**COMMONWEALTH OF VIRGINIA**
**DEPARTMENT OF ENVIRONMENTAL QUALITY**

# Virginia Stormwater Management Handbook
# Technical Review Committee (TRC) Meeting #6
**Thursday April 16, 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

- Sign-In
- FOIA Information

**Updates** — DEQ Staff

- V1.2 Status
- V1.3 Topics and schedule

**Specifications Review** — All

- P-FIL-01 Rooftop Disconnect
- P-FIL-02 Vegetated Roof
- P-FIL-04 Infiltration Practices
- P-FIL-06 Filtering Practices

**Lunch Break – 12:00 pm** — All

**Specifications Review Continued** — All

- P-FIL-07 Sheet Flow to Vegetated Filter Strip
- P-FIL-08 Soil Compost Amendments

**New Topics Review** — All

- C-SCM-02 Construction Road Stabilization with Timber Mats
- C-SCM-03 Temporary Stone Construction Entrance with Timber Mats
- Section 6.3.3.4 Addition of Continuous Monitoring Adaptive Controls Language
- Flocculant Specification

**Public Forum** — All

**Next Steps** — DEQ Staff

**Wrap Up** — DEQ Staff

# P-FIL-01 Rooftop Disconnection

## 1.0 Definition

Impervious areas that immediately drain to a stormwater conveyance system or other impervious surface are “connected impervious” areas and produce stormwater that flows untreated to surface water bodies. Disconnection occurs when impervious surfaces are redirected and dispersed into sheet flow across an expanse of turf grass or natural vegetation. Directing runoff from impervious areas onto vegetated areas as sheet flow will increase infiltration, resulting in a direct reduction in runoff and corresponding storage volume requirements.

## 2.0 Purpose and Applicability of Best Management Practice

By disconnecting direct rooftop or impervious surface runoff, the flow is redirected to designated pervious areas, which will reduce runoff volumes and rates.

**2.1 Benefits**

- Sending runoff to pervious areas and implementing low-impact practices help to increase overland flow time and reduce peak flows (New York Department of Environmental Conservation [NYDEC] 2015).
- Vegetated and pervious areas can filter and infiltrate runoff, thus increasing water quality. **2.2 Feasibility/Limitations**

- Redirected rooftop runoff may increase a property owner’s maintenance burden.
- Alternative rooftop runoff mitigations may be costly.
- Local law may prohibit or limit rooftop disconnection.

Two kinds of disconnection are allowed (see Figure P-FIL-01-1 ~~and Figure P-FIL-02-2~~):

1. Simple Disconnection: Impervious surfaces are dissipated and dispersed as sheet flow over a 40-foot-long flow path before it reaches a natural or manmade stormwater conveyance system.
2. Disconnection leads to alternate runoff reduction practice(s) adjacent to the roof or small residential impervious area.

**Alternative Disconnection Practices.** Alternative disconnection practices are structural practices that provide runoff reduction rates equivalent to those seen with simple disconnection. Alternative practices are needed when the simple disconnection criteria cannot be met. Alternate disconnection practices are used only when the flow length or slope criteria cannot be met. Alternative disconnection provides the same runoff reduction rates as those seen with simple disconnection. Alternative practices intercept impervious runoff at the source before the receiving stormwater conveyance system or other impervious surface. One practice may treat more than one downspout if the practice is within 40 feet of closest downspout. Infiltration practices should only be used where there are suitable soils and applicable setbacks allow. Larger-scale (e.g., commercial) applications that use disconnection and/or sheet flow for runoff reduction credit for small impervious areas should consult best management practice (BMP) specification BMP P-FIL-07, Sheet Flow to Vegetative Filter Strip/Open Space.

**Figure P-FIL-01-1 Roof Disconnection with Alternate Runoff Reduction Practices – Plan View**

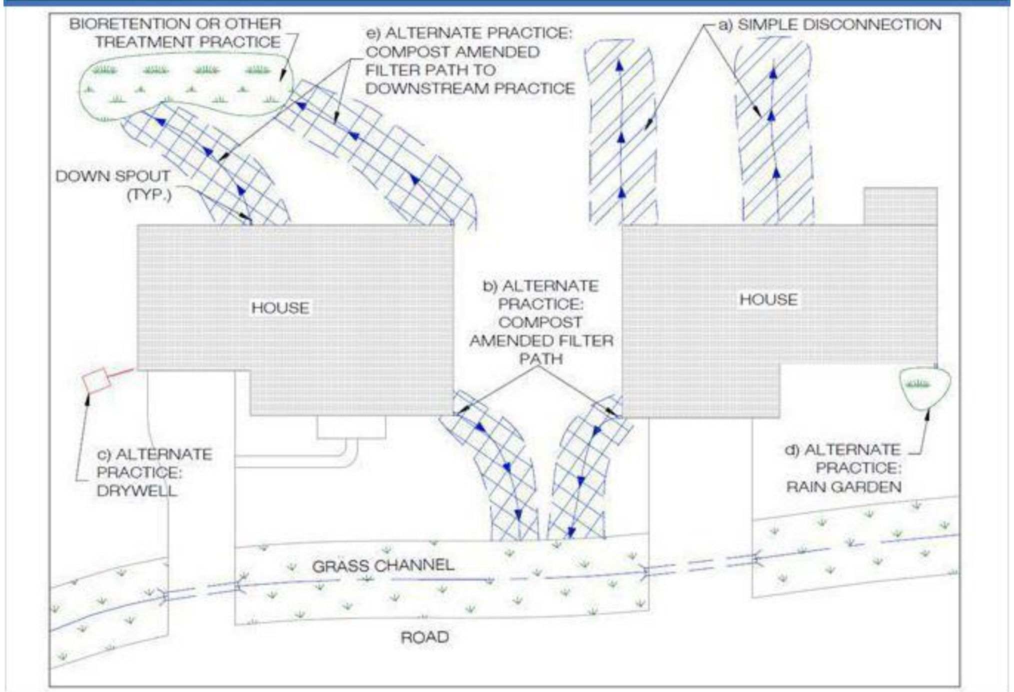




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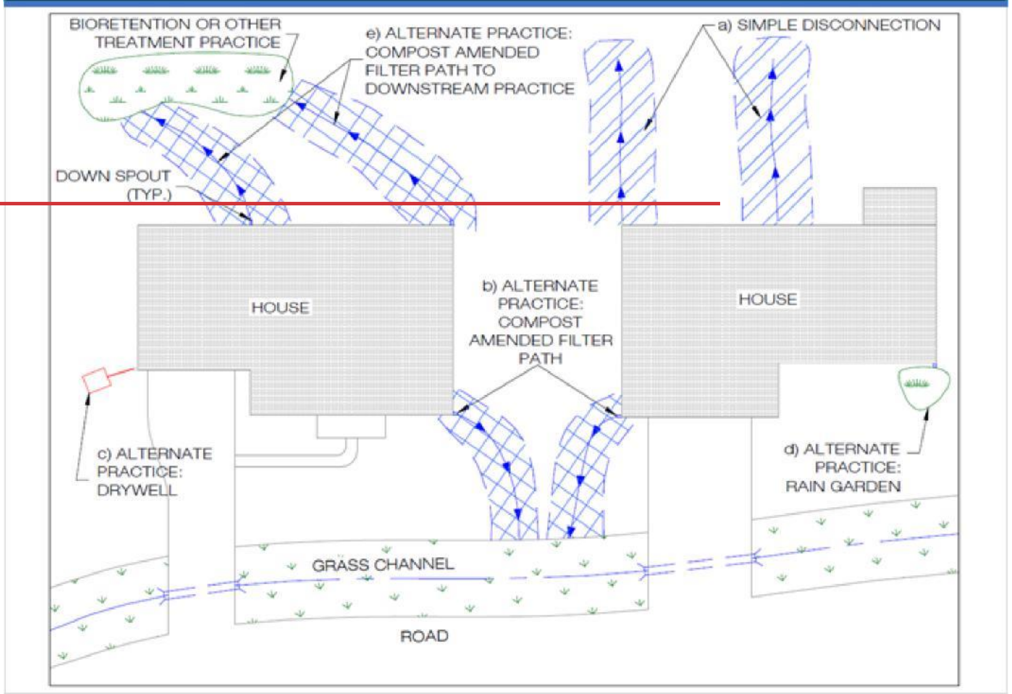
**Figure P-FIL-01-2 Residential Rooftop Treatment – Plan View**




*a) Simple Disconnection*

*b) Disconnection – Alternate Practice: Compost-Amended Filter Path*

*c) Disconnection – Alternate Practice: Dry Well (micro-infiltration)*

*d) Disconnection – Alternate Practice: Rain Garden*

*e) Disconnection – Alternate Practice: Compost-Amended Filter Path to Downstream Practice – Bioretention*

## 3.0 Planning and Considerations

The following considerations are adapted from the State of New York (NYDEC 2015) and apply to simple disconnections:

- Disconnections are encouraged on uncompacted, permeable soils (Hydrologic Soil Groups [HSGs] A and B) Runoff from disconnected rooftops must be directed to a designated area that is appropriately graded for storage and infiltration of the runoff, revegetated and protected from other uses, and designed for conveyance in a non-erosive manner within the site boundary. Use splash pads or level spreaders as necessary to distribute runoff to designated areas with infiltration capacity. Yards without positive drainage should not be used for simple disconnection.
- Use an appropriate pre-treatment measure as necessary to dissipate and disperse runoff to designated flow paths.

- In less permeable soils (HSGs C and D or previously impacted HSGs A and B), permeability and water table depth should be evaluated to determine whether a soil enhancement is needed for the designated flow path. In some cases, soil restoration by deep tilling, decompaction, and compost amendment are needed. Downstream flow path area limits should be perpendicular to contours. With converging contours, the downstream flow path width cannot be less than half of the upstream width.
- Runoff must be directed to a designated flow path that is appropriately graded, revegetated, and protected from other uses. The flow path should be designed in a non-erosive manner using appropriate construction BMPs.
- Simple disconnection is generally not advisable for residential lots smaller than 6,000 square feet in area, although it may be possible to employ one of the alternate disconnection runoff reduction practices on these lots (e.g., cistern, infiltration).

## 4.0 Stormwater Performance Summary

With proper design and maintenance, the simple rooftop disconnection options can provide relatively high runoff reduction rates, although they are not credited with nutrient event mean concentration (EMC) reduction (see Table P-FIL-01-1). If an alternate disconnection runoff reduction practice that does achieve EMC reduction in addition to volume reduction is employed to achieve rooftop disconnection, the higher total removal credit for that practice can be used for the contributing drainage area of the rooftop. In some cases, the designer may use one of the alternate disconnection practices identified in this specification to provide both runoff reduction and nutrient removal regardless of space constraints.

The runoff reduction achieved by rooftop disconnections can help reduce the overall channel protection and flood control volume for the site. Designers can use the Virginia Runoff Reduction Method (VRRM) Compliance spreadsheet to calculate a curve number adjustment for each design storm for the contributing drainage area based on the degree of runoff reduction achieved.

**Table P-FIL-01-1 Summary of Stormwater Functions Provided by Rooftop Disconnection**

| Function Provided by Simple Rooftop Disconnection | HSG Soils A and B | HSG Soils C and D |
|---|---|---|
| Annual Runoff Reduction Volume | 50% | 25% |
| Total Phosphorus EMC Reduction by BMP Treatment Process | 0 | 0 |
| Total Phosphorus Mass Load Removal | 50% | 25% |
| Total Nitrogen EMC Reduction by BMP Treatment Process | 0 | 0 |
| Total Nitrogen Mass Load Removal | 50% | 25% |
| Channel and Flood Protection | Partial: Designers can use the VRRM Compliance spreadsheet to adjust curve number for each design storm for the contributing drainage area (CDA) based on the annual runoff reduction achieved. | |

| Table P-FIL-01-1 Summary of Stormwater Functions Provided by Rooftop Disconnection | | |
|---|---|---|
| Function Provided by Simple Rooftop Disconnection | HSG Soils A and B | HSG Soils C and D |

**Notes:**

Source: Center for Watershed Protection (CWP) and Chesapeake Stormwater Network (CSN) 2008; CWP 2007.

1. When simple disconnection is not possible, alternative practices can be implemented, but no additional runoff reduction is provided beyond 50% unless the design is in accordance with other approved BMP specifications.
2. Designers should consult the applicable specification for alternative practice design standards.
3. Compost amendments are not credited with additional volume reduction on HSG A and B soils. Primary use is to improve the volume reduction performance of disconnection in C and D soils.

## 5.0 Design Criteria

### 5.1 Simple Rooftop Disconnection

Table P-FIL-01-2 provides the primary design criteria for simple rooftop disconnection. Components of a simple rooftop disconnection, including roof drain, downspout, concentrated inflow energy dissipator, flow length and flow width, are illustrated in Figure P-FIL-01-3 2 and Figure P-FIL-01-43 illustrate the application of simple disconnection. These figures also illustrate the alternate disconnection practice of a compost-amended filter path when applied in HSG C or D soils as well as the option of discharging to a downstream practice.

The following provides the general design criteria for simple disconnection:

- Flow from the downspout should be spread over a minimum 10-foot-wide disconnection flow path extending downgradient from the structure and should be at least 40 feet long.
- Where it is determined that the disconnection can be safely spread across a yard area meeting the minimum dimensions (i.e., the flow will remain sufficiently spread beyond the level spreader and will not create nuisance conditions), a defined flow path cross-section need not be constructed.
- Simple disconnection can be used on any post-construction HSG. However, the erodibility of soils, slope, and both existing and planned vegetative cover must be considered to ensure no erosion is created from concentrated flows.
- Provide pre-treatment that dissipates and disperses flows. A pea gravel or river stone diaphragm or other accepted flow-spreading device should be installed at the downspout outlet to distribute flows evenly across the flow path.

| Table P-FIL-01-2 Simple Rooftop Disconnection Design Criteria | |
|---|---|
| **Design Factor** | **Simple Disconnection** |
| Maximum impervious (rooftop or residential impervious) area treated | 1,000 square feet per disconnection |
| Disconnection Geometry | Width ≥ 10 feet; Length equal to longest flow path, but<br>no less than 40 feet [1] |
| Disconnection slope | < 5% with turf reinforcement [2] |
| Type of Pretreatment | External (e.g., leaf screens, gravel diaphragm dissipation and dispersion) |

**Table P-FIL-01-2 Simple Rooftop Disconnection Design Criteria**

| Design Factor | Simple Disconnection |
|---|---|

**Notes:**

1. An alternate disconnection runoff reduction practice must be used when the disconnection length is less than 40 feet.
2. Turf reinforcement may include EC-3 or other appropriate reinforcing materials that are confirmed by the designer to be non-erosive for the specific characteristics and flowrates anticipated at each individual application and acceptable to the plan-approving authority.
1. For alternate disconnection runoff reduction practices, see the applicable specification for design criteria. See Table P-FIL-01-1 for eligible practices and associated specification numbers.
2. Note that the downspout extension of 5 feet is intended for simple foundations. Any dry well or rock trench adjacent to an in-ground basement or finished floor area should be carefully designed and coordinated with the design of the structure's water-proofing system (e.g., foundation drains) or avoided altogether.

### 5.2 Alternate Disconnection: Soil Compost-Amended Filter Path

The incorporation of compost amendments should conform to BMP P-FIL-08, Soil Compost Amendment, and include the following design elements:

- Flow from the downspout should be spread over a 10-foot-wide flow path extending downgradient from the structure.
- The compost-amended filter path should be 10 feet wide and at least 20 feet long within the longer disconnection flow path.
- A pea gravel or river stone diaphragm or other accepted flow-spreading device should be installed at the downspout outlet to distribute flows evenly across the filter path.
- The compost-amended filter path should have adequate "freeboard" so that flow remains within the amended soil strip and is not diverted away from the strip. In general, this means that the strip should be lower than the surrounding land area to keep flow within the filter path. Similarly, the flow area of the filter path (as well as the larger disconnection flow path) should be level to discourage concentration of the flow.

***Figure P-FIL-01-~~3~~ 2 Disconnection: Alternate Practice Soil Compost Amended Filter Path***

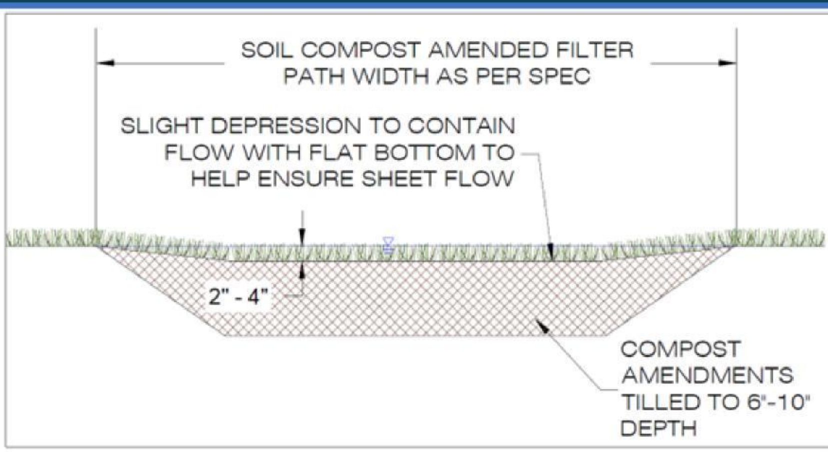


*Figure P-FIL-01-~~4~~3 Disconnection: Alternate Practice: Compost Amended Filter Path to Downstream Bioretention Section View*

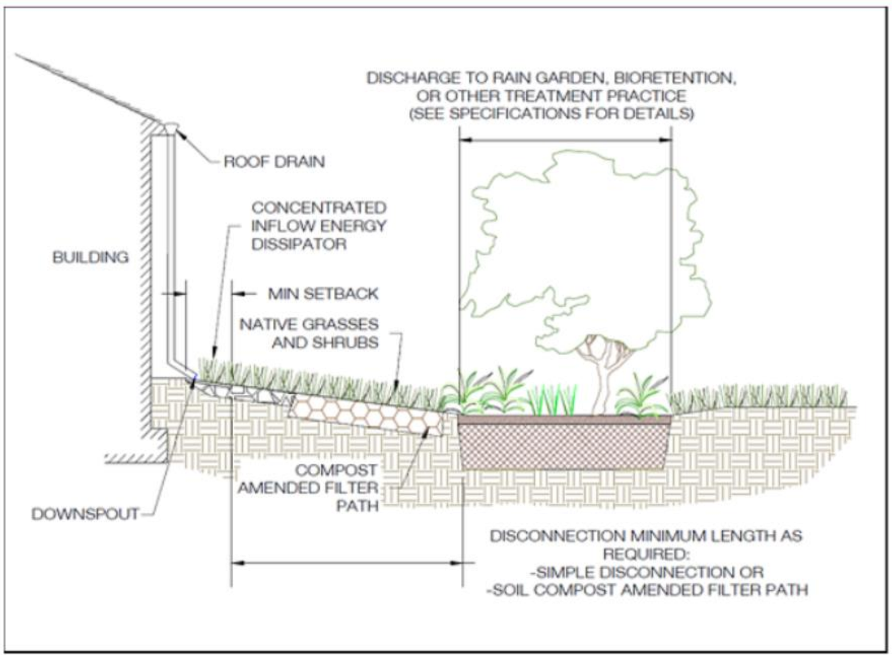
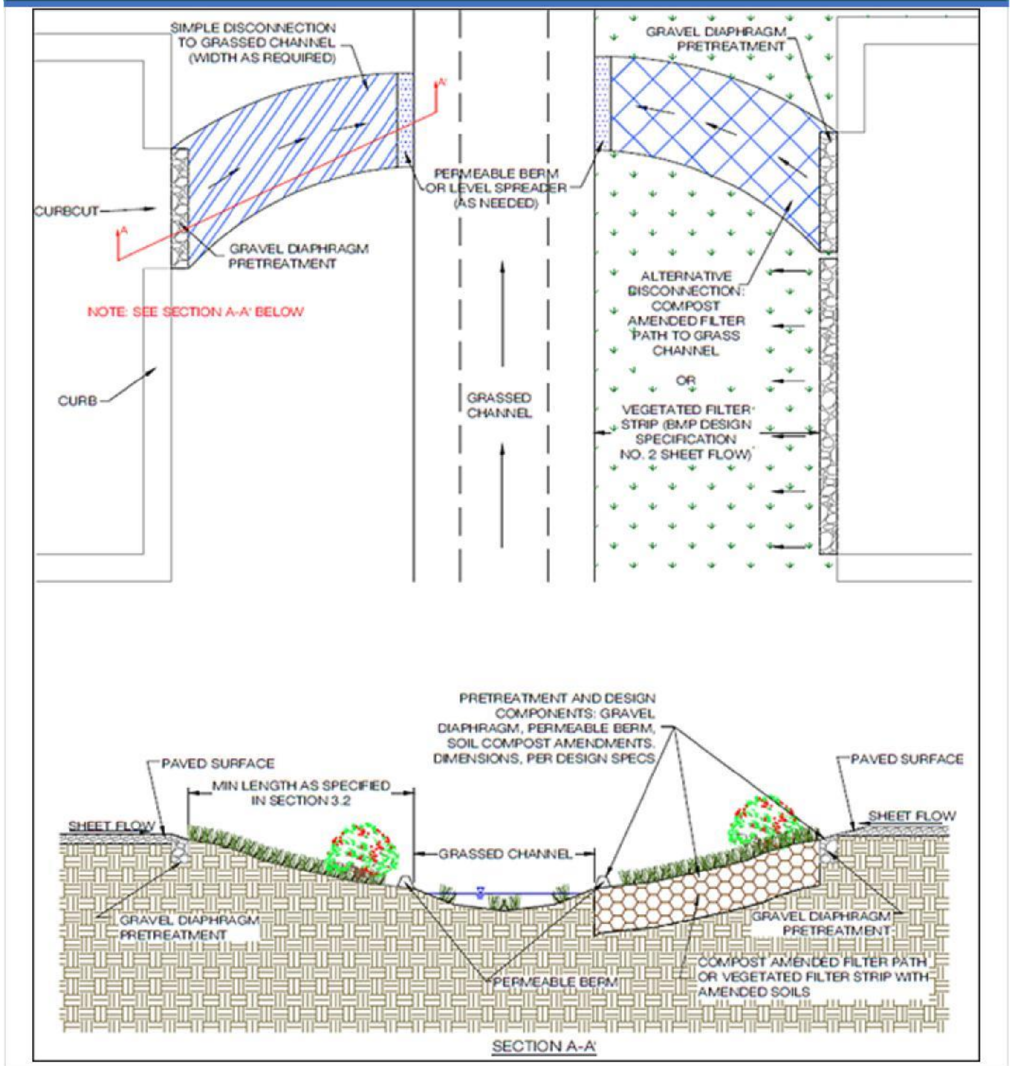


**Figure P-FIL-01-~~5~~ 4 Disconnection: Alternate Practice Amended Filter Path to Downstream Grass Channel (or other treatment)**




### 5.3 Alternate Disconnection: Micro-Infiltration

Table P-FIL-01-3 provides the primary design criteria for using micro-infiltration as an alternative disconnection practice. Micro-infiltration alternatives include dry wells and rock trenches.

The following general design criteria must be met for micro-infiltration:

- Soils must have an infiltration rate of 0.5 inch per hour or greater.
- As general rule, approximately 18 cubic feet of stone per 100 square feet of rooftop area is needed to provide storage for 1-inch volume of runoff. If a hollow manufactured tank-style chamber is used, approximately 8.33 cubic feet of storage per 100 square feet of rooftop area is needed for capturing the 1-inch volume of runoff.
- cubic feet of storage per 100 square feet of rooftop area is needed for capturing the 1-inch volume of runoff.
- Provide a flat bottom to promote infiltration. Provide non-woven geotextile fabric as a separation barrier with the native soil.
- Provide pre-treatment that screens and filters debris.
- Provide an elevated overflow to pop-up emitter or similar device.
- Chamber systems require a cleanout port. The pop-up emitter can be used as a cleanout.
- The use of micro-infiltration adjacent to an in-ground basement or finished floor area should be carefully designed and coordinated with the design of the structure's waterproofing system (e.g., foundation drains) or avoided altogether.

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**Table P-FIL-01-3 Micro-Infiltration Design Criteria**

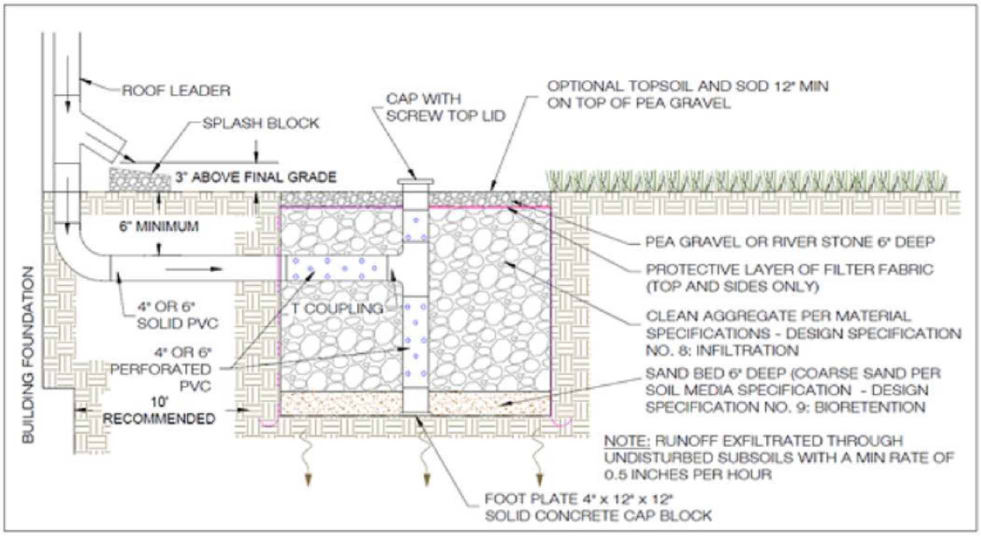
| Design Factor | Micro-Infiltration Design |
|---|---|
| Roof Area Treated | 250 to 2,500 square feet |
| Typical Practices | Dry Well and Rock Trench |
| Recommended Maximum Depth | 3 feet |
| Runoff Reduction Sizing | See BMP P-FIL-04, Infiltration Practices |
| Minimum Soil Infiltration Rate | 0.5 inch/hour |
| Observation Well | No |
| Type of Pretreatment | External (e.g., leaf screens, grass strip) |
| UIC Permit Needed | No |
| Required Soil Test | One soil profile and one infiltration test per practice |
| Building Setbacks | 10 feet [1] |

**Note:**

1. Note that the building setback of 10 feet is intended for simple foundations. Any dry well or French drain adjacent to an in-ground basement or finished floor area should be carefully designed and coordinated with the design of the structure's waterproofing system (e.g., foundation drains) or avoided altogether.

In general, micro-infiltration areas will require a surface area up to 3% of the contributing roof area. An onsite soil test is needed to determine whether soils are suitable for infiltration. It is recommended that the micro-infiltration facility be in an expanded right-of-way or stormwater easement so that it can be easily accessed for maintenance.

**Figure P-FIL-01-~~6~~ 5 Disconnection: Alternate Practice Dry Well (Micro**

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Replace Design Specification No. 8 Infiltration with P-FIL-04 Infiltration Practices
Replace Design Specification No. 9 Bioretention with P-FIL-05 Bioretention

### 5.4 Alternate Disconnection: Micro-Bioretention

Depending on site soil properties, roof runoff may be filtered through a shallow bioretention area. The design for this option should meet the requirements of micro-bioretention (rain garden) or urban bioretention (stormwater planters) as described in BMP P-FIL-05, Bioretention, and summarized in Table P-FIL-01-4.

For some residential applications, front, side, and/or rear yard bioretention may be an attractive option. This form of bioretention captures roof, lawn, and driveway runoff from low- to medium-density residential lots in a depressed area (6 to 12 inches) between the home and the primary stormwater conveyance system (e.g., roadside ditch or pipe system). The micro-bioretention or rain garden connects to the drainage system with an underdrain if needed; (connection to the drainage system must comply with the appropriate connection requirements). The concept is to take advantage of the drop from the roof leader to the conveyance system by creating a 10-foot-wide (minimum) bioretention corridor from the roof to the street with a shallow (6- to 12-inch deep) temporary ponding area. The bioretention corridor must have a minimum effective flow length of at least 20 feet. The ponding area may have a turf or landscape cover depending on homeowner preference. The advantage of using micro-bioretention over a soil compost-amended filter path is the additional pollutant removal credit provided by bioretention. The following general design criteria identify design requirements for bioretention planters:

- No infiltration test is needed.
- Minimum soil medium depth is 18 inches with 6-inch gravel sump and under drain.
- Planter wall maximum height is 3 feet. Wall should have stable footings and internal drainage.

| Table P-FIL-01-4 Micro-Bioretention Design Criteria | |
|---|---|
| **Design Factor** | **Micro Bioretention (i.e., Rain Garden)** |
| Impervious Area Treated [1] | 2,500 square feet |
| Type of Inflow | Sheet flow or roof leader downspout |
| Runoff Reduction Sizing [1] | Surface Area = 5% of roof area (Level 1); 6% of roof area (Level 2) |
| Minimum Soil Infiltration Rate | 0.5 inch/hour; 1 inch/hour to remove underdrain requirement |
| Observation Well/Cleanout Pipes | No |
| Type of Pretreatment | Leaf screens, gravel diaphragm |
| Underdrain and Gravel Layer | Level 1: Yes |
| Minimum Filter Media Depth | 18 inches (Level 1) |
| Media Source | Mixed on site |
| Required Soil Borings | One soil profile and one infiltration test, only when an underdrain is not used |
| Building Setbacks | 10 feet [2] |

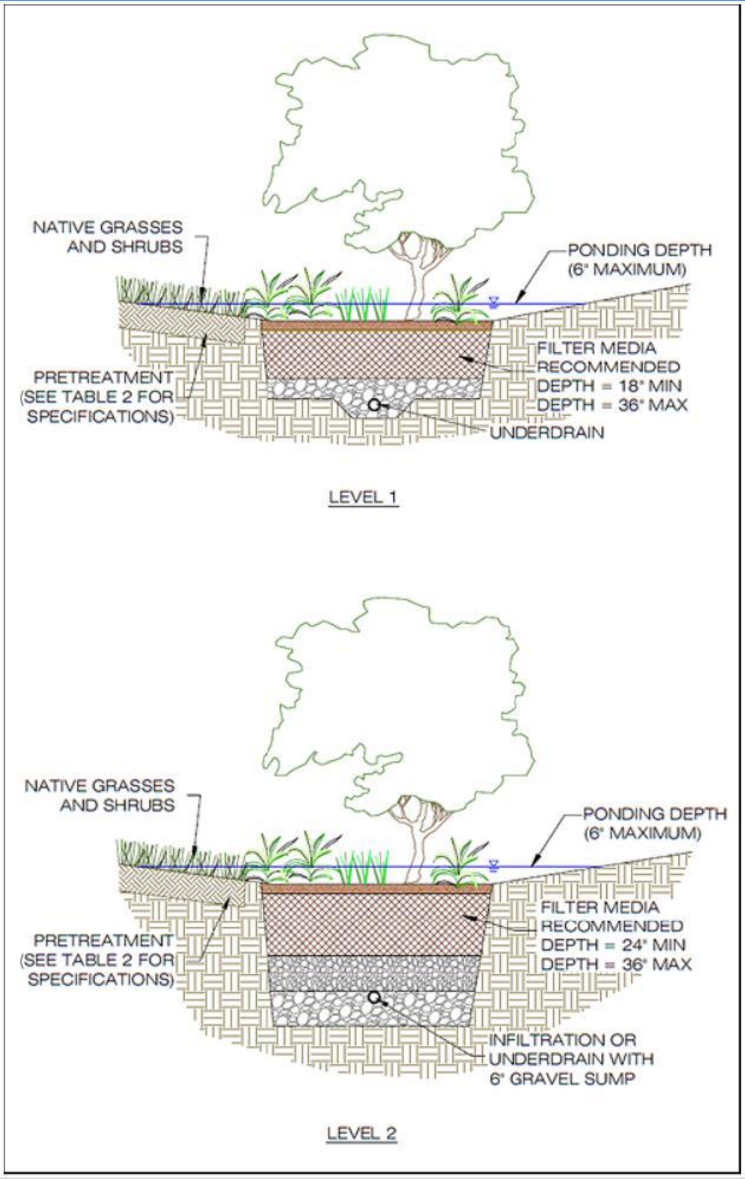
**Notes:**

1. Refer to BMP P-FIL-05, Bioretention, for Level 1 and Level 2 Design Criteria and sizing criteria for individual and multiple downspout applications.
2. Note that the building setback of 10 feet is intended for simple foundations. Any micro-bioretention practice located adjacent to an in-ground basement or finished floor area should be carefully designed and coordinated with the design of the structure's waterproofing system (e.g., foundation drains) or avoided altogether.

The rain garden medium is 18 to 24 inches deep and is located atop a 12- to 24-inch-deep stone reservoir (as required by the Micro-Bioretention design criteria provided in BMP P-FIL-05. A perforated underdrain is installed above the stone reservoir to promote storage and recharge, even on poorly draining soils. In urban settings, the underdrain is directly connected into the storm drainpipe running underneath the street or in the street right-of- way. A trench needs to be excavated during construction to connect the underdrain to the street storm drain system. Appropriate approvals are required for making any connections to a common or public drainage system.

Construction of the remainder of the bioretention system is deferred until after the lot has been stabilized. The designer can reduce the risk of homeowner conversion by specifying the choice of either turf or landscaping as selected by the homeowner. However, the use of Virginia native plants adapted to regional conditions for rain gardens (provided in Appendix G) is recommended. Rain gardens require regular mowing and/or landscape maintenance to perform effectively. It is recommended that the practice be in an expanded right-of-way or stormwater easement so that it can be easily and legally accessed if it fails to drain properly.

