M-8. Swales

Swales are channels that provide conveyance, water quality treatment, and flow attenuation of stormwater runoff. Swales provide pollutant removal through vegetative filtering, sedimentation, biological uptake, and infiltration into the underlying soil media. Three design variants covered in this section include grass swales, wet swales, and bio-swales. Implementation of each is dependent upon site soils, topography, and drainage characteristics.

Applications:

Swales can be used for primary or secondary treatment on residential, commercial, industrial, or institutional sites. Swales can also be used for retrofitting and redevelopment. The linear structure allows use in place of curb and gutter along highways, residential roadways, and along property boundaries. Wet swales are ideal for treating highway runoff in low-lying or flat terrain with high groundwater. Bio-swales can be used in all soil types due to the use of an underdrain. Grass swales are best suited along highway and roadway projects.

Performance:

The P_E values determined by the equations 5.2 and 5.3 (reprinted below) may be applied to the ESD sizing criteria when grass swales and bio-swales are designed according to the guidance provided below. For wet swales, P_E for the contributing drainage area is based on the volume captured. Re_v requirements are also met when the applicable P_E meets or exceeds the soil specific recharge factor listed in Section 2.2.

Swales should not be designed to meet Q_p or Q_f requirements except under extremely unusual conditions. Swales may be used to convey runoff for these larger storm events however, the ESD_v should be treated separately. This can be accomplished with a flow splitter or diversion so that the entire design storm is passed safely.

Constraints:

The following constraints are critical when considering the use of swales to capture and treat stormwater runoff:

- **Topography:** Steep slopes will increase velocity, erosion, and sediment deposition thus shortening the design life of the swale.
- **Soils:** Design variants are dependent upon soil types. Grass swales work best in HSG A, B, or C and wet swales are best suited for HSG C or D. Bio-swales typically include an underdrain and may be installed in all soil types. Extreme temperatures and frozen ground need to be considered when calculating design volumes.
- **Drainage Area:** The drainage area contributing to all design variants should be less than one acre. Practices in Chapter 3 should be considered for larger drainage areas.

- **Hotspot Runoff:** Swales should not be used to treat hotspots that generate higher concentrations of hydrocarbons, trace metals, or toxicants than are found in typical stormwater runoff and may contaminate groundwater.

- **Location:** The location of swales needs to be considered carefully. Wet swales are not recommended for residential developments due to the potential nuisance or mosquito breeding conditions. Swales along roadways can be damaged by off-street parking and are susceptible to winter salt applications. Also, the choice of vegetation and landscaping can be limited in adjacent areas.

Design Guidance:

The following conditions should be considered when designing swales:

- **Conveyance:** Stormwater discharged into and through swales needs to be non-erosive. Sheetflow should be promoted wherever possible using precise grading, level earthen weirs, or pea gravel diaphragms. If concentrated flow is delivered from curb cuts or storm drain pipes, some form of energy dissipation (e.g., plunge pools or rip-rap) is needed.

- **Treatment:** All swales shall meet the following criteria:

  - *Swales shall have a bottom width between two and eight feet.*
  - *The channel slope shall be less than or equal to 4.0%.*
  - *The maximum flow velocity for the ESD_v shall be less than or equal to 1.0 fps.*
  - *Swales shall be designed to safely convey the 10-year, 24-hour storm at a non-erosive velocity with at least six inches of freeboard.*
  - *Channel side slopes shall be 3:1 or flatter.*
  - *A thick vegetative cover shall be provided for proper function.*

  The following criteria apply to each specific design variant:

  Grass swales: *Grass swales shall be used for linear applications (e.g., roadways) only, and shall be as long as the treated surface. The surface area (A_f) of the swale bottom shall be at least 2% of the contributing drainage area, and a P_E value based on Equation 5.3 shall be applied to the contributing drainage area.* The maximum flow depth for ESD_v treatment should be 4 inches, and the channel should have a roughness coefficient (Manning's n) value of 0.15. This can be accomplished by either maintaining vegetation height equal to the flow depth or using energy dissipaters like check dams, infiltration berms, or riffle/pool combinations.

$$P_E = 10^{"} \times \frac{A_f}{DA} \quad \text{(Equation 5.3)}$$

  Bio-swales: *The surface area (A_f) of the bio-swale bottom shall be at least 2% of the contributing impervious area and a P_E value based on Equation 5.2 shall be applied to the contributing drainage area. Bio-swales shall be designed to temporarily store at least 75%*

of the ESD_v. A two to four-foot deep layer of filter media shall be provided in the swale bottom. Underdrains shall be provided in HSG C or D and shall conform to the specifications found in Appendix B.4. The use of underdrains is recommended for all applications.

$$P_E = 15" \times \frac{A_f}{DA} \quad \text{(Equation 5.2)}$$

Wet swales: *Wet swales shall be designed to store at least 75% of the ESD_v. A P_E value equivalent to the volume captured and treated shall be applied to the contributing drainage area.* Wet swales should be installed in areas with a high groundwater table and check dams or weirs may be used to enhance storage.

