Advanced Design Workshop: Filter Strip & Bioslope
...to discuss process of designing Filter Strips and Bioslopes
FILTER STRIPS
Filter Strip

A uniformly sloped and vegetated area designed to treat sheet stormwater flow
Filter Strip

A uniformly sloped and vegetated area designed to treat sheet stormwater flow
Filter Strip

• Purpose
  • Remove pollutants from stormwater runoff by vegetative filtering
  • Reduce suspended solids, metals, and nutrients in some cases

• Considerations
  • Most applicable roadway use is adjacent to the roadway shoulder along non-curb and gutter sections (rural sections).
  • Must consider additional BMPs to achieve 80% TSS removal
  • Performance is directly related to the density of vegetation.
Design Considerations

• Slope between 2% and 25% (perpendicular to roadway)
• Minimum strip length = 15 feet (25 feet preferred)
• Minimize slope at top and toe to encourage sheet flow before and after filter strip
• Make filter strip slope flat as allowable by site conditions
• Use a level spreader where appropriate
Other Considerations - Vegetation

• See GDOT Specification Section 700 for grass and vegetation types
• Protect bare earth prior to grass establishment with TRM
• Sheet flow required prior to filter strip
• A level spreader or pea gravel diaphragm can be used upslope

Reminder:

Outfall Exclusion #4
Stormwater discharges from the project site are designed to exit the right-of-way as sheet flow (non-point source discharges)
However, sheet flow cannot immediately channelize after exiting the R/W
Other Considerations

• Inspection & maintenance
  • Provide adequate right-of-way or easement

• Roadside safety
  • Provide adequate area for vehicle maintenance activities; safe highway entrance and exit
## Advantages/Disadvantages

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Minimal construction effort and change to existing landscape</td>
<td>• Sensitive to erosion and concentrated flow</td>
</tr>
<tr>
<td>• Effective for highway runoff pollution</td>
<td>• May require additional R/W to accommodate required length</td>
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<tr>
<td>• Adaptable to a variety of site conditions</td>
<td>• Must be used in conjunction with another BMP to meet WQ treatment requirements</td>
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<tr>
<td>• Flexible in design and layout</td>
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<td>• Lower cost alternative</td>
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</table>
FILTER STRIP DESIGN PROCESS
Table 10.6.1-1 should be used to select Filter Strip Length based on Pavement Width and Slope if:

- Stormwater runoff drains via sheet flow directly to the filter strip.
- Filter strip is the same width as the roadway segment length being treated.

Table developed based on providing a contact time of 5 minutes.
Design Process

- The steepest portion of the slope should be utilized in the sizing of the filter strip.
  - Example: shoulder has a 6% slope of grassing going to a 4:1 slope. Designer should use the 4:1 slope and the pavement width to determine the length of filter strip.

<table>
<thead>
<tr>
<th>Pavement Width (ft)</th>
<th>Slope 4:1</th>
<th>Slope 6:1</th>
<th>Slope 8:1</th>
<th>Slope 6%</th>
<th>Slope 4%</th>
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Design Example

PROPOSED FILTER STRIP AREA

Filter strip width matches roadway drainage area
• Pavement Width = 30 ft
• Un-paved shoulder slope = 4' at 6%
• 4:1 shoulder fore-slope
• Area drains via sheet flow
Table 10.6.1-1 can be utilized.

<table>
<thead>
<tr>
<th>Pavement Width (ft)</th>
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BIOSLOPES
Bioslope

A BMP with engineered soil mix and an underdrain installed on slopes or embankments

1. A recommended grassed filter strip (4’ min) provides additional pretreatment by intercepting solids and promoting infiltration.
   - Grass strip is not Filter Strip BMP and does not have the same length requirements.

2. The bioslope engineered soil mix filters out solids and other stormwater pollutants.
A BMP with engineered soil mix and an underdrain installed on slopes or embankments
Bioslope

• **Purpose**
  - Reduce pollutants by filtration and infiltration processes
  - Filtration by engineered soil mix

• **Applications**
  - Applicable for roadway embankments where runoff exits as sheet flow
  - Areas of limited ROW constraints that limit other BMPs

<table>
<thead>
<tr>
<th>Vegetative Conveyance</th>
<th>Filteration</th>
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<th>Infiltration</th>
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</table>

TSS Removal = 85%

Detention

Runoff Reduction = 25-50%
Design Considerations

• Slope perpendicular to bioslope 3:1 or flatter
• Longitudinal slope < 5%
• Edge of pavement to bioslope ideally < 30 ft
• 2 ft separation between bottom bioslope and Seasonal High Water Table (SHWT)
• Bioslope length = roadway length to be treated
Other Considerations - Pretreatment