*Figure P-FIL-01-~~7~~ 6 Disconnection: Alternate Practice Rain Garden (Micro Bioretention)*



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| Table P-FIL-01-5 Regional and Special Case Design Adaptations | |
|---|---|
| Case | Adaptation |
| Karst Terrain | Rooftop disconnection is strongly recommended in karst areas for most residential lots larger than 6,000 square feet, particularly if it can be combined with a secondary micro-practice to increase small-scale runoff volume reduction. The discharge point from the disconnection should extend at least 15 feet from any building foundations. Rooftop disconnection is also recommended for commercial sites that are not likely to be stormwater hotspots. |
| Coastal Plain Terrain | Disconnection is strongly recommended in the coastal plain for rooftops or other impervious areas on most residential lots larger than 6,000 square feet. Because this practice is especially suited to the coastal plain, the VSMP Authority and/or VESMP Authority may encourage the use of an alternate disconnection practice, particularly if it can be combined with a secondary micro-practice to increase small-scale runoff volume reduction while reducing the overall footprint of simple disconnection. The disconnection corridor should have a minimum slope of 1% in the first 10 feet and a minimum 2 feet of vertical separation from the water table. |

## 6.0 Construction Specifications

### 6.1 Construction Sequence for Simple Impervious Disconnection

Impervious cover disconnection will be installed after all impervious areas have been constructed and adjacent pervious areas have been stabilized. This usually includes the construction of the individual residences and driveways and the stabilization of the yards. The design of the practices may require adjustments to fit exact driveway locations, structure rooflines, and downspout locations. The VESMP Authority should enact provisions such as the Erosion Control Program “Agreements in Lieu of Plans” to include all the appropriate parties (e.g., site operator, home builder, and homeowner) to ensure that the residential disconnection practices are installed and stabilized in accordance with the approved plans.

To the extent practicable, the construction of alternate disconnection practices should follow the construction guidance, checklists, and inspections outlined for the micro-scale versions of the individual runoff reduction practices (soil amendments, micro-infiltration, micro-bioretention, rainwater harvesting, and urban planters).

The following are general procedures for implementing simple and, when applicable, alternate disconnection practices:

- Before construction begins, identify the general boundaries of the disconnection practice on the site/plot plan and clearly mark them on the site.
- Minimize construction traffic (e.g., staging of materials, contractor parking), especially during foundation construction.
- Stockpile existing topsoil if it is stripped in preparation for foundation construction.
- Achieve any grading to establish filter or flow paths with lightweight equipment.
- Divert downspouts until the filter path is completely stabilized. It may be appropriate to use stabilization matting (e.g., EC-3 or an equivalent) regardless of slope to encourage thick turf cover growth.

### 6.2 Construction Inspection

Construction inspection is critical to ensure that the minimal slope away from the structure is maintained.

Disconnection practices should be constructed after most of the site work has been completed and the house or building structure has been enclosed. Therefore, especially in residential developments, the disconnection practice may be constructed by the builder and/or the residential landscape contractor responsible for the final lot grading and stabilization. The specific locations of the practices may change because of the actual downspout or driveway locations. It is important that the site designer and contractor be able to adapt the original design of the disconnection to the new location and achieve the same overall performance goals in terms of geometry, volume, and impervious areas treated.

The as-built survey or certification should document that the disconnection practices have: (1) been installed either consistent with the plan or as adapted to fit the specific site conditions; and (2) been accepted by the homeowners.

Global Positioning System coordinates should be logged for any of these practices upon facility acceptance and submitted for entry into the local BMP maintenance tracking database.

An example construction phase inspection checklist for simple disconnection is provided in Appendix H. Construction inspection recommendations for alternate disconnection practices are provided in the BMP specifications for those practices in the same appendix.

## 7.0 Operations and Maintenance Considerations

### 7.1 Maintenance Agreements

The Virginia Erosion and Stormwater Management Regulation requires long-term responsibility for maintenance and operation of stormwater management facilities (9VAC25-875-535). The requirements must be set forth in an instrument recorded in the local land records prior to permit termination and include 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.

### 7.2 Maintenance Inspections

Long-term inspections of simple and alternate disconnection practices can be accomplished through a property owner inspection program developed by the VESMP Authority.

Maintenance of a simple disconnection flow path typically involves traditional lawn or landscaping maintenance. In some cases, runoff from a simple disconnection may be directed to a more natural, undisturbed setting (e.g., where lot grading and clearing is “fingerprinted” and the proposed filter path is protected), thereby reducing or even eliminating the need for maintenance. If the simple disconnection flow path is directed toward a turf area, it should be regularly mowed at a tall grass setting and kept to a height of no more than 6 inches.

Inspections should ensure that:

1. Flows through the disconnection filter or flow path are not channelizing or short-circuiting.
2. Debris and sediment do not build up at the top of the flow path.
3. Foot or vehicular traffic does not compromise the gravel diaphragm or energy dissipater.
4. Scour and erosion do not occur within the flow path.
5. Sediments and decomposed leaves or debris are cleaned out of the energy dissipater.
6. Vegetative density exceeds a 90% cover in the filter or flow path and is being regularly mowed to a height of 6 inches or less (Virginia Cooperative Extension 2019; Massachusetts Department of Environmental Protection 2008).
7. In karst areas, subsidence does not occur at the point of discharge or downstream along the flow path.

An example maintenance inspection checklist for Simple Rooftop Disconnection is provided in Appendix H. Maintenance checklists for the alternate micro-scale practices are provided with their respective maintenance checklists in the same appendix.

## 8.0 References


CWP. 2007. National Pollutant Removal Performance Database Version 3.0. Center for Watershed Protection, Ellicott City, Maryland.

CWP and CSN 2008. Technical Memorandum: The Runoff Reduction Method.

Massachusetts Department of Environmental Protection. 2008. Volume 2, Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook. Available online at: https://www.mass.gov/guides/massachusetts-stormwater-handbook-and-stormwater-standards.

NYDEC. 2015. New York State Stormwater Management Design Manual. Originally Prepared by the Center for Watershed Protection, updated by the New York State Department of Environmental Protection.

Virginia Cooperative Extension. 2019. Best Management Practice Fact Sheet 3: Grass Channels. Publication 426-122. Available online at: https://digitalpubs.ext.vt.edu/vcedigitalpubs/3588686348927379/MobilePagedReplica.action?pm=1&folio=1#pg1.

Virginia Department of Environmental Quality. 2016. Virginia Runoff Reduction Method Compliance Spreadsheets.

# P-FIL-02 Vegetated Roof

## 1.0 Definition

A vegetated roof, or green roof, are alternative roof surfaces that typically consist of waterproofing and drainage materials and an engineered growing medium that is designed to support low-growing plant growth.

## 2.0 Purpose and Applicability of Best Management Practice

Vegetated roofs capture and temporarily store stormwater runoff in the growing medium before it is conveyed into the storm drain system. A portion of the captured stormwater evaporates or is taken up by plants, which helps reduce runoff volumes, peak runoff rates, and pollutant loads otherwise generated by rooftops. Vegetated roofs are typically not designed to retain stormwater from larger storms.

Vegetated roofs present an above-ground management alternative when onsite space for stormwater practices is limited. They can be installed on flat roofs or on roofs with slopes up to 30% with special strapping and erosion control devices (Peck and Kuhn 2003; New York Department of Environmental Conservation [NYDEC] 2015).

Vegetated roofs typically contain a layered system of roofing. The roofs are designed so that water drains vertically through the medium and then horizontally along a waterproofing layer toward the outlet. There are two types of vegetated roof systems:

- **Intensive vegetated roofs** have a growing medium layer that ranges from 6 inches to 4 feet thick, which is planted with a wide variety of plants including trees.
- **Extensive vegetated roofs** have a much shallower growing medium layer (4 to 6 inches), which is planted with carefully selected drought-tolerant vegetation. Extensive vegetated roofs are much lighter and less expensive than intensive vegetated roofs and are recommended for use on buildings on most development and redevelopment sites.

Note: This specification is intended for situations for which the primary design objective of the vegetated roof is stormwater management and, unless specified otherwise, addresses extensive roof systems.

Vegetated roofs are generally designed to have minimal maintenance requirements. Plant species are selected such that the vegetated roof will require minimal irrigation or fertilization after vegetation is initially established.

Vegetated roofs are ideal for use on commercial, institutional, municipal, and multi-family residential buildings. They are particularly well suited for use on ultra-urban development and redevelopment sites. Vegetated roofs can be used on a variety of rooftops including:

- Non-residential buildings (e.g., commercial, industrial, institutional, and transportation uses);
- Multi-family residential buildings (e.g., condominiums or apartments); and
- Mixed-use buildings.

Generally, extensive green roofs can be built on flat or sloped roofs, whereas intensive systems are built on flat or tiered roofs (NYDEC 2015). Local regulations may also permit the use of vegetated roofs on single-family residential roofs; however, the designer should verify any requirements or limitations in the local zoning or building codes.

## 3.0 Planning and Considerations

| Table P-FIL-02-1 Common Site Constraints | |
|---|---|
| **Site Feature** | **Constraint** |
| Structural Capacity of the Roof | When designing a vegetated roof, designers must not only consider the stormwater storage capacity of the vegetated roof, but also its structural capacity to support the weight of the additional water. A conventional rooftop typically must be designed to support an additional 15 to 30 pounds per square foot for an extensive vegetated roof. As a result, a structural engineer, architect, or other qualified professional should be involved with all vegetated roof designs to ensure that the building has enough structural capacity to support a vegetated roof. |
| Roof Pitch | Treatment volume (Tv) is maximized on relatively flat roofs (a pitch of 1% to 2%). Some pitch is needed to promote positive drainage and prevent ponding and/or saturation of the growing medium. Vegetated roofs can be installed on rooftops with slopes up to 25%; however, a qualified designer should be consulted regarding any vegetated roof proposed for a 2/12 pitch or greater. Further, the drainage system must be carefully designed in conjunction with any baffles, grids, or strips that may be used to prevent slippage of the medium on a sloped roof. The effective Tv of the roof system diminishes on rooftops with steep pitches (Van Woert et al. 2005). |
| Roof Access | Adequate access to the roof must be available to deliver construction materials and perform routine maintenance. Roof access can be achieved either by an interior stairway through a penthouse or by an alternating tread device with a roof hatch or trap door not less than 16 square feet in area and with a minimum dimension of 24 inches (Northern Virginia Regional Commission [NVRC] 2007). Designers should also consider how they will get construction materials up to the roof (e.g., by elevator or crane) and how construction materials will be stockpiled in the confined space. |
| Roof Type | Vegetated roofs can be applied to most roof surfaces, although concrete roof decks are preferred. Certain roof materials, such as fiberglass shingles, exposed treated wood, and uncoated galvanized metal, may not be appropriate for vegetated rooftops due to pollutant leaching through the medium (Clark et al. 2008). |
| Setbacks | The design of vegetated roofs must be in accordance with the American National Standards Institute (ANSI)/Single Ply Roofing Industry (SPRI)'s VF-1 External Fire Design Standard for minimum criteria for fire breaks and setback dimensions for all roof penetrations such as mechanical sheds, penthouses, ducts, pipes, and skylights as well as rooftop electrical, heating, ventilation, and air conditioning (HVAC), and other mechanical systems. |

| Table P-FIL-02-1 Common Site Constraints | |
|---|---|
| **Site Feature** | **Constraint** |
| Retrofitting Vegetated Roofs | Retrofitting of existing rooftops would appear to be an attractive option for redevelopment. However, the following key feasibility factors must be considered when evaluating a retrofit:<br>• The structural capacity of the existing rooftop area. This includes a balance between the structural weight tolerances and the required resistance to wind uplift. The designer should refer to the ANSI/SPRI RP-14 Wind Design Standard for Vegetated Roofing Systems;<br>• The age and accessibility of the existing roof.<br>• The capability of the building owner(s) to maintain the roof.<br>Options for vegetated roof retrofits are described in Profile Sheet RR-3 of Schueler et al. (2007). |
| Local Building Codes | Building codes often differ in each municipality, and local planning and zoning authorities should be consulted to obtain proper permits. In addition, the vegetated roof design should comply with the Virginia Uniform Statewide Building Code with respect to roof drains and emergency overflow devices. |
| Construction Cost | When viewed strictly as stormwater treatment systems, vegetated roofs can cost between $12 and $25 per square foot, ranking them among the costliest stormwater practices available (Moran et al. 2005; Schueler et al. 2007). These cost analyses, however, do not include life cycle cost savings relating to increased energy efficiency and increased roof longevity due, in part, to the insulating feature of the planting medium (see Risks of Roof Leaks below). These cost saving and energy efficiency benefits could make vegetative roofs a more attractive investment, and some communities offer density bonuses or other incentives for installing vegetated roofs. |
| Risks of Roof Leaks | Well designed and installed vegetated roofs should have fewer problems with roof leaks than traditional roofs due to the protective layer provided by the vegetated roof: ultraviolet light blockage, less temperature-induced expansion and contraction of waterproofing material seams, and projectile blockage. For a discussion on how to properly manage risk in vegetated roof installations, see Chapter 9 in Weiler and Scholz-Barth (2009). |

## 4.0 Stormwater Performance Summary

The overall stormwater functions of vegetated roofs are summarized in Table P-FIL-02-2.

| Table P-FIL-02-2 Summary of Stormwater Functions Provided by Vegetated Roofs | | |
|---|---|---|
| **Stormwater Function** | **Level 1 Design** | **Level 2 Design** |
| Annual Runoff Reduction Volume | 45% | 60% |
| Total Phosphorus Event Mean Concentration (EMC) Reduction[1] by Best Management Practice (BMP) Treatment Process | 0 | 0 |
| Total Phosphorus Mass Load Removal | 45% | 60% |
| Total Nitrogen EMC Reduction[1] by BMP Treatment Process | 0 | 0 |
| Total Nitrogen Mass Load Removal | 45% | 60% |
| Channel Protection and Flood Mitigation[2] | Use the following Curve Numbers for Design Storm events: 1-year storm = 64; 2-year storm = 66; 10-year storm = 72; 100-year storm = 75 | |

**Notes:**

Source: Center for Watershed Protection (CWP) and Chesapeake Stormwater Network (CSN) 2008; CWP 2007.

1. Moran et al. (2004) and Clark et al. (2008) indicate no nutrient reduction or even negative nutrient reduction (due to leaching from the medium) in early stages of vegetated roof development.
2. See Miller 2008, NVRC 2007, and Maryland Department of Environment 2008.

## 5.0 Design Criteria

The design goals of vegetated roofs are to hold water for runoff storage, support plant life, minimize total suspended solids and nutrients export, maintain high permeability, and maintain minimum weight (North Carolina Department of Environmental Quality [NCDEQ] 2017).

To this end, designers may choose the baseline design (Level 1) or an enhanced design (Level 2) that maximizes nutrient and runoff reduction. In general, most intensive vegetated roof designs will automatically qualify as Level 2. Table P-FIL-02-3 lists the design criteria for Level 1 and 2 designs.

| Table P-FIL-02-3 Vegetated Roof Design Guidance | |
|---|---|
| **Level 1 Design** | **Level 2 Design** |
| **Runoff Reduction: 45; Total Phosphorous: 0; Total Nitrogen: 0** | **Runoff Reduction: 60; Total Phosphorous: 0; Total Nitrogen: 0** |
| Tv = 1.0 (Rv)[1] (A)/12 | Tv = 1.1 (Rv)1 (A)/12 |
| Depth of media up to 4 inches | Medium depth 4 to 8 inches |
| Drainage System | 2-inch stone drainage layer |
| No more than 20% organic matter in media | No more than 10% organic matter in media |
| All designs must conform to ASTM International (ASTM) Green (Vegetated) Roof Standards (2005). | |

**Note:**

1. Rv represents the runoff coefficient for a conventional roof, which will usually be 0.95. The runoff reduction rate applied to the vegetated roof is for “capturing” the treatment volume (Tv) compared to what a conventional roof would produce as runoff.

### 5.1 Overall Sizing

The required size or depth of a vegetated roof will depend on the porosity and hydraulic conductivity of the growing medium and the underlying drainage materials. Site designers and planners should consult with vegetated roof manufacturers and material suppliers for specific sizing guidelines. As a general sizing rule, the following equation can be used to determine the required water quality treatment storage volume retained by a vegetated roof:

***Equation P-FIL-02-1***

$$\text{Vegetated Roof Volume} = (RA*D*n)/12$$

Where:

RA Storage Volume = roof area storage volume provided in the media (cubic feet).

RA = vegetated roof area (square feet).

D = media depth (inches).

$n$ = media porosity (usually 0.25, but consult manufacturer specifications).

The resulting RA storage volume can then be compared to the required Tv for the entire rooftop area (including all non-vegetated areas) to determine whether it meets or exceeds the required Tv for Level 1 or Level 2 design, as shown in Table P-FIL-02-3. Vegetated roofs are not typically designed to capture runoff from other areas of the roof and are considered Level 1 or Level 2 based on the Tv storage volume for the rainfall depth landing on the portion of roof being designed.

### 5.2 Pre-treatment

Pre-treatment is not needed for vegetated roofs.

### 5.3 Elements of a Vegetated Roof System

A vegetated roof is composed of up to eight different systems or layers, from bottom to top, combined to protect the roof and maintain a vigorous vegetation cover. See Table P-FIL-02-4 below.

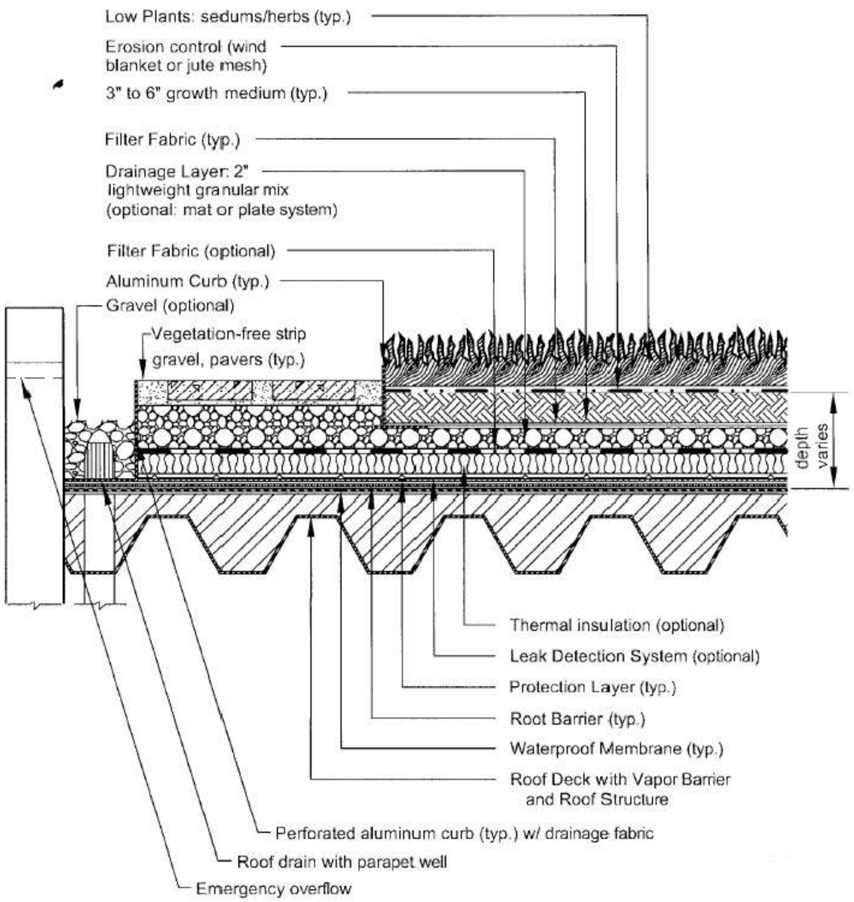
Designers can employ a wide range of materials for each layer, which can differ in cost, performance, and structural load. The entire system must be assessed to meet design requirements. Some manufacturers offer proprietary vegetated roofing systems, whereas in other cases, the designer or architect must assemble their own system, in which case they are advised to consult Weiler and Scholz-Barth (2009), Snodgrass and Snodgrass (2006), and Dunnett and Kingsbury (2004). See Figure P-FIL-02-1 and Figure P-FIL-02-2 for visual depictions of a vegetated roof system.

| Table P-FIL-02-4 Vegetated Roof Layer Composition | |
|---|---|
| **Layer** | **Composition** |
| Deck Layer | The roof deck layer is the foundation of a vegetated roof. It may be composed of concrete, wood, metal, plastic, gypsum, or a composite material. The type of deck material determines the strength, load-bearing capacity, longevity, and potential need for insulation and waterproofing in the vegetated roof system. |
| Waterproofing Layer | All vegetated roof systems must include an effective and reliable waterproofing layer to prevent water damage through the deck layer. The designer should carefully consider specification and installation of the waterproofing system, as prevention is almost always less costly than repair. The following are key considerations for specifying and installing waterproofing membranes (NCDEQ 2017):<br>1. Specify at least a double-ply waterproofing membrane of high quality or a specialty green roof product such as a heavy-duty, single-ply membrane with felt layer.<br>2. Protect the waterproof membrane throughout construction from nails, screws, or cutting implements. Consider using a drainage mat to provide a physical block for shovels or other gardening implements that could poke holes.<br>3. Test the integrity of the waterproofing layer in place before installing any other features. See Section 6.1 for suggestions on membrane testing methods.<br>4. Cover the waterproof membrane completely with either flashing or growing medium. Any exposed membrane is susceptible to ultraviolet light damage.<br>5. Seal thoroughly around all roof protrusions (e.g., parapets, skylights, mechanical systems, vents). For new construction, roof design should minimize protrusions when a green roof is to be built. Protrusions provide opportunities for leaks in any roof.<br>6. Use a commercial root barrier with the waterproof membrane. Root barriers may be physical or chemical. Some synthetic drainage mats are available with the root barrier already incorporated. Copper, due to its harmful impact on aquatic health, must never be used in root barrier products.<br>The waterproofing layer must be 100% waterproof and have an expected life span as long as any other element of the vegetated roof system. The design of the waterproofing layer should also consider methods of leak detection. (See Section 6.0, Construction Specifications). |
| Insulation Layer | Many vegetated rooftops contain an insulation layer usually located above (but sometimes below) the waterproofing layer. The insulation increases the energy efficiency of the building and/or protects the roof deck (particularly for metal roofs). According to Snodgrass and Snodgrass (2006), the trend is to install insulation on the outside of the building, in part to avoid mildew problems. |

| Table P-FIL-02-4 Vegetated Roof Layer Composition | |
|---|---|
| **Layer** | **Composition** |
| Root Barrier | The next layer of a vegetated roof system is a root barrier that protects the waterproofing membrane from root penetration. A wide range of root barrier options is described in Weiler and Scholz-Barth (2009). Chemical root barriers or physical root barriers impregnated with pesticides, metals, or other chemicals that could leach into stormwater runoff should be avoided. Similarly, fibrous systems should be avoided because roots tend to adhere and tangle in the fibers, allowing possible penetration of the waterproofing layer. |
| Drainage Layer and Drainage System | A drainage layer is placed between the root barrier and the growing medium to convey excess water from the vegetation root zone. The drainage layer should consist of synthetic or inorganic materials (e.g., gravel, recycled polyethylene) that can retain moisture while also providing efficient drainage. A wide range of prefabricated water cups or plastic modules can be used as well as a traditional system of protected roof drains, conductors, and roof leader. Extended retention of water in this layer should be avoided due to potential root rot. The required depth of the drainage layer is governed by both the required stormwater storage capacity and the structural capacity of the rooftop. ASTM Standards E2396 and E2398 can be used to evaluate alternative material specifications.<br><br>Conveyance and Overflow: The drainage should be designed to convey the 10-year storm without water backing up into the growing medium. The drainage layer should convey flow to an outlet or overflow system such as a traditional rooftop drainage system with inlets set slightly above the elevation of the vegetated roof surface. Roof drains adjacent to the growing medium should be boxed and protected by flashing extending at least 3 inches above the growing medium to prevent clogging. |
| Root-Permeable Filter Fabric | A semi-permeable polypropylene filter fabric is normally placed between the drainage layer and the growing medium of a conventional system (not a tray or hybrid system) to prevent the medium from migrating into the drainage layer and clogging it. Proper installation of the fabric is crucial to avoid pooling of water in the drainage layer and leading to root rot. |

| Table P-FIL-02-4 Vegetated Roof Layer Composition | |
|---|---|
| **Layer** | **Composition** |
| Growing Media | Growing medium for a vegetated roof is typically 2.5 to 8 inches deep. The recommended growing medium for extensive vegetated roofs is composed of approximately 80% to 90% lightweight inorganic materials, such as expanded slates, shales or clays, pumice, scoria, or other similar materials. The remaining medium should contain no more than 20% organic matter, normally well-aged compost; see BMP P-FIL-08, Soil Compost Amendment. The percentage of organic matter should be limited because it can clog the permeable filter fabric and lead to increased weed growth while also leaching nutrients into the runoff from the roof. The growing medium should have a maximum water retention capacity of approximately 30%.<br><br>It is advisable to mix the medium in a batch facility before delivery to the roof. More information on growing medium is provided in Weiler and Scholz-Barth (2009) and Snodgrass and Snodgrass (2006). |
| Vegetation and Surface Cover | The top layer of a vegetated roof consists of shallow-rooted, perennial, succulent plants that can withstand harsh conditions at the roof surface. Plant selection for vegetated rooftops is an integral design consideration that is governed by local climate and design objectives. A planting plan showing a minimum of 80% plant coverage must be prepared for a vegetated roof by a landscape architect, botanist, or other professional experienced with vegetated roofs, and it must be reviewed and approved by the local development review authority.<br><br>Guidance on selecting the appropriate vegetated roof plants for hardiness zones in the Chesapeake Bay watershed is provided in Snodgrass and Snodgrass (2006). A mix of drought-tolerant Sedum species and accent plants can enhance the visual amenity value of a vegetated roof. |

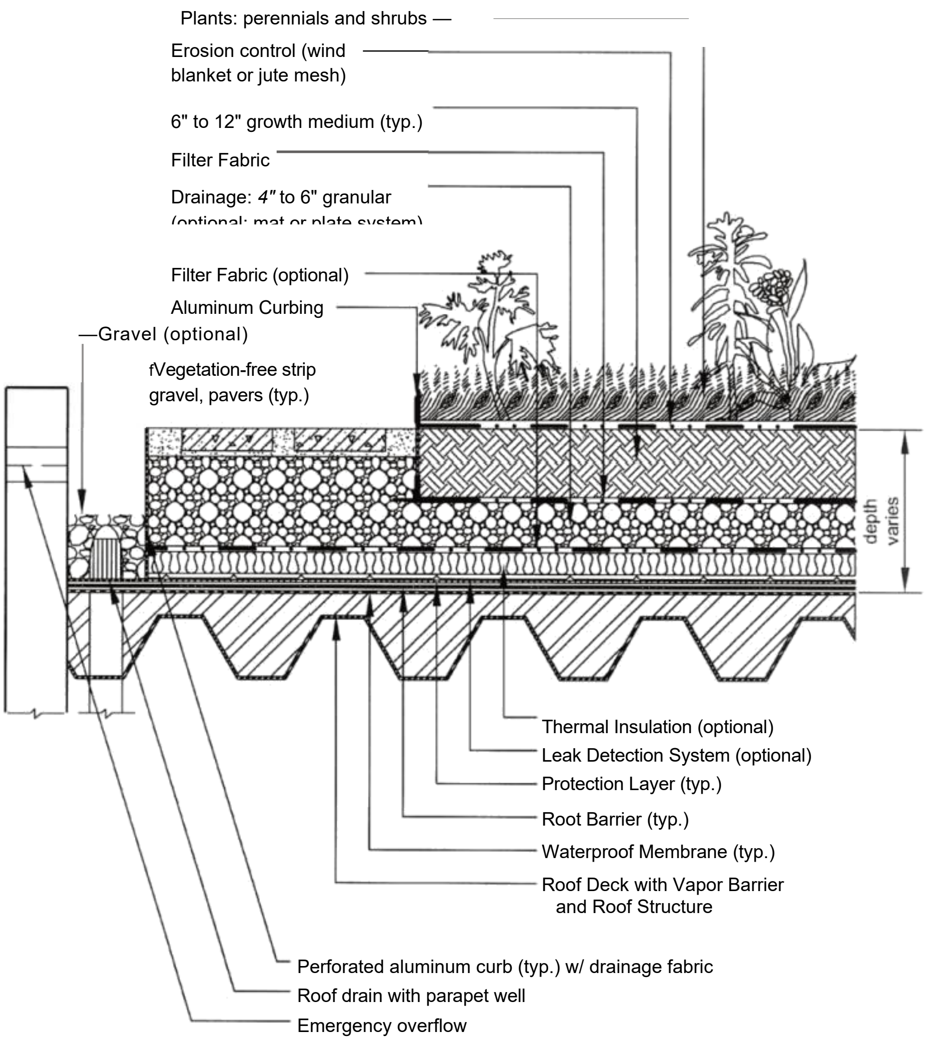
**Figure P-FIL-02-1 Typical Section – Extensive Vegetated Roof**




*Source: NVRC 2007*

**Commented [CM1]:** FIGURE: Arcadis update growing media to reflect 6 inches to 4 feet for intensive vegetated roofs and 4-6 inches for extensive vegetated roofs per Section 2.0 text

Figure P-FIL-02-2 Typical Section – Intensive Vegetated Roof




Source: NVRC 2007

### 5.4 Vegetation and Surface Cover

The primary ground cover for most vegetated roof installations is a hardy, low-growing succulent such as *Sedum, Delosperma, Talinum, Semperivum,* or *Hieracium* that is matched to the local climate conditions and can tolerate the difficult growing conditions of building rooftops (Snodgrass and Snodgrass 2006). Much of the Chesapeake Bay watershed lies within U.S. Department of Agriculture Plant Hardiness Zone 7, although some northern and western areas of the watershed are within the colder Hardiness Zone 6, and some areas in the extreme southeastern portion of the watershed are within the slightly warmer Hardiness Zone 8 (American Horticultural Society 2003).

Table P-FIL-02-5 contains a list of some common vegetated roof plant species that work well in the Chesapeake Bay watershed. Designers may also want to directly contact the short list of mid-Atlantic nurseries for vegetated roof plant recommendations and availability. Designers should encourage the use of at least five species of plants to accommodate seasonal and environmental variation or shifts.

Plant choices can be much more diverse for deeper intensive vegetated roof systems. Herbs, forbs, grasses, shrubs, and even trees can be used, but designers should understand that these carry higher watering, weeding, and landscape maintenance requirements.

The species and layout of the planting plan should reflect the location of building in terms of its height, exposure to wind, snow loading, heat stress, orientation to the sun, and shading by surrounding buildings. In addition, plants should be selected that are fire-resistant and able to withstand heat, cold, and high winds.

**Table P-FIL-02-5 Ground Covers for Vegetated Roofs in Zones 6 and 7 of the Chesapeake Bay Watershed**

| Plant Hardiness Zone 7 | Plant Hardiness Zone 6 |
|---|---|
| *Delosperma cooperi* 'Tiffendell Magenta' ('Tiffindell Magenta' Ice Plant) | *Delosperma cooperi* (Trailing Ice Plant, Hardy Ice Plant, Pink Carpet) |
| *Hieracium lanatum* (Hairy Hawkweed, Leafy Hawkweed, Woolly Hawkweed) | *Delosperma ecklonis var.latifolia* (Giant Ice Plant) |
| *Sedum lineare 'Variegatum'* (Variegated Carpet Sedum) | *Hieracium villosum* (Shaggy Hawkweed) |
| *Sedum makinoi* (Japanese Stonecrop) | *Orostachys boehmeri* (Duncecap) |
| *Sedum tetractinum* (Chinese Stonecrop) | *Sedum hispanicum* (Spanish Stonecrop) |
| *Sedum stoloniferum* (Stolon Stonecrop) | *Sedum pluricaule var. ezawe* (Island of Sakhalin Stonecrop) |
| | *Sedum urvillei* (Watchchain Sedum) |

**Note:**

Landscape architects should choose species based on shade tolerance, ability to sow, foliage height, and spreading rate. See Snodgrass and Snodgrass (2006) for a definitive list of vegetated roof plants, including accent plants.

- Designers should also match species to optimize the expected rooting depth of the growing medium, which can also provide enough lateral growth to stabilize the growing medium surface. The planting plan should usually include several accent plants to provide diversity and seasonal color. For a comprehensive resource on vegetated roof plant selection, consult Snodgrass and Snodgrass (2006).
- It is also important to note that most vegetated roof plant species will *not* be native to the Chesapeake Bay watershed (which is in contrast to *native* plant recommendations for other stormwater practices, such as bioretention and constructed wetlands).
- Given the limited number of vegetated roof plant nurseries in the region, designers should order plants or pre- grown trays at least 6 months (and up to 12 months) before the expected planting or installation date. It is also advisable to have plant materials contract-grown, when feasible.

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- When appropriate species are selected, and depending on installation date, most vegetated roofs in the Chesapeake Bay watershed will not require supplemental irrigation, except for possible temporary irrigation during the hot, dry summer months as the vegetated roof is established. More frequent irrigation will likely be required to achieve establishment of a plug-planted system. The planting window extends from the spring to early fall, although it is important to allow plants to root thoroughly before the first killing frost.
- Plants can be established using cuttings; plugs; mats; and, more rarely, seeding or containers. Several vendors also sell mats, rolls, or proprietary vegetated roof planting modules. For the pros and cons of each method, see Snodgrass and Snodgrass (2006).
- The goal for vegetated roof systems designed for stormwater management is to establish a full and vigorous cover of low-maintenance vegetation (i.e., minimal mowing, trimming, and weeding) that is self-sustaining.

The vegetated roof design should include non-vegetated walkways (e.g., permeable paver blocks) to allow for easy access to the vegetated areas of the roof for weeding and making spot repairs. Installation of walkways should be coordinated with the drainage design.

**5.5 Material Specifications**

Standards specifications for North American vegetated roofs continue to evolve, and no universal material specifications exist that cover the wide range of roof types and system components currently available. ASTM has issued several overarching vegetated roof standards, which are described and referenced in Table P-FIL-02-6.

