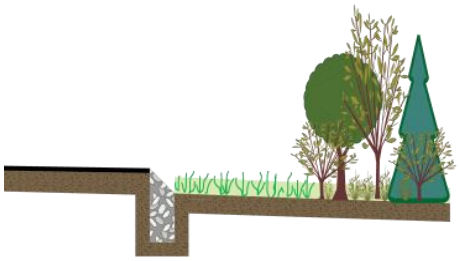
9.10 VEGETATIVE FILTER STRIPS



A vegetative filter strip is a stable, evenly graded area that removes pollutants from stormwater runoff through filtration and biological uptake. In order to provide pollutant treatment, runoff must enter and move through the filter strip as sheet flow; therefore, vegetative filter strips must have shallow enough slopes to maintain sheet flow. When designed in accordance with this chapter, the total suspended solid (TSS) removal rate is 60 - 80%, depending on the type of vegetation.

N.J.A.C. 7:8 Stormwater Management Rules - Design and Performance Standards		
	Nonstructural Strategies	Assist with Strategies #1, 3, 4, 5, and 7; See Page 2
	Water Quantity	Not Allowed
GR	Groundwater Recharge	Not Allowed
%	Water Quality	60 - 80% TSS, depending on type of vegetation

Water Quality Mechanisms and Corresponding Criteria	
Vegetative Uptake and Filtration	
Minimum Density of Vegetation	85%
Species Selection	Turf Grass, Meadow Cover, Planted Woods, or Existing Forest Areas
Required Length	Minimum Length 25 feet Maximum Length 100 feet See Appropriate Chart on Pages 10-12
Maximum Allowable Slope	See Table on Page 11
Flow Characteristics	Sheet Flow Only

Introduction

A vegetative filter strip is a stable, evenly graded area designed to remove pollutants from the stormwater runoff that flows through it. Filter strips can be designed and planted with a variety of vegetation, or an existing on-site vegetated area with appropriate vegetation and slope can be used. In order to function properly, all runoff must both enter and move through the filter strip as sheet flow. Vegetative filter strips are intended to treat runoff generated from drainage areas that are uniformly graded, such as yards, parking lots and driveways, where runoff moves as sheet flow.

Vegetative filter strips treat the pollutants in stormwater runoff through filtration and biological uptake. Because these mechanisms rely on the vegetation in the filter strip, that vegetation must be dense and remain healthy; therefore, filter strips can be used wherever soil conditions, slopes and sunlight permit the establishment and maintenance of a robust plant community.

Vegetative filter strips must have a maintenance plan, and, if privately owned, must be protected by easement, deed restriction, ordinance or other legal measure that prevents its neglect, adverse alteration or removal.

Applications

The nonstructural stormwater management strategies design standard in the Stormwater Management rules must be addressed for all major development, pursuant to N.J.A.C. 7:8 -5.3(a). The site evaluation for nonstructural strategies should consider all nine strategies. The design of a vegetative filter strip can assist in maximizing the following strategies:

- Strategy #1: The protection of areas that are susceptible to erosion or that provide water quality benefits;
- Strategy #3: The maximization of the protection of natural drainage features and vegetation;
- Strategy #4: The minimization of the decrease in time of concentration;
- Strategy #5: The minimization of land disturbance;
- Strategy #7: The provision of low maintenance landscaping, which encourages retention and planting of native vegetation and minimizes the use of lawns, fertilizers and pesticides.

To receive credit for the 60-80% total suspended solids (TSS) removal rate, vegetative filter strips must be designed to treat the Water Quality Design Storm and in accordance with all of the criteria below. The actual TSS removal rate for a particular vegetative filter strips will depend on the slope, length and type of vegetation in the filter strip. The following table shows the maximum achievable rate for each category of vegetation.

Type of Vegetation	TSS Removal Rate
Turf Grass	60%
Meadow Cover	70%
Planted Woods	70%
Existing Forest Areas	80%

Design Criteria

Basic Requirements

There are two categories of vegetative filter strips. The following design criteria apply to all categories and must be met in order to receive the TSS removal rate listed in the preceding table for this BMP. For criteria specific to each category, see the applicable section, beginning on Page 5.

Inflow Drainage Area Limitations

- Flow through the inflow drainage area must be uniformly distributed and sufficiently low in peak velocity such that sheet flow is maintained throughout the entire inflow drainage area.
- For this to occur, the inflow drainage area must be uniformly graded, with a shallow enough slope to maintain sheet flow; the downstream edge, which is in contact with the upstream edge of the vegetative filter strip, must be perpendicular to the direction of the flow of stormwater runoff.
- The length of the inflow drainage area, measured in the direction of flow, represents the flow path of stormwater runoff. The maximum inflow drainage length is 100 feet.

Vegetation

- There are a number of different types of vegetation that can be used in a filter strip; however, in order to receive the adopted TSS removal rates, selection is limited to the following:

  1. Turf grass,
  2. Meadow cover,
  3. Planted woods, and
  4. Existing forest areas.

- To achieve the best performance, the plants must be healthy and the vegetative cover dense; the minimum density of vegetation is 85%. In addition, to attain sufficient surface roughness, the following requirements also apply:

  1. A minimum 3-inch mulch layer is required for newly planted woods, and
  2. A minimum 1-inch organic detritus layer is required for existing forested areas.

- Vegetation must be fully established before the vegetative filter strip is put into use as a stormwater management measure.

Required Length

In order to maintain sheet flow throughout, the length of a filter strip must be between:

- The minimum length of 25 feet and
- The maximum length of 100 feet.

The required length of a vegetative filter strip is governed by:

- The slope of the filter strip,
- The vegetation within the filter strip, and
- The soils within the inflow drainage area; if the inflow drainage is impervious, use the soil classification beneath the impervious surface.

Vegetative filter strips greater than 100 feet in length will only receive water quality credit for the first 100 feet.

Maximum Allowable Slope

The maximum slope of a vegetative filter strip is determined by the following:

- Soils within the upstream drainage area, and
- Filter strip vegetation.

Flow Characteristics

- The flow of runoff through the vegetative filter strip must be sheet flow.
- Because the maximum length runoff can flow before beginning to concentrate is 100 feet, a mechanism to distribute flow, such as a flow leveler or a stone cutoff trench, is required when the sum of the flow path in the inflow drainage area and the vegetative filter strip exceeds 100 feet. This flow distribution mechanism may only be placed at the boundary between the inflow drainage area and the vegetative filter strip.

Stability

- Vegetative filter strips must be stabilized in accordance with the current version of *Standards for Soil Erosion and Sediment Control in New Jersey*.

