Dirt and Gravel Road Best Management Practice Guide

Landowner's Handbook to Building and Maintaining Private Roadways

Published by the Culpeper Soil and Water Conservation District with funding from the Chesapeake Bay Restoration Fund. January 2019

351 Lakeside Dr.
Culpeper, Va. 22701
Office: 540-825-8591

Table of Contents

Dirt and Gravel Road BMP Guide

Introduction

There are close to 400 miles of dirt and gravel roads in the Culpeper District. Dirt and gravel roads are low-volume roads that have relatively low use and provide service to residences and agricultural, logging and recreational areas. Most dirt and gravel roads are privately maintained and serve individual lots or small subdivisions. Maintaining and improving these roads can be a major responsibility for landowners.

Over time many roads and driveways deteriorate for a variety of reasons: poor construction, improper maintenance, excessive weather events, heavy traffic loads, and others. In addition to the high and frequent repair costs, many of these roads and roadside ditches drain directly into our waterways. The transport of both sediment and gravel into stream channels has a destructive impact to the stream ecosystem resulting in the smothering of aquatic habitat and reduction of the channel's capacity to carry water. Sedimentation of the channel causes increased frequency of flooding and streambank erosion. Competent construction and maintenance of dirt and gravel roads can save the landowner money and better protect local waterways.

The goal of this BMP guide is to help you plan and manage dirt and gravel roads to minimize the environmental impacts of uncontrolled runoff on local waterways. Our objective is to provide landowners with low cost solutions to common problems associated with building and maintaining dirt and gravel roads.

The following sections will discuss Site Assessment, Road Assessment, Common Problems, Troubleshooting, and Maintenance. The guide will also provide an Inspection Checklist, Maintenance Schedule, and Practice Specifications.

Figure 1

Figure 2

Figure 1: Gravel driveway directing runoff to stream crossing.

Figure 2: Well-maintained gravel driveway

Site Assessment

Whether your road is already built or you are planning to build, the existing site conditions should influence the location and design. A poorly designed road in a good location can always be improved. A well designed road in a poor location will need more maintenance. The topography, soils and land cover play a part in the alignment and stability of the road.

Ideally, the topography or slope of the land determines the location of the road. The steeper the terrain the longer the road should be as it traverses a series of switchbacks. Careful selection of road location can also help to minimize the need for culverts and drainage structures. Unfortunately most road right-of-ways are arbitrarily placed on deeds and plats. Costs also determine the location and length of the road. Shorter roads are not always less expensive in mountainous terrains.

Figure 3

Figure 3: A sinuous road can be better than the straight path.

Stable soils are needed to provide a solid base for the road. Soils are stable when the structure is suitable for compaction and the soil particles are slip resistant. The base soils should not have any organic matter that can decompose. The soil should have a low shrink-swell potential and be relatively dry. Soils with a high water table may need subsurface drainage.

Vegetation should be preserved on critical areas such as steep slopes and along waterways. Land cover affects the flow of runoff and can prevent erosion. Tree canopy can intercept rainfall and protect the understory from heavy rains. Good understory with groundcover can prevent erosion and further slow runoff. Forest cover can impact how the road banks are stabilized. The groundcover will need to be shade tolerant.

Figure 4

Figure 4: A road that follows close to the stream will erode.

Design and Construction Considerations

The Best Management Practices or BMPs in the Practice Specifications of this guide will aid in the design and construction of dirt and gravel roads. These BMPs help minimize problems associated with runoff and ensure the dirt and gravel road will be functional and easier to maintain. Below are suggestions for incorporating the BMPs listed in this guide and describe basic erosion control practices for construction.

The shape and grade of the road affects how well it drains. The roadside ditches transport runoff from the roadway, side slopes and adjacent areas. The ditches should minimize stream connection by using turnouts. The ditch outlets need to dissipate and disperse runoff flows. Conveying runoff safely off the road can be done over the road using dips and diversions or under the road using cross culverts. Controlling runoff is critical to long term maintenance.

Ditches are functional as soon as they are constructed so immediate stabilization is critical. During construction the ditches should be seeded, mulched and matted as soon as possible. Temporary matting that is staked in place is important to prevent mulch and seed washing. In some cases adding rock check dams will help slow runoff.

The side slopes need to be mulched and seeded after grading is complete. Temporary stabilization matting or other surface roughing techniques can be used on steep slopes to keep the seed and mulch in place.

Soil testing should be done to determine application rates for lime and fertilizers. This will help with vegetation establishment.

Minimize stream crossings and encroachments whenever possible. These areas can funnel sediments into waterways and each crossing will be a maintenance burden. Utilize the stream crossing BMPs in this guide to reduce the road's impact and maintenance.

Figure 5: Elevated (In-slope) Gravel Driveway to inside ditch.

Figure 6: Open top Culvert; Figure 7: Temporary stabilization matting in ditch

Road Assessment

Once the road is installed, routine inspection and maintenance should be performed to maintain the road. The surface condition of dirt and gravel roads can change rapidly. Heavy rains and traffic accelerate changes to the surface characteristics. Inspecting the road after unusually heavy rains and at least once a year is a good practice. Divide the roadway into segments with similar conditions. Common segments include the intersections, stream crossings, changes in shape (i.e. out-sloping / in-sloping), changes in slopes, and changes in surface aggregate. Document the condition of the road to set realistic maintenance goals to make timely repairs and stay on budget.

Figure 8

Figure 9

The inspections should assess the crown and roadway cross section; thickness and condition of the surface aggregate; and all drainage structures and flow paths.

- The crown height should be at least 6 inches higher than the shoulder and the cross slope of the roadway should be unrestricted and at least 4 percent; see the practice specifications on road surface shaping. The cut and fill slopes should be stable with a good stand of vegetation and little or no erosion or slumping.
- The depth of the gravel surface should be a minimum of 6 inches. The gravel surface should not show signs of loose gravel. Culverts and geotextile fabrics should have at least 12 inches of cover to prevent damage.
- Surface runoff should not be flowing laterally across or down the roadbed. The side ditches should be deep enough to contain surface runoff. The cross culverts should be clean and sized to prevent frequent impoundment of water. Stream crossings should be clean of debris, stable and show little signs of scour upstream or downstream. Groundwater seeps should be identified and should not contribute to the deformation of the roadbed or increase surface flows across or down the roadbed.

Figure 8: The shape of the road and the surface aggregates should be visibility evaluated for deficiencies.

Figure 9: When rills or other drainage problems exist, determine the source of the water. Is the shape or surface materials of the roadbed contributing to the drainage problem?

Common Problems

Below are five of the most common problems found on dirt and gravel roads. Make note of locations with these problems and measure the depth of damage. When these problems are severe, regrading and shaping of the road will be necessary to improve drainage and to reinforce the roadbed.

1. Erosion down the roadbed occurs when the crown is lost and thereby a flat road is created; or when the ditches are obstructed or non-existent and the runoff then create a u-shaped road.

