# 4.3.9 Filter Strip

**General Application
Water Quality BMP**


**Description**: Filter strips are uniformly graded and densely vegetated sections of land engineered and designed to treat runoff and remove pollutants through vegetative filtering and infiltration.

## KEY CONSIDERATIONS

**DESIGN GUIDELINES:**

- Drainage area size based on flow length and slope.
- Must have slopes between 2% and 6%.
- Must maintain sheet flow across the entire filter strip.
- Minimum 15 ft flow length; the longer the flow length, the higher the pollutant removal, if sheet flow is maintained.

**ADVANTAGES / BENEFITS:**

- High community acceptance in any type of setting.
- Easy to maintain once ground cover and/or trees are established.
- Can be used as pre-treatment for other BMPs, with an effect similar to a sediment forebay.
- Filter strips are easily incorporated into new construction/development designs.

**DISADVANTAGES / LIMITATIONS:**

- Cannot meet the 80% TSS goal without another BMP in a treatment train. A 50' filter strip is assumed to achieve a 50% TSS removal. A 25 ft strip is assumed to achieve a 10% TSS removal.
- Filter strips and level spreaders have limited drainage areas.
- It can be difficult to construct a level lip on level spreaders.

**MAINTENANCE REQUIREMENTS:**

- Maintain a dense, healthy stand of grass and other vegetation.
- Repair areas of erosion and re-vegetate as needed.
- Remove sediment build-up.

## STORMWATER MANAGEMENT SUITABILITY

| | |
|---|---|
| Stormwater Quality: | **Yes** |
| Channel Protection: | **No** |
| Detention/Retention: | **No** |

**Accepts hotspot runoff:** *Yes, with pre-treatment*

## COST CONSIDERATIONS

| | |
|---|---|
| Land Requirement: | **Med - High** |
| Capital Cost: | **Low** |
| Maintenance Burden: | **Low** |

## LAND USE APPLICABILITY

| | |
|---|---|
| Residential/Subdivision Use: | **Yes** |
| High Density/Ultra Urban Use: | **Yes** |
| Commercial/Industrial Use: | **Yes** |

## POLLUTANT REMOVAL

| | |
|---|---|
| Total Suspended Solids (less than 10 feet): | **0%** |
| Total Suspended Solids (between 10 and 50 feet): | **10%** |
| Total Suspended Solids (greater than 50 feet): | **50%** |

### 4.3.9.1 General Description

Filter strips are uniformly graded and densely vegetated sections of land, engineered and designed to treat runoff and remove pollutants through vegetative filtering and infiltration. Because they cannot accept channelized runoff, filter strips are best suited to treating runoff from roads and highways, roof downspouts, very small parking lots, and pervious surfaces. They are also ideal for use as pre-treatment measures for a stream buffer or structural stormwater controls such as enhanced swales or basins. Filter strips can serve as a buffer between incompatible land uses, can be landscaped to be aesthetically pleasing, and can provide groundwater recharge in areas with pervious soils.

Pollutant removal from filter strips is highly variable and depends primarily on density of vegetation and contact time for filtration and infiltration. These, in turn, depend on soil and vegetation type, slope, and presence of sheet flow. Pollutant removal efficiencies are based upon a 50-foot long strip. Filter strips with shorter flow lengths are considered to have lower removal efficiencies and should be used as coarse sediment settling areas for other structural controls. Filter strips are often considered to be an integral component of those controls, similar to sediment forebays for stormwater basins or other structural BMPs. Uniform sheet flow must be maintained through the filter strip to provide pollutant reduction and avoid erosion. To obtain sheet flow when discharging runoff from a developed area, a level spreader may be required.

There are two different filter strip designs: a simple filter strip and a design that includes a permeable berm at the bottom. The presence of the berm increases the contact time between the filter strip and the runoff, thus reducing the overall width of the filter strip required to treat stormwater runoff. An example schematic of a filter strip is presented in Figure 4-42.

### 4.3.9.2 Stormwater Management Suitability

Filter strips are designed primarily for stormwater quality and do not have the ability to provide channel protection or flood protection.

<u>Water Quality (WQv)</u>
To treat stormwater runoff, filter strips rely on the use of vegetation to slow runoff velocities and filter out sediment and other pollutants from urban stormwater. There can also be a significant reduction in runoff volume for smaller flows that infiltrate through pervious soils within the filter strip. To be effective, however, sheet flow must be maintained across the entire filter strip. Once runoff flow concentrates, it effectively short-circuits the filter strip and reduces any water quality benefits. Therefore, a flow spreader must normally be included in the filter strip design.