Categories of Vegetative Filter Strips

There are two categories of Vegetative Filter Strips:

1. Vegetative Filter Strips Comprised of Existing Features
2. Newly Created Vegetative Filter Strips

Individual Types of Vegetative Filter Strips

The following section provides additional design criteria for each category of vegetative filter strips. These illustrations depict possible configurations and flow paths and are not intended to limit the design.

Characteristics of Vegetative Filter Strips Comprised of Existing Features

An existing on-site feature can be used as a vegetative filter strip only when the following criteria apply:

- Must have surface features that delay, pond and/or disperse runoff over the entire length of the filter strip; however these features cannot concentrate flow, and
- Be surveyed and inspected during rain events under existing conditions to determine runoff flow patterns.

Characteristics of Newly Created Vegetative Filter Strips

A newly designed vegetative filter strip must meet the following criteria:

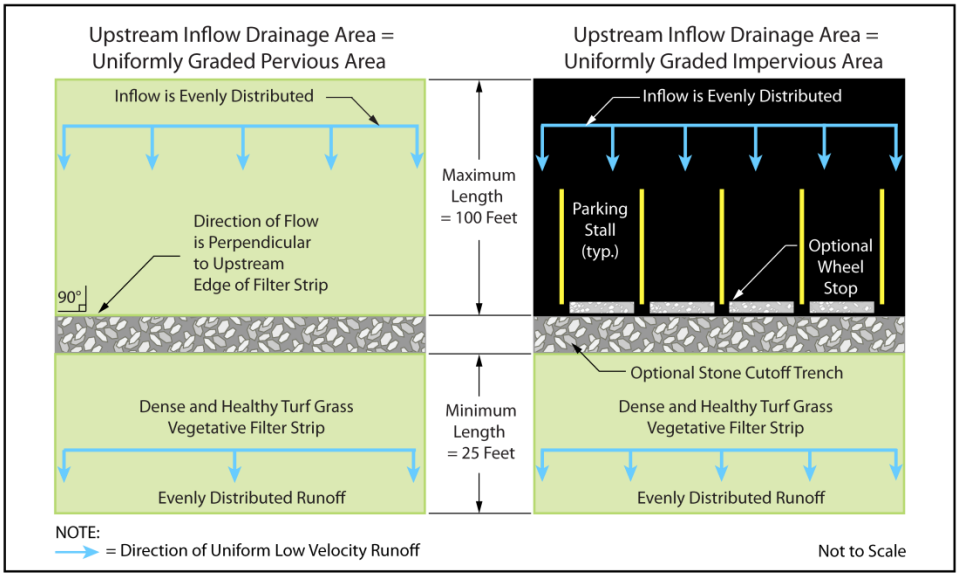
- Uniform grading throughout,
- Mild slopes, and
- Have a minimum length of 25 feet, with the measurement taken in the direction of flow.

Basics of Vegetative Filter Strip Configuration

Filter Strips with a Single Type of Vegetation

The illustration below shows, side by side, two examples of vegetative filter strip configurations. On the left side of the figure, runoff flows evenly from a uniformly graded pervious area to a stone cutoff trench and then into the filter strip. On the right side of the figure, runoff flows from a uniformly graded parking lot through a stone cutoff trench and then into the filter strip. As shown in the figure, the maximum length of each inflow drainage areas is 100 feet. In this example, a stone trench, positioned perpendicular to the flow, is employed. The figure below also shows the vegetated filter strip at its minimum required length of 25 feet. In this chapter, length is always measured in the direction of the flow of runoff.

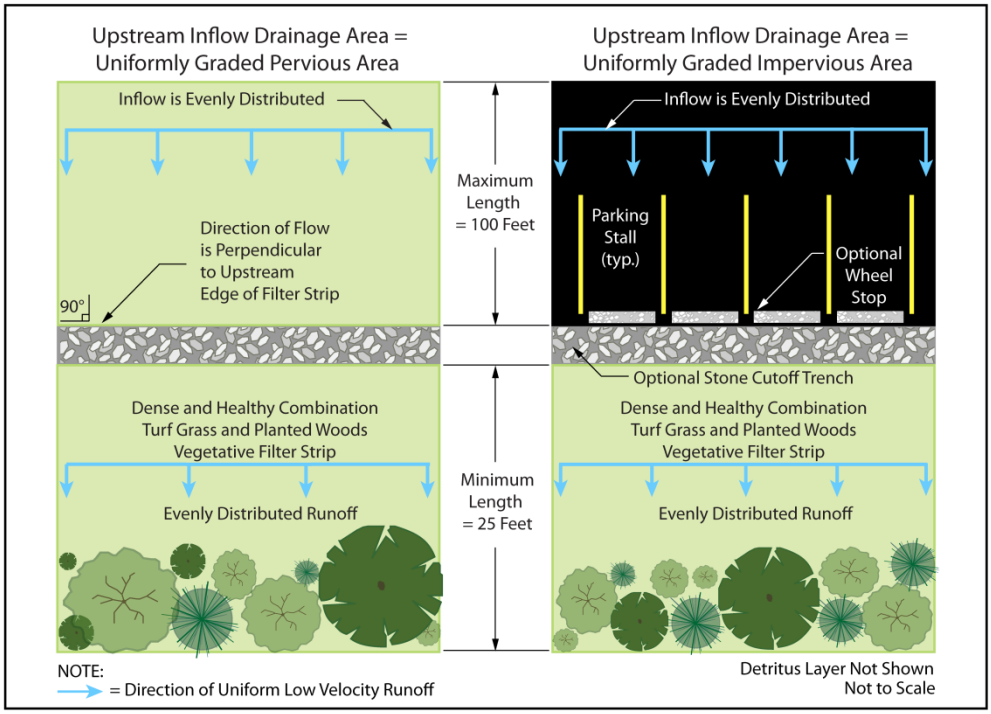
Basic Vegetative Filter Strip Configuration - Plan View



Filter Strips with More Than One Type of Vegetation

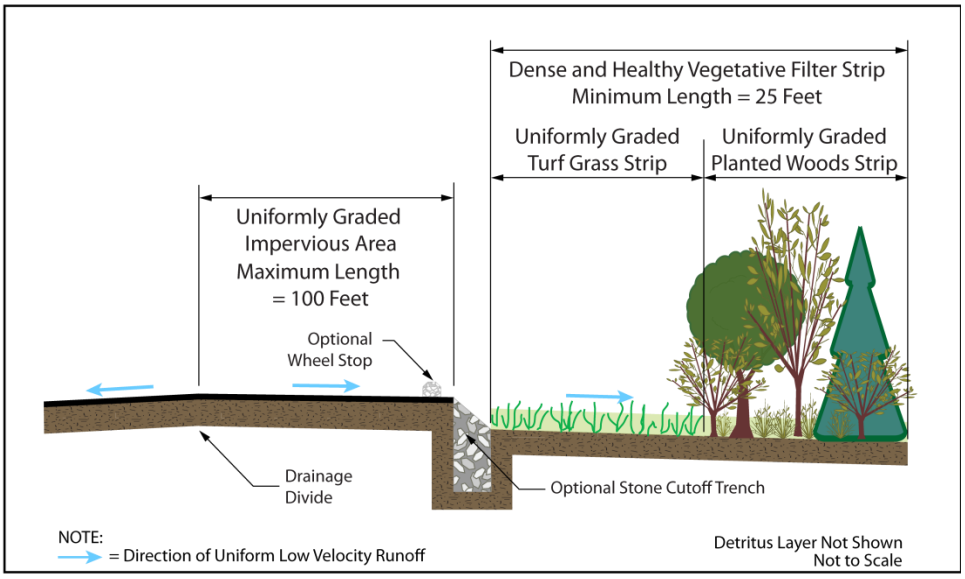
The following illustration shows the same filter strip configurations as above with two different types of vegetation.

