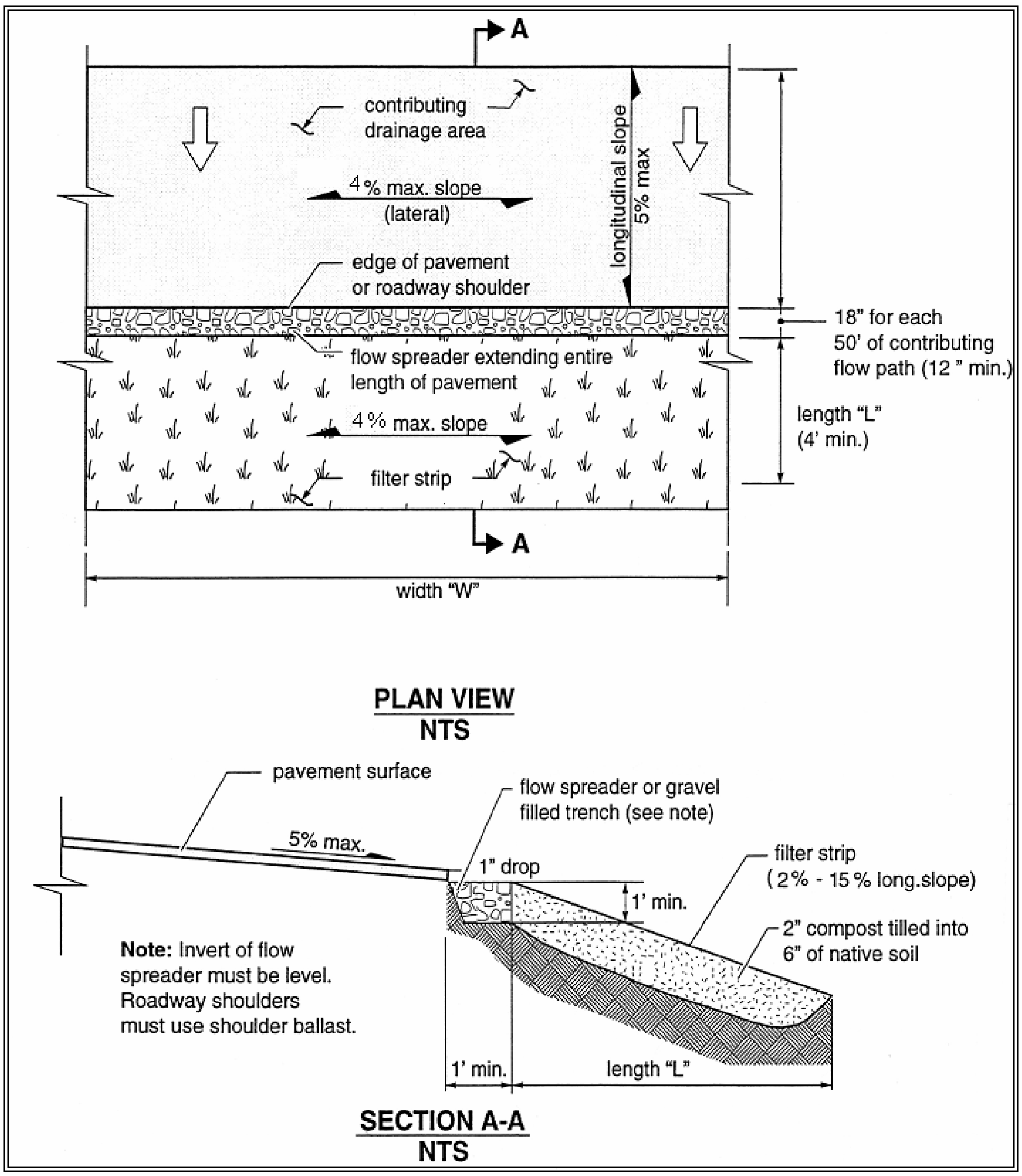
Example Vegetative Filter Strips

Introduction to Vegetative Filter Strips

A Vegetative Filter Strip is a BMP's that uses areas of planted vegetation (typically grass) and a flat cross slope to maintain sheet flow and remove sediment and other pollutants from runoff coming directly off pavement. Vegetative filter strips are only intended to provide runoff treatment and are thus situated between the pavement surface and a surface water collection system, pond, wetland, or river. The short duration storm should be used when determining runoff values.