**Table P-FIL-02-6 Extensive Vegetated Roof Material Specifications**

| Material | Specification |
|---|---|
| Roof | Structural Capacity should conform to ASTM Standard E-2397-05, Practice for Determination of Live Loads and Dead Loads Associated with Green (Vegetated) Roof Systems. In addition, use standard test methods described in ASTM Standard E2398-05 for Water Capture and Media Retention of Geocomposite Drain Layers for Green (Vegetated) Roof Systems, and ASTM Standard E2399-05 for Maximum Media Density for Dead Load Analysis. |
| Waterproof Membrane | See Chapter 6 of Weiler and Scholz-Barth (2009) for waterproofing options designed to convey water horizontally across the roof surface to drains or gutters. This layer may sometimes act as a root barrier. |
| Root Barrier | Impermeable liner that impedes root penetration of the membrane. |
| Drainage Layer | Use 1- to 2-inch layer of clean, washed granular material such as ASTM Standard D 448 size No. 8 stone. Roof drains and emergency overflow should be designed in accordance with the Virginia Uniform Statewide Building Code. |
| Filter Fabric | Needled, non-woven, polypropylene geotextile. Density (ASTM Standard D3776) greater than 16 ounces per square yard, or approved equivalent. Puncture resistance (ASTM Standard D4833) greater than 220 pounds or approved equivalent. |

| Table P-FIL-02-6 Extensive Vegetated Roof Material Specifications | |
|---|---|
| **Material** | **Specification** |
| Growth Media | Use 80% lightweight inorganic materials and 20% organic matter (e.g., well-aged compost). Medium should have a maximum water retention capacity of approximately 30%. Medium should provide sufficient nutrients and water-holding capacity to support the proposed plant materials. Determine acceptable saturated water permeability using ASTM Standard E2396-05. |
| Plant Materials | Use sedum, herbaceous plants, and perennial grasses that are shallow-rooted, self- sustaining, and tolerant of direct sunlight, drought, wind, and frost. See ASTM Standard E2400-06, Guide for Selection, Installation and Maintenance of Plants for Green (Vegetated) Roof Systems. |

| Table P-FIL-02-7 Extensive Vegetated Roof Additional Design Guidance | |
|---|---|
| **Feature** | **Design Guidance** |
| Structural Capacity of the Roof/Weight | Weight is one of the main factors controlling the feasibility and cost of a green roof. Vegetated roofs can be limited by the additional weight of the fully saturated soil and plants and should be accounted for in the structural design. The designer should consult with a licensed structural engineer or architect to ensure that the building will be able to support the additional live and dead structural load. Dead loads should assume completely saturated media (in lieu of the ASTM weight at the maximum medium water retention) (NCDEQ 2017).<br>The weight of the green roof should be determined per ASTM Standard E2397-11, Standard Practice for Determination of Dead Loads and Live Loads associated with Green Roof Systems, and ASTM Standard E2399-11, Standard Test Method for Maximum Media Density for Dead Load Analysis of Green Roof Systems (NCDEQ 2017). |
| Karst Terrain | Vegetated roofs are ideal stormwater control measures for karst terrain, although it is advisable to direct downspout discharges at least 15 feet away from the building foundation to minimize the risk of sinkhole formation. |
| Coastal Plain Applications | Vegetated roofs are an acceptable runoff reduction practice for the coastal plain, but they have a limited water quality function because rooftops are not a major loading source for nutrients or bacteria. Designers should also choose plant materials that can tolerate drought and salt spray. |
| Cold Climate and Winter Performance | Several design adaptations may be needed for vegetated roofs. The most important is to match the plant species to the appropriate plant hardiness zone. In parts of the Chesapeake Bay watershed with colder climates, vegetated roofs should be designed such that the growing medium is not subject to freeze-thaw and to provide greater structural capacity to account for winter snow loads. |

| Table P-FIL-02-7 Extensive Vegetated Roof Additional Design Guidance | |
|---|---|
| **Feature** | **Design Guidance** |
| Acid Rain | Much of the Chesapeake Bay watershed experiences acid rain, with rainfall pH ranging from 3.9 to 5.1. Research has shown that vegetated roof growing medium can neutralize acid rain (Berhage et al. 2007), but it is not clear whether acid rain will impair plant growth or leach minerals from the growing medium. |

## 6.0 Construction Specifications

### 6.1 Construction Sequence

Given the diversity of extensive vegetated roof designs, there is no typical step-by-step construction sequence for proper installation. However, follow these general construction considerations:

- Construct the roof deck with the appropriate slope and material.
- Install the waterproofing method according to manufacturer's specifications.
- Conduct a test to ensure the system is watertight.

The following two methods are used for testing waterproof membranes for leaks (NCDEQ 2017):

- **Flood test**: For flat roofs only. Fill the roof with water and measure water level drop over approximately 24 hours before installing the drainage layer, growing medium, or vegetation. One problem with this method is that very small leaks can be missed. Also, this method can cause damage to the roof if the membrane leaks.
- **Electric Field Vector Mapping (EFVM)**: EFVM is a non-destructive and non-invasive method and may be performed on a sloped roof. A thin layer of water is spread over the geomembrane and a low electrical voltage is applied under the membrane. A leak is present if voltage is detected. The technology indicates the location of the breach, and may also identify future failures (e.g., small punctures that may not have yet fully penetrated the membrane surface).
- Add additional system components (e.g., insulation, root barrier, drainage layer and interior drainage system, and filter fabric) or modules, taking care not to damage the waterproofing. Drain collars and protective flashing should be installed to ensure free flow of excess stormwater.
- The growing medium should be mixed before delivery to the site. Medium should be spread evenly over the filter fabric surface. Allow for some settlement by adding additional medium depth. The growing medium should be covered until planting to prevent weeds from growing. Sheets of exterior-grade plywood can also be laid over the growing medium to accommodate foot or wheelbarrow traffic. Foot traffic and equipment traffic should be limited over the growing medium to reduce compaction.
- The growing medium should be moistened before planting and then planted with the ground cover and other plant materials per the planting plan or in accordance with ASTM Standard E2400. Plants should be watered and the medium saturated such that water is running from all the vegetated sections of the roof immediately after installation and routinely during establishment.
- It generally takes 12 to 18 months to fully establish the vegetated roof. An initial fertilization using slow-release fertilizer (e.g., 14-14-14) with adequate minerals is often needed to support growth; (pre-grown systems will often include the required fertilization required for establishment). Temporary watering may also be needed during the first summer if drought conditions persist. Hand weeding is also critical in the first 2 years; (see Table 10-1 of Weiler and Scholz-Barth [2009] for a photo guide of common rooftop weeds).

- Most construction contracts should contain a Care and Replacement Warranty that specifies a 75% minimum survival after the first growing season of species planted and a minimum effective vegetative ground cover of 75% for flat roofs and 90% for pitched roofs.

**6.2 Construction Inspection**

Inspections during construction are needed to ensure that the vegetated roof is built in accordance with these specifications. Detailed inspection checklists should be used that include signoffs by qualified individuals at critical stages of construction and confirmation that the contractor's interpretation of the plan is consistent with the intent of the designer and/or manufacturer.

An experienced installer should be retained to construct the vegetated roof system. The vegetated roof should be constructed in sections for easier inspection and maintenance access to the membrane and roof drains. Careful construction supervision is needed during the following steps of vegetated roof installation:

- During placement of the waterproofing layer to ensure that it is properly installed and watertight;
- During placement of the drainage layer and drainage system;
- During placement of the growing medium to confirm that it meets the specifications and is applied to the correct depth;
- Upon installation of plants to ensure they conform to the planting plan; and
- Before issuing use and occupancy approvals.

An additional inspection should be conducted at the end of the first or second growing season to ensure that the desired surface cover specified in the Care and Replacement Warranty has been achieved.

Upon final inspection and acceptance, log the Global Positioning System coordinates for the vegetated roof and submit them for entry into the local BMP maintenance tracking database.

## 7.0 Operations and Maintenance Considerations

Maintenance of a vegetated roof must be ensured through written documentation and an enforceable mechanism as per the Virginia Erosion and Stormwater Management Regulation (9VAC25-875-535) between the VESMP authority and the property owner or manager. Documentation should include provisions for adequate notification or authorization for access to conduct inspections.

In addition, the vegetated roof should be hand-weeded to remove invasive or volunteer plants, and plants/medium should be added to repair bare areas (refer to ASTM Standard E2400). Many practitioners also recommend an annual application of slow-release fertilizer in the first 5 years after the vegetated roof is installed.

If a roof leak is suspected, it is advisable to perform an electric leak survey (i.e., EFVM) to pinpoint the exact location, make localized repairs, and then reestablish system components and ground cover.

The use of herbicides, insecticides, and fungicides should be avoided because their presence could hasten degradation of the waterproof membrane. Also, power washing and other exterior maintenance operations should be avoided so that cleaning agents and other chemicals do not harm the vegetated roof plant communities.

An example maintenance inspection checklist for vegetated roofs is provided in Appendix H, BMP Inspection Checklist.

Records of operation and maintenance must be kept in a known set location and must be available upon request.

| Table P-FIL-02-8 Typical Maintenance Activities Associated with Vegetated Roofs | |
|---|---|
| **Maintenance Activity** | **Schedule** |
| Water to promote plant growth and survival. | As Needed (following construction) |
| Inspect the vegetated roof and replace any dead or dying vegetation. | |
| Inspect the waterproof membrane for leaking or cracks. Apply annual fertilization (first 5 years). | Semi-Annually |
| Weed to remove invasive plants. | |
| Inspect roof drains, scuppers, and gutters to ensure they are not overgrown or contain organic matter deposits. Remove any accumulated organic matter or debris. | |
| Inspect the green roof for dead, dying, or invasive vegetation. Plant replacement vegetation as needed. | |

Source: NCDEQ 2017.

| Table P-FIL-02-9 Potential Stormwater Control Measure (SCM) Problems and Remedies | | |
|---|---|---|
| **SCM Element** | **Potential Problem** | **How to Remediate the Problem** |
| Plant materials | Weeds are present. | Remove the weeds by hand. For repeat growth of the same weed, systemic weed killer may be applied to the single plant using a cotton swab or paintbrush. Weed killer should not be sprayed. |
| | Plants are dead, diseased, or dying. | Determine the source of the problem (e.g., soils, hydrology, disease). Remedy the problem and replace plants. An alternative species may be required. |
| Growing media | Ponding occurs after the first few rain events. | If not washed before mixing and installation, some aggregates may create a thin surface crust. The crust may be removed by light tilling and should not recur. If it does, consult with the supplier. |
| | Persistent ponding occurs. | Check the particle size distribution of a sample(s) from the area susceptible to ponding. The sample should be representative of the full substrate depth. If particles less than 1 millimeter in diameter exceed 5% by mass, excessive fine particulates are likely the problem. Consult the supplier. The medium may need to be replaced. |
| | Substantial loss of material over time. | Loss can result because of excessive organic matter (>20% by volume) in the medium. Assess whether a reduced medium depth would compromise stormwater retention and hinder permit compliance. Check with a horticultural consultant regarding implications on plant health. Plants should not be sustained by regular fertilizer addition. If needed (and feasible), amend with additional medium. |
| Gutters, drains, and spouts | Clogging has occurred. | Remove leaves, debris, and other foreign matter and dispose of in a manner that will not impact streams or the SCM. Inspect permeable edging and clear if needed. |

| Table P-FIL-02-9 Potential Stormwater Control Measure (SCM) Problems and Remedies | | |
|---|---|---|
| SCM Element | Potential Problem | How to Remediate the Problem |
| | Damage has occurred. | Repair or replace the damaged conveyances. |

Source: NCDEQ 2017.

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# P-FIL-04 Infiltration Practices

## 1.0 Definition

Infiltration practices use temporary surface or underground storage to allow incoming stormwater runoff to exfiltrate into underlying soils. Runoff first passes through multiple pretreatment mechanisms to trap sediment and organic matter before it reaches the practice. As the stormwater penetrates the underlying soil, chemical and physical adsorption processes remove pollutants. Infiltration practices have the greatest runoff reduction capability of any stormwater practice and are suitable for use in residential and other urban areas where *measured* soil permeability rates exceed 1/2 inch per hour. To prevent possible groundwater contamination, infiltration should not be used at sites designated as stormwater hotspots.

## 2.0 Purpose and Applicability of Best Management Practice

Since infiltration practices have a very high runoff reduction capability, they should always be considered when initially evaluating a site. Designers should evaluate the range of soil properties during initial site layout and seek to configure the site to conserve and protect the soils with the greatest recharge and infiltration rates. In particular, areas of Hydrologic Soil Group A or B soils shown on U.S. Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS) soil surveys should be considered as primary locations for infiltration practices. At this point, designers should carefully identify and evaluate constraints on infiltration, as follows:

***Contributing Drainage Area.*** The maximum contributing drainage area (CDA) to an individual infiltration practice should be less than 2 acres and as close to 100% impervious as possible. This specification covers three scales of infiltration practices: Micro-infiltration (250 to 2,500 square feet of CDA); small-scale infiltration (2,500 to 20,000 square feet of CDA); and conventional infiltration (20,000 to 100,000 square feet of CDA). The design, pretreatment and maintenance requirements differ, depending on the scale at which infiltration is applied. See Table P-FIL-04-1 for a summary.

**Table P-FIL-04-1 The Three Design Scales for Infiltration Practices**

| Design Factor | Micro-Infiltration | Small-Scale Infiltration | Conventional Infiltration |
|---|---|---|---|
| Impervious Area Treated | 250 to 2,500 square feet | 2,500 to 20,000 square feet | 20,000 to 100,000 square feet |
| Typical Practices | Dry Well<br>French Drain Paving Blocks | Infiltration Trench<br>Permeable Paving[1] | Infiltration Trench<br>Infiltration Basin |
| Minimum Infiltration Rate | 1/2 inch per hour field verified | | |
| Design Infiltration Rate | 50% of measured rate | | |
| Observation Well | No | Yes | Yes |
| Type of Pretreatment | External (leaf screens, grass filter strip, etc.) | Vegetated filter strip or grass channel, forebay, etc. | Pretreatment cell, forebay |
| Depth Dimensions | Maximum 3-foot depth | Maximum 5-foot depth | Maximum 6-foot depth |

## Table P-FIL-04-1 The Three Design Scales for Infiltration Practices

| Design Factor | Micro-Infiltration | Small-Scale Infiltration | Conventional Infiltration |
|---|---|---|---|
| Underground Injection Control Permit Needed? | No | No | Only if the surface width is less than the maximum depth |
| Head Required | Nominal: 1 to 3 feet | Moderate: 1 to 5 feet | Moderate: 2 to 6 feet |
| Underdrain Requirements? | An elevated underdrain only on marginal soils | None required | Back up underdrain |
| Required Soil Tests | Based on surface area of practice; minimum of one soil profile, one infiltration tests per location. Refer Appendix C. | Varies based on surface area of practice Refer to Appendix C. | Varies based on surface area of practice. Refer to Appendix C. |
| Building Setbacks | 10 feet ~~downgradient2~~ upgradient of building | 10 feet downgradient 50 feet upgradient of building | 25 feet downgradient and 100 feet upgradient of building |

**Notes:**

1. Although permeable pavement is an infiltration practice, a more detailed specification is provided in BMP P-FIL-03, Permeable Pavement.
2. Note that the building setbacks are intended for simple foundations. The use of a dry well or French drain adjacent to an in-ground basement or finished floor area or any building should be carefully designed and coordinated with the design of the structure's waterproofing system (foundation drains, etc.) or avoided altogether.

## Table P-FIL-04-2 Feasibility Criteria

| Site Feature | Requirement |
|---|---|
| Site Topography | Unless slope stability calculations demonstrate otherwise, infiltration practices should be located a minimum horizontal distance of 200 feet from downgradient slopes greater than 20%. The average slope of the contributing drainage areas should be less than 15%. |
| Practice Slope | The bottom of an infiltration practice should be flat (i.e., 0% longitudinal slope) to enable even distribution and infiltration of stormwater, although a maximum longitudinal slope of 1% is permissible if an underdrain is employed. Lateral slopes should be 0%. |
| Minimum Hydraulic Head | The elevation difference needed to operate a micro-scale infiltration practice is nominal. However, 2 feet or more of head may be needed to drive small-scale and conventional infiltration practices. |

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| Table P-FIL-04-2 Feasibility Criteria | |
|---|---|
| **Site Feature** | **Requirement** |
| Minimum Depth to Water Table or Bedrock | A minimum vertical distance of 2 feet must be provided between the bottom of the infiltration practice and the seasonal high-water table or bedrock layer. The seasonal high-water table (SHWT) is defined as the shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero for a significant period (more than a few weeks). Other factors that influence the determination of the SHWT include (but are not limited to) natural vegetation (overstory and understory), soil colors, soil mottles (an indicator of water-saturated anaerobic conditions), depth to the root zone (free standing water is the greatest impediment to root growth), and depth to the clay layer (hardpan). All of the above indicators may not be present in the soil. |
| Soils | Native soils in proposed infiltration areas must have a minimum infiltration rate (permeability or hydraulic conductivity per Appendix C, Soil Characterization and Infiltration Testing) of 1/2 inch per hour; (typically Hydrologic Soil Group A and B soils meet this criterion). Initially, soil infiltration rates can be estimated from USDA- NRCS soil data, but they must be confirmed by an onsite infiltration evaluation. |
| Use on Urban Soils/Redevelopment Sites | Sites that have been previously graded or disturbed do not retain their original soil permeability due to compaction. Therefore, such sites are not good candidates for infiltration practices. In addition, infiltration practices should never be situated above fill soils. |
| Dry Weather Flows | Infiltration practices should not be used on sites receiving regular dry weather flows from sump pumps, irrigation nuisance water, and similar kinds of flows. |
| High Loading Situations | Infiltration practices are not intended to treat sites with high sediment or trash/debris loads, because such loads will cause the practice to clog and fail. |
| Hotspots and Groundwater Protection | Table P-FIL-04-5 presents a list of potential stormwater hotspots that pose a risk of groundwater contamination. Infiltration of runoff from designated hotspots is highly restricted or prohibited. |

| Table P-FIL-04-3 Infiltration Offset Guidance | | |
|---|---|---|
| **Feature** | **Offset*** | **Notes** |
| Existing buildings, bridge supports, and similar structures | 25-foot horizontal | Closer offsets may be considered on a case-by-case basis where impermeable liners are specified by the designer as a part of the practice.<br>Infiltration practices should not be hydraulically connected to structure foundations or pavement, to avoid harmful seepage. Setbacks to structures and roads vary based on the scale of infiltration. |
| Property Lines | 10-foot horizontal | |
| Septic System Drain Fields | 50-foot horizontal | |

| Table P-FIL-04-3 Infiltration Offset Guidance | | |
|---|---|---|
| **Feature** | **Offset*** | **Notes** |
| Private Water Wells | 100-foot horizontal | |
| Wet and Dry Utilities | 5-foot horizontal | |

**Note:**

* Local subdivision and zoning ordinances and design criteria should be consulted to determine minimum setbacks. Offsets are measured from the toe of the embankment on the downstream side and the design high water on the upstream side.

***Site-Specific Considerations***. Infiltration practices can be applied to most land uses that have measured soil infiltration rates that exceed 1/2 inch per hour. However, there is no single infiltration application that fits every development situation. The nature of the actual design application depends on four key design factors, described below:

1. The first factor is the **design scale** at which infiltration will be applied:
   - **Micro-infiltration** is intended for residential rooftop disconnection, rooftop rainwater harvesting systems, or other small-scale application (250 to 2,500 square feet of impervious area treated).
   - **Small-scale infiltration** is intended for residential and/or small commercial applications that meet the feasibility criteria noted above.
   - **Conventional infiltration** can be considered for most typical development and redevelopment applications and therefore has more rigorous site selection and feasibility criteria.

   Table P-FIL-04-1 compares different design approaches and requirements associated with each infiltration scale.
2. The second key design factor relates to the **mode** (or method) of temporarily storing runoff prior to infiltration – either on the surface or in an underground trench. When storing runoff on the surface (e.g., an infiltration basin), the maximum depth should be no greater than 1 foot. However, if pretreatment cells are used, a maximum depth of 2 feet is permissible if appropriate safety features are included. In the underground mode, runoff is stored in the voids of the stones, and infiltrates into the underlying soil matrix. Perforated corrugated metal pipe, plastic pipe, concrete arch pipe, or comparable materials can be used in conjunction with the stone to increase the available temporary underground storage. In some instances, a combination of filtration and infiltration cells can be installed in the floor of a dry extended detention (ED) pond.
3. The third design factor relates to the degree of **confidence that exfiltration can be maintained** over time, given the measured infiltration rate for the subsoils at the practice location and the anticipated land uses. This factor helps determine whether infiltration is an appropriate practice for the site. Alternative practices that provide comparable volume and pollutant reduction include bioretention, the dry swale, permeable pavement, etc., all of which can incorporate an underdrain.
4. The final factor is whether the infiltration practice will be designed as an **on-line or off-line facility**, as this determines the nature of conveyance and overflow mechanisms needed. Off-line practices are sized to only accept some portion of the treatment volume (*Tv*) and employ a flow splitter to safely bypass large storms. On-line infiltration practices may be connected to underground perforated pipes to detain the peak storm event or have suitable overflows to pass the storms without erosion. On-line designs require careful design of the pretreatment in order to avoid the large flows from causing scour or turbulence within the practice that can lead to clogging.

## 3.0 Planning and Considerations

### 3.1 Regional and Special Case Design Adaptations

| Table P-FIL-04-4 Community and Environmental Concerns | |
|---|---|
| **Concern** | **Requirement** |
| Karst Terrain | Conventional infiltration practices should not be used in karst regions due to concerns about sinkhole formation and groundwater contamination. In karst areas, Mmicro- or small-scale infiltration areas are permissible only if geotechnical studies indicate there is at least 4 feet of vertical separation between the bottom of the infiltration facilities and the underlying bedrock ~~and the underlying karst layer AND an impermeable liner and underdrain are used~~. Inspections of infiltration BMPs in karst areas should include for signs of subsidence, which would indicate possible collapse of the facility into underlying voids. In many cases, bioretention is a preferred stormwater management alternative to infiltration in karst areas. Refer to Appendix E for guidance for karst areas. |
| Coastal Plain | The flat terrain, low head and high-water table of many coastal plain sites can constrain the application of conventional infiltration practices. However, such sites are still suited for micro-scale and small-scale infiltration practices. Designers should maximize the surface area of the infiltration practice and keep the depth of infiltration to less than 24 inches plus the groundwater separation. Where soils are extremely permeable (more than 4.0 inches per hour), shallow bioretention is a preferred alternative. Where soils are more impermeable (i.e., marine clays with less than 0.5 inch per hour), designers may prefer to use a constructed wetland practice. |
| Steep Terrain | Forcing conventional infiltration practices in steep terrain can be problematic with respect to slope stability, excessive hydraulic gradients, and sediment delivery. Unless slope stability calculations demonstrate otherwise, it is generally recommended that infiltration practices should be located a minimum horizontal distance of 200 feet from downgradient slopes greater than 20%. Micro-scale and small-scale infiltration can work well, as long as their smaller up gradient and downgradient building setbacks are satisfied. |
| Cold Climate and Winter Performance | Infiltration practices can be designed to withstand more moderate winter conditions. The main problem is caused by ice forming in the voids or the subsoils below the practice, which may briefly result in nuisance flooding when spring melting occurs. The following design adjustments are recommended for infiltration practices installed in higher elevations:<br>• The bottom of the practice should extend below the frost line.<br>• Infiltration practices are not recommended at roadside locations that are heavily sanded and/or salted in the winter months (to prevent movement of chlorides into groundwater and prevent clogging by road sand).<br>• Pretreatment measures can be oversized to account for the additional sediment load caused by road sanding (up to 40% of the Tv).<br>• Infiltration practices must be set back at least 25 feet from roadways to prevent potential frost heaving of the road pavement. |

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| Table P-FIL-04-4 Community and Environmental Concerns | |
|---|---|
| **Concern** | **Requirement** |
| Linear Highway Sites | Infiltration practices can work well for linear highway projects, where soils are suitable and can be protected from heavy disturbance and compaction during road construction operations. |
| Linear Utility Sites | Infiltration practices are poorly suited to treat runoff within utility rights-of-way or easements due to their size and would typically require acquisition of additional land adjacent to the utility corridor. |

### 3.2 Designation of Stormwater Hotspots

Stormwater hotspots are operations or activities that are known to produce higher concentrations of stormwater pollutants and/or have a greater risk for spills, leaks, or illicit discharges. Table P-FIL-04-5 presents a list of potential land uses or operations that may be designated as a stormwater hotspot. It should be noted that the actual hotspot generating area may only occupy a portion of the entire proposed use, and that some "clean" areas (such as rooftops) can be diverted away to another infiltration or runoff reduction practice. Communities should carefully review development proposals to determine whether any future operation on all or part of the site will be designated as a potential stormwater hotspot. Based on this designation, one or more design responses are required, as shown below:

1. ***Stormwater Pollution Prevention Plan (SWPPP).*** The SWPPP, required as part of a Virginia Pollutant Discharge Elimination System (VPDES) industrial activity or a municipal stormwater permit, outlines pollution prevention and treatment practices that will be implemented to minimize polluted discharges from the ongoing operations of the facility. (Note: This is different from the SWPPP required as part of regulated construction activities.) Other facilities or operations that are not classified as industrial activities (SIC Codes) are not required to have an Industrial VPDES permit but may still be designated as potential stormwater hotspots by the local review authority as part of their local stormwater ordinance (these are shown in the shaded areas of Table P-FIL-04-5). It is recommended that these facilities include an addendum to their stormwater plan that details the pollution prevention practices and employee training measures that will be used to reduce contact of pollutants with rainfall or snowmelt.
2. ***Restricted Infiltration.*** A minimum of 50% of the total Tv must be treated by a filtering or bioretention practice prior to any infiltration. Portions of the site that are not associated with the hotspot-generating area should be diverted away and treated by another acceptable stormwater management practice.
3. ***Infiltration Prohibition***. The risk of groundwater contamination from spills, leaks, or discharges is so great at hotspot sites that infiltration of stormwater or snowmelt is prohibited.

| Table P-FIL-04-5 Potential Stormwater Hotspot and Site Design Responses | | | | |
|---|---|---|---|---|
| **Potential Stormwater Hotspot Operation** | **SWPPP Required?** | **Restricted Infiltration** | **No Infiltration** | |
| Facilities with National Pollutant Discharge Elimination System industrial permits | | Yes | ■ | ■ |
| Public works yard | Yes | | | |
| Ports, shipyards, and repair facilities | Yes | | | |
| Railroads/equipment storage | Yes | | | |
| Auto and metal recyclers/scrapyards | Yes | | | |

| Table P-FIL-04-5 Potential Stormwater Hotspot and Site Design Responses | | | |
|---|---|---|---|
| Potential Stormwater Hotspot Operation | SWPPP Required? | Restricted Infiltration | No Infiltration |
| Petroleum storage facilities | Yes | | |
| Highway maintenance facilities | Yes | | |
| Wastewater, solid waste, and composting facilities | Yes | | |
| Industrial machinery and equipment | Yes | | |
| Trucks and trailers | Yes | | |
| Airfields | Yes | | |
| Aircraft maintenance areas | Yes | | |
| Fleet storage areas | Yes | | |
| Parking lots (with 40 or more parking spaces) | No | | |
| Gas stations | No | | |
| Highways (2,500 ADT) | No | | |
| Construction business (paving, heavy equipment storage, and maintenance | No | | |
| Retail/wholesale vehicle/equipment dealers | No | | |
| Convenience stores/fast food restaurants | No | | |
| Vehicle maintenance facilities | No | | |
| Car washes | No | | |
| Nurseries and garden centers | No | | |
| Golf courses | No | | |

**Note:** For a full list of potential stormwater hotspots consult Schueler et al. 2005.

**Key:** ■ = depends on facility;  = criterion applies.

### 3.3 Other Environmental and Community Issues

The following is a list of several other community and environmental concerns that may also arise when infiltration practices are proposed:

| Table P-FIL-04-6 Community and Environmental Concerns | |
|---|---|
| **Concern** | **Requirement** |
| Nuisance Conditions | Poorly designed infiltration practices can create potential nuisance problems such as basement flooding, poor yard drainage, and standing water. In most cases, these problems can be minimized through proper adherence to the setback, soil testing, and the pretreatment requirements outlined in this specification. |
| Mosquito Risk | Infiltration practices have some potential to create conditions favorable to mosquito breeding, if they clog and have standing water for extended periods. |
| Groundwater Injection Permits | Groundwater injection permits are required if the infiltration practice is deeper than the longest surface area dimension of the practice (U.S. Environmental Protection Agency 2008). Designers should investigate whether or not a proposed infiltration practice is subject to a state or local groundwater injection permit requirements. |

## 4.0 Stormwater Performance Summary

When used appropriately, infiltration has a very high runoff volume reduction capability, as shown in Table P-FIL-04-7.

| Table P-FIL-04-7 Summary of Stormwater Functions Provided by Infiltration | | |
|---|---|---|
| **Stormwater Function** | **Level 1 Design** | **Level 2 Design** |
| Annual Runoff Reduction Volume | 50% | 90% |
| Total Phosphorus EMC Reduction[1] by BMP Treatment Process | 25% | 25% |
| Total Phosphorus Mass Load Removal | 63% | 93% |
| Total Nitrogen EMC Reduction[1] by BMP Treatment Process | 15% | 15% |
| Total Nitrogen Mass Load Removal | 57% | 92% |
| Channel and Flood Protection | • Use the Virginia Runoff Reduction Method (VRRM) Compliance Spreadsheet to calculate the Curve Number (CN) Adjustment; or<br>• Design for extra shortage (optional; as needed) on the surface or in the subsurface storage volume to accommodate larger storm volumes, and use USDA-NRCS TR-55 Runoff Equations[2] to compute the CN Adjustment. | |

| Table P-FIL-04-7 Summary of Stormwater Functions Provided by Infiltration | | |
|---|---|---|
| Stormwater Function | Level 1 Design | Level 2 Design |

**Notes:**

Source: Center for Watershed Protection (CWP) and Chesapeake Stormwater Network (CSN) 2008; CWP 2007.