Combination Vegetative Filter Strip Configuration – Plan View



The next graphic illustrates a combination vegetative filter strip in profile view. This view highlights the restriction against allowing additional flow to enter at the upstream limit of the inflow drainage area. Again the inflow drainage area has a maximum length of 100 feet and the filter strip has a minimum length of 25 feet. The use of wheel stops or other parking guides must not impede sheet flow of runoff.

Combination Vegetative Filter Strip Configuration – Profile View



TSS Removal Rates for Filter Strips with More Than One Type of Vegetation

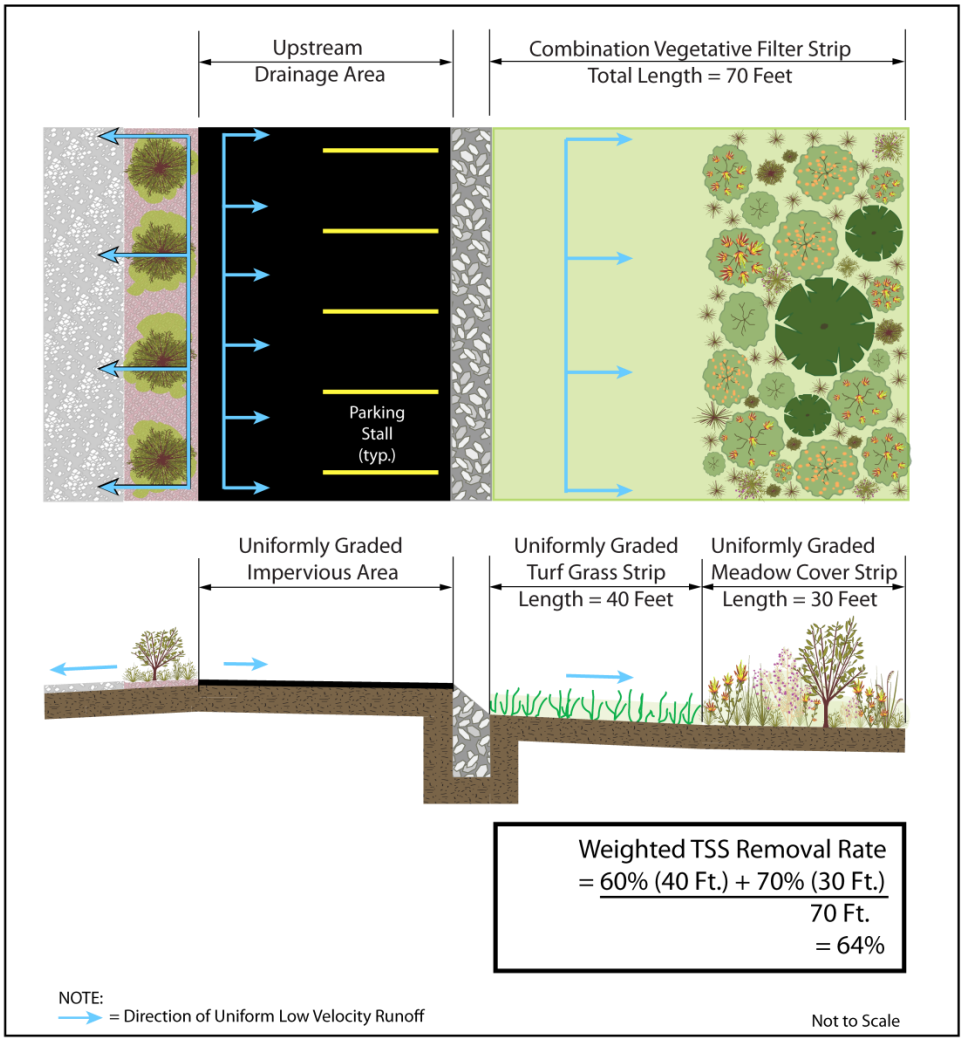
When a vegetative filter strip includes more than one type of vegetation, the TSS removal rate is calculated using a weighted average based on the vegetation types and the length runoff flows through each type of vegetation. The following example demonstrates how to calculate the removal rate for a combination vegetative filter strip.

Example 1: Compute the weighted TSS removal rate for a combination vegetative filter strip consisting of a Turf Grass section 40 feet in length and a Meadow Cover section 30 feet in length, as shown in the following illustration.

To determine the weighted TSS removal rate for combination vegetative filter strip, the equation used is as follows:

$$\% \text{ TSS Removal Rate} = \frac{\sum_{i=1}^{n} [(\%TSS)_i * L_i]}{\sum_{i=1}^{n} L_i},$$

where n is the number of sections, $(\%TSS)_i$ is the TSS removal rate of an individual section, and L_i is the corresponding length of that section.



Required Filter Strip Length

The required length of a vegetative filter strip is based on its slope, its vegetation, and the soil type and hydrologic soil group (HSG) within the inflow drainage area. The inflow drainage area soils are important because they determine the amount of stormwater that runs off of the drainage area and enters the filter strip during a given rain event. In addition, the soils provide the comparable particle sizes that the filter strip will be treating. The following charts are used to determine the required filter strip length; each chart covers a different soil type. The length for any vegetative filter strip is 25 feet or greater, up to 100 feet. Extrapolation beyond the extents of the curves is not permitted.

