4.7 Filter Strip/Wooded Buffer Strip BMP Summary Fact Sheets

Description: Filter strips are uniformly graded and densely vegetated sections of land engineered and designed to treat runoff from and remove pollutants through vegetative filtering and infiltration. Wooded buffer strips are natural areas adjacent to streams that are maintained to perform similarly to filter strips. Pollution removal is provided by sedimentation, filtration, adsorption, infiltration, biological uptake, and microbacterial activity. Some infiltration may occur depending on the characteristics of the soils. Filter strips can be designed with and without permeable berms.

IMPORTANT CONSIDERATIONS

DESIGN REQUIREMENTS:
- Sheet flow must be provided into the filter/buffer strip and through the filter/buffer strip. Thus a flow spreader or other device must be included in the filter/buffer strip design.
- The length of the filter/buffer strip (parallel to flow direction) can vary based on pollutant removal design goals.
- A vegetation plan is required which will ensure dense deep routed vegetation that is resistant to saturation and drought.
- The maximum slope for a filter strip is 2%. The maximum slope for a buffer strip is 5%.
- For filter strips with slopes greater than 2%, berms or other hydraulic structures can be used to lower the effective slope to 2%.
- The maximum flow depth for the 1-inch, 6-hour storm event is 1 inch.
- The maximum velocity through the filter strip is 2 ft/sec for the 10-year storm event.
- Maximum contributing drainage area is 5 acres.

ADVANTAGES/BENEFITS:
- Can be used as part of the runoff conveyance system to provide pretreatment for other BMPs.
- Can provide groundwater recharge.
- Reasonably low construction cost.

DISADVANTAGES/LIMITATIONS:
- Filter/buffer strips cannot achieve the 85% TSS and/or 70% TP removal target alone.
- A bypass channel or overflow spillway with protected channel section may be needed to handle flows in excess of the 1-inch, 6-hour storm event.
- Large land requirement is usually needed.

MAINTENANCE CONSIDERATIONS:
- Requires periodic repair, regrading, and sediment removal to prevent channelization.
- Filter strips require similar maintenance to other vegetative practices.
- Maintenance is very important to ensure that flow does not short circuit the BMP.

STORMWATER MANAGEMENT SUITABILITY

| **L** = Low   **M** = Moderate   **H** = High |

M   **1-inch, 6-hr Water Quality Control**

L   **1-yr, 24-hr Channel Protection Volume**

L   **Peak Attenuation Control for 10-yr, 6-hr Storm**

L   **Peak Attenuation Control for 25-yr, 6-hr storm**

Filter/buffer strips can provide some water quality benefit for the 1-inch, 6-hour storm event, but provide minimal benefit for control of larger storm events such as the 1-year, 24-hour storm or other flood control storm events.

IMPLEMENTATION CONSIDERATIONS

H   **Land Requirements**

L   **Capital Cost**

M   **Maintenance Cost**

M   **Maintenance Considerations**

PRIMARY POLLUTANT REMOVAL PROCESSES
- Filtration

POLLUTANT REMOVAL RATES

Effectiveness	Length (parallel to flow)	Pollutant Removal Rates
Optimal	100 feet	20% TSS 0% TP
Standard	50 feet	15% TSS 0% TP
Minimal	30 feet	10% TSS 0% TP

4.7   Filter/Buffer Strips

4.7.1   General Description

Filter strips are uniformly graded and densely vegetated sections of land designed to treat runoff and remove pollutants through filtering and infiltration. Buffer strips are natural areas adjacent to streams that are designed and maintained to perform similarly to filter strips. Filter/buffer strips are best suited to treating small amounts of runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces. They are also ideal components of a stream buffer, or as pretreatment for another structural storm water control. Filter/buffer strips can serve as a buffer between incompatible land uses, be landscaped to be aesthetically pleasing, and provide groundwater recharge in areas with pervious soils.

