9.0 Sheet Flow to Filter Strip or Open Space

Definition:

Filter strips are vegetated areas that treat sheet flow delivered from adjacent impervious and managed turf areas by slowing runoff velocities and allowing sediment and attached pollutants to settle and/or be filtered by the vegetation. The two design variants of filter strips are Vegetated Filter Strips and Conserved Open Space. The design, installation, and management of these design variants are quite different, as outlined in this specification.

In both instances, stormwater must enter the filter strip or conserved open space 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.

Applicable practices include:

■ 9-A. Sheet Flow to Vegetated Filter Strip
■ 9-B. Sheet Flow to Vegetated Conserved Open Space

Sheet flow practices reduce a portion of the Resource Protection Volume (RPv). In order to meet requirements for larger storm events, sheet flow practices must be combined with additional practices.
Figure 9.1. Sheet Flow To Vegetated Filter Strip or Conserved Open Space
9.1 **Sheet Flow Stormwater Credit Calculations**

Sheet flow practices receive varying retention volume management credit (RPv) depending upon the specific type employed (see Table 9.1(a) and Table 9.1(b)).

### 9.1(a) Sheet Flow to Vegetated Filter Strip Performance Credits*

<table>
<thead>
<tr>
<th>Retention Allowance</th>
<th>Runoff Reduction</th>
<th>Pollutant Reduction</th>
</tr>
</thead>
</table>
| **RPv - A/B Soil or Compost Amended C Soil** | Turf: 25% Annual Runoff Reduction  
Afforest: 30% Annual Runoff Reduction  
Forest: 40% Annual Runoff Reduction |  |
| **RPv - C/D Soil** | Turf: 10% Annual Runoff Reduction  
Afforest: 15% Annual Runoff Reduction  
Forest: 20% Annual Runoff Reduction |  |
| **CV** | 10% of RPv Allowance |  |
| **Fv** | 1% of RPv Allowance |  |
| **Pollutant Reduction** | | |
| **TN Reduction** | 100% of Load Reduction  
(max. 20% Removal Efficiency) |  |
| **TP Reduction** | 100% of Load Reduction  
(max. 20% Removal Efficiency) |  |
| **TSS Reduction** | 100% of Load Reduction  
(max. 80% Removal Efficiency) |  |

### 9.1(b) Sheet Flow to Vegetated Open Space Performance Credits*

<table>
<thead>
<tr>
<th>Retention Allowance</th>
<th>Runoff Reduction</th>
<th>Pollutant Reduction</th>
</tr>
</thead>
</table>
| **RPv - A/B Soil or Compost Amended C Soil** | Turf: 50% Annual Runoff Reduction  
Afforest: 60% Annual Runoff Reduction  
Forest: 65% Annual Runoff Reduction |  |
| **RPv - C/D Soil** | Turf: 20% Annual Runoff Reduction  
Afforest: 30% Annual Runoff Reduction  
Forest: 40% Annual Runoff Reduction |  |
| **CV** | 10% of RPv Allowance |  |
| **Fv** | 1% of RPv Allowance |  |
| **Pollutant Reduction** | | |
| **TN Reduction** | 100% of Load Reduction | |
| **TP Reduction** | 100% of Load Reduction | |
| **TSS Reduction** | 100% of Load Reduction | |

3.06.2.9-3
*See Appendix A-7 Alternative Methods for RPv Compliance for additional information on modeling this practice using traditional hydrologic methods.

The sheet flow practices described above must be designed using the guidance detailed in Section 9.6 Sheet Flow Design Criteria.

9.2 Sheet Flow Design Summary

Table 9.2 summarizes design criteria for sheetflow practices. For more detail, consult Sections 9.3 through 9.7. Sections 9.8 and 9.9 describe practice construction and maintenance criteria.