Chart A. Vegetative Filter Strip Length:
Drainage Area – Hydrologic Soil Group A & Soil Type = Sand

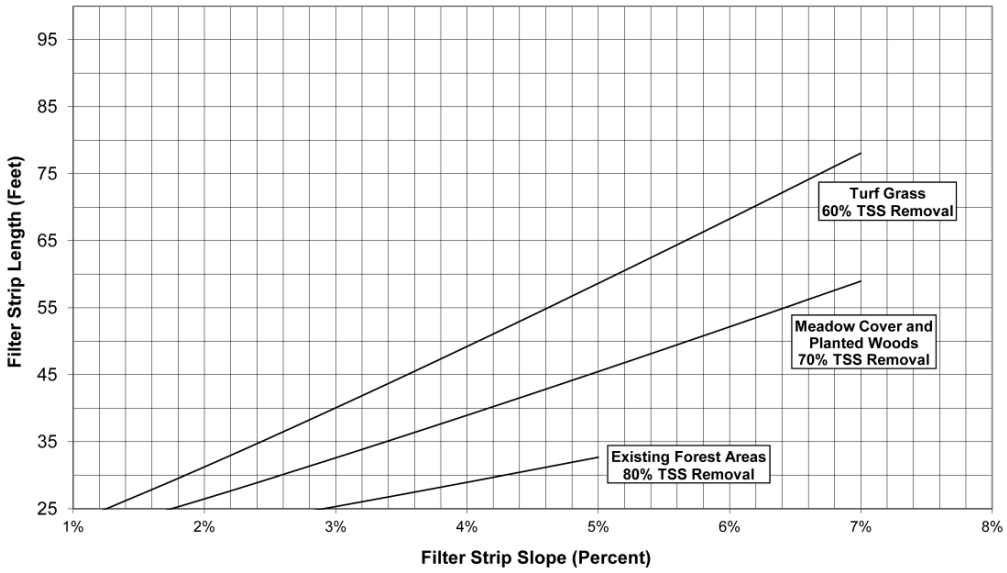


Chart B. Vegetative Filter Strip Length:
Drainage Area – Hydrologic Soil Group A & Soil Type = Sandy Loam

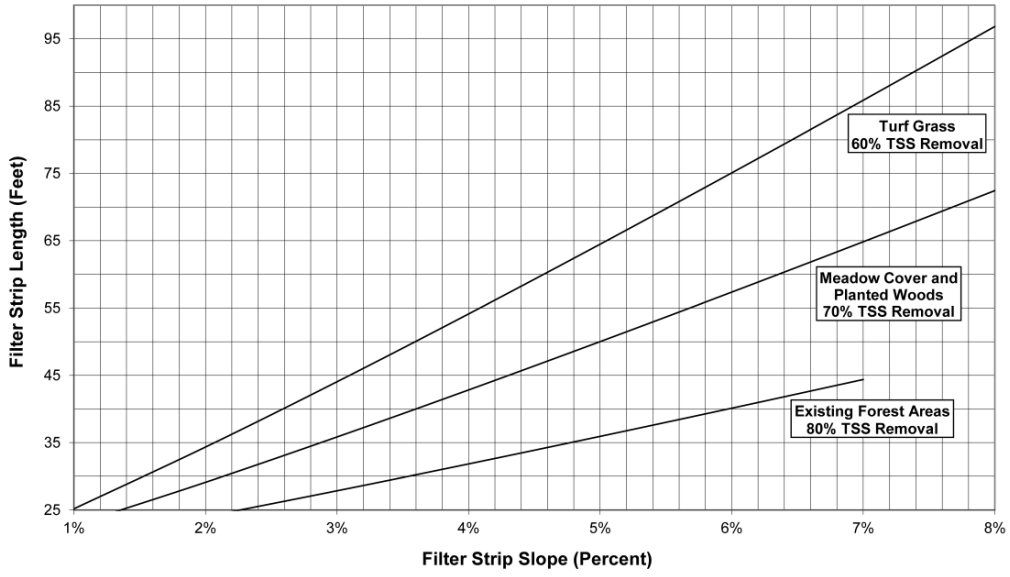


Chart C. Vegetative Filter Strip Length:
Drainage Area – Hydrologic Soil Group B & Soil Type = Loam, Silt Loam

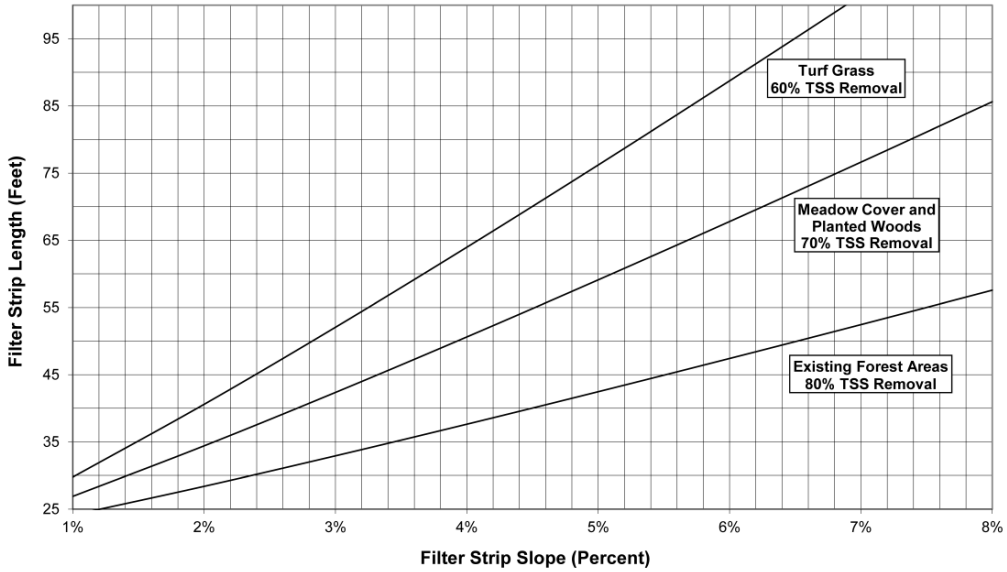


Chart D. Vegetative Filter Strip Length:
Drainage Area – Hydrologic Soil Group C & Soil Type = Sandy Clay Loam