This tutorial provides two methods for sizing filter strips: narrow area filter strips and basic area filter strips. The Figure below illustrates a filter strip and design criteria that applies to both types.



Narrow Area Filter Strips

Example Vegetative Filter Strips

Design Procedure

The method described in this tutorial is for flow paths equal to or less than 30', for flow paths greater than 30' designers should consult the basic area filter strips portion of this tutorial. This procedure is based on the Narrow Area Filter Strips presented in the 1998 King County Surface Water Design Manual and will appear in the 2005 HRM. The filter strip is sized using the length of the flowpath draining and the longitudinal slope of the filter strip itself (parallel to the flowpath). Since filter strips only provide basic treatment, they should be used where the roadway ADT is less than 30,000. In areas where enhanced treatment is required, compost should be added to the filter strip and designers should consult BMP RT.02 in the HRM.

Design Criteria

The following guidelines should be followed when sizing a Narrow Area Vegetative Filter Strip:

- The flow path from the contributing area delivering sheet flow to the filter strip should not exceed 30 feet.
- Filter Strips should be placed at least 1 foot, from the edge of pavement to accommodate a vegetative free zone or install a flow spreader.
- The longitudinal slope of the contributing drainage area perpendicular to the pavement edge should be 5 percent or less because of the difficulty in maintaining the necessary sheet flow conditions.
- The longitudinal slope of the filter strip shall not exceed 15%.
- The maximum lateral slope of the filter strip is 4%.
- Once a filter strip has treated stormwater, it will need to be collected and conveyed to a stormwater flow control BMP.
- The flow from the roadway must enter the filter strip as sheet flow and must not receive concentrated flow discharges.

Construction and Maintenance Criteria

- Vegetated filter strips should be constructed after other portions of the project are completed, ie they should not be used for Temporary Erosion Control (TESC).
- Groomed filter strips planted in grasses should be mowed during the summer to promote growth.
- Inspect filter strips periodically, especially after periods of heavy runoff. Remove sediments and reseed as necessary. Catch basins or sediment sumps that precede filter strips should be cleaned to maintain proper function.

Example Vegetative Filter Strips

Narrow Area Vegetative Filter Strip Sample Problem Description

A new highway near the city of Spokane is being constructed that will shed 25' of runoff from pavement at a 2% cross-section slope and a continuous 3% profile off the road. It has been determined that a vegetative filter strip would best fit the site.

Step 1: Determine length of flowpath draining to the filter strip.

Determine the length of the flowpath from the upstream to the downstream edge of the impervious area draining to the filter strip. This is the same as the width of the paved area.

For this example the length of the flow path is equal to the width of the road or ***25'****.*

Step 2: Determine average longitudinal slope of the filter strip:

Calculate the longitudinal slope of the filter strip (parallel to the flowpath), averaged over the total width of the filter strip. If the slope is less than 2 percent, use 2 percent for sizing purposes. The maximum longitudinal slope allowed is 17 percent.

For this tutorial the longitudinal slope of the filter strip is ***10%****. This value will likely be determined by the road geometry and natural terrain where the filter strip will be located.*

Step 3: Determine required length of the filter strip:

Use Figure 5.5.1 to size the filter strip based on flowpath length and filter strip (longitudinal) slope. To use the figure, find the length of the flowpath on one of the curves (interpolate between curves as necessary). Move along the curve to the point where the design longitudinal slope of the filter strip is directly below. Read the filter strip length to the left on the y-axis. The filter strip must be designed to provide this minimum length "L" along the entire stretch of pavement draining to it.

