Grass Channel

Description: Limited application structural control intended for small drainage areas. Open channels that are vegetated and are designed to filter stormwater runoff through settling and biological uptake mechanisms, as well as to slow water for treatment by another structural control.

Components:

- Broad bottom channel on gentle slopes (4% or less)
- Gentle side slopes (3:1 (H:V) or less)
- Dense vegetation that assists in stormwater filtration
- Check dams can be installed to maximize treatment

Advantages/Benefits:

- Provides pretreatment if used as part of runoff conveyance system
- Provides partial infiltration of runoff in pervious soils
- Cost effective – less expensive than curb and gutter
- Good for small drainage areas
- Wildlife habitat potential

Disadvantages/Limitations:

- Potential for thermal impacts downstream
- Must be carefully designed to achieve low, non-erosive flow rates in the channel
- May re-suspend sediment
- May not be acceptable for some areas due to standing water in channels

Design considerations:

- Maximum drainage area of 5 acres
- Requires slopes of 4% or flatter
- Runoff velocities must be non-erosive
- Appropriate for all but the most impermeable soils
- Requires vegetation that can withstand both relatively high velocity flows and wet and dry periods
- Generally used in conjunction with downstream practices to increase runoff reduction
- Will not receive additional runoff reduction credit if more than one grass channel is used in a series

Selection Criteria:

Runoff Reduction Removal Credit:

Level 1 – 10 - 20% for HSG soils C and D

Level 2 – 20 - 30% for HSG Soils A and B

Land Use Considerations:

- [X] **Residential**
- [X] **Commercial**
- [X] **Industrial (with MWS approval)**

Maintenance:

- Monitor sediment accumulation and periodically clean out
- Inspect for and correct formation of rills and gullies
- Remove debris from inlet and outlet structures
- Maintain side slopes/remove invasive vegetation
- Ensure that vegetation is well-established

[L] **Maintenance Burden**
L = Low M = Moderate H = High

SECTION 1. DESCRIPTION

Grass channels 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 other impervious areas.

Grass channels can provide a modest amount of runoff filtering and volume attenuation within the stormwater conveyance system resulting in the delivery of less runoff and pollutants than a traditional system of curb and gutter, storm drain inlets and pipes. The performance of grass channels will vary depending on the underlying soil permeability as shown in **Table 8.1**. Grass channels, however, are not capable of providing the same stormwater functions as water quality swales as they lack the storage volume associated with the engineered soil media. Their runoff reduction performance can be increased when compost amendments are added to the bottom of the swale (See **Appendix 7-A, Downspout Disconnection GIP-07**). Grass channels are a preferable alternative to both curb and gutter and storm drains as a stormwater conveyance system, where development density, topography and soils permit.

SECTION 2. PERFORMANCE

Table 8.1. Runoff Volume Reduction Provided by Grass Channels[1]

Stormwater Function	Level 1 HSG Soils C and D		Level 2 HSG Soils A and B	
	No CA[2]	With CA	No CA[2]	With CA[3]
Runoff Volume Reduction (RR)	10%	20%	20%	30%[3]

[1] CSN (2008) and CWP (2007).

[2] CA= Compost Amended Soils, see GIP-07.

[3] Compost amendments are generally not applicable for A and B soils, although it may be advisable to incorporate them on mass-graded and/or excavated soils to maintain runoff reduction rates. In these cases, the 30% runoff reduction rate may be claimed, regardless of the pre-construction HSG.

SECTION 3: DESIGN TABLE

Grass channels must meet the minimum criteria outlined in **Table 8.2** to qualify for the indicated level of runoff reduction.

Table 8.2. Grass Channel Design Guidance

Design Criteria
The bottom width of the channel should be between 4 to 8 feet wide.
The channel side-slopes should be 3H:1 V or flatter.
The maximum total contributing drainage area to any individual grass channel is 5 acres.
The longitudinal slope of the channel should be no greater than 4%.
Check dams may be used to increase residence time.
The maximum flow velocity of the channel must be less than 1 foot per second during a 1-inch storm event.
The dimensions of the channel should ensure that flow velocity is non-erosive during the 2-year and 10-year design storm events and the 10-year design flow is contained within the channel (minimum of 6 inches of freeboard).
The vegetation used should be hardy and able to withstand relatively high velocities as well as a range of moisture conditions from very wet to dry.

