# 14. Grassed Swale

**Description**:
A water quality grassed swale is a shallow open-channel drainageway stabilized with grass or other herbaceous vegetation that is designed to filter pollutants.

**Curb Outlet Systems for Low Density Projects**

| Regulatory Credits | | Feasibility Considerations | |
|---|---|---|---|
| *Pollutant Removal* | | | |
| 0% | Total Suspended Solids | Small | Land Requirement |
| 0% | Nitrogen | Small | Cost of Construction |
| 0% | Phosphorus | Small | Maintenance Burden |
| *Water Quantity* | | Small | Treatable Basin Size |
| no | Peak Runoff Attenuation | Some | Possible Site Constraints |
| no | Runoff Volume Reduction | | |

**Swales Seeking Pollutant Credit ("For-Credit" Swales)***

| Regulatory Credits | | Feasibility Considerations | |
|---|---|---|---|
| *Pollutant Removal* | | | |
| 35% | Total Suspended Solids | Small | Land Requirement |
| 20% | Nitrogen | Small | Cost of Construction |
| 20% | Phosphorus | Small | Maintenance Burden |
| *Water Quantity* | | Small | Treatable Basin Size |
| no | Peak Runoff Attenuation | Some | Possible Site Constraints |
| no | Runoff Volume Reduction | | |

**Conveyance Swales *Not* Seeking Pollutant Credit***

| Regulatory Credits | | Feasibility Considerations | |
|---|---|---|---|
| *Pollutant Removal* | | | |
| 0% | Total Suspended Solids | Small | Land Requirement |
| 0% | Nitrogen | Small | Cost of Construction |
| 0% | Phosphorus | Small | Maintenance Burden |
| *Water Quantity* | | Small | Treatable Basin Size |
| no | Peak Runoff Attenuation | Some | Possible Site Constraints |
| no | Runoff Volume Reduction | | |

*May include roadside swales, lot line swales, and primary outlet swales

- Roadside swales: These swales are usually on both sides of a road. They are typically interconnected with cross pipes, and empty into a primary outlet swale(s) carrying runoff off site. These swales often collect runoff from lot line swales, and therefore carry heavy hydraulic and pollutant loads.
- Lot line swales: These swales are usually located between houses and run the length of the lot. They typically receive sheet flow from lots, and flow directed from gutters.
- Primary outlet swales: These swales usually collect drainage from roadside swales and lot line swales, though they are sometimes located along lot lines. Because of the heavy hydraulic load, they are usually deeper, wider, and longer than roadside or lot line swales. These swales usually serve the same function as low-density curb outlet swales.

| Advantages | Disadvantages |
|---|---|
| – Can reduce the use of costly development infrastructure, e.g., curb and gutter.<br>– Can be aesthetically pleasing.<br>– Low-slope swales can create wetland areas.<br>– Unmowed systems not adjacent to roadways can provide valuable "wet meadow" habitat. | – Could be subject to standing water and mosquito infestations.<br>– May be subject to channelization due to concentrated flows.<br>– Low pollutant removal rates and essentially no volume control. Must be used with other BMPs to meet most stormwater rule requirements. |

## Major Design Elements

### All Swales

| | |
|---|---|
| **Required by the NC Administrative Rules of the Environmental Management Commission.** Other specifications may be necessary to meet the stated pollutant removal requirements. | |
| 1 | Sizing shall take into account all runoff at ultimate build-out including off-site drainage. |
| 2 | BMP shall be located in a recorded drainage easement with a recorded access easement to a public ROW. |
| 3 | The design must non-erosively pass the peak runoff rate for the 10-year storm. |
| 4 | Where practicable, the maximum longitudinal slope shall be 5%. |
| **Required by DWQ policy.** These are based on available research, and represent what DWQ considers necessary to achieve the stated removal efficiencies. | |
| 5 | Swales shall convey the design discharge while maintaining a 0.5-foot freeboard and without exceeding the maximum permissible velocity. |

## Major Design Elements (Continued)

**Curb Outlet Swales for Low Density Projects**

| | |
|---|---|
| **Required by the NC Administrative Rules of the Environmental Management Commission.** Other specifications may be necessary to meet the stated pollutant removal requirements. | |
| 1 | The maximum velocity shall be as specified in the NC Erosion and Sediment Control Manual (and replicated in this document, Table 14-2). |
| 2 | Side slopes shall be no steeper than 5:1. |
| 3 | Swale length shall be 100 ft or greater. |
| **Required by DWQ policy.** These are based on available research, and represent what DWQ considers necessary to achieve the stated removal efficiencies. | |
| 4 | A maintenance agreement is required. |
| 5 | Curb outlet swales shall have a 1-ft minimum distance from the bottom of the swale to the seasonal high water table (SHWT). |

**Swales Seeking Pollutant Removal Credit ("For-Credit" Swales)**

| | |
|---|---|
| **Required by DWQ policy.** These are based on available research, and represent what DWQ considers necessary to achieve the stated removal efficiencies. | |
| 1 | The maximum velocity shall be 1 ft/sec for the 10-year storm.. |
| 2 | Side slopes shall be no steeper than 5:1. |
| 3 | A maintenance agreement is required. |
| 4 | Swale length shall be 150 ft or greater. |
| 5 | Swales shall have a 1-ft minimum distance from the bottom of the swale to the seasonal high water table (SHWT). |

**Conveyance Swales *Not* Seeking Pollutant Removal Credit**

| | |
|---|---|
| **Required by the NC Administrative Rules of the Environmental Management Commission.** Other specifications may be necessary to meet the stated pollutant removal requirements. | |
| 1 | Side slopes shall be no steeper than 3:1. |
| **Required by DWQ policy.** These are based on available research, and represent what DWQ considers necessary to achieve the stated removal efficiencies. | |
| 2 | The maximum velocity shall be as specified in the NC Erosion and Sediment Control Manual (and replicated in this document, Table 14-2). |

| | |
|---|---|
| 3 | The majority of the bottom of the conveyance swale shall be above the seasonal high water table (SHWT), but not necessarily 1-ft of separation. |

## General Characteristics and Purpose

Grassed swales are typically long open drainage channels integrated into the surrounding development or landscape that are lined with grass or other vegetation. They are often used in residential and commercial developments as well as along highway medians as alternatives or enhancements to conventional storm sewers (see Figure 14-1). Swales are suitable for many types of development, but are most practical for campus-type developments and single-family residential sites.