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

## 5.0 Design Criteria

The major design goal for Infiltration is to maximize runoff volume reduction and nutrient removal. To this end, designers may choose to go with the baseline design (Level 1) or choose an enhanced design (Level 2) that maximizes nutrient and runoff reduction. To qualify for Level 2, the infiltration practice must meet all the design criteria shown in the right-hand column of Table P-FIL-04-8.

| Table P-FIL-04-8 Level 1 and Level 2 Infiltration Design Guidelines | |
|---|---|
| **Level 1 Design** | **Level 2 Design** |
| **Runoff Reduction: 50; Total Phosphorous: 25; Total Nitrogen: 15** | **Runoff Reduction: 90; Total Phosphorous: 25; Total Nitrogen: 15** |
| Sizing: Tv = [(Rv)(A)/12]<br>– the volume reduced by an upstream BMP | Sizing: Tv = [1.1(Rv)(A)/12]<br>– the volume reduced by an upstream BMP |
| At least two forms of pretreatment (see Table P-FIL-04-~~11~~10) | At least three forms of pretreatment (see Table P-FIL-04-~~11~~10) |
| Soil infiltration rate 1/2 to 1 inch/hour<br>(see Appendix C, Soil Characterization and Infiltration Testing); number of tests depends on the scale<br>(see Table P-FIL-04-1). | Soil infiltration rates of 1.0 to 4.0 inches/hour<br>(see Appendix C); number of tests depends on the scale (see Table P-FIL-04-1). |
| Minimum of 2 feet between the bottom of the infiltration practice and the seasonal high-water table or bedrock. Tv infiltrates within 36 to 48 hours.<br>Building setbacks – see Table P-FIL-04-3.<br>All designs are subject to hotspot runoff restrictions/prohibitions.<br>Infiltration practices must completely drain within 72 hours of the end of a rainfall event. | |

*Figure P-FIL-04-1 Infiltration Trench or Basin Plan View with Concentrated Inflow and Sheet Inflow*

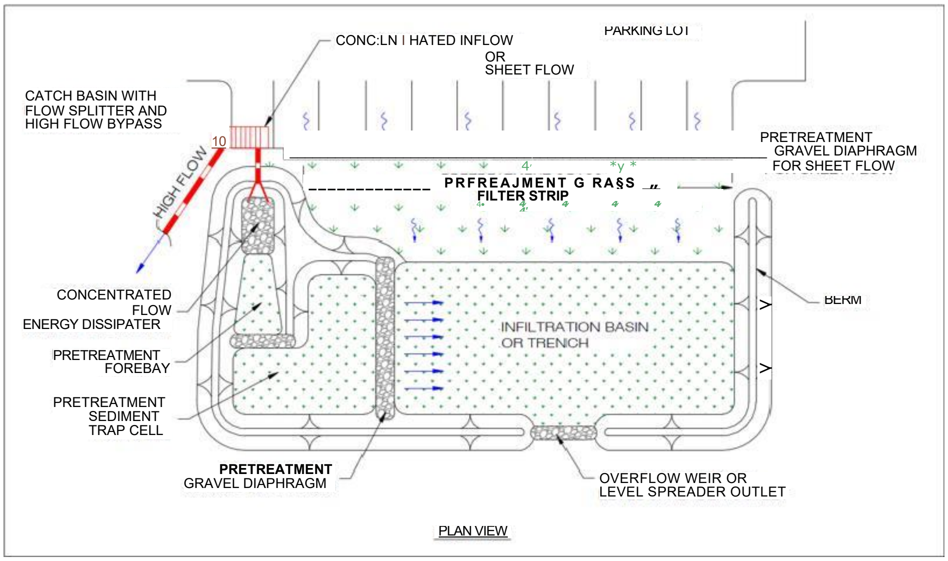
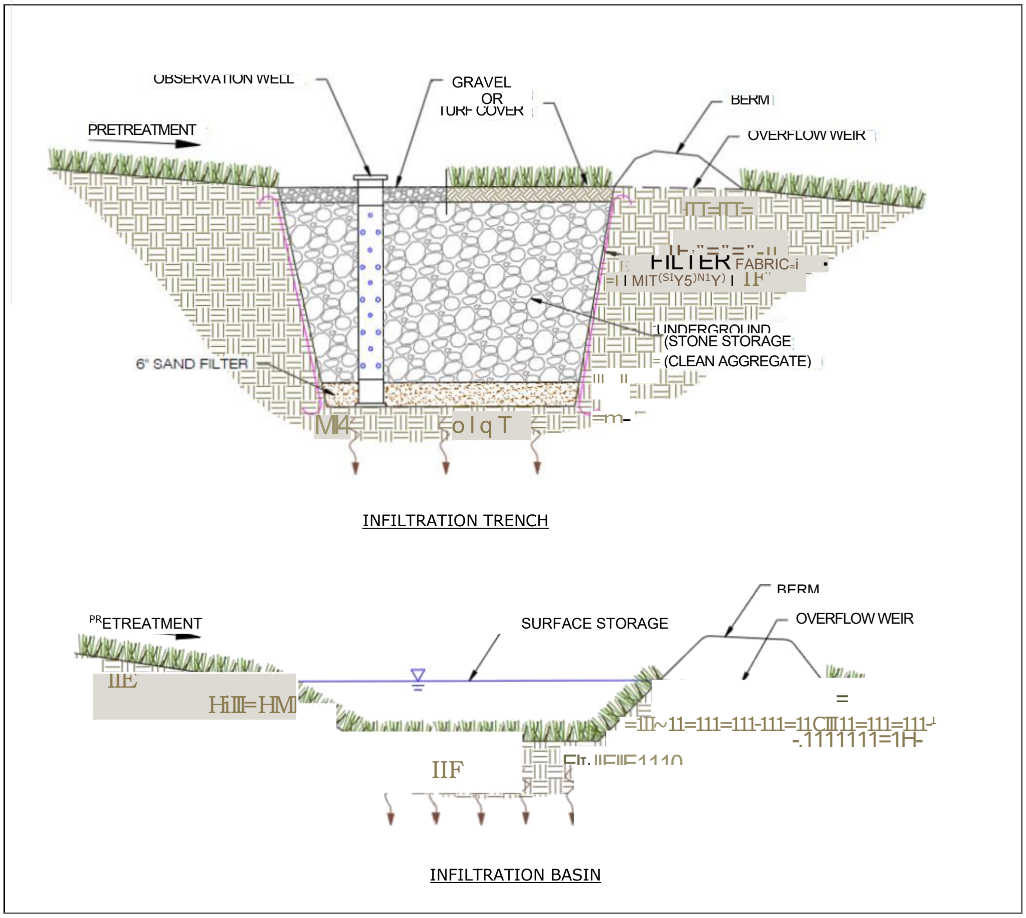


**Figure P-FIL-04-2 Infiltration Trench or Basin Section View**



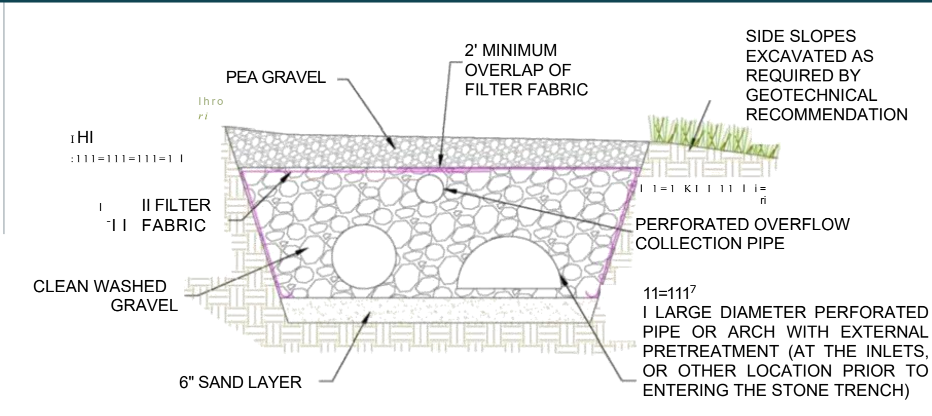





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**Figure P-FIL-04-4 Infiltration Combined with Detention (Channel and/or Flooding Protection)**

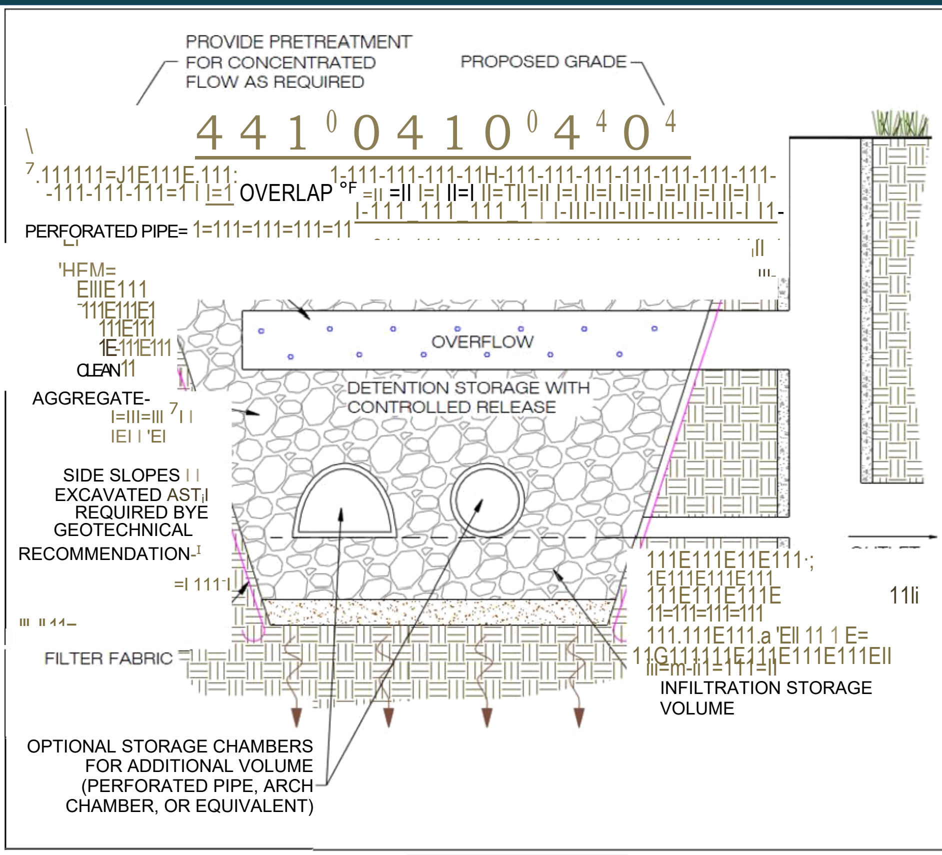


**Figure P-FIL-04-5 Observation Well**

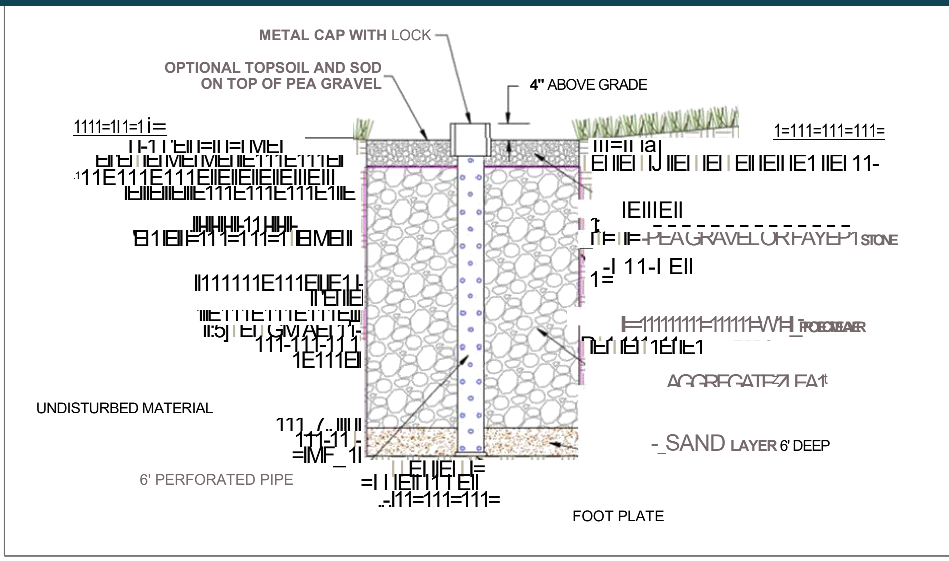
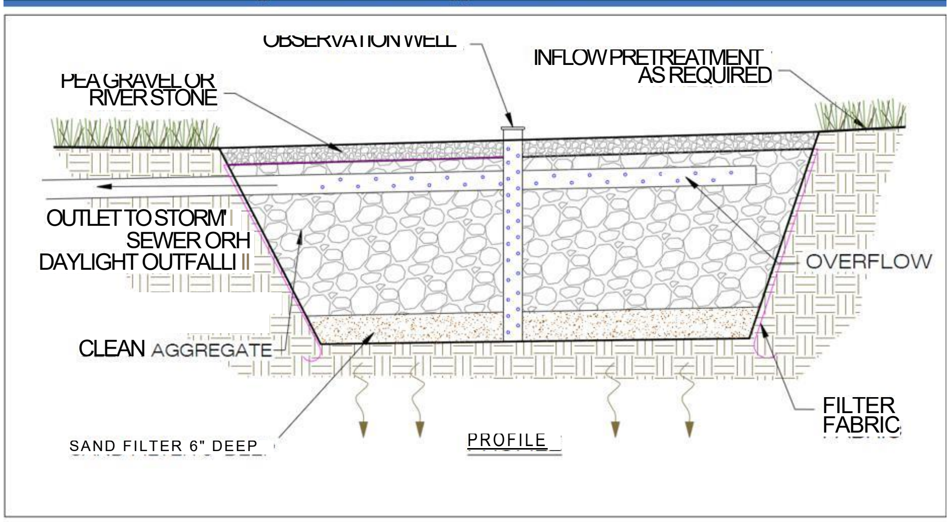



**Figure P-FIL-04-6 Typical Infiltration Trench**




## 5.1 Defining the Infiltration Rate

Soil permeability is the single most important factor when evaluating infiltration practices. A field-verified minimum infiltration rate of at least 1/2 inch per hour is needed for the practice to work.

***Projected Infiltration Rate***. For planning purposes, the projected infiltration rate for the site can be estimated using the USDA-NRCS soil textural triangle for the prevailing soil types shown on the local USDA-NRCS Soil Survey. This data is used solely to locate portions of the site where infiltration may be feasible and to pinpoint where actual on-site infiltration tests will be taken to confirm feasibility.

***Measured Infiltration Rate****.* Onsite infiltration investigations should always be conducted to establish the actual infiltration capacity of underlying soils, using the methods presented in Appendix C, Soil Characterization and Infiltration Testing.

***Design Infiltration Rate***. Several studies have shown that ultimate infiltration rates decline by as much as 50% from initial rates; therefore, designers should be conservative and not attempt to use infiltration on questionable soils. To provide a factor of safety, the infiltration rate used in the design may be no greater than 50% of the measured rate.

**5.1.1 Sizing of Infiltration Facilities**

Several equations are needed to size infiltration practices. The first equations establish the maximum depth of the infiltration practice, depending on whether it is a surface basin (Equation P-FIL-04-1) or underground reservoir (Equation P-FIL-04-2).

***Equation P-FIL-04-1 Maximum Surface Basin Depth***

$$d_{max} = (\frac{1}{2} f \times t_d)/12$$

***Equation P-FIL-04-2 Maximum Underground Reservoir Depth***

$$d_{max} = (\frac{1}{2} f \times t_d)/(\eta \times 12)$$

Where:

= maximum depth of the infiltration practice (feet).

= measured infiltration rate (inch per hour).

= maximum drawn down time (normally 48 hours).

= porosity of the stone reservoir (assume 0.4).

Designers should compare these results to the maximum allowable depths in Table P-FIL-04-9, and use whichever value is *less* for subsequent design.

**Table P-FIL-04-9 Maximum Depth (in feet) for Infiltration Practices**

| Mode of Entry | Scale of Infiltration | | |
|---|---|---|---|
| | Micro-Infiltration | Small-Scale Infiltration | Conventional Infiltration |
| Surface Basin | 1.0 | 1.5 | 2.0 |
| Underground Reservoir | 3.0 | 5.0 | ~~varies~~6.0 |

Once the maximum depth is known, calculate the surface area needed for an infiltration practice using Equation P-FIL-04-3 or Equation P-FIL-04-4.

***Equation P-FIL-04-3 Surface Basin Surface Area***

$$SA = Tv_{BMP}/d + \left[\frac{\left(\frac{1}{2}\right) f \times t_f}{12}\right]$$

***Equation P-FIL-04-4 Underground Reservoir Surface Area***

$$SA = Tv_{BMP}/(\eta \times d) + \left[\frac{\left(\frac{1}{2}\right) f \times t_f}{12}\right]$$

Where:

= Surface area (square feet).

= Design volume for the BMP, e.g., Tv from the contributing drainage area plus any remaining volume from upstream runoff reduction practices (cubic feet).

= Porosity of stone reservoir (assume 0.4).

= Infiltration depth (maximum depends on the scale of infiltration and the results of Equation P-FIL-04-1 (feet).

= Measured infiltration rate (inch per hour).

= Time to fill the infiltration facility (typically 2 hours).

If the designer chooses to infiltrate less than the full *Tv* (e.g., using micro-infiltration or small-scale infiltration), the runoff reduction rates shown in Table P-FIL-04-1 must be directly prorated in the VRRM compliance spreadsheet.

To qualify for Level 2 runoff reduction rates, designers must provide 110% of the site-adjusted *Tv* (1.1**Tv*).

#### 5.1.2 Soil Infiltration Rate Testing

Regardless of the scale of the infiltration application, perform at least one soil profile and one infiltration test per facility. The acceptable methods and the number of on-site soil explorations are outlined in Appendix C, Soil Characterization and Infiltration Testing.

### 5.2 Pretreatment Features

Every infiltration practice must include multiple pretreatment techniques, although the nature of pretreatment practices depends on the scale at which infiltration is applied. The number, volume, and type of acceptable pretreatment techniques needed for the three scales of infiltration are provided in Table P-FIL-04-11. Refer to BMP P-SUP-06, Pre-Treatment, for design details and guidance on pretreatment.

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| Table P-FIL-04-10 Required Pretreatment Elements for Infiltration Practices | | | |
|---|---|---|---|
| | Scale of Infiltration | | |
| Pretreatment[1] | Micro-Infiltration | Small-Scale Infiltration | Conventional Infiltration |
| Number and Volume of Pretreatment Techniques Employed | Two external techniques; no minimum pretreatment volume required | Three techniques; 15% minimum pretreatment volume required (inclusive) | Three techniques; 25% minimum pretreatment volume required (inclusive); at least one separate pretreatment cell |
| Acceptable Pretreatment Techniques | Leaf gutter screens<br>Grass filter strip<br>Upper sand layer<br>Washed bank run gravel<br>Roof stormwater isolation | Grass filter strip<br>Grass channel<br>Plunge pool<br>Gravel diaphragm<br>Treatment train<br>Limit hydraulic loading | Sediment forebay<br>Sand filter cell<br>Inlet sumps<br>Grass filter strip<br>Grass channel<br>Gravel diaphragm<br>Manufactured treatment device<br>Manufactured flow control devices<br>Treatment train<br>Limit hydraulic loading |

**Note:**

1. A minimum of 50% of the runoff reduction volume must be pretreated by a filtering or bioretention practice prior to infiltration if the site is a restricted stormwater hotspot.

Note that conventional infiltration practices require pretreatment of at least 25% of the Tv, including a surface pretreatment cell capable of keeping sediment and vegetation out of the infiltration cell. All pretreatment practices should be designed such that exit velocities are non-erosive for the 2-year design storm and evenly distribute flows across the width of the practice (e.g., using a level spreader).

### 5.3 Conveyance and Overflow

The nature of the conveyance and overflow to an infiltration practice depends on the scale of infiltration and whether the facility is on-line or off-line (Table P-FIL-04-11). Where possible, conventional infiltration practices should be designed off-line to avoid damage from the erosive velocities of larger design storms.

**Table P-FIL-04-11 Conveyance and Overflow Choices Based on Infiltration Scale**

| Conveyance and Overflow | Scale of Infiltration | | |
|---|---|---|---|
| | Micro Infiltration | Small-Scale Infiltration | Conventional Infiltration |
| On-line Design | Discharge to a non-erosive pervious overland flow path designed to convey the 10-year design storm to the street or storm drain system. | | An overflow mechanism such as an elevated drop inlet or flow splitter should be used to redirect flows to a non-erosive down-slope overflow channel or stabilized water course designed to convey the 10-year design storm. Inlet areas should be stabilized to ensure that non-erosive conditions exist during storm events up to the overbank flood event (i.e., the 10-year storm event). Outlet protection or energy dissipation should be provided consistent with BMP C-ECM-15, Outlet Protection. |
| Off-line Design | Not recommended. | | A flow splitter or overflow structure; the overflow should be sized to safely pass the peak flows anticipated to reach the practice, up to a 100-year, 24-hour storm event. |

#### 5.4 Internal Geometry and Drawdowns

***Runoff Reduction Volume Sizing***. The proper approach for designing infiltration practices is to avoid forcing a large volume of runoff into a comparatively small area. Therefore, individual infiltration practices that are limited in size due to soil permeability and available space need not be sized to achieve the full Tv for the contributing drainage area, as long as other runoff reduction practices are applied at the site to meet the remainder of the Tv. Account for the total Tv as computed using the VRRM compliance spreadsheet.

***Infiltration Basin Restrictions***. The maximum vertical depth to which runoff may be ponded over an infiltration area is 24 inches (i.e., infiltration basin). The side slopes should be no steeper than 4H:1V; if the basin serves a CDA greater than 20,000 square feet, a surface pretreatment cell must be provided (this may be sand filter or dry sediment basin).

***Rapid Drawdown***. When possible, infiltration practices should be sized such that the target runoff reduction volume infiltrates within 36 to 48 hours to provide a factor of safety that prevents nuisance ponding conditions.

***Conservative Infiltration Rates***. Designers should always use the design infiltration rate (safety factor of 2), rather than the measured infiltration rate, to approximate long term infiltration rates.

***Porosity***. A value of 0.40 should be used in the design of stone reservoirs, although a larger value may be used if perforated corrugated metal pipe, plastic pipe, concrete arch pipe, or comparable materials are installed within the reservoir.

#### 5.5 Landscaping and Safety

Infiltration trenches can be effectively integrated into the site plan and aesthetically designed with adjacent native landscaping or turf cover, subject to the following additional design considerations:

- Infiltration practices should never be installed until all upgradient construction is completed *AND* pervious areas are stabilized with dense and healthy vegetation.

- A landscaping plan should be prepared for all infiltration basins. The landscaping plan should be reviewed and approved by the local development review authority prior to construction.
- Vegetation associated with the infiltration practice buffers should be regularly mowed and maintained to keep organic matter out of the infiltration device and maintain enough native vegetation to prevent soil erosion from occurring.
- Infiltration practices should fit into and blend with the surrounding area. Native grasses are preferable, if compatible (refer to Appendix G for plant selection guidance). A basin may be covered with permeable topsoil and planted with grass in a landscaped area.
- Infiltration practices do not pose any major safety hazards after construction. However, if an infiltration practice will be excavated to a depth greater than 5 feet, then Occupational Safety and Health Administration health and safety guidelines must be followed for safe construction practices.
- Infiltration trenches and basins with temporary ponding should not be designed to hold water greater than 1 foot deep. Deeper surface ponding (up to 2 feet maximum) may require safety provisions.
- The landscaped area above the surface of an infiltration practice may also be covered with pea gravel (i.e., ASTM International Standard D448 size No. 8, 3/8-inch to 1/8-inch). This pea gravel layer provides sediment removal and additional pretreatment upstream of the infiltration practice and can be easily removed and replaced when it becomes clogged.
  - Alternatively, an infiltration practice may be covered with an engineered soil mix, such as that prescribed for an infiltration basin, and planted with managed turf or other herbaceous vegetation. This may be an attractive option when infiltration practices are placed in disturbed pervious areas (e.g., lawns, parks, and community open spaces).
- Vegetation commonly planted in infiltration basins includes native trees, shrubs, and other herbaceous vegetation. When developing a landscaping plan, site planning and design teams should choose vegetation that will be able to stabilize soils and tolerate the stormwater runoff rates and volumes that will pass through the infiltration basin. Vegetation used in infiltration basins should also be able to tolerate both wet and dry conditions. See Appendix G, Plant Selection, for a list of grasses and other plants that are appropriate for use in infiltration practices installed in the state of Virginia.
- Methods used to establish vegetative cover within an infiltration basin should achieve at least 75% vegetative cover one year after installation.
- The soils used within infiltration basin planting beds should be an engineered soil mix that meets the following specifications:
  - Texture: Sandy loam or loamy sand should be used.
  - Sand Content: Soils should contain 85% to 88% clean, washed sand.
  - Topsoil Content: Soils should contain 8% to 12% topsoil.
  - Organic Matter Content: Soils should contain 3% to 5% organic matter.
  - Infiltration Rate: Soils should have an infiltration rate of at least 0.25 inch per hour, although an infiltration rate of between 1 and 2 inches per hour is preferred.
  - Phosphorus Index (P-Index): Soils should have a P-Index of less than 30.
  - Exchange Capacity (CEC): Soils should have a CEC that exceeds 10 milliequivalents per 100 grams of dry weight.
  - pH: Soils should have a pH of 6 to 8.

The organic matter used within an infiltration basin planting bed should be a well-aged compost that meets the specifications outlined in BMP P-FIL-08, Soil Compost Amendments.

Designers should always evaluate the nature of future operations to determine whether the proposed site will be designated as a potential stormwater hotspot (see Table P-FIL-04-5) and comply with the appropriate restrictions or prohibitions applicable to infiltration.

### 5.6 Maintenance Reduction Features

Maintenance is a crucial element that ensures the long-term performance of infiltration practices. The most frequently cited maintenance problem for infiltration practices is clogging of the surface stone by organic matter and sediment. The following design features can either minimize the risk of clogging or help to identify maintenance issues before they cause failure of the facility:

***Pretreatment Filter Strip of Low Maintenance Vegetation.*** Regular mowing of turf generates a significant volume of organic debris that can eventually clog the surface of an infiltration trench or basin when located in a turf area; similarly, mulch from landscaped areas can migrate into the infiltration facility. Landscaping vegetation adjacent to the infiltration facility should consist of low maintenance ground cover.

***Observation Well.*** Small-scale and conventional infiltration practices should include an observation well, consisting of an anchored 6-inch diameter perforated polyvinyl chloride (PVC) pipe fitted with a lockable cap installed flush with the ground surface, to facilitate periodic inspection and maintenance.

***Filter Fabric.*** Geotextile filter fabric should not be installed along the bottom of infiltration practices. Experience has shown that filter fabric is prone to clogging, and a layer of coarse washed stone (choker stone) is a more effective substitute. However, permeable filter fabric must be installed on the trench sides to prevent soil piping. A layer of fabric may also be installed along the top of the practice to help keep organic debris or topsoil from migrating downward into the stone. Periodic maintenance to remove and replace this surface layer will be required to ensure that surface runoff can get into the infiltration practice.

***Direct Maintenance Access.*** Access must be provided to allow personnel and equipment to perform non-routine maintenance tasks, such as practice reconstruction or rehabilitation. While a turf cover is permissible for micro-and small-scale infiltration practices, the surface should not be covered by an impermeable material, such as asphalt or concrete.

### 5.7 Infiltration Material Specifications

The basic material specifications for infiltration practices are outlined in Table P-FIL-04-12.

**Table P-FIL-04-12 Infiltration Material Specifications**

| Material | Specification | Notes |
|---|---|---|
| Grass and Landscaping | See BMP C-SSM-10, Permanent Seeding, and Appendix G, Plant Selection. | Prevent adjacent vegetation from forming an overhead canopy above infiltration practices to prevent leaf litter, fruits, and other vegetative material from clogging the stone. |
| Inlet and Outlet Protection | See BMP C-ECM-15, Outlet Protection, and BMP C-ECM-13, Riprap. | |
| Pretreatment | See BMP Support Component: Pretreatment. | |
| Infiltration Planting Bed | See BMP P-FIL-08, Soil Compost Amendment, and BMP P-FIL-05, Bioretention. | |

| Table P-FIL-04-12 Infiltration Material Specifications | | |
|---|---|---|
| **Material** | **Specification** | **Notes** |
| Stone | Use clean aggregate with a maximum diameter of 3.5 inches and a minimum diameter of 1.5 inches (Virginia Department of Transportation [VDOT] No. 1 Open-Graded Coarse Aggregate) or the equivalent. | |
| Observation Well | Install a vertical 6-inch Schedule 40 PVC perforated pipe with a lockable screw cap and anchor plate. | Install one per 50 feet of length of infiltration the practice. |
| Trench Bottom | Install a 6- to 8-inch sand layer (VDOT Fine Aggregate, Grade A or B). | |
| Trench Surface Cover | Install a 3-inch layer of river stone or pea gravel. Turf is acceptable when there is subsurface inflow (e.g., a roof leader). | This provides an attractive surface cover that can suppress weed growth. |
| Filter Fabric (sides only) | Use non-woven polyprene geotextile with a flow rate of >110 gallons/minute/square foot (e.g., Geotex 351 or equivalent). | |
| Choking Layer | Install a 2- to 4-inch layer of choker stone (typically #8 or #89 washed gravel) over the underdrain stone. | |
| Overflow Collection Pipe (where needed) | Use 6-inch rigid Schedule 40 PVC pipe, with 3/8-inch perforations at 6 inches on center, with each perforated underdrain installed at a slope of 1% for the length of the infiltration practice. | Install non-perforated pipe with one or more caps, as needed. |

## 6.0 Construction Specifications

### 6.1 Construction Sequence

The following is a typical construction sequence to properly install infiltration practices. The sequence may need to be modified to reflect the scale of infiltration, site conditions, and whether or not an underdrain needs to be installed.

Infiltration practices are particularly vulnerable to failure during the construction phase for two reasons. First, if the construction sequence is not followed correctly, construction sediment can clog the practice. In addition, heavy construction can result in compaction of the soil, which can then reduce the soil's infiltration rate. For this reason, a careful construction sequence needs to be followed. Ideally, the infiltration practice should be outside the limits of disturbance.

During site construction, the following steps are absolutely critical:

- Avoid excessive compaction by delineating the area of the proposed practice and preventing construction equipment and vehicles from traveling over the proposed location.
- Keep the infiltration practice "off-line" until construction is complete. Prevent sediment from entering the infiltration site by using super silt fence, diversion berms, or other means. In the erosion and sediment control plan, indicate the earliest time at which stormwater runoff may be directed to a

conventional infiltration basin The erosion and sediment control plan must also indicate the specific methods to be used to temporarily keep runoff from the infiltration site.

- Infiltration practice sites should never serve as the sites for temporary sediment control devices (e.g., sediment traps, etc.) during construction.
- Upland drainage areas must be completely stabilized with a thick layer of vegetation prior to commencing excavation for an infiltration practice, as verified by the local erosion and sediment control inspector/program.

**6.2 Installation**

The infiltration practice should be installed according to the following steps:

1. Excavate the infiltration practice to the design dimensions from the side using a backhoe or excavator. The floor of the pit should be completely level, but equipment should be kept off the floor area to prevent soil compaction.
2. Correctly install filter fabric on the trench sides. Large tree roots should be trimmed flush with the sides of infiltration trenches to prevent puncturing or tearing of the filter fabric during subsequent installation procedures. When laying out the geotextile, the width should include sufficient material to compensate for perimeter irregularities in the trench and for a 6-inch minimum overlap at the top of the trench. The filter fabric itself should be tucked under the sand layer on the bottom of the infiltration trench. Stones or other anchoring objects should be placed on the fabric at the trench sides to keep the trench open during windy periods. Voids may occur between the fabric and the excavated sides of a trench. Natural soils should be placed in all voids to ensure the fabric conforms smoothly to the sides of excavation.
3. Scarify the bottom of the infiltration practice and spread 6 inches of sand on the bottom as a filter layer.
4. Anchor the observation well(s) and add stone to the practice in 1-foot lifts.
5. Use sod to establish a dense turf cover for at least 10 feet on each side of the infiltration practice to reduce erosion and sloughing. If the vegetation is seeded instead, use native grasses adapted to local climates and soil conditions. Refer to Appendix G for information on plant selection.

**6.3 Construction Inspection**

Inspections are needed during and immediately after construction to ensure that the infiltration practice is built in accordance with the approved design and this specification. Qualified individuals should use detailed inspection checklists, including sign-offs, at critical stages of construction to ensure that the contractor's interpretation of the plan is consistent with the designer's intentions. (See Appendix H.) Inspection during the following key points during construction will help insure successful performance:

- Check elevations of the excavation invert. Ensure that the soil at the bottom of the infiltration facility has not been smeared by the excavation equipment. The bottom soil should be scarified with the teeth of the backhoe bucket.
- Inspect the installation of the bottom 6-inch sand filter layer and the initial layer of stone prior to placement of any storage components.
- Verify the top cover of pea gravel or turf as required on plans.
- Inspect the stabilization of adjacent pretreatment filter strips and the contributing drainage area prior to bringing the infiltration area into service.
- Upon final inspection and acceptance, Global Positioning System coordinates should be logged for all infiltration practices and submitted for entry into the local BMP maintenance tracking database.

## 7.0 Operations and Maintenance Considerations

### 7.1 Maintenance Agreements

The Virginia Erosion and Stormwater Management Regulation (9VAC25-875-535) includes requirements for long-term maintenance of stormwater management facilities. To ensure successful implementation of infiltration practices, long-term maintenance and operation should consider the following, to include 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.

- When micro-scale or small-scale infiltration practices are installed on private residential lots, homeowners will need to: (1) be educated about their routine maintenance needs; (2) understand the long-term maintenance plan; and (3) be subject to a deed restriction, drainage easement, or other mechanism enforceable by the VESMP Authority to ensure that infiltrating areas are not converted or disturbed.
- The mechanism should, if possible, grant authority for local agencies to access the property for inspection or corrective action.

### 7.2 Maintenance Inspections

Annual site inspections are critical to the performance and longevity of infiltration practices, particularly for small-scale and conventional infiltration practices. Maintenance of infiltration practices is driven by annual inspections that evaluate the condition and performance of the practices, including the following:

- The drawdown rate should be measured at the observation well for 3 days following a storm event in excess of 1/2 inch in depth. If standing water is still observed in the well after 3 days, this is a clear sign that clogging is a problem.
- Check inlets, pretreatment cells, and any flow diversion structures for sediment buildup and structural damage. Note whether any sediment needs to be removed.
- Inspect the condition of the observation well and make sure it is still capped.
- Check that no vegetation forms an overhead canopy that may drop leaf litter, fruits, and other vegetative materials that could clog the infiltration device.
- Evaluate the vegetative quality of the adjacent grass buffer and perform spot-reseeding if the cover density is less than 90%.
- Generally, inspect the upland contributing drainage area for any controllable sources of sediment or erosion.
- Look for weedy growth on the stone surface that might indicate sediment deposition or clogging.
- Inspect maintenance access to ensure it is free of woody vegetation and verify whether valves, manholes, and/or locks can be opened and operated.
- Inspect internal and external infiltration side slopes for evidence of sparse vegetative cover, erosion, or slumping, and make necessary repairs immediately.

Based on inspection results, specific maintenance tasks will be triggered. See Appendix H for example maintenance inspection checklists for infiltration practices.

### 7.3 Ongoing Maintenance

Effective long-term operation of infiltration practices requires a dedicated and routine maintenance inspection schedule with clear guidelines and schedules, as shown in Table P-FIL-04-13. Where possible, facility maintenance should be integrated into routine landscaping maintenance tasks.

| Table P-FIL-04-13 Typical Maintenance Activities for Infiltration Practices | |
|---|---|
| **Maintenance Activity** | **Schedule** |
| Replace pea gravel/topsoil and top surface filter fabric (when clogged). needed Mow vegetated filter strips as necessary and remove the clippings. | As |
| Ensure that the contributing drainage area, inlets, and facility surface are clear of debris.<br>Ensure that the contributing drainage area is stabilized.<br>Remove sediment and oil/grease from pretreatment devices, as well as from overflow structures.<br>Repair undercut and eroded areas at inflow and outflow structures. | Quarterly |
| Check observation wells 3 days after a storm event in excess of 1/2 inch in depth. Standing water observed in the well after 3 days is a clear indication of clogging.<br>Inspect pretreatment devices and diversion structures for sediment build-up and structural damage.<br>Remove trees that start to grow in the vicinity of the infiltration facility. | Semi-annually |
| Clean out accumulated sediments from the pretreatment cell. | Annually |

## 8.0 References


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# P-FIL-06 Filtering Practices

## 1.0 Definition

Stormwater filters capture, temporarily store, and treat stormwater runoff by passing it through an engineered filter media, collecting the filtered water in an underdrain, and then returning it back to the storm drainage system.

## 2.0 Purpose and Applicability of Best Management Practice

Stormwater filters can be applied to most types of urban land. They are not always cost-effective, given their high unit cost and small area served, but there are situations where they are clearly the best option (e.g., hotspot runoff treatment, small high-traffic parking lots, ultra-urban areas). Stormwater filters are a versatile option because they occupy very little surface land and have few site restrictions that make it a favorable option for most sites. Additionally, stormwater filters are a useful practice to treat stormwater runoff from small, highly impervious sites.

The filter consists of two chambers: the first is devoted to settling, and the second serves as a filter bed consisting of sand or other filter media.

## 3.0 Planning and Considerations

The feasibility criteria shown in Table P-FIL-06-1 should be evaluated when designing a stormwater filter.

