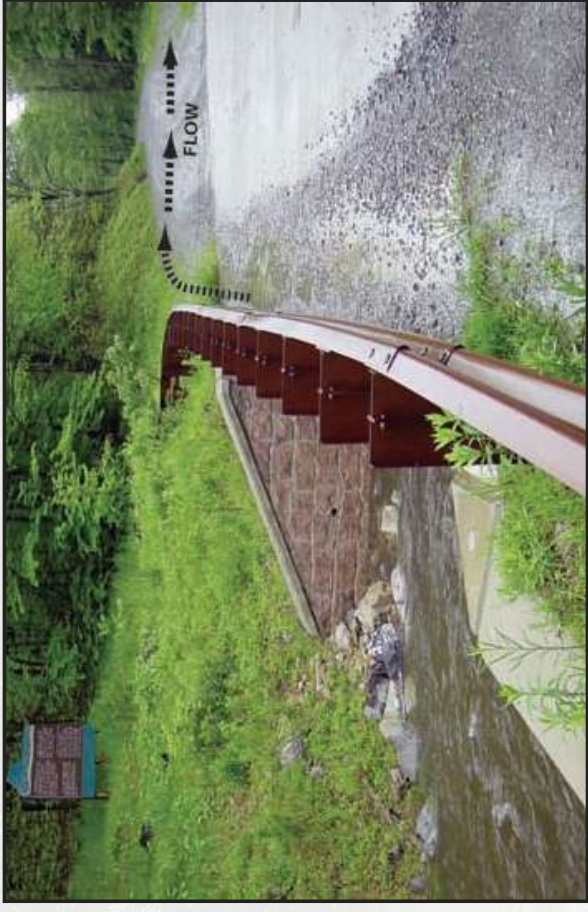
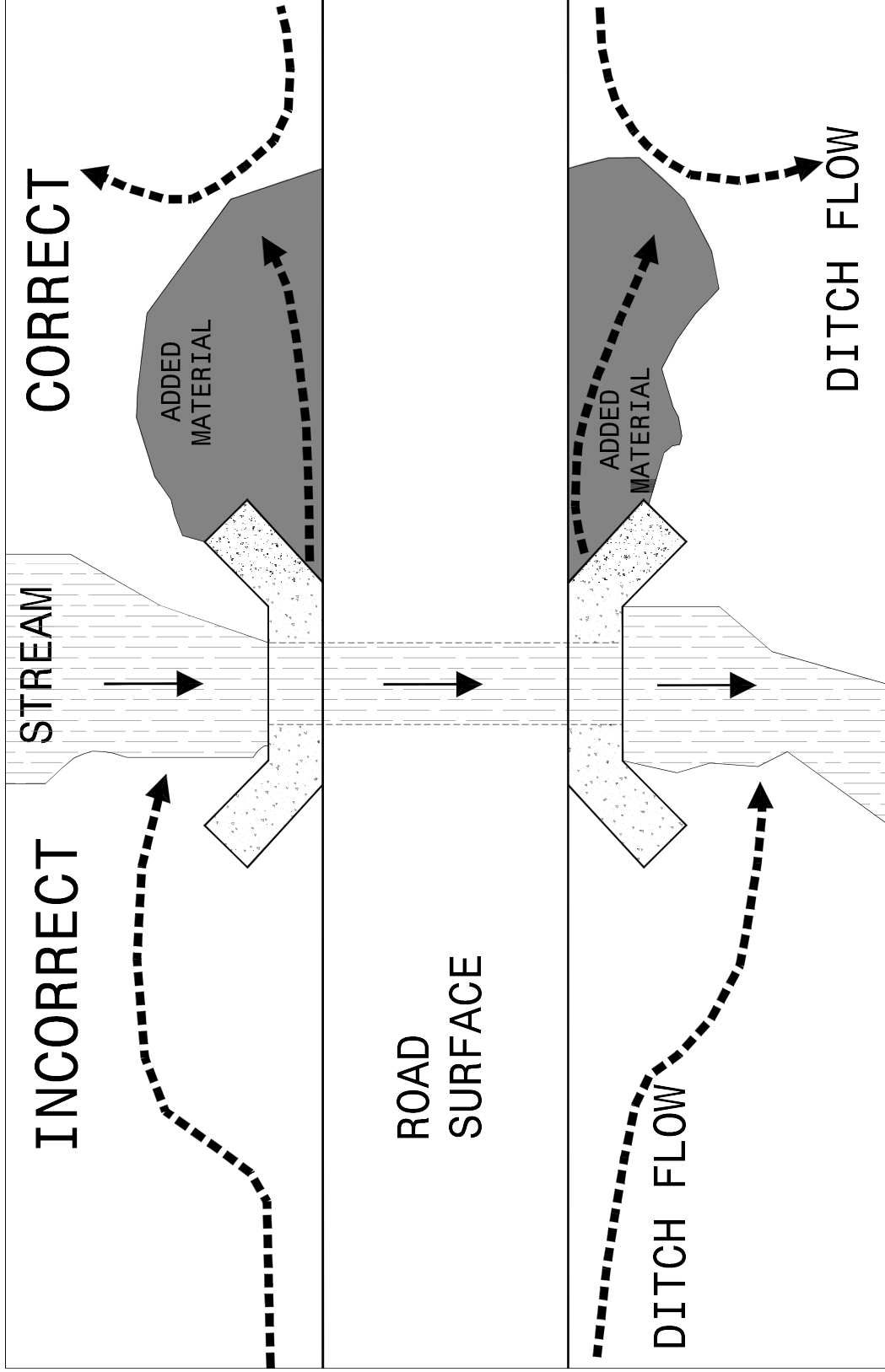