2. Lateral erosion across the roadbed occurs at low spots in the road or where a ditch or cross culvert has been clogged with debris.


Figure 10

Figure 10: Erosion down the roadbed, see #1.


Figure 11

Figure 11: Lateral erosion across the roadbed, see #2.

3. Washboarding is a rough road with a series of ridges and depressions (or corrugations) across the road that is caused by fast or heavy traffic over poor surface material.

4. Rutting occurs where tire wear has created channels in the roadbed due to poor base material and high groundwater. Minor ruts are less than 3 inches and major ruts are over 9 inches deep.

5. Potholes are holes in the roadbed caused by poor drainage and traffic. Minor holes are isolated shallow depressions. Major holes are widespread and deeper than 6 inches.


Figure 12

Figure 12: Common pothole in tire wear tracks. Formation can be due to poor soils or freeze/thaw action or shade prevents the area from drying out, see #5.

Troubleshooting

Surface distress such as washboarding, ruts and potholes indicate loss of roadbed strength. The three primary causes of distress are poor subgrade, improper drainage or inadequate gravel cover.

- The subgrade is the foundation of the road base, usually made of native soil and rock. The subgrade becomes a problem when the native soil is poorly compacted, has too much organic matter or has groundwater seepage. Regrading and shaping the roadway to remove undesirable materials and compacting the soil will improve the subgrade. The use of a Geotextile fabric will reinforce the base materials and protect from over saturation. A subsurface practice such as a French Mattress or underdrain may also be needed to improve the road base.
- Surface drainage over or across the roadway washes the gravel cover and weakens the road. Runoff from the side slopes and uphill sources needs to be conveyed safely around the roadway. Cross Culverts and Dips are the primary tool to convey runoff under or over the road surface to minimize dirt and gravel erosion. Diversions and grade breaks intercept runoff down the road and diverts to a safe location.
- The surface aggregate should use 6 inches of fine gravel like VDOT #21A.Coarse gravel like VDOT #57s can be used as a base aggregate for strength and drainage. Maintaining the shape of the road will reduce the loss of gravel. Proper compaction of the gravel surface and routine blading and smoothing of the road surface will ensure uniform distribution. See Penn State's Center for Dirt and Gravel Road Studies Driving Surface Aggregate technical bulletin for specifications.

Figure 13

Figure 13: Massive ruts formed in a dirt road. The soils are soft and should be reinforced with Geotextile and need additional surface aggregate.

Figure 14

Figure 14: Runoff is conveyed down the driveway. The runoff needs to be diverted to a side ditch. A Dip or Diversion can be used; see the practice specifications.

Stream crossings are vulnerable to damage from major storms. Crossings can have localized scour, become overtopped or can be washed out.

- Scour is the erosion of the stream bank due to direct and vortex flows at individual locations in the stream channel. Scour primarily occurs when there are blockages of the stream channel or when the crossing itself restricts flow and causes backwater eddies. To reduce scour potential the upstream end of a culvert crossing could be reinforced with a solid headwall, wingwall or riprap lining. The culvert pipe can also be sized to pass more flows or the stream channel could be reconnected with the floodplain to dissipate erosive flows.

Figure 15

Figure 15: Inadequate culvert bedding combined with high flow depths causes piping; which is the loss of fill material. A headwall or riprap lining is needed.

Figure 16

Figure 16: Frequent high flows that can clog and overtop the roadbed need a high water bypass; see practice specifications.

- Overtopping occurs when the stream crossing is flooded during high water events. Low Water crossings are designed to overtop. Culvert crossings may need a high water bypass or secondary high flow pipe. The crossing could be enlarged to pass larger events.

- Washing out occurs when the crossing material is either overcome with erosive flows or there may have been a structural problem. Structural problems include piping along the culvert pipe; pipe buoyancy or floatation; or undermining of the crossing base material.

Figure 17- photo credit Va. DCR

Figure 17: Poor placement of culvert resulted in buoyancy failure during high flow event. Culverts need 1 foot of cover and plastic pipes need to be weighted down.

Maintenance

Annually the dirt and gravel road needs to be inspected and maintained. There are four maintenance components to consider for dirt and gravel roads. The roadway includes the road surface (shape and surface aggregate), side slopes (cut and fill banks), drainage system (ditches and culvert), and riparian buffers (vegetative area along waterways for dispersion of runoff).

There are three main functions involved with maintaining the road surface:

1. Blading and Smoothing to remove high spots and redistribute materials. Blading and Smoothing is an annual task for the spring to clear accumulated materials left by the snowplows.
2. Grading and Reshaping repairs the road shape and improves road drainage. Grading and Reshaping is a repair task performed every couple of years to maintain the crown of the road.
3. Adding Materials to resurface the roadbed or stabilizing gravel with binding agents for dust control and strength. Adding Materials can be annual or as needed depending on the quality of the base materials, traffic and weather.

Figure 18

Figure 19

Figure 18: Accumulation of loose materials along the shoulder or in the ditch does not allow runoff to sheet off the roadbed.

Figure 19: Placement of rock lining should not comprise the capacity of the side ditch.

The side slopes are very important for transitioning the roadway to the adjacent natural grades. Cut slopes can be steep and difficult to mow or maintain vegetation. Fill slopes are vulnerable to rill and gully erosion. Mowing high (4-6 inches), over seeding and taking soil samples to amend in accordance with a soil test will keep a mature and uniform stand of vegetation on these slopes. Repair eroding areas by maintaining erosion control measures such as surface diversions, subsurface drains, stabilization matting, rock linings or terraces.

The drainage system includes ditches, cross-culverts and stream crossings. These structures take the runoff from uphill and the roadway and convey it to a stable outlet. Debris removal may be needed multiple times a year to keep the structures free flowing. Mowing grass channels to maintain uniform and mature vegetation will be needed during the growing season. Woody vegetation should not be allowed to impede channel and culvert flows. Repair erosion as needed, with stabilization matting, check dams and rock lining.

Riparian Buffers are vegetative areas adjacent to streams that protect stream banks and shorelines. Ideally the roadway should be located at least 50-feet from the top of stream bank or shoreline so that runoff can be dispersed and filtered by vegetation prior to reaching the waterway. Grass buffers will need to be mowed no shorter than 6 inches and no more than 2 times a year. Where ditches or cross culverts are dispersed with a level spreader or turnout, these areas will need annual removal of debris and periodic erosion repair. Forested buffers may need trees cut when they fall into the stream channel.

Maintenance Schedule

Maintenance is generally done as needed for most gravel roads. Regular inspections and maintenance will protect a good road from becoming degraded. The following maintenance schedule table was adapted from: Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads; Kennebec County Soil and Water Conservation District and Maine Department of Environmental Protection, Bureau of Land and Water Quality; April 2010.