**Table P-FIL-06-1 Filtering Practice Feasibility Criteria**

| Feature | Criteria |
|---|---|
| Available Hydraulic Head | The principal design constraint for stormwater filters is available hydraulic head. The hydraulic head that is preferred for stormwater filters can range from 2 to 10 feet, depending on the design variant, making them difficult to employ in extremely flat terrain. Perimeter sand filters can be specified in areas where reduced hydraulic head is a concern. |
| Depth to Water Table and Bedrock | It is preferred that the standard separation distance is at least 2 feet between the seasonally high groundwater table and/or bedrock layer and the bottom invert of the filtering practice. |
| Contributing Drainage Area (CDA) | Stormwater filters are best applied on small sites where the CDA area is as close to 100% impervious as possible to minimize the sediment and organic solids load to the filter. A maximum CDA of 5 acres is recommended for surface sand filters, and a maximum CDA of 2 acres is recommended for perimeter or underground filters. Filters can be designed to treat runoff from larger areas; however, the increased hydraulic loading will contribute to greater frequency of media surface clogging and/or maintenance costs. |

| Table P-FIL-06-1 Filtering Practice Feasibility Criteria | |
|---|---|
| **Feature** | **Criteria** |
| Space Required | The amount of space required for a filter practice depends on the design variant selected. Both sand and organic surface filters typically consume about 2% to 3% of the CDA, while perimeter sand filters typically consume less than 1%. Underground stormwater filters can be placed under parking or open space and generally consume no surface area. This makes stormwater filters well suited to treat runoff from redevelopment of commercial sites or stormwater hotspots. |

There are several design variations of the basic sand filter that enable designers to use filters at challenging sites or to improve pollutant removal rates. The most common design variants include surface, underground, and perimeter sand filters, as described below and depicted on Figure P-FIL-06-1, Figure P-FIL-06-2, through Figure P-FIL-06-3; (detailed drawings are shown on Figure P-FIL-06-4, Figure P-FIL-06-5, Figure P-FIL-06-6, through Figure P-FIL-06-7 within Section 6.1).

**Surface Sand Filters** are normally designed to be off-line facilities to economize the size of the filter components and reduce maintenance costs. However, in some cases they can be installed as a treatment component within the bottom of a dry extended detention pond that has a shallow total ponding depth (see Figure P-FIL-06-5 and BMP P-BAS-03, Extended Detention Pond).

The surface sand filter is applied to sites less than ~~2~~ 5 acres in size, and is essentially the same as a bioretention basin (see BMP P-FIL-05, Bioretention), with the following exceptions:

- The bottom is lined with an impermeable filter fabric and always has an underdrain.
- The surface cover is native ground cover.
- The filter media is 100% sand.
- The filter surface is not planted with trees, shrubs or herbaceous materials.
- The filter has two cells, with a dry or wet sedimentation chamber preceding the sand filter bed.

The surface sand filter is designed with both the filter bed and pretreatment settling chamber or forebay located at ground level. Both chambers can be constructed with earthen components (see Figure P-FIL-06-5) or pre-cast or cast-in-place concrete (Austin sand filter; see Figure Figure P-FIL-06-2).

*Figure P-FIL-06-1 Sand Filter in a Detention Basin*

**Figure P-FIL-06-2 Austin Surface Sand Filter**

**Underground Sand Filter**. The underground sand filter is modified to install the filtering components underground and is often designed with an internal flow splitter or overflow device that bypasses runoff from larger stormwater events around the filter. Underground sand filters consume very little space and are well suited to ultra-urban areas.

***Perimeter Sand Filter***. The perimeter sand filter (Figure P-FIL-06-3) also includes the basic design elements of a sediment chamber and a filter bed in a linear configuration allowing the overall system to be relatively small and shallow (see Figure P-FIL-06-7). However, this also serves to limit the CDA since treating a large area becomes very challenging with the linear configuration; (designers will recognize the value of shifting to a traditional underground sand filter or proprietary filter on large drainage areas). Flow enters the system as sheet flow through linear grates, usually at the edge of a small parking lot. The perimeter sand filter is usually designed as an on-line practice (i.e., all flows enter the system), but larger events bypass treatment by overflowing the internal treatment chamber weir. One major advantage of the perimeter sand filter design is that the smaller scale of the design reduces the required hydraulic head, making it a good option for sites with low topographic relief.

Figure P-FIL-06-3 Perimeter Sand Filter

***Organic Media Filter***. Organic media filters are a design variant for the filtering systems described above with an organic filter medium replacing the sand. Two notable examples are the peat/sand filter and the compost filter system. Organic filters achieve higher pollutant removal for metals and hydrocarbons due to the increased cation exchange capacity of the organic media, making them useful for targeting specific hotspot pollutants.

***Proprietary Filters***. Proprietary filters are discussed elsewhere in Chapter 8.

## 4.0 Stormwater Performance Summary

Stormwater filters provide moderate pollutant removal performance and provide no runoff volume reduction credit (see Table P-FIL-06-2); therefore, designers should consider using upgradient runoff reduction practices to decrease the treatment volume (Tv) and the required size of the filtering practice. Filters are usually designed only for water quality treatment.

**Table P-FIL-06-2 Summary of Stormwater Functions Provided by Filtering Practices**

| Stormwater Function | Level 1 Design | Level 2 Design |
|---|---|---|
| Annual Runoff Reduction Volume | 0% | 0% |
| Total Phosphorus EMC Reduction[1] by BMP Treatment Process | 60% | 65% |

| Table P-FIL-06-2 Summary of Stormwater Functions Provided by Filtering Practices | | |
|---|---|---|
| Stormwater Function | Level 1 Design | Level 2 Design |
| Channel Protection | Limited – Runoff diverted off-line into a storage facility for treatment can be supplemented with an outlet control to provide peak rate control. | |
| Flood Mitigation | None. Most filtering practices are off-line and do not materially change peak discharges. | |

**Note:**

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

## 5.0 Design Criteria

This is a water quality BMP that is used to maximize nutrient removal. To this end, designers may choose the baseline design (Level 1) or an enhanced Level 2 design that maximizes nutrient removal. See Table P-FIL-06-3.

| Table P-FIL-06-3 Filtering Practice Design Guidance | |
|---|---|
| Level 1 Design | Level 2 Design[1] |
| **Runoff Reduction: 0; Total Phosphorous: 60; Total Nitrogen: 30** | **Runoff Reduction: 0; Total Phosphorous: 65; Total Nitrogen: 45** |
| Tv = [(1.0)(Rv)(A)] / 12 – the volume reduced by an upstream BMP | Tv = [(1.25)(Rv)(A)] / 12 – the volume reduced by an upstream BMP |
| One cell design[2] | Two cell design[2] |
| Sand media | Sand media with an organic layer |
| CDA contains pervious area | CDA is nearly 100% impervious |
| Two feet separate from bottom of dry swale and seasonally high groundwater table or bedrock, whichever is encountered first | |

**Notes:**

1. Level 2 runoff reduction may be increased if the second cell is utilized for infiltration in accordance with BMP P-FIL-04, Infiltration Practices, or BMP P-FIL-05, Bioretention. The runoff reduction credit should be proportional to the fraction of the Tv designed to be infiltrated.
2. A pretreatment sedimentation chamber or forebay is not considered a separate cell.

### 5.1 Overall Sizing

Filtering devices are sized to accommodate a specified Tv. The volume to be treated by the device is a function of the storage depth above the filter and the surface area of the filter. The storage volume is the volume of ponding above the filter. For a given Tv, Equation P-FIL-06-1 is used to determine the required filter surface area.

***Equation P-FIL-06-1 Minimum Surface Area for Filtering Practice***

= ( ) ( ) / ( ) ( h + ) ( )

Commented [CM1]: replace with equation below

Where:

$$Af = \frac{(Tv)(df)}{(K)(hf+df)(tf)}$$

*Af* = area of the filter surface (square feet).

*Tv* = treatment volume*, volume of storage (cubic feet).

*df* = filter media depth (thickness) = minimum 1 foot (feet).

*K* = coefficient of permeability – partially clogged sande (feet per day) = 3.5 feet per day.

*hf* = average height of water above the filter bed (feet), with a maximum of 5 feet = $h_{max}/2$.

*tf* = allowable drawdown time = 1.67 days.

** Stormwater filters are typically the only practice in a drainage area, or in some cases pretreatment; however, where runoff reduction practices are upstream of the filter, the design TV is reduced by the upstream runoff reduction, or* $Tv_{BMP}$.

The coefficient of permeability (feet/day) is intended to reflect the worst-case situation (i.e., the condition of the sand media at the point in its operational life where it requires replacement or maintenance). Filtering practices are therefore sized to function within the desired constraints at the end of the media's operational life cycle.

***Equation P-FIL-06-2 Required Treatment Volume Storage for Filtering Practices***

$$= 0.75()$$

Where:

*Vs* = volume of storage (cubic feet).

*Tv* = treatment volume (cubic feet).

A storage volume of a least 75% of the design Tv – including the volume over the top of the filter media and the volume in the pretreatment chamber(s), as well as any additional storage – is required in order to capture the volume from high-intensity storms prior to filtration and avoid premature bypass. The reduced volume of storage (75% of Tv) takes into account the varying filtration rate of the water through the media as a function of a gradually declining hydraulic head.

**5.2 Soil Testing Requirements**

At least one soil boring must be taken at a low point within the footprint of the proposed filtering practice to establish the water table and bedrock elevations and evaluate soil suitability for the proposed structure.

**5.3 Pretreatment**

Adequate pretreatment is needed to distribute flow across the filter surface and capture coarse sediment to facilitate filter media longevity. Sedimentation chambers may be wet or dry but must be sized to accommodate at least 25% of the total design Tv (inclusive). Refer to BMP P-SUP-06, Pretreatment, for design details and specifications for other applicable pretreatment options.

**5.4 Conveyance and Overflow**

Filtering practices should be designed as off-line systems with either an internal or external bypass to divert larger flows around the filter to an outlet chamber. Claytor and Schueler (1996) and the Atlanta Regional Commission (2001, 2016) provide design guidance for flow splitters for filtering practices.

Underground filtering practices with an internal bypass must include design information to indicate how the device will safely pass the full range of design storms (e.g., 10-year event) without resuspending or flushing previously trapped material. All stormwater filters should be designed to drain or dewater within 36 hours (1.5 days) after a storm event to reduce the potential for nuisance conditions.

Stormwater filters are normally designed with an impermeable liner and underdrain system that meet the criteria provided in Table P-FIL-06-4 and Table P-FIL-06-6.

| Table P-FIL-06-4 Filter Media and Surface Cover | |
| --- | --- |
| **Media** | **Requirement** |
| Type of Media | Sand filter media consists of clean, washed concrete sand with individual grains between 0.02 and 0.04 inch in diameter. Alternatively, organic media can be used, such as a peat/sand mixture or a leaf compost mixture. The decision to use organic media in a stormwater filter depends on which stormwater pollutants are targeted for removal. Organic media may enhance pollutant removal performance with respect to metals and hydrocarbons (Claytor and Schueler 1996). However, some organic media can leach soluble nitrate and phosphorus back into the discharge water, making it a poor choice when nutrients are the pollutant of concern. Designers must provide documentation that the selected media has been tested and verified for use as a stormwater filtering media. |
| Type of Filter | The choice of which sand filter design to apply depends on available space and hydraulic head and the level of pollutant removal desired. In ultra-urban situations where surface space is at a premium, underground sand filters are often the only design that can be used. Surface and perimeter filters are often a more economical choice when adequate surface area is available. |
| Surface Cover | The surface cover for surface sand filters should consist of a 3-inch layer of topsoil; (refer to BMP P-FIL-05, Bioretention) on top of a nonwoven filter fabric laid above the sand layer.<br>The surface may also have pea gravel inlets in the topsoil layer to promote filtration. The pea gravel may be located where sheet flow enters the filter, around the margins of the filter bed, or at locations in the middle of the filter bed. Underground sand filters may utilize a mono-filament filter fabric with a high flow rate and a thin layer of pea gravel ballast on top of the pea-gravel helps to prevent biofouling or blinding of the sand surface. The fabric serves to facilitate removing the gravel during maintenance operations. |
| Depth of Media | The depth of the filter media plays a role in how quickly stormwater moves through the filter bed and how well it removes pollutants. A minimum filter bed depth from 12 to 18 inches is recommended. Depths greater than 18 inches can be used to facilitate the removal up to 3 inches of sand during maintenance without having to replace the sand upon each scheduled maintenance. |
| Impervious Drainage Area | The CDA should be as close to 100% impervious as possible to reduce the risk that eroded sediments will clog the filter. |

### 5.5 Observation Wells and Cleanouts

The maintenance issues identified in Table P-FIL-06-5 should be addressed during filter design to reduce future maintenance problems.

| Table P-FIL-06-5 Maintenance Concerns | |
|---|---|
| **Feature** | **Requirement** |
| Observation Wells and Cleanouts | Surface filters should include an observation well consisting of a 6-inch diameter non-perforated polyvinyl chloride pipe fitted with a lockable cap. It should be installed flush with the ground surface to facilitate periodic inspection and maintenance. In most cases, a cleanout pipe will be tied into the end of all underdrain pipe runs. The portion of the cleanout pipe/observation well in the underdrain layer should be perforated. At least one cleanout pipe must be provided for every 2,000 square feet of filter surface area. |
| Access | Good maintenance access is needed to allow crews to perform regular inspections and maintenance activities. "Sufficient access" is operationally defined as the ability to get a vacuum truck or similar equipment close enough to the sedimentation chamber and filter to enable cleanouts. |
| Manhole Access (for Underground Filters) | Access to the headbox and clear well of underground filters must be provided by manholes at least 30 inches in diameter, along with steps to the areas where maintenance will occur. |
| Visibility | Stormwater filters should be clearly visible at the site so inspectors and maintenance crews can easily find them. Adequate signs or markings should be provided at manhole access points for underground filters. |
| Monofilament Fabric and Pea Gravel Ballast | The use of the fabric and ballast should simplify the maintenance of the filter media surface for both underground and surface filters. |
| Confined Space Issues | Underground filters are often classified as an underground confined space; therefore, Occupational Safety and Health Administration rules apply and training is required to protect workers. Required procedures often involve training about confined space entry, venting, and the use of gas probes. |

**5.6 Filtering Material Specifications**

The basic material specifications for filtering practices are outlined in Table P-FIL-06-6. Adaptations for specific environments are identified in Table P-FIL-06-7.

| Table P-FIL-06-6 Filtering Practice Material Specifications | | |
|---|---|---|
| **Material** | **Specification** | |
| Sand | Use clean silica based coarse sand (American Association of State Highway and Transportation Officials [AASHTO] M-6/ASTM C-33). | |
| | Organic Layer | See BMP P-FIL-08, Soil Compost Amendment. |
| Underdrain and Observation Well | See BMP P-FIL-05, Bioretention.<br>Install perforated pipe for the full length of the filtering practice. Observation wells should be installed as stated in BMP P-FIL-05 in a way to facilitate effective monitoring filter media performance. | |

| Table P-FIL-06-6 Filtering Practice Material Specifications | |
|---|---|
| **Material** | **Specification** |
| Filter Fabric | See BMP P-FIL-05, Bioretention, and BMP P-FIL-06, Filtering Practices. Choose an appropriate filter fabric for the individual applications. Filter fabric must be impermeable liner or woven fabric. For hotspots and karst sites only: use an appropriate liner on the bottom. |
| Stone Jacket for Underdrain | See BMP P-FIL-05, Bioretention.<br>Use a 9- to 18-inch layer (depending on the desired depth of storage) of 1-inch stone that is Virginia Department of Transportation (VDOT)-compliant aggregate and clean and free of all fines (e.g., VDOT #57 stone). |

| Table P-FIL-06-7 Regional and Special Case Design Adaptations | |
|---|---|
| **Feature** | **Requirement** |
| Karst Terrain | Stormwater filters are a good option in karst areas, since they are not connected to groundwater and therefore minimize the risk of sinkhole formation and groundwater contamination. Construction inspection should certify that the filters are watertight and that excavation will not extend into a karst layer. |
| Coastal Plain Terrain | The flat terrain, low head, and high-water table of the coastal plain make several filter designs difficult to implement. However, the perimeter sand filter generally has a low head requirement and can work effectively at many small coastal plain sites, subject to the following criteria:<br>• The combined depth of the underdrain and sand filter bed can be reduced to 18 inches.<br>• The designer may wish to maximize the length of the stormwater filter or provide treatment in multiple connected cells.<br>• The minimum depth to the seasonally high groundwater table may be relaxed to 18 inches, as long as the filter is equipped with a large diameter underdrain (e.g., 6 inches) that is only partially efficient at dewatering the filter bed.<br>• The depth to the seasonally high groundwater can be reduced further if the filter is entirely self-contained to prevent untreated stormwater from entering the groundwater. A geotechnical or structural engineer must verify sufficient support and anchoring to counteract any uplift from hydrostatic pressure.<br>• It is important to maintain at least a 0.5% slope of the underdrain to ensure drainage and to tie it into the receiving ditch or conveyance system. |
| Steep Terrain | The gradient of slopes contributing runoff to sand filters can be increased to 15% in areas of steep terrain, as long as a two-cell terraced design is used to dissipate erosive energy prior to filtering. The drop in elevation between cells should be limited to 1 foot and the slope should be armored with river stone or a suitable equivalent. |

| Table P-FIL-06-7 Regional and Special Case Design Adaptations | |
|---|---|
| **Feature** | **Requirement** |
| Cold Climate and Winter Performance | Surface or perimeter filters may not always be effective during the winter months. The main problem is ice that forms over and within the filter bed. Ice formation may briefly cause nuisance flooding if the filter bed is still frozen when spring melt occurs. To avoid these problems, filters should be inspected before the onset of winter (prior to the first freeze) to dewater wet chambers and scarify the filter surface. Other measures to improve winter performance include the following:<br>• Place a weir between the pretreatment chamber and filter bed to reduce ice formation; the weir is a more effective substitute than a traditional standpipe orifice.<br>• Extend the filter bed below the frost line to prevent freezing within the filter bed.<br>• Oversize the underdrain to encourage more rapid drainage and to minimize freezing of the filter bed.<br>• Expand the sediment chamber to account for road sand. Pretreatment chambers should be sized to accommodate up to 40% of the Tv. |
| Linear Highway Sites | Linear stormwater filters are a preferred practice for constrained highway rights-of-way 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 with vegetated filter strip pretreatment. Salt-tolerant grass species should be selected if the contributing roadway will be salted in the winter. |
| Linear Utility Sites | Stormwater filters are generally not suitable to treat runoff within fully vegetated utility rights-of-way or easements because the CDA should be as close to 100% impervious as possible to reduce the risk that eroded sediments will clog the filter. |

## 6.0 Construction Specifications

Figure P-FIL-06-4 and Figure P-FIL-06-5 provide typical schematics for a surface sand filter and organic filter, respectively. Figure P-FIL-06-6 provides a schematic for an underground sand filter, and Figure P-FIL-06-7 provides a schematic of a perimeter sand filter.

**Figure P-FIL-06-4 Schematic of a Surface Sand Filter**

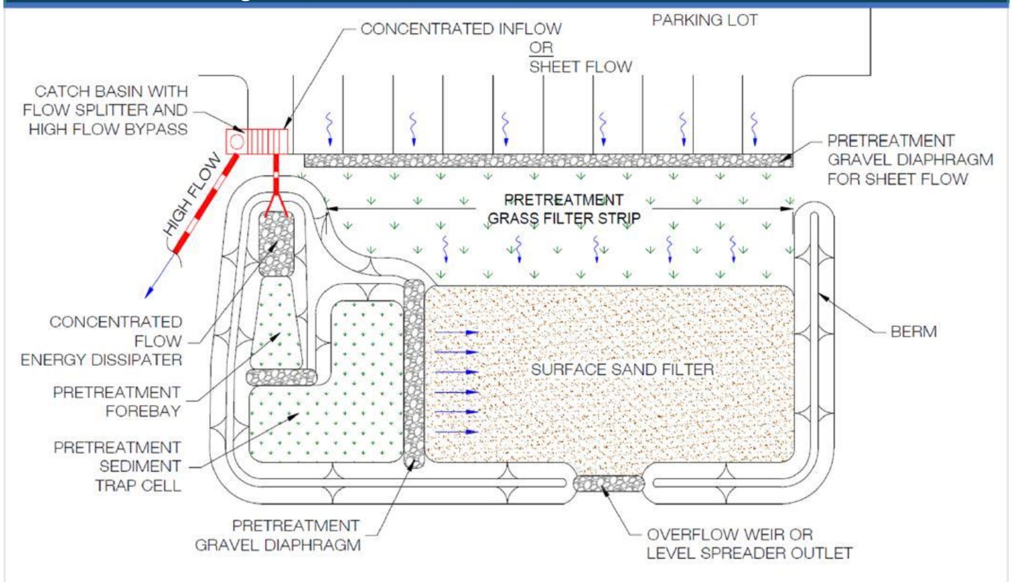



**Figure P-FIL-06-5 Profile of an Organic Filter**

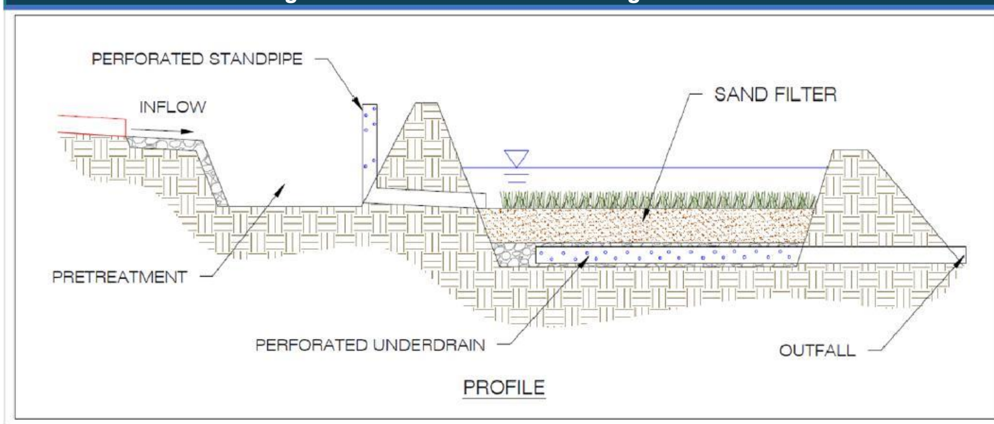


*Figure P-FIL-06-6 Underground Filter Schematic*

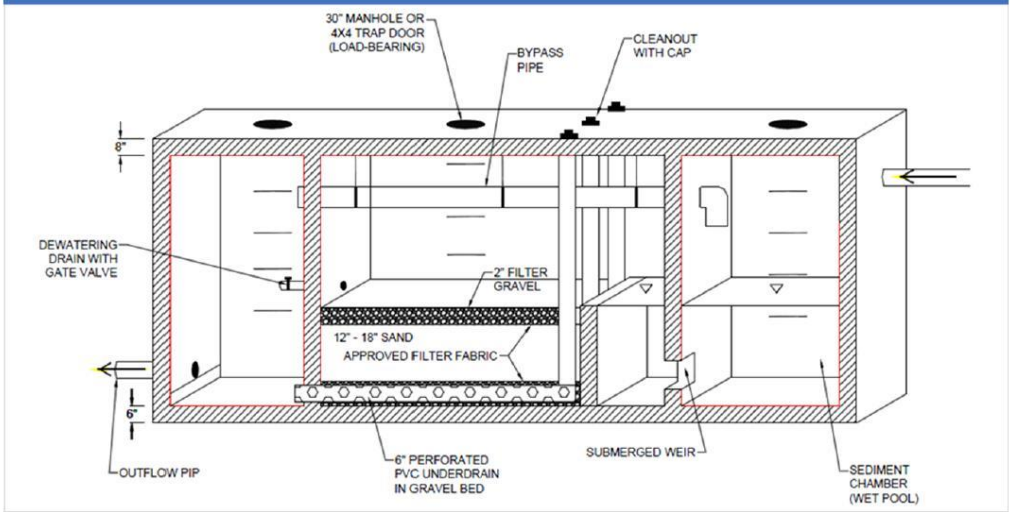
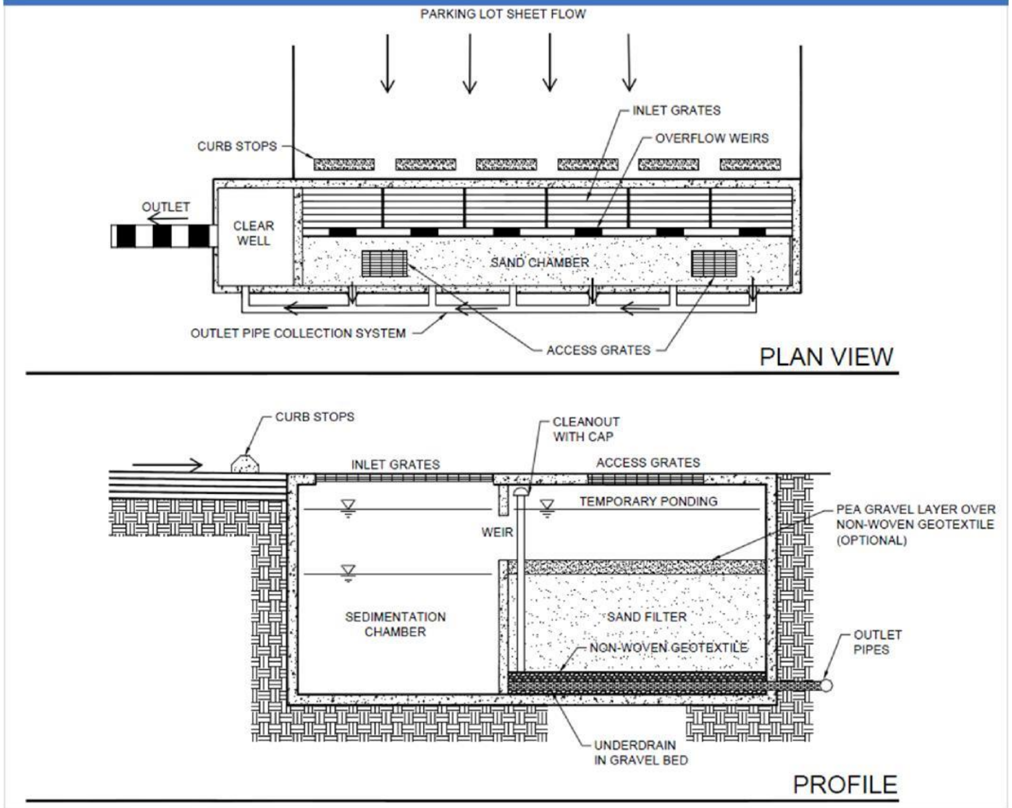


**Figure P-FIL-06-7 Perimeter Filter Plan and Profile Schematic**




### 6.2 Construction Sequence for Filtering Practices

The following is the typical construction sequence to properly install a structural stormwater filter. This sequence can be modified to reflect different filter designs, site conditions, and the size, complexity, and configuration of the proposed filtering application.

***Step 1: Use of Filtering Practices as an Erosion and Sediment Control***. The future location of a filtering practice may be used as the site of a temporary sediment basin or trap during site construction, as long as design elevations are set with final cleanout and conversion in mind. The bottom elevation of the filtering practice should be lower than the bottom elevation of the temporary sediment basin. Appropriate procedures should be implemented to prevent discharge of turbid waters when the temporary basin is converted to a filtering practice.

***Step 2: Stabilize Drainage Area***. Filtering practices should only be constructed or opened to runoff after the CDA to the facility is completely stabilized, so sediment from the CDA does not flow into and clog the filter. If the proposed filtering area is used as a sediment trap or basin during the construction phase, the construction notes should clearly specify that, after site construction is complete, the sediment control facility is to be dewatered, dredged, and regraded to design dimensions for the post-construction filter.

***Step 3: Install Erosion and Sediment Controls for the Filtering Practice.*** Stormwater should be diverted around filtering practices as they are being constructed. This is usually not difficult to accomplish for off-line filtering practices. It is extremely important to keep runoff and eroded sediments away from the filter throughout the construction process. Silt fence or other sediment controls should be installed around the perimeter of the filter, and erosion control fabric may be needed during construction on exposed side slopes with gradients exceeding 4H:1V. Exposed soils in the vicinity of the filtering practice should be rapidly stabilized by hydro-seed, sod, mulch, or other locally approved method of soil stabilization.

***Step 4: Assemble Construction Materials*** onsite, ensure they meet design specifications, and prepare any staging areas.

***Step 5: Excavate/Grade*** until the appropriate design elevations are achieved for the bottom and side slopes of the filtering practice.

***Step 6: Install the Filter Structure*** and check all design elevations (e.g., concrete vault pipe cut- out holes, bottom of excavation for surface filters).

***Step 7: Ensure Watertight Storage and Filter Structure.*** Upon completion of the filter structure shell, the inlets and outlets should be temporarily plugged and the structure filled with water to the brim to demonstrate watertightness. Maximum allowable leakage is 5% of the water volume in a 24-hour period. If the structure fails the test, repairs must be performed to make the structure watertight before any filter media is installed.

***Step 8: Install Underdrain, and Gravel and Choker Stone Layers.***

***Step 9: Spread Filter Media Across the Filter Bed*** in 1-foot lifts up to the design elevation. Backhoes or other equipment should deliver the media from outside the filter structure. Sand should be manually raked.

***Step 10: Consolidate the Filter Media.*** Fill the sedimentation and filter media chamber with clean water and allow to drain, hydraulically compacting the sand layers. Verify the depth of filter media meets the design minimum.

***Step 11: Install the Permeable Filter Fabric.***

- **For Surface Filters** – Install the permeable filter fabric (if specified) over the sand, add a 3-inch topsoil layer with pea gravel inlets diaphragms located with stakes, and immediately seed with the permanent grass species. The grass should be watered, and the facility should not be switched online until a vigorous grass cover has become established.
- **For Underground Filters** – Install the permeable filter fabric and a thin layer of pea gravel ballast (if specified) over the filter media.

***Step 12: Stabilize Exposed Soils*** on the perimeter of the structure with temporary seed mixtures appropriate for a buffer. All areas above the ponding area should be permanently stabilized by hydroseeding or seed and straw mulch.

***Step 13:*** Conduct the final construction inspection. Remove excess straw and any unwanted vegetation.

### 6.3 Construction Inspection

Multiple construction inspections during and immediately after construction are critical to ensure that stormwater filters are properly constructed. The following interim verification inspections are recommended during critical stages of construction:

- Conduct pre-construction meetings.
- Verify excavation/grading is to design dimensions and elevations.
- Verify the installation of the filter structure, including the watertightness test.

- Verify the installation of the underdrain and sand filter bed.
- Verify that turf cover is vigorous enough to switch the facility on-line.
- Perform the final inspection after a rainfall event to ensure that it drains properly. Develop a punch list for facility acceptance.
- Log the filtering practice's Global Positioning System (GPS) coordinates and submit them for entry into the Virginia Stormwater Management Program (VSMP) authority's BMP maintenance tracking database.

### 6.4 Sample Construction Inspection Checklist for Filtering Practices

The following checklist provides a basic outline of the anticipated items for the construction inspection of filtering practices. Users may wish to incorporate these items into a VSMP Authority Construction Checklist format consistent with the format used for erosion and sediment control and BMP construction inspections.

- **Certification of Pre-Construction Meeting**: Pre-construction meeting with the contractor designated to install the filtering practice has been conducted.
- Subsurface investigation and soils report supports the placement of a surface or an underground filtering 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 CDA have been adequately stabilized with a thick layer of vegetation and erosion control measures have been removed.
- Stormwater has been diverted around the area of the filtering practice and perimeter erosion control measures to protect the facility during construction have been installed.

#### 6.4.1 Surface Filter

- Excavation of the filtering practice has achieved proper grades and the required geometry for the filter media placement.
- No groundwater seepage or standing water is present. Any standing water is dewatered to an acceptable dewatering device.
- Installation of the impermeable liner (if required). Liner meets project specifications and is placed in accordance with manufacturers specifications.
- All aggregates, including the reservoir layer around the underdrain, the choker stone layer, and the filter media (sand) conform to specifications as certified by quarry.
- Underdrain size and perforations meet the specifications.
- Placement of the underdrain, observation wells, and underdrain fittings (45-degree wyes, cap at upstream end, etc.) are in accordance with the approved plans.
- **Certification of Excavation and Placement of Liner and Underdrains**: Inspector certifies the successful completion of the previous steps for a surface filter.
- Placement of the stone aggregate, spread (not dumped) around the underdrain, and placement of the layer of the choker stone in accordance with the approved plans.
- Placement of the sand filter media in 1-foot lifts.
- Verify proper depth of filter media.
- Verify surface treatment (vegetation, pea gravel, etc., in accordance with the approved plans.

#### 6.4.2 Underground Structural Filter

- Excavation of the filtering practice has achieved proper grades and the required geometry for the underground structural housing – typically a vault or container made of concrete of other approved material.
- No groundwater seepage or standing water is present. Any standing water is dewatered to an acceptable dewatering device.
- Installation of fabric (if needed) and gravel bedding.
- Placement of the structural housing and verification of internal and external plumbing invert elevations.
- **Certification of Watertightness Test Inspection**: Inspector certifies the successful completion of the watertightness test completed and signed off by contractor or vault supplier.
- Installation of perforated pipes and other piping as required, and filter media to the required depth.
- Connection of inlet and outlet pipes to the site drainage system.

#### 6.4.3 All Filters

- **Certification of Opening of Stormwater Inflow to the Filter Inspection**: Inspector certifies that the CDA(s) are stabilized and 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 filtering practices on the parcel.

## 7.0 Operations and Maintenance Considerations

### 7.1 Maintenance Agreements

The Virginia Erosion and Stormwater Management Regulation (9VAC25-875-535) includes requirements for long-term maintenance of stormwater management facilities. To ensure successful implementation of stormwater filtering practices, long-term maintenance and operation should consider the following, to include 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 stormwater filtering practices must include a long-term maintenance agreement consistent with the provisions of the VESMP Regulation and must include the recommended maintenance tasks and a copy of an annual inspection checklist.
- When stormwater filters are applied on private residential lots, owners should be educated regarding their routine maintenance needs by being provided a document that explains their purpose and routine maintenance needs.
- A deed restriction, drainage easement, or other mechanism enforceable by the VESMP Authority must be in place to help ensure that stormwater 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 VESMP Authority to access the property for inspection or corrective action.