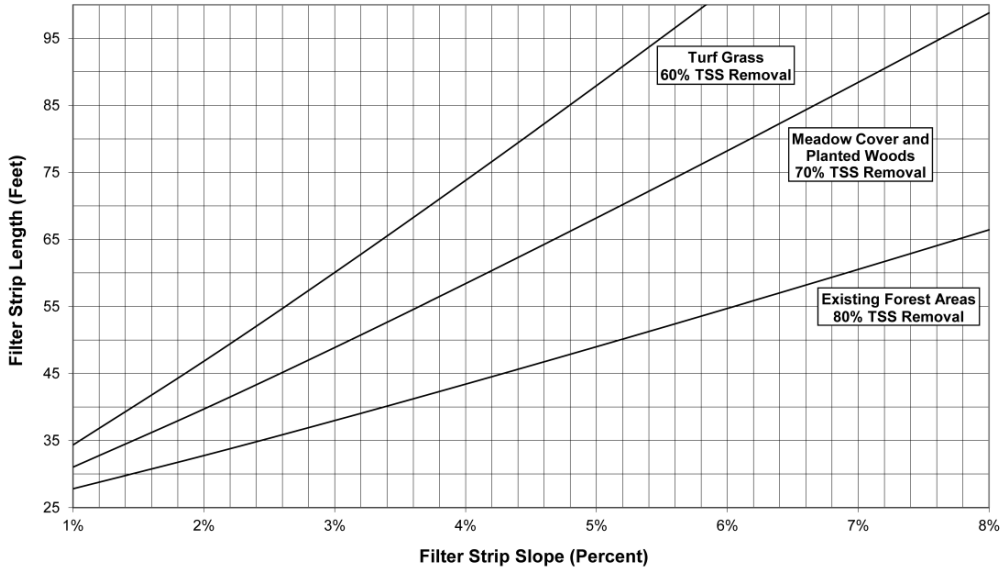
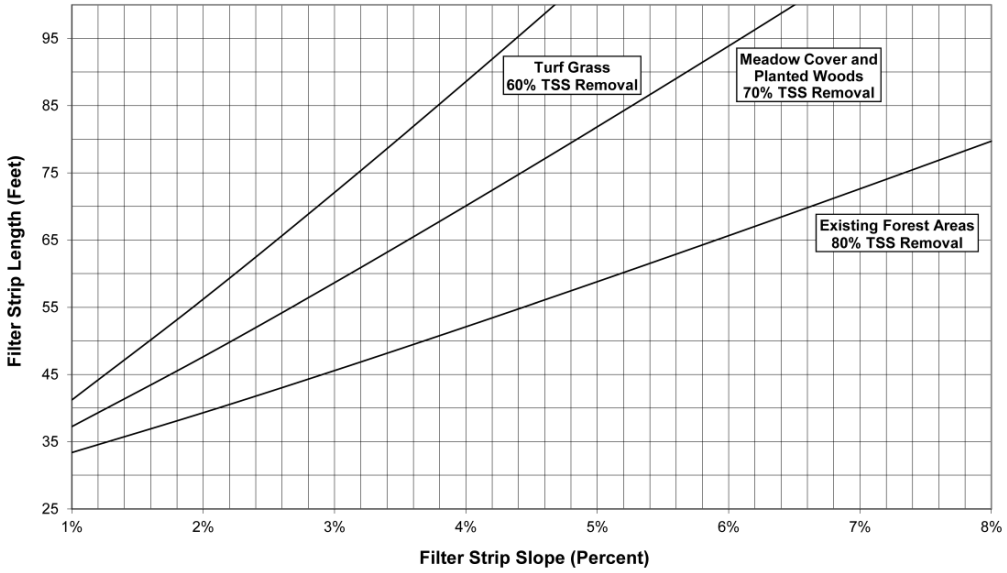


Chart E. Vegetative Filter Strip Length:
Drainage Area – Hydrologic Soil Group D & Soil Type = Clay Loam, Silty Clay, Clay



Maximum Filter Strip Slope

The maximum allowable slope for a vegetative filter strip is determined by the inflow drainage area soils and the type of vegetation within the filter strip. Both onsite soil investigations and the Web Soil Survey can be used to determine the soils types; if more than one type of soil exists, the soil type with the smallest particle size should be used in the filter strip's design. If the post-development inflow drainage area is impervious, the pre-development soil type should be used. Once the soil type is determined, the chart below can be used to determine the maximum allowable slope for a given vegetative cover. It should be noted these maximums correspond to the slopes shown for each of the three curves in the five preceding charts.

Maximum Filter Strip Slope (Percent)				
Soil Type	**Hydrologic Soil Group**	**Turf Grass**	**Meadow Cover or Planted Woods**	**Existing Forest Areas**
Sand	A	7	7	5
Sandy Loam	A	8	8	7
Loam, Silt Loam	B	6.9	8	8
Sandy Clay Loam	C	5.8	8	8
Clay Loam, Silty Clay, Clay	D	4.6	6.5	8

How to Determine Filter Strip Length for a Given Slope

The following example illustrates how to use the charts to determine the required vegetative filter strip length:

Example 2: Compute the required filter strip length assuming the strip is to be vegetated with turf grass. A vegetative filter strip with a uniform 5% slope is proposed to treat the stormwater runoff from a drainage area consisting of a paved parking lot. Runoff enters the filter strip as sheet flow. The maximum sheet flow length across the parking lot does not exceed 100 feet. The soil type in the inflow drainage area is silt loam.

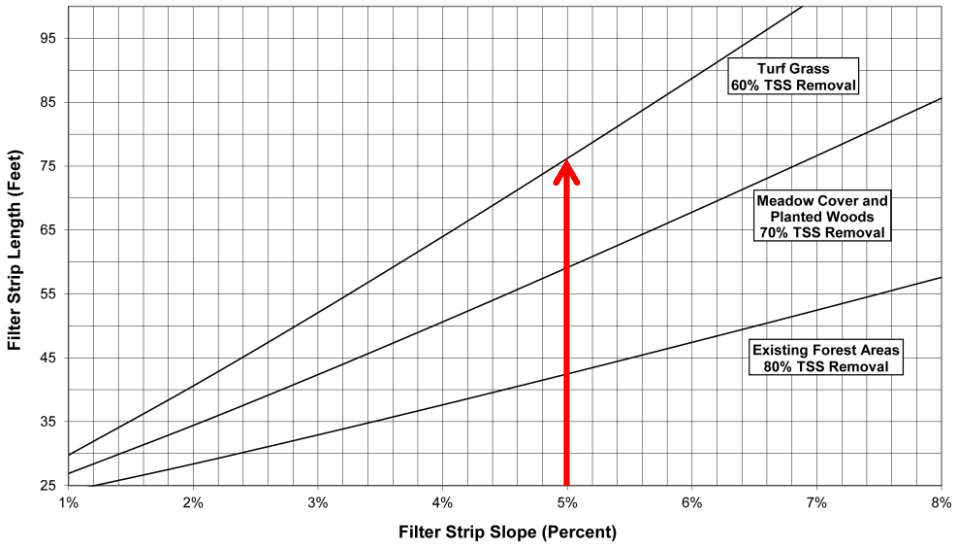
Step #1: Verify that sheet flow is maintained throughout the inflow drainage area.

Step #2: Verify that sheet flow lengths do not exceed maximum allowable.