Figure 4.22b—**After:** Material has been added and the ditch has been reprofiled to drain away from the stream through a new cross pipe and into the woods.

Disconnecting Ditches And Streams



* Aerial depiction of road-stream crossing. The left side of the diagram shows the traditional practice of discharging water to the stream. The right side of the diagram shows material added to redirect ditch flow and outlet water away from the stream.

D-4-2 STANDARDS AND SPECIFICATIONS

FOR

PLUNGE POOL

Definition

An excavated depression lined with riprap and placed at the outfall of a culvert.

Purpose

To dissipate the energy of a discharge and prevent scour at a pipe outfall.

Conditions Where Practice Applies

Where discharge velocity and energy at a pipe outlet is sufficient to erode the downstream channel reach. This applies to outlets of all types such as road culverts, sediment basins, and stormwater management facilities. Plunge pools are an alternative to rock outlet protection and are preferable in locations where space constraints exist. A plunge pool may be temporary or permanent, based on design.

Design Criteria

1. Select type of plunge pool (larger stone required for Type 1):

Type I: Plunge pool is depressed $\frac{1}{2}$ the size of the culvert rise.

Type II: Plunge pool is depressed the full height of the culvert rise.

2. Determine the riprap (d_{50}) stone size for the plunge pool type and design storm flow.

Type I: $d_{50} = (0.0125d^2/Tw) \times (Q/d^{2.5})^{4/3}$

Type II: $d_{50} = (0.0082d^2/Tw) \times (Q/d^{2.5})^{4/3}$

3. Determine plunge pool dimensions.

$$C = (3 \times d) + (6 \times F)$$

$$B = (2 \times d) + (6 \times F)$$

Where: d_{50} = the median stone size in feet (refer to Table H.2: Stone Size)

d = the culvert diameter or span in feet

Tw = the tailwater depth in feet

Q = the design flow for the culvert, minimum 10-year, 24-hour storm, in cfs

B = the plunge pool width in feet

C = the plunge pool length in feet

D = $2 \times d_{50}$ = riprap thickness in feet

E = the culvert diameter or span in feet equal to d

3E = the plunge pool bottom length in feet

2E = the plunge pool bottom width in feet

F = plunge pool depth in feet = d (for Type II) or 0.5 d (for Type I)