Task	Spring	Fall	Major Storms	Inspection Date & Condition
ROADWAYS				
Clear accumulated winter sand along the roadway and remove false berms	X			
Maintain the crown of the road surface and shoulder, as needed at least once per year.	X		X	
Clean out sediment within Diversions; Dips; Fords; or High Water Bypass.	X	X	X	
SIDE SLOPES				
[1]Replant bare areas or areas with sparse growth. Seed or plant at appropriate time.	X	X		
[2]Collect Soil Sample and Test, every 3 years	X			
Eroding Areas: armor with riprap or stabilization matting; or divert erosive flows to a stable area.			X	
DITCHES AND CULVERTS				
Remove obstruction and accumulated sediments, leaves, or debris.	X	X	X	
Stabilize any erosion			X	
Mow grass ditches		X		
Remove woody vegetation		X		
Repair slumping side slopes			X	
Replace stone lining where underlying geotextile fabric is showing or where stones have dislodged.			X	
Repair any erosion damage at the culvert's inlet			X	
OUTLETS AND RIPARIAN BUFFERS				
Mow vegetation in non-wooded buffer no shorter than 6 inches and no more than 2 times per year.		X		
Repair erosion below culverts and turnouts	X		X	
Install more level spreaders or ditch turnouts if needed for better distribution of flow		X		
Clean out accumulation of sediment within the level spreader or turnout.	X	X	X	

[1]Consider a drought or shade tolerant seed mix or plugs for problematic areas. www.mgnv.org/plants/ground-cover

[2]Soil Sampling refer to VCE Publication 452-129. www.pubs.ext.vt.edu/452/452-129/452-129.html

Inspection Checklists

Photocopy this page to use it, and keep it for your records.

If you observe 'yes' for any of these conditions on your road, promptly take action to resolve the problem.

Road Segment Inspected: _____ Date: _____

Roadway

Yes No

__ __ Erosion of the road surface; or sediment washed into streams, ditches or waterways

__ __ Washboarding, potholes, or rutting of the surface

__ __ Displacement of surfacing gravel

__ __ Spots in the road that remain soft and wet throughout the year

__ __ Soil is being tracked or washed out onto the public roadway

__ __ Over-hanging trees and limbs that cast abundant shade onto the road surface

__ __ Tree limbs and shrubs that obscure a driver's vision at the public road entrance

Side Slopes

__ __ Soil slumping or eroding down the face of cut banks and fill slopes

__ __ Bare areas or areas with sparse growth

__ __ Groundwater seepage coming out from cut bank

Ditches and Culverts

__ __ Clogged culverts or obstructions in ditches

__ __ Erosion in the ditch or scour around culverts

__ __ Rust, corrosion or deformation of metal pipes

__ __ Caving-in atop of a culvert pipe

__ __ Stream flow undermining culvert

__ __ Ruts in the stream bottom at a ford crossing; or stream flow dammed up at the ford

Outlets and Riparian Buffers

__ __ Sediment being washed away into the woods or onto neighbor's property

__ __ Sediment build-up within dips, turnouts, diversions, or level spreaders

__ __ Bare areas or areas with sparse growth within 35-feet of outlet.

Definitions

Base Coarse or Surface Aggregate – Main surface of travelway, normally consisting of well graded crushed stone mixture.

Subbase or Base Aggregate – second layer underlying the base coarse, normally consisting of an open graded stone mixtures that provide load distribution and internal drainage for the road.

Subgrade – surface of roadbed under subbase, usually the native load bearing soils.

Cut Slope or Back Slope or Cut Bank – the slope cut into soil or rock along the inside edge of the road.

Fill Slope or Embankment Slope – The inclined slope extending from the outside edge of the road shoulder to the toe of the fill.

Roadway – Total horizontal width of land affected by construction of the road from top of cut slope to toe of fill slope.

Travelway – portion of road for use by moving vehicles.

Roadbed – the driving surface and underlying materials used in the travelway

Shoulder – unpaved strip along edge of travelway. Inside shoulder is adjacent to cut slope. Outside shoulder is adjacent to fill slope.

Side Slope or Slope Ratio – Expressing constructed slopes as a ratio of horizontal distance to vertical rise such as 3:1 is 3 feet horizontal for every 1 foot vertical.

Through Cut – A road cut through a hill slope or ridge in which there is a cut slope on both sides.

Through Fill – Road comprised of fill material, where fill slopes are on both sides.

Drainage Structure – structures installed to control, divert, or move water off or across road; includes ditches, culverts, fords, dips, etc.

Surface Flow – overland runoff that can be dispersed or concentrated.

Subsurface Flow – groundwater moving through the soil or base aggregate.

Unimproved Roads – are unpaved roadways with a dirt or gravel surface.

References:

A Guide For Forest Access Road Construction and Maintenance in the Southern Appalachian Mountains. 2014. N.C. Forest Service. WQ-02-14. http://www.ncforestservice.gov/publications/WQ0214.pdf

A Landowner's Guide to Building Forest Access Roads. July 1998. USDA-Forest Service, State and Private Forestry, Northeastern Area. Publication number NA-TP-06-98.
http://www.na.fs.fed.us/spfo/pubs/stewardship/accessroads/accessroads.htm

Environmentally Sensitive Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA-Forest Service, San Dimas Technology and Development Center. Publication Number 1177-1802P.
http://www.fs.fed.us/eng/pubs/pdf/11771802.pdf

Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads. April 2010. Maine Department of Environmental Protection. Bureau of Land and Water Quality. Kennebec County Soil and Water Conservation District. https://www.maine.gov/dep/land/watershed/camp/road/gravel_road_manual.pdf

Keller, G. and Sherar, J. Low-Volume Roads Engineering Best Management Practices Field Guide. July 2003. USDA Forest Service and US AID. http://ntl.bts.gov/lib/24000/24600/24650/Index_BMP_Field_Guide.htm

Natural Resources Conservation Service. Conservation Practice Standard Code 560. Access Road. July 2010.
http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_026142.pdf

Natural Resource conservation service. Virginia Engineering Design Note #1 (DN-1). Road Drainage Practices. March 2008. https://efotg.sc.egov.usda.gov/references/public/VA/DN_1_Design_Note_1_Road_Drainage.pdf

Pennsylvania State University. The Center for Dirt and Gravel Road Studies. www.dirtandgravel.psu.edu

Transportation Information Center. University of Wisconsin-Madison. Wisconsin Transportation Bulletins.
https://epd.wisc.edu/tic/topics-and-resources/publications-order-form/

Transportation Information Center. University of Wisconsin-Madison. Gravel-Paser Manual, Pavement Surface Evaluation and Rating. May 1989. Revised 2002. https://epd.wisc.edu/tic/topics-and-resources/publications-order-form/

Transportation Information Center. University of Wisconsin-Madison. Unimproved-Paser Manual, Pavement Surface Evaluation and Rating. September 2001. https://epd.wisc.edu/tic/topics-and-resources/publications-order-form/

Virginia Department of Conservation and Recreation Division of Soil and Water Conservation. Virginia Erosion and Sediment Control Handbook (VESCH). Third Edition. 1992.
https://www.deq.virginia.gov/Programs/Water/StormwaterManagement/Publications/ESCHandbook.aspx

