4.4.11 Weep Berms

Source: Warner et al. (2012)

Definition and Purpose

A weep berm is an earthen structure constructed perpendicular to the direction of runoff, designed to control stormwater runoff and improve water quality. The berm temporarily stores runoff, allowing sediments and sediment-bound pollutants to settle before discharging runoff to the downgradient side of the berm, usually to a grassed or riparian area. This slow "weeping" release enhances the treatment capacity of the buffer by extending the residence time and contact time with vegetation and soils.

Appropriate Applications

Weep berms are best suited for locations downgradient of disturbed areas and located on contour such that runoff can be temporarily stored and treated without causing damage to the berm or surrounding land. Further, they may be located off contour when diversions redirect runoff to the weep berm (Warner et al., 2012). They are commonly placed along linear developments such as haul roads, pipelines, and transmission lines, as well as below stockpiles and cut or fill slopes. These structures are most effective in flatter drainage areas with slopes under 10%, where they can slow runoff and promote infiltration and settling; on larger sites, multiple berms may be installed to divide the drainage area and prevent excessive flow to any single structure (MPCA, 2023).

Limitations and Maintenance

Weep berms are not to be placed in streams or wetlands. Further, it is recommended that they are not placed in ditches or swales unless the earthen berm is stabilized with a rolled erosion control product. Accumulated sediment must be removed and disposed of properly or stabilized once half the storage capacity is reached. Periodic mowing may also be necessary to manage vegetation. Lastly, inspect outlet pipes for clogging and clear debris when necessary.

Planning and Design Considerations

Weep berms are a space-efficient EPSC measure and may be a viable alternative when sediment basins or traps are infeasible. For disturbed areas greater than one acre, two or more berms or intermediate dikes should be used in series, spaced so that the toe of the upstream berm aligns with the crest of the next downstream berm (GSWCC, 2016). When sized properly, weep berms are capable of completely capturing, infiltrating, or detaining, and treating runoff from small storms and a sizable portion from larger storms. Warner et al. (2012) advocated that weep berms typically remove 90% of sediments in addition to the removal capabilities of nutrients and bacteria. However, the authors also noted that performance can be influenced by the types of soils used to construct the berm (infiltration capacity), sediment yield of the drainage area, and the type of weep berm used.

Generally, two types of weep berms are considered: contour and gradient. Contour weep berms are built along contours of equal elevation, with their ends curving upslope. This design gives them a horseshoe-shaped storage area and, when properly installed, allows them to blend naturally into the surrounding landscape. On longer stretches, earthen dikes may be placed at intervals to divide the berm into storage cells, reducing risk by ensuring that failure of one cell does not release the full volume of stored runoff. Gradient weep berms, by contrast, are typically used in combination with diversions or sediment ditches. They often include check dams along their length, which provide temporary runoff detention. During heavier storms, these check dams slow the flow of water, promoting infiltration and allowing more sediment to settle out before runoff continues downstream (Warner et al. 2012).

When designing a contour weep berm, the berm is to be sized to provide adequate runoff storage while accounting for the extent of the disturbed area. Berm length is typically based on the area of disturbance, with longer berms built at lower heights and shorter berms constructed taller. For large drainage areas, multiple berms may be placed in series to create a larger storage capacity. The berm height is generally set to contain runoff from the 5-year, 24-hour storm, while also accommodating additional storage for sediment when needed. This creates a tradeoff between the overall berm size and the frequency of required sediment clean-out. Outlets are set at elevations that correspond to the top of the sediment storage zone. Access should be provided for the maintenance and removal of deposited sediments. Design guidelines also suggest that weep berms should not exceed four feet in height and should have a minimum top width of 12 inches.

A gradient weep berm consists of a trapezoidal channel with check dams placed at intervals along its length and outlets located on the downgradient slope. The channel dimensions, including bottom width, side slopes, and overall slope, are selected based on site conditions. Check dams regulate runoff detention, with their crests designed to store runoff from the design storm while also accounting for sediment storage. Spacing of check dams is important for volume control; they are typically positioned so that the crest of each downstream dam is at the same elevation as to toe of the upstream dam. As with contour berms, outlet pipes should dewater between 48 and 72 hours.

For both types, total storage volume guidance is 3,618 cubic feet per acre of disturbed area draining to the berm, which is divided evenly between the sediment storage and live storage zones. The berms must be stabilized, either through compaction, vegetation, or a rolled erosion control product, before land disturbing activities commence. Outlets for weep berms are typically limited to straight pipes or rock lenses (Figure 4.4.11-A), with the invert set to store 1,806 cubic feet per acre of disturbed area for sediment storage. Clean-out markers should be placed at intermediate dikes to track when sediment removal is required. The outlet type, size, and spacing control the discharge rate. One option is to install outlets during berm construction, though this requires care to avoid crushing pipes when compacting. Alternatively, outlets can be installed by excavating trenches after the berm has been completed and then backfilling and compacting the soil around them, or by driving a steel pipe with a conical end through the berm to create openings for PVC outlets. To prevent embankment failure during extreme events, bypass outlets or stabilized emergency spillways should be incorporated, with flow directed toward stable, undisturbed areas. The spillway will be used to pass the design storm (2-year, 24-hour or 5-year, 24-hour) corresponding to the entire drainage area, as resiliency of the measure(s) is increasingly important as rainfall patterns change and more intense storm events occur. A riparian buffer, either grassed or forested, is a critical downstream component that aids in infiltration and filtering of released water.