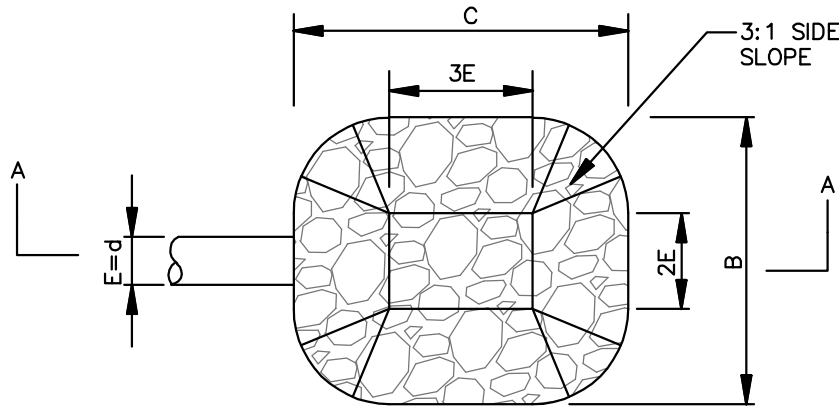
4. For permanent uses, provide a toewall at the downstream end at a depth twice the (D) dimension and at a width equal to the (D) dimension, on nonwoven geotextile. Extend the rip-rap a minimum of 18 inches under the outlet pipe if the outlet does not have a footer or headwall.
5. Provide an underdrain to a suitable outfall if standing water in the plunge pool is an issue or as required by the appropriate approval authority.
6. Provide the design values on the plans for the following dimensions: B, C, D, E, and F.

Maintenance

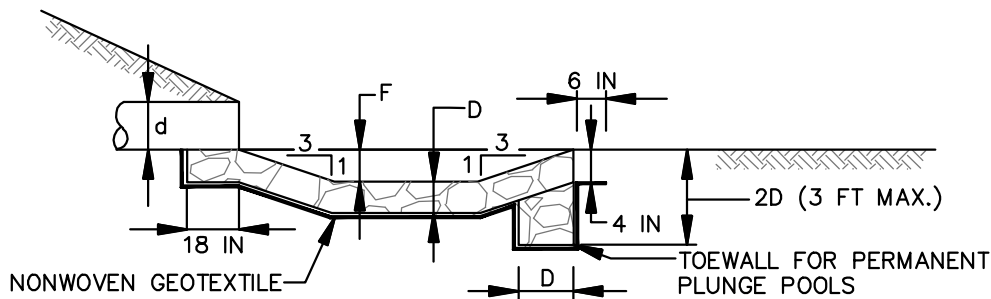
Maintenance needs are generally low for plunge pools. The line, grade, and cross section must be maintained, and the outlet must be kept free of erosion. After high flows inspect for scour and dislodged riprap. Repairs must be made immediately. Accumulated sediment and debris must be removed.