### 4.3.9.3 Pollutant Removal Capabilities

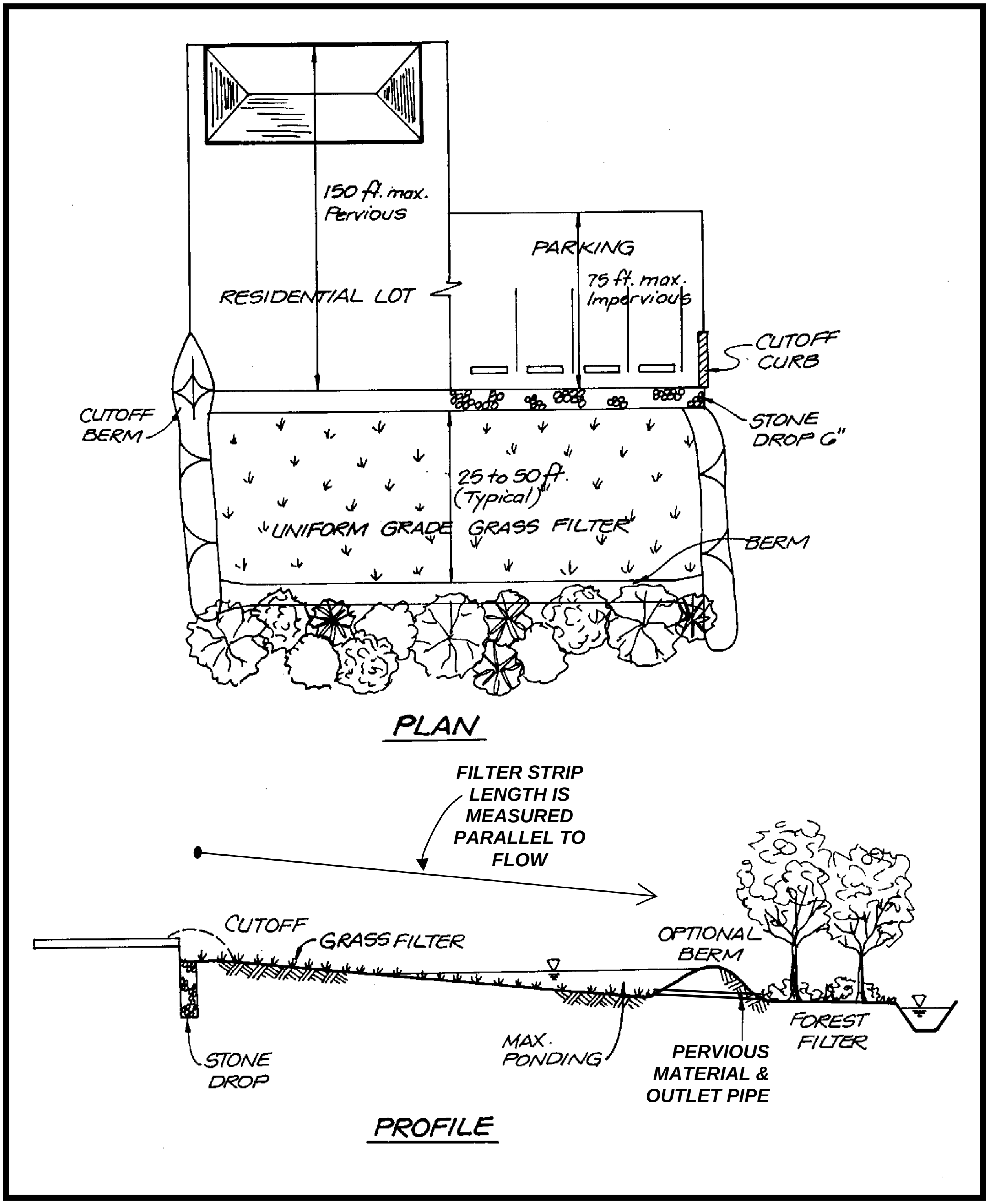
The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment. Research indicates that the pollutant removal ability of a filter strip is highly dependant upon the minimum flow path length, as follows.

