NATURAL RESOURCES CONSERVATION SERVICE
VIRGINIA ENGINEERING DESIGN NOTE #1 (DN-1)
ROAD DRAINAGE PRACTICES

INTRODUCTION

Proper road construction will minimize disturbance to waterflow over the landscape and ensure the longevity and stability of the road. Culverts, broad-based drainage dips, and water bars are practices that can be used to provide drainage on access roads and on animal trails and walkways. The purpose of these structures is to prevent build-up of excess runoff and subsequent erosion.

The road or trail profile can also influence the drainage and stability characteristics of the road. Outsloping, insloping, crowning, and grading can be used to minimize water accumulation on roads.

GENERAL CRITERIA

Install surface drainage controls at intervals that remove storm water from the roadbed before the flow gains enough volume and velocity to erode the surface. Avoid discharge onto fill slopes unless the fill slope has been adequately protected. Avoid draining surface water from roads and ditches directly into streams, ponds, lakes, or wetlands. Instead, drain the water into a filter strip or other vegetated area. Drainage structures that convey walkway runoff shall not discharge directly to a stream. All structures should convey runoff water to stable outlets at velocities that are non-erosive.

Proper installation of these practices will reduce the amount of sediment entering the water. Improperly installed practices often contribute more sediment to the streams than if the practice were not installed at all. The design of these practices should include selecting the appropriate practice, calculating the minimum spacing needed, routing the road drainage through adequate filtration zones, maintaining the structures, and evaluating the need for energy dissipaters.

The following recommendations should be used to minimize erosion:

1. Control the flow of surface water on roads by using a combination of the appropriate road cross-section and water diversion structures within the roadbed itself.
2. Install cross drains and diversion ditches to avoid carrying water long distances in roadside ditches.
3. Road cross drains may include pipe culverts, broad-based dips, or water bars.
4. A 15” pipe culvert is the minimum recommended size for cross drainage. Smaller culverts can clog with debris and require frequent maintenance.

CROSS DITCH OR RELIEF CULVERTS

Definition. Pipe made of metal, plastic or other suitable material installed under roads to transmit water from an inside ditch to the outside edge of a road for dispersion.

Installation Guide

1. Pipe material should be long enough so both ends extend at least one foot beyond the side slope of the fill material.

2. The culvert should be placed 1%-2% downgrade to prevent clogging and be laid so the bottom of the culvert is as close as possible to the natural grade of the ground or drain.

3. The culvert should be angled across the road at a downslope angle of 30-45 degrees, as measured from a line perpendicular to the road.

4. The inlet and outlet should be protected from erosion. This protection can be in the form of headwalls, riprap, geotextile filter fabric, large stone, or prefabricated outflow and inflow devices.

5. A small berm may installed in the ditch at a point slightly downstream of the inlet to direct water into the culvert.

6. Culverts should be firmly seated and earth compacted at least halfway up the side of the pipe. Cover equal to a minimum of half the culvert diameter (preferably one foot of fill per one foot of culvert diameter) should be placed above the culvert or as recommended by the manufacturer, whichever is greater. Never use less than one foot of cover.

7. The distance between pipes in a multiple culvert application should be a minimum of half the pipe diameter.

8. The distance between culverts on an access road shall be determined by use of Figure 1 in the Virginia Conservation Practice Standard *Access Road (Code 575)*. Distances between culverts on animal trails or walkways can be determined by the following formula:

   a. $$Spacing(\,feet) = \frac{400\,feet}{slope(\%)} + 100\,feet$$

9. Refer to the EPA publication *National Management Measures to control Nonpoint Source Pollution from Forestry* for additional information.

BROAD-BASED DRAINAGE DIPS

Definition. A dip and a reverse slope in the trail or walkway surface with a cross slope in the dip to provide cross drainage. It can be described as a gentle roll in the centerline profile of the

road that is designed to be a relatively permanent and self-maintaining water diversion structure that can be traversed by any vehicle.

Restrictions. Drainage dips should not be used on a road, trail or walkway that has a grade greater than 10 percent. The dip(s) should be installed during initial construction using the following design criteria.

Installation Guide

1. Construct a twenty (20) foot long, three (3) percent reverse grade in the trail or walkway by cutting from upgrade of the dip location and using cut material for the reverse grade.