Given a road width of 25' shedding runoff to the filter strip, designers should estimate between the 20' and 30' lines. Then locate a 10% slope for a filter strip, and from the y-axis the filter strip should be 12' long and run parallel to the road.

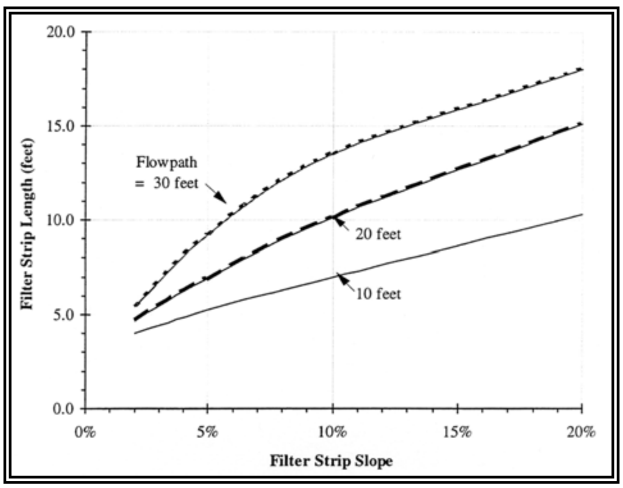


Figure 5.5.1 Vegetated Filter Strip Design Graph

Example Vegetative Filter Strips

Basic Area Filter Strip

Design Procedure

This is a summary of the BMP RT.02 Vegetated Filter Strips from the HRM. For more information, designers should consult the HRM or contact the Region Hydraulics Engineer. The sizing of the basic area filter strip is more complicated than with the narrow filter strip method. Unlike the narrow filter strip that only requires the length of the flowpath and the longitudinal slope of the filter strip itself, the basic area filter strip requires: the Manning's value and slope of the filter strip, the width of the filter strip parallel to the road and design flow from the road surface.

There is several design variations for filter strips: compacted roadside embankment, compost-amended vegetated filter strips, engineered roadside embankments, combination vegetative filter strip/swale systems. Again filter strips provide basic treatment and they should only be used where the roadway ADT is less than 30,000. In areas where enhanced treatment is required, only filter strips that include compost should be used. This tutorial will only cover basic treatment; designers should consult BMP RT.02 in the HRM for enhanced treatment guidance.

Compacted Roadside Embankment – The most basic configuration is a compacted roadside embankment that is subsequently hydroseeded.

Compost Amended Vegetative Filter Strips - Adding compost to the filter strip can improve infiltration characteristics, increase the surface roughness, improve plant stability and improve removal of contaminants.

Engineered Roadside Embankments - A further adaptation of the compost-amended vegetated filter strip design. Trenches are excavated into the embankment under the filter strip and back filled with 1½ to 2 inches of washed stone aggregate to provide subsurface water storage capacity.

Combination Filter Strip/Swale - can be useful when the area of available roadside embankment is not sufficient for a full-sized vegetative filter strip system.

The steps in this tutorial could be used to design any of the before mentioned filter strips, however designers should consult the HRM for biofiltration swale design.

Design Criteria

The guidelines for sizing a Basic Area Vegetative Filter Strip are the same as for Narrow Areas except as noted below:

- The design the flow path should not exceed 75 feet for impervious surfaces and 150 feet for pervious surfaces.
- The longitudinal slope of the filter strip shall not exceed 15%. (For 15%-25% slopes, the HRM encourage designers to consider ecology embankment.)
- The maximum design velocity cannot exceed 0.50 ft/s.
- The design flow depth cannot exceed 1-inch.