Virginia Department of Forestry. Virginia's Forestry Best Management Practices for Water Quality Technical Manual. March 2011. http://dof.virginia.gov/infopubs/BMP-Technical-Guide_pub.pdf

Acknowledgements:

Author: Richard Jacobs, PE Culpeper Soil and Water Conservation District

Peer Review: Rodney Newlin, Water Quality Engineer Virginia Department of Forestry; Wayne Stanton, PE Culpeper Engineering P.C.; Greg Wichelns, Culpeper SWCD

Section 2: Practice Specifications

2.1 Road Surface Shaping

2.2 Roadside Ditches

2.3 Ditch Turnouts

2.4 Cross Culverts

2.5 Dips

2.6 Diversions

2.7 Subsurface Drains

2.8 Geotextiles

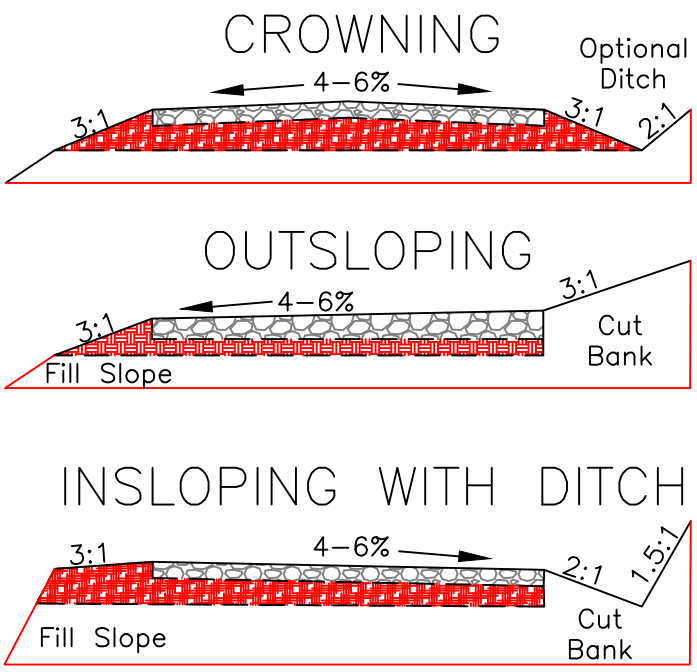
2.9 Clearwater Crossing

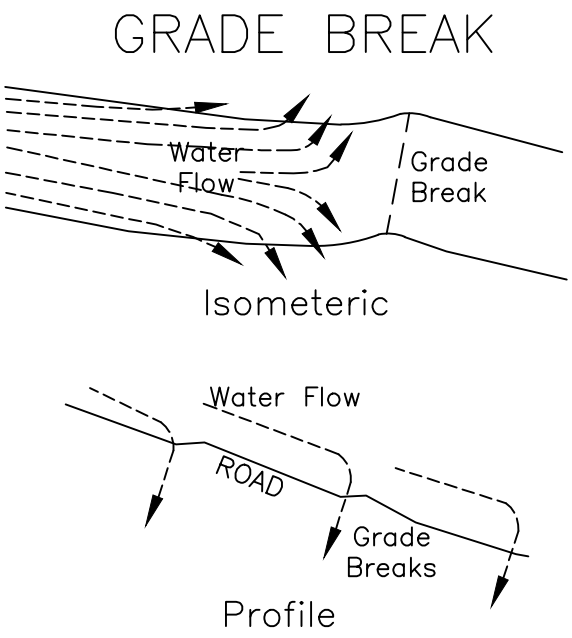
2.10 Low Water Crossing

2.11 Culvert Crossing

2.12 High Water Bypass

2.1 ROAD SURFACE SHAPING





Description:
Road surface shaping is the grading of the roadbed to allow positive drainage and prevent erosion of the roadbed. Road shaping includes crowning, in–sloping, out–sloping and grade breaks. Crowning has an elevated center and continuous fall towards the shoulders. In–sloping grades the road to drain water towards the back slope or cut bank and away from the fill slope. Inslope road concentrates runoff against the backslope or inside ditch. Out–sloping grades the road to drain surface water to the downhill or fill slope side allowing sheet flow off of the road. Grade breaks are small intentional increases in road elevation on a downhill slope, which shorten flow paths and sheds runoff to one or both sides into ditches or dispersal areas.

Limitations:
- Steep side slopes and unstable fill prevents use of out–sloping.
- Narrow right–of–ways prevents the use of in–sloping.
- Heavy loads and traffic speeds may disrupt grading.

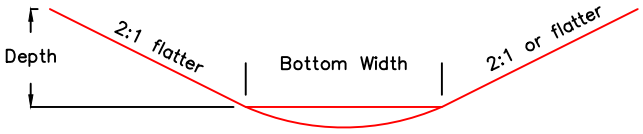
Construction:
1. Crowning can be used where there is adequate drainage away from either side of the roadbed; such as ridges and floodplains. Effective for road slopes of 8% or greater. Remove berms from road shoulder that may trap water.
2. Out–sloping should be used on road slopes of 8% or less. Use on roads where side–slopes are gentle and where runoff is not concentrated and drainage area small.
3. In–sloping should be used on steep side slopes and where the fill–slope is unstable. The ditch shall have adequate capacity for the design flows. Consider frequent use of cross–culverts, road diversions and dips to disperse the concentrated ditch runoff at adequate turnouts. Requires more frequent maintenance.
4. Grade Breaks should be used on long road slopes where adequate space is available to safely shed runoff into ditches or dispersal areas. Located prior to gradient changes and stream crossings. Construct elevated berm perpendicular to roadway and taper the edges into the road grade.
5. Unpaved roads shall have a cross slope of 4 to 6 percent ($\frac{1}{2}$ to $\frac{3}{4}$ inch per 12 feet) to quickly shed runoff.

Maintenance:
- Maintain the cross slope during snow plowing and maintenance blading.
- Educate road crews to maintain these grading features, such as side ditches and grade breaks.
- Add materials to maintain cross slope and grade breaks as necessary.

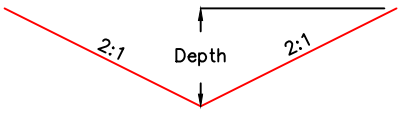
Resources:

- Penn State Center for Dirt and Gravel Road Studies. Crown and Cross–Slope TB. 2005.
- Penn State Center for Dirt and Gravel Road Studies. Grade Breaks TB. 2004.
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Forest Roads Specification 1.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC.Chapter 3 Road Surface Shape.