2. Use the following formula as a guide to dip spacing:

$$Spacing(\,feet) = \frac{400\,feet}{slope(\%)} + 100\,feet$$

Table 1. Spacing for common slopes (using formula)

Road grade (percent)	Appropriate distance between dips (feet)
1	500
2	300
5	180
10	140

3. The cross drain slope will be 3% (approximately 1 inch in 3 feet) in the direction of water flow. The cross drain should be installed at an angle across the road or trail of 5-30 degrees, as measured from a line perpendicular to the road. The drain should also flair out at about a 30 degree angle. See Figures 1 and 2.

4. The dip and reverse grade section may require bedding with gravel for stability.

5. Install dips to outlet water onto undisturbed or stable areas. Where this is not practical, an energy absorber such as riprap and, in some cases, a level area where the water can spread, should be installed at the outfall of the dip to reduce water velocity.

Figure 1. Broad-based drainage dips – example of usage.

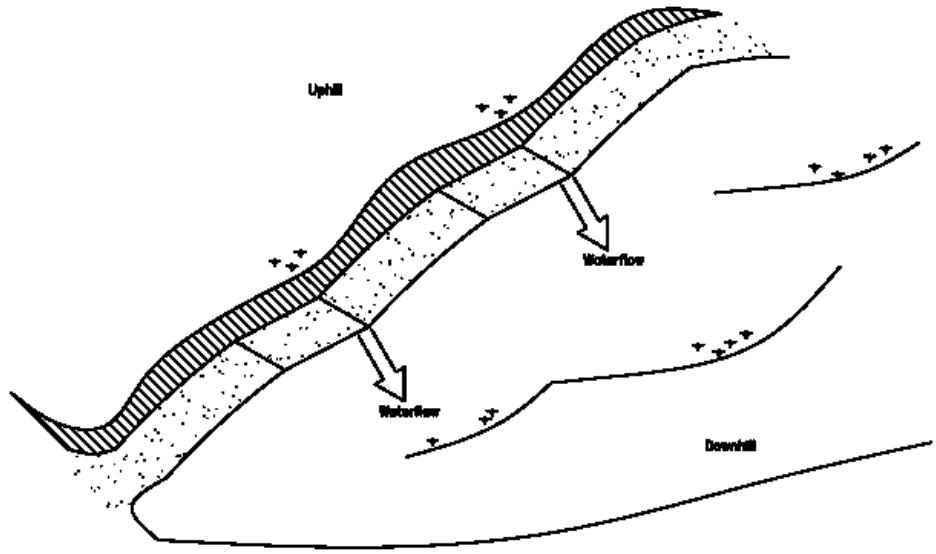
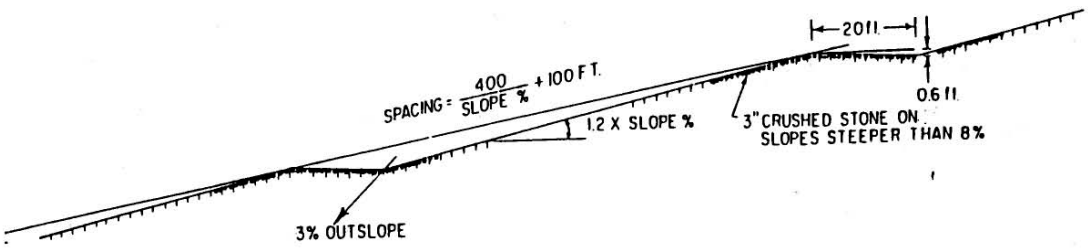


Figure 2. Broad-based drainage dips – spacing criteria and dimensions.



NARROW-BASED WATER BARS (BREAKS)

Narrow-based Water Bars (Breaks). A combined shallow trench and ridge made of earth, rocks, or logs constructed diagonally across a trail or walkway to remove and disperse surface runoff from the trail or walkway. A water bar can be used to divert water from an inside (uphill) ditch. Typical length of structure is 6-12 feet.

Installation Guide

1. Dig a shallow trench 6” to 12” deep at an angle of approximately 30-45 degrees down-slope to turn surface water off the road.

2. The outflow end of the bar should be fully open and extend far enough beyond the edge of the road to safely convey runoff water away from the road surface. The outflow end of the water bar should be protected by a buffer or filter zone to clean the sediment out of the water and prevent erosion.

3. The uphill end of the bar should be tied into the cut bank of the road or trail, or into the upper bank of the side ditch to fully intercept any ditch flows. Water bars should be installed using the spacing guidance in Figure 3. Figures 4 and 5 show locations and dimensions.