SECTION 4: TYPICAL DETAILS

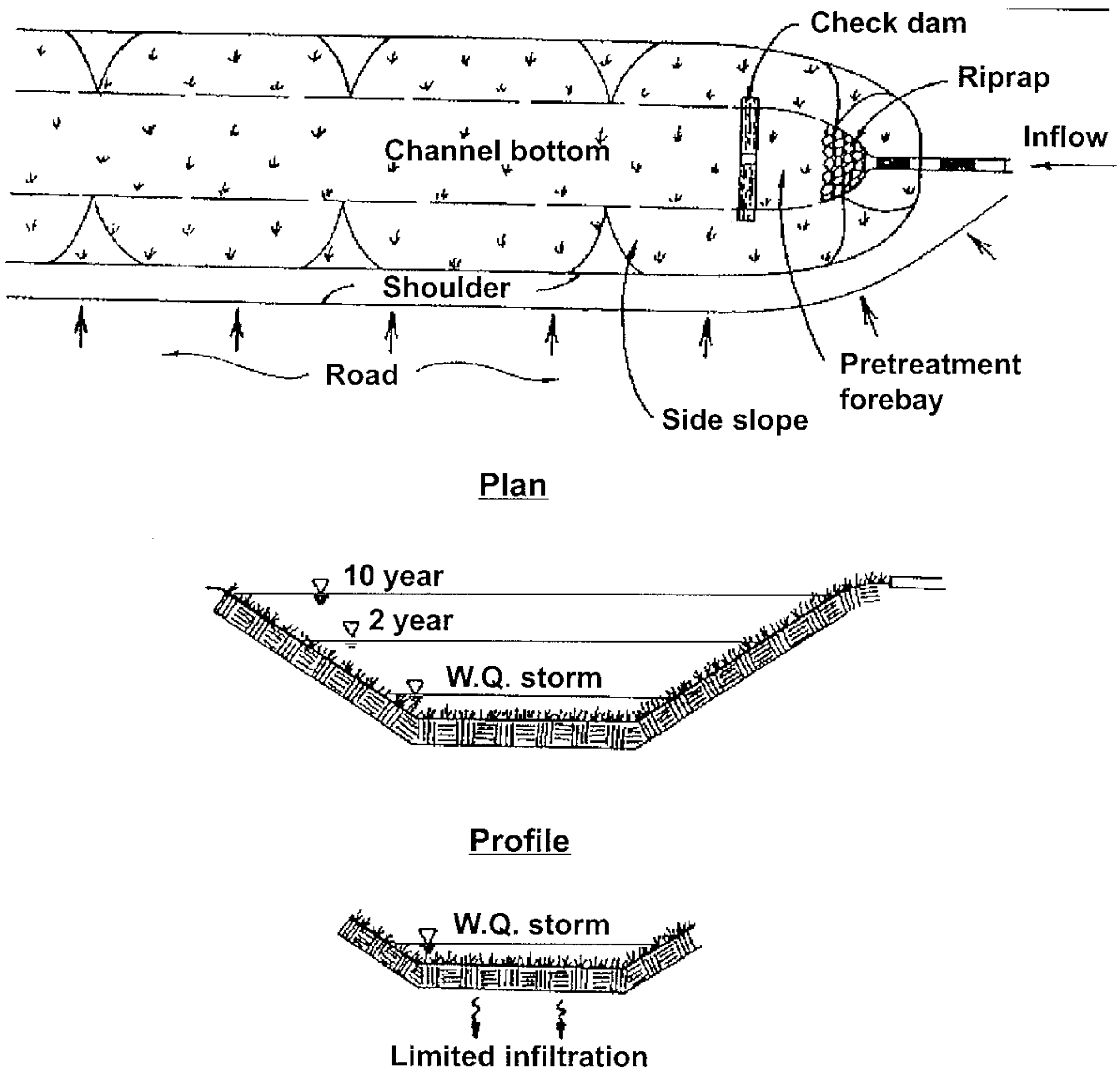

Figure 8.1. Grass Channel – Typical Plan, Profile and Section