Filter/buffer strips rely on the use of vegetation to slow runoff velocities and filter out sediment and other pollutants from urban storm water. There can also be a reduction in runoff volume for smaller flows that infiltrate pervious soils contained within the filter/buffer strip. Typically, infiltration rates are greater for buffer strips relative to filter strips because of the natural soils and ground cover associated with the buffer strips.

To be effective, sheet flow must be maintained across the entire filter/buffer strip. Once runoff flow concentrates, it effectively short-circuits the filter/buffer strip and reduces any water quality benefits. Therefore, a flow spreader or other suitable device must be included in the filter/buffer strip design.

Filter strips can be used in a variety of development types; however, they are primarily applicable to areas of low to moderate density where sufficient land is available. Filter strips are used to treat runoff from small areas such as highways, roofs, downspouts, parking areas, and in general, between up-gradient development and streams or ponds, primarily in residential areas or where the development density is low.   Because of their relatively large land requirement, filter strips are generally not used in large and higher density areas.

The topography, soils and vegetation of a site will determine the applicability of the use of filter strip designs. Overall, the topography should allow for the design of a filter strip with relatively flat slopes and sufficient area to maintain non-erosive velocities.

There are two different filter strip designs: a standard filter strip and a design that includes a permeable berm or berms throughout the filter strip to reduce flow velocity. The presence of berms increases the contact time with the vegetation, which increases the pollutant removal efficiency. Typically, buffer strips do not use permeable berms because of the desire to keep the area natural. Filter/buffer strips are typically an on-line practice, so they must be designed to withstand the full range of storm events without eroding. However, larger storm events can be designed to bypass the filter/buffer strip so that facility is considered to be an off-line application.

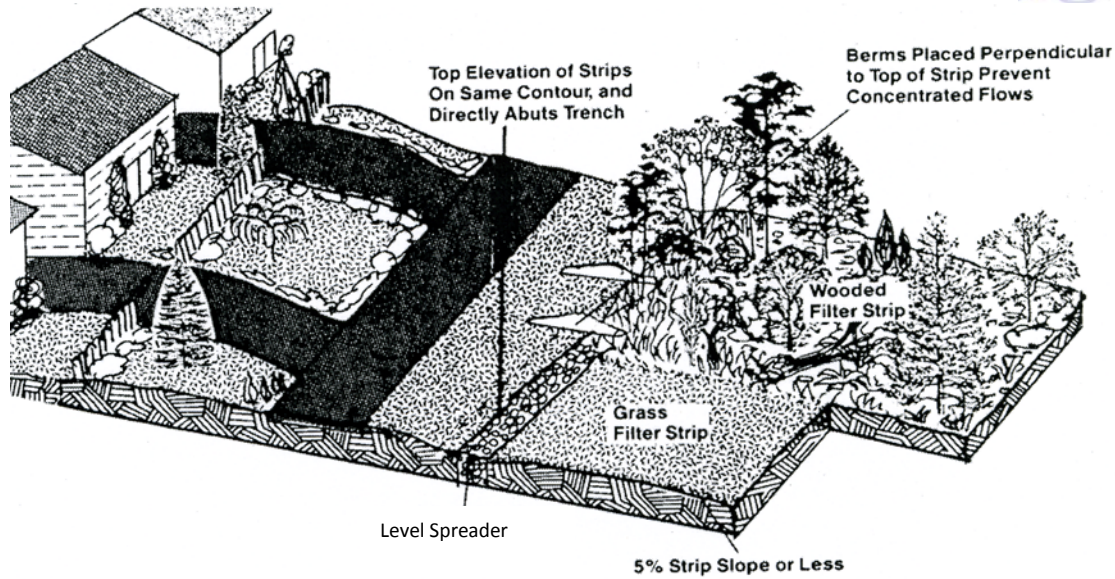Figure 4.7.1 and 4.7.2 shows a typical filter strip and Figure 4.7.3 shows a schematic of a filter strip.