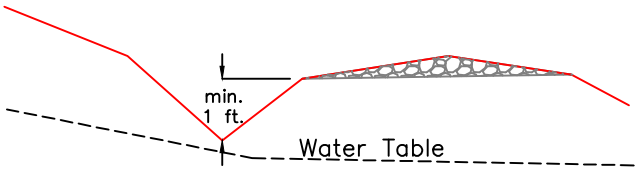
2.2 ROADSIDE DITCHES



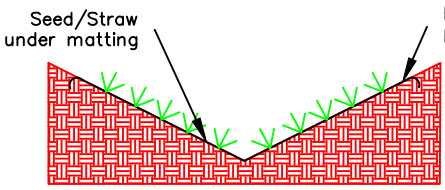
TRAPEZOIDAL/PARABOLIC



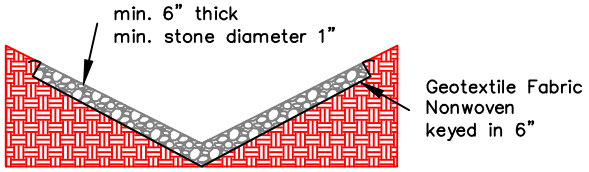
V–DITCH



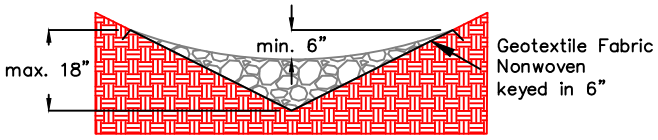
*Avoid the interception of ground water



Fiber Matting



Stone Lining



Rock Check Dam

*use 2" to 3" stone, combine with riprap for heavier flows.

Description:
Roadside ditches collect runoff from the road and abutting properties and drain it away from the road. Ditches can be on both sides of the road or one side. Typical ditches are v–shaped for ease of construction and maintenance. A trapezoidal or parabolic ditch are preferred to slow and disperse road runoff. Ditches should be vegetated or where needed lined with stone.

Limitations:
- Bedrock and narrow right–of–way can prevent the shaping of ditches.
- Entrenched or u–shaped roads have limited space for ditches.
- Steep Slopes increase erosion potential.

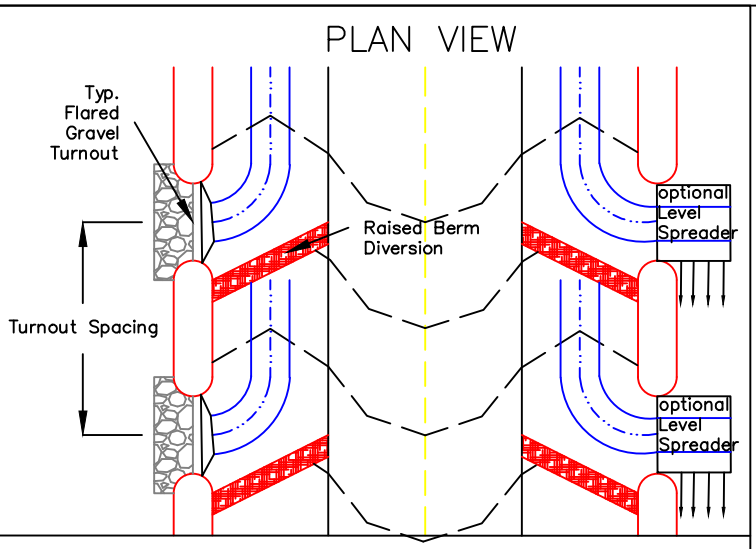
Construction:
1. Sizing is based on the volume of runoff and should be done by an experienced or qualified professional. Design flows should be based on the 10–year peak flow for channel capacity and velocity.
2. Avoid excavating the ditch below the water table if possible. Use subsurface drains to convey excess water away from ditch.
3. Ditches should be constructed on cut soils. If fill is used to create the ditch, the fill will need to be compacted and lined with fiber matting or stone.
4. A wide grass–lined trapezoidal or parabolic ditch is preferred. Bottom width of between 2 and 4 feet.
5. Ditch should have a shallow drop off from road surface. Side slopes of 2:1 or flatter; with a 3:1 side slope preferred.
6. Grass established with sod is preferred for immediate vegetated cover. The sod should be rolled out perpendicular to the flow of water and pegged. Temporary stabilization matting should be used if seeding the ditch. Ensure the matting is installed with continuous contact with the soil per manufacturer specifications.
7. Ditch Slopes greater than 2% should be lined with fiber matting and check dams.
8. Ditch Slopes greater than 5% should be lined with stone suitable for the flow velocity.
9. Disconnect ditches from stream channels, wetlands and ponds whenever possible, see Clearwater Crossing practice.
10. Avoid directing ditch flows toward wells, septic tanks, and drain fields.

Maintenance:
- Remove sediments and debris to maintain ditch capacity and vegetation.
- Ditches should be checked for erosion. Stabilize with matting or rock as needed. Consider the use of turnouts or cross culverts to minimize erosive flows.
- Remove unnecessary berms or debris windrows along the shoulder of the road to ensure sheet flow off the road surface.
- Reseed and mulch whenever soil is disturbed. Seed in fall for cool season lawn grass mix or spring for warm season grass mix. Maintain a cover density of 75%.

Resources:

- Virginia Erosion and Sediment Control Handbook, 3rd edition. 1992. Stormwater Conveyance Channel Spec. 3.17; RipRap Spec. 3.19; Rock Check Dams Spec. 3.20; and Stabilization Matting Spec. 3.36
- Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads. April 2010. Maine Department of Environmental Protection. Bureau of Land and Water Quality. Kennebec County Soil and Water Conservation District. Ditches Pg. 39.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 4 Low Maintenance Ditch and Berm Removal.

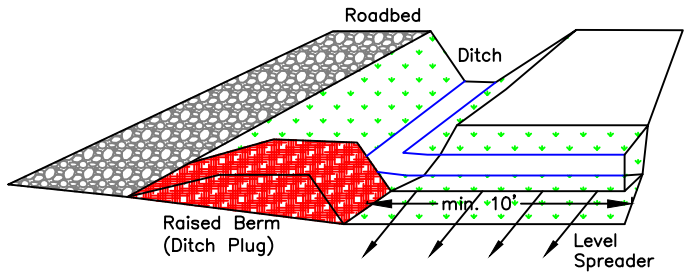
2.3 DITCH TURNOUTS



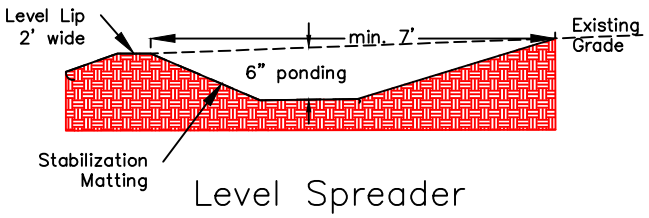
DITCH TURNOUT SPACING:

Min. Spacing = 400/(Slope %) + 100 feet;
Additional spacing may be needed based on site specific considerations.

When a road is within 25 feet of a stream and runs parallel to a stream for more than 300 feet, decrease the spacing by a minimum of 25%.



ISOMETRIC



Level Spreader
CROSS SECTION

Description:
Ditch turnout or Wing Ditch is a diversion ditch constructed to disperse runoff away from the road and side ditches into adjacent undisturbed areas so that the volume and velocity of roadside ditch runoff is reduced on slopes. Turnouts properly disconnect concentrated ditch flow from streams, wetlands and ponds. The turnouts disperse runoff before erosion can occur. Typical turnouts use flared gravel aprons. Level spreaders can be used to aid in the dispersion of high runoff flows and provide additional sediment trapping.

