4.3.10 Grass Channel

General Application Stormwater BMP

Description: Grass channels are vegetated open channels that are designed to filter stormwater runoff, as well as slow water for treatment by another structural BMP.

KEY CONSIDERATIONS

DESIGN GUIDELINES:

- Broad bottom channel on slopes of 4% or less.
- Gentle side slopes (3:1 (H:V) or less).
- Check dams can be installed to maximize treatment.
- Requires vegetation that can withstand both relatively high velocity flows and wet and dry periods.

ADVANTAGES / BENEFITS:

- Provides pretreatment if used as part of runoff conveyance system.
- Provides infiltration of runoff in some soil conditions.
- Generally less expensive than extruded curb.
- Good for small drainage areas.
- Relatively low maintenance requirements.

DISADVANTAGES / LIMITATIONS:

- Cannot alone achieve 80% removal of TSS.
- Must be carefully designed to achieve low flow rates in the channel for WQv purposes (<1.0 ft/s).
- May re-suspend sediment.
- May not be acceptable for some areas because of standing water in channel.

MAINTENANCE REQUIREMENTS:

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

STORMWATER MANAGEMENT SUITABILITY

- [x] **Water Quality**
- [ ] **Channel/Flood Protection**
- [ ] **Overbank Flood Protection**
- [ ] **Extreme Flood Protection**

Accepts runoff from SPAP land uses: *Yes, with pre-treatment.*

FEASIBILITY CONSIDERATIONS

L	**Land Requirement**
L	**Capital Cost**
L	**Maintenance Burden**

Residential/Subdivision Use: *Yes*

Drainage Area: *5 acres maximum*

Soils: *Any soil is suitable – must be fully vegetated with no areas of erosion.*

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

POLLUTANT REMOVAL

L	**Total Suspended Solids**
L	**Nutrients**: Total Phosphorus / Total Nitrogen
L	**Metals**: Cadmium, Copper, Lead, and Zinc
No data	**Pathogens**: Coliform, Streptococci, E.Coli

OTHER CONSIDERATIONS

- Grass channels are generally well suited to a large number of applications and land uses.

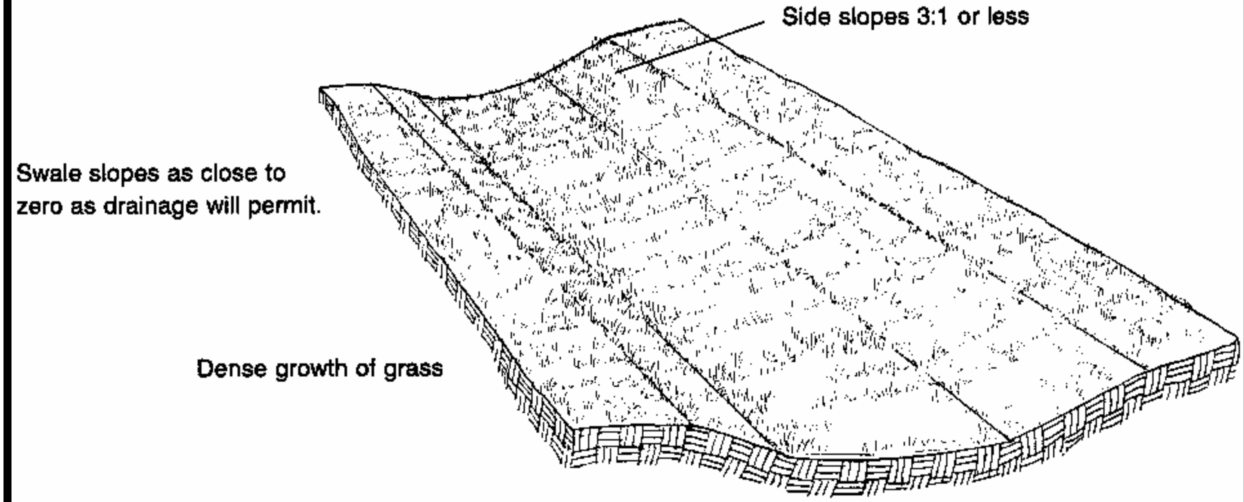
4.3.10.1 General Description

Grass channels, sometimes called biofilters, are conveyance channels that are designed to provide some treatment of runoff, as well as to slow down runoff velocities for treatment in other structural controls. Grass channels are appropriate for a number of applications including treating runoff from paved roads and from pervious areas.