Construction and Maintenance Criteria

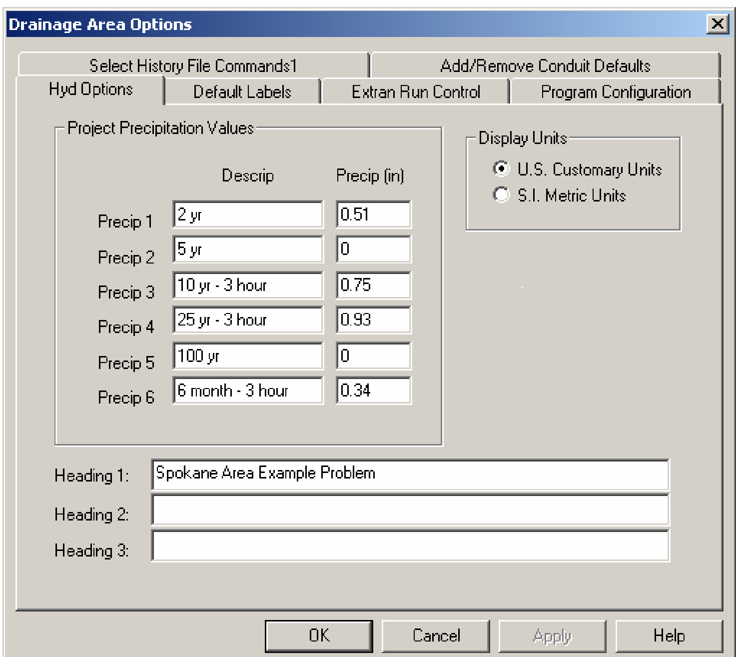
The Construction and Maintenance Criteria are the same as for Narrow Vegetated Filter Strips.

Vegetative Filter Strip Sample Problem Description

A new four-lane roadway section is being constructed near Spokane. A vegetative filter strip is to be constructed on each side of a 2000 ft section of the highway with a 4-foot inside shoulder, two 12-foot lanes, and a 12-foot outside shoulder shedding runoff toward each filter strip. The road has a 2% cross section and 3% continuous profile. The filter strip will have a longitudinal slope of 3%, Type B soil with fully compacted and hydro seeded soil and vegetation conditions.

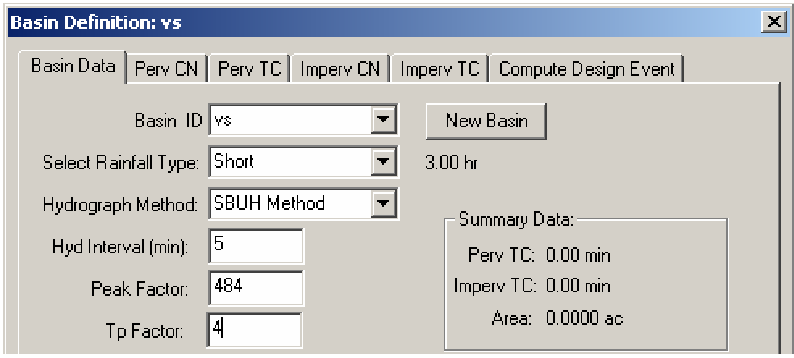
Step 1: Determine the runoff treatment design flow Q.

For eastern Washington, the design flow rate is determined based on the 5-minute interval for the design strom, which is the 6-month, 3-hour event. Storm Shed can be used to obtain this value. Go to Drainage Area Options in Storm Shed to verify the precipitation rates set as noted below. For further discussion on how the values were obtained, see the Beginning Storm Shed Basin Tutorial for eastern Washington.