DETAIL D-4-2 PLUNGE POOL

STANDARD SYMBOL



PLAN VIEW



SECTION A-A

CONSTRUCTION SPECIFICATIONS

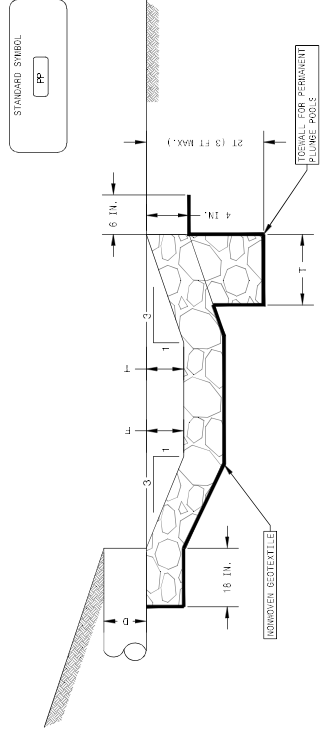
1. USE SPECIFIED CLASS OF RIPRAP.
2. USE NONWOVEN GEOTEXTILE AS SPECIFIED IN SECTION H-1 MATERIALS, AND PROTECT FROM PUNCHING, CUTTING, OR TEARING. REPAIR ANY DAMAGE OTHER THAN AN OCCASIONAL SMALL HOLE BY PLACING ANOTHER PIECE OF GEOTEXTILE OVER THE DAMAGED PART OR BY COMPLETELY REPLACING THE GEOTEXTILE. PROVIDE A MINIMUM OF ONE FOOT OVERLAP FOR ALL REPAIRS AND FOR JOINING TWO PIECES OF GEOTEXTILE.
3. PREPARE THE SUBGRADE FOR THE PLUNGE POOL TO THE REQUIRED LINES AND GRADES. COMPACT ANY FILL REQUIRED IN THE SUBGRADE TO A DENSITY OF APPROXIMATELY THAT OF THE SURROUNDING UNDISTURBED MATERIAL.
4. EMBED THE GEOTEXTILE A MINIMUM OF 4 INCHES AND EXTEND THE GEOTEXTILE A MINIMUM OF 6 INCHES BEYOND THE EDGE OF THE SCOUR HOLE.
5. STONE FOR THE PLUNGE POOL MAY BE PLACED BY EQUIPMENT. CONSTRUCT TO THE FULL COURSE THICKNESS IN ONE OPERATION AND IN SUCH A MANNER AS TO AVOID DISPLACEMENT OF UNDERLYING MATERIALS. DELIVER AND PLACE THE STONE FOR THE PLUNGE POOL IN A MANNER THAT WILL ENSURE THAT IT IS REASONABLY HOMOGENEOUS WITH THE SMALLER STONES AND SPALLS FILLING THE VOIDS BETWEEN THE LARGER STONES. PLACE STONE FOR THE PLUNGE POOL IN A MANNER TO PREVENT DAMAGE TO THE GEOTEXTILE. HAND PLACE TO THE EXTENT NECESSARY.
6. AT THE PLUNGE POOL OUTLET, PLACE THE STONE SO THAT IT MEETS THE EXISTING GRADE.
7. MAINTAIN LINE, GRADE, AND CROSS SECTION. KEEP OUTLET FREE OF EROSION. REMOVE ACCUMULATED SEDIMENT AND DEBRIS. AFTER HIGH FLOWS INSPECT FOR SCOUR AND DISLODGED RIPRAP. MAKE NECESSARY REPAIRS IMMEDIATELY.

MARYLAND STANDARDS AND SPECIFICATIONS FOR SOIL EROSION AND SEDIMENT CONTROL

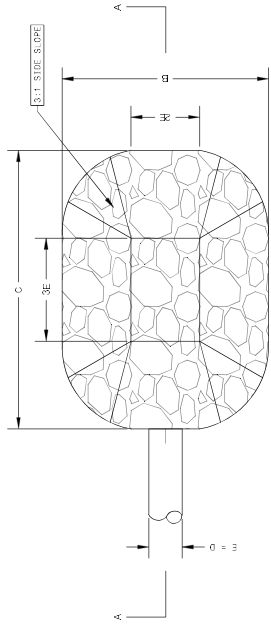
U.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