*<u>Filter Strips that have a minimum flow path length of 50 feet or greater:</u>*
- Total Suspended Solids – 50%

*<u>Filter Strips that have a minimum flow path length between 25 feet and 50 feet (pretreatment control for coarse sediments):</u>*
- Total Suspended Solids – 10%

*Filter strips that have a flow path length less than 25 feet are assigned a 0% TSS removal value.*

**Figure 4-42. Schematic of a Filter Strip (with Berm)**



### 4.3.9.4 Application and Feasibility Criteria

Filter strips can be used in a variety of development types. However, because of their relatively large land requirement, filter strips are generally not determined to be useful in higher density areas. The topography and proposed site layout will determine the applicability of filter strips.

General Feasibility

- Suitable for use in residential subdivisions and in non-residential areas.
- Can be used in high density/ultra-urban areas, but land requirements may preclude their use.
- Not suitable for use as a regional stormwater control.

### 4.3.9.5 Planning and Design Standards

The following standards shall be considered **minimum** design standards for the design of a filter strip. Filter strips that are not designed to these standards will not be approved. The local jurisdiction shall have the authority to require additional design conditions if deemed necessary.

A. LOCATION AND SITING

- Filter strips are most appropriate for treating the stormwater runoff from small drainage areas. Flow must enter the filter strip as sheet flow spread out over the length (long dimension normal to flow) of the strip. The design depth of flow shall be no greater than 2 inches. As a rule, flow starts to channelize within a maximum of 75 feet for impervious surfaces, and 150 feet for pervious surfaces (CWP, 1996). For longer flow paths, special provision must be made to ensure design flows spread evenly across the filter strip.
- A level spreader may be needed to achieve sheet flow, the design of which should be factored into the location and siting of the filter strip and into the overall site layout. Level spreader design is presented in Chapter 3 of this manual.
- Filter strips should be integrated into site designs.
- Filter strips should be constructed outside the natural stream buffer area whenever possible to maintain a more natural buffer along the streambank.
- Filter strips shall not be in areas or on soils that cannot sustain a dense vegetative cover with high retardance.
- Pedestrian traffic across the filter strip should be limited through channeling onto sidewalks.
- Each filter strip shall be placed in an easement that is recorded with the deed. The easement shall be defined at the outer edge of the filter strip.

B. PHYSICAL SPECIFICATIONS / GEOMETRY

- Filter strips shall be designed having a slope between 2% and 6%. Greater slopes than this will encourage the formation of concentrated flow. Flatter slopes will encourage standing water. Both the top and toe of the slope shall be as flat as possible to encourage sheet flow and prevent erosion.
- The filter strip shall have a minimum length (flow path) of 25 feet long to provide filtration and contact time for water quality treatment. At least fifty (50) feet is necessary to achieve the 50% TSS removal value.
- Flow must enter the filter strip as sheet flow, designed to spread out over the width of the strip with a depth of 1 to 2 inches.
- The design of the filter strip and the area draining to the filter strip shall be such that stormwater flows in excess of the design flow can discharge across or around the strip without causing erosion or other damage. Often a bypass channel or overflow spillway with a protected channel section is designed to handle higher flows.

- An effective flow spreader is to use a pea gravel diaphragm at the top of the slope (ASTM D 448 size no. 6, 1/8" to 3/8"). The pea gravel diaphragm (a small trench running along the top of the filter strip) serves two purposes. First, it acts as a pre-treatment device, settling out sediment particles before they reach the practice. Second, it acts as a level spreader, maintaining sheet flow as runoff flows over the filter strip. Other types of flow spreaders include a concrete sill, curb stops, or curb and gutter with "sawteeth" cut into it. Level spreader design can be found in Chapter 3 of this manual.

- Maximum discharge loading per foot of filter strip width (perpendicular to flow path) shall be determined using the Manning equation:

**Equation 4.3.9.1**

$$q = \frac{0.00236}{n} Y^{\frac{5}{3}} S^{\frac{1}{2}}$$

where: q = discharge per foot of width of filter strip (cfs/ft)
Y = allowable depth of flow (inches) = 2 inches maximum
S = slope of filter strip (percent)
n = Manning's "n" roughness coefficient (use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass)

- Using *q* computed above, the minimum width of a filter strip shall be calculated using the following equation:

**Equation 4.3.9.2**

$$W_{fMIN} = \frac{Q_{wq}}{q}$$

where: $W_{fMIN}$ = minimum filter strip width perpendicular to flow (feet)
Q = peak discharge of stormwater runoff (cfs)
q = discharge per foot of width of filter strip (cfs/ft)