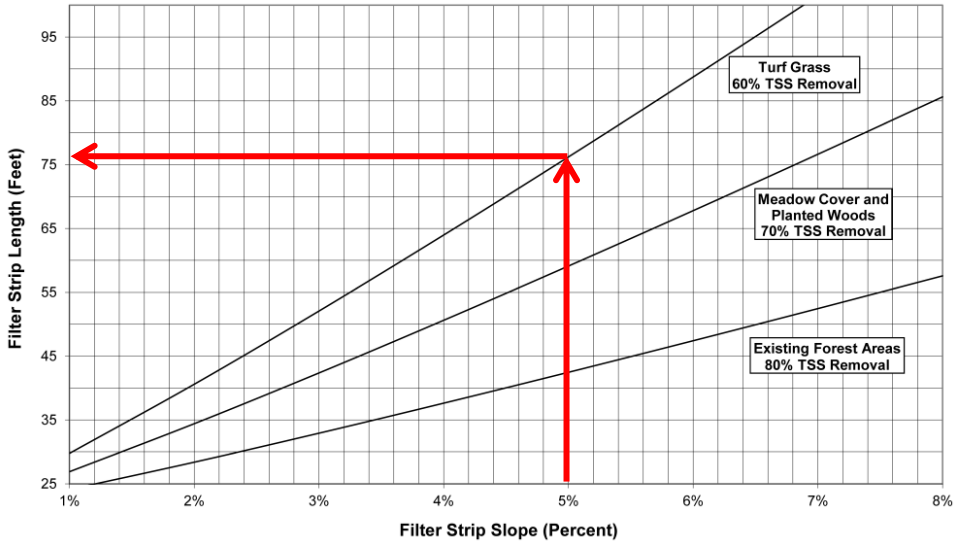
Step #3: Select the appropriate chart based on the Hydrologic Soil Group and soil type. For this example, use Chart C.

Step #4: Verify that the maximum allowable slope is greater than the design. The proposed vegetative filter strip is turf grass. From the table on page 8, the maximum slope for turf grass in HSG B is 8%. The proposed slope is less than the maximum allowable.

Step #5: Using Chart C, draw a vertical line on the slope axis at the 5% mark up to the curve for turf grass, as follows:



Step #6: Draw a 2nd line from the point of intersection with the turf grass curve over to the filter strip length axis, as follows:



Step #7: Determine the required length of the filter strip. The answer is approximately 76 feet.

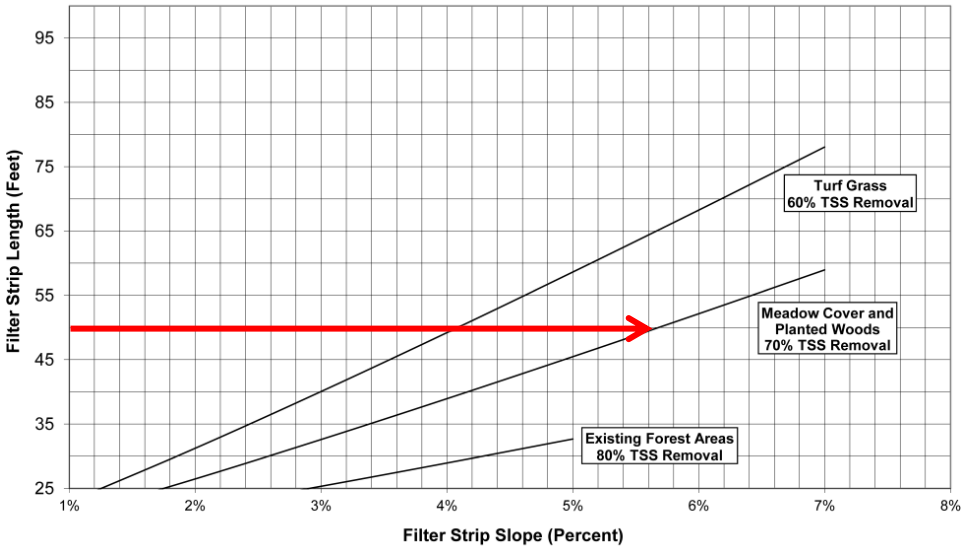
Answer: If constructed in accordance with this chapter, a turf grass vegetative filter strip 76 feet in length at 5% slope will be awarded a TSS removal rate of 60%.

How to Determine Filter Strip Slope When the Length is Known

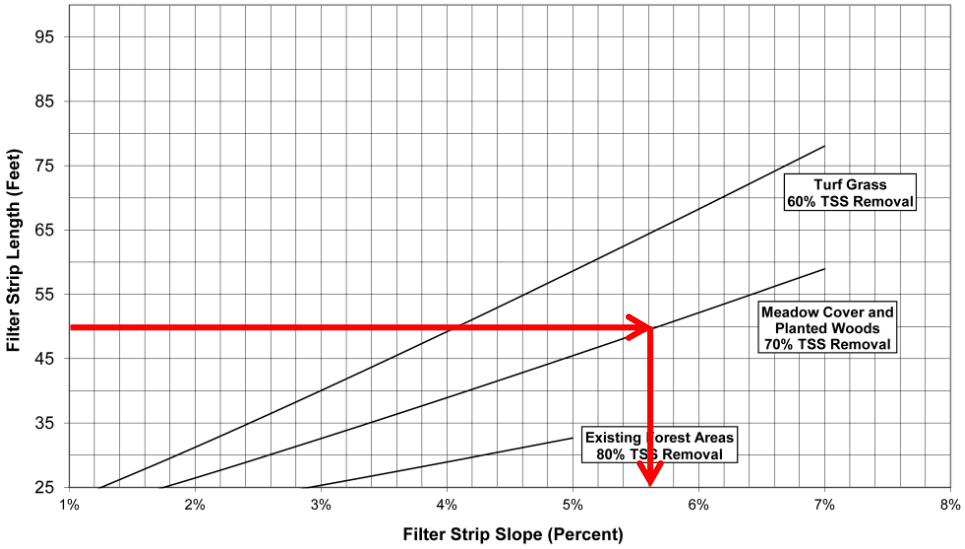
The charts can also be used in reverse to determine the required slope for a drainage area's given HSG and soil type, length of filter strip and type of vegetative cover, as in the following example:

Example 3: The proposed design has an upstream drainage area with HSG A and soil type sand. A meadow cover filter strip 50 feet in length is proposed. What slope is required?

Step #1: Using Chart A, a horizontal line is drawn from the vertical axis at the 50 ft mark over to the meadow cover curve.



Step #2: A vertical line is then drawn down from the intersection of the line in Step 1 with the meadow cover curve to the horizontal axis.



Step #3: Determine the maximum slope of the filter strip. The answer is 5.6%.

Answer: If constructed in accordance with this chapter, a meadow cover vegetative filter strip 50 feet in length at 5.6% slope will be awarded a TSS removal rate of 70%.