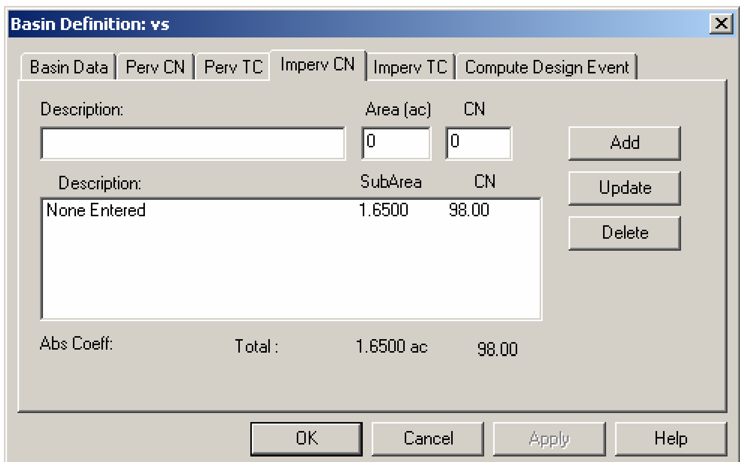


Next create a new basin called **VS**. Verify the rainfall type is **Short** and the interval is **5 minutes**. There is no pervious area contributing to the vegetative filter strip, so those tabs are not used.

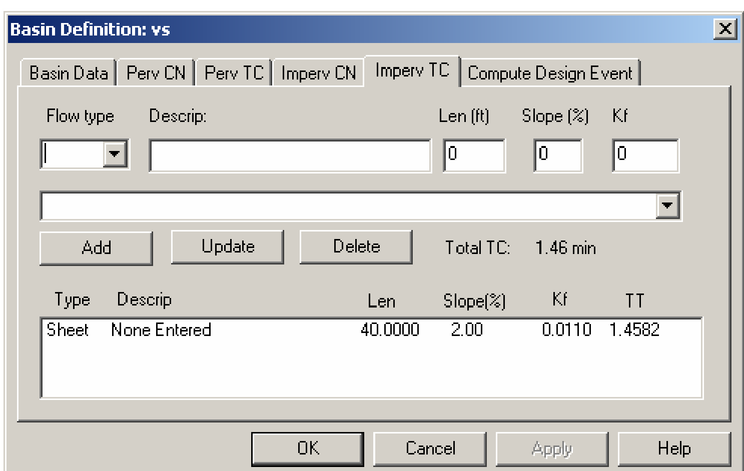
Example Vegetative Filter Strips



The impervious area is calculated to be **1.65 AC** with a **CN** value of **98**.

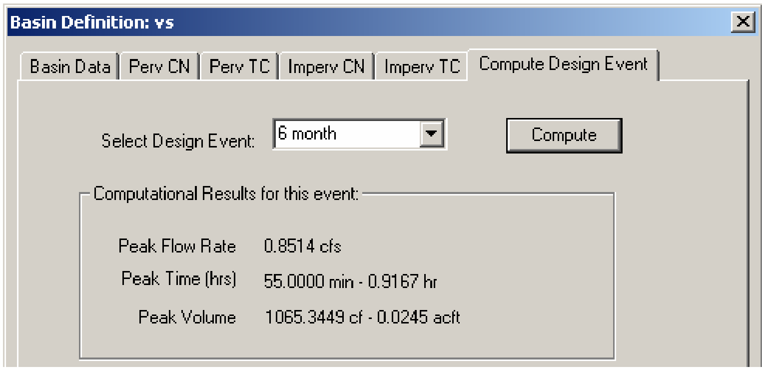


Next, select the impervious tc tab and input the values shown below. Note the only type of flow contributing to the filter strip is sheet flow.



Finally select the Compute Design Event tab and pick the **6 month** design event from the pull down menu and then select **Compute**.

For this example the Q is found to be 0.8514 cfs as shown below.



Step 2: Calculate the design flow depth.

As noted in the design criteria, the design flow depth cannot exceed 1-inch. Use the following equation to determine the flow depth.

$$y = \left[\frac{nQ}{1.49Ws^{0.5}}\right]^{0.6}$$

Where:

Q = Runoff treatment design flow

n = Manning’s roughness coefficient from Table RT.02.1 below

y = design flow depth (not to exceed 1-inch)

W = width of the filter strip parallel to the pavement edge

s = slope of the filter strip parallel to the direction of flow

Table RT.02.1. Surface roughness/Manning’s *n* for filter strip design calculations.