<table>
<thead>
<tr>
<th>Feasibility (Section 9.3)</th>
<th>Filter Strips</th>
<th>Sheet Flow to Open Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typically &lt;5,000 sf impervious cover</td>
<td>Max. 8% slopes</td>
<td>Max. 1% slope</td>
</tr>
<tr>
<td></td>
<td>Appropriate for all soils except fill, but runoff reduction dependent on soil type.</td>
<td>Appropriate for all soils except fill, but runoff reduction dependent on soil type.</td>
</tr>
<tr>
<td></td>
<td>Cannot receive hotspot runoff</td>
<td>Cannot receive hotspot runoff</td>
</tr>
<tr>
<td></td>
<td>Does not include jurisdictional wetlands</td>
<td>Does not include jurisdictional wetlands</td>
</tr>
</tbody>
</table>

Conveyance (Section 9.4)

- Must receive sheet flow.
- Can be achieved by receiving a relatively short flow path (<150’ pervious or <75’ impervious surfaces), or
- Can use an engineered level spreader for concentrated flows (Section 9.6)

Pretreatment (Section 9.5)

- Not required

Minimum Dimensions (Section 9.6)

- Length dependent on slope and practice option (See Tables 9.3 and 9.4)
- Area dependent on slope and impervious cover in CDA

Other Design Elements (Section 9.6)

- Gravel diaphragm at the top of the slope for sheet flow applications.
- Engineered level spreader for concentrated flow
- Permeable berm at the toe of slope of filter strips
- Compost amendments when applied on C soils to increase soil permeability

Landscaping (Section 9.7)

- Achieve 90% coverage with herbaceous materials for vegetated filter strips and vegetated open space.
- Create an invasive species plan, and damage no native species for all conservation areas.
- Requires 80% tree canopy for forested filter strips and conserved open space.
- Specific criteria for reforestation.
- Maximum velocity versus species type in Table 9.5.
9.3 Sheet Flow Feasibility Criteria

Sheet Flow to a Filter Strip or Open Space can be employed on commercial, institutional, municipal, multi-family residential and single-family residential buildings. Key constraints include available space, soil permeability, soil compaction.

**Vegetated Filter Strips**

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. Filter strips may also be used as pretreatment for another stormwater practice such as a bioswale, bioretention, or infiltration areas. If sufficient pervious area is available at the site, larger areas of impervious cover can be treated by filter strips, using an engineered level spreader to recreate sheet flow. Filter strips are also well suited to treat runoff from turf-intensive land uses, such as the managed turf areas of sports fields, golf courses, and parkland. Filter strips tend to have more linear configurations and greater cross-slopes than areas that qualify as “Conserved Open Space”.

**Forested Filter Strips**

Forested filter strips are a subset of Vegetated Filter Strips in which the vegetation cover consists mostly of established tree species with an organic duff layer having greater hydrologic storage capacity than a non-forested filter strip. Runoff through a forested filter strip would be more likely to occur as interflow than as true surface runoff.

**Conserved Open Space**

The most common design applications of Conserved Open Space are on sites that are hydrologically connected to a protected stream buffer, wetland buffer, floodplain, forest conservation area, or other protected lands. Conserved Open Space is an ideal component of the "outer zone" of a stream buffer, which normally receives runoff as sheet flow. Care should be taken to locate all energy dissipaters or flow spreading devices outside of the protected area. Conserved Open Space generally has a less linear configuration and flatter cross-slope than Vegetated Filter Strips. Runoff reduction in Conserved Open Space is achieved mainly through storage and/or extended residence time. These areas therefore require minimal slope or even slight sump conditions to allow shallow ponding to occur. Similar to Vegetated Filter Strips, Conserved Open Space can be either in the form of turf vegetation or preserved forested areas.

Both Vegetated Filter Strips and Conserved Open Space must meet the following requirements:

- **Slopes.** Maximum slope for Vegetated Filter Strips is 8%, in order to maintain sheet flow through the practice. Maximum slope for Conserved Open Space is 1%. In addition, the overall contributing drainage area must likewise be relatively flat to ensure sheet flow.
draining into the filter. Where this is not possible, alternative measures, such as an engineered level spreader, can be used.

- **Soils.** Vegetated Filter Strips and Conserved Open Space are appropriate for all soil types, except fill material. As it applies to this practice, fill is defined as any placed soil that requires compaction to meet a design grade or elevation. The runoff reduction rate, however, is dependent on the underlying Hydrologic Soil Groups (see *Table 9.1* above) and whether soils receive compost amendments.