Top Elevation of Strips On Same Contour, and Directly Abuts Trench

Berms Placed Perpendicular to Top of Strip Prevent Concentrated Flows

Wooded Filter Strip

Grass Filter Strip

Level Spreader

5% Strip Slope or Less

Figure 4.7.1 Filter Strip in Residential Area
Source: Adapted from Schueler, 1987

Figure 4.7.2 Typical Filter Strip Photograph
Source: Adapted from Schueler, 1987

PLAN
NOT TO SCALE
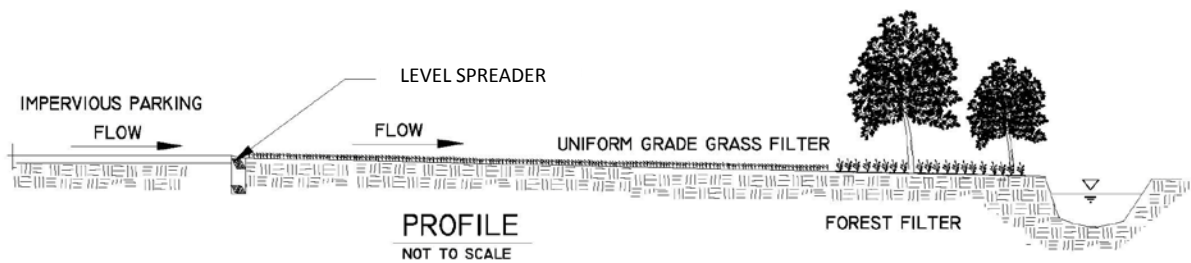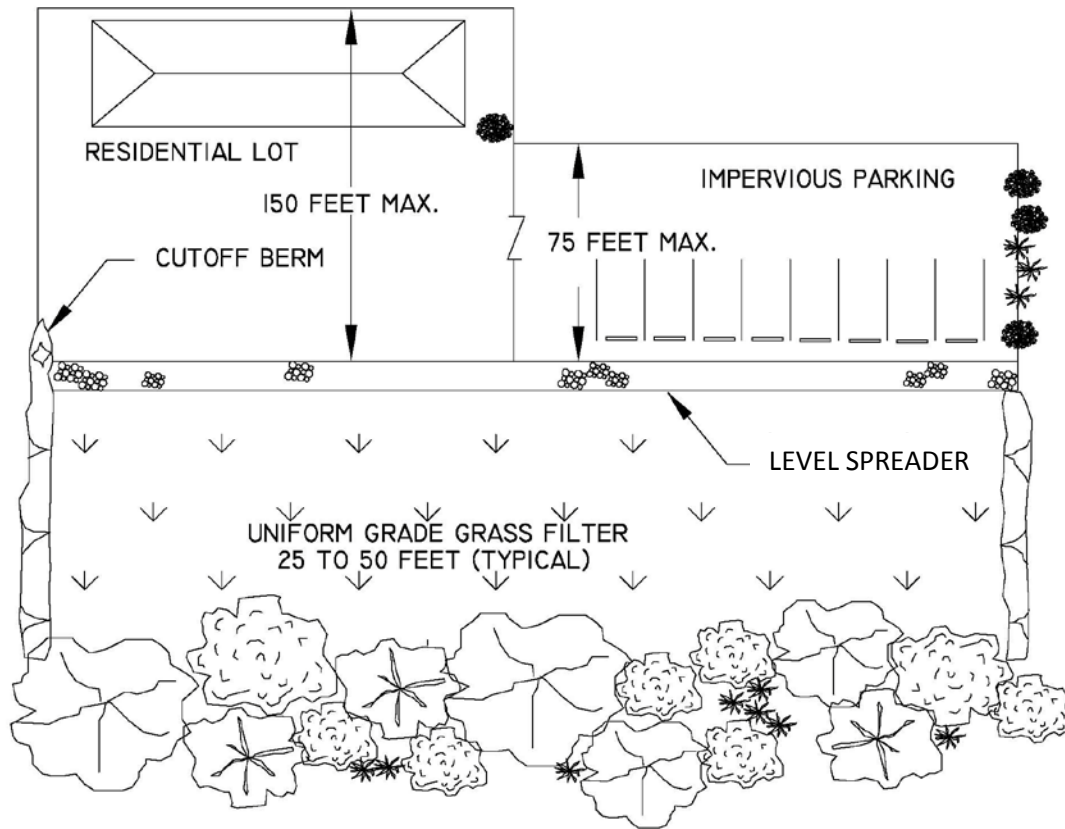
PROFILE
NOT TO SCALE