Limitations:
- Narrow Roadways such as entrenched or u–shaped roads
- Steep or unstable fill slopes
- Wet and Flat areas without positive drainage
- Impacts to neighboring property

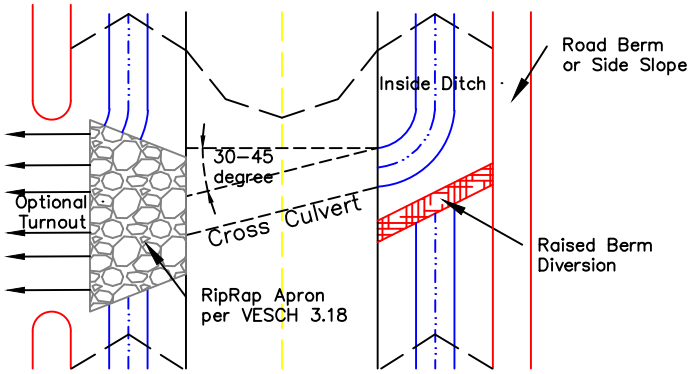
Construction:
1. Turnouts should be located so that they use the natural contour of the land.
2. Do not discharge directly into gullies or streams. Turnouts should discharge to vegetated buffers or filter strips.
3. Install multiple turnouts to minimize the accumulation of large volumes of runoff. Spacing guidelines are provided. Turnouts should be no more than 300 feet apart since erosion increases on ditches longer than 300 feet.
4. Turnouts with a slope less than 5% can be seeded and matted or sodded. Turnouts with slopes greater than 5% should be lined with 4" to 6" crushed angular stone over nonwoven geotextile fabric.
5. On sloping roads, the turnout should be angled at a 30 to 45 degree angle to the roadbed and downsloped less than 2% of the natural contour.
6. Level Spreader should be used with the turnout slopes greater than 10% or when the turnout is within 50 feet of a stream, pond, or other sensitive area.
7. Install Turnouts and Level Spreader on cut material and wide enough to allow for maintenance.
8. Turnouts can be a component of other water diversion structures such as dips, waterbars and cross culverts.

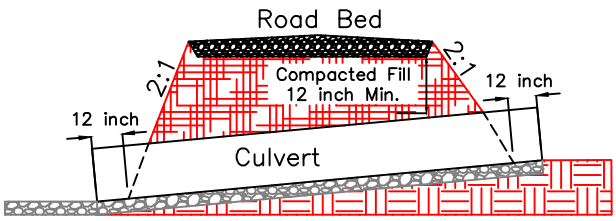
Maintenance:
- Inspect annually and after major storms.
- Clean out debris and sediments.
- Ensure runoff is dispersed into vegetation.
- Repair erosion in and downstream of flow dispersion structures.

Resources:
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Specification 3 Wing Ditches.
- Virginia Erosion and Sediment Control Handbook. 3rd Edition 1992. Level Spreader specification 3.21.
- Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads. April 2010. Maine Department of Environmental Protection. Bureau of Land and Water Quality. Kennebec County Soil and Water Conservation District. Ditch Turnouts Section Pg. 49.

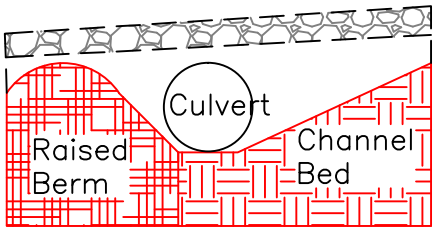
2.4 CROSS CULVERT

PLAN VIEW





PROFILE



CROSS SECTION

CROSS CULVERT SPACING:

Min. Spacing = 400/(Slope %) + 100 feet;
Additional spacing may be needed based on site specific considerations.

When a road is within 25 feet of a stream and runs parallel to a stream for more than 300 feet, decrease the spacing by a minimum of 25%.

Description:
Cross Culvert is a pipe made of corrugated metal (CMP), high density plastic (HDPE), or reinforced concrete (RCP) installed under roads to convey water from an inside ditch to the outside edge of a road for dispersion.

Limitations:
- Bedrock depth less than 2 feet prevent culvert placement.
- Fill cover greater than 1 foot is needed to prevent damage to the culvert from traffic and buoyancy protection.
- Adequate grade from inside ditch to culvert outlet.
- Not intended for springs/seeps or crossing live streams.

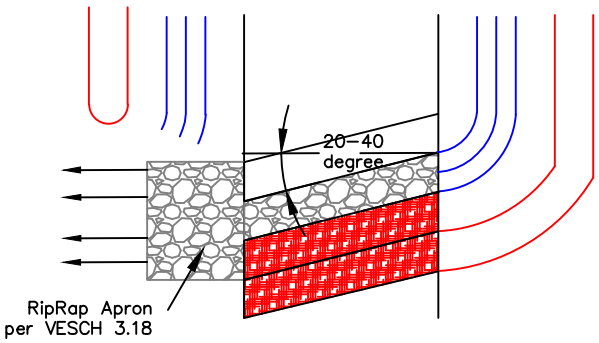
Construction:
1. Unless installed in a sag of the road, the cross culvert should be angled 30 to 45 degrees as measured from a line perpendicular to the road.
2. A raised berm diversion is installed in the ditch below the culvert inlet to direct water into the culvert. This berm should plug the ditch. The berm should be at least 4 feet wide.
3. The cross culvert should have a slope of 1–2% to prevent clogging and the bottom should be as close as possible to the natural grade of the outlet.
4. Cross culvert should be firmly seated and earth compacted at least halfway up the side of the pipe. Provide cover over the pipe that is equal to one foot per foot of culvert diameter. Never use less than one foot of cover.
5. The pipe should be long enough so both ends extend at least one foot beyond the side slope of the fill material.
6. Provide a stabilized outlet. Use riprap underlined with geotextile fabric or another structure such as a level spreader to disperse runoff and reduce flow velocities.
7. Provide inlet protection measures during construction to prevent clogging. Headwalls may be necessary to prevent erosion at the inlet.
8. Install multiple cross culverts to minimize the accumulation of large volumes of runoff. Spacing guidelines are provided above. Generally, cross culverts should be installed as needed.

Maintenance:
- Inspect after each major runoff event and provide maintenance as needed.
- Annually remove debris and sediment at inlet and outlet of the culvert.
- Ensure outlets are stable, repair as necessary.
- Ensure inlets are stable, repair as necessary.
- Vegetated outlets shall be maintained with adequate cover. Amend the soil, reseed and mow as needed.