### 7.2 Maintenance Inspections

Regular inspections are critical to schedule sediment removal operations, replace filter media, and relieve any surface clogging. Frequent inspections are especially needed for underground and perimeter filters since an organic mat can quickly clog the filter surface. Depending on the level of traffic or the particular land use, a filter system may become clogged within a few months of normal rainfall. Frequent maintenance can quickly establish a routine frequency acclimated to the land use. Maintenance inspections should be conducted within 24 hours following a storm that exceeds 1/2 inch of rainfall in order to evaluate the condition and performance of the filtering practice, including checking for the following:

- Inspect whether sediment accumulation in the sedimentation chamber has exceeded 6 inches. If so, schedule a cleanout.
- Inspect whether inlets and flow splitters are clear of debris and are operating properly.
- Inspect the dry sediment chamber and sand filter bed for any evidence of standing water or ponding more than 48 hours after a storm and take necessary corrective action to restore permeability.
- Dig a small test pit in the sand filter bed to determine whether the first 3 inches of sand are visibly discolored and need replacement.
- Inspect whether the CDA to the filter is stable and not a source of sediment.
- Inspect whether turf on the filter bed and buffer is more than 12 inches high, and schedule necessary mowing operations.
- Inspect the integrity of observation wells and cleanout pipes.
- Inspect concrete structures and outlets for any evidence of spalling, joint failure, leakage, corrosion, etc.
- Ensure that the filter bed is level and remove trash and debris from the filter bed. Sand or gravel covers should be raked to a depth of 3 inches. Filters with a turf cover should have 95% vegetative cover.

The results of the inspection will then determine the level of maintenance required (routine or major – see Table P-FIL-06-8). Example maintenance inspection checklists for filtering practices are included in Chapter 10, BMP Inspection and Maintenance.

**7.3 Routine Maintenance Tasks**

A cleanup should be scheduled at least once per year to remove trash and floating debris that accumulate in the pretreatment cells and filter bed. Sediment cleanouts in the dry and wet sedimentation chambers should be performed as needed to maintain the function and performance of the filter. If the filter treats runoff from a stormwater hotspot, crews may need to test the filter bed media before disposing of the media and trapped pollutants. Testing is not needed if the filter does not receive runoff from a designated stormwater hotspot, in which case the media can be safely disposed by either land application or land filling.

**Table P-FIL-06-8 Suggested Annual Maintenance Activities for Filtering Practices**

| Maintenance Tasks | Frequency |
|---|---|
| Mow grass filter strips and perimeter turf. | At least four times per year |
| Remove blockages and obstructions from inflows. Relieve clogging.<br>Stabilize CDA and side slopes to prevent erosion. | As needed |
| Inspect and clean up. | Annually |

| Table P-FIL-06-8 Suggested Annual Maintenance Activities for Filtering Practices | |
|---|---|
| **Maintenance Tasks** | **Frequency** |
| Clean out wet sedimentation chambers.<br>Remove sediments from dry sedimentation chamber. | Once every 2 to 3 years or as needed |
| Replace top sand layer.<br>Till or aerate surface to improve infiltration/grass cover. | Every 5 years |

## 8.0 References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Claytor, R. and T. Schueler. 1996. Design of Stormwater Filtering Systems. Chesapeake Research Consortium and the Center for Watershed Protection. Ellicott City, Maryland. 329

# P-FIL-07 Sheet Flow to Vegetated Filter Strip or Conserved Open Space

## 1.0 Definition

Filter strips are vegetated areas that treat sheet flow delivered from adjacent managed turf and impervious areas by slowing runoff velocities and allowing sediment and attached pollutants to settle and/or be filtered by the vegetation.

## 2.0 Purpose and Applicability of Best Management Practice

Stormwater must enter the vegetated filter strip or conserved open space as sheet flow. A typical configuration consists of the stormwater runoff from the paved area uniformly entering the practice along a linear edge (such as the edge of a road or parking lot) and draining across the length of the filter strip or open space parallel to the flow. This configuration would be accompanied by a gravel diaphragm or other pretreatment practice to establish a non-erosive transition between the pavement and the filter strip or open space. If the inflow to the filter strip is from a pipe or channel, a level spreader must be designed in accordance with BMP ~~C-ECM-14, Level Spreader~~P-SUP-08 Permanent Level Spreader, to convert the concentrated flow to sheet flow.

The two design variants of filter strips are: conserved open space and designed vegetated filter strips. The differences in design, installation, and management of these design variants are outlined in this specification.

**2.1 Conserved Open Space**

The most common design applications of conserved open space are on sites that are hydrologically connected to a protected stream buffer, wetland buffer, floodplain, forest conservation area, or other protected lands.

- Conserved open space is an ideal component of the "outer zone" of a stream buffer, such as a Resource Protection Area (as is required in some regions), which normally receives runoff as sheet flow. Care should be taken to locate all energy dissipaters or flow spreading devices outside of the protected area.

  Designers may apply a runoff reduction credit to any impervious or managed turf cover that is hydrologically connected and effectively treated by a protected conserved open space that meets the following eligibility criteria:

- The goal of establishing conserved open space is to protect a vegetated area contiguous to a receiving system, such as a stream or natural channel, for treating stormwater runoff. Establishing isolated conserved open space pockets on a development site may not achieve this goal unless they effectively serve to connect the surface runoff to the receiving system. Therefore, a locality may choose to establish goals for minimum acreage to be conserved (in terms of total acreage or percentage of the total project site), and the physical location (adjacent to a stream or other criteria) for the cumulative conserved open space to qualify for the runoff reduction credit.
- Minimal disturbance shall occur within the conserved open space during or after construction (i.e., no clearing or grading is allowed except temporary disturbances associated with incidental utility construction, restoration operations, or management of nuisance vegetation). The conserved open space area shall not be stripped of topsoil. Some minimal grading may be needed at the boundary to establish a level entry into the conserved open space. This shall be accomplished using rubber tracked vehicles to prevent compaction.

  The limits of disturbance shall be clearly shown on all construction drawings and protected by acceptable signage and erosion control measures.
- A long-term vegetation management plan must be prepared to maintain the conserved open space in a natural vegetative condition. Generally, conserved open space management plans do not encourage or even allow any active management. However, a specific plan should be developed to manage the unintended consequences of passive recreation, control invasive species, provide for tree and understory maintenance,

etc. Managed turf is not considered an acceptable form of vegetative management, and only the passive recreation areas of dedicated parkland are eligible for the practice (e.g., the actively used portions of ball fields and golf courses are not eligible), although conservation areas can be ideal treatment practices at the edges of turf-intensive land uses.

The conserved open space must be protected by a perpetual easement or deed restriction that assigns the responsible party to ensure that no future development, disturbance, or clearing may occur within the area.

The practice does not apply to jurisdictional wetlands that are sensitive to increased inputs of stormwater runoff (e.g., bogs and fens).

**2.2 Vegetated Filter Strip**

Vegetated filter strips are best suited to treat runoff from small segments of impervious cover (usually less than 5,000 square feet) adjacent to road shoulders, small parking lots, and rooftops. Vegetated filter strips may also be used as pretreatment for another stormwater practice, such as a dry swale, bioretention, or infiltration areas. Refer to Support Component: BMP P-SUP-06, Pre-Treatment, for more information regarding pretreatment requirements. If sufficient pervious area is available at the site, larger areas of impervious cover can be treated by vegetated filter strips using a level spreader to recreate sheet flow. Vegetated filter strips are also well suited to treat runoff from turf-intensive land uses, such as the managed turf areas of sports fields, golf courses, and parkland.

Vegetated filter strips can be used in a variety of situations; however, there are several constraints to their use:

- Soil compaction or disturbance in and around the area of a proposed vegetated filter strip should be minimized to the extent practical. If this is unavoidable, the area should be restored by tilling or otherwise re-establishing the soil permeability in accordance with requirements of BMP P-FIL-08, Soil Compost Amendment. The plan-approving authority may require the applicant to verify the restoration of the soils, either through compost amendments or other means sufficient to achieve the goal of treating runoff from upgradient areas.
- The proposed vegetated filter strip shall be shown on the soil erosion and stormwater management plan.
- A vegetation management plan should be developed to maintain the vegetation density of the filter strip. Herbaceous native species with deep roots of several feet for infiltration should be managed to the extent necessary to maintain a healthy cover. However, any fertilizing or other maintenance, such as mowing, should be identified in a management plan as part of the long-term best management practice operation and maintenance plan.

The vegetated filter strip should be identified and protected in a perpetual easement, deed restriction, or other accepted mechanism that assigns the responsible party to ensure that no future development, disturbance or clearing may occur within the area, except as stipulated in the vegetation maintenance plan. Signage and or markings should be installed to identify the location and extents of vegetated filter strips.

## 3.0 Planning and Considerations

**Table P-FIL-07-1 Feasibility/Limitations**

| | |
|---|---|
| Filter Slopes and Length | Maximum slopes for conserved open space and vegetated filter strips are between 6% and 8%. Minimum lengths (flow path) for conserved open space and vegetated filter strips are dependent on filter strip slope, as specified in Table P-FIL-07-3. The maximum length of a filter strip is 100 feet. |
| Soils | Vegetated filter strips are appropriate for all soil types, except fill soils. The runoff reduction rate, however, is dependent on the underlying Hydrologic Soil Groups (HSGs) and whether soils receive compost amendments; (see Table P-FIL-07-2). |
| Contributing Flow Path to Filter | Vegetated filter strips are used to treat small drainage areas of several thousand square feet of contributing drainage area. The limiting design factor is the length of flow directed to the filter. As a rule, the upstream contributing length of sheet flow to a filter strip shall be no more than 100 feet. When flow concentrates, it moves too rapidly to be effectively treated by a vegetated filter strip unless a level spreader or gravel diaphragm is used upstream for the filter strip. |
| Hydraulic Capacity | Sheet flow practices to conserved open space or vegetated filter strips designed as an on-line practice must be checked to verify the increased volumes of sheet flow will not cause or contribute to erosion, sedimentation, or flooding of downgradient properties or resources. Both conserved open space and vegetated filter strips should be designed as an off-line practice by using periodic diversion or overflow structures to take the runoff in excess of the design treatment volume BMP to an alternative conveyance system. |
| Hotspot Land Uses | Filter strips are not recommended to treat stormwater hotspots due to the potential for infiltration of hydrocarbons, trace metals, and other toxic pollutants into groundwater. |
| Turf-Intensive Land Uses | Both conserved open space and vegetated filter strips are appropriate to treat managed turf and the actively used areas of sports fields, golf courses, parkland, and other turf-intensive land uses. |
| Proximity of Underground Utilities | Underground pipes and conduits that cross the vegetated filter strip are acceptable if the previously disturbed soils from trenching are properly restored. |
| Karst Areas | Both conserved open space and vegetated filter strips are preferred BMPs in karst areas. |
| Depth to Water Table | A separation distance of 1 to 2 feet is recommended between the bottom of the vegetated filter strip and the elevation of the seasonally high-water table. |
| Minimum Setbacks | Local ordinances and design criteria should be consulted to determine minimum setbacks from property lines, structures, utilities, and wells. As a rule, filter strips should be at least 10 feet from building foundations, 10 feet from residential structures, 35 feet from septic system fields, and 50 feet from private wells. |

## 4.0 Stormwater Performance Summary

**Table P-FIL-07-2 Summary of Stormwater Functions Provided by Filter Strips**

| Stormwater Function | Conservation Area | | Vegetated Filter Strip | |
|---|---|---|---|---|
| | HSG A and B | HSG C and D | HSG A | HSG B[4], C and D |
| | Assume no CA[2] in Conservation Area | | No CA[3] | With CA[2] |
| Annual Runoff Reduction Volume | 75% | 50% | 50% | 50% |
| Total Phosphorus EMC Reduction[1] by BMP Treatment Process | 0 | | 0 | |
| Total Phosphorus Mass Load Removal | 75% | 50% | 50% | 50% |
| Total Nitrogen EMC Reduction by BMP Treatment Process | 0 | | 0 | |
| Total Nitrogen Mass Load Removal | 75% | 50% | 50% | 50% |
| Channel Protection and Flood Mitigation | Partial. Use the Virginia Runoff Reduction Method (VRRM) Compliance spreadsheet to adjust curve number for each design storm for the contributing drainage area; and Account for a lengthened time-of-concentration flow path in computing peak discharge. | | | |

**Notes:**

Source: Center for Watershed Protection (CWP) and Chesapeake Stormwater Network (CSN) 2008; CWP 2007.

CA = compost amended soils

EMC = event mean concentration

HSG = Hydrologic Soil Group

1. There is insufficient monitoring data to assign a nutrient removal rate for filter strips at this time.
2. See BMP P-FIL-08, Soil Compost Amendment.
3. Compost amendments are generally not applicable for undisturbed HSG A soils, although it may be advisable to incorporate them on mass-graded A or B soils and/or filter strips on B soils in order to maintain runoff reduction rates.
4. The plan approving authority may waive the requirement for compost amended soils for filter strips on B soils under certain conditions.

## 5.0 Design Criteria

Conserved open space and vegetated filter strips do not have two levels of design. Instead, each must meet the appropriate minimum criteria outlined in this section to qualify for the indicated level of runoff reduction (see Table P-FIL-07-3). In addition, designers must conduct a site reconnaissance prior to design to confirm topography and soil conditions.

**Table P-FIL-07-3 Filter Strip Design Criteria**

| Design Issue | Conserved Open Space | Vegetated Filter Strip |
|---|---|---|
| Soil and vegetation Vegetative Cover | Undisturbed soils and native | Amended soils and dense turf grass cover or landscaped with herbaceous cover, shrubs, and trees |
| Overall Slope and Length[1] | HSG A and B<br>1% to 2% Slope – Minimum 25-foot length<br>2% to 4% Slope – Minimum 40-foot length<br>4% to 6% Slope – Minimum 50-foot length<br>6% to 8% Slope – Minimum 60-foot length<br>Maximum length of 100 feet<br>HSG C and D<br>1% to 2% Slope – Minimum 40-foot length<br>2% to 4% Slope – Minimum 50-foot length<br>4% to 6% Slope – Minimum 65-foot length<br>6% to 8% Slope – Minimum 80-foot length<br>Maximum length of 100 feet | 1% to 2% Slope – Minimum 25-foot length<br>2% to 4% Slope – Minimum 50-foot length<br>4% to 6% Slope – Minimum 75-foot length<br>6% to 8% Slope – Minimum 95-foot length<br>Maximum length of 100 feet |
| Contributing Area | There is no specific maximum contributing drainage area; however, there is a maximum flow length of 100 feet from upstream contributing drainage areas. The contributing drainage area must be uniformly graded, with a shallow enough slope to maintain sheet flow. If concentrated flow is directed to a conserved open space or vegetated filter strip, then a level spreader must be installed upstream of the filter strip. | |
| Level Spreader for dispersing Concentrated Flow | Refer to BMP ~~C-ECM-14, Level Spreader~~P-SUP-08 Permanent Level Spreader, for design | |
| Construction Stage | Locate outside the limits of disturbance and manage according to construction BMPs. | Prevent soil compaction by heavy equipment. |
| Typical Applications | Treat adjacent to stream or wetland buffer or forest conservation area. | Treat small areas of impervious cover (e.g., 5,000 square feet) and/or turf-intensive land uses (e.g., sports fields, golf courses) close to source. |

**Notes:**

1. A minimum of 1% slope is recommended to ensure positive drainage.
2. The plan approving authority may waive the requirement for compost amended soils for filter strips on HSG B soils under certain conditions.

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### Table P-FIL-07-3 Filter Strip Design Criteria

| Design Issue | Conserved Open Space | Vegetated Filter Strip |
|---|---|---|
| Compost Amendments | No | Yes (HSG B, C, and D soils) |
| Boundary Spreader | Gravel diaphragm at top of filter; Permeable berm at toe of filter | Gravel diaphragm at top of filter |
| On-line or Off-line Practice | Can be installed as either an on-line or off-line practice. | Typically installed as an on-line practice. |

**Notes:**

1. A minimum of 1% slope is recommended to ensure positive drainage.
2. The plan approving authority may waive the requirement for compost amended soils for filter strips on HSG B soils under certain conditions.

#### 5.1 Compost Soil Amendments

Compost soil amendments will enhance the runoff reduction capability of a vegetated filter strip when located on HSGs B, C, and D, subject to the following design requirements:

- The compost amendments should extend over the full length and width of the filter strip.
- The amount of approved compost material and the depth to which it must be incorporated is outlined in BMP P-FIL-08, Soil Compost Amendments.
- The amended area will be raked to achieve the most level slope possible without using heavy construction equipment, and it will be stabilized rapidly with perennial grass and/or herbaceous species.
- If filter strip slopes exceed 3%, a protective biodegradable fabric, blankets, or matting should be installed to stabilize the site prior to runoff discharge. Refer to BMP C-SSM-05, Soil Stabilization Blankets and Matting.
- Compost amendments should not be incorporated until the gravel diaphragm and/or level spreader is installed.
- The local plan approval authority may waive the requirement for compost amendments on HSG-B soils in order to receive credit as a filter strip if the following conditions are met:
  - The designer can provide verification of the adequacy of the onsite soil type, texture, and profile to function as a filter strip.
  - The area designated for the filter strip will not be disturbed during construction.

#### 5.2 Planting and Vegetation Management

##### 5.2.1 Conserved Open Space

No grading or clearing of native vegetation is allowed within the conserved open space. An invasive species management plan should be developed and approved by the local plan approval authority.

**Reforested Conserved Open Space**. At some sites, the proposed conserved open space may be in turf or meadow cover or overrun with invasive plants and vines. In these situations, a landscape architect or horticulturalist should prepare a reforestation or restoration plan for the conserved open space. The entire area can be planted with native trees and shrubs or planted to achieve a gradual transition from turf to meadow to shrub and forest. Trees and shrubs with deep rooting capabilities are recommended for planting to maximize soil infiltration capacity (PWD 2007). Over-plant with seedlings for fast establishment and to account for mortality.

Plant larger stock at desired spacing intervals (25 to 40 feet for large trees) using random spacing (Cappiella et al. 2006). Plant ground cover or an herbaceous layer to ensure rapid vegetative cover of the surface area. The Virginia Department of Conservation and Recreation's Riparian Buffer Modification and Mitigation

Handbook (2003) provides references for planting densities and shrub to tree ratios for reforestation and forested buffer areas. Refer to BMP P-FIL-09, Tree Planting, and Appendix G, Plant Selection, for additional details regarding tree plantings.

### 5.2.2 Vegetated Filter Strips

Vegetated filter strips should be planted at such a density to achieve a 90% grass/herbaceous cover after the second growing season. Vegetated filter strips should be seeded, not sodded. Seeding establishes deeper roots, and sod may have muck soil that is not conducive to infiltration (Wisconsin Department of Natural Resources 2007). The filter strip vegetation may consist of turf grasses, meadow grasses, other herbaceous plants, shrubs, and trees, as long as the primary goal of at least 90% coverage with grasses and/or other herbaceous plants is achieved. Designers should choose vegetation that stabilizes the soil and is salt tolerant. Vegetation at the toe of the filter, where temporary ponding may occur behind the permeable berm, should be able to withstand both wet and dry periods. The planting areas can be divided into zones to account for differences in inundation and slope.

Refer to BMP C-SSM-10, Permanent Seeding, and Appendix G, Plant Selection, for permanent turf grass and landscaping specifications.

## 5.3 Conveyance and Overflow

### 5.3.1 On-Line Systems

Conserved open space and vegetated filter strips may be designed as an on-line system. In such cases increased volumes of sheet flow resulting from pervious or disconnected impervious areas, or from physical spreading of concentrated flow through level spreaders, should be identified and evaluated for potential impacts on downgradient properties or resources.

For discharge of sheet flow from pervious or disconnected impervious areas, documentation/computations should be provided demonstrating that increased volumes of sheet flow:

- Will not adversely impact any downgradient property (i.e., cause erosion and/or cause or worsen localized flooding).
- Will not adversely impact any downgradient environmental features (e.g., wetlands, streams).
- Will be conveyed within any downgradient manmade stormwater conveyance system without causing erosion of the system for the 2-year, 24-hour storm AND will be confined within any downgradient manmade stormwater conveyance system without causing or worsening localized flooding for the 10-year, 24-hour storm.
- Will meet the design parameters of any downgradient restored stormwater conveyance system.
- Will be conveyed within any downgradient natural stormwater conveyance system without causing erosion of the system for the 1-year, 24-hour storm AND will be confined within any downgradient manmade stormwater conveyance system without causing or worsening localized flooding for the 10-year, 24-hour storm.

For discharges of sheet flow from level spreaders, documentation/computations should be provided demonstrating that discharges of sheet flow from level spreaders:

- Will not adversely impact any downgradient property (i.e., cause erosion and/or cause or worsen localized flooding).
- Will not adversely impact any downgradient environmental features (e.g., wetlands, streams).

### 5.3.2 Off-Line Systems

Conserved open space and vegetated filter strips may also be designed as an off-line system, with a flow splitter or diversion to divert runoff in excess of the design storm to a separate conveyance system.

## 5.4 Support Components

### 5.4.1 Gravel Diaphragms

Refer to BMP P-SUP-06, Pre-Treatment, for gravel diaphragm design specifications and details.

**5.4.2 Permeable Berm**

Vegetated filter strips should be designed with a permeable berm at the toe of the filter strip to create a shallow ponding area. Runoff ponds behind the berm gradually flows through outlet pipes in the berm or through a gravel lens in the berm with a perforated pipe. During larger storms, runoff may overtop the berm (Cappiella et al. 2006).

The permeable berm should have the following properties:

- A wide and shallow trench between 3 to 4 feet in width and 6 to 12 inches in depth should be excavated at the upstream toe of the berm, parallel with the contours.
- Media for the berm should consist of 40% sandy loam soil, 40% sand (Virginia Department of Transportation [VDOT] Grade A Fine aggregate per VDOT 2020 Road and Bridge Specifications, Section 202.03), and 20% pea gravel (American Association of State Highway and Transportation Officials [AASHTO] M-43 1/2 inch to 1 inch).
- The berm, 12 to 18 inches high, should be located downgradient of the excavated depression and should have gentle side slopes to promote easy mowing (Cappiella et al. 2006).
- Stone may be needed to armor the top of berm to handle extreme storm events and one or more armored weirs can be sized to allow for nonerosive overflows during large storm events.

  A permeable berm is not needed when vegetated filter strips are used as pretreatment to another stormwater practice.

**5.4.3 Engineered Level Spreaders**

Refer to P-SUP-08, Permanent Level Spreader, for design specifications and details pertaining to level spreaders designed to convert concentrated flow to sheet flow.

**5.4.4 Vegetated Filter Strip Material Specifications**

Table P-FIL-07-4 and Table P-FIL-07-5 provide materials specifications and guidance for the primary treatment within filter strips.

**Table P-FIL-07-4 Vegetated Filter Strip Materials Specifications**

| Material | Specification |
|---|---|
| Gravel Diaphragm | See BMP P-SUP-06, Pre-Treatment. |
| Turf Grass and Plantings | See BMP C-SSM-10, Permanent Seeding, and Appendix G, Plant Selection. |
| Engineered Level Spreader | See BMP P-SUP-08, Level Spreader. |
| Erosion Control Blanket | See BMP C-SSM-05, Soil Stabilization Blankets and Matting.<br>Where filter path slope and sheet flow velocities dictate, use woven biodegradable erosion control fabric or mats that are durable enough to last at least two growing seasons. |
| Topsoil | See BMP C-SSM-02, Topsoiling. |
| Compost Amendments | See BMP P-FIL-08, Soil Compost Amendment.<br>Compost shall be derived from plant material and provided by a member of the U.S. Composting Seal of Testing Assurance program, as outlined in BMP P-FIL-08, Soil Compost Amendment. |

| Table P-FIL-07-5 Additional Design Guidance | |
|---|---|
| **Feature** | **Guidance** |
| Karst Terrain | Conserved open space areas are highly recommended in karst terrain, particularly when storm flow discharges to the outer boundary of a karst protection area; (see CSN 2009).<br>Vegetated filter strips can also be used to treat runoff from small areas of impervious cover (e.g., less than 5,000 square feet). Some communities use wide grass filter strips to treat runoff from the roadway shoulder.<br>In no case should the use of a conserved open space or vegetated filter strip be considered as a replacement for an adequate receiving system for developed- condition stormwater discharges, unless the adequacy of the design has been demonstrated consistent with the Virginia Stormwater Management Handbook. |
| Coastal Plain | The use of conserved open space areas and vegetated filter strips are highly recommended in the coastal plain, particularly when sheet flow (or concentrated flow with an appropriately sized level spreader) discharges to the outer boundary of a shoreline, stream or wetland buffer. Vegetated filter strips can also be used to treat runoff from small areas of impervious cover (e.g., less than 5,000 square feet). In both cases, however, the designer must consider the depth to the water table. In general, shallow water tables may inhibit the function of vegetated filter strips and 1 to 2 feet of separation from the seasonal high-water table should be provided. |
| Linear Highway Sites | Vegetated filter strips are recommended to treat highway runoff if the median and/or road shoulder is wide enough to provide an adequate flow path. |
| Linear Utility Sites | Vegetated filter strips are recommended to treat runoff from utility right-of-ways, given the site is wide enough to provide an adequate flow path. |
| Cold Climate and Winter Performance | Vegetated filter strips can store snow and treat snowmelt runoff when they serve road or parking lot drainage. If roadway salt is applied in their contributing drainage area, filter strips should be planted with salt-tolerant species such as creeping bent grass or switchgrass. Bluegrass should be avoided in areas where salt loading is high. Consult the Minnesota Stormwater Manual (Minnesota Stormwater Steering Committee 2005) for a list of salt-tolerant grass species. |

## 6.0 Construction Specifications

**6.1 Construction Sequence for Conserved Open Space Areas**

The conserved open space must be fully protected during the construction stage of development and kept outside the limits of disturbance designated in the Erosion and Sediment Control Plan prepared for the site.

- No clearing, grading, or heavy equipment access is allowed except minimal, temporary disturbances associated with incidental utility construction, restoration operations, or management of nuisance vegetation.
- The perimeter of the conserved open space shall be protected from construction sediment by super silt fence in accordance with BMP C-PCM-04, Silt Fence.
- The limits of disturbance should be clearly shown on all construction drawings and identified and protected in the field by acceptable signage, and chain link fence, orange safety fence, snow fence or other protective barrier should be used to keep unnecessary construction activity out of the area. Construction of the gravel diaphragm or level spreader shall not commence until the contributing drainage area has been stabilized and perimeter erosion and sediment controls have been removed and cleaned out.
- Some minimal grading may be needed at the conserved open space boundary; tracked vehicles should be used to prevent compaction.
- Stormwater should not be diverted into the conserved open space until the gravel diaphragm and/or level spreader are installed and stabilized.

**6.2 Construction Sequence for Vegetated Filter Strips**

Vegetated filter strips can be within the limits of disturbance during construction. The following procedures should be followed during construction:

- Before site work begins, vegetated filter strip boundaries should be clearly marked.
- Only vehicular traffic used for filter strip construction should be allowed within 10 feet of the vegetated filter trip boundary.
- If existing topsoil is stripped during grading, it shall be stockpiled for later use.
- Construction runoff should be directed away from the proposed filter strip site using appropriate erosion control measures and a diversion dike or other measure.
- Construction of the gravel diaphragm or level spreader shall not commence until the contributing drainage area has been stabilized and perimeter erosion and sediment controls have been removed and cleaned out.
- Vegetated filter strips require light grading to achieve desired elevations and slopes; tracked vehicles should be used to prevent compaction. Topsoil and or compost amendments should be incorporated evenly across the filter strip area, stabilized with seed, and protected by biodegradable erosion control matting or blankets.
- Stormwater should not be diverted into the filter strip until the turf cover is dense and well established.

**6.3 Construction Inspection**

Inspections during construction are needed to ensure that the filter strip is built in accordance with these specifications.

- Construction inspection is critical to obtain adequate spot elevations and to ensure the gravel diaphragm or level spreader is completely level, on the same contour, and constructed to the correct design elevation.
- As-built surveys should be required to ensure compliance with design standards.
- Inspectors should evaluate the performance of the filter strip after the first rainfall event of 0.1-inch depth or greater to look for evidence of gullies, outflanking, undercutting, or sparse vegetative cover. Spot repairs should be made as needed.

The Global Positioning System (GPS) coordinates should be logged for all filter strips and conserved open spaces, upon acceptance, and submitted for entry into the local BMP maintenance tracking database.

***Sample Construction Inspection Checklist for Sheet Flow to Vegetated Filter Strip or Conserved OpenSpace:*** The following subsections provide a checklist or basic outline of the anticipated items for the construction inspection of sheet flow practices. Users may wish to incorporate these items into a Virginia Stormwater Management Program (VSMP) Authority Construction Checklist format consistent with the format used for erosion and sediment control and BMP construction inspections.

**6.3.1 Sheet Flow to Conserved Open Space Areas**

- Pre-construction meeting with the contractor designated to install the sheet flow practice has been conducted.
- Impervious cover has been constructed/installed and the area is free of construction equipment, vehicles, material storage, etc.
- All pervious areas of the contributing drainage areas have been adequately stabilized and erosion control measures have been removed.
- The area of the conserved open space has been clearly marked and protected from construction traffic with adequate signage and fencing and is in good condition (undisturbed – other than for pruning or other vegetation management needs).
- Area of the conserved open space has been clearly marked and protected from construction runoff and sediment with appropriate sediment control measures (super silt fence, berms, etc.).
- Stormwater has been diverted for the construction of the inflow (level spreader or gravel diaphragm).
- Any light grading required to establish the upper boundary of the conserved open space has been performed with light equipment and minimal impact to the existing vegetation.
- Construction of engineered level spreader for concentrated inflow or a gravel diaphragm or other pretreatment measure for sheet flow has been completed and the area stabilized as needed.
- Stormwater runoff directed into conserved open space after the area at the upper boundary has been stabilized.
- All erosion and sediment control practices have been removed.
- A follow-up inspection and as-built survey/certification has been scheduled.
- GPS coordinates have been documented for all conserved open spaces on the parcel.

**6.3.2 Sheet Flow to Vegetated Filter Strips**

- Pre-construction meeting with the contractor designated to install the sheet flow practice has been conducted.
- Impervious cover has been constructed/installed and the area is free of construction equipment, vehicles, material storage, etc.
- All pervious areas of the contributing drainage areas have been adequately stabilized and erosion control measures have been removed.
- Area of the vegetated filter strip has been clearly marked and protected from construction traffic with adequate signage and fencing, and is in good condition; or
- Area of the vegetated filter strip has been previously (temporarily) stripped of topsoil during construction is scheduled for restoration and soil amendments (if required).
- Topsoil and/or soil amendments are nearby and certified as meeting the design specifications.
- Proper grades have been achieved with light equipment to avoid compaction to provide the required geometry of the disconnection practice: length, width, and slope, and preparation of the upper boundary has been performed.

- Stormwater has been diverted for the construction of the inflow measures (level spreader or gravel diaphragm).
- Soil amendments, if specified, have been incorporated as specified (thickness of compost material and incorporated to the required depth).
- Construction of engineered level spreader for concentrated inflow or a gravel diaphragm or other pretreatment measure for sheet flow has been completed.
- The entire area of the vegetated filter strip has been stabilized and achieved a dense turf cover prior to diverting runoff into the practice.
- All erosion and sediment control practices have been removed.
- A follow-up inspection and as-built survey/certification has been scheduled.
- GPS coordinates have been documented for all vegetated filter strips on the parcel.

### 6.4 Typical Details

Figure P-FIL-07-1 shows a typical approach for sheet flow to a conserved open space (adapted from Cappiella et al. 2006). Figure P-FIL-07-2 illustrates the gravel diaphragm providing pretreatment, and Figure P-FIL-07-3 details a level spreader with a rigid and a vegetated overflow lip. Figure P-FIL-07-4 illustrates the combination of simple disconnection discussed in BMP P-FIL-01, Rooftop Impervious Surface Disconnection, to conserved open space as the downstream practice.