**Figure 14-1**
Grassed Swale in Residential Area, Pembroke Woods Subdivision in Emmittsburg, MD
(Courtesy of Mike Clar, Ecosite, Inc., Columbia, MD)

Swales remove pollutants from stormwater by biofiltration, settling, and infiltration. Grassed swales filter pollutants as stormwater runoff moves through the leaves and roots of the grass. By reducing flow velocities and increasing a site's time of concentration, grassed swales contribute to reducing runoff peaks. Grassed swales that are designed with check dams or incorporate depression storage promote infiltration and can help contribute to satisfying a site runoff capture/storage requirement.

The effectiveness of a swale in both reducing the flow rates and volume of runoff, and removing pollutants, is a function of the size and composition of the drainage area, the slope and cross section of the channel, the permeability of the soil, the density and type of vegetation in the swales, and the swale dimensions. Broad swales on flat slopes with dense vegetation are the most effective. Removal efficiencies are highest for sediment-bound pollutants.

Figures 14-2 through 14-4 show examples of grassed swales used for primary drainage of residential subdivisions, parking lots, and commercial developments, respectively. Figure 14-5 shows a more detailed sketch of swales in a parking lot, as well as optional raised storm sewer inlets.

**Figure 14-2**

Schematic of Plan for Retrofit of Grassed Swales in Residential Subdivision

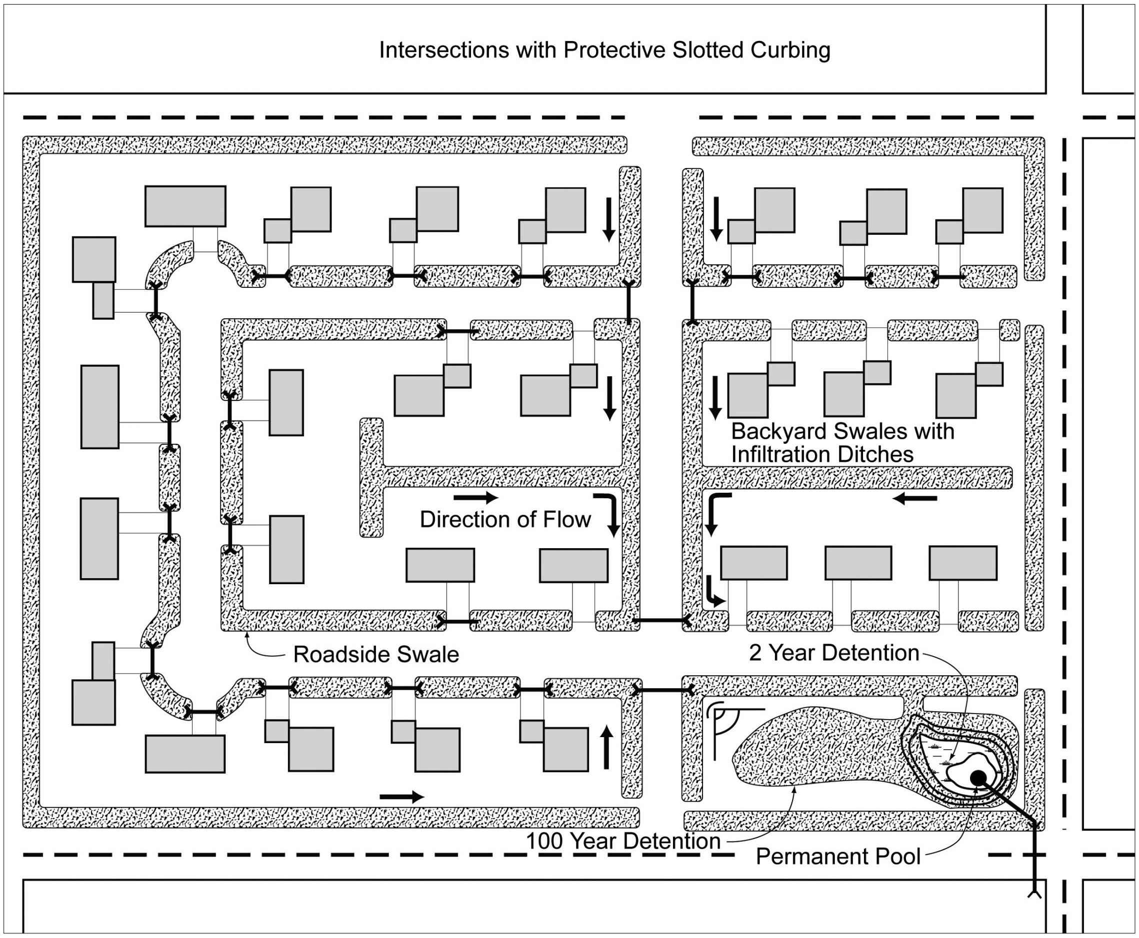


**Figure 14-3**
Example of Grassed Swale Used for Parking Lot

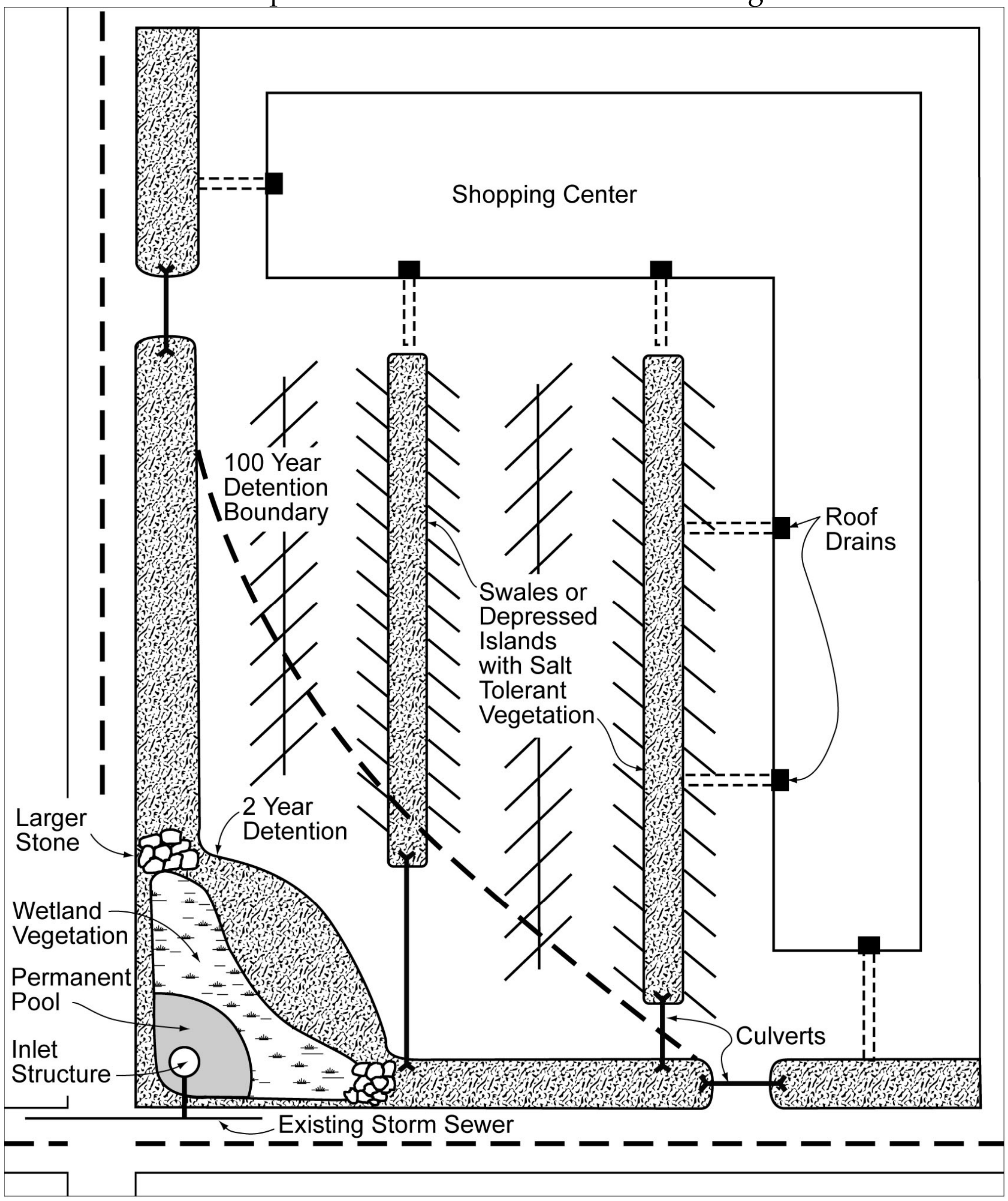


