8.3.1 Closed Conduit Inlet/Outlet Design

Description
To prevent soil erosion due to excessive velocities, end treatment and soil stabilization measures should be used with all inlets and outlets for closed conduits. Some types of outlets should also discharge to the watercourse at a prescribed elevation. In addition, a grate should be provided on some closed conduit inlets and outlets to prevent children or animals from entering the conduit.

End Treatments
All storm water enclosure inlets/outlets in a roadside ditch or adjacent to County Roads must have a flared end section type of end treatment for road safety purposes. The following requirements apply to storm water enclosure inlets/outlets which are not in a roadside ditch or adjacent to a roadway.

- For inlets/outlets on County park property, end treatments may be either the “reverse wingwall” headwall with a splash pan shown in the detail provided in Appendix E-1 of this manual, or the standard headwall described below.

- For enclosures 36 inches in diameter or smaller, the inlet/outlet treatment should be a flared end section (MDOT Standard Plan Series R-86-D (concrete) or R-88-D (steel)) or an outlet headwall (Standard Plan Series R-85).

- For enclosures larger than 36 inches in diameter, the inlet/outlet treatment should be either a site-specific designed concrete headwall or, if approved by the Permit Office for the specific location and under 84 inches in diameter, a flared end section (MDOT Standard Plan Series R-86-D (concrete) or R-88-D (steel)).

Soil Stabilization
Soil stabilization measures should be provided around each end treatment to prevent any soil erosion around the end treatment or in the flow path leading to or from the end treatment. Storm sewer outlets located across from the cutting side of a watercourse also should include soil stabilization measures for the opposite embankment.

Soil stabilization measures may include riprap with geotextile fabric, revet mattresses, cobbles, stone, crushed rock, precast blocks, gabions. Depending on the location, the biotechnical streambank stabilization techniques described in Section 8.4 of this manual also may be appropriate. Crushed/broken concrete is not an acceptable substitute for riprap. Soil stabilization measures should be put in place immediately after final grading and before the inlet or outlet receives flow.

Outlet Elevations
In general, the invert elevation of a closed conduit which outlets to a watercourse should be at or below the low water level of the watercourse. Special provisions may be required if the outlet is located on the cutting bank of a bend in the watercourse.

To minimize the possibility of backflow from a watercourse into an open detention basin, the permanent pool water...
level in the detention basin should be at least 1 foot above the low water level in the watercourse.

**Grates**
Grates for animal protection should be provided for all storm water inlets/outlets within open detention basins, retention basins, and forebays. For other storm water inlets/outlets, grates for animal protection are only used for enclosures larger than 24 inches in diameter. Grates should comply with MDOT Standard Plan Series R-92-C.

**Maintenance**
Closed conduit inlets and outlets should be inspected periodically for signs of soil erosion and to identify any damage to the end treatment or grate. Any trash or debris caught on the grates should also be removed on a regular basis.
8.3.2 Vegetated Swales

Description
Vegetated swales are broad, shallow channels lined with vegetation that slow and filter storm water runoff and promote infiltration. Vegetated swales can serve as storm water management conveyance and may also be used to achieve a degree of stormwater treatment. Common applications include:

- Storm water conveyance within a development site.
  Vegetated swales can replace curbs, gutters, and storm sewer systems along roads or and/or parking areas where local community standards and site conditions permit.
- Storm water management retrofit and redevelopment situations. The addition of grassed swales will provide some improvement in the amount of runoff and in water quality.

Vegetated swales are best suited for relatively small drainage areas such as areas of sheet drainage up to 2 acres (e.g. along roadways, around parking lots, and as buffers between properties). They may count both as part of the required storm water management system and toward local landscape and/or green space requirements.

Design Criteria

- A maximum 150-foot distance of sheet drainage to the swale is recommended, with varying grades up to a maximum of 3%.
- If a storm sewer discharges into a swale, energy dissipation should be used at the point of inlet.
- The flow capacity of vegetated swales used as conveyance in storm water management systems must equal or exceed the peak flow rate for the 10-year storm.
- To reduce the possibility of erosion, swales should be designed with peak flows that do not exceed 5 cfs.
- Flow velocities in vegetated swales should range between a minimum of 2 ft/sec and a maximum of 5 ft/sec.
- Check dams may be used to reduce velocities, promote infiltration, increase storage and enhance water quality. Earthen check dams are not recommended because of their potential to erode. Toe protection is recommended for all check dams.
- The minimum acceptable longitudinal slope of a vegetated swale is 0.15% unless other techniques such as infiltration devices are employed.
- The maximum longitudinal slope of a vegetated swale should not exceed 3%, unless check dams are used.