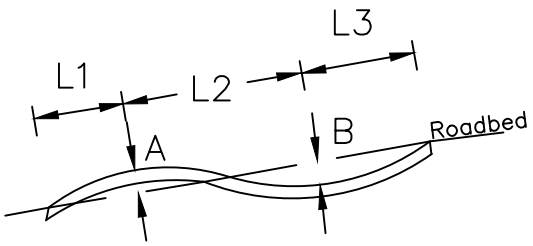
Resources:

- Penn State Center for Dirt and Gravel Road Studies, Crosspipe Installation TB. 2006.
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Culvert Sizes for Cross Drainage of Roads specification 4.
- Virginia Engineering Design Note #1 Road Drainage Practices. 2008. USDA Natural Resource Conservation Service.

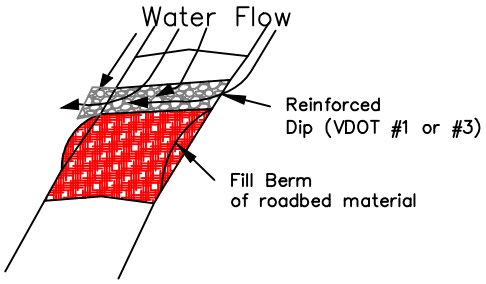
2.5 DIPS



PLAN VIEW



Dip Profile



Isometeric

DIP SPACING:

Min. Spacing = 400/(Slope %) + 100 feet; Additional spacing may be needed based on site specific considerations.

When a road is within 25 feet of a stream and runs parallel to a stream for more than 300 feet, decrease the spacing by a minimum of 25%.

Description:
Dips are depressed grade breaks built across the road surface to convey ditch flows from one side to the other side of the road. The road profile (vertical alignment) is changed by simultaneously constructing a dip and raising the grade below the dip. The dip is skewed to one side to shed and disperse runoff. Used where cross culverts are not applicable or where the road is entrenched or u–shaped.

Limitations:
- Not intended to convey or divert springs or small streams.
- Use on low volume roads where traffic loads and speed is not a concern.
- Bedrock can impact the grading of Dips.
- Not to be used on roadbeds with slopes greater than 10 percent.

Construction:
1. The dip will be reinforced with VDOT #1 or #3 sized stones over nonwoven geotextile fabric.
2. Dip depth, B shall be a minimum of 6 inches. Approaching length, L3 shall be between 10 and 25 feet.
3. Angle the Dip across the road in the direction of flow between 20 and 40 degrees.
4. Maintain a cross–slope in the dip of 1 to 4 percent.
5. Reinforce the dip with stone and geotextile fabric to resist erosion.
6. The fill berm is part of the road and should be composed of roadbed material. The fill berm can tie into the roadbed or have a height, A, of less than 18 inches. The fill berm shall have a reverse grade of between 2 and 8 percent with a length, L2 of 10 to 15 feet.
7. Length, L1 should be 10 to 15 feet and tie into the roadbed grade.
8. The outlet shall be stabilized with stone apron in accordance with VESCH 3.18.
9. Use before stream crossings to direct water into vegetative filters and reduce hydrologic connectivity.

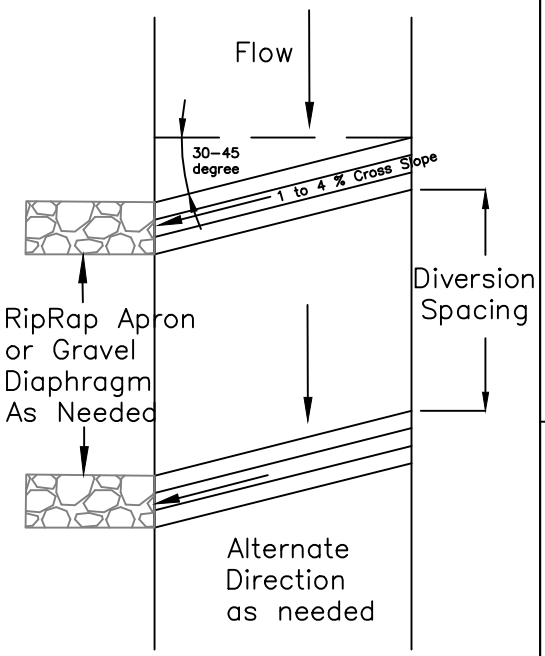
Maintenance:
- Inspect dips after each major runoff event and provide maintenance as needed
- Maintain the reverse grade.
- Remove debris and sediments from the dip.
- Ensure outlets are stable, repair as necessary.

Resources:

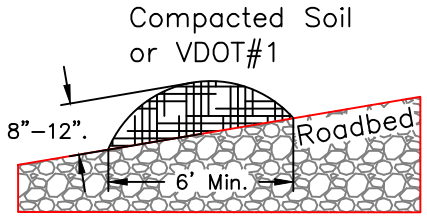
- Penn State Center for Dirt and Gravel Road Studies, Broad Based Dips TB. 2008.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. Broad–Based Dlp
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Broad–Based Dip and Rolling Dip Specification 5 and 6.
- Virginia Erosion and Sediment Control Handbook. 3rd edition 1992. Outlet Protection Spec. 3.18.

2.6 ROAD DIVERSIONS

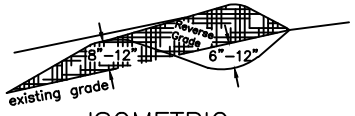
PLAN VIEW



WATERBAR DIVERSION



Typical Section



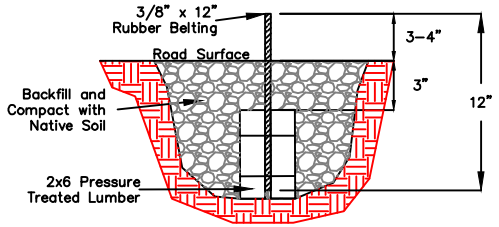
ISOMETRIC

DIVERSION SPACING:

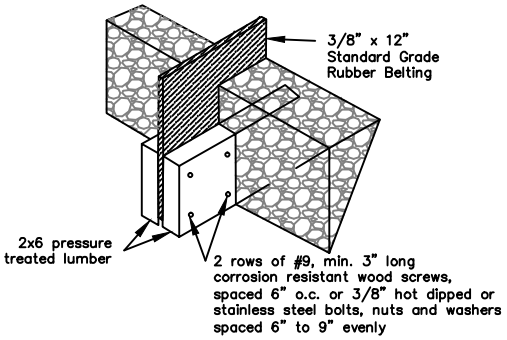
Min. Spacing = 400/(Slope %) + 100 feet; Additional spacing may be needed based on site specific considerations.

When a road is within 25 feet of a stream and runs parallel to a stream for more than 300 feet, decrease the spacing by a minimum of 25%.

