## Sheet Flow

**Description:** Impervious areas are disconnected and runoff is routed over a level spreader to sheet flow over adjacent vegetated areas. This slows runoff velocities, promotes infiltration, and allows sediment and attached pollutants to settle and/or be filtered by the vegetation.

## Advantages/Benefits:

- Cost effective
- Wildlife habitat potential
- High community acceptance

## Disadvantages/Limitations:

- Small drainage area
- Sheet flow must be maintained to achieve design goals
- Often requires additional SCMs to achieve runoff reduction goals

### Selection Criteria:

**50%-75% Runoff Reduction Credits**
**See Table 8.1**

### Land Use Considerations:

- [x] **Residential**
- [x] **Commercial**
- [x] **Industrial**

### Maintenance:

- Maintain dense, healthy vegetation to ensure sheet flow
- Inspect regularly for signs of erosion

M **Maintenance Burden**
L = Low M = Moderate H = High

# SECTION 1: DESCRIPTION

The two design variants that treat sheet flow runoff are (1) *Conserved Open Space* and (2) designed *Vegetated Filter Strips*. They act by slowing the runoff velocity and forcing the contaminants to separate from the runoff by means of settling or filtration. The design, installation, and management of these two design variants are quite different, as outlined in this specification. In both instances, storm water runoff must enter the conserved open space or vegetated filter strip as sheet flow. If the inflow is from a pipe or channel, an engineered level spreader must be designed in accordance with the criteria contained herein to convert the concentrated flow to sheet flow.

# SECTION 2: PERFORMANCE

With proper design and maintenance, these practices can provide relatively high runoff reduction as shown in **Table 8.1**.

**Table 8.1: Runoff Volume Reduction Provided by Filter Strips**

| Stormwater Function | Conservation Area | | Vegetated Filter Strip[1] |
|---|---|---|---|
| | HSG Soils A and B | HSG Soils C and D | HSG Soils A, B, C, D |
| **Runoff Vol. Reduction (RR)** | 75% | 50% | 50% |

[1] Compost amended soils required for B, C, & D (see **Appendix 8-B**)

# SECTION 3: SCHEMATICS

See Appendix 8-A for schematics for use in sheet flow treatment design.

# SECTION 4: PHYSICAL FEASIBILITY & DESIGN APPLICATIONS

Conserved open space or vegetated filter strips can be implemented on development sites where development density, topography and soils are suitable. Key considerations for conserved open space or vegetated filter strips include:

***Soils.*** Conserved open space and vegetated filter strips are appropriate for all soil types, except fill soils.

***Available Space.*** The conserved open space must be fully protected during the construction stage of development and kept outside the limits of disturbance.

***Utilities.*** Public underground utilities and associated easements shall not be located within the conserved open space. Underground utilities that cross vegetated filter strips are acceptable.

***Contributing Drainage Area.*** Designers may apply a runoff reduction credit to any impervious area that is hydrologically connected and effectively treated by a protected conserved open space and vegetated filter strip. Vegetated filter strips are used to treat very small drainage areas containing 5,000 square feet of impervious area or less.

***Hotspot Land Uses.*** Conserved open space or vegetated filter strips should not receive hotspot runoff, since the infiltrated runoff could cause groundwater contamination.

***Applications.*** Areas adjacent to water quality buffers or within forests or floodplains are well suited for conserved open space. Vegetated Filter Strips are best suited to treat runoff from small segments of impervious cover (usually less than 5,000 sq. ft) 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. If sufficient pervious area is available at the site, larger areas of impervious cover can be treated by vegetated filter strips, using an engineered level spreader to recreate sheet flow.

## SECTION 5. DESIGN CRITERIA

### 5.1 Stormwater Quality

Conserved open space and vegetated filter strips must meet the appropriate minimum criteria outlined in **Table 8.2** to qualify for the indicated level of runoff reduction. In addition, designers must conduct a site reconnaissance prior to design to confirm topography and soil conditions.

| Table 8.2. Sheet Flow Design Criteria | | |
|---|---|---|
| **Design Issue** | **Conserved Open Space** | **Vegetated Filter Strip** |
| Soil and Vegetative Cover | Undisturbed soils and native vegetation | Amended soils and dense turf cover or landscaped with herbaceous cover, shrubs, and trees |
| Overall Slope and Length (parallel to flow) | 0.5% to 3% Slope – Minimum 35 ft length<br>3% to 6% Slope – Minimum 50 ft length<br>The first 10 ft. of filter must be 2% or less in all cases | 1% to 4% Slope – Minimum 35 ft. length<br>4% to 6% Slope – Minimum 50 ft. length<br>6% to 8% Slope – Minimum 65 ft. length<br>The first 10 ft. of filter must be 2% or less in all cases |
| Width (perpendicular to flow) | Equal to the width of the contributing drainage area (CDA). Pretreatment is required. | |