- Pretreatment removes sediment and promotes sheet flow prior to bioslope
- Provide minimum 4 foot filter strip upslope of bioslope media
- Pea gravel diaphragms can also be used as pretreatment
Other Considerations - Vegetation

- Bioslopes should be vegetated with sod that meets Special Provision 169.
- Sod should be grown in primarily sand/sandy-loam soils with less than 6% clay content.
- Sod shall be half cut or thin cut to promote infiltration.
- Sod shall consist of at least 75% of the designated grass species specified in the plans.

SOURCE: NCDOT.
Other Considerations – Engineered Topsoil

- Top 3 inches should consist of an engineered topsoil mix that meets the requirements of Special Provision 169.

- Topsoil should be obtained from sources approved by the Engineer.
**Other Considerations – Engineered Soil Mix**

<table>
<thead>
<tr>
<th>Amendment</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Aggregate: GDOT size #89 stone</td>
<td>3 yd³</td>
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<tr>
<td>Perlite</td>
<td>1 yd³/3 yd³ of mineral aggregate</td>
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<tr>
<td>Dolomite</td>
<td>10 lbs/yd³ of perlite</td>
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<tr>
<td>Gypsum</td>
<td>1.5 lbs/yd³ of perlite</td>
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<tr>
<td>See ROADS website for Details and Specifications</td>
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</table>

*Designers should refer to Special Provision 169 for more information on media*
Other Considerations - Underdrain

• Place minimum 24in. above water table
• Pipe: perforated polyethylene sized for $Q_{wq}$ (typ.)
• Aggregate layer: No. 57 stone
• Discharge to existing/proposed storm drainage structure or stable outlet
• See Underdrain Special Construction Detail for more information.
Other Considerations

• Roadside safety
  • Provide adequate area for inspection & vehicle maintenance activities; safe highway entrance and exit
# Advantages/Disadvantages

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>• LID/GI design practice</td>
<td>• Sheet flow is required</td>
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<tr>
<td>• Water quality benefits</td>
<td>• Unsuitable for steep embankments</td>
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<td>• Applicable in highly constrained areas</td>
<td>• Does not typically provide detention</td>
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</table>

BIOSLOPE DESIGN PROCESS
Design Process

• Check approach stability and evaluate need for pretreatment
• Calculate the bioslope width
• Design the underdrain system
• Calculate the runoff reduction volume (RRv) conveyed to the practice
• Calculate the runoff reduction volume credited
1. The filter strip provides additional pretreatment by intercepting solids and promoting infiltration.
2. The bioslope media filters out solids and other stormwater pollutants.

Note: Grass Filter Strip shown is not a Filter Strip BMP
Design Process

• Determine length of roadway to treat (bioslope length)
• Calculate the $Q_{wq}$ per Section 10.4 of drainage manual

Where:

$$Q_{WQ} = q_u \times A \times Q_{WV}$$

Where:

$Q_{WQ}$ = water quality peak flow rate ($ft^3/s$)
$q_u$ = unit peak discharge [($ft^3/s$)/mi$^2$/in.]]
$A$ = drainage area (mi$^2$)
$Q_{WV}$ = water quality volume (in.)
Sizing Guidelines (Based on Darcy’s Law)

• Bioslope Width (perpendicular to roadway)

\[ W = \frac{C Q_{wq} SF}{kL} \]

Where:
- \( W \) = bioslope width perpendicular to roadway (ft)
- \( C \) = conversion factor = 43,200 [(in/hr)/(ft/s)]
- \( Q_{wq} \) = water quality volume peak flow (ft³/s)
- \( SF \) = safety factory (set SF to 1 for Bioslopes)
- \( k \) = infiltration rate (in/hr) = 10 in/hr
- \( L \) = bioslope length parallel to roadway (ft)
Design Example

PROPOSED BIOSLOPE

24' 6' ?
• Bioslope length is the length of roadway to be treated parallel to proposed bioslope
• Bioslope length = 200 ft
• Lateral slope < 3:1
• Longitudinal slope < 5%
• Sheet flow with no heavy loading
• Preliminary calculations
  • $WQ_v = 606 \text{ ft}^3$
  • $Q_{wq} = 0.16 \text{ ft}^3/s$
• Bioslope width = ?
Bioslope Width

\[ W = \frac{C Q_{wq} SF}{k L} \]