How to Determine Whether Sheet Flow is Maintained

Because runoff must both enter and travel through the filter strip as sheet flow, and because runoff begins to concentrate after traveling 100 feet, a mechanism to distribute energy may be necessary to maintain sheet flow. If the length of the inflow drainage area plus the length of the filter strip exceeds 100 feet, an energy dissipation mechanism, such as a stone cutoff trench, placed at the boundary between the inflow drainage area and the vegetative filter strip, may be necessary to maintain sheet flow. For additional information on energy dissipation mechanisms, refer to the *Standards for Soil Erosion and Sediment Control in New Jersey.*

The following examples illustrate when energy dissipation is necessary.

Example 4: A vegetative filter strip is proposed for an inflow drainage area 25 feet in length. Determine whether a stone cutoff trench, or other energy dissipation mechanism, may be necessary at the upstream boundary of a vegetative filter strip under each of the following conditions. What is the % TSS Removal Rate?

a. Turf grass filter strip at 6.9% Slope on HSG B, soil type Loam, with a stone cutoff trench located at the upstream boundary of the filter strip.

b. Meadow cover filter strip at 5.7% Slope on HSG C, soil type Sandy Clay Loam

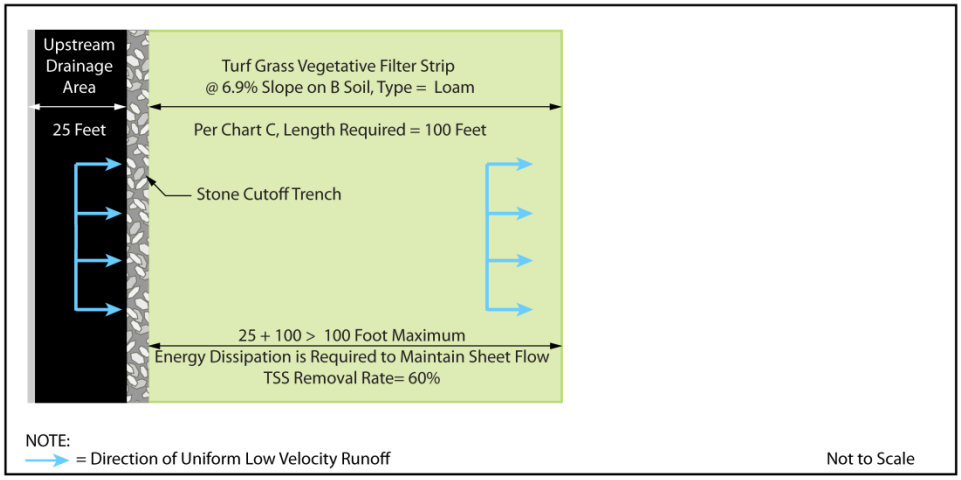
Step #1: Start with the Appropriate Chart

a. Using Chart C for the specified type of filter strip and slope, the length required is 100 feet. The TSS removal rate is 60%.

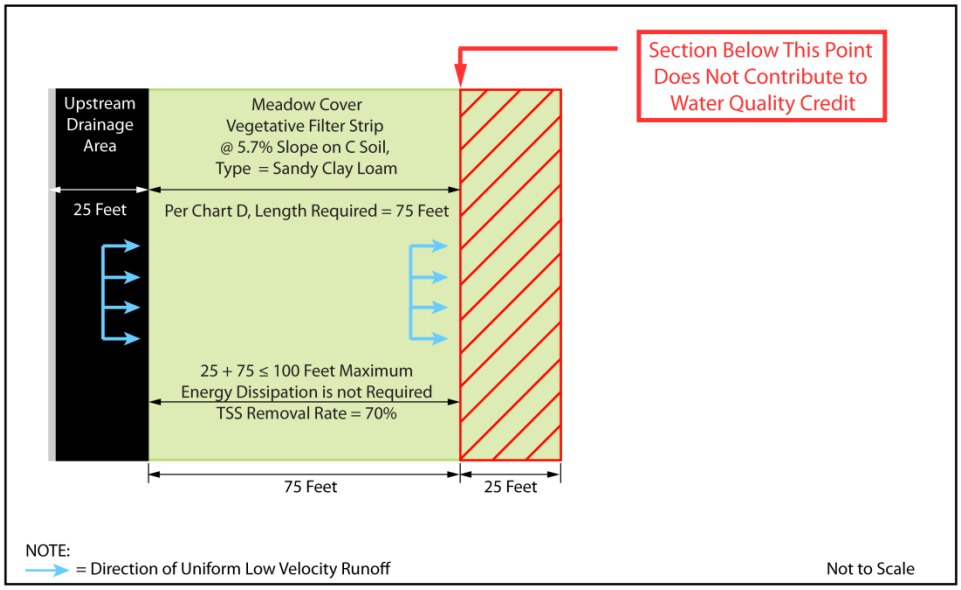
b. Using Chart D for the listed type of filter strip and slope, the length required is 75 feet. The TSS removal rate is 70%.

Step #2: Check for Maintenance of Sheet Flow

a. From Step #1, the required length of the filter strip is 100 feet, as shown in the following illustration. Because the length of the inflow drainage area plus the length of the filter strip exceeds 100 feet, a stone cutoff trench may be necessary to maintain sheet flow.



b. From Step #1, the required length of the filter strip is 75 feet, as shown in the following illustration. Because the length of the inflow drainage area plus the length of the filter strip is 100 feet, a stone cutoff trench is not necessary, and the inflow drainage area receives the 70% TSS removal rate. The downstream section hatched in red does not contribute to water quality because the distance of travel exceeds the 100 foot maximum established for sheet flow.



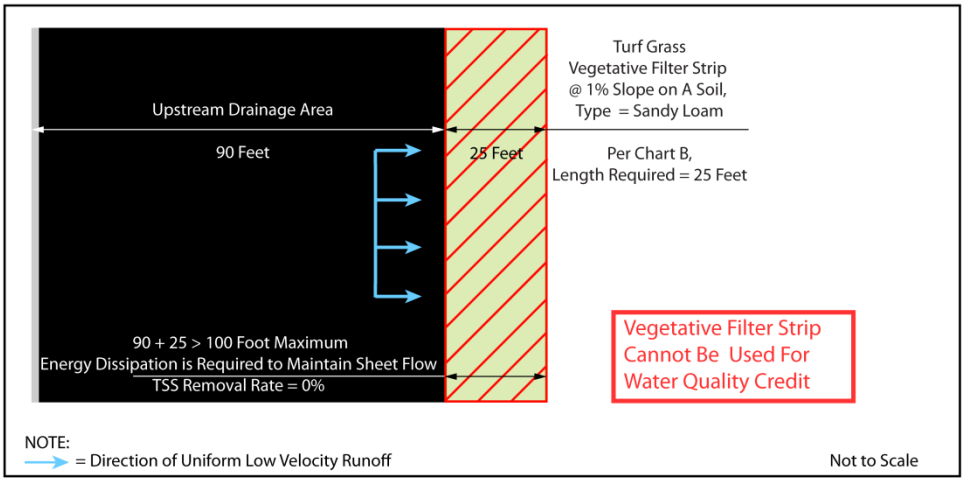
Although the 25 foot section hatched above in red does not count towards water quality, it may qualify as an area of preserved vegetation for the purposes of demonstrating compliance with the nonstructural stormwater management strategies. For additional information on nonstructural stormwater management strategies, see *Chapter 2: Low Impact Development Techniques*.