- **Check Dams**: Check dams or weirs may be used to enhance storage and channel roughness or provide grade control in steeper applications. Where used, these structures should be anchored into the swale wall and notched to allow passage of larger design storms with a minimum six-inch freeboard. Plunge pools or other energy dissipation may be required where the elevation difference between the tops of weirs to the downstream channel invert is a concern.

- **Landscaping**: *Landscaping plans shall specify proper grass or wetland plantings based on the design variant chosen and anticipated hydrologic conditions along the channel (see Appendix A).* Native species are best for survival and enhancing bio-diversity and wildlife.

Construction Criteria:

Construction specifications for swales can be found in Appendix B.3. In addition, the following items should be addressed during the construction of projects with swales:

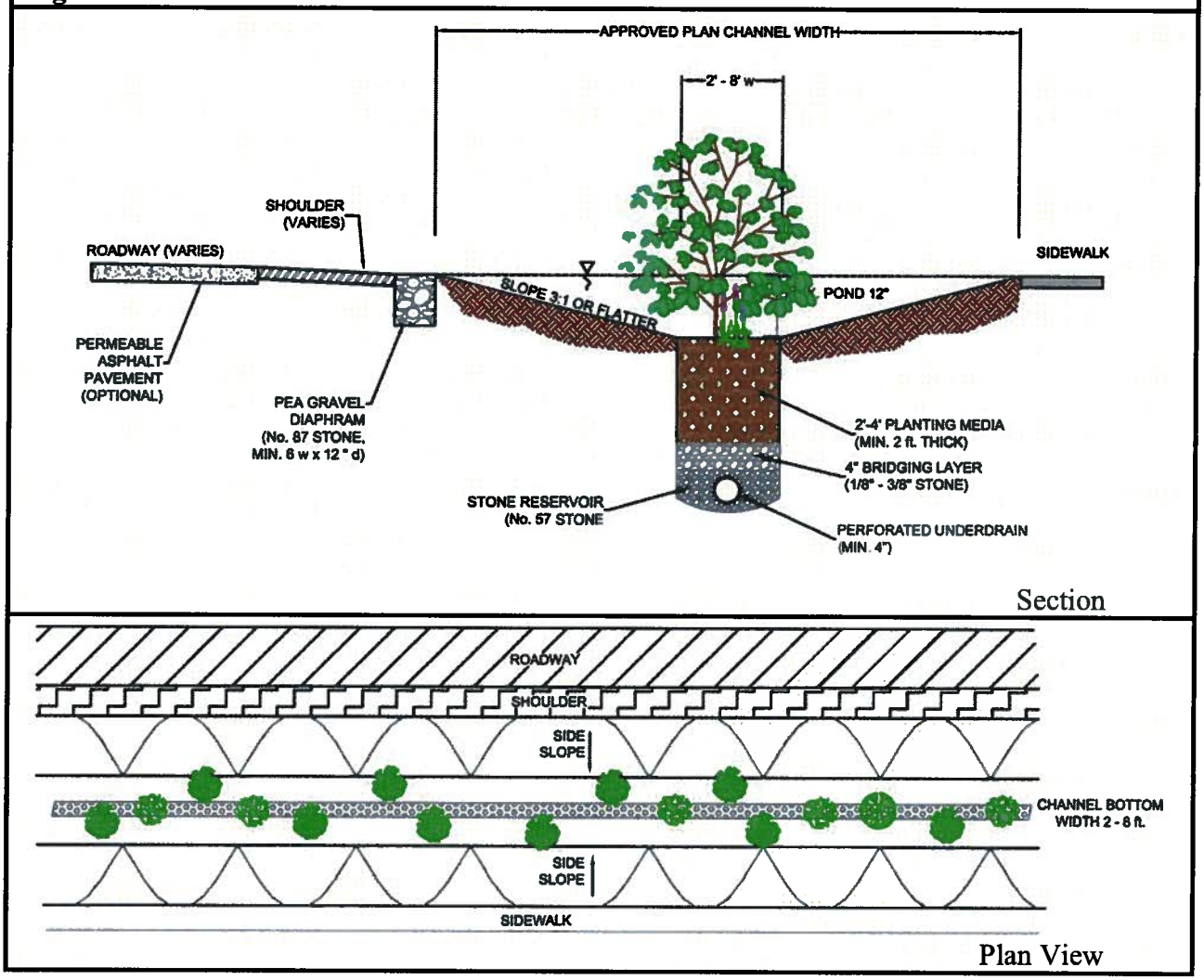
- **Erosion and Sediment Control:** Swales are often used for conveying runoff to sediment trapping devices during site construction. Care should be taken to ensure proper construction where stormwater management swales are used for this purpose. After the drainage area is completely stabilized, accumulated sediment should be removed and the swale excavated to the required dimensions. Any required infrastructure (e.g., check dams, underdrains) may then be installed, the bottom and side slopes scarified, and a good stand of vegetation established.