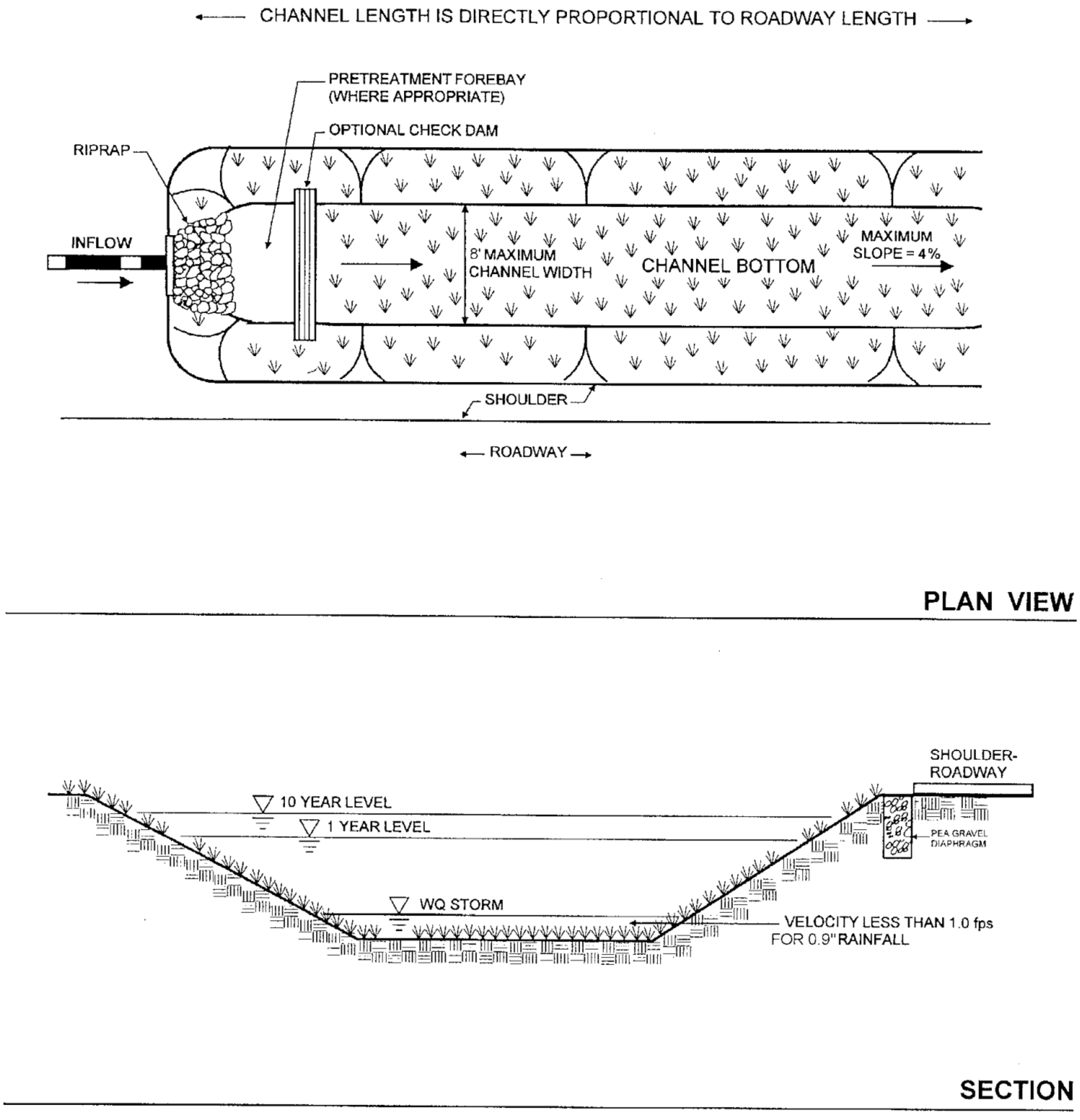

Figure 8.2. Grass Channel along Roadway – Typical Plan, Profile and Section (Source: VADCR, 2011)