2011

MARYLAND DEPARTMENT OF ENVIRONMENT
WATER MANAGEMENT ADMINISTRATION



SECTION A-A



PLAN VIEW

CONSTRUCTION SPECIFICATIONS

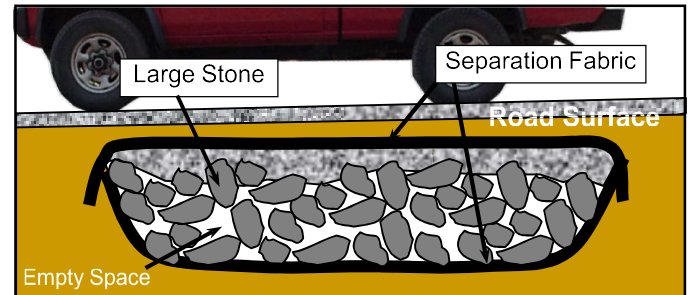
1. USE SPECIFIED CLASS OF RIPRAP
2. USE NONWOVEN GEOTEXTILE AS SPECIFIED AND PROTECT FROM PUNCHING, CUTTING, OR TEARING. REPAIR ANY DAMAGE OTHER THAN AN OCCASIONAL SMALL HOLE BY PLACING ANOTHER PIECE OF GEOTEXTILE OVER THE DAMAGED PART OR BY COMPLETELY REPLACING THE GEOTEXTILE. PROVIDE A MINIMUM OF ONE FOOT OVERLAP FOR ALL REPAIRS AND FOR JOINING TWO PIECES OF GEOTEXTILE.
3. PREPARE THE SUBGRADE FOR THE PLUNGE POOL TO THE REQUIRED LINES AND GRADES. COMPACT ANY FILL REQUIRED IN THE SUBGRADE TO A DENSITY OF APPROXIMATELY THAT OF THE SURROUNDING UNDISTURBED MATERIAL.
4. EMBED THE GEOTEXTILE A MINIMUM OF 4 INCHES AND EXTEND THE GEOTEXTILE A MINIMUM OF 6 INCHES BEYOND THE EDGE OF THE SCOUR HOLE.
5. STONE FOR THE PLUNGE POOL MAY BE PLACED BY EQUIPMENT. CONSTRUCT TO THE FULL COURSE THICKNESS IN ONE OPERATION AND IN SUCH A MANNER AS TO AVOID DISPLACEMENT OF UNDERLYING MATERIALS. DELIVER AND PLACE THE STONE FOR THE PLUNGE POOL IN A MANNER THAT WILL ENSURE THAT IT IS A MANNER TO PREVENT DAMAGE TO THE GEOTEXTILE. HAND PLACE TO THE EXTENT NECESSARY.
6. AT THE PLUNGE POOL OUTLET, PLACE THE STONE SO THAT IT MEETS THE EXISTING GRADE.

PLUNGE POOL

FRENCH MATTRESS – A structure under a road consisting of clean coarse rock wrapped in geotextile through which water can freely pass. French Mattresses are used in saturated soils, such as in wetlands, to support the roadbed while allowing unrestricted water movement.

CRITERIA FOR FRENCH MATTRESS USE

- Areas where roadside springs and low gradient road ditches result in road base saturation.
- Areas where springs under the road saturate the road base or come to the surface in the road.
- Areas where the road lays over soils with a high water table, such as wetlands and creek bottoms.



Side view schematic of a French Mattress.

BENEFITS OF FRENCH MATTRESSES

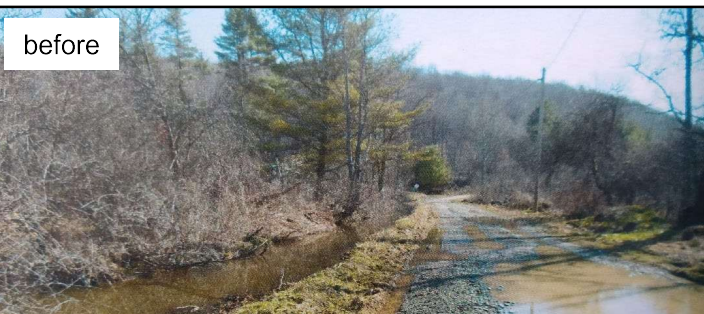
- Stabilizes the road base in areas where the road is weakened by water saturation.
- Allows for the free movement of water through road base (can be bi-directional).
- Maintains dispersed flows and prevents gully erosion associated with concentrated outlets.
- Can be used in wetland situations where a traditional pipe may lower the wetland water level.
- Requires little or no maintenance and has a long service life.
- Unlike pipes, a French Mattresses effectively reduces damming by beavers.
- Maintains floodplain connectivity through the roadway.
- Effectively insulates the road surface from water under the road, keeping the travel-way high and dry.