### 5.2 Pretreatment

***Gravel Diaphragms:*** A gravel diaphragm at the top of the slope is required for both Conserved Open Space and Vegetated Filter Strips that receive sheet flow equal to the CDA width. Refer to **Figure 8.2** in **Appendix 8-A.**

- The flow should travel over the impervious area and to the practice as sheet flow and then drop at least 2 to 3 inches onto the gravel diaphragm.
- A layer of filter fabric shall be placed between the gravel and the underlying soil trench (ASTM D4632, ASTM D3786, ASTM D4491, and ASTM D4751).
- The gravel diaphragm is created by excavating a 2-foot wide and 1-foot deep trench that runs on the same contour at the top of the filter strip.
- Gravel shall consist of clean washed #57 stone meeting TDOT construction specifications.

***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. The permeable berm should have the following properties:

- The berm 6 to 12 inches high.
- A permeable berm is not needed when vegetated filter strips are used as pretreatment to another stormwater practice.
- Permeable berm shall consist of TDOT machined rip-rap class A-3.

***Engineered Level Spreaders (ELS).*** The design of engineered level spreaders ensure non-erosive sheet flow into the vegetated area. Section 7.26 of the TDEC Erosion and Sediment Control Handbook or TDOT specification EC-STR-61 shall be used for ELS design and material specifications. The maximum flow permitted through the ELS is 30 cfs for the 10-year storm event.

### 5.3 Planting and Vegetation Management

***Conserved Open Space.*** No grading or clearing of native vegetation is allowed within Conserved Open Space. A long-term vegetation management plan must be prepared and the area must be protected by a perpetual easement or deep restriction. See **Section 8.1** for additional information.

***Vegetated Filter Strips.*** 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. If used in conjunction with Reforestation reference GIP-10 for planting requirements.

## SECTION 6: CONSTRUCTION

### 6.1 Construction Erosion Prevention and Sediment Control

**Construction Stage EPSC Controls.** Sheet Flow areas should be fully protected by EPSC measures as specified in the plans. These areas should remain outside the limits of disturbance during construction to prevent soil compaction by heavy equipment. In addition, the Sheet Flow areas shall be clearly identified on all construction drawings and EPSC plans during construction.

### 6.2 Construction Sequence

The following is a typical construction sequence for a Sheet Flow area, although steps may be modified to reflect different site conditions.

***Step 1.*** The designer and the installer should have a preconstruction meeting, checking the boundaries of the contributing drainage area to ensure they conform to original design. The designer should clearly communicate, in writing, any project changes determined during the preconstruction meeting to the installer and the plan review/inspection authority.

***Step 2.*** Sheet Flow area construction may only begin after the entire contributing drainage area has been stabilized with vegetation. Any accumulation of sediments that does occur within the Sheet Flow area must be removed during the final stages of grading. EPSC for construction of the Sheet Flow area should be installed as specified in the erosion and sediment control plan.

***Step 3 (Optional).*** Incorporate compost amendments according to Appendix 8-B.

***Step 4.*** Install pretreatment measure(s).

***Step 5.*** Install plantings and ground cover per approved plan. The construction contract should contain a care and replacement warranty extending at least two growing seasons, to ensure adequate growth and survival of the plant community.

***Step 6.*** Conduct the final construction inspection and develop a punch list for facility acceptance. Then log the GPS coordinates for Sheet Flow and submit them to MWS.

## SECTION 7. AS-BUILT REQUIREMENTS

After the Sheet Flow area has been constructed, the owner/developer must have an as-built certification conducted by a registered Professional Engineer. The as-built certification verifies that the GIP was installed per the approved plan. Supporting documents such as invoices and compost certification shall be provided in addition to the as-built requirements found in SWMM Volume 1.

# SECTION 8. MAINTENANCE

### 8.1 Maintenance Document

The Sheet Flow GIP must be covered by a drainage easement to allow inspection and maintenance and be included in the site's Maintenance Document. If the filter area is a natural Conserved Open Space, it 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, except as stipulated in the vegetation maintenance plan.