**Figure 14-4**
Schematic Showing Use of Grassed Swale for Primary Drainage of Commercial Development

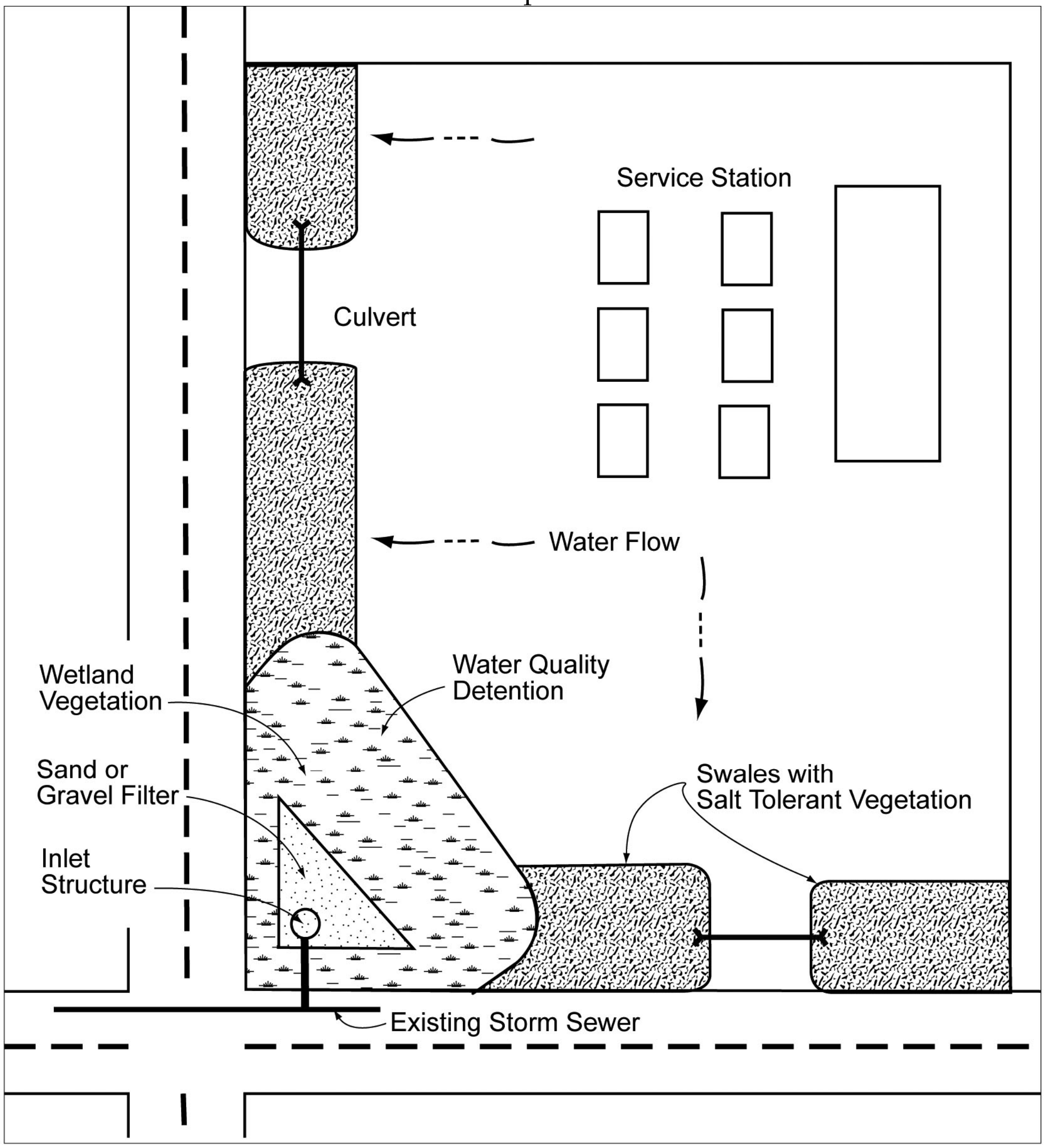
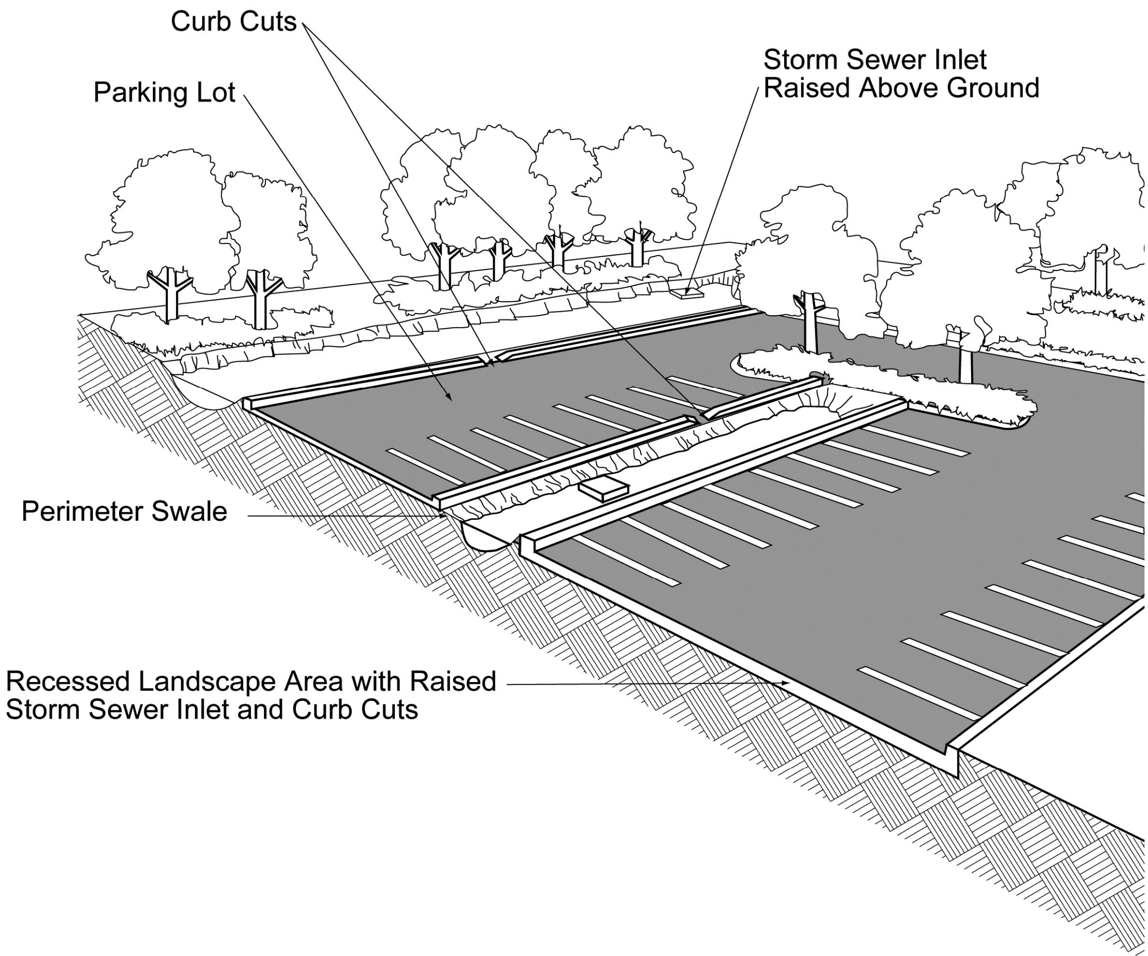


**Figure 14-5**
Parking Lot Swale Drainage (from NIPC, 1993).




## 14.1. Meeting Regulatory Requirements

A listing of the major design elements is provided on the first page of this section.

*Types of grassed swales*
There are three types of grassed swales addressed in this chapter. The design requirements and the credit granted is specific to the type of grassed swale designed. Designers who wish to get credit for TN, TP, and TSS for curb outlet systems for low-density projects must meet both sets of requirements. Where these requirements conflict, the more stringent requirement takes precedence.