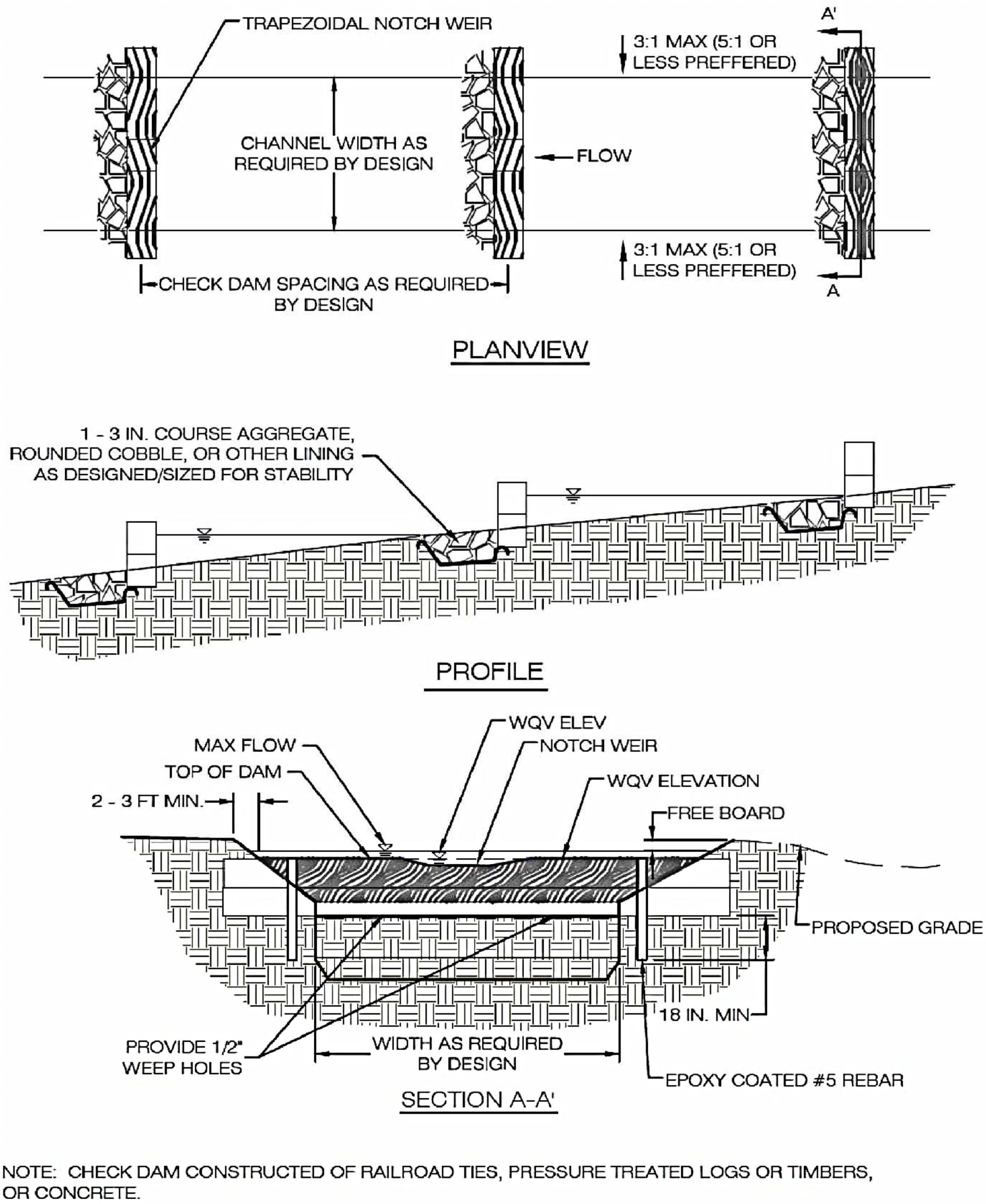

Figure 8.3 Grass Channel with Check Dams – Typical Plan, Profile, and Section

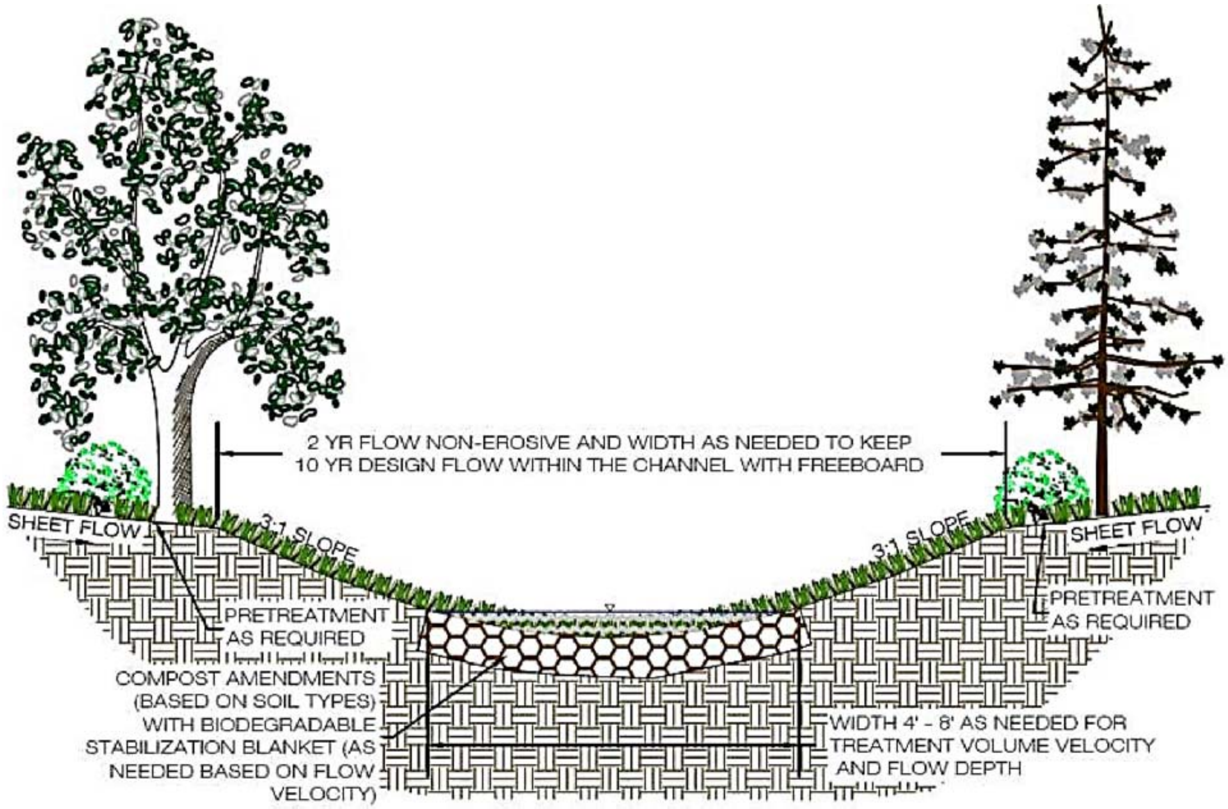

Figure 8.4: Grass Channel with Compost Amendments - Section

SECTION 5: PHYSICAL FEASIBILITY AND DESIGN APPLICATIONS

Grass channels can be implemented on development sites where development density, topography and soils are suitable. The linear nature of grass channels makes them well-suited to treat highway runoff, low and medium density residential road runoff and small commercial parking areas or driveways. However, a **Water Quality Swale (GIP-05)** will provide much greater runoff reduction and pollutant removal performance.

Key constraints for grass channels include:

Land Uses. Grass channels can be used in residential, commercial or institutional development settings. However, when grass channels are used for both conveyance and water quality treatment, they should be applied only in linear configurations parallel to the contributing impervious cover, such as roads and small parking areas. Grass channels within the right of way will only receive credit for treating stormwater generated within the right of way.

- Large commercial site applications may require multiple channels in order to effectively break up the drainage areas and meet the design criteria.
- The linear nature of grass channels makes them well suited to treat highway or low- and medium-density residential road runoff, if there is adequate right of way width and distance between driveways.

Contributing Drainage Area. The drainage area (contributing or effective) to a grass channel must be 5 acres or less. When grass channels treat and convey runoff from drainage areas greater than 5 acres, the velocity and flow depth through the channel becomes too great to treat runoff or prevent channel erosion.

Available Space. Grass channels can be incorporated into linear development applications (e.g., roadways) by utilizing the footprint typically required for an open section drainage feature. The footprint required will likely be greater than that of a typical conveyance channel (TDOT or equivalent). However, the benefit of the runoff reduction may reduce the footprint requirements for stormwater management elsewhere on the development site.