The requirements for the Maintenance Document are in Appendix C of Volume 1 of the Manual. They include the execution and recording of an Inspection and Maintenance Agreement or a Declaration of Restrictions and Covenants, and the development of a Long-Term Maintenance Plan (LTMP) by the design engineer. The LTMP contains a description of the stormwater system components and information on the required inspection and maintenance activities. The property owner must submit annual inspection and maintenance reports to MWS.

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 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.

### 8.2 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.

Inspectors should check to ensure that:

- Flows through the Filter Strip do not short-circuit the overflow control section;
- Debris and sediment does not build up at the top of the 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 a 90% cover in the boundary zone or grass filter.

### 8.3 Ongoing Maintenance

Once established, Vegetated Filter Strips have minimal maintenance needs outside of the spring clean-up, regular 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 a year to prevent woody growth.

## SECTION 9. REFERENCES

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## APPENDIX 8-A
## SCHEMATICS

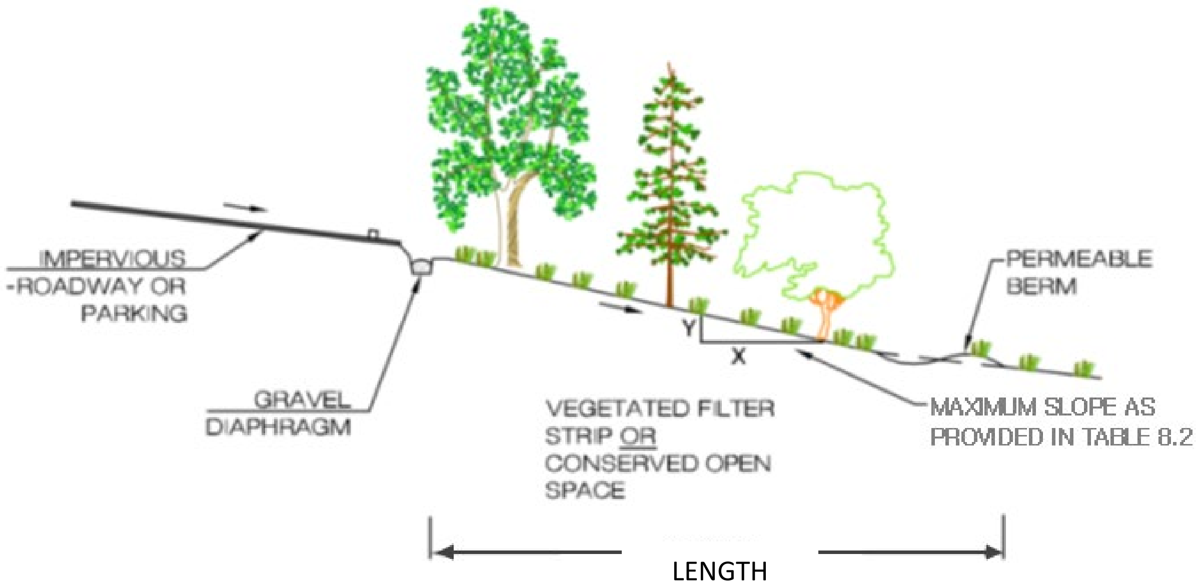


*Figure 8.1. Typical Configuration of Sheet Flow to Filter Strip or Conserved Open Space (Source: VA, 2013; MWS edited 2020)*