*<u>Filter Strips without a permeable berm:</u>*

- The length of the filter strip (parallel to flow path across the filter strip) shall be sized to achieve a contact time between the stormwater runoff and filter strip vegetation of no less than five (5) minutes. The equation for filter strip length (the flow path) is based on the SCS TR-55 travel time equation (SCS, 1986):

**Equation 4.3.9.3**

$$L_f = \frac{(T_t)^{1.25}(P_{2-24})^{0.625}(S)^{0.5}}{3.34n}$$

where: $L_f$ = length of filter strip parallel to flow path (ft)
$T_t$ = travel time through filter strip (minutes), minimum 5 minutes
$P_{2-24}$ = 2-year, 24-hour rainfall depth (inches)
S = slope of filter strip (percent)
n = Manning's "n" roughness coefficient (use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass)

*<u>Filter Strips with a permeable berm:</u>*

- The filter strip shall be sized to contain the entire WQv within the wedge of water that backs up behind the berm.

- The maximum height of the berm is 12 inches.

- Outlet pipes from the berm shall be sized to ensure that the runoff stored behind the berm drains within 24 hours.

- The outlet pipes shall be designed such that runoff discharges from the berm in a non-erosive manner.

- The berm shall be constructed of a mixture of sand, gravel and sandy loam to encourage grass cover. Specifications for sand and gravel are: sand - ASTM C-33 fine aggregate concrete sand 0.02”-0.04”; gravel - AASHTO M-43 ½” to 1”.

*Filter Strips used for pre-treatment:*

- A number of other structural controls, including bioretention areas and infiltration trenches, may utilize a filter strip as a pre-treatment measure. The required length of the filter strip depends on the drainage area, imperviousness, and the filter strip slope. Table 4-9 provides sizing guidance for using filter strips for pre-treatment.

**Table 4-9. Sizing of Filter Strips for Pre-treatment**

(Source: Adapted from Georgia Stormwater Management Manual)

| Parameter | Impervious Areas[1] | | | | Pervious Areas (Lawns, etc)[2] | | | |
|---|---|---|---|---|---|---|---|---|
| Maximum inflow approach length (feet) | 35 | | 75 | | 75 | | 100 | |
| Filter strip slope (max = 6%) | ≤ 2% | > 2% | ≤ 2% | > 2% | ≤ 2% | > 2% | ≤ 2% | > 2% |
| Filter strip minimum length (feet)[3] | 10 | 15 | 20 | 25 | 10 | 12 | 15 | 18 |

1 – 75 feet maximum impervious area flow length to filter strip.
2 – 150 feet maximum pervious area flow length to filter strip.
3 – At least 25 feet is required for minimum pre-treatment credit of 10% TSS removal. Fifty feet is required for 50% removal.

C. SPECIAL CONSIDERATIONS FOR THE AS-BUILT CERTIFICATION

- Like any other water quality BMP, the filter strip must be shown on the as-built certification specifically as a water quality BMP. The following components must be addressed in the as-built certification:
  1. Ensure the design flows are spread evenly across the filter strip.
  2. Ensure the design slope is between 2% and 6%.
  3. The dimensions of the filter strip must be verified.
  4. The type of vegetation used in the filter strip.

D. MAINTENANCE ACCESS

- A minimum 20 foot wide maintenance right-of-way or drainage easement shall be provided for the length and width of the filter strip from a driveway, public or private road. The maintenance access easement shall have a maximum slope of no more than 15% and shall have a minimum unobstructed drive path having a width of 12 feet, appropriately stabilized to withstand maintenance equipment and vehicles. The right-of-way shall be located such that maintenance vehicles and equipment can access the entire filter strip.

E. LANDSCAPING

- The vegetation in a filter strip can be grassed, or a combination of grass and woody plants. Filter strips that are vegetated with forest vegetation may be able to qualify as a water quality volume (WQv) reduction. See Chapter 5 for more information on the stream and vegetated buffer reduction.
- Designers should choose a grass that can withstand relatively high velocity flows at the entrances, and both wet and dry periods.
- For filter strips with a permeable berm, vegetation that can withstand frequent inundation must be utilized in the area where shallow ponding will occur.