- Curb Outlet Systems for Low Density Projects: Swales designed into these systems are intended to convey stormwater through low-density projects as outlined in NCAC 15A 02B .1008(g).
- Swales Seeking Pollutant Credit ("For-Credit" Swales): These swales are intended to be mechanisms for pollutant removal. They may include roadside swales, lot line swales, and primary outlet swales

- Conveyance Swales *Not* Seeking Pollutant Credit: These swales are not intended to be mechanisms for pollutant removal. They may include roadside swales, lot line swales, and primary outlet swales. Water in swales meeting the requirements for this design is allowed to travel through the swale faster and the side slopes are allowed to be steeper than for swales that seek pollutant removal credit.

*Pollutant Removal Calculations*
The pollutant removal calculations for grassed swales are as described in Section 3.4, and use the pollutant removal rates shown at the beginning of this Section. Construction of a grassed swale also passively lowers nutrient loading since it is counted as pervious surface when calculating nutrient loading.

*Volume Control Calculations*
A grassed swale typically does not provide any active volume capture or peak flow attenuation. A grassed swale provides some passive volume control capabilities by providing pervious surface and therefore reducing the total runoff volume to be controlled. In addition, a grassed swale can be constructed with check dams, depression storage, etc., that can provide a small amount of volume control.

## 14.2. Design

The design of a grassed swale must comply with the requirements outlined in this section, and appropriate local channel design provisions. A diagram of the grassed swale requirements is provided in Figure 14-6. If a swale is trapezoidal, having the bottom of the swale two or more feet wide is recommended for maintenance purposes.

### 14.2.1. Converting Sediment and Erosion Control Devices

Swales are often used as part of the site construction sediment and erosion control plan. The same swales can be later used as grassed swale BMPs, however, all of the sediment must be removed, the channel configuration and slope must be re-established (if necessary), and the proper vegetation must be established.

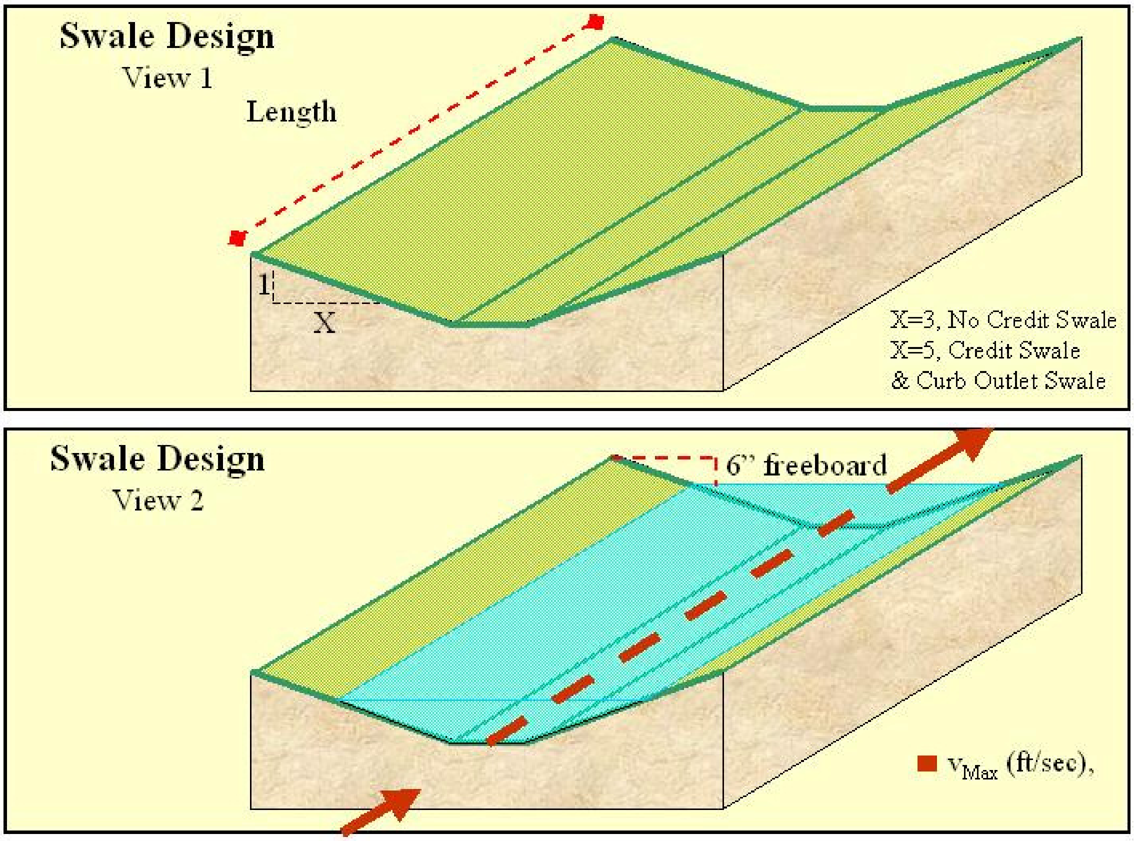
### 14.2.2. Siting Issues

The location of swales should be based on site topography and natural features. Where possible, natural drainage ways on the site should be maintained and integrated into the swale drainage system.

**With the exception of conveyance swales**, swales should always be sited in areas where the seasonal high water table (SHWT) is at least 1 foot below the bottom of the swale. If the SHWT is less than 1 foot below the bottom of the swale, the swale will likely be chronically wet. Swales should not carry dry-weather flows or constant flows. Note that even for conveyance swales, the majority of the bottom of the swale should be above the SHWT.

Sites with steep slopes can be can be difficult to design due resulting high velocities of flow. Roadside swales may pose traffic hazards in residential subdivisions. Shallow swales and curbs with diversion devices can help alleviate this problem.