Figure 4.7.3 Schematic of Filter Strip

4.7.2   Storm Water Management Suitability

Filter/buffer strips are designed primarily to partially treat the water quality volume (WQ_v) and will typically need to be used in conjunction with other structural controls to meet pollutant removal goals. Filter/buffer strips have a small amount of benefit in controlling the channel protection volume (CP_v) and larger flood control events through infiltration to the underlying soils. However, ensuring that the infiltration benefit is provided for the entire design life is challenging, therefore, these infiltration benefits are considered negligible for application in the Mecklenburg County area. They can be used to convey higher flows to other BMP controls.

Water Quality Control (WQ_v)

Filter/buffer strips rely on filtration by creating sheet flow conditions through the vegetation to provide removal of storm water contaminants. A small amount water quality benefit occurs through infiltration to the underlying soils.

Channel Protection (CP_v)

Generally, only the WQ_v is treated by a filter/buffer strip, and another structural control must be used to control the channel protection volume (CP_v). Many filter/buffer strip designs bypass the larger storm events through the facility to prevent the formation of concentrated flows and associated damages to the filter/buffer strips through the formation of rills, channelization, etc.

Peak Attenuation Control (Q_p)

Another structural control is typically required in conjunction with a filter/buffer strip to reduce the post-development peak flows to pre-development conditions. The design of filter strips may include flow diversion and/or be designed to safely pass flood flows without damaging the filter/buffer strip. A maximum flow velocity of 2 fps must be maintained for the 10-year, 6-hour storm event to prevent damage through rill formation, channelization, etc.

4.7.3   Pollutant Removal Capabilities

Three filter/buffer strip designs have been developed for application in the Mecklenburg County area. The optimal efficiency design has the capability to remove 20% of the total suspended solids and 0% of the total phosphorus load. The standard efficiency design has the capability to remove 15% of the total suspended solids and 0% of the total phosphorus load. The minimal efficiency design has the capability to remove 10% of the total suspended solids and 0% of the total phosphorus load. All of these designs assume urban post-development runoff conditions that has been observed in the Mecklenburg County area and that the facilities are sized, designed, constructed, and maintained in accordance with the appropriate recommended specifications contained in this manual. The design pollutant rates are desired from sampling data and computations completed for the development of this manual. In a situation where a removal rate is not deemed sufficient, additional controls may be put in placed at the given site in a series or treatment train approach. See section 4.7.4 for a discussion of design values and appropriate pollutant removal rates for specific designs.

4.7.4   Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of filter/buffer strips. Items listed in Section 4.1.4.A through 4.1.4.F. are requirements and must be addressed in the design. Items listed in Section 4.1.4.G. are recommendations and are optional.

A: Design Requirements

Following is a list of design requirements that must be followed in the design of filter/buffer strips.

- Following are the design values that are required for the three filter/buffer strip designs that are available for application in Mecklenburg County. The appropriate minimum design values and associated pollutant removal rates for each of the designs are given in Table 4.7.1.

Table 4.7.1 Design Values and Pollutant Removal Rates

Effectiveness	Length (parallel to flow)	Pollutant Removal Rates
Optimal	100 feet	20% TSS 0% TP
Standard	50 feet	15% TSS 0% TP
Minimal	30 feet	10% TSS 0% TP

- Filter/buffer strips should be used to treat small drainage areas with a maximum contributing drainage area of 5 acres.