Figure 3. Recommended Spacing of Relief Culverts and Water Bars Based on Soil Types

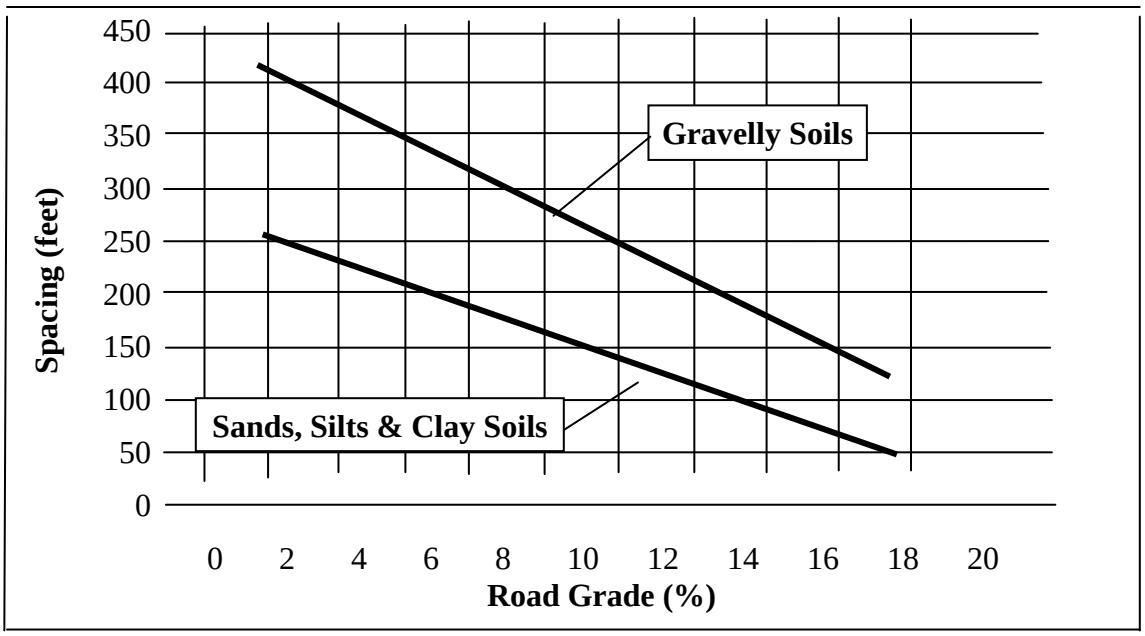


Figure 4. Narrow-based Water Break – example of usage.

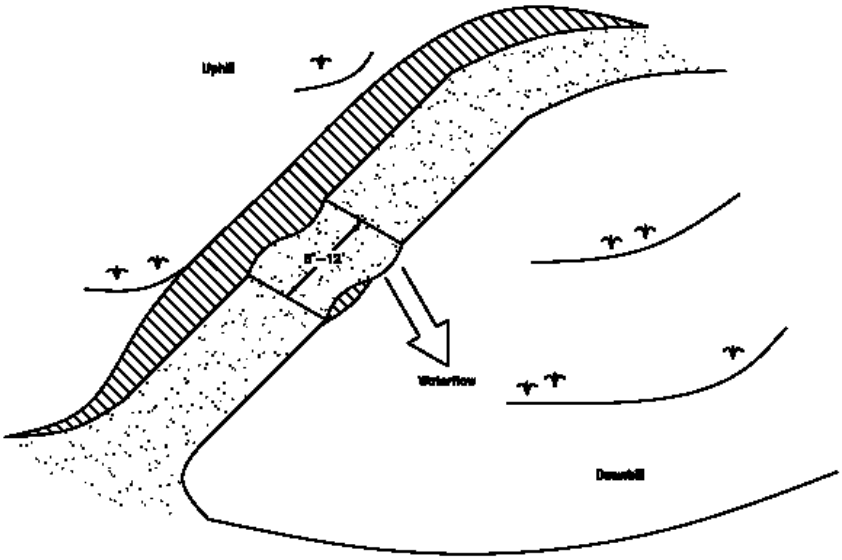
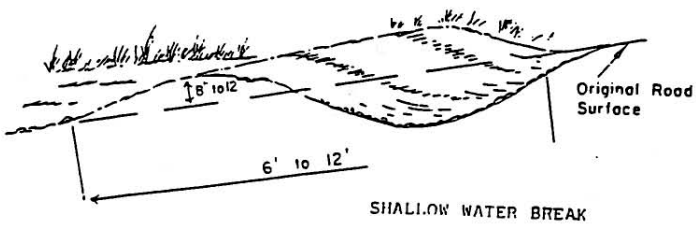


Figure 5. Narrow-based Water Break – dimensions.