**Figure 14-6**
Diagram of Water Quality Grassed Swale Requirements




### 14.2.3. Contributing Drainage Basin

There are no minimum or maximum size requirements on the drainage basin for a grassed swale. A swale serving a tributary area more than 10 or 20 acres, or with very high impermeable surface percentages, can be difficult to design due to high volumes of flow and/or high velocities of flow.

### 14.2.4. Swale Design

The swale should be designed as either a curb and gutter system for a low-density project or as a water treatment swale. The requirements are outlined under Major Design Elements at the beginning of this chapter. Curb and gutter designs that also seek pollutant removal credit shall meet the requirements of both designs. Where requirements conflict, the more stringent requirement takes precedence. See Table 14-1 for a summary of the design requirements.

**Table 14-1**
Summary of Swale Design Requirements

| | Curb Outlet | "For-Credit" Swale | Conveyance Swale (*Not* Seeking Credit) |
|---|---|---|---|
| Sizing shall take into account all runoff at ultimate build-out including off-site drainage. | X | X | X |
| BMP shall be located in a recorded drainage easement with a recorded access easement to a public ROW. | X | X | X |
| The design must non-erosively pass the peak runoff rate for the 10-year storm. | X | X | X |
| The treatment volume shall be determined as specified in Section 3. | X | X | X |
| Where practicable, the maximum longitudinal slope shall be 5%. | X | X | X |
| Swales shall convey the design discharge while maintaining a 0.5-foot freeboard and without exceeding the maximum permissible velocity. | X | X | X |
| $1^{+}$ft from bottom swale to SHWT | X | X | |
| Majority of bottom of swale above SHWT | | | X |
| Maintenance agreement required. | X | X | |
| Max velocity as in E&SC Manual, see Table 14-2 | X | | X |
| Max velocity, 1 ft/sec for the 10 year 24 hour storm | | X | |
| Max side slopes, 3:1 | | | X |
| Max side slopes, 5:1 | X | X | |
| Swale length shall be 100 ft | X | | |
| Swale length shall be 150 ft | | X | |

Where necessary, particularly for curb outlet systems for low-density projects, include a supplement sheet containing pertinent design information when applying for a State Stormwater permit. Such a supplement may be necessary in other instances as well. If the design uses check dams, elevated drop inlets, elevated culverts, underdrains, or other advanced design options include this information in the supplement.

The treatment volume shall be calculated as specified in Section 3. The swale is typically parabolic or trapezoidal in cross section for ease of construction and maintenance and for reducing the potential for scour. However, V-shaped swales are also allowed for curb and gutter systems for low-density projects. To reduce maintenance and prevent scour, the bottom width should be no less than 2 feet. The maximum bottom width should be 6 feet to prevent erosion making a smaller, better-defined flow path.

**Table 14-2**
Curb Outlet Systems for Low Density Projects: Maximum Allowable Velocities (Slopes 0-5%) (Derived from the NC E&SC Manual)[1]

| Soil Characteristics | Grass Lining | Permissible Velocity[3] for Established Grass Lining (ft/sec) |
|---|---|---|
| Easily Erodible Non-Plastic (Sands & Silts) | Bermudagrass | 5.0 |
| | Tall Fescue | 4.5 |
| | Bahiagrass | 4.5 |
| | Kentucky Bluegrass | 4.5 |
| | Grass-Legume Mixture | 3.5 |
| Erosion Resistant Plastic (Clay Mixes) | Bermudagrass | 6.0 |
| | Tall Fescue | 5.5 |
| | Bahiagrass | 5.5 |
| | Kentucky Bluegrass | 5.5 |
| | Grass-Legume Mixture | 4.5 |

[1] Permissible velocity based on 10-yr storm peak runoff

[2] Soil erodibility based on resistance to soil movement from concentrated flowing water.

[3] Before grass is established, permissible velocity is determined by the type of temporary liner used

The longitudinal slope of the swale shall be as flat as possible to minimize velocities and improve pollutant filtering. The maximum slope shall be 5 percent; however, if slopes are less than 1 percent, ponding may occur in minor depressions, which may be objectionable to some residents. If slopes are flatter than 1 percent, an underdrain below the bottom of the swale can help to drain the swale. If ponding is not a concern to residents, vegetation that is suited to wetter conditions should be used. If land surface slopes are too steep for grassed swales, the slopes can be modified with check dams (see Figure 14-6) to reduce the slope and velocities or to enhance detention.

The designer also should evaluate the potential for transitioning from supercritical flow to subcritical flow at grade transitions. When evaluating the flow regime, the designer should consider the range of discharge rates up to and including the design rate. At grade transitions, hydraulic jumps may cause scouring of the channel and flooding of the banks. For locations where hydraulic jumps are anticipated, the designer should consider using turf reinforcement, energy dissipaters, or lined channel segments.

The methodology for channel liner design is presented in the DENR *Erosion and Sediment Control Planning and Design Manual*. If this procedure is used, a channel geometry must be selected that does not exceed either the maximum permissible velocity or the maximum allowable flow depth for the design flow rate.

The capacity of the swale must also be checked to ensure that it will be adequate after vegetation is fully established. The resistance to flow should be evaluated using the NRCS retardance factor for the vegetation selected (consult the DENR *Erosion and Sediment Control Planning and Design Manual*).

The flow depth of the design event should be evaluated using Manning's equation for the swale type used (parabolic, trapezoidal, or V-shaped). The design requirement is that the swales convey the design discharge while maintaining a 0.5-foot freeboard and without exceeding the maximum permissible velocity.

If driveways or roads cross the swale, the capacity of the culvert crossing the road or driveway may determine the depth of flow for the design event. In these instances, the culverts should be checked to establish that the backwater elevation does not exceed the banks of the swale. If the culvert discharges to a minimum tailwater condition, the exit velocity for the culvert should be evaluated for design conditions. If the maximum permissible velocity is exceeded at the culvert outlet, riprap or another measure to prevent scour must be used.