**Commented [MC1]:** FIGURE: ARCADIS
Change 'Gravel Diaphragm (Figure 2.2)' to 'BMP P-SUP-06 Gravel Diaphragm'

Change 'Width as Determined (Table 2.2) to 'Length as Determined (Table P-FIL-07-3);
(and delete 'length' box)

Change 'Permeable Berm (Sec. 6.3)' to 'Permeable Perm (Section 5.4.2)'

Change 'Maximum Slope as Provided in Table 2.2' to 'Maximum Slope (P-FIL-07-3)'

*Figure P-FIL-07-1 Typical Configuration of Sheet Flow to Filter Strip or Conserved Open Space*

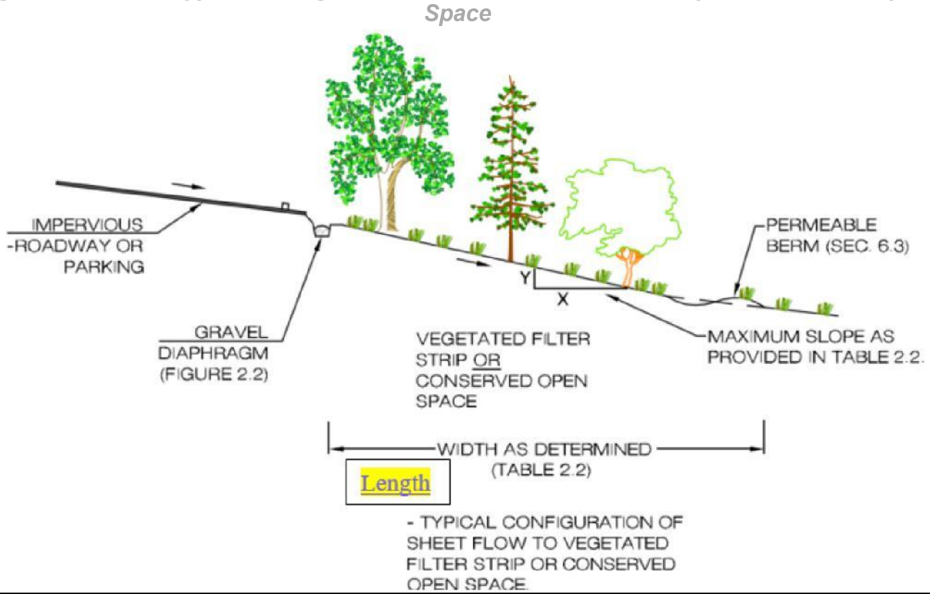


*Figure P-FIL-07-2 Gravel Diaphragm – Sheet Flow Pretreatment*

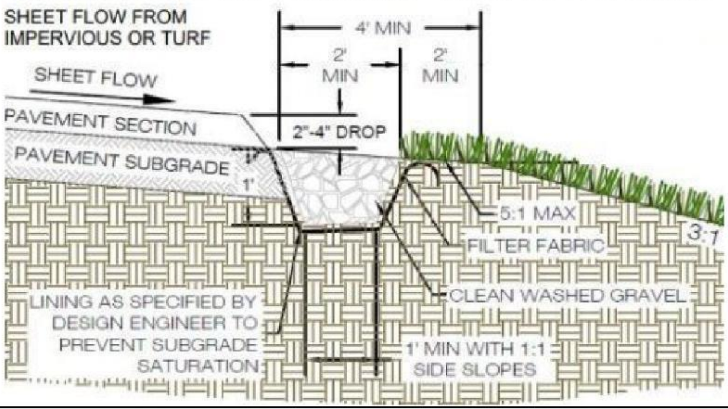
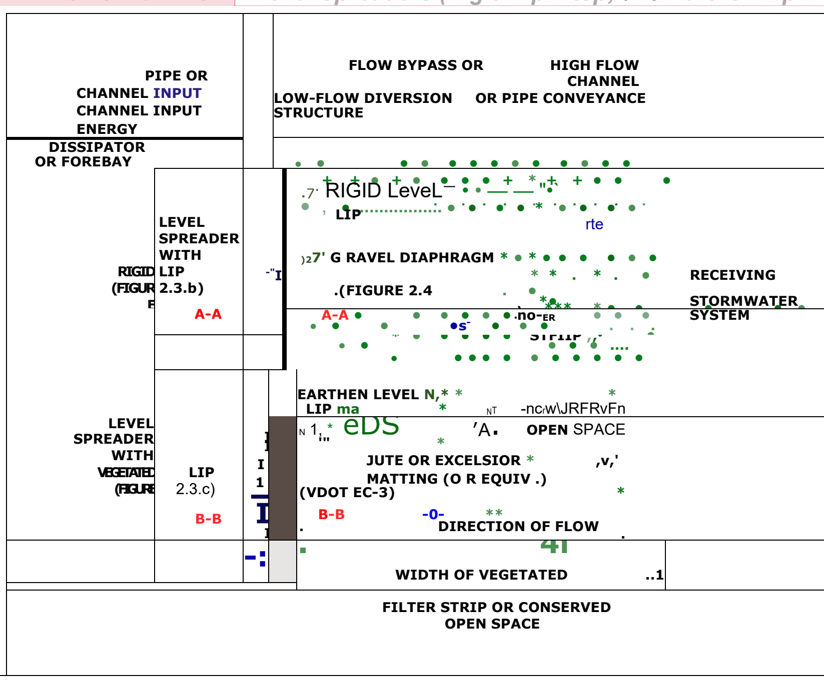



*Figure P-FIL-07-3 Plan View – Level Spreaders (Rigid Lip – top;* ***and*** *Earthen Lip – bottom)*

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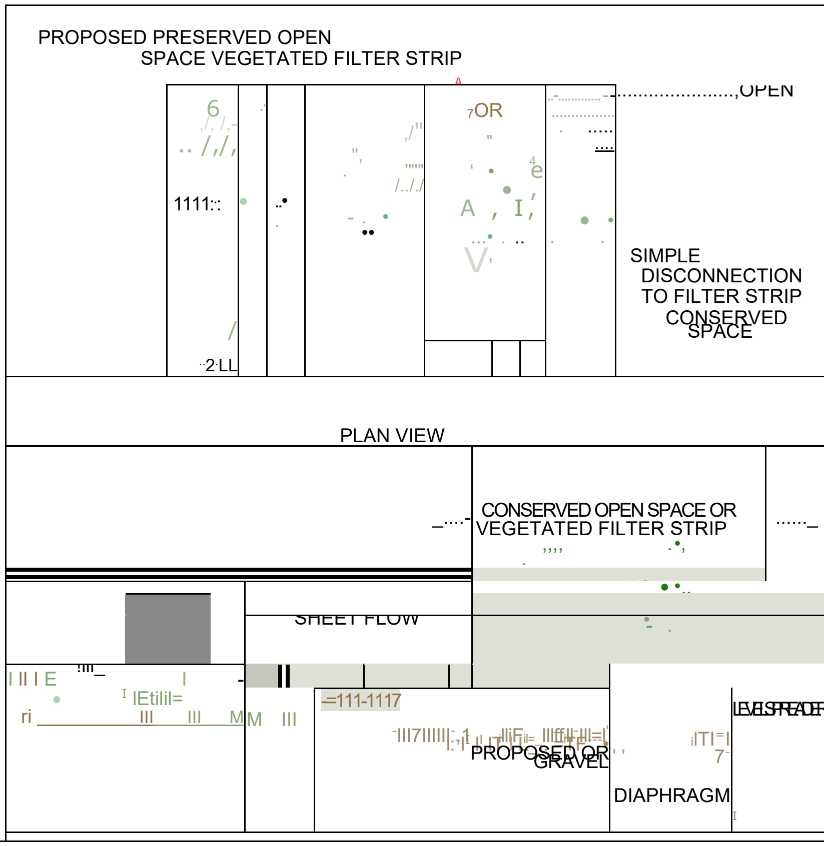
Remove cross sections A-A and B-B (no reference)

***Figure P-FIL-07-4 Simple Disconnection to downstream Conserved Open Space or Vegetated Filter Strip***

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Remove cross section A'-A (no reference)

## 7.0 Operations and Maintenance Considerations

### 7.1 Maintenance Agreements

The Virginia Erosion and Stormwater Management Regulation (9VAC25-875-535) includes requirements for long-term maintenance of stormwater management facilities. To ensure successful implementation of vegetated filter strips, long-term maintenance and operation should consider the following, to include 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.

**Table P-FIL-07-6 Maintenance Agreements**

| Activity |
|---|
| All vegetated filter strips must be covered by a long-term maintenance agreement and drainage easement consistent with the provisions of VESMP Regulation to allow inspection and maintenance. |
| If the vegetated filter strip is located on a residential private lot, the existence and purpose of the filter strip shall be noted on the deed of record. |
| Property owners shall be provided a document that explains the purpose of the filter strip and routine maintenance needs. |
| A deed restriction or other mechanism enforceable by the VESMP Authority must be in place to help ensure that filter strips are maintained. |
| Conserved open space shall be protected by a perpetual easement, deed restriction, or other mechanism enforceable by the VESMP aAuthority that assigns the responsible party to ensure that no future development, disturbance, or clearing may occur within the area, except as stipulated in the vegetation maintenance plan. |
| The existence and purpose of the open space shall be noted on the deed of record, and the owners shall be provided with a simple document that explains the purpose of the open space and routine maintenance needs. |

In cases of both vegetated filter strips and conserved open space, the protective mechanism for ensuring maintenance should grant authority for local agencies to access the property for inspection or corrective action.

### 7.2 Maintenance Inspections

Annual inspections are used to trigger maintenance operations such as sediment removal, spot re-vegetation, and level spreader repair. Ideally, inspections should be conducted in the non-growing season when it easier to see the flow path.

Inspections should check to ensure that:

- Flows through the vegetated filter strip do not short-circuit the overflow control section;
- Debris and sediment do not build up at the top of the vegetated filter strip;
- Foot or vehicular traffic does not compromise the gravel diaphragm;
- Scour and erosion do not occur within the filter strip;
- Sediments are cleaned out of level spreader forebays and flow splitters; and
- Vegetative density exceeds 90% cover in the boundary zone or grass filter.

Example maintenance inspection checklists for sheet flow to a vegetated filter strip or conserved open space areas are included in Appendix H, Soil Characterization and Infiltration Testing.

### 7.3 Ongoing Maintenance

Once established, vegetated filter strips have minimal maintenance needs outside of the spring cleanup, periodic mowing, repair of check dams, and other measures to maintain the hydraulic efficiency of the strip and a dense, healthy grass cover. Vegetated filter strips that consist of grass/turf cover should be mowed at least twice per year to prevent woody growth. Turf grass should not be cut shorter than 4 to 6 inches and can be left to grow as tall as 12 inches, depending on aesthetic requirements.

## 8.0 References

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# P-FIL-08 Soil Compost Amendment

## 1.0 Definition

Soil restoration and compost amendment is a technique that enhances compacted soils to improve their porosity and nutrient retention. It includes amending soil with compost to enhance the soil food web (or biological elements of a soil), mechanical aeration, mechanical loosening (tilling), planting dense vegetation, and applying soil amendments.

## 2.0 Purpose and Applicability of Best Management Practice

Soil restoration involves the spreading and mixing of mature compost into disturbed and compacted urban soils. These soil amendments can reduce the generation of runoff from compacted urban lawns and may also enhance the runoff reduction performance of areas that receive runoff such as downspout disconnections, grass channels, and filter strips (Table P-FIL-08-1).

Soil restoration is suitable for any pervious area in which soils have been or are expected to be compacted by grading and construction. This practice is particularly well suited when the pervious area will be used to filter runoff (downspout disconnections, grass channels, and vegetated sheet flow filter strips). The area or strip of amended soils should be hydraulically connected to the stormwater conveyance system. Soil restoration is recommended for sites that will be subject to mass grading, which is the removal and stockpiling of existing topsoil and replacing it on top of the newly graded (and compacted) landscape.

## 3.0 Planning and Considerations

### 3.1 Feasibility/Limitations

Soil restoration and compost amendments are not recommended where:

- Existing soils have high infiltration rates (e.g., Hydrologic Soils Group [HSG] A and B), although compost amendments may be needed at mass-graded HSG B soils in order to maintain runoff reduction rates.
- The water table or bedrock is located within 1.5 feet of the soil surface.
- Slopes exceed 10 percent (compost can be used on slopes exceeding 10 percent if proper soil erosion and sediment control measures are included in the plan). Amendments will not be used on slopes of 3:1 and steeper because an increase in soil moisture may cause slope instability (Virginia Cooperative Extension 2019).
- Existing soils are saturated or seasonally wet.
- Application would harm roots of existing trees (keep amendments outside the tree drip line).
- The downhill slope runs toward an existing or proposed building foundation.
- The contributing impervious surface area exceeds the surface area of the amended soils.
- Amendments and soil restoration can increase infiltration, which may result in groundwater contamination at hot spots such as gas stations.

Compost amendments can be applied to the entire pervious area of a development or only to select areas of the site to enhance the performance of runoff reduction practices. Some common design applications include:

- Reduce runoff from compacted lawns (while also enhancing the long-term viability of the turf) in HSG A-D and in any compacted low permeability soil in HSG B-D.

- Increase runoff reduction for rooftop disconnections directed over otherwise poor soils.
- Increase runoff reduction within a grass channel with HSG C or D soils.
- Increase runoff reduction within a vegetated filter strip with HSG C or D soils.
- Increase the runoff reduction function of a tree cluster or reforested area of the site.
- Increase the runoff reduction function of a natural, vegetated utility right-of-way.

## 4.0 Stormwater Performance Summary

**Table P-FIL-08-1 Stormwater Functions of Soil Compost Amendments**

| Stormwater Function | HSG A and B | | HSG C and D | |
|---|---|---|---|---|
| | No CA[1] | With CA | No CA | With CA |
| Annual Runoff Reduction Volume | | | | |
| Simple Rooftop Disconnection | 50% | NA[2] | 25% | 50% |
| Filter Strip | 50% | NA[2] | NA[3] | 50% |
| Grass Channel | 20% | NA[2] | 10% | 30% |
| Total Phosphorus EMC Reduction[3] by BMP Treatment Practice | 0 | | 0 | |
| Total Phosphorus Mass Load Removal | Same as for annual runoff reduction volume | | Same as for annual runoff reduction volume | |
| Total Nitrogen EMC Reduction by BMP Treatment Practice | | | 0 | |
| Total Nitrogen Mass Load Removal | Same as for annual runoff reduction volume | | Same as for annual runoff reduction volume | |
| Channel Protection and Flood Mitigation | Partial. Use the Virginia Runoff Reduction Method (VRRM) Compliance spreadsheet (https://swbmp.vwrrc.vt.edu/vrrm/) to adjust the curve number for each design storm for the contributing drainage area, based on annual runoff volume reduction achieved. | | | |

- BMP P-FIL-01, Rooftop Impervious Surface Disconnection;
- BMP P-FIL-02, Vegetated Roof;
- BMP P-FIL-07, Sheet Flow to Vegetated Filter Strip or Conserved Open Space;
- BMP P-CNV-01, Grass Channels;
- BMP P-FIL-09, Tree Planting

## 5.0 Design Criteria

### 5.1 Soil Testing

Soil tests are required during two stages of compost amendment. The first test is conducted to ascertain pre-construction soil properties at proposed amendment areas. The second soil test is taken at least one week after the compost has been incorporated into the soils.

The results are used to determine soil properties to a depth 1 foot below the proposed amendment area, with respect to bulk density, pH, salts, and soil nutrients. One test will be conducted for every 5,000 square feet of proposed amendment area. The test results are used to characterize potential drainage problems and determine what, if any, further soil amendments are needed.

A representative soil sample consists of a well-mixed composite of 10 subsamples. A soil sample from a single spot, instead of the representative sample described here, could result in inaccurate nutrient recommendations. Collect at least 10 subsamples from the uniform test area and mix them together in a clean container. The soil analysis should be conducted by a reputable laboratory to determine whether any further nutritional requirements, pH adjustments, and/or organic matter adjustments are necessary for plant growth. This soil analysis should be done in conjunction with the final construction inspection to ensure tilling or subsoiling has achieved design depths.

### 5.2 Determining Depth of Compost Incorporation

The depth of compost amendment is based on the relationship of the surface area of the soil amendment to the contributing area of impervious cover that it receives. Table P-FIL-08-2 presents some general guidance derived from soil modeling by Holman-Dodds (2004) that evaluates the required depth to which compost must be incorporated. The recommended incorporation depth was adjusted to reflect alternative recommendations of Roa-Espinosa (2006), Balousek (2003), Chollak and Rosenfeld (1998), and others.

**Table P-FIL-08-2 Shortcut Method to Determine Compost and Incorporation Depths**

| Parameter | Contributing Impervious Cover to Soil Amendment Area Ratio [1] | | | |
|---|---|---|---|---|
| | IC/SA = 0 [2] | IC/SA = 0.5 | IC/SA = 0.75 | IC/SA = 1.0 [3] |
| Compost (inches) [4] | 2 to 4 [5] | 3 to 6 [5] | 4 to 8 [5] | 6 to 10 [5] |
| Incorporation Depth (inches) | 6 to 10 [5] | 8 to 12 [5] | 15 to 18 [5] | 18 to 24 [5] |
| Incorporation Method | Rototiller | Tiller | Subsoiler | Subsoiler |

Notes:

1. IC = contributing impervious cover (square feet) and SA = surface area of compost amendment (square feet).
2. For amendment of compacted lawns that do not receive offsite runoff.
3. In general, IC/SA ratios greater than 1 should be avoided.
4. Average depth of compost added.
5. Lower end for HSG B soils, higher end for HSG C/D soils.

Once the area and depth of the compost amendments are known, the designer can estimate the total amount of compost needed using an estimator developed by TCC 1997:

***Equation P-FIL-08-1***

Where:

C = compost needed (cubic yards).

A = area of soil amended (square feet). D = depth of compost added (inches).

**5.3 Compost Specifications**

- Compost will be derived from plant material and meet the general criteria set forth by the U.S. Composting Seal of Testing Assurance (STA) program. See www.compostingcouncil.org for a list of local providers.
- The compost will be the result of the biological degradation and transformation of plant-derived materials under conditions that promote aerobic decomposition. The material will be well composted, free of viable weed seeds, and stable with regard to oxygen consumption and carbon dioxide generation. The compost will have a moisture content that has no visible free water or dust produced when handling the material. It will meet the following criteria as reported by the U.S. Composting Council STA Compost Technical Data Sheet provided by the vendor:
  - 100% of the material must pass through a 0.5-inch screen.
  - The pH of the material will be between 5.5 and 8.5.
  - Manufactured inert material (e.g., plastic, concrete, ceramics, metal) will be less than 0.5 percent by weight.
  - The organic matter content will be >35 percent.
  - Soluble salt content will be less than 6.0 millimohs per centimeter (mmhos/cm).
  - Compost must be mature and stable per the appropriate test(s) as specified by STA.
  - Carbon/nitrogen ratio will be less than 25:1.
  - Must meet United States Environmental Protection Agency (USEPA) part 503 levels for heavy metals.
  - The compost should have an optimum dry bulk density ranging from 40 to 50 lbs/ft3. However, certain fully mature coarse textured composts may be lower.
  - Compost should be pesticide-free.

In general, fresh manure should not be used for compost because of high bacteria and nutrient levels. If manure is used, it must be aged (composted) and meet the criteria listed above.

**5.4 Minimum Design Criteria for Site Reforestation**

Several design criteria apply when compost amendments are used as one of the methods to enhance the performance of reforested areas. Site reforestation involves planting trees on existing turf or barren ground at a development site with the explicit goal of establishing a mature forest canopy that will intercept rainfall, increase evapotranspiration rates, and enhance soil infiltration rates. Reforestation areas at larger development sites (and individual trees at smaller development sites) are eligible under the following qualifying conditions.

- The minimum contiguous area of reforestation must be greater than 5,000 square feet.
- A long-term vegetation management plan must be prepared and filed with the local review authority in order to maintain the reforestation area in a natural forest condition.
- The reforestation area must be protected by a perpetual stormwater easement or deed restriction which stipulates that no future development or disturbance may occur within the area.
- Reforestation methods must achieve 75 percent forest canopy within 10 years.
- The planting plan must be approved by the appropriate local forestry or conservation authority including any special site preparation needs.

- The construction contract should contain a care and replacement warranty extending at least three growing seasons to ensure adequate growth and survival of the plant community.
- The reforestation area will be shown on all construction drawings and Erosion and Sediment Control Plans during construction.
- A minimum compost incorporation depth of 18 inches is required for reforestation areas where trees and shrubs are being planted.

**5.5 Minimum Design Criteria for Linear Utility Site Restoration to a Natural Vegetated State**

Several design criteria apply when compost amendments are used to return a disturbed linear utility site to a natural, vegetated state. Site restoration involves restoring the soils to a hydrologically functional state that will mimic the natural, undisturbed condition. Restoration for linear utility projects (not individual utilities included in larger development sites) are eligible to be considered an open space for post-development land cover condition under the following qualifying conditions.

- A long-term vegetation management plan (including being bushhogged no more than four times per year) must be prepared and filed with the local review authority in order to maintain the restored area in a natural, vegetated condition.
- The restored linear utility area must be protected by deeded operation and maintenance agreements and plans, third-party protective easement, deed restriction, or other document approved by the Virginia Stormwater Management Program (VSMP) authority. This component may include coordination and joint agreement with landowners to ensure the area will remain in a natural, vegetated state until an amended Stormwater Management Plan is approved for the site.
- The construction plans detail the removal and reclamation of all temporary structures, roads, pads, and how those areas will be returned to a hydrologically functional state.
- Restoration methods must achieve 90 percent ground cover with the first year.
- The restoration area will be shown on all construction drawings and Erosion and Sediment Control Plans during construction.

**5.6 Regional and Special Case Design Adaptations**

**Table P-FIL-08-3 Regional and Special Case Design Adaptations**

| Condition | Details |
|---|---|
| Karst Terrain | No special adaptations are needed in karst terrain, but the designer should take soil tests to ensure that soil pH is adjusted to conform to pre-existing soil conditions found in limestone dominated areas. |
| Coastal Plain Terrain | Designers should evaluate drainage and water table elevations to ensure the entire depth of soil amendment will not become saturated (i.e., a minimum separation depth of 1.5 feet from groundwater). Compost amendments are most cost-effective when used to boost the runoff reduction capability of grass vegetated filter strips, grass channels, and rooftop disconnections. |
| Steep Terrain | Compost amendments are ineffective when longitudinal slopes exceed 10%; therefore, some terracing may be needed on steeper slopes. Compost amendments should not be used when slopes exceed 3:1. |
| Cold Climate and Winter Performance | Soil restoration is not recommended for areas that will be used for snow storage. |

| Table P-FIL-08-3 Regional and Special Case Design Adaptations | |
|---|---|
| **Condition** | **Details** |
| Linear Highway Sites | Soil amendments can improve the runoff reduction of grass channels and filter strips in open section of rights-of-way and highway medians. |
| Linear Utility Sites | Soil amendments can restore disturbed areas within utility easements or rights-of- way that are to remain in a natural, vegetated state and be considered “open space” to a functionally hydrologic state. |

## 6.0 Construction Specifications

### 6.1 Construction Sequence for Soil Compost Amendment

The construction sequence for compost amendments differs depending on whether the practice will be applied to a large area or a narrow filter strip such as in a rooftop disconnection or grass channel. For larger areas, a typical construction sequence is as shown in Table P-FIL-08-4.

| Table P-FIL-08-4 Construction Sequence for Soil Compost Amendment | |
|---|---|
| **Step** | **Details** |
| Step 1 | To help minimize compaction, heavy vehicular and foot traffic should be kept out of all restored pervious areas during and after construction. This can typically be accomplished by clearly delineating soil restoration and compost amendment areas on all development plans and, if necessary, protecting them with temporary construction fencing. |
| Step 2 | For large areas of soils to be restored (typically with an IC/SA less than 0.5 ): after the area has been cleared of construction activity, the area should be deep tilled to a depth of 2 to 3 feet using a tractor and subsoiler with two deep shanks (curved metal bars) to create rips perpendicular to the direction of flow. This establishes a vertical pathway for the compost to influence microbial activity into the adjacent soil. (This step may be omitted when compost is used for narrower filter strips.) |
| Step 3 | Spread the specified compost depth in accordance with Table P-FIL-08 across the surface and incorporate into the soil using a rototiller, tiller, or subsoiler as specified. It is important to have dry conditions at the site prior to incorporating compost. |
| Step 4 | To limit soil erosion and sediment loss, landscaping should be installed immediately after the soil restoration and amendments have been completed. The site should be leveled and seed or sod used to establish a vigorous grass cover. Lime and/or temporary irrigation may initially be needed to help the grass grow quickly. |
| Step 5 | Areas of compost amendments exceeding 2,500 square feet should employ simple erosion control measures, such as silt fence or diversions, to reduce the potential for erosion and trap sediment. |

### 6.2 Construction Inspection

Construction inspection involves digging a test pit to verify the depth of mulch, amended soil, and scarification. A rod penetrometer should be used to establish the depth of uncompacted soil at one location per 10,000 square feet. The test pits will be used to verify that the compost amendments have reached the required incorporation depth.

Upon final inspection and acceptance, log the filtering soil compost amendment practice's global positioning system (GPS) coordinates and submit them for entry into the local best management practice (BMP) maintenance tracking database.

## 7.0 Operations and Maintenance Considerations

### 7.1 Maintenance Agreements

The Virginia Erosion and Stormwater Management Regulation (9VAC25-875-535) includes requirements for long-term maintenance of stormwater management facilities. To ensure successful implementation of the BMP, long-term maintenance and operation should consider the following, to include 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.

The long-term maintenance requirements for soil amendments are minor compared with many other BMPs; however, the following items should be addressed as part of a long-term maintenance program for amended soils:

- When soil amendments are applied on private residential lots, homeowners should be educated on the long-term performance goal and any routine maintenance needs that will ensure continued performance.
- It will be the responsibility of the VESMP Authority to identify through the local ordinance what type of Maintenance Agreement, deed restriction, or other mechanism, if any, will be required where soil amendments are applied across the graded portions of residential lots to reduce runoff at the site scale.
- Where soil amendments are applied to specific runoff reduction practices, the presence and purpose of the soil amendments must be identified within the required Maintenance Agreement, maintenance plan, and applicable enforcement mechanism for those practices.
- In all cases, the mechanism should grant authority for local agencies to access the property for inspection or corrective action, especially where the application of soil amendments has been credited in lieu of a structural BMP.

In cases of soil restoration associated with more than 10,000 square feet of reforestation, a simple Maintenance Agreement, along with a conservation easement and/or deed restriction, which also identifies a responsible party, may be required to make sure the newly developing forest cannot be cleared or developed and appropriate management is accomplished (i.e., thinning, invasive plant removal).

Soil compost amendments within a filter strip or grass channel should be located within a dedicated stormwater or drainage easement or in a public right-of-way as required by the specifications for those individual practices.

### 7.2 First Year Maintenance Operations

In order to ensure the success of soil compost amendments, the tasks outlined in Table P-FIL-08-5 must be undertaken in the first year following soil restoration.

| Table P-FIL-08-5 Operations and Maintenance Schedule | |
|---|---|
| **Activity** | **Details** |
| Initial inspections | For the first 6 months following the incorporation of soil amendments, the site should be inspected at least once after each storm event that exceeds 0.5 inch of rainfall. |
| Spot Reseeding | Inspections should note bare or eroding areas in the contributing drainage area or around the soil restoration area and ensure that they are immediately stabilized with grass cover. |
| Fertilization | Depending on the findings of a soils test of the amended area, a one-time spot fertilization may be needed in the fall after the first growing season to increase plant vigor. |
| Watering | Water once every 3 days for the first month and then weekly during the first year (April through October) depending on rainfall. |

**7.3 Ongoing Maintenance**

- Dethatch and aerate turf and mulching bed areas to increase permeability as needed.
- Consider temporary irrigation during extreme droughts to keep vegetation healthy.

The owner should also be aware that there are maintenance tasks needed for filter strips, grass channels, and reforestation areas. An example maintenance inspection checklist for an area of soil compost amendments is provided in Chapter 10, BMP Inspection and Maintenance.

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**Commented [MC1]:** Document available via online search but future links are unreliable

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# C-SCM-02 Construction Road Stabilization

## 1.0 Definition

Construction road stabilization is the stabilization of temporary construction access routes, onsite vehicle transportation routes, and construction parking areas.

**Download File** – CAD and PDF files for C-SCM-02 Construction Road Stabilization

## 2.0 Purpose and Applicability of Best Management Practice

This specification applies to temporary or permanent access roads and parking areas for use by construction traffic. Additionally, this specification applies to (but is not limited to) streets and highways, parking areas, and other traffic areas immediately after grading to reduce erosion caused by vehicles during wet weather conditions.

This construction best management practice (BMP) is used to:

1. Reduce the erosion of temporary roadbeds caused by construction traffic during wet weather.
2. Reduce the erosion and subsequent regrading of permanent roadbeds between the time of initial grading and final stabilization.
3. Reduce ground compaction from vehicular traffic.
4. Reduce excess disturbance to root zones and shrubs within ecologically sensitive environments (e.g., wetlands, streams, riparian buffers, forested grounds).

## 3.0 Planning and Considerations

Areas graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters 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 cause sediment to be transported offsite on the wheels of construction vehicles. During wet weather, dirt roads can be unusable.

Construction of a conventional haul road through forested and/or soft ground results in additional ground disturbance and a potential source of sediment into adjacent streams and waterways.

Both stone and temporary timber deck mats are suitable stabilization materials for a construction access road.

If construction or project access roads are located within 50 feet of and drain to a sinkhole or other karst feature capable of conveying water underground, the edge of the road near the karst feature should be protected using super silt fence (Specification BMP C-PCM-04).

To avoid erosion, compaction, and runoff problems when siting a construction access route or parking area, follow the planning steps recommended by American Electric Power Service Corporation (AEP 2018, p.72) and:

1. Coordinate with resources agencies (e.g., Virginia Department of Conservation and Recreation, Virginia Department of Wildlife Resources, Virginia Department of Historic Resources) to determine the appropriate areas for access routes, taking into consideration aquatic resources and sensitive areas including karst resources (AEP 2018).
2. Evaluate information from the Natural Resources Conservation Service (NRCS) Web Soil Survey, U.S. Geological Survey, National Wetlands Inventory, and other available resources to determine the most appropriate areas for access routes and/or parking based on areas of erodible soils, karst topography, wet or rocky areas, and areas with seasonally high water tables.

3. Evaluate the site topography to locate natural benches and flatter slopes and use these areas for access routes and/or parking. Avoid long, steep road grades and narrow valleys.
4. Evaluate aquatic resources in the area to minimize stream and/or wetland crossings. Where crossings are unavoidable, consider the following:
    a. Cross at right angles to minimize the length of the crossing.
    b. Cross where the resource is narrowest and upland areas are most stable.
    c. Minimize the number of crossings.
    d. Leave a buffer zone of undisturbed ground between the road and resource, where the road runs parallel to the resource.
    e. Divert water from the road with a temporary diversion to prevent water running directly into the resource.
5. Where possible, use switchbacks to lessen the road grade on steeper sloped areas.
6. Locate roads and/or parking areas on stable geology that includes well-drained soils and rock formations that tend to dip into the slope. Avoid slumps and slide-prone areas characterized by steep slopes, highly weathered bedrock, clay beds, concave slopes, hummocky topography, or rock layers that dip parallel to the slope.
7. Ridge tops can be good places for roads if proper drainage can be constructed. Be aware that conditions may change when constructing during the dry season. Be prepared to add culverts after construction when hidden springs and streams start back up in the winter and spring.
8. If possible, build roads on the drier south- or west-facing slopes.

## 4.0 Stormwater Performance Summary

**MS-4: First-Step Measures** – When used appropriately, low-volume construction access roads and driveways will preserve the existing land conditions and topography and reduce erosion. Low-volume access roads and their culverts, diversions, outlet protection, and other used measures shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

**MS-17: Vehicular Tracking and Construction Entrances** – Where construction vehicle access routes intersect paved or public roads, provisions shall be made to minimize the transport of sediment by vehicular tracking onto the paved surface. Where sediment is transported onto a paved or public road surface, the road surface shall be cleaned thoroughly at the end of each day. Sediment shall be removed from the roads by shoveling or sweeping and transported to a sediment control disposal area. Street washing shall be allowed only after sediment is removed in this manner. This provision shall apply to individual development lots as well as to larger land-disturbing activities.

9VAC25-875-560

**Erosion Control Efficiency: MODERATE**

**Sediment Removal Efficiency: LOW**

## 5.0 Design Criteria

**Table C-SCM-02-1 Design Criteria for Construction Road Stabilization**

| Design Criteria for Construction Road Stabilization | |
|---|---|
| Road Cross- Sections | 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-02-1).<br>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.<br>• **Crowned Fill Section:** Use on flat ground where water standing on a road surface may be a problem.<br>• **Crowned Turnpike Section:** Use on low ground roads where fill is not available.<br>• **Outslope:** Use on moderate slopes for low-volume roads and stable soils. Outsloping can be more dangerous in wet and snowy weather.<br>• **Inslope with Ditch Section:** Use on steep hills, areas with fine-textured soils, winter logging roads, and where drainage is necessary.<br>• **Crowned and Ditched Section:** Use on high-volume roads on steep side hills. |
| Road Width | Construct roadbeds to be a minimum of 14 feet wide for one-way traffic and 20 feet wide for two-way traffic. |
| Alignment (Natural Resources Conservation Service 2021) | Adapt the gradient and horizontal alignment to the intensity of use, the mode of travel, the type of equipment and load weights, and the level of development. Frequent grade changes generally cause fewer erosion problems than long, continuous gradients.<br>Design horizontal curves and switchbacks with sufficient radius for trucks and other large vehicles to negotiate easily. Provide a radius no less than 35 feet for standard vehicles and 50 feet for tractor-trailers. Design the lengths of vertical curves, in feet, to use a minimum 'K' value of 10 in the design. |

Source: AEP 2018, unless otherwise specified.

Table C-SCM-02-1 Design Criteria for Construction Road Stabilization

| Design Criteria for Construction Road Stabilization | |
|---|---|
| Drainage Ditches | Provide drainage ditches as needed. The design and construction of drainage ditches shall be in accordance with Stormwater Conveyance Channel (Specification BMP C-ECM-09). |
| Stabilization | Clear the roadbed or parking surface of all vegetation, roots, and other objectionable material.<br>**Stone:** Apply a 6-inch course of Virginian Department of Transportation (VDOT) #1, #2, or #3 Coarse Aggregate immediately after grading or the completion of utility installation within the right-of-way. For additional stability, geotextile may be applied to the roadbed surface before coarse aggregate placement. Design specifications for geotextile are provided in Temporary Stone Construction Entrance (Specification BMP C-SCM-03). In "heavy duty" traffic situations, place stone at an 8- to 10-inch depth to avoid excessive dissipation or maintenance needs.<br>**Timber Mat Stabilization:** Typical timber matting will be manufactured hardwood board (usually oak or poplar), laminated pine board, plastic composite, or similar. Dimensions shall vary by manufacturer. Use timber matting on low gradient roads in wet areas, across environmentally and culturally sensitive areas, and agricultural fields. Timber matting may also be used for temporary laydown yards and material staging areas in locations where the topography is generally flat.<br>The use of timber matting for a duration which would result in loss of vegetation cover would constitute land disturbance which should be accounted for in calculations. Soil decompaction plans and seeding/ planting plans should account for these areas and return them to original hydrologic conditions or address the change in land cover in accordance with 9VAC25-875-590 (et seq.) |

**Commented [KA1]:** Should we consider cfs along the sides of the mats for roads? Maybe only for those external to the project area?

| | |
|---|---|
| Ditch Relief or Cross-Drain Culvert (PADEP 2012) | Ditch relief or cross-drain culverts are used on crowned or ditched roads to minimize the potential for erosion of roadside ditches as well as flooding of the roadway by reducing the volume of flow conveyed by the ditch. It is important to provide additional culverts at intervals along the roadway where runoff is being conveyed by a ditch.<br>Place ditch relief culverts with slopes of 2% to 4% to help keep the culvert clean and ensure water flow. Install culverts between 25 to 45 degrees to the centerline of the ditch to minimize turbulence at the inlet.<br>Size and space culverts according to Table C-SCM-02-2 for temporary culverts and Table C-SCM-02-3 for permanent culverts or size the culverts for the 10-year storm event based on the drainage area to the culvert.<br>The minimum diameter for any culvert is 12 inches unless other regulatory conditions apply. Otherwise, size the culvert to pass the flow from the 10-year storm event without overtopping the construction road. Extend the culvert 12 inches beyond the base of the road fill on both sides. Firmly pack fill around the culvert, especially the bottom half.<br>Cover the top of the culvert with at least 12 inches of fill, more if heavy loads are anticipated on the road.<br>To be sure that no water bypasses the inlet, install a control backstop of earth, riprap, sandbags, or half-culvert sections on the downhill level of the inlet.<br>Do not discharge onto the side of a road fill. Provide suitable outlet stabilization; see Outlet Protection (Specification BMP C-ECM-15) and, where appropriate, Inlet Protection (Specification BMP C-SCM-04). |

Source: AEP 2018, unless otherwise specified.