Longitudinal Slope. Grass channels should be designed on areas with slopes of less than 4%. Slopes steeper than 4% create rapid runoff velocities that can cause erosion and do not allow enough contact time for infiltration or filtering, unless check dams are used. Slopes of 1-2% are recommended, and slopes of less than 2% may eliminate the need for check dams. Channels designed with longitudinal slopes of less than 1% should be monitored carefully during construction to ensure a continuous grade, in order to avoid flat areas with pockets of standing water.

Soils. Grass channels can be used on most soils with some restrictions on the most impermeable soils. Grass channels situated on Hydrologic Soil Group C and D soils will require compost amendments in order to improve performance. Grass channels should not be used on soils with infiltration rates 0.5 inches per hour or less if infiltration of small runoff flow is intended.

Hydraulic Capacity. Grass channels are an on-line practice and must be designed with enough capacity to convey runoff from the 10-year design storm event within the channel banks and be non-erosive during both the 2-year and 10-year design storm events. This means that the much of the surface dimensions are driven by the need to pass these larger storm events. Larger flows should be accommodated by the channel if dictated by the surrounding conditions. For instance, Metro requires site drainage to accommodate the 10-year design storm. The channel should accommodate the 2-year, 24-hour storm without eroding.

Depth to Water Table. Designers should ensure that the bottom of the grass channel is at least 2 feet above the seasonally high water table to prevent a moist swale bottom and ensure that groundwater does not intersect the filter bed and possibly lead to groundwater contamination or practice failure.

Utilities. Designers should consult local utility design guidance for the horizontal and vertical clearance between utilities and the channels. Typically, utilities can cross grass channels if they are specially protected (e.g., double-casing) or are located below the channel invert. Tennessee One Call (811) should be contacted before digging onsite begins.

Minimum Setbacks. Grass channels should be set back at least 10 feet down-gradient from building foundations, 50 feet from septic system fields and 100 feet from private wells.