IMPORTANT MATTRESS CONSIDERATIONS

- Mattresses are not suitable replacements for road drainage pipes, or anywhere concentrated overland flow carries sediment. These flows will clog the mattress over time and are to be handled by drainage pipes..
- Mattress size is flexible. In the examples below the smaller mattress allows roadside springs to bleed through the road base while maintaining road stability. The larger mattress creates a stable foundation for the road through an area of soft wet soils.
- A French Mattress should be covered by a minimum of 12" of compacted fill material.
- In most situations the mattress should be level end to end (with the road alignment).
- A French Mattress should provide unrestricted flow through the road. In wetland situations, the side slope may be flat or minimal. In sloped areas a 1- to 2-percent fall from inlet to outlet will aid drainage.
- The mattress must be free draining at the outlet to avoid ponding water beneath the road.



The small mattress shown during construction was installed to drain a group of small hillside seeps that saturated the roadway. The larger mattress is being constructed to create a free draining and stable road base in a low land stream bottom.



CONSTRUCTION SEQUENCE

The mattress shown on the left traverses a wide wetland. The numbers refer to picture sequence.

1. Excavate the mattress to desired depth and slope, allowing for min 12 inches of compacted cover over the mattress. Place geotextile fabric in the trench. Allow enough fabric on the ends to overlap the top piece of geotextile in the finished mattress.
2. Place porous AASHTO 1 stone on top of the fabric and spread into a uniform bed of the desired depth.
3. Place a piece of fabric ovetop of the installed stone. Be sure to overlap all fabric joints by at least 12 inches. Leave the stone exposed along the road edges.
4. Shape and compact fill ovetop of the finished mattress. Establish the desired road surface shape in the fill. Place enough fill to ensure a minimum of 12" of compacted cover once the fill and surface aggregate are installed.

MATERIALS REQUIRED FOR A FRENCH MATTRESS

- **Geotextile fabric** (Class 1 Non-woven). Separation fabric around the mattress allows water to pass through while blocking fine silt and clay, which would eventually clog the structure.
- **Clean stone**. It is important to use clean stone. Clean stone is relatively uniform in size with no fine material. Typically 3- to 4-inch-diameter stone is used. Smaller stone should be avoided, as it requires lateral confinement to stabilize. Additionally, larger stone will increase the bridging potential and the flow capacity of the mattress.

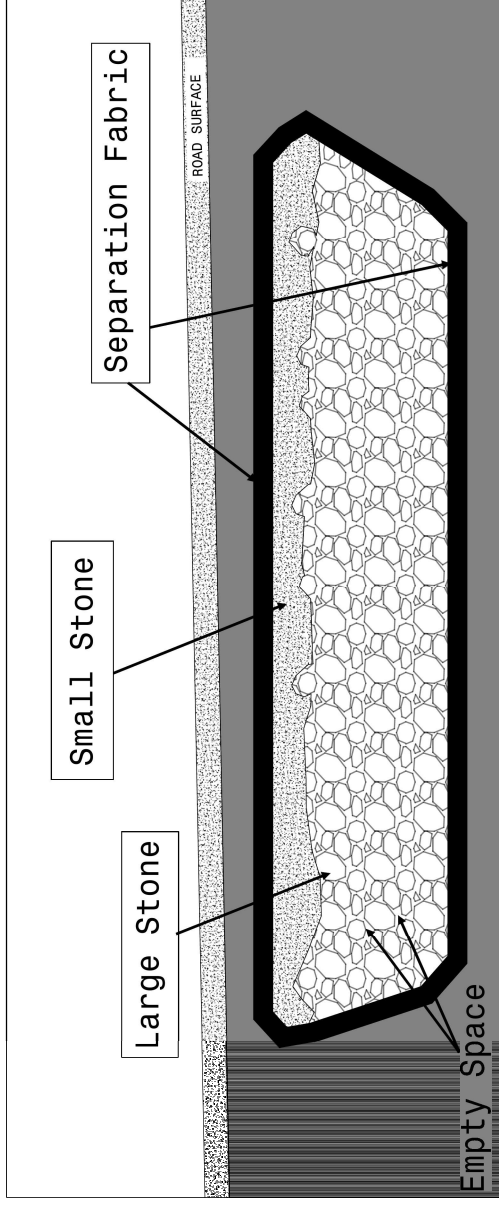
EQUIPMENT REQUIRED FOR A FRENCH MATTRESS