- Level spreaders or other suitable devices must be included in the filter/buffer strip design. Design of Level spreaders is discussed in Chapter 5.5 of this manual.

- Maximum discharge loading per foot of filter/buffer strip width (perpendicular to flow path) is found using the following derivation of Manning's equation:

$$q = \frac{0.0237}{N} S^{\frac{1}{2}} \qquad \textbf{(4.7.1)}$$

where:
    q = discharge per foot of width of filter/buffer strip (cfs/ft)
    S = slope of filter/buffer strip (percent)
    N = Manning's "n" roughness coefficient for sheet flow conditions

(use 0.15 for medium grass, 0.24 for dense grass, and 0.40 for very dense grass)

- The minimum width of a filter/buffer strip is:

$$W_{fMIN} = \frac{Q}{q} \qquad \textbf{(4.7.2)}$$

where:
    W_{fMIN} = minimum filter/buffer strip width perpendicular to flow (feet)
    Q = discharge for the 1-inch, 6-hour storm event
    q = discharge per foot of filter/buffer strip, see equation 4.7.1.

- A vegetation plan is required which will ensure dense deep routed vegetation that will be resistant to saturation and drought.

- The maximum velocity for the 10-year storm event through the filter/buffer strip is 2 ft/sec and/or appropriate erosion threshold velocities for the filter/buffer strip soil and vegetation, whichever is more protective.

B.   Physical Specifications/Geometry

Filter strip slopes in the direction of flow must be 2% or less unless topography necessitates a steeper slope. A maximum of 5% slope is allowed, in which case hydraulic structures can be used to limit the energy slope to within the recommended 2% range. Energy dissipation may be required below the hydraulic structures. Depth of the WQ_v must not exceed 1 inch during the 1-inch, 6-hour storm event.

Buffer strip slopes in the direction of flow must be 5% or less. Depth of the WQ_v must not exceed 1 inch during the 1-inch, 6-hour storm event.

For filter strips with berms:
- o Size outlet pipes to ensure that the bermed area drains within 24 hours.
- o Specify grasses resistant to frequent inundation within the shallow ponding limit.
- o Berm material should be sand, gravel and sandy loam to encourage grass cover (Sand: ASTM C-33 fine aggregate concrete sand 0.02"-0.04", Gravel: AAASHTO M-43 1/2" to 1").
- o Maximum berm height is 12 inches.

C.   Pretreatment/Inlets

Filter strips must be designed so sheet flow is maintained across the entire filter strip for the water quality storm event (WQ_v). Level spreaders or other suitable devices must be included in the filter/buffer strip design. Design of Level spreaders is discussed in Chapter 5.5 of this manual.

D.   Emergency Spillway

Filter strips must be adequately designed to safely pass flows that exceed the design storm flows.

E.   Maintenance Access

An access route that is 12 feet in width and centered within a 20 foot easement must be provided for all filter/buffer strips for inspection and maintenance.