### 14.2.5. Plant and Landscape Requirements

Landscape design is based on specific site, soils, and hydric conditions along the channel. A dense grass cover is the best vegetation to maximize the performance of a grass swale.

Standard turf grasses may be used if a lawn appearance is desired. The turf grasses include standard mixtures such as those recommended in the DENR *Erosion and Sediment Control Planning and Design Manual* and the recommended vegetation tables in Section 6 of this document. The recommendation is to use taller growing grasses to improve the filtering capability of the swale. Bluegrass should be avoided for areas where salt loading is high.

Soil with a high infiltration rate is typically most appropriate for grassed swale BMPs. Topsoil should be suitable for healthy turf growth. Where the existing soil is unsuitable for growth (such as clayey or rocky soil), applying about 12 inches of loamy or sandy soil is beneficial.

### 14.2.6. Ponding and Infiltration

Ponding can be beneficial if intended and accepted, or it can be a negative if unintended. If unintended and not designed for, extended periods of standing water may result in nuisance conditions and create complaints from residents. Mosquitoes are typically the biggest concern, however, they should generally not be a problem because of the frequent flushing of the ponded water, and if wetland vegetation develops, mosquito predators such as other insects and birds often mitigate the mosquito problem. If wetland vegetation and standing water are persistent concerns, these problems can be reduced by maintaining more uniform, steeper slopes in the swale invert or by installing underdrains.

If temporary retention of small amounts of water is desired for enhanced treatment of the stormwater and ecological and visual diversity, there are many ways to achieve that goal. The paragraphs below discuss several methods for retaining water or otherwise modifying the typical swale hydrology. The retained water will infiltrate, be lost through evapotranspiration, or slowly released downstream. It should be noted that the maximum allowable ponding time within a channel is 48 hours and an underdrain system must be provided if that requirement cannot be met.

*Check Dams*

A check dam is constructed of earth, stone, or timber 3 to 6 inches high to retain runoff from routine events. A weep hole may be added to enable the area behind an earthen or timber dam to drain slowly. However, the weep hole may be subject to clogging. Shorter check dams can act as level spreaders to help distribute the flow along the swale's cross section. See Figure 14-6.

*Elevated Drop Inlets*

A drop inlet can be used when a combined system of swales and storm sewers is being used. The swales would serve as the collector system, and the inlet into the main storm sewer system would be elevated slightly to retain runoff from routine events. The height of elevation would depend on the soil, the slope of the swale, and the tolerance for ponding. Wetland vegetation may develop in the ponded areas if the underlying soils are poorly drained.

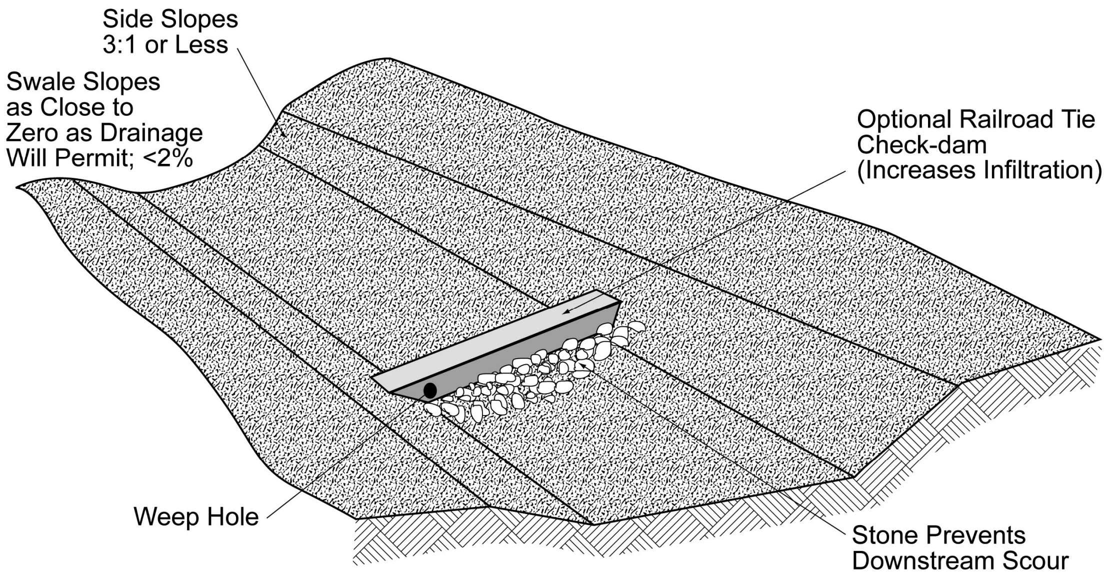
*Elevated Culverts*

Elevated culverts are used for the same purpose as check dams and elevated drop inlets, to retain runoff from routine events. As with elevated drop inlets, wetland vegetation may develop in the ponded areas if the underlying soils are poorly drained.

*Depression storage*

Small depressions along the bottom of the swale will trap and store stormwater for later infiltration into the soils. These depressions will also likely accumulate sediment at a quicker pace than other parts of the swale, and will also probably develop wetland vegetation.

**Figure 14-7**
Schematic of Grassed Swale with Check Dam (from NIPC, 1993 and Schueler, 1987)*.




*Side slopes must be 5:1 or less to attain water quality credit

*Underdrains*

Underdrains can enhance the performance of swales by providing additional filtration through soil similar to the process that takes place in bioretention facilities. These "bioretention" swales have a layer of engineered soil underlain by a gravel layer surrounding a perforated pipe. This configuration also reduces ponding time where standing water may be a concern. No additional removal credit is given for the addition of underdrains. If a system is designed with an underdrain and operates similar to a bioretention system and higher removal rates are desired, the system must meet the requirements of a bioretention BMP as described in Section 8.

## 14.3. Construction

To maximize the infiltration capacity of the swale, compaction of the soil underlying the swale should be avoided. For example, equipment for excavating or grading should operate from the side of the swale instead of the bottom of the swale.