In addition to their ability to provide a minimal level of filtration of pollutants, grass channels can partially infiltrate runoff from small storm events when they are located in areas that have suitable soils (types A, B, and sometimes C). When properly incorporated into a site's layout, grass channels can provide other ancillary benefits, such as reduction of impervious cover, accent of natural features and reduced construction and maintenance costs when compared with traditional extruded curb.

When designing a grass channel, the two primary considerations are channel capacity and minimization of erosion. The channel must be designed with a runoff velocity less than 1.0 foot per second during the peak discharge associated with the water quality design rainfall event, and the total length of a grass channel should provide at least 5 minutes of residence time. To enhance water quality treatment, grass channels must have broader bottoms, lower slopes and denser vegetation than most drainage channels. Additional treatment can be provided by placing check-dams across the channel below pipe inflows, and at various other points along the channel. Example schematics of grass channels are presented in Figures 4-43 and 4-44.

Figure 4-43. Typical Grass Channel

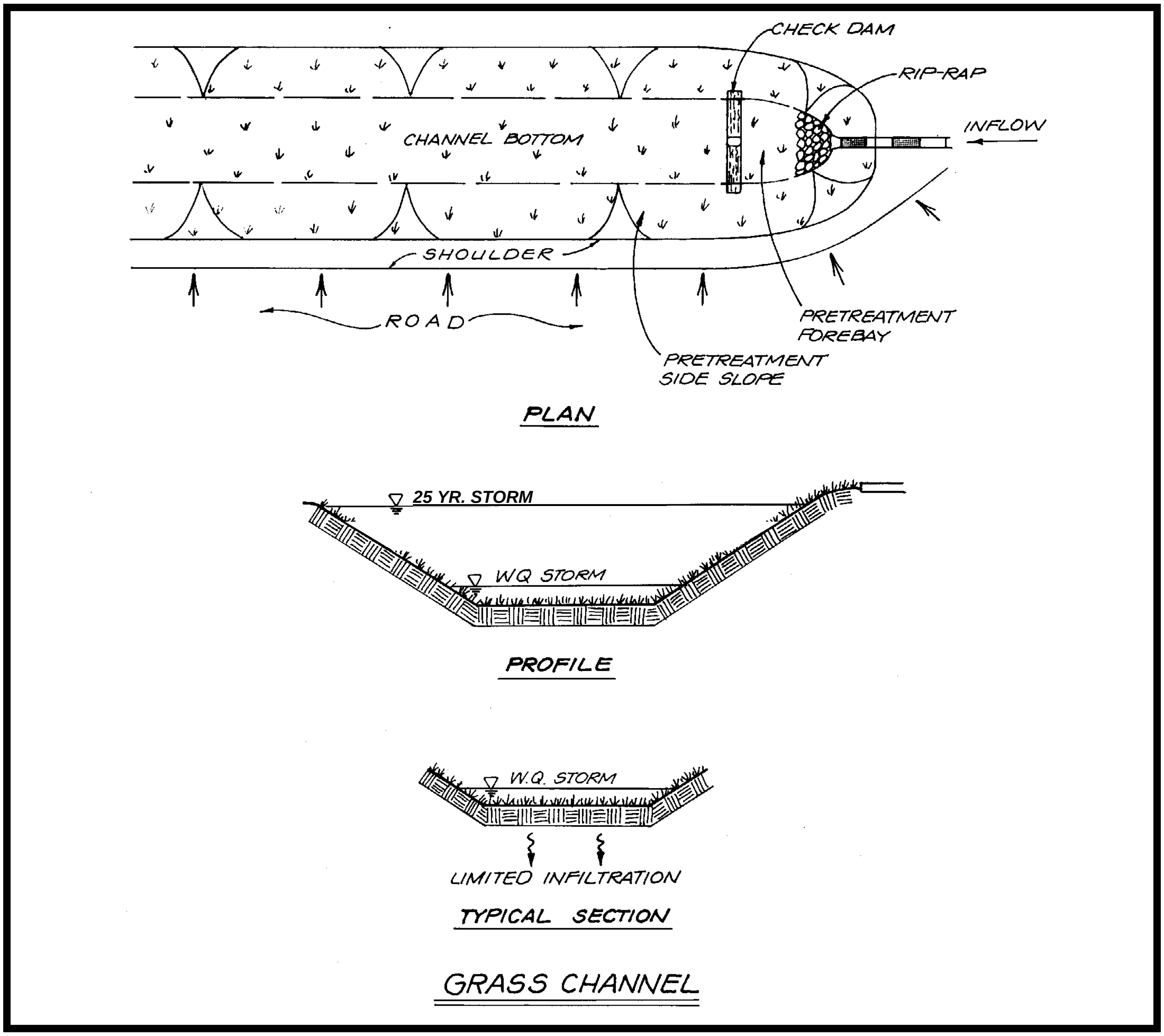


4.3.10.2 Stormwater Management Suitability

Grass channels are designed primarily for stormwater quality treatment and runoff conveyance and do not have the ability to provide channel protection or flood protection.

<u>Water Quality (WQv)</u>
To treat stormwater runoff, grass channels 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 reduction in runoff volume for smaller flows that infiltrate through pervious soils within the filter strip.

Figure 4-44. Typical Grass Channel (Plan and Profile Views)



Channel Protection (CPv), Overbank Flood Protection (up to Qp_{25}) and Extreme Flood Protection (Qp_{100})
Grass channels will not provide for channel protection, overbank or extreme flood protection. Another structural BMP, such as a wet pond that is designed to handle flood control, must be used in conjunction with the grass channel to achieve the CPv, Qp_2, Qp_{10}, Qp_{25} and Qp_{100} design criteria. However, grass channels are typically BMPs that are located "on-line", so they must be designed to withstand the full range of storm events without eroding.