F.   Landscaping

Landscape design must specify proper grass species and other plants based on specific site, soils, and hydric conditions present along the filter strip. See Chapter 6 – Vegetation and Landscaping. Figure 4.7.4 illustrates the typical planting zones for a filter strip.
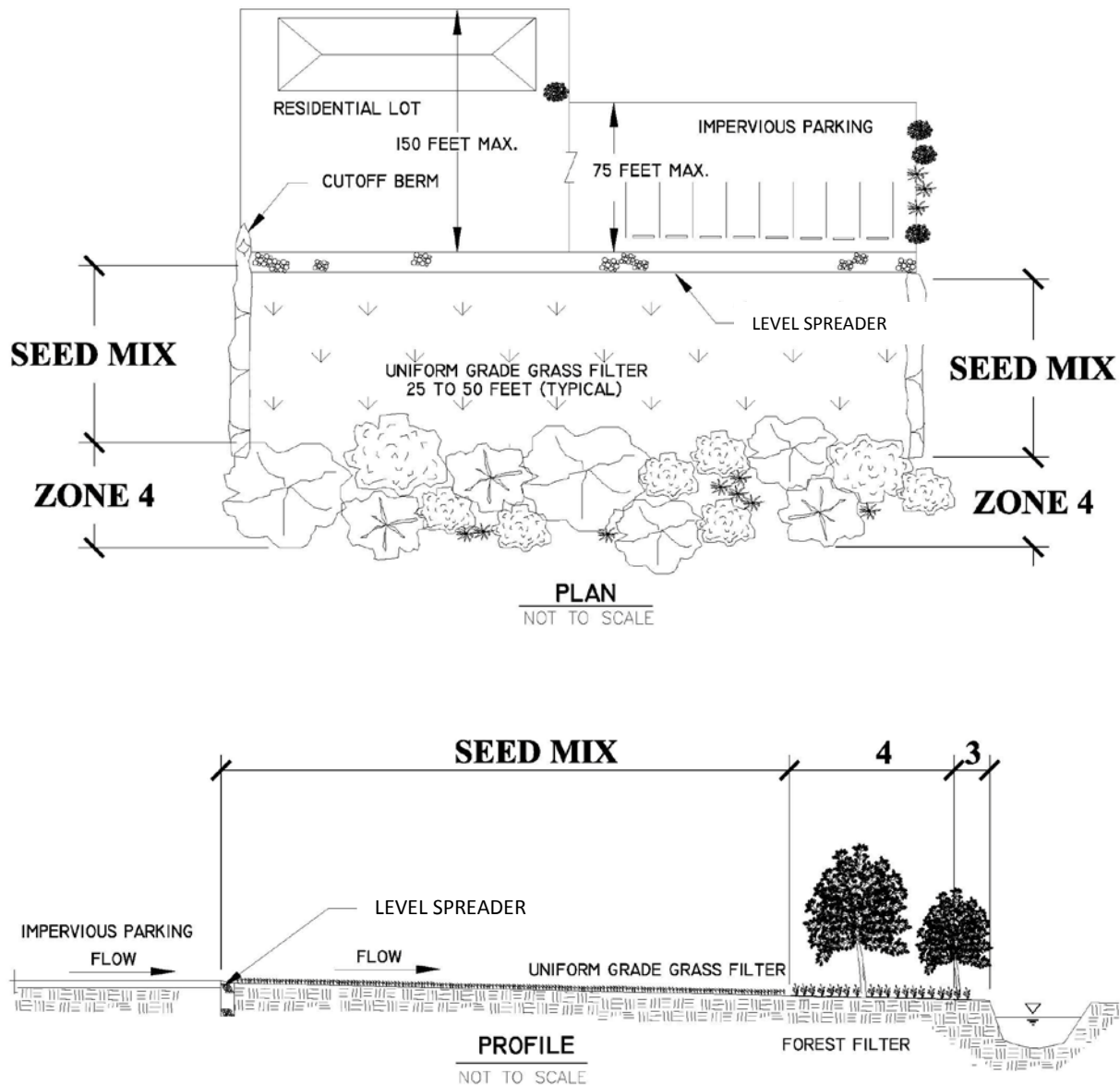
Figure 4.7.4   Planting Zones for Filter Strip

G: Design Recommendations

In addition to the design requirements and variables, following are some design recommendations that should be considered for filter/buffer strip design:

- As a rule, flow concentrates within a maximum of 75 feet for impervious surfaces, and 150 feet for pervious surfaces (CWP, 1996). For longer flow paths, additional design care may be appropriate to ensure design flows spread evenly across the filter strip, instead of becoming concentrated.

- Filter strips should be constructed outside the natural stream buffer area whenever possible so that the natural buffer along the streambank is not disturbed.