Example 5: A vegetative filter strip is proposed for an inflow drainage area 90 feet in length. Determine if a stone cutoff trench may be necessary to maintain sheet flow if the filter strip proposed is at 1% Slope on HSG A, soil type Sandy Loam and vegetated with turf grass. There is only 25 feet of space available. Determine the length of the vegetative filter strip required. What is the % TSS Removal Rate?

Step #1: Using Chart B for the specified type of filter strip and slope, the length required is 25 feet. The TSS Removal Rate is 60% per the chart.

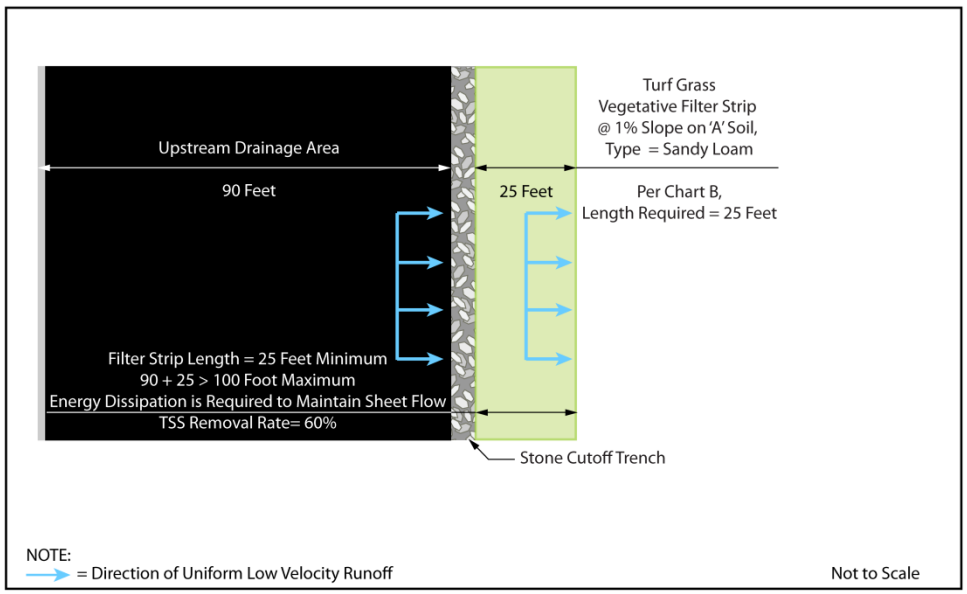
Step #2: Check for maintenance of sheet flow.

The following illustration shows a vegetative filter strip with no mechanism to dissipate energy. The sum of the lengths of the flow paths in the upstream drainage area and the vegetative filter strip (90 + 25 = 115) exceeds 100 feet; therefore, sheet flow is not maintained, and **the resulting TSS removal rate for this design is 0%**.



Note: The following alternative provides water quality credit.

The illustration which follows shows an identical upstream drainage area and vegetative filter strip. The addition of the stone cutoff trench at the upstream boundary of the filter strip allows sheet flow to be maintained; therefore, the TSS removal rate for this configuration is 60%, based on the chart used in Step #1.



Considerations

A number of factors should be considered when using a vegetative filter strip to treat stormwater runoff, including drainage and existing on-site features. Good drainage, both surface and subsurface, is necessary to ensure satisfactory performance. When designing a newly created filter strip, the designer should be aware of potential ponding factors during the planning stage and design the system to allow for sufficient dry periods between flows in order to re-establish aerobic soil conditions. Finally, the most common, naturally occurring filter strips are those upland vegetative stands that are found adjacent to natural watercourses. In some cases, preservation of these upland areas will allow them to continue to function as filter strips.

Maintenance

Regular and effective maintenance is crucial to ensure effective vegetative filter performance; in addition, maintenance plans are required for all stormwater management facilities associated with a major development, pursuant to N.J.A.C. 7:8-5.8. There are a number of required elements in all maintenance plans; these are discussed in more detail in *Chapter 8: Maintenance of Stormwater Management Measures*. Furthermore, maintenance activities are required through various regulations, including the New Jersey Pollutant Discharge Elimination System (NJPDES) Rules, N.J.A.C. 7:14A. Specific maintenance requirements for vegetative filters are presented below; these requirements must be included in the vegetative filter's maintenance plan.

General Maintenance

- All structural components must be inspected, at least once annually, for cracking, subsidence, spalling, erosion and deterioration.
- Components expected to receive and/or trap debris and sediment must be inspected for clogging at least twice annually. These components may include vegetated areas, stone cutoffs and, in particular, the upstream edge of the filter strip where coarse sediment and debris accumulation could cause inflow to concentrate.
- Sediment removal should take place when the filter strip is thoroughly dry and should not result in the loss of vegetation.
- Disposal of debris, trash, sediment and other waste material must be done at suitable disposal/recycling facilities and in compliance with all applicable local, state and federal waste regulations.
- All areas of the filter strip should be inspected for excess ponding after significant storm events, and corrective actions taken when excessive ponding occurs.

Vegetated Areas

- Bi-weekly inspections are required when establishing/restoring vegetation.
- A minimum of one inspection during the growing season and one inspection during the non-growing season is required to ensure the health, density and diversity of the vegetation.
- Mowing/trimming within the filter strip must be performed on a regular schedule based on specific site conditions.
- Vegetated areas must be inspected at least once annually for erosion, scour and unwanted growth; any unwanted growth should be removed with minimum disruption to the remaining vegetation.
- Vegetative cover must be maintained at 85%; damage in excess of 50% must be addressed through replanting in accordance with the original specifications.

- All use of fertilizers, pesticides, mechanical treatments and other means to ensure optimum vegetation must not compromise the intended purpose of the filter strip.

Drain Time

- The approximate time for the vegetative filter strip to drain the maximum design storm runoff volume must be indicated in the maintenance manual.
- If the actual drain time is significantly different than the design drain time, the filter strip's planting bed, vegetation and groundwater levels must be evaluated and appropriate measures taken to return the filter strip to minimum and maximum drain time requirements.

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