Weep berms are generally built using common on-site construction equipment such as skid steers, backhoes, or track hoes. Construction begins with clearing vegetation from the berm footprint while protecting surrounding areas, since infiltration efficiency depends on minimizing soil compaction both up- and down-gradient of the structure. The berm itself should be compacted enough to ensure stability but still allow seepage, with soils containing at least 10% clay and 20% combined silt and clay considered most suitable. Berms are typically installed in six to nine-inch lifts. For structural strength, compaction can be accomplished by tracking with a dozer, running a skid loader with a full bucket, or applying pressure with the bucket of a backhoe. A minimum of 90% standard Proctor density is often recommended to achieve the required balance between strength and permeability (Warner et al., 2012).

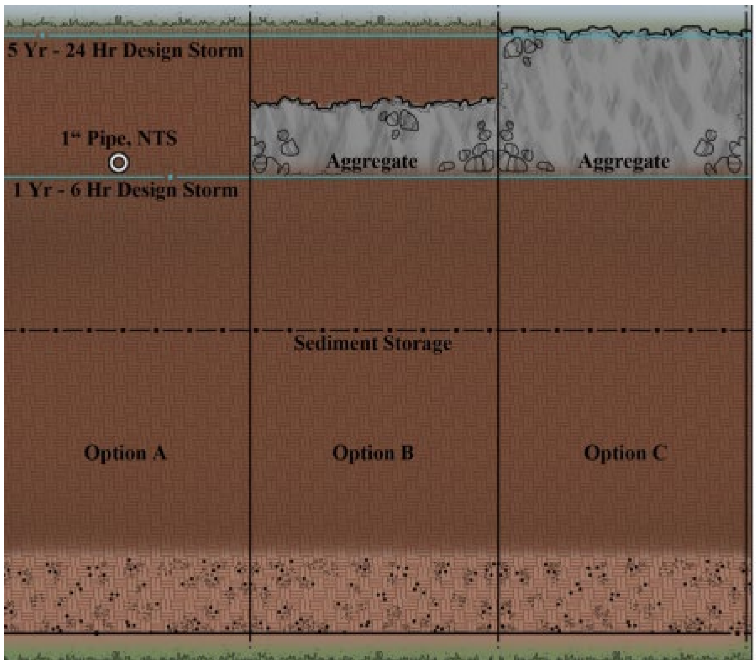

Figure 4.4.11-A: Weep berm outlet options. Source: Warner et al. (2012).

Example Application

-Example amended from Warner et al. (2012)

Given:

The land slope upgradient of the planned location of the weep berm is 2 percent with a drainage area of 4 acres that is fully disturbed. Soils at the project site are Bluegrass-Maury silt loam, which places them in HSG B. For sediment storage requirements, she needs 67 cubic yards per acre of disturbed land. The 5-year, 24-hour, which is the design storm, rainfall depth is 3.8 inches.

Determine:

a.) The berm height to storage volume relationship for a 2 percent slope and a 500-foot berm length;
b.) The sediment storage and live storage requirements for the weep berm; and
c.) The runoff volume associated with the five-year 24-hour design storm.

Solution:

a.) Assume the deposited sediment will form a triangular wedge, the watershed slope is constant, and the interior weep berm slope is 1.5:1 (height to volume). The table below shows the volume of sediment that could be stored behind a 500 ft long weep berm of varying berm heights based on the storage geometry. This can be used to determine when sediment removal is necessary.

Weep Berm Height (ft)	Storage Volume (ac-ft)
0.5	0.0739
1	0.2956
1.5	0.665
2	1.1823
2.5	1.8473
3	2.6601
3.5	3.6207
4	4.7291

b.) The given sediment storage requirement is 67 cubic yards per acre of disturbed land. For 4 acres, 268 cubic yards, or 0.166 acre-feet is required. Use the above table to determine the associated weep berm height for a sediment storage volume of 0.166 acre-feet. From linear interpolation, a height of 0.71 feet is determined. This height sets the outlet elevation. The live storage requirement is also 0.166 acre-feet. Therefore, the top of the live storage is 1.42 feet. Ensure the 0.166 acre-feet of live storage can be drained in 48-72 hours utilizing the orifice equation from Section 4.4.12.2.1 (Eqn 29).

c.) The CN for a newly graded Bluegrass Maury silt loam (HSG B) is 86. For a 3.8-inch rainfall depth over 4 acres, the associated runoff volume is 0.789 acre-feet (Eqns 1, 2, and 3). Linearly interpolating from the table, his corresponds to a height of 1.62 ft, which sets the height of the emergency spillway. Utilize a peak flow rate associated with the design storm (not enough information provided in the example to compute this) and the weir equation (Eqn 17 or 18, Section 4.3.3) or software such as HEC-HMS or HydroCAD, as shown in Step 10 of the example in Section 4.4.7, to appropriately size the emergency spillway.

References

GSWCC. (2016). *Manual for Erosion and Sediment Control in Georgia*.

MPCA. (2023). *Minnesota Stormwater Manual: Sediment control practices –Stabilized earth/soil berm.*

Warner, R. C., Agouridis, C. T., & Guffey, R. (2012). *Using Weep Berms to Improve Water Quality*. University of Kentucky College of Agriculture.