SECTION 6: DESIGN CRITERIA

6.1 Sizing of Grass Channels

Unlike other stormwater practices, grass channels are designed based on a peak rate of flow. Designers must demonstrate channel conveyance and treatment capacity in accordance with the following guidelines:

- The longitudinal slope of the channel should ideally be between 1% and 2% in order to avoid scour and short-circuiting within the channel. Longitudinal slopes up to 4% are acceptable; however, check dams will likely be required in order to meet the allowable maximum flow velocities.
- A minimum residence time is of five minutes is required.
    - Hydraulic capacity should be verified using Manning's Equation or an accepted equivalent method, such as erodibility factors and vegetal retardance.
    - The Flow Depth for the peak treatment volume should be maintained at 3 inches or less.
    - Manning's "n" value for grass channels should be 0.2 for flow depths up to 4 inches, decreasing to 0.03 at a

depth of 12 inches (which would apply to the 2-year and 10-year storms if an on-line application – NOVA, 2007; Haan et. al, 1994).
  - Peak Flow Rates for the 2-year and 10-year frequency storms must be non-erosive, and the 10-year peak flow rate must be contained within the channel banks (with a minimum of 6 inches of freeboard).

- Larger flows should be accommodated by the channel if dictated by the surrounding conditions. For instance, Metro requires site drainage to accommodate the 10-year design storm.
- Calculations for peak flow depth and velocity should reflect any increase in flow along the length of the channel, as appropriate. If a single flow is used, the flow at the outlet should be used.
- The minimum length may be achieved with multiple swale segments connected by culverts with energy dissipaters.

Table 8.3: Maximum Permissible Velocities for Grass Channels

Cover Type	Erosion Resistant Soils (ft./sec.)	Easily Eroded Soils (ft./sec.)
Bermuda grass	6	4.5
Kentucky bluegrass Tall fescue	5	3.8
Grass-legume mixture	4	3
Kentucky blue grass Tall fescue	3	2.3
Red fescue	2.5	1.9

Sources: VADCR (1992), Ree (1949), Temple et al (1987)

6.2 Geometry and Site Layout

- Grass channels should generally be aligned adjacent to and the same length (minimum) as the contributing drainage area identified for treatment.
- Grass channels should be designed with a trapezoidal or parabolic cross section with relatively flat side slopes. A parabolic shape is preferred for aesthetic, maintenance and hydraulic reasons.
- The bottom width of the channel should be between 2 to 8 feet wide. If a channel will be wider than 8 feet, the designer should incorporate benches, check dams, level spreaders or multi-level cross sections to prevent braiding and erosion along the channel 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.
- Grass channel side slopes should be no steeper than 3 H:1 V for ease of mowing and routine maintenance. Flatter slopes are encouraged, where adequate space is available, to aid in pretreatment of sheet flows entering the channel.

6.3 Check dams

Check dams may be used for pre-treatment, to break up slopes, and to increase the hydraulic residence time in the channel. Design requirements for check dams are as follows:

- Check dams should be spaced based on the channel slope, as needed to increase residence time, provide T_v storage volume, or any additional volume attenuation requirements. The ponded water at a downhill check dam should not touch the toe of the upstream check dam.
- The maximum desired check dam height is 12 inches (for maintenance purposes). The average ponding depth throughout the channel should be 12 inches.
- Armoring may be needed at the downstream toe of the check dam to prevent erosion.

- Check dams must be firmly anchored into the side-slopes to prevent outflanking; check dams must also be anchored into the channel bottom so as to prevent hydrostatic head from pushing out the underlying soils.
- Check dams must be designed with a center weir sized to pass the channel design storm peak flow (10-year storm event for man-made channels).
- The check dam should be designed so that it facilitates easy mowing.
- Each check dam should have a weep hole or similar drainage feature so it can dewater after storms.
- Check dams should be composed of wood, concrete, stone, or other non-erodible material, or should be configured with elevated driveway culverts.
- Individual channel segments formed by check dams or driveways should generally be at least 25 to 40 feet in length.

6.4 Compost Soil Amendments

Soil compost amendments serve to increase the runoff reduction capability of a grass channel. The following design criteria apply when compost amendments are used:

- The compost-amended strip should extend over the length and width of the channel bottom, and the compost should be incorporated to a depth as outlined in **Appendix A** of **GIP-07 – Downspout Disconnection**.
- The amended area will need to be rapidly stabilized with grass.
- Depending on the slope of the channel, it may be necessary to install a protective biodegradable geotextile fabric to protect the compost-amended soils. Care must be taken to consider the erosive characteristics of the amended soils when selecting an appropriate geotextile.
- For redevelopment or retrofit applications, the final elevation of the grass channel (following compost amendment) must be verified as meeting the original design hydraulic capacity.

6.5 Planting Grass Channels

Designers should choose grass species that can withstand both wet and dry periods as well as relatively high-velocity flows within the channel. For applications along roads and parking lots, salt tolerant species should be chosen. Taller and denser grasses are preferable, though the species of grass is less important than good stabilization.