Where:
- \( W \) = bioslope width perpendicular to roadway = ?
- \( C \) = conversion factor = 43,200 \((\text{in/hr})/(\text{ft/s})\)
- \( Q_{wq} \) = water quality volume peak flow \((\text{ft}^3/\text{s})\) = 0.16 \(\text{ft}^3/\text{s}\), previously calculated
- \( SF \) = safety factor = 1
- \( k \) = infiltration rate \((\text{in/hr})\) = 10 \(\text{in/hr}\)
- \( L \) = bioslope length parallel to roadway = 200 \(\text{ft}\)

\[
W = \frac{43,200 \times 0.16 \times 1}{10 \times 200} = 3.5 \text{ ft}
\]
Runoff Reduction Volume

\[ RR_v = \frac{1.0 \text{ in} (R_v) \times A \times 43560 \text{ ft}^2/\text{acre}}{12 \text{ in/ft}} \]

Where:
- \( RR_v \) = runoff reduction volume conveyed to the practice (ft\(^3\))
- 1.0 in. is the runoff depth for treatment
- \( R_v \) = volumetric runoff coefficient = 0.05+0.009(I) (dimensionless)
- \( I \) = percent imperviousness of onsite area
- \( A \) = Area draining to the bioslope (acres)
Runoff Reduction Volume

Where:  \( RR_v = \) runoff reduction volume conveyed to the practice (ft\(^3\))

1.0 in. is the runoff depth for treatment

\( I = \) percent imperviousness of onsite area = 100

\( R_v = \) volumetric runoff coefficient = 0.05 + 0.009(\( I \)) = 0.05 + 0.009 (100) = 0.95

\( A = \) area draining to the bioslope = 200 ft x 30 ft = 6,000 ft\(^2\) = 0.138 acres

\[
RR_v = \frac{(R_v) \times (A)}{12 \text{ in/ft}} = \frac{1.0''(0.95 \times 0.138) \times 43,560 \text{ ft}^2/\text{acre}}{12 \text{ in/ft}} = 500 \text{ ft}^3
\]
Runoff Reduction Volume (credited)

- Using Table 10.5-1, lookup the appropriate runoff reduction percentage (or credit) provided by the practice:

\[ RR_v (credited) = RR_v(RR\%) \]

Where:  
- \( RR_v (credited) \) = runoff reduction volume provided by this practice (ft\(^3\))  
- \( RR_v \) = runoff reduction volume conveyed to the practice (ft\(^3\))  
- \( RR\% \) = runoff reduction percentage, or credit, assigned to the specific practice

- Table 10.5-1 says that a bioslope in A & B hydrologic soils has an RR\% of 50%

\[ RR_v (credited) = 500 \text{ ft}^3 \times (50\%) = 250 \text{ ft}^3 \]
Underdrain System

Underdrain Outlet

Cleanout
BIOSLOPE TYPICAL SECTION

GEOTEXTILE METAL ANCHOR

NOTE: NONREIN GEOTEXTILE SHALL BE ANCHORED WITH 8-GAUGE METAL STAPLES OR ROUND TOP ANCHOR. ANCHORS SHALL BE LONG ENOUGH TO PROVIDE SUFFICIENT GROUND PENETRATION TO RESIST PULL OUT.

BIOSLOPE PLAN VIEW

BIOSLOPE UNDERDRAIN CLEANOUT

CLEANOUT GENERAL NOTES:
1. CLEANOUTS SHALL BE PVC STRUCTURES IN ALL VERTICAL SECTIONS WITH ADAPTERS TO CONNECT DISTRIBUTION AND UNDERDRAIN PIPING MATERIALS AS REQUIRED.
2. A CLEANOUT SHALL BE PLACED AT A MAXIMUM SPACING OF 100 LINEAR FEET ALONG THE UNDERDRAIN PIPE.

