Dry Swale (Bioswale)

A bioswale or dry swale is essentially a bioretention cell that is shallower, configured as a linear channel, and covered with turf or surface material other than mulch and ornamental plants (MDE/CWP 2009; Nashville 2012). The dry swale is a soil filter system that temporarily stores and then filters a desired runoff volume for treatment. Such swales rely on a pre-mixed soil media filter below the channel. If the native soils are permeable, runoff infiltrates into underlying soils. Otherwise, the runoff treated by the soil media flows into an underdrain, which conveys treated runoff back to a conveyance system further downstream or safely daylights down-gradient. The underdrain system typically consists of a perforated pipe within a gravel layer on the bottom of the swale, beneath the filter media.

Constraints

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

- **Topography:** Steep slopes will increase velocity, erosion, and sediment deposition thus shortening the design life of the swale. (MDE/CWP 2009). Dry swales should be used on sites with longitudinal slopes of 4% or less. Check dams can be used to reduce the effective slope of the swale and lengthen the contact time to enhance filtering and/or infiltration. Steeper slopes adjacent to the swale may generate rapid runoff velocities into the swale that may carry a high sediment loading, requiring pretreatment (Nashville 2012). *(Note: Nashville 2012 also provides guidance for utilization with contributing slopes of up to 20% gradient, as long as a multiple cell design is used to dissipate erosive energy prior to filtering.)*
- **Soils:** Soil conditions do not constrain the use of dry swales, although they normally determine whether an underdrain is needed. Low-permeability soils with an infiltration rate of less than or equal to 0.5 inch per hour, such as those classified in Hydrologic Soil Groups (HSG) C and D, will require an underdrain (MDE/CWP 2009, Nashville 2012).
- **Depth to Water Table:** Designers should ensure that the top of the dry swale is at 2 feet above the seasonally high groundwater table, or that the practice's underdrain is above the seasonal high water table, to ensure that groundwater does not intersect the filter bed (Nashville 2012).
- **Drainage Area:** The maximum impervious contributing drainage area to a dry swale should be 2.5 acres (Nashville 2012). *Recommendations in other jurisdictions range from less than 1 acre (MDE/CWP 2009) to 5 acres (VA DCR 2011). VTDEC 2002 is silent on max. contributing area for swales*.
- **Available Space:** Dry swale footprints can fit into relatively narrow corridors between utilities, roads, parking areas, or other site constraints. Dry swales should be approximately 3% to 10% of the size of the contributing drainage area, depending on the amount of impervious cover (Nashville 2012).
- **Hotspot Runoff:** Dry 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 (MDE/CWP 2009). If dry swales are used as filtering practices in a hotspot application, an impermeable liner should be used beneath the practice (Nashville 2012).
- **Location:** Location needs to be considered carefully. Swales along roadways can be damaged by off-street parking and are susceptible to winter salt applications. The choice of vegetation and landscaping can be limited in adjacent areas (MDE/CWP 2009).

Design Guidance

The following conditions should be considered when designing dry swales:

Conveyance: Stormwater discharged into and through swales needs to be non-erosive (VTDEC 2002; MDE/CWP 2009). 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

DRAFT

form of energy dissipation (e.g., plunge pools or rip-rap) is needed (MDE/CWP 2009).

Treatment: All swales shall meet the following criteria:

- Swales shall have a bottom width between two and eight feet (VTDEC 2002; MDE/CWP 2009). If a swale will be wider than 8 feet, the designer should incorporate berms, check dams, level spreaders or multi-level cross-sections to prevent braiding and erosion of the swale bottom (VA DCR 2011).
- The longitudinal channel slope shall be less than or equal to 4.0% (VTDEC 2002; MDE/CWP 2009). Check dams can be used to reduce the effective slope of the swale.
- The maximum flow velocity for the WQv (1" storm) shall be less than or equal to 1.0 fps. (MDE/CWP 2009)
- 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. (VTDEC 2002; MDE/CWP 2009)
- Channel side slopes shall be 3:1 or flatter. (MDE/CWP 2009; VTDEC 2002). 2:1 is the absolute maximum side slope (VTDEC 2002).
- A thick vegetative cover shall be provided for proper function (MDE/CWP 2009; VA DCR 2011)
- The maximum allowable temporary ponding time within a channel shall be less than 6 hours (VA DCR 2013). An under-drain system shall be used in the dry swale to ensure this ponding time (VTDEC 2002).

Check Dams: Check dams or weirs may be used to enhance storage and channel roughness or provide grade control in steeper applications. Check dams are typically 6- to 12-inch vertical drops that can be constructed of wood, stone, concrete, or earth (VTDEC 2002; VA DCR 2011; Nashville 2012). Where used, these structures should be anchored or keyed 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 (MDE/CWP 2009).

Sizing (based on VA DCR 2011, Nashville 2012)

Sizing of the surface area (SA) for Dry Swales is based on the computed Treatment Volume (Tv) of the contributing drainage area and the storage provided within the swale media and gravel layers and behind check dams. The required surface area (in square feet) is computed as the Treatment Volume (in cubic feet) divided by the equivalent storage depth (in feet). The equivalent storage depth is computed as the depth of the soil media, the gravel, and surface ponding (in feet) multiplied by the accepted void ratio.

The accepted Void Ratios (Vr) are:

Dry Swale Soil Media Vr = 0.25
Gravel Vr = 0.40
Surface Storage behind check dams Vr = 1.0

The minimum storage depth for design (without considering surface ponding) is therefore computed as:

$(1.5 \text{ ft.} \times 0.25) + (0.25 \text{ ft.} \times 0.40) = 0.5 \text{ ft.} = D_{eff}$

The effective storage depths will vary according to the actual design depths of the soil media and gravel layer.

The treatment volume (Tv) will be calculated as follows:

$Tv = (SA)(D_{eff})$, where:

Tv = Treatment Volume (cu. ft.) = [(1 inch)(Rv)(A)] / 12
SA = surface area of the swale practice
D_{eff} = effective water storage depth in media in feet

The final dry swale design geometry will be determined by dividing the SA by the swale length to compute the required width; or by dividing the SA by the desired width to compute the required length.

Performance

Recognizing that dry swales are ultimately designed for some amount of conveyance, in addition to treatment, the treatment volume will need to be reduced. Dry swales are assigned a credit of 40% (minimum design) to 60% (with deeper soil media and underdrain/stone sump or full infiltration) (CSN 2008; ISBD 2011). Available research indicates that dry swale performance is similar to that of bioretention with underdrains (CSN 2008). Since an underdrain is often an integral design

DRAFT

feature for dry swales, a conservative runoff reduction of 40% is assigned--a value equivalent to that for bioretention with underdrains. If a dry swale lacks an underdrain due to highly permeable soils, or is designed with an underdrain and an additional underground stone storage layer, the credit based on the practice's volume reduction performance can be increased to 60%.

For dry swales with an effective slope between 1% and 2% (with or without an underdrain), the treatment volume will need to be reduced by a factor of 0.4 (VA DCR 2011):

$T_{v(adj)} = 0.4(T_v)$

For dry swales with a maximum effective slope of not more than 1%, which are underlain by soils suitable for infiltration or where a minimum 12-inch stone sump is provided below the invert of the underdrain, the treatment volume will only need to be reduced by a factor of 0.6 (VA DCR 2011):

$T_{v(adj)} = 0.6(T_v)$

For More Information

All information regarding the Vermont Stormwater Management Manual Update process is available at: http://www.vtwaterquality.org/stormwater/htm/sw_manualrevision.htm.

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DRAFT