ROAD PROFILE GRADING

Definition. Shaping the surface of the road to allow drainage. Figure 6 shows the possible configurations and the optimum location for use.

Outsloping. Outsloping involves grading a road so that the entire width of the road slopes toward the hill it is cut into, and it is appropriate when fill slopes are stable and drainage will not flow directly into stream channels. Outsloping the roadbed keeps water from flowing next to and undermining the cut bank, and it is intended to spill water off the road in small volumes along its length. The effectiveness of outsloping is limited by roadbed rutting during wet conditions.

Installation Guide – Outsloping

1. Give the width of the road a 2 to 3 percent outslope.

2. Construct a short broad-based dip to turn water off the surface.

3. Providing a berm on the outside of an outsloped fill during construction, and until loose fill material is protected by vegetation, can eliminate erosion of the fill. (A continuous berm along a roadside can reduce total sediment loss by an average of 99 percent over a standard graded soil road surface. Berms need to have openings provided to allow water to drain off the road surface at appropriate locations where a suitable infiltration or sediment trap site is reached. Natural berms that form along the road over time should be cut at appropriate locations to provide drainage.

4. A graveled road surface or a grassed strip on the edge of the driving surface can reduce total loss of sediment from roads by up to 60 percent over a standard graded road surface.

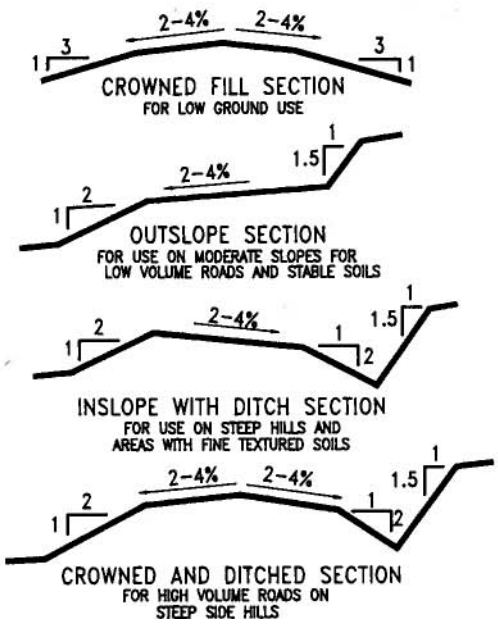
Insloping. Insloped roads carry road surface water to a ditch along the cut bank.

Installation Guide – Insloping
Ditch gradients of between 2 and 8 percent usually perform best. Slopes greater than 8 percent give runoff waters too much momentum and enough erosive force to carry excessive sediment and debris for long distances. Slopes of less than 2 percent tend to cause water to drain too slowly and do not provide the runoff with enough energy to move accumulated debris. The ditch grade also depends on the soil type: Use a slope closer to 2 percent on less stable soils and nearer to 8 percent on stable soils.

Crowned Road Surface. A crowned road surface is a combination of both an outsloped and insloped surface with the high point (crown) at the center of the road. The crowned road provides drainage to both sides of the roadway.

Installation Guide – Crowned road surface
A drainage ditch is usually placed next to the road on the insloped side. Properly spaced and sized culverts then direct the runoff to an appropriate grassed buffer, detention basin, or other sediment control structure.

Figure 6. Typical Road Design for Drainage, Stability, and Safety. (From Virginia DOF)



REFERENCES

Best Management Practices (BMP) Field Guide. Virginia Department of Forestry. July 2002.

National Management Measures to Control Nonpoint Source Pollution from Forestry. EPA 841-B-05-001. U. S. Environmental Protection Agency. May 2005.

Pennsylvania Conservation Practice Standard *Animal Trails and Walkways (Code 575),* June 2003.

Tennessee Conservation Practice Standard *Animal Trails and Walkways (Code 575),* May 2003.

Virginia's Forestry Best Management Practices for Water Quality. Virginia Department of Forestry. July 2002.

Woodlands of the Northeast, Erosion and Sediment Control Guides. Prepared by USDA Soil Conservation Service, Northeast Technical Center, Broomall, PA and USDA Forest Service, Northeastern Area State and Private Forestry, Upper Darby, PA. 1977.