4.3.10.3 Pollutant Removal Capabilities

Grass channels differ from enhanced swales (discussed in Section 4.3.8 of this manual) in that they do not have an engineered filter media to enhance pollutant removal capabilities. Because of this, grass channels have a lower pollutant removal rate than for a dry or wet (enhanced) swale.

The following design pollutant removal rates are based upon a grass channel that has sufficient length for a runoff residence time (in the channel) of at least 5 minutes. The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from sampling data, modeling and professional judgment. Grass channels with residence times less than five (5) minutes may be employed, but no water quality credit will be granted.

- Total Suspended Solids – 30%
- Total Phosphorus – 25%
- Total Nitrogen – 20%
- Pathogens – Insufficient data to provide a pollutant removal value
- Heavy Metals – 30%

4.3.10.4 Application and Feasibility Criteria

Grass channels can be used in a variety of development types. However, because of strict requirements for low slopes, grass channels will generally not be useful in developments that have steep topography.

General Feasibility

- Suitable for use in residential subdivisions and in non-residential areas.
- Can be used in high density/ultra-urban areas, but runoff velocity restrictions may preclude their use.
- Not suitable for use as a regional stormwater control due to small drainage area requirements.

4.3.10.5 Planning and Design Standards

The following standards shall be considered **minimum** design standards for the design of a grass channel. Grass channels that are not designed to these standards will not be approved. The Director shall have the authority to require additional design conditions if deemed necessary.

A. LOCATION AND SITING

- The drainage area (contributing or effective) for a grass channel shall be 5 acres or less. Runoff flows and volumes from larger drainage areas prevent proper filtration and infiltration of stormwater.
- Grass channels can be used on most soils. However, grass channels shall not be used for water quality treatment purposes on soils with infiltration rates less than 0.27 inches per hour.