- **Hotspot Land Uses.** Vegetated Filter Strips and Conserved Open Space should not receive hotspot runoff, since the infiltrated runoff could cause groundwater contamination.

- **Proximity of Underground Utilities.** Underground pipes and conduits that cross a Vegetated Filter Strip or Conserved Open Space are acceptable.

- **Jurisdictional Wetlands.** Restrictions may apply when these practices are located adjacent to jurisdictional wetlands that are sensitive to increased inputs of stormwater runoff (e.g., bogs and fens).

### 9.4 Sheet Flow Conveyance Criteria

Vegetated Filter Strips and Conserved Open Space are used to treat very small drainage areas of a few acres or less. The limiting design factor is the length of flow directed to the filter. As a rule, flow tends to concentrate after 75 feet of flow length for impervious surfaces, and 150 feet for pervious surfaces (Claytor, 1996). When flow concentrates, it moves too rapidly to be effectively treated, unless an engineered level spreader is used.

### 9.5 Sheet Flow Pretreatment Criteria

Pretreatment is not needed for Sheet Flow to Vegetated Filter Strips or Conserved Open Space.

### 9.6 Sheet Flow Design Criteria

For Vegetated Filter Strips, the following minimum lengths apply, unless maximum velocity calculations are provided as detailed per the Maximum Velocity section below (length is measured in direction of flow):

<table>
<thead>
<tr>
<th>Table 9.3 Minimum Length of Filter Strips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope of Filter Strip</td>
</tr>
<tr>
<td>-----------------------</td>
</tr>
<tr>
<td>&lt;- 3%</td>
</tr>
<tr>
<td>3% - 8%</td>
</tr>
</tbody>
</table>

*The first 10 feet of filter must be 2% or less in all cases.*

For Conserved Open Space, the following minimum area a

<table>
<thead>
<tr>
<th>Table 9.4 Minimum Area of Conserved Open Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope of Open Space</td>
</tr>
</tbody>
</table>

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Velocity Calculations
The slopes and lengths provided in Table 9.3 were calculated out to maintain a sheet flow condition through the Filter Strip at a velocity low enough that filtering and potentially infiltration may occur at rates equal to the Runoff Reduction credit for these practices. By providing velocity calculations, it is possible to shorten the minimum Filter Strip lengths shown in Table 9.3 if the design professional can prove that the sheet flow is maintained with a maximum velocity of 0.5 feet/second (fps). An acceptable velocity calculation in this case would be usage of the TR-55 Sheet flow Travel Time ($T_t$) calculations (available in TR-55 eq. 3-3) to determine the sheet flow $T_t$ and then back-calculate out the average velocity of that path. For these sheet flow calculations the licensed design professional should use Manning’s $n$ values consistent with a smooth surface for the paved areas ($n = 0.011$), an $n$ value consistent with a gravel surface should be used for a gravel shoulder ($n = 0.029$), an $n$ value consistent with a grassed range, short surface for the filtering practice ($n = 0.15$), and an $n$ value consistent with a gravel surface for either a gravel diaphragm or a level spreader ($n = 0.30$). Finally, the $T_t$ calculation may also be amended to utilize the RPv storm rainfall depth instead of the 2-year, 24-hour rainfall depth.

Once this velocity has been reached, the design professional may calculate the treatment credit utilizing the following two equations:

For A/B Soils:
$$f(A/B) = \left( \frac{L}{15} \right) \times 25\%, \quad 0 \leq f(A/B) \leq 25\%$$

For C/D Soils:
$$f(C/D) = \left( \frac{L}{15} \right) \times 10\%, \quad 0 \leq f(C/D) \leq 10\%$$

Where $L$ is the length of proposed Filter Strip after a maximum velocity of 0.5 fps has been achieved. Note that in Table 9.3 the first 10’ of the Filter Strip are necessary to reduce the Sheet Flow Velocity down to 0.5 fps for the shorter 25’ length Filter Strip.

The output of these equations is the treatment credit that may be applied for a Filter Strip BMP of length $L$ in the functionally equivalent Hydraulics and Hydrology calculations provided by the Licensed Design Professional.