Before vegetation is established in a swale, the swale is particularly vulnerable to scour and erosion. Therefore, protecting the seedbed with a temporary erosion-resistant lining, such as a geosynthetic, fiberglass roving, or other suitable erosion controls is generally necessary. Most vendors will furnish information about the Manning's coefficient, n, and will also specify the maximum permissible velocity or allowable unit tractive force (also referred to as the "tractive stress") for the lining material. Swales should be constructed and vegetated early in the construction schedule, preferably before area grading and paving increase the rate of runoff.

Temporary erosion-resistant channel linings should be used to stabilize the swale until the vegetation becomes established. The vendor's instructions for installing channel linings should be followed. If velocities will be high, designers should consider sodding the swale or diverting runoff until vegetation is established.

## 14.4. Maintenance

### 14.4.1. Common Maintenance Issues

Maintenance of grassed swales involves grooming the vegetation and occasionally removing trash. If native vegetation is used instead of turf, vegetation has to be mowed only seasonally to retard the growth of woody vegetation. Routine mowing is required if turf grasses are used. The recommendation is that grass be cut no lower than 5 inches. In addition, the grass should be allowed to grow to the maximum height consistent with the species and aesthetic requirements. Swales populated with wetland vegetation or other low-maintenance ground cover do not require mowing of the channel. The frequency of trash removal depends on the location and attractiveness of the swale as a disposal site.

Excessive sediment should not accumulate if erosion is controlled adequately upstream. However, if excessive siltation occurs, the sediment must be removed periodically (no less than once annually). Sediment that accumulates in the swale may be prone to resuspension during large storm events and can kill the grass. Sediment should be removed when it reaches a depth of 4 inches or when it covers the grass.

Additional annual maintenance activities are as follows:

- Repair erosion and regrade the swale to ensure that runoff flows evenly in a thin sheet through the swale.
- Revegetate the swale as needed to maintain a dense growth.

### 14.4.2. Sample Inspection and Maintenance Provisions

Important maintenance procedures:

- The drainage area of the grassed swale will be carefully managed to reduce the sediment load to the grassed swale.
- After the first-time fertilization to establish the grass in the swale, fertilizer will not be applied to the grassed swale.

The grassed swale will be inspected **once a quarter**. Records of inspection and maintenance will be kept in a known set location and will be available upon request.

Inspection activities shall be performed as follows. Any problems that are found shall be repaired immediately.

**Table 14-3**
Sample Inspection and Maintenance Provisions

| BMP element: | Potential problems: | How to remediate the problem: |
|---|---|---|
| **The entire length of the swale** | Trash/debris is present. | Remove the trash/debris. |
| | Areas of bare soil and/or erosive gullies have formed. | Regrade the soil if necessary to remove the gully, and then re-sod (or plant with other appropriate species) and water until established. Provide lime and a one-time fertilizer application. |
| | Sediment covers the grass at the bottom of the swale. | Remove sediment and dispose in an area that will not impact streams or BMPs. Re-sod if necessary. |
| | Vegetation is too short or too long. | Maintain vegetation at a height of approximately six inches. |
| **The receiving water** | Erosion or other signs of damage have occurred at the outlet. | Contact the NC Division of Water Quality 401 Oversight Unit at 919-733-1786. |

September 28, 2007 Changes:

1. Major Design Elements and Table 14-1:
   i. Reformatted to include numbered requirements.
   ii. All swales:
      1. Removed reference to the Simple Method. Treatment volume will be calculated as stated in Section 3.
      2. Removed the requirement for all swales to have 1-ft minimum distance from the bottom of the swale to the seasonably high water table (SHWT). This is now only a requirement for curb outlet systems and conveyance swales seeking credit.
   iii. Curb outlet systems:
      1. Removed the per acre requirement from the following sentence, "Swale length will be 100 ft/acre drainage."
      2. Specified the following requirement as an Administrative Code requirement, "The maximum velocity shall be as specified in the NC Erosion and Sediment Control Manual (and replicated in this document, Table 14-2)," per 15A NCAC 02H .1008(g)(1).
      3. Added the requirement to have 1-ft minimum distance from the bottom of the swale to the seasonably high water table (SHWT).
   iv. Conveyance swales seeking credit:
      1. Removed the per acre requirement from the following sentence, "Swale length will be 150 ft/acre drainage."
      2. Specified that the maximum velocity shall be calculated from the 10 year 24 hour storm.
      3. Added the requirement to have 1-ft minimum distance from the bottom of the swale to the seasonably high water table (SHWT).
   v. Conveyance swales not seeking credit:
      1. Removed the swale length requirement.
      2. Specified the following requirement as an Administrative Code requirement, "Side slopes shall be no steeper than 3:1, " per 15A NCAC 02H .1008(c)(2).
2. 14.3.2: Included exclusion for the 1 ft to the SHWT requirement for swales not seeking pollutant removal credit.
3. 14.3.4: Removed the reference to the Simple Method. The volume shall be calculated as specified in Section 3.
4. 14.3.5: Removed references to wetland plantings.
5. Table 14-2 *(Note: Track changes are not visible in this table)*: Added a missing reference to a footnote. Corrected footnote 3, which had been cut-off. Updated this table to match the changed requirements in the Major Design Elements section.
6. Table 14-3: Labeled (previously unlabeled).

June 2009 Changes:

1. Design elements required by DWQ policy for conveyance swales revised to allow less than 1' separation between SHWT and bottom of swale.
2. Revisions to distinguish between "conveyance" swales (where less than 1' separation from SHWT now allowed) and "for-credit" swales (where 1' minimum separation from SHWT is required) throughout chapter.
3. Table 14-1 and Section 14.3.2 were revised to be consistent with new DWQ policy regarding SHWT separation for conveyance swales.