### 4.3.9.6 Design Example

Basic Data

Small commercial lot 150 feet deep x 100 feet wide

- Drainage area (A) = 0.34 acres
- Impervious percentage (I) = 70%
- Slope equals 4%
- Manning's n = 0.25

Step 1: Calculate Maximum Discharge Loading Per Foot of Filter Strip Width (q):

Using Equation 4.3.9.1 above:

$q = (0.00236/0.25) * (1.0)^{5/3} * (4)^{1/2} = 0.019$ cfs/ft

Step 2: Calculate the Water Quality Flow Rate ($Q_{wq}$):

*(See Chapter 3 for equation information)*
Compute the Runoff Peak Volume ($Q_{wv}$) in inches for 1.1-inch rainfall (P = 1.1):

$Q_{wv} = PRv = 1.1Rv = 1.1(0.015 + (0.0092)(70)) = 0.72$ inches

Compute modified CN:

$$CN = 1000/[10+5P+10\,Q_{wv} - 10(Q_{wv}{}^{2}+1.25Q_{wv}P)^{½}]$$
$$= 1000/[10+5(1.1)+10(0.72)-10(0.72^{2}+1.25(0.72)1.1)^{½}]$$
$$= 95.98 \text{ (Use CN = 96)}$$

For CN = 96 and an estimated time of concentration ($T_c$) of 8 minutes (0.13 hours), compute the $Q_{wq}$ for a 1.1 inch storm.

$I_a = 0.083$ (from Table 3-14 in Chapter 3), therefore $I_a/P = 0.083/1.1 = 0.075$.

Using Figure 3-6 in Chapter 3, $q_u$ can be estimated for a Type II storm at approximately 950 csm/in.
$q_u$ = 950 csm/in, and therefore:

$Q_{wq} = q_u A\, Q_{wv}$ = (950 csm/in) (0.34ac/640ac/mi$^2$) (0.72in) = 0.36 cfs

Step 3: Calculate the Minimum Filter Width

Using Equation 4.3.9.2 above:

$W_{fMIN} = Q_{wq}/q = 0.36/0.019 = 19$ feet

Since the width of the lot is 100 feet, the actual width of the filter strip will depend on site grading and the ability to deliver the drainage to the filter strip in sheet flow through a pea gravel filled trench.

The next step is to calculate the filter length. This calculation is different for a filter designed without a permeable berm (presented in Step 4a), than for a filter designed with a berm (presented in Step 4b).

Step 4a: Calculate the Filter Length ($L_f$) for a filter without a berm:

Basic Data:

- Depth of 2-year, 24-hour storm = 3.3 inches (see Chapter 3, Table 3-5)
- Use 5 minute travel (contact) time

Using Equation 4.3.9.3 above:

$L_f = (5)^{1.25}(3.3)^{0.625}(4)^{0.5} / (3.34)(0.25) = 37.8$ feet (use 38 feet)

*Note: Reducing the filter strip slope to 2% and planting a more dense grass (raising the Manning "n" to 0.35) would reduce the filter strip length to 19 feet.*

Step 4b: Calculate the Filter Length (assume filter is designed with a berm):

*(See Chapter 3 for equation information)*

Basic Data:

- The height of the permeable berm (h) will be 6 inches (0.5 feet).
- Assume the filter width = the maximum lot width ($W_f$) = 100 feet.

Compute the Water Quality Volume (WQv) in cubic feet:

$WQv = 1.1R_vA/12 = 1.1(0.015 + 0.0092(70))0.34/12 = 0.021$ ac-ft or 895 $ft^3$

This is the volume of the "wedge" of water that ponds behind the berm.

For a berm height of 6 inches (0.5 feet), the "wedge" of volume captured by the filter strip is:

The area of the "wedge" = $½L_fh$, therefore,

The volume of the "wedge" = $W_f½L_fh = (100)\ ½(L_f)(0.5) = 895$ $ft^3$

Solving for $L_f$, the length of the filter = 35.8 feet (use 36 feet).

*Note: Increasing the berm height to 1 foot will result in a filter length of 18 feet.*

### 4.3.9.7 Maintenance Requirements and Inspection Checklist

**Note: Section 4.3.9.7 must be included in the Operations and Maintenance Plan that is recorded with the deed.**

Regular inspection and maintenance is critical to the effective use of filter strips as stormwater best management practices. It is the responsibility of the property owner to maintain all stormwater facilities in accordance with the minimum design standards and other guidance provided in this manual. The local jurisdiction has the authority to impose additional maintenance requirements where deemed necessary.