The following accessory structures may be necessary or required as part of a filter strip or conserved open space:
Gravel Diaphragms
A gravel diaphragm at the top of the slope is required for both filter strips and conserved open space. 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. The diaphragm serves two purposes. First, it acts as a pretreatment 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.

- The flow should travel over the impervious area and to the practice as sheet flow and then drop at least 3 inches onto the gravel diaphragm. The drop helps to prevent runoff from running laterally along the pavement edge, where grit and debris tend to build up (thus allowing bypass of the Filter Strip).
- A layer of filter fabric should be placed between the gravel and the underlying soil trench.
- If the contributing drainage area is steep (6% slope or greater), then larger stone should be used in the diaphragm.
- If the contributing drainage area is solely turf (e.g., sports field), then the gravel diaphragm may be eliminated.

Engineered Level Spreaders
The design of engineered level spreaders should conform to the following design criteria based on recommendations of Hathaway and Hunt (2006), in order to ensure non-erosive sheet flow into the vegetated area. At times, it may be necessary to include a bypass structure (see Figure 9.1 above) that diverts the design storm to the level spreader, and bypasses the larger storm events around the Vegetated Filter Strip or Conserved Open Space through an improved channel. An alternative approach would be to direct the entire flow through a stilling basin energy dissipator and then a level spreader such that the entire Conveyance Event (Cv) storm for the) is discharged as sheet flow through the buffer.

Key design elements of the engineered level spreader, as provided in Figures 9.3 and 9.4, include the following:

- The length of the level spreader should be determined by the type of filter area and the design flow:
  - 13 feet of level spreader length per every 1 cubic foot per second (cfs) of inflow for discharges to a filter strip or turf conservation area;
  - 40 feet of level spreader length per every 1 cfs of inflow when the spreader discharges to a forested conservation area (Hathaway and Hunt, 2006).
  - The minimum level spreader length is 13 feet and the maximum is 130 feet.
  - For the purposes of determining the level spreader length, the peak discharge shall be determined using the Rational Equation with an intensity of 2.7-inch/hour.

- The level spreader lip should be concrete, wood or pre-fabricated metal, with a well-anchored footer, or other accepted rigid, non-erodible material.
• The ends of the level spreader section should be tied back into the slope to avoid scouring around the ends of the level spreader; otherwise, short-circuiting of the facility could create erosion.

• The width of the level spreader channel on the up-stream side of the level lip should be three times the diameter of the inflow pipe, and the depth should be 9 inches or one-half the culvert diameter, whichever is greater.

Figure 9.3: Example Level Spreader

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. Runoff ponds behind the berm and gradually flows through outlet pipes in the berm or through a gravel lens in the berm with a perforated pipe. During larger storms, runoff may overtop the berm (Cappiella et al., 2006). The permeable berm should have the following properties:

- A wide and shallow trench, 6 to 12 inches deep, should be excavated at the upstream toe of the berm, parallel with the contours.
- Media for the berm should consist of 40% excavated soil, 40% sand, and 20% pea gravel.
- The berm 6 to 12 inches high should be located downgradient of the excavated depression and should have gentle side slopes to promote easy mowing (Cappiella et al., 2006).
- Stone may be needed to armor the top of berm to handle extreme storm events.
- A permeable berm is not needed when vegetated filter strips are used as pretreatment to another stormwater practice.

**Compost Soil Amendments**
Compost soil amendments can enhance the runoff reduction capability of a Vegetated Filter Strip or Conserved Open Space when located on hydrologic soil group C, subject to the following design requirements:

- The compost amendments should extend over the full length and width of the vegetated area.
- The amount of approved compost material and the depth to which it must be incorporated is outlined in **Specification 14, Soil Amendments**.
- The amended area must be raked to achieve the most level slope possible without using heavy construction equipment, and stabilized with perennial grass and/or herbaceous species prior to receiving runoff discharges.
- If slopes exceed 3%, an erosion control matting should be installed in accordance with the Delaware ESC Handbook to assist with stabilization of the site.
- Compost amendments should not be incorporated until the gravel diaphragm and/or engineered level spreader are installed (see below).