- **Excavator/backhoe**: Needed for excavation; helps to spread stone after dumping.
 - **Trucks**: Needed to import clean stone and haul away excavated material.
 - **Hand Tools**: Rakes and shovels to move and level stone.
 - **Grader***: To establish uniform depth and shape of fill.
 - **Compaction***: A vibratory roller is needed to compact fill.
- * *Alternative equipment can be used on smaller mattresses*

Reminder: A French Mattress should not be used to handle storm drainage. The sediment load carried in storm flows will eventually clog the mattress.

In the example above a French Mattress is used to convey wetland flows while providing a stable road base.

Graphical side view of the mattress components.



A structure under a road consisting of clean coarse rock wrapped in geotextile fabric through which water can pass freely. French mattresses are used in extremely wet areas, such as wetlands, to support the roadbed while allowing unrestricted water movement.

- Areas where concentrated outlet flow through a pipe is undesirable, impractical, or regulated.
- Low-lying areas near streams or wetlands where installing cross drains would be difficult due to lack of grade or vegetation.
- Areas where the road acts as a dam by cutting off the natural flow of subsurface water.
- Areas with high water table.

- Mattresses are NOT pipe replacements. Mattresses should NOT be used for concentrated overland flow, such as small stream channels or stormwater from ditches. These flows naturally carry sediment, which will clog the mattress over time.
- The finished mattress should be covered by at least 8 inches of compacted fill material.
- French mattresses should be installed to match the slope of the land. In some wetland situations, this slope may be minimal. In sloped areas a 1- to 2- percent slope should be used to aid drainage.

Materials required for a French mattress

- Geotextile fabric (Class 2 woven). The fabric around the mattress allows water to pass through while blocking fine silt and clay, which would eventually clog the structure. In situations where water flowing into the mattress may contain sediment (farm fields, etc.), the ends of the mattress should also be wrapped in fabric.
- Clean stone. Use clean stone. Clean stone is relatively uniform in size with no fine material. Typically 3- to 4-inch-diameter stone is used. Larger stones will increase the flow capacity of the mattress.

TABLE II-3
Sizes of Open-Graded Coarse Aggregates

Va. Size No.	Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Weight)														
	4 in.	3½ in.	3 in.	2½ in.	2 in.	1½ in.	1 in.	¾ in.	½ in.	3/8 in.	No. 4	No. 8	No. 16	No. 50	No. 100
1	Min. 100	90-100		25-60		Max. 15		Max. 5							
2			Min. 100	90-100	35-70	Max. 15		Max. 5							
3				Min. 100	90-100	35-70	0-15		Max. 5						
357				Min. 100	95-100		35-70		10-30		Max. 5				
5						Min. 100	90-100	20-55	Max. 10	Max. 5					
56						Min. 100	90-100	40-85	10-40	Max. 15	Max. 5				
57						Min. 100	95-100		25-60		Max. 10	Max. 5			
67							Min. 100	90-100		20-55	Max. 10	Max. 5			
68							Min. 100	90-100		30-65	5-25	Max. 10	Max. 5		
7								Min. 100	90-100	40-70	Max. 15	Max. 5			
78							Min. 100	90-100		40-75	5-25	Max. 10	Max. 5		
8								Min. 100	85-100	10-30	Max. 10	Max. 5			
8P								Min. 100	75-100	5-30	Max. 5				
9									Min. 100	85-100	10-40	Max. 10	Max. 5		
10									Min. 100	85-100					10-30