Grass channels should be seeded at such a density to achieve a 90 % turf cover after the second growing season. Performance has been shown to fall rapidly as vegetative cover falls below 80%.Grass channels should be seeded and not sodded. Seeding establishes deeper roots and sod may have muck soil that is not conducive to infiltration (Storey et. al., 2009). Grass channels should be protected by a biodegradable erosion control fabric to provide immediate stabilization of the channel bed and banks.

6.6 Grass Channel Material Specifications

The basic material specifications for grass channels are outlined in **Table 8.4** below.

Table 8.4. Grass Channel Materials Specifications	
Component	**Specification**
Grass	A dense cover of water-tolerant, erosion-resistant grass. The selection of an appropriate species or mixture of species is based on several factors including climate, soil type, topography and sun or shade tolerance. Grass species should have the following characteristics: a deep root system to resist scouring; a high stem density with well-branched top growth; water-tolerance; resistance to being flattened by runoff; an ability to recover growth following inundation; and, if receiving runoff from roadways, salt-tolerance.
Check Dams	• Check dams should be constructed of a non-erosive material such as wood, gabions, riprap or concrete. All check dams should be underlain with filter fabric conforming to local design standards. • Wood used for check dams should consist of pressure treated logs or timbers, or water-resistant tree species such as cedar, hemlock, swamp oak or locust. • Computation of check dam material is necessary, based on the surface area and depth used in the design computations. (see http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/Introduction_App%20A_Earthen%20Embankments_SCraftonRev_03012011.pdf).
Diaphragm	Pea gravel used to construct pre-treatment diaphragms should consist of washed, open-graded, course aggregate between 3 and 10 mm in diameter and must conform to local design standards.
Erosion Control Fabric	Where flow velocities dictate, biodegradable erosion control netting or mats that are durable enough to last at least two growing seasons must be used.
Filter Fabric (check dams)	Needled, non-woven, polypropylene geotextile meeting the following specifications: Grab Tensile Strength (ASTM D4632): > 120 lbs Mullen Burst Strength (ASTM D3786): > 225 lbs./sq. in. Flow Rate (ASTM D4491): > 125 gpm/sq. ft. Apparent Opening Size (ASTM D4751): US #70 or #80 sieve

SECTION 7: SPECIAL CASE DESIGN ADAPTATIONS

7.1 Steep Terrain

Grass swales are not practical in areas of steep terrain, although terracing a series of grass swale cells may work on slopes from 5% to 10%. The drop in elevation between check dams should be limited to 18 inches in these cases, and the check dams should be armored on the down-slope side with suitably sized stone to prevent erosion.

SECTION 8: CONSTRUCTION

8.1 Construction Sequence

The following is a typical construction sequence to properly install a grass channel, although steps may be modified to reflect different site conditions. Grass channels should be installed at a time of year that is best to establish turf cover without irrigation.

Step 1: Protection during Site Construction. Ideally, grass channels should remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment. However, this is seldom practical, given that the channels are a key part of the drainage system at most sites. In these cases, temporary EPSC such as dikes, silt fences and other erosion control measures should be integrated into the swale design throughout the construction sequence. Specifically, barriers should be installed at key check dam locations, and erosion control fabric should be used to protect the channel.

Step 2. Grass channel installation may only begin after the entire contributing drainage area has been stabilized with vegetation. Any accumulation of sediments that does occur within the channel must be removed during the final stages of grading to achieve the design cross-section. EPSC for construction of the grass channel should be installed as specified in the erosion and sediment control plan. Stormwater flows must not be permitted into the grass channel until the bottom and side slopes are fully stabilized.

Step 3. Grade the grass channel to the final dimensions shown on the plan.

Step 4. Install check dams, driveway culverts and internal pre-treatment features as shown on the plan. Fill material used to construct check dams should be placed in 8- to 12-inch lifts and compacted to prevent settlement. The top of each check dam should be constructed level at the design elevation.

Step 5 (Optional). Till the bottom of the channel to a depth of 1 foot and incorporate compost amendments according to **Appendix 7-A** of **GIP 07 – Downspout Disconnection**.

Step 6. Add soil amendments as needed, hydro-seed the bottom and banks of the grass channel, and peg in erosion control fabric or blanket where needed. After initial planting, a biodegradable erosion control fabric should be used, conforming to soil stabilization blanket and matting requirements found in MA–1 of the Tennessee Erosion and Sediment Control Handbook.

St*ep 7.* Prepare planting holes for any trees and shrubs, then plant materials as shown in the landscaping plan and water them weekly in the first two months. The construction contract should include a Care and Replacement Warranty to ensure vegetation is properly established and survives during the first growing season following construction.