Inspection:

- Regular inspections shall be made during the following stages of construction:

    - *During placement and backfill of underdrains and the installation of diaphragms, forebays, check dams, or weirs.*
    - *Upon completion of final grading and establishment of permanent stabilization.*

Figure 5.18 Bio-Swale



Maintenance Criteria:

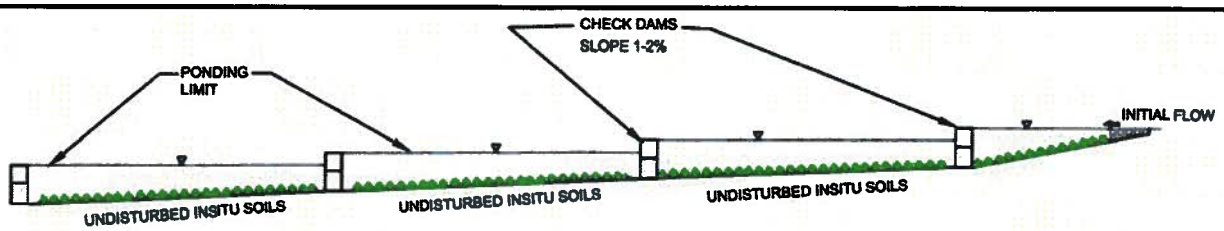
The following items should be addressed to ensure proper maintenance and long-term performance of swales:

- For grassed swales, regular mowing (at least bi-annually) is critical in order to reduce competition from weeds and irrigation may be needed during dry weather to establish vegetation. Sparsely vegetated areas need to be re-seeded to maintain dense coverage.

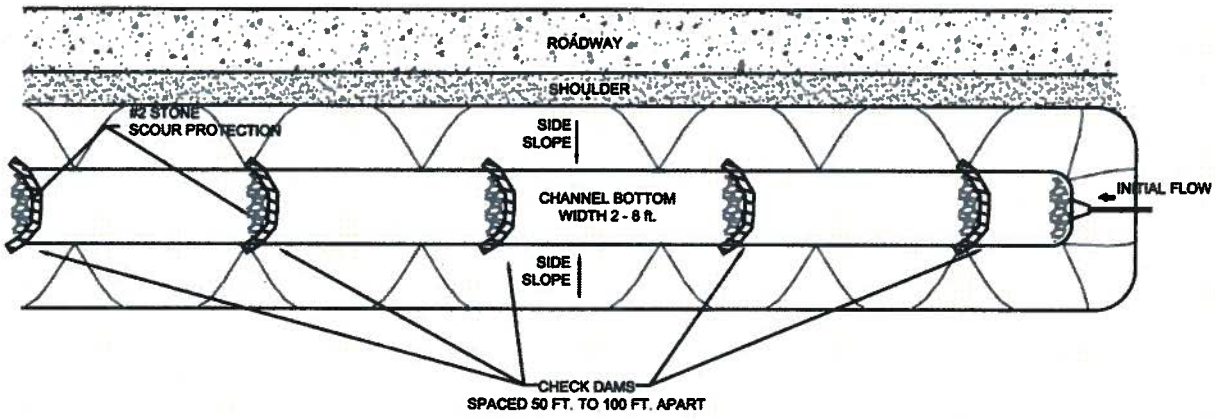
- If water does not drain within 48 hours, the bottom soil should be tilled and revegetated.

- Inspections should be performed once a year to assess slope integrity, vegetative health, soil stability, compaction, erosion, ponding, and sedimentation. Periodic removal of sediment, litter, or obstructions should be done as needed. Eroded side slopes and the swale bottom should be repaired and stabilized where needed.

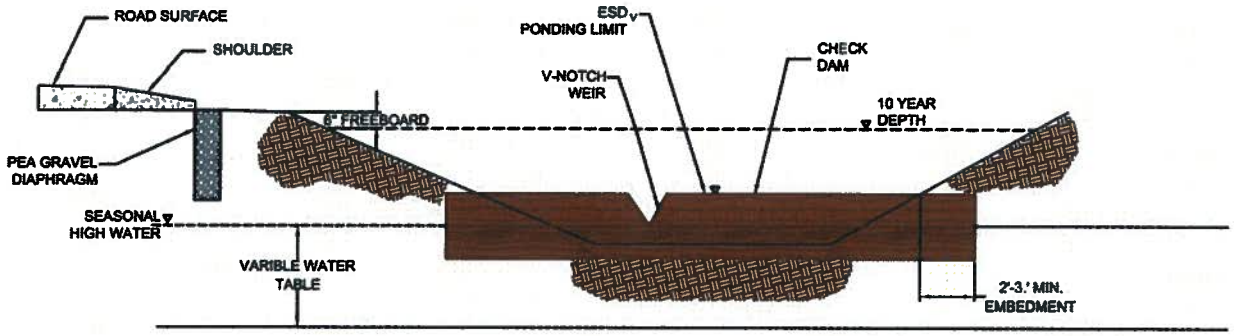
Figure 5.19 Wet Swale



Profile



Plan View



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