Option	Soil and Vegetation Conditions	Manning’s *n*
1	Fully compacted and hydroseeded	0.20
2	Compaction minimized and soils amended, hydroseeded	0.35
3	Compaction minimized, soils amended to a minimum 10% organic content (App. 5A-2), hydroseeded, grass maintained at 95% density and 4-inch length via mowing, periodic reseeding, possible landscaping with herbaceous shrubs	0.40*
4	Compost-amended filter strip: Compaction minimized, soils amended to a minimum 10% organic content (App. 5A-2), filter strip top-dressed with ≥3 inches vegetated compost or compost/mulch (seeded and/or landscaped)	0.55*

* These values were estimated using the SCS TR-55 Peak Discharge and Runoff Calculator at http://www.lmnoeng.com/Hydrology/hydrology.htm. This tool lists the Manning’s *n* values for woods–light underbrush at 0.4 and woods–dense underbrush at 0.8. The intent of Option 3 is to amend the soils so that they have surface roughness characteristics equivalent to forested conditions with light underbrush. Option 4 adds a 3-inch top dressing of compost or compost/mulch to simulate a thick forest duff layer, which warrants a higher Manning’s *n*, estimated at 0.55.

$$y = \left[\frac{(0.2)(0.8514)}{1.49(1800)(0.03)^{0.5}} \right]^{0.6} = 0.009 \text{ feet}$$

The maximum allowable depth is 1-inch or 0.083 feet, so the depth is acceptable and will allow the flow to maintain sheet flow. If the depth exceeds 1-inch, either adjust the filter strip geometry or use another runoff treatment BMP.

Step 3: Calculate the design flow velocity passing through the filter strip at the runoff treatment design flow rate.

The design flow velocity is based on the runoff treatment design flow rate, the width of the filter strip and the design flow depth as shown below:

$$V = \frac{Q}{Wy}$$

Where:

V = design flow velocity (feet per second)

$$V = \frac{0.8514}{1800\text{x}0.009} = 0.05 \text{ ft/s}$$

As noted in the Design Criteria, the maximum design velocity cannot exceed 0.50ft/s, therefore the design velocity at this filter strip is acceptable.

Step 4: Calculate the filter strip length

The length of the filter strip is determined by the residence time of the flow through the filter strip. A 5-minute (300-second) residence time is used to calculate the filter strip length as shown below:

$$L = 300 \text{ x } V$$

Where:

L = filter strip length (feet)

T = time (seconds)

$$L = 300 \text{ x } 0.05 = 15 \text{ feet}$$

Step 5: Flow Spreaders

Gravel flow spreaders need to be installed between the pavement surface and the filter strip to maintain sheet flow. Flow spreaders serve three important functions: pretreatment, maintain sheet flow, and promote infiltration of runoff. The flow spreaders described in this tutorial are gravel, for other flow spreaders (such as concrete sill, curb stop, or curb and gutter with saw teeth cut into it) designers should consult section 5-4.4.4 of the HRM for design guidance. The following design criterion for gravel flow spreaders is a summary of section RT 02 of the HRM.

- Gravel flow spreader should be a minimum of 1-foot wide by 1-foot deep and placed 1-inch below the surface of the contributing impervious area.
- Gravel flow spreaders should use gravel that meets the specifications for shoulder ballast listed in Section 9-03.9(2) of the WSDOT Standard Specifications (see Table RT.02.2).

Table RT.02.2.

Shoulder ballast specification for gravel flow spreaders.

Sieve Size	Percent Passing
2.5 inches	100
¾ inch	40–80
¼ inch	5 maximum
#100	0–2

- If there are concerns that water percolated within the gravel flow spreader may exfiltrate into the highway prism, impervious geotextiles can be used to line the bottom of the flow spreader.