Step 8. Conduct the final construction inspection and develop a punch list for facility acceptance.

8.2 Construction Inspection

Inspections during construction are needed to ensure that the grass channel is built in accordance with these specifications. Some common pitfalls can be avoided by careful post-storm inspection of the grass channel:

- Make sure the desired coverage of turf or erosion control fabric has been achieved following construction, both on the channel beds and their contributing side-slopes.
- Inspect check dams and pre-treatment structures to make sure they are at correct elevations, are properly installed, and are working effectively.
- Make sure outfall protection/energy dissipation at concentrated inflows are stable.

The real test of a grass channel occurs after its first big storm. Minor adjustments are normally needed as part of this post-storm inspection (e.g., spot reseeding, gully repair, added armoring at inlets or realignment of outfalls and check dams).

SECTION 9: MAINTENANCE

9.1 Maintenance Document

The requirements for the Maintenance Document are in Appendix C of Volume 1 of the Manual. They include the execution and recording of an Inspection and Maintenance Agreement or a Declaration of Restrictions and Covenants, and the development of a Long Term Maintenance Plan (LTMP) by the design engineer. The LTMP contains a description of the stormwater system components and information on the required inspection and maintenance activities. The property owner must submit annual inspection and maintenance reports to MWS.

Maintenance requirements for grass channels include the following:

1. Maintain grass height of 3 to 4 inches.
2. Remove sediment build up in channel bottom when it accumulates to 25% of original total channel volume.
3. Ensure that rills and gullies have not formed on side slopes. Correct if necessary.
4. Remove trash and debris build up.
5. Replant areas where vegetation has not been successfully established.

All grass channels must be covered by a drainage easement to allow inspection and maintenance. If a grass channel is located in a residential private lot, the existence and purpose of the grass channel shall be noted on the deed of record.

9.2 Ongoing Maintenance

Once established, grass channels have minimal maintenance needs outside of the spring cleanup, regular mowing, repair of check dams and other measures to maintain the hydraulic efficiency of the channel and a dense, healthy grass cover.

Table 8.5 Suggested Spring Maintenance Inspections/Cleanups for Grass Channels[1]

Activity
Add reinforcement planting to maintain 90% turf cover. Reseed any dead vegetation.
Remove any accumulated sand or sediment deposits behind check dams.
Inspect upstream and downstream of check dams for evidence of undercutting or erosion, and remove and trash or blockages at weepholes.
Examine channel bottom for evidence of erosion, braiding, excessive ponding or dead grass.
Check inflow points for clogging and remove any sediment.
Inspect side slopes and grass filter strips for evidence of any rill or gully erosion and repair.
Look for any bare soil or sediment sources in the contributing drainage area and stabilize immediately.

[1] Source: VADCR (2011)

SECTION 10. AS-BUILT REQUIREMENTS

10.1 Grass Channel as Pretreatment

A number of structural controls such as bioretention areas and infiltration trenches may be supplemented by a grass channel that serves as pretreatment for runoff flowing to the device. The lengths of grass channels vary based on the drainage area imperviousness and slope. Channels must be no less than 20 feet long. **Table 8.6** below gives the minimum lengths for grass channels based on slope and percent imperviousness.

Table 8.6 Grass Channel Length Guidance[1]						
Parameter	**<=33% Impervious**		**Between 34% and 66% Impervious**		**>=67% Impervious**	
Slope (max = 4%)	< 2%	> 2%	< 2%	> 2%	< 2%	> 2%
Grass channel minimum length (feet)[2]	25	40	30	45	35	50

[1] Source: ARC (2001)
[2] Assumes 2-foot bottom width

After the grass channel has been constructed, an as-built certification of the grass channel must be prepared by a registered Professional Engineer and submitted to Metro. The as-built certification verifies that the BMP was installed as designed and approved.

The following components must be addressed in the as-built certification:

1. The channel must be adequately vegetated.
2. The water quality channel flow velocity must not exceed 1.0 foot per second.
3. A mechanism for overflow for large storm events must be provided.

SECTION 11: ROADWAY APPLICATION

Grass-lined channels have been widely used in roadway drainage systems for many years. They are easily constructed and maintained and work well in a variety of climates and soil conditions. Grass channels are applicable to:

- Major Thoroughfares (Interstates and Other Freeways)
- Major Urban Streets (Principal Arterials, Minor Arterials and Collectors)
- Local Roads

Grass channels within the right of way will only receive credit for treating water from within the right of way.

Figure 8.5: Typical Grass Channel

Figure 8.6: Roadside Channel in Spokane, WA (VADCR, 2011)

SECTION 12: REFERENCES

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