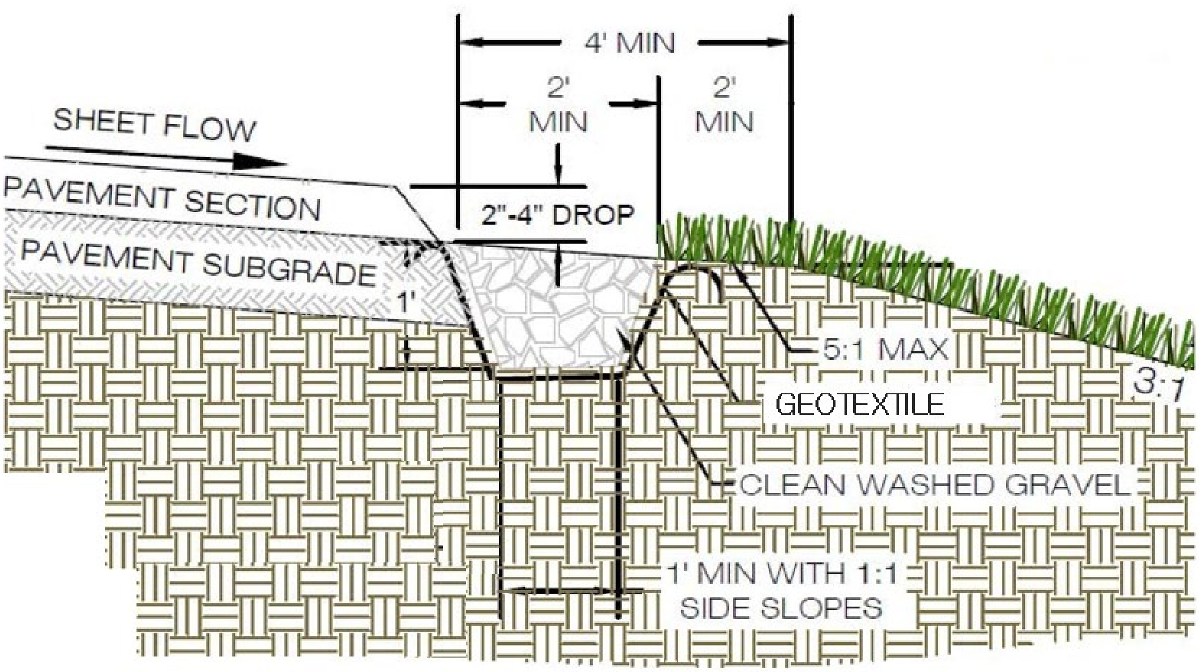


*Figure 8.2 – Gravel Diaphragm – Sheet Flow Pretreatment (source: VADCR, 2011; MWS edited 2020)*

# APPENDIX 8-B
# DESIGN CRITERIA FOR AMENDING SOILS WITH COMPOST

## SECTION 1: DESCRIPTION

Soil restoration is a practice applied after construction, to deeply till compacted soils and restore their porosity by amending them with compost. These soil amendments can reduce the generation of runoff from compacted urban lawns and may also be used to enhance the runoff reduction performance.

## SECTION 2: DESIGN CRITERIA

### 2.1 Determining Depth of Compost Incorporation

Table 8-B.1 presents some general guidance for compost amendments and incorporation depths.

| Table 8-B.1. Compost and Incorporation Depths | |
|---|---|
| Compost (in) | 12 |
| Incorporation Depth (in) | 24 |
| Incorporation Method | Subsoiler |

Once the area and depth of the compost amendments are known, the designer can estimate the total amount of compost needed using the following estimator equation:

***Equation 8.1. Compost Quantity Estimation***

$$C = A * D * 0.0031$$

Where: C = compost needed (cu. yds.)
A = area of soil amended (sq. ft.)
D = depth of compost added (in.)

### 2.2 Compost Specifications

The basic material specifications for compost amendments are outlined below:

- Compost shall be derived from plant material and provided by a member of the U.S. Composting Seal of Testing Assurance (STA) program. See www.compostingcouncil.org for a list of local providers.
- The compost shall be the result of the biological degradation and transformation of plant-derived materials under conditions that promote anaerobic decomposition. The material shall be well composted, free of viable weed seeds, and stable with regard to oxygen consumption and carbon dioxide generation. The compost shall have a moisture content that has no visible free water or dust produced when handling the material. It shall meet the following criteria, as reported by the U.S. Composting Council STA Compost Technical Data Sheet provided by the vendor:
    a. 100% of the material must pass through a half inch screen
    b. The pH of the material shall be between 6 and 8
    c. Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0% by weight
    d. The organic matter content shall be between 35% and 65%
    e. Soluble salt content shall be less than 6.0 mmhos/cm
    f. Maturity should be greater than 80%
    g. Stability shall be 7 or less
    h. Carbon/nitrogen ratio shall be less than 25:1
    i. Trace metal test result = "pass"
    j. The compost must have a dry bulk density ranging from 40 to 50 lbs./cu.ft.

# APPENDIX 8-C
# STANDARD NOTES

**Required Bioretention Notes:**

- Contractor, Engineer, or Owners Representative shall notify MWS NPDES Staff at least 48 hours prior to the installation of the compost amendments. Compost amendments must meet the requirements of GIP-08, Sheet Flow. Invoices or receipts for the compost amendments should be retained and submitted as part of the as-built.

# APPENDIX 8-D
# MISCELLANEOUS PHOTOS

**Filter strip surrounding bioretention cell, Fort Bragg, NC.**
***(Source: N. Weinstein, LIDC)***