This page provides guidance on maintenance activities that are typically required for filter strips, along with a suggested frequency for each activity. Individual filter strips may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes or redevelopment in the upstream land use. Each property owner shall perform the activities identified below at the frequency needed to maintain filter strips properly at all times.

| Inspection Activities | Suggested Schedule |
|---|---|
| • Inspect pea gravel diaphragm for clogging (i.e., standing water or sediment build-up).<br>• Inspect vegetation for signs of erosion or un-vegetated areas.<br>• Inspect to ensure that grass has established.<br>• Inspect general flow paths to determine if runoff discharges into and across the filter strip in an unchannelized fashion. | Annually<br>(Semi-annually first year) |
| **Maintenance Activities** | **Suggested Schedule** |
| • Maintain a dense, healthy stand of grass and other vegetation by frequent mowing. Grass heights of 3 to 5 inches should be maintained, with a maximum grass height of 8 inches. | Regularly (frequently) |
| • Repair areas of erosion and re-vegetate.<br>• Re-vegetate as needed to maintain healthy vegetation.<br>• Remove sediment buildup. | As needed |

The local jurisdiction encourages the use of the inspection checklist presented below for guidance in the inspection and maintenance of the filter strip. The local jurisdiction can require the use of this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the filter strip. Questions regarding inspection and maintenance should be referred to the local jurisdiction.

## INSPECTION CHECKLIST FOR FILTER STRIPS

Location: ______________________________ Owner Change since last inspection? Y N
Owner Name, Address, Phone: ______________________________
Date: ___________ Time: ______________ Site conditions:______________________________

| Inspection Items | Satisfactory (S) or Unsatisfactory (U) | Comments/Corrective Action |
|---|---|---|
| Healthy vegetation? | | |
| Signs of erosion? | | |
| Clogged pea gravel diaphragm? | | |
| Sediment buildup behind level spreader at top? | | |
| Sediment buildup in filter strip? | | |
| Other (describe)? | | |
| **Hazards** | | |
| Have there been complaints from residents? | | |
| Public hazards noted? | | |

If any of the above inspection items are **UNSATISFACTORY**, list corrective actions and the corresponding completion dates below:

| Corrective Action Needed | Due Date |
|---|---|
| | |
| | |
| | |
| | |
| | |

Inspector Signature:______________________________ Inspector Name (printed)______________________________

#### 4.3.9.8 References

Atlanta Regional Council (ARC). *Georgia Stormwater Management Manual Volume 2 Technical Handbook.* 2001.

City of Nashville, Tennessee. *Metropolitan Nashville and Davidson County Stormwater Management Manual Volume 4 Best Management Practices.* 2006.

Knox County, Tennessee. *Knox County Stormwater Management Manual Volume 2, Technical Guidance*. 2006.

#### 4.3.9.9 Suggested Reading

California Storm Water Quality Task Force. *California Storm Water Best Management Practice Handbooks.* 1993.

City of Austin, TX. *Water Quality Management*. Environmental Criteria Manual. Environmental and Conservation Services, 1988.

City of Sacramento, CA. *Guidance Manual for On-Site Stormwater Quality Control Measures.* Department of Utilities, 2000.

Claytor, R.A., and T.R. Schueler. *Design of Stormwater Filtering Systems.* The Center for Watershed Protection, Silver Spring, MD, 1996.

Driscoll, E., and P. Mangarella. *Urban Targeting and BMP Selection.* Prepared by Woodward-Clyde Consultants, Oakland, CA, for U.S. Environmental Protection Agency, Washington, DC, 1990.

Maryland Department of the Environment. *Maryland Stormwater Design Manual, Volumes I and II.* Prepared by Center for Watershed Protection (CWP), 2000.

Metropolitan Washington Council of Governments (MWCOG), *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Nonpoint Source Pollution in the Coastal Zone.* March 1992.

Urbonas, B.R., J.T. Doerfer, J. Sorenson, J.T. Wulliman, and T. Fairley. *Urban Storm Drainage Criteria Manual. Vol. 3. Best Management Practices, Stormwater Quality.* Urban Drainage and Flood Control District, Denver, CO, 1992.

Wong, S.L., and R.H. McCuen. *The Design of Vegetative Buffer Strips for Runoff and Sediment Control. Appendix J in Stormwater Management for Coastal Areas.* American Society of Civil Engineers, New York, New York, 1982.

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