B. PHYSICAL SPECIFICATIONS / GEOMETRY

The following specifications apply to grass channels that are designed to achieve a % TSS removal rate of 30%. The reader should refer to Volume 2, Chapter 7 for additional specifications and design information on runoff conveyance in open grass channels.

- Grass channels shall be designed on relatively flat slopes of less than 4%; channel slopes between 1% and 2% are recommended.
- A grass channel shall be designed to accommodate the peak flow for the water quality design storm, Q_{wq}, and the 2-year, 24-hour design storm without eroding (see Volume 2, Chapter 3) for more information on Q_{wq}). Larger flows should be accommodated by the channel if dictated by the surrounding conditions. For example, Knox County requires site drainage features to accommodate the 25-year design storm, and in some cases the 100-year storm.
- Grass channels shall have a trapezoidal or parabolic cross-section and shall have side slopes of 3:1 (horizontal:vertical) or flatter.
- For trapezoidal sections, the minimum width of the channel bottom shall be no less than 2 feet. The maximum width of the channel bottom shall be no greater than 6 feet. The minimum width ensures a minimum filtering surface for water quality treatment, and the maximum width prevents braiding, which is the formation of small channels within the swale bottom. The bottom width is a dependent variable in the calculation of velocity based on Manning's equation. If a larger channel is needed, the use of a compound cross section is recommended.
- The channel shall be designed to have a depth of flow no greater than 4-inches, for the WQv design flow. Depth of flow can be greater for the Cp_v, Qp_{25} and Qp_{100} flows.
- Runoff velocities carried in the channel must be non-erosive. The full-channel design velocity will typically govern. Runoff velocity must be less than 1.0 ft/sec for the WQv design flow.

- The channel shall be designed such that the water quality peak flow (Q_{wq}) is contained in the channel for no less than 5-minutes. This residence time may be increased by reducing the slope of the channel, increasing the wetted perimeter, or planting a denser grass (raising the Manning's "n"). Check dams can be utilized in the channel to maximize Q_{wq} retention time. However, the channel must not be designed to hold a permanent pool of standing water. Channel slope shall be sufficient to drain the channel if infiltration does not occur.
- The depth from the bottom of the channel to groundwater shall be at least 2 feet to prevent a moist swale bottom, or contamination of the groundwater.
- Designers should choose a grass that can withstand relatively high velocity flows at the entrances, and both wet and dry periods.

Grass Channels Used for Pretreatment:

- A number of other structural controls, including bioretention areas and infiltration trenches, may utilize a grass channel as a pretreatment measure. The length of the grass channel depends on the drainage area, land use, and channel slope. To be used as a pretreatment measure, the grass channel must have a minimum length of 20 feet. Table 4-10 provides minimum lengths for grass channels based on channel slope and percent imperviousness (of the contributing drainage area).

Table 4-10. Grass Channel Sizing Guidance

(Source: Georgia Stormwater Management Manual)

Parameter	≤ 33% Impervious		Between 34% and 66% Impervious		≥ 67% Impervious	
Slope (max = 4%)	≤ 2%	> 2%	≤ 2%	> 2%	≤ 2%	> 2%
Grass channel min. length (feet) assumes 2-ft bottom width	25	40	30	45	35	50

C. SPECIAL CONSIDERATIONS FOR THE AS-BUILT CERTIFICATION

- Like any other water quality BMP, the grass channel 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. The channel must be adequately vegetated.
  2. The channel flow velocities must not exceed 1.0 foot per second for the WQv design flow.
  3. A mechanism for overflow of large storm events must be provided.

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 grass channel 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 channel.

E. LANDSCAPING

- The vegetation in a grass channel shall be composed entirely of grasses that can withstand relatively high velocity flows at the entrances and periods of inundation and drought.