- Filter strips should not be used on soils that cannot sustain a dense grass cover with high retardance to flow. Designers should choose a grass that can withstand relatively high velocity flows at the entrances, and both wet and dry periods.

- Both the top and toe of the slope should be as flat as possible to ensure that sheet flow is maintained and to prevent erosion.

- An effective flow spreader is discussed in Chapter 5.5. of this manual.

- Filter/buffer strips that receive direct concentrated runoff may have a level spreader at the upstream end of the control.

- Pedestrian traffic across the filter/buffer strip should be limited through channeling onto sidewalks.

4.7.5   Design Procedure

The following steps outline the procedure to be used for the design of filter/buffer strip BMPs.

Step 1   Using the BMP Selection Matrix presented at the beginning of Chapter 4 determine if the development site and conditions are appropriate for the use of a filter strip.

Step 2   Consider any special site-specific design conditions.

Step 3   Calculate the Water Quality Volume (WQ_v), Channel Protection Volume (CP_v), and On-Site Flood Protection Volume Q_{10} and Q_{25} (if required) hydrographs.

Step 4   Calculate maximum discharge loading per foot of filter strip width using Equation 4.7.1.

Step 5   Estimate the minimum filter/buffer width (perpendicular to flow) using Equation 4.7.2.

Step 6   For filter strips, compute number of berms required, if needed, to produce a hydraulic grade line slope of 2% or less. Calculate the outlet pipe size for the berm so the bermed area drains within 24 hours.

Step 7   Check for erosive velocities for all storm events up to the 10 year, 6-hour storm event and modify design as appropriate.

Step 8   Prepare Vegetation and Landscaping Plan.

A landscaping plan for the filter strip must be prepared to indicate how the filter strip will be stabilized and established with vegetation. Vegetation and landscaping plan must include plans for the first year of operation and full maturity (i.e. 3-year duration). The landscaping plan for the buffer strip depends on natural vegetation. Plan must also include an invasive species prevention plan.

4.7.6   Inspection and Maintenance Requirements

Specific maintenance inspections and requirements are contained in the Administrative Manual.

Design Procedure Form: Filter/Buffer Strips

FILTER/BUFFER STRIP FEASIBILITY	**NOTES:**
1. Is the use of filter/buffer strip appropriate?	
2. Confirm local design criteria and applicability.	
PRELIMINARY HYDROLOGIC CALCULATIONS	

3. Compute, WQ_v water quality requirements
   Compute Runoff Coefficient, R_v
   Compute WQ_v volume requirements
	$Rv =$ _____
	$WQ_v =$ _____ acre-ft

4. Compute site hydrologic input parameters
   Area
   CN
   Time of concentration
	_____ acres
	_____
	_____ hours

5. Compute WQ_p peak flow Compute modified SCS curve number	$WQ_p =$ _____ cfs $CN =$ _____

6. Compute CP_v
   Compute CP_v peak flow
   Compute Q_{10} peak flow
   Compute Q_{25} peak flow
   Compute (as necessary) Q_{100}
	CP_v peak flow = _____ cfs
	$Q_{p10} =$ _____ cfs
	$Q_{p25} =$ _____ cfs
	$Q_{100} =$ _____ cfs

FILTER STRIP DESIGN	
4. Calculate maximum discharge loading per foot of filter strip width.	$q =$ _____ cfs/ft
5. Calculate minimum filter width.	$W_{fMIN} =$ _____ ft
6. Compute number of berms required, if needed, to produce a hydraulic grade line slope of 2% or less. Calculate the outlet pipe size for the berm so the bermed area drains within 24 hours.	Number of berms = _____ Diameter of outlet = _____ inches
7. Check low flow and design event velocity and erosion potential.	**NOTES:**
8. Attached vegetation and landscaping plan including an invasive species prevention plan.	

Notes: _____
_____

4.7.8   Design Example

The design example prepared for the enhanced grassed swale and presented in Section 4.4.8 serves as the filter/buffer strip design example.