**9.7 Impermeable Surface Disconnection Landscaping Criteria**

**Vegetated Filter Strips.** Vegetated Filter Strips should be planted at such a density to achieve a 90% grass/herbaceous cover after the second growing season. Vegetated Filter Strips should be seeded, not sodded. Seeding establishes deeper roots, and sod may have muck soil that is not conducive to infiltration (Wisconsin DNR, 2007). The 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. Designers should choose vegetation that stabilizes the soil and is salt tolerant. Vegetation at the toe of the filter, where temporary ponding may occur behind the permeable berm, should be able to withstand both wet and dry periods. The planting areas can be divided into zones to account for differences in inundation and slope.
**Afforested Filter Strips.** Afforested filter strips shall be planted in accordance with Specification 17. Afforestation.

**Forested Filter Strips.** No grading or clearing of native vegetation is allowed within the Forested Filter Strip. Forested Filter Strips must have at least 80% tree canopy coverage. An invasive species management plan should be developed and approved as part of plan review.

**Conserved Open Space.** No grading or clearing of native vegetation is allowed within the Conserved Open Space. An invasive species management plan should be developed and approved as part of plan review.

**Vegetated Conservation Area.** In addition to the constraints listed for Conserved Open Space in section 9.3 above, turf conservation areas must have at least 90% coverage with grasses and/or other herbaceous plants, although tree coverage in portions is acceptable.

**Afforested Conservation Area.** Afforested conservation areas will be planted in accordance with Specification 17. Afforestation.

**Forested Conservation Area.** In addition to the constraints listed for Conserved Open Space in section 9.3 above, Forested Conservation Areas must have at least 80% tree canopy coverage.

**Re-vegetated Conserved Open Space.** At some sites, the proposed Conserved Open Space may not meet the coverage requirements above, may be previously disturbed, or may be overrun with invasive plants and vines. In these situations, a landscape architect or horticulturalist should prepare a re-vegetation or restoration plan for the Conserved Open Space to achieve the coverage requirements for a turf or aforested conservation area. The entire area can be planted with herbaceous cover for a vegetated conservation area, with native trees and shrubs in accordance with Specification 17. Afforestation for an aforested conservation area, or allowed to revegetate to a forested condition through natural succession.

(Note: The runoff reduction allowance for Re-vegetated Conserved Open Space shall be determined on a case-by-case basis following Departmental review of the proposed landscaping plan.)

**Stabilization.** All Vegetated Filter Strips and re-vegetated Conserved Open Space must be stabilized to prevent erosion or transport of sediment to receiving practices or drainage systems. Several types of grasses appropriate for filter strips or turf conservation areas are listed in Table 9.5. Designers should ensure that the maximum flow velocities do not exceed the values listed in the table for the selected grass species and the specific site slope.

**Table 9.5. Recommended vegetation for filter strips and turf conservation areas.**
# 9.8 Sheet Flow Construction Sequence

## Construction Sequence for Vegetated Filter Strips

Vegetated Filter Strips can be within the limits of disturbance during construction. The following procedures should be followed during construction:

- Before site work begins, filter strip boundaries should be clearly marked.
- Only vehicular traffic used for filter strip construction should be allowed within the filter strip boundary.
- If existing topsoil is stripped during grading, it shall be stockpiled for later use.
- Construction runoff should be directed away from the proposed filter strip site, using perimeter silt fence, or, preferably, a diversion dike.
- Construction of the gravel diaphragm or engineered level spreader shall not commence until the contributing drainage area has been stabilized and perimeter erosion and sediment (E&S) controls have been removed and cleaned out.
- Filter strips require light grading to achieve desired elevations and slopes. This should be done with tracked vehicles to prevent compaction. Topsoil and or compost amendments should be incorporated evenly across the filter strip area, stabilized with seed, and protected by biodegradable erosion control matting or blankets.
- Stormwater should not be diverted into the filter strip until the turf cover is dense and well established.
- For afforested filter strips, refer to Specification 17. Afforestation.

## Construction Sequence for Vegetated Conserved Open Space

No major disturbance may occur within the Conserved Open Space during or after construction (i.e., no clearing or grading is allowed except temporary disturbances associated with incidental...
utility construction, restoration operations, or management of nuisance vegetation). The Conserved Open Space area shall not be stripped of topsoil. Some light grading may be needed at the boundary using tracked vehicles to prevent compaction.