- Swale length should be a minimum of 200 feet wherever possible, to increase the contact time of storm water.
- A parabolic or trapezoidal shape is recommended, with side slopes no steeper than 3:1. Soil conditions, vegetative cover and maintenance ability should be considered when designing the side slopes.
- A minimum freeboard of 6 inches below the top of bank is recommended.
- The maximum recommended water depth for temporary pooling of water is 6 inches. A maximum of 3 inches to 4 inches is preferred for areas that receive high hydraulic loading or have soils with low infiltration rates. This should be done in combination with a smaller drainage area.
- Clearance between the swale invert and underground utilities should be addressed as part of the design process. A minimum clearance of 5 feet between swale invert and underground utilities is recommended unless special provisions are employed.
- There may be additional design criteria for vegetated swales adjacent to roads, particularly those under the jurisdiction of another agency (e.g., MDOT).
- Grading plans for the development project should clearly identify the location of vegetative swales in relation to the topography and physical location. The grading plans should clearly identify the routing of construction traffic such that it does not traverse the swale locations.
- Swales should follow the natural, pre-development drainage path when possible.
Vegetation Specifications

Applicants that propose to use vegetated swales as part of a storm water management system must submit a landscaping plan with the application for storm water construction approval. The landscaping plan is required because vegetation is essential to the proper functioning of the swale. Landscaping is part of the regulated construction activity for which financial assurance must be provided.

Vegetation should be uniform and should consist of fine, turf-forming water-resistant grasses. Deep-rooted native wetland and upland grasses are preferred for infiltration and reduced maintenance.

In areas with high groundwater and/or little slope, the southeast Michigan native plants suitable for bioretention areas (see Section 8.2.2) should be considered. The plants listed in Section 8.2.2 are excellent for moist organic areas that are “dry” within 48 hours of a rain.

Plant material and planting applications should meet guidelines set by the American Standard of Nursery Stock (see “References” on page 8-5). Plant stock should be grown by suppliers or nurseries certified by the Michigan Native Plant Producers Association.

Maintenance

Maintenance of vegetated swales should be focused on keeping a dense, healthy vegetated cover and keeping up the hydraulic and removal efficiency of the channel. Maintenance activities related to the vegetated cover include mowing (with grass never cut shorter than the design flow depth), weed control, and re-planting/seeding of bare areas. “River friendly” lawn and garden practices (see References below) should be followed in the maintenance of vegetated swales.

Vegetated swales should periodically be cleared of debris and blockages. Periodic sediment cleanout should be done manually to avoid the transport of resuspended sediments in periods of low flow and to prevent a damming effect from sediment buildup.

Damaged areas (e.g., ruts or holes) within a channel should be repaired utilizing a suitable soil that is properly tamped and seeded.

Inlets and outlets should be inspected periodically for blockage, signs of soil erosion, and structural damage. Swales should be inspected for sediment accumulation semiannually and after rain events. Sediment that is impeding flow should be removed. Inlets, outlets, and appurtenances (e.g., grates) should be inspected annually for structural integrity. Outlets should be checked regularly for clogging and should be cleaned when necessary, especially after large storm events.

References

  (Also document ANSI Z60.1-2004 of the American National Standards Institute (ANSI), www.ansi.org)
- International Storm Water Best Management Practices Database. www.bmpdatabase.org
- The following documents, published by the (SE MI) Healthy Lawns and Gardens Technical Advisory Committee, are available from Wayne County's website at http://www.waynecounty.com/doe/watershed/mgmtBioretention.htm
  - “Healthy Law Care Tips”, Spring 2006.
  - See also their website www.healthylandscapes.com
- United States Environmental Protection Agency, Office of Water. Storm Water Technology Fact Sheet: Vegetated...
http://www.epa.gov/owm/mtb/vegswale.pdf

**References: Native Landscaping**

  http://www.macd.org/rollovers/nativeplants/nphome.html
- United States Environmental Protection Agency 
  www.epa.gov/greenacres/
- Wild Ones Organization. Landscaping with Native Plants. 
  www.for-wild.org

**Resources For Native Plant Material**

- Michigan Native Plant Producers Association, “Plants and Seeds Source Guide” and “List of Member Nurseries”. 
  http://www.MNPPA.org