**Table C-SCM-02-1 Design Criteria for Construction Road Stabilization**

| Design Criteria for Construction Road Stabilization | |
| --- | --- |
| Temporary Right-of- Way Diversion | Temporary right-of-way diversions (Specification BMP C-ECM-07) may be used on construction access roads to direct surface water off the road into a constructed outlet but are not recommended for high-volume roads due to difficulty of moving equipment over the diversions (18 inches high with a 6-foot base width) and the need for continual maintenance due to damage from traffic. Temporary right-of-way diversions are useful on infrequently used roads.<br><br>Temporary right-of-way diversions used on active access roads will often require reinforcement with a log, steel pipe, or other support to maintain the integrity of the diversion between maintenance operations. Do not use temporary right-of-way diversions on in-sloping roadways where there is no opportunity to discharge runoff to either side. |
| Turnout (PADEP 2012) | Turnouts are channels that drain water away from roads or roadside ditches into well- vegetated areas. Turnouts are typically located along crowned roadways where runoff cannot sheet flow off the roadway. Like ditch relief culverts, the purpose of turnouts is to minimize the volume of water in a roadside ditch. Locate turnouts to take advantage of natural drainage courses or buffer areas where possible.<br><br>Grade the approach to a turnout on a 2% to 3% slope to allow constant 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 directly into a stream or waterbody.<br><br>An excavated sump at the end of the turnout can effectively pond and settle out sediment before discharging to a vegetated buffer; however, discharges from a turnout should be handled as other concentrated discharges.<br><br>Where a suitable vegetative filter strip is not available to remove sediment, install a compost filter sock, rock filter, or other sediment removal BMP at the outlet of the turnout. Design discharges from a turnout to minimize erosion.<br><br>Consult Outlet Protection (Specification BMP C-ECM-15) for design guidance.<br><br>Stabilize the turnout 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). |
| Stream or Wetland Crossing | Refer to Stable Wetland Crossing (Specification BMP C-ENV-06) for temporary wetland crossing design specifications and Temporary Vehicular Stream Crossing (Specification BMP C-ENV-03) for temporary stream crossing design specifications.<br><br>Construction roads should not be constructed within sinkholes (as defined by a closed topographic depression) or over cave entrances. |

Source: AEP 2018, unless otherwise specified.

## Table C-SCM-02-2 Sizing and Spacing of Ditch Relief Culverts for Temporary Access Roads

Sizing and Spacing of Ditch Relief Culverts for Temporary Access Roads

| Road Grade (%) | Culvert Spacing[a] (feet) | Length of Upslope Drainage (feet) | | | | |
|---|---|---|---|---|---|---|
| | | <300 | 300 – 400 | 400 – 500 | 500 – 600 | >600 |
| | | Minimum Culvert Size (inches) | | | | |
| 2 | 300 | 12 | 15 | 15 | 15 | 18 |
| 3 | 235 | 12 | 15 | 15 | 15 | 18 |
| 4 | 200 | 12 | 15 | 15 | 15 | 18 |
| 5 | 180 | 12 | 12 | 15 | 15 | 15 |
| 6 | 165 | 12 | 12 | 12 | 15 | 15 |
| 7 | 155 | 12 | 12 | 12 | 12 | 15 |
| 8 | 150 | 12 | 12 | 12 | 12 | 15 |
| 9 | 145 | 12 | 12 | 12 | 12 | 15 |
| 10 | 140 | 12 | 12 | 12 | 12 | 15 |
| 12 | 135 | 12 | 12 | 12 | 12 | 15 |

**Note:**

a. Culvert spacing may be adjusted slightly to take advantage of natural drainage courses.

Source: PADEP 2012, Table 3.3, p.31.

## Table C-SCM-02-3 Recommended Spacing of Ditch Relief Culverts (18-inch diameter Corrugated Metal Pipe) for Permanent Access Roads

Recommended Spacing of Ditch Relief Culverts (18-inch diameter Corrugated Metal Pipe) for Permanent Access Roads

| Road Grade (%) | Soil Type in Ditch | | | | |
|---|---|---|---|---|---|
| | Gravels, Sandy Gravels, Aggregate Surfacing | Silty Gravels, Clayey Gravels | Plastic and Non-Plastic Inorganic Clays | Inorganic Silts, Silty or Clayey Sands | Sands, Silty Sands, & Gravelly Sands |
| | Maximum Culvert Spacing Feet[a] | | | | |
| 2 | 390 | 315 | 245 | 170 | 95 |
| 4 | 335 | 275 | 210 | 145 | 85 |
| 6 | 285 | 230 | 180 | 125 | 75 |
| 8 | 240 | 195 | 150 | 105 | 65 |
| 10 | 200 | 160 | 125 | 90 | 55 |
| 12 | 160 | 130 | 105 | 75 | 45 |
| 14 | 130 | 110 | 85 | 60 | 35 |

**Note:**

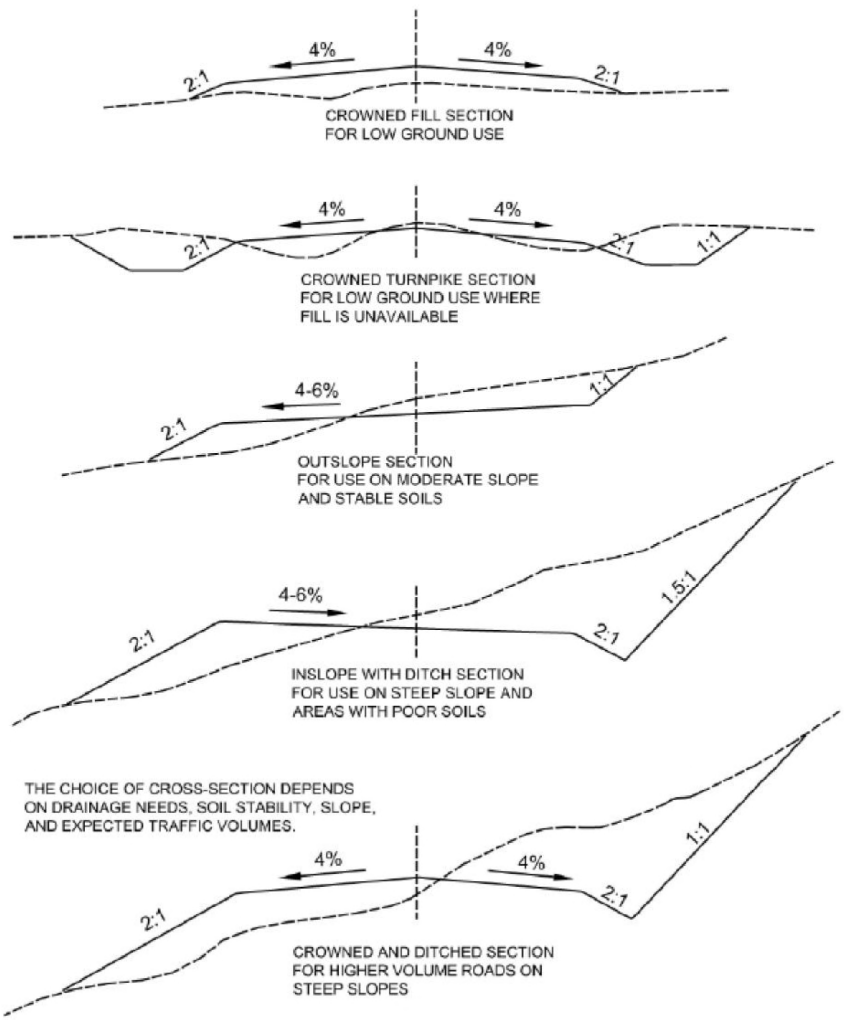
a. Culvert spacing may be adjusted slightly to take advantage of natural drainage courses.

Source: PADEP 2012, Table 3.4, p.32.

## 6.0 Construction Specifications

Before construction, install the appropriate erosion and sediment controls downgradient of the construction access road grading, including Compost Filter Socks (Specification BMP C-PCM-05), Silt Fence (Specification BMP C-PCM-04), Temporary Sediment Trap (Specification BMP C-SCM-11), Temporary Sediment Basin (Specification BMP C-SCM-12), and other structures. Upon completion of roadway or parking area grading, immediately stabilize cut and fill slopes.

*Figure C-SCM-02-1 Types of Cross Road Sections*




*Source: AEP 2018, Appendix B. AEP Erosion and Sediment Control Details: West Virginia BMP 3.35 – Access Road/Low Volume Road/Driveway, p.3.35-9.*

## 7.0 Operations and Maintenance Considerations

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

Monitor roadways and cut/fill slopes for gully or rill erosion or sloughing and scour in the ditches. If temporary right-of-way diversions or broad-based dips are used, ensure that the measures have been maintained and are deep enough to capture road surface runoff. If runoff overruns these measures, repair immediately. Inspect culverts, roadside ditches, and outlets and restore flow capacity as needed (AEP 2018).

*Example of Poorly Maintained Vehicular Route Stabilization*

Ensure that the proper cross-section is available, and outlets are stable. Fill low areas in travel treads and re-grade, as needed, to maintain road cross-section. Repair or replace surfacing materials as needed (AEP 2018).

Observe roadside ditches and other drainage structures to ensure that the measures do not become clogged with silt or other debris. Remove accumulated debris as necessary to maintain flow capacity (AEP 2018).

Check timber mats to ensure the mats are installed correctly and functioning properly. Remove accumulated sediment as needed to ensure that it is not transported offsite. Immediately replace any severely damaged mats (Wetland Studies and Solutions, Inc. 2020; Dominion Energy 2019).

Monitor seeded areas adjacent to the roads and parking areas to ensure that vegetation is maintained (AEP 2018).

## 8.0 References


AEP. 2018. FY 2018 General Erosion and Sediment Control and Stormwater Management Specifications for the Construction and Maintenance of Electric Utility Lines. American Electric Power Service Corporation Environmental Services. March, revised. Available online at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/bmp-design-specifications.

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

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

Virginia Department of Environmental Quality. 1992. Virginia Erosion and Sediment Control Handbook. Third ed. Available online at: https://www.deq.virginia.gov/water/stormwater/stormwater-construction/handbooks.

Wetland Studies and Solutions, Inc. 2020. Erosion and Sediment Control Standards for Wetland and Stream Bank Construction Projects. WSSI #21698.01. Revised September 17. Available online at: https://www.deq.virginia.gov/our-programs/water/stormwater/stormwater-construction/bmp-design-specifications.

# C-SCM-03 Temporary Stone Construction Entrance

## 1.0 Definition

A temporary stone construction entrance is a pad with a geotextile liner underneath the stone located at points of vehicular ingress and egress on a construction site. There are several types of track-out controls that minimize the amount of sediment, such as dirt or mud, leaving or being tracked out from the construction site attached to vehicles.

**Download File** – CAD and PDF files for C-SCM-03 Temporary Stone Construction Entrance

## 2.0 Purpose and Applicability of Best Management Practices

Construction entrances provide an opportunity for significant removal of mud from construction vehicle tires before they enter a public road, and, just as important, the soil adjacent to the paved surface can be kept intact. Temporary stone construction entrances reduce the tracking of mud onto paved public roads by motor vehicles or runoff and provide a stable entry to or exit from the construction site.

This practice applies where traffic leaves a construction site and moves directly onto a public road or other paved area.

## 3.0 Planning and Considerations

*Stone Construction Entrance with Washrack*

A geotextile liner is used as a “separator” to minimize the dissipation of aggregate into the underlying soil due to construction traffic loads. If the action of the vehicles traveling over the gravel pad is not sufficient to remove most of the mud, or there exists an especially sensitive traffic situation on the adjacent paved road, wash the tires before the vehicle enters the public road. If washing is necessary, make provisions to intercept the wash water and trap the sediment so it can be collected and stabilized.

Use construction entrances in conjunction with stabilization of construction roads (see Construction Road Stabilization [BMP C-SCM-02]) to reduce the amount of mud picked up by construction vehicles and better remove mud. Encourage vehicles (other than construction equipment) to remain in stabilized areas where possible to avoid mud accumulation on vehicles' tires that will regularly enter and leave the site. Other innovative techniques for accomplishing the same purpose (such as a bituminous entrance) can be used, but only after specific plans and details are submitted and approved by the appropriate certified plan reviewer.

## 4.0 Stormwater Performance Summary

**MS-17: VEHICULAR TRACKING AND CONSTRUCTION ENTRANCES** – Provisions shall be made to minimize the transport of sediment from the site onto the paved surface.

**MS-4: FIRST-STEP MEASURES** – Sediment basins and traps, perimeter dikes, sediment barriers, and other measures intended to trap sediment shall be constructed as a first step in any land-disturbing activity and shall be made functional before upslope land disturbance takes place.

9VAC25-875-560

**Erosion Control Efficiency: MODERATE**

**Sediment Removal Efficiency: MODERATE**

## 5.0 Design Criteria

**Table C-SCM-03-1 Design Criteria for Temporary Stone Entrance**

| Parameter | Notes on Proper Use |
|---|---|
| Aggregate Size | Use Virginia Department of Transportation (VDOT) #1, #2, or #3 Coarse Aggregate (1.5- to 3.5-inch stone) or American Association of State Highway and Transportation Officials (AASHTO) #1 Course Aggregate (2.5- to 3.5-inch stone). |
| Entrance Dimensions | Construct the aggregate layer to be a minimum of 6 inches thick and place a minimum 3 inches of aggregate in a cut section to give the entrance added stability and help secure the geotextile separator.<br>Extend the entrance to the entire width of the vehicular ingress and egress area and have a minimum 12-foot width.<br>Construct the entrance length at a minimum of 70 feet except for smaller construction projects (total disturbance area of less than 1 acre) or sites with entrance constraints.<br>For these project sites, the minimum length is the greater of either 30 feet or a length sufficient for all on-site equipment to make at least two tire revolutions when crossing the trackout surface.<br>Where site conditions warrant that it may be necessary to extend the length or width of the rock to ensure the effectiveness of the entrance. |
| Mountable Berm & Culvert Pipe | Where access to the site crosses a roadside ditch, stream channel, or natural drainage course, provide a suitable means of conveying the flow past the entrance (e.g., an appropriately sized culvert pipe). Size the pipe to convey the runoff generated by the 2-year, 24-hour frequency storm at a minimum. The minimum permissible pipe size is 6 inches.<br>For such installations, install a mountable berm above the pipe to avoid crushing the pipe. Construct the 3-foot-wide mountable berm centered above the pipe with 5H:1V side slopes and 6 inches higher than the elevation of the rest of the construction entrance. |
| Geotextile | Use geotextile that is a woven fabric consisting only of continuous-chain polymeric filaments or yarns of polyester. Use geotextile inert to commonly encountered chemicals and hydrocarbons, mildew and rot-resistant, and conforms to the physical properties noted in Table 1. |

Table C-SCM-03-1 Design Criteria for Temporary Stone Entrance

| Parameter | Notes on Proper Use |
|---|---|
| Washing | If most mud is not removed by the vehicles traveling over the stone or timber mat surfaces, wash the vehicles' tires before entering the public road. Carry wash water away from the entrance to an approved settling area or sediment removal device (e.g., sediment basin or trap, silt fence, or compost filter sock) to remove sediment. Prevent all sediment from entering storm drains, ditches, or watercourses.<br><br>Use a wash rack to make washing more convenient and effective for washing mud from the tires of the work vehicles only. A reinforced concrete or metal wash rack are both viable options to reduce the presence of sediment from work vehicles leaving the construction site (PA DEP 2012).<br><br>Wash racks are unsuitable for complete truck washing and only apply to washing the vehicle tires. If there is a need for a full wash of vehicles, refer to standard detail Concrete Washout Pit (C-SCM-13). Additionally, ensure that wash racks immediately discharge to a sediment removal device (e.g., sediment basin or trap, silt fence, or compost filter sock) before the water enters waterbodies (PA DEP 2012). |
| Location | Locate the entrance to provide for maximum use by all construction vehicles. Locate the entrance on level ground at an appropriate site distance. Avoid locating the entrance on steep slopes and ensure the entrance drains transversely to prevent runoff from the entrance flowing into the adjacent roadway.<br><br>Entrance configurations off the paved road may be modified to allow tractor trailers or longer delivery vehicles adequate area to safely exit the paved road onto the construction entrance and re-enter onto the paved road from the construction entrance. |
| Timber Matting | Timber Matting may be used in locations where construction entrances intersect an existing gravel road or non-public road. Typical timber matting will be manufactured hardwood board (usually oak or poplar), laminated pine board, plastic composite, or similar. Dimensions vary by manufacturer.<br><br>Use appropriate washing procedures as described in this table to remove sediment and debris from tires prior to entering the public road. Where timber matting is used as a construction entrance, either for the entire or partial length, the total minimum construction entrance length is 70 feet.<br><br>Use of timber matting for a duration which would result in loss of vegetative cover would constitute a change in land cover which should be accounted for in hydrologic analyses. Soil decompaction plans and seeding or planting plans should address for these areas. Typically, a maximum duration of 6 months is recommended; however, field observations and knowledge of the site characteristics, including geology, provide more accurate information. |

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Commented [AK1]: Discuss -should we get CFS on the edges the matting for the CE to address cast off?

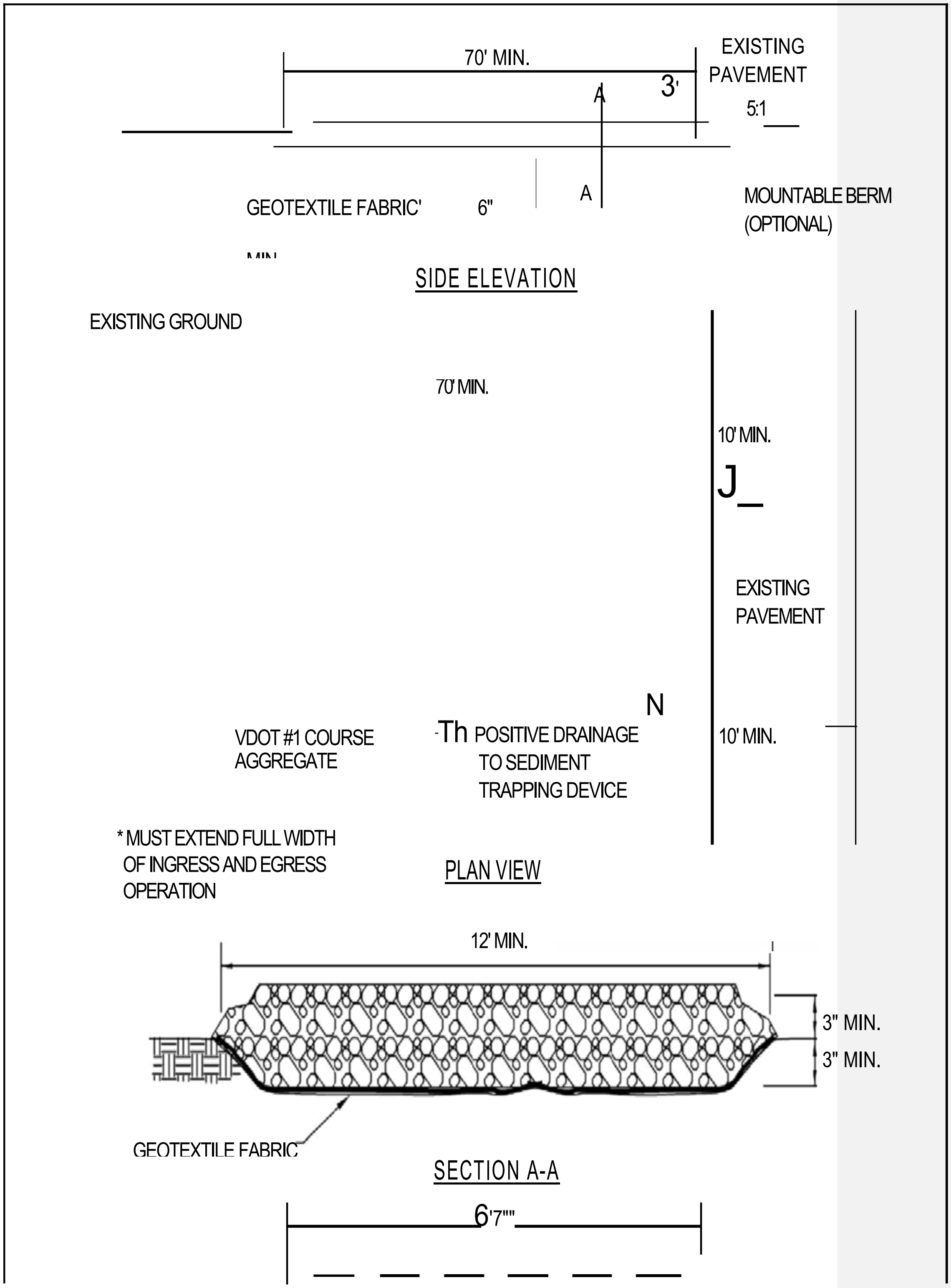
Table C-SCM-03-2 Construction Specifications for Geotextile Liner Under Aggregate Stone

| Geotextile Properties[1] | Light-Duty Entrance[2] (Graded Subgrade) | Heavy-Duty Entrance[3] (Rough Graded) | Test Method |
|---|---|---|---|
| Grab Tensile Strength (lbs.) | 200 | 315 | ASTM D4632 |
| Grab Tensile Elongation (%) | 15 | 15 | ASTM D4632 |
| Trapezoidal Tear (lbs.) | 75 | 113 – 120 | ASTM D4533 |
| CBR Puncture Strength (lbs.) | 700 | 900 | ASTM D6241 |
| Apparent Opening Size | 40 | 40 | ASTM D4751 |

1. Only use geotextile not meeting these specifications when design procedure and supporting documentation are supplied to determine aggregate depth and geotextile strength.
2. **Light-Duty Entrance:** Sites that have been graded to subgrade and where most travel would be by single-axle vehicles and an occasional multi-axle truck. Examples of geotextile that can be used are: Mirafi 500X, Skaps SW200, Geotex 200 ST, or equivalent.
3. **Heavy-Duty Entrance:** Sites with only rough grading and where most travel would be by multi-axle vehicles. Examples of geotextile that can be used are: Mirafi 600X, Skaps SW315, Geotex 315 ST, or the equivalent.

## 6.0 Construction Specifications

1. Excavate the entrance area to a minimum of 3 inches and clear the area of all vegetation, roots, and other objectionable material.
2. Construct any drainage facilities according to specifications. Provide for the conveyance of surface water under the entrance through culverts.
3. Place the geotextile underlayment atop the entire width and length of the entrance.
4. Following the geotextile installation, place the stone to the specified dimensions (including the construction of the mountable berm) as necessary.
5. If wash racks are used, install wash racks according to manufacturer's specifications. Ensure the wash rack can convey sediment-laden water immediately to a sediment control treatment device before entering a water body.
6. Confirm the length and width of the construction entrance before setting up erosion control measures and perimeter control measures.


70' MIN.
EXISTING
PAVEMENT
A
3'
5:1
GEOTEXTILE FABRIC'
6"
A
MOUNTABLE BERM
(OPTIONAL)
SIDE ELEVATION
EXISTING GROUND
70' MIN.
10' MIN.
EXISTING
PAVEMENT
N
VDOT #1 COURSE
AGGREGATE
POSITIVE DRAINAGE
TO SEDIMENT
TRAPPING DEVICE
10' MIN.
* MUST EXTEND FULL WIDTH
OF INGRESS AND EGRESS
OPERATION
PLAN VIEW
12' MIN.
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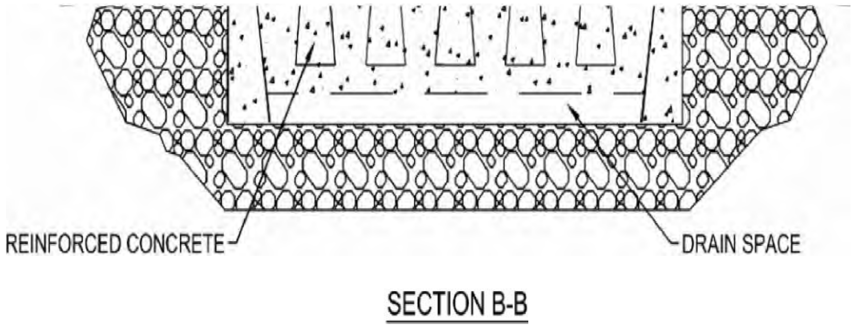
GEOTEXTILE FABRIC
SECTION A-A




*Source: Maryland Water Resources Administration et al. 1983*

## 7.0 Operations and Maintenance Considerations

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

Maintain the entrance to prevent tracking or flow of dirt, mud, or sediment onto public rights-of-way, including periodic top dressing with additional stone and repair or cleanout of structures that trap sediment or both. Maintain a stockpile of rock at the site for top dressing purposes.

*Improperly Maintained Stone Construction Entrance-Stones Dislodged Spilling into Adjoining Roadway*

Mud and soil particles will eventually clog the voids in the stone and compromise the effectiveness of the construction entrance. When this occurs, top dress the pad with new stone. Complete stone replacement is necessary when the pad becomes wholly clogged with sediment and the topdressing is no longer effective at removing accumulated sediment from tires.

Immediately remove all materials spilled, dropped, washed, or tracked from vehicles onto roadways or storm drains. Do not use water trucks to remove materials dropped, washed, or tracked onto roadways under any circumstances.

Immediately remove stones from the adjoining roadway that construction traffic dislodged from the entrance.

Maintain the area under the wash rack free of accumulated sediment. Repair or replace the wash rack if it becomes damaged.

## 8.0 References

Maryland Water Resources Administration, Soil Conservation Service, and State Soil Conservation Committee. 1983. Maryland Standards and Specifications for Soil Erosion and Sediment Control. April.

**Chapter 6 Stormwater Site Design and BMP Selection**

**Section 6.3.3.4 Post-Construction Stormwater BMP Selection**

Under this heading towards the end:

**Stormwater Function – Volume Reduction and PR**

Determine how each BMP option compares in terms of PR. In this step, focus on the removal of select pollutants to determine the best BMP options for water quality. Table 6-21 examines the capability of each BMP option to remove specific pollutants from stormwater runoff. Total pollutant reductions (TR) indicated in Table 6-21 for TP, TN, and TSS reflect a combination of PR processes. These numbers assume a typical concentration for each pollutant in the total site runoff. These concentrations are typically expressed as an amount per unit of volume (e.g., 0.26 milligram per liter of TP). When part of a site's total runoff volume is removed through the use of RR practices (e.g., rainwater capture, infiltration), the pollutants in that portion of the site runoff are removed from the remaining runoff that must still be managed. Then, as stormwater treatment processes (e.g., settling, filtration, chemical conversion, vegetation uptake) are applied to the remaining runoff, the actual concentration of pollutant in the runoff is further reduced. So, the total mass load removal of pollutants is a result of the combination of runoff volume reduction and supplementary treatment practices.

**Table 6-21 Pollutant Removal Efficiencies and Volume Removal Rates for Post-Construction BMPs**

| BMP Category | Specific BMP | Runoff Volume Reduction[1] (%RR) | TP EMC Reduction[2] (%PR) | Total TP Reduction[3] (%TR) | TN EMC Reduction[2] (%PR) | Total TN Reduction[3] |
|---|---|---|---|---|---|---|

See chart - no change. This new section is below it.

Volume reduction is a key component of stormwater management and a function of most BMPs. As a supplement to post-construction BMP design, developing technology using active/adaptive flow control devices/systems, including continuous monitoring and adaptive control (CMAC) may assist with active storage volume management and potentially decrease the BMP footprint. CMAC is an automated valve that integrates information directly from field-deployed sensors with real-time weather forecast data to directly monitor performance and make automated and predictive control decisions to actively manage stormwater storage and flows within a facility. Active/adaptive flood control devices (FCDs) can be integrated into the design of any type of new structural BMPs, treatment trains, or applied as a retrofit to optimize BMP design. Benefits from the incorporation of active/adaptive FCDs include the restoration of pre-development hydrology (reducing the volume of stormwater released during a precipitation event and decreasing peak flow rates released by the BMP), mitigation of flood frequency and magnitude, maximizing the volume of water available for reuse, mitigation of downstream erosion issues, and increased resilience against a changing climate. Perhaps one of the most unique functions of active/adaptive control systems is the ability to adapt to changes in management objectives and/or changing weather patterns without modifying the physical structure of the BMP.

As with all stormwater installations, active/adaptive FCD applications should be fully vetted by the responsible governmental entity(ies) and comply with all state and local requirements. Common hydrologic and hydraulic modeling tools such as HydroCAD or EPA SWMM 5 can be used to verify that flow rate requirements are being met. Maximum allowable outflow rates can be programmed into the system software and should be verified as a part of the as-built. The design, installation, and operation of active/adaptive flow controls should consider selection and location of hardware to optimize maintenance, redundancy and fail-safes across physical, mechanical, and cloud-based infrastructure, and security.

# C-SCM-14 Flocculant Chemical Additives

## 1.0 Definition

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

## 2.0 Purpose and Applicability of Best Management Practice

Flocculants can be used for direct application to bare or disturbed soil for temporary stabilization, dust control, or as part of a treatment train with other construction BMPs.

Only products listed on the [Virginia DEQ Approved Flocculant] Product List (Appendix K) may be used.

The purpose of flocculants is to complement, not replace, construction BMPs and may be used to maximize sediment removal and water quality.

Use of cationic flocculants, water-soluble polymers, or other chemical additives that possess a net positive (cationic) charge, is permitted only with written DEQ approval through the process in Section 6.0 of this specification.

## 3.0 Planning and Considerations

Flocculants should be used in combination with other construction BMPs in the Handbook, never as a stand-alone construction BMP for a drainage area.

Provide clear, site-specific justification for flocculant use, describing unique sediment control challenges and how their use in conjunction with other construction BMPs will ultimately prove to be the preferred solution. Also provide a map with the following information: locations where flocculant will be applied and stored on site, points of discharge, and soil types.

Flocculant products must be matched to site soils and water via performance testing (e.g., jar testing) and manufacturer input.

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

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

Flocculants should be introduced at points of high turbulence (e.g., basin inlets, slope drains) to ensure thorough mixing and maximize sediment removal.

Direct application to bare or disturbed soils is permitted under this specification and may be used for temporary stabilization, dust control, or as part of a treatment train.

## 4.0 Stormwater Performance Summary

**Sediment Removal Efficiency: High**

**Erosion Control Efficiency: Low**

The use of flocculants is intended to improve the effectiveness of sediment and erosion control measures at construction sites, particularly in conditions where conventional BMPs may not sufficiently control fine or colloidal sediment.

## 5.0 Design Criteria

Only products listed on the [Virginia DEQ Approved Flocculant] Product List (Appendix K) may be used.

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

Flocculants should be introduced to stormwater at points of high turbulence or applied directly to disturbed soils as part of stabilization, dust control, or treatment train of construction BMPs.

Dosage rates must follow manufacturer guidance, DEQ-approved limits, and be verified by site-specific jar testing (typically 1–5 mg/L for PAM).

Jar tests must be conducted for each soil type or application configuration and be repeated if soil conditions change. Jar test protocols should follow manufacturer guidance and recommended EPA procedures for site-specific performance evaluation.

If visible sediment or turbidity persists in discharges after flocculant application, the application rate, method, product selection, or BMP sequencing must be reviewed and adjusted as needed to improve performance.

All observations and resulting adjustments must be documented in the project SWPPP and be available for inspection.

Field turbidity shall be monitored using a clear turbidity tube (minimum 60 cm in length) with a Secchi pattern or similar visual threshold at the base. Observations should be recorded in the project SWPPP and used to guide corrective actions. If water clarity fails to meet the visual standard (Secchi disk no longer visible at 10 cm or less), additional BMP adjustments or flocculant application modifications are required. Turbidity tube readings may be supplemented by handheld turbidity meters for confirmation as needed.

## 6.0 Construction Specifications

Install and maintain dosing systems per manufacturer instructions.

Inspect dosing equipment daily during use and after each rain event; repair or remove malfunctioning equipment immediately.

For passive devices, ensure they are securely anchored in the flow path and not buried or bypassed by runoff.

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

Replace or reposition passive flocculant devices that become ineffective due to coating, drying, or displacement.

Ensure all treated runoff is directed to a sediment basin, trap, or other effective sediment removal BMP before discharge from the site.

All construction and installation must comply with the approved SWPPP and manufacturer's guidelines. Jar tests must be conducted at each site to verify the effectiveness and safety of the selected flocculant under site-specific conditions. The demonstration must confirm sediment removal performance and ensure no adverse chemical or toxicity impacts to receiving waters.

All jar tests, operational and treatment application rates and schedules must be documented and available for DEQ review on request.

For any proposed cationic flocculant, applicants must submit product chemistry, EPA/DEQ protocol toxicity data, site-specific risk assessment, and justification for use to DEQ for written approval prior to use.

DEQ may require supplemental construction or post-construction stormwater BMPs as a condition of approving cationic flocculant use. These measures may include enhanced sediment basins, additional filtration, increased monitoring, or other site-specific controls necessary to prevent water quality violations associated with cationic chemical discharge.

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

## 7.0 Operations and Maintenance Considerations

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

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

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

Visual turbidity monitoring is required for influent and effluent during chemical treatment according to the manufacturer's recommendations. If visual inspection shows poor sediment control, re-evaluate application rate, method, or product selection. A log of daily visual inspection should be maintained with the SWPPP.

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

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

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

## 8.0 References


Applied Polymer Solutions. 2024. Technical Bulletin 2: Anionic Polyacrylamide (PAM) Guidance for Erosion and Sediment Control in Construction Stormwater. APS, Greensboro, NC.

Maryland Department of the Environment, Standards for Use of Chemical Additives for Sediment Control

North Carolina Department of Environmental Quality, Construction Stormwater Flocculant Guidance

Minnesota Pollution Control Agency, Polyacrylamide (PAM) for Construction Stormwater

U.S. Environmental Protection Agency. 2019. Use of Treatment Chemicals for Particulate Removal from Construction Stormwater. EPA-832-F-19-001

Washington Department of Ecology, Stormwater Management Manual for Western Washington, Appendix III-D