The Conserved Open Space must be fully protected during the construction stage of development and kept outside the limits of disturbance on the Sediment & Stormwater Plan.

- The perimeter of the Conserved Open Space shall be protected by super silt fence, chain link fence, orange safety fence, or other measures to prevent compaction and sediment discharge.
- The limits of disturbance should be clearly shown on all construction drawings and identified and protected in the field by acceptable signage, silt fence, snow fence or other protective barrier.
- Construction of the gravel diaphragm or engineered level spreader shall not commence until the contributing drainage area has been stabilized and perimeter E&S controls have been removed and cleaned out.
- Stormwater should not be diverted into the conserved open space until the gravel diaphragm and/or level spreader are installed and stabilized.
- For afforested open space, refer to **Specification 17. Afforestation**.

**Construction Inspection.** Construction inspection is critical to ensure compliance with design standards. Inspectors should evaluate the performance of the filter strip or open space after the first big storm to look for evidence of gullies, outflanking, undercutting or sparse vegetative cover. Spot repairs should be made, as needed.

**Post Construction Verification Documentation.** The following items shall be included in the Post Construction Verification Documentation for Sheet Flow Practices:

- Dimensions of Vegetated Filter Strips (length and width).
- Area of Conserved Open Space.
- Cross-slope.
- Volume dimensions of any pre-treatment component.
- Elevations of any structural components, such as gravel diaphragms or engineered level spreaders.

**9.9 Sheet Flow Maintenance Criteria**

An Operation and Maintenance Plan for the project will be approved by the Department or the Delegated Agency prior to project closeout. The Operation and Maintenance Plan will specify the property owner’s primary maintenance responsibilities and authorize the Department or Delegated Agency staff to access the property for maintenance review or corrective action in the event that proper maintenance is not performed. Sheet Flow Practices that are, or will be, owned and maintained by a joint ownership such as a homeowner’s association must be located in common areas, community open space, community-owned property, jointly owned property, or

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within a recorded easement dedicated to public use.

Operation and Maintenance Plans should clearly outline how vegetation in the Sheet Flow Practice will be managed or harvested in the future. Maintenance of Sheet Flow Practices is driven by annual maintenance reviews that evaluate the condition and performance of the practice. Based on maintenance review results, specific maintenance tasks may be required.

Table 9.6. Sheet Flow to Filter Strip or Open Space Maintenance Items and Frequency

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Maintenance Items</th>
</tr>
</thead>
</table>
| During establishment, as needed (first year)  | • Inspect the site after storm event that exceeds 0.5 inches of rainfall.  
• Stabilize any bare or eroding areas in the contributing drainage area including the Wet Pond perimeter area  
• Water trees and shrubs planted in the Wet Pond vegetated perimeter area during the first growing season. In general, water every 3 days for first month, and then weekly during the remainder of the first growing season (April - October), depending on rainfall. |
| Quarterly or after major storms (>1 inch of rainfall) | • Remove debris and blockages  
• Repair undercut, eroded, and/or bare soil areas                                                                                                                                                                |
| Twice a year                                   | • Mowing of the Wet Pond vegetated perimeter area and embankment turf filter strip or turf open space  
• Inspect and treat for invasive species as needed                                                                                                                                                                |
| Annually                                       | • Shoreline cleanup to remove trash and debris  
• Remove debris and blockages  
• A full maintenance review  
• Open up the riser to access and test the valves  
• Repair broken mechanical components, if needed                                                                                                                                                                  |
| One time during the second year following construction | • Wet Pond vegetated perimeter and aquatic bench reinforcement plantings                                                                                                                                 |
| Every 5 to 7 years                              | • Forebay sediment removal                                                                                                                                                                                         |
| From 5 to 25 years                              | • Repair pipes, the riser and spillway, as needed  
• Remove sediment from Wet Pond area outside of forebays                                                                                                                                                        |
9.10 References


Henrico County, Virginia. Henrico County Environmental Program Manual. Available online at: http://www.co.henrico.va.us/works/eesd/


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