4.3.10.6 Design Example

Basic Data

Small commercial lot 300 feet deep x 145 feet wide

- Drainage area (A) = 1.0 acres
- Impervious percentage (I) = 70%
- Site slope (S) = 2%

Step 1: Calculate the Water Quality Peak 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):

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

Compute modified CN:

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

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:

$$Q_{wq} = q_u A\, Q_{wv} = (950 \text{ csm/in})\ (1.0\text{ac}/640\text{ac/mi}^2)\ (0.72\text{in}) = 1.07 \text{ cfs}$$

Step 2: Utilize Q_{wq} to Calculate the Minimum Channel Bottom Width

The maximum flow depth for water quality treatment should be approximately the same height of the grass. A maximum flow depth of 4 inches is allowed for water quality design. A maximum flow velocity of 1.0 foot per second for water quality treatment is required. For Manning's "n" use 0.15 for medium grass, 0.25 for dense grass, and 0.35 for very dense Bermuda-type grass.

Input variables: n = 0.15
S = 0.02 ft/ft
D = 4/12 = 0.33 ft

Then: $Q_{wq} = Q = VA = 1.49/n\ D^{2/3}\ S^{1/2}\ DW$

where: Q = peak flow (cfs)
V = velocity (ft/sec)
A = flow area (ft^2) = WD
W = channel bottom width (ft)
D = flow depth (ft) *(approximates the hydraulic radius for shallow flows)*
S = slope (ft/ft)

The above equation can be solved for the minimum channel bottom width (W), as follows:

$$(nQ)/(1.49\ D^{5/3}\ S^{1/2}) = W = (0.15*1.07)/(1.49*0.33^{5/3}*0.02^{1/2}) = 4.8 \text{ feet } \textit{(minimum width)}$$

The velocity of the water quality peak flow rate must be less than 1.0 feet per second (fps). Check this, as follows:

V = Q/(WD) *(where WD approximates the flow area, A, for shallow flows)*
V = 1.07/(4.0 * 4/12) = 0.80 fps *(Design confirmed: the velocity is < 1.0 fps.)*

Step 3: Calculate the Channel Length

The minimum length for a 5-minute (300 seconds) residence time is calculated as follows:

V = L/T

where:
V = velocity (ft/sec)
L = channel length (ft)
T = residence time (seconds)

The above equation can be solved for the minimum channel length (L), as follows:

L = (0.8)(5*60) = 240 feet

Depending on the site geometry, the width or the slope or density of grass (Manning's "n" value) can be adjusted to slow the velocity and shorten the channel within the design specifications discussed above.

Step 4: Complete the Grass Channel design for other design storms

Refer to Volume 2, Chapter 7 to complete the grass channel design for a specified design storm event.

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4.3.10.7 Maintenance Requirements and Inspection Checklist

Note: Section 4.3.10.7 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 grass channels 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 Director has the authority to impose additional maintenance requirements where deemed necessary.

This page provides guidance on maintenance activities that are typically required for grass channels, along with a suggested frequency for each activity. Individual grass channels 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 grass channels properly at all times.

Inspection Activities	Suggested Schedule
• Inspect check dams (if used) for clogging (i.e., standing water or sediment build-up). • Inspect vegetation for signs of erosion or un-vegetated areas. • Inspect to ensure that grass is healthy and well-established.	Annually (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)
• Remove trash, debris and sediment accumulated in the channel or behind check dams (if present). • Repair areas of erosion and re-vegetate. • Re-vegetate as need to maintain healthy vegetation.	As-needed

Knox County encourages the use of the inspection checklist presented below for guidance in the inspection and maintenance of the grass channel. The Director 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 channel. Questions regarding inspection and maintenance should be referred to the Knox County Department of Engineering and Public Works, Stormwater Management Division.

INSPECTION CHECKLIST FOR GRASS CHANNELS

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 check dams?		
Sediment build-up on channel bottom?		
Standing water for extended periods?		
Soggy channel bottom for extended periods?		
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)___________________________

4.3.10.8 References

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

AMEC. *Metropolitan Nashville and Davidson County Stormwater Management Manual Volume 4 Best Management Practices.* 2006.

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

4.3.10.9 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.

Horner, R.R. *Biofiltration Systems for Storm Runoff Water Quality Control.* Washington State Department of Ecology, 1988.

IEP. *Vegetated Buffer Strip Designation Method Guidance Manual.* Narragansett Bay Project, 1991.

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.