BIOSLOPE DATA

BIOSLOPE GENERAL NOTES:
1. SEE DRAWING SECTIONS 13 AND 25 OF THE PLANS FOR ADDITIONAL INFORMATION ON THE LIMITS OF THIS POST-CONSTRUCTION STORMWATER BMP.
2. SEE SPECIAL PROVISION FOR BIODEGRADABLE MEDIA COMPONENTS AND MATTING. TOTAL QUANTITIES OF MEDIA COMPONENTS SHALL BE ADJUSTED BASED ON THE DIMENSIONS FOR EACH BIODEGRADABLE MEDIA COMPONENTS.
3. EACH BIODEGRADABLE MEDIA COMPONENTS SHALL BE CONSTRUCTED AT LESS THAN 3" DEEP AND PERMANENTLY STABILIZED AS REQUIRED BY THE ENGINEER.
4. EXCAVATION AND MINOR GRADING SHALL BE LIMITED TO THE DIMENSIONS SPECIFIED FOR EACH BIODEGRADABLE MEDIA COMPONENTS.
5. THE TRENCH SHALL BE SHAPED WITH VERTICAL SIDES AS PRAC TICAL. WITHOUT LARGE VERRORS AND TRIMMED OF LARGE ROOTS. THE SLOPE OF THE TRENCH SHALL BE SHAPED TO THE INSTALLATION OF SPECIFIED MATERIALS. AVOID BACKFILLING IN A MANNE R THAT CAUSES SOIL COMPACTION IN THE BOTTOM OF THE TRENCH.
6. ANCHOR NONREIN GEOTEXTILE WITH FILTER STRIPS INTO GRID SURFACE WITH SPECIFIED ANCHORS 6-INCHES FROM FRONT EDGE AND NO GREATER THAN 8-INCHES APART. USE ANCHORS AS NECESSARY TO ALSO SECURE AND CONFORM GEOTEXTILE TO THE SHAPED OF THE TRENCH. OVERLAP GEOTEXTILE 5-INCHES ON SEAMS AND SEAL EVERY 4-INCHES ALONG SEAM EDGE.
7. PERMANENTLY STABILIZED DISTURBED AREAS ACCORDING TO THE ENGINEER, SEPARATION, AND POLLUTION CONTROL PLANS.
8. ALL ITEMS SHOWN AND INCLINED ITEMS NEEDED TO COMPLETE BIODEGRADABLE MEDIA COMPONENTS, INCLUDING OUTLET AND SIGNAGE, WITHIN THE LIMITS SPECIFIED ARE INCLUDED IN THE UNINSTALL BIODEGRADABLE MEDIA COMPONENTS.
9. IF POST-CONSTRUCTION STORMWATER BMP IS NOT COMPLETE WITHIN THE LIMITS SHOWN, THE CONSTRUCTION PROJECT MANAGER SHALL NOTIFY THE OFFICE OF PROGRAM DELIVERY PROJECT MANAGED AND AREA ENGINEER. MODIFICATIONS MUST BE APPROVED BY THE GEOT OFFICE OF DESIGN FOLEY AND SUPPORT PRIOR TO INSTALLATION.

DATA TABLE GENERAL NOTES:
1. DATA TABLE SHALL BE FILLED OUT AND SHOWN ON THE SPECIAL PLANNING DRAWINGS.
2. CONTRACTOR IS RESPONSIBLE FOR SUPPLYING THE AS-BUILT DATA TO THE CONSTRUCTION PROJECT ENGINEER/INSPECTOR.

SPECIAL CONSTRUCTION DETAIL

REVISION DATE

SPECIAL CONSTRUCTION DETAIL

POST-CONSTRUCTION BMP

BIOSLOPE SHEET 1 OF 2

38-
BIOSLOPE TYPICAL SECTION

GEOTEXTILE METAL ANCHOR

NOTE: NONWOVEN GEOTEXTILE SHALL BE ANCHORED WITH 8-GAUGE METAL STAPLES OR ROUND TOP ANCHORS. ANCHORS SHALL BE LONG ENOUGH TO PROVIDE SUFFICIENT GROUND PENETRATION TO RESIST PULL OUT.
BIOSLOPE UNDERDRAIN CLEANOUT

CLEANOUT GENERAL NOTES:

1. CLEANOUTS SHALL BE PVC STRUCTURES IN ALL VERTICAL SECTIONS WITH ADAPTERS TO CONNECT DISTRIBUTION AND UNDERDRAIN PIPING MATERIALS AS REQUIRED.

2. A CLEANOUT SHALL BE PLACED AT A MAXIMUM SPACING OF 100 LINEAR FEET ALONG THE UNDERDRAIN PIPE.
## BIOSLOPE DATA

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### AS-BUILT DATA

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### DATA TABLE GENERAL NOTES:

1. DATA TABLE SHALL BE FILLED OUT AND SHOWN ON THE SPECIAL GRADING PLANS.
2. CONTRACTOR IS RESPONSIBLE FOR SUPPLYING THE AS-BUILT DATA TO THE CONSTRUCTION PROJECT ENGINEER/INSPECTOR.
Questions

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More GDOT Advanced Design Workshops can be found at https://learning.dot.ga.gov/