RUBBER BELT DIVERSION

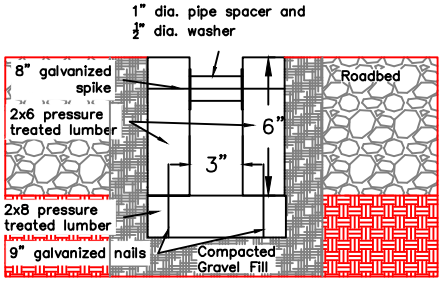


Typical Section

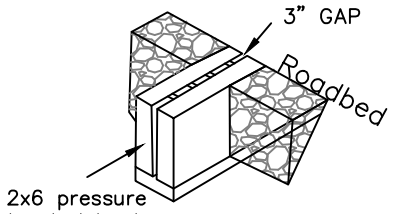


ISOMETRIC

OPEN TOP CULVERT



Typical Section



ISOMETRIC

Description:
Road Diversions are used to shed runoff from the roadbed to minimize erosion. These diversions must be resistant to erosion. Diversions are ideal above or in entrenched roadbeds and at major grade breaks. Diversions include Water Bars; Rubber Belts; and Open Top Culverts.

Limitations:
- Water Bars and Rubber Belts are intended for low volume roads since they use above grade barriers. Frequent snow plowing can also damage these structures.
- Bedrock and groundwater intrusion can affect Open–Top Culverts and Rubber Belt installation.
- Do not use a diversion for live water flows.
- Do not use a diversion to convey ditch flows across the roadbed. Refer to the Cross Culvert or Dip practices.

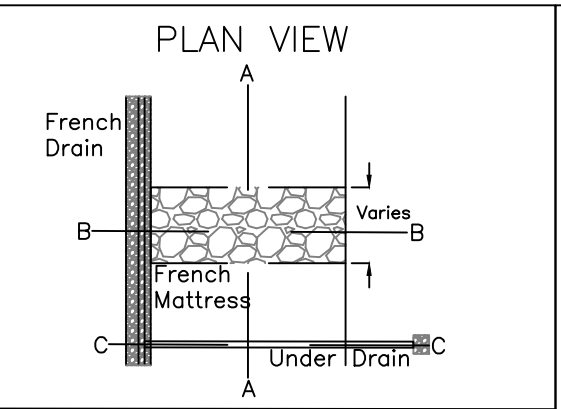
Construction:
1. Waterbar: dig a shallow trench 6" to 12" deep at an angle of approximately 30–45 degrees down slope to turn surface water off road; use the excavated material to form a 8" to 12" berm on the downhill side.
2. Rubber Belts: rubber belting is fastened to two pieces of treated lumber and buried in the road with at least 3 inches of the belting protruding.
3. Open Top Culvert: install timber flush with the roadbed; use 1" pipe spacers to reinforce the openings, spaced as needed.
4. The outlet end of the diversion should be fully open and extend far enough beyond the edge of the road to safely convey runoff away from the road surface. The outlet should drain into stable vegetated areas or be protected, as necessary, by a riprap apron or gravel diaphragm to capture sediments and prevent erosion.
5. Maintain a diversion cross slope of 1 to 4 percent.
6. Where no ditch is present on the uphill side, extend the diversion from the cut bank across full width of road.

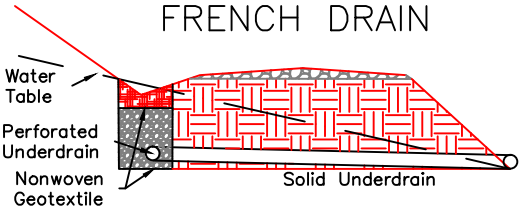
Maintenance:
- Inspect diversion after each major runoff event and provide maintenance as needed to maintain proper drainage.
- Remove debris and sediment behind the diversion. Use a small hoe or trowel to clean out the Open Top Culvert.
- Ensure outlets are stable, repair as necessary.
- Plow and Grade carefully around diversions during routine maintenance of the roadbed. Flag locations to alert snow plows.
- Vegetated outlets shall be maintained with adequate cover. Amend the soil, reseed and mow as needed.

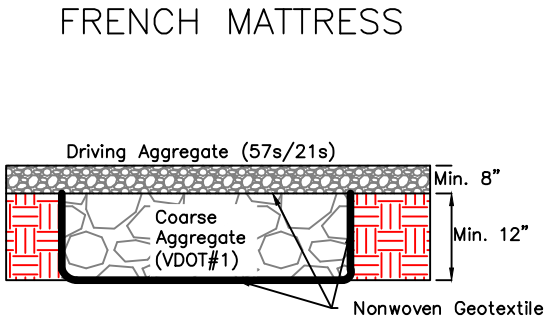
Resources:

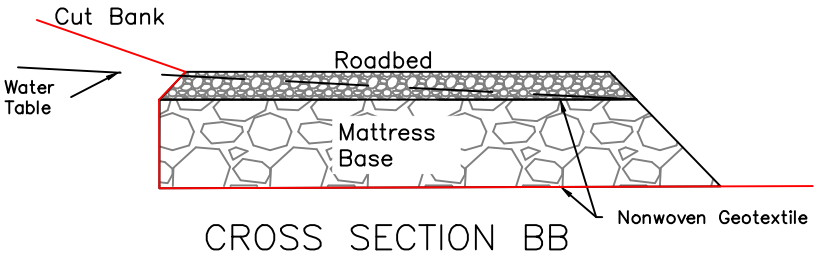
- Virginia Erosion and Sediment Control Handbook 3rd edition 1992, Right–of–way Diversions Spec 3.11.
- Penn State Center for Dirt and Gravel Road Studies, Conveyor Belt Diversions TB. 2009.
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Water Bar Specification 7.
- Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads. April 2010. Maine Department of Environmental Protection. Bureau of Land and Water Quality. Kennebec County Soil and Water Conservation District. Open–top Culverts Pg. 69.
- A Landowner's Guide to Building Forest Access Roads. July 1998. Wiest, Richard. USDA Forest Service. NA–TP–06–98. Road Construction: Open Top and Pole Culverts.
- Virginia Engineering Design Note #1 Road Drainage Practices. 2008. USDA Natural Resource Conservation Service (NRCS).

2.7 SUBSURFACE DRAINS









Description:
Subsurface Drains allows the road cutslope, ditch and base to drain and separate groundwater from surface runoff. There are two types of drains, French Mattress and French Drains.

French Matress is a subsurface structure under a road consisting of clean coarse rock wrapped in geotextile fabric through which water can pass freely. French Mattresses are used in low–lying areas near streams and wetlands, areas where the road cuts off the natural subsurface flows or areas with high water table where concentrated outlet flows is undesirable.

French Drain is an under drain structure used to collect subsurface flows associated with springs and seeps at the edge of the cutslope, shoulder or below the ditch. French drains are composed of stones wrapped in geotextile fabric or can be combined with a perforated pipe.

Limitations:
- Should not be sized for the collection of surface flows.
- Not for concentrated flows associated with streams or ditches.

Construction:
French Mattress
1. Remove the road fill material to natural ground. This should be the width of wet area or seep.
2. Place non–woven geotextile on the bottom the full width of the area. Overlap multiple sheets at least 1–2 feet.
3. Place at least a foot of large, clean 3" to 6" rock.
4. Place a layer of geotextile fabric on top of the rock. Overlap joints by 12 inches.
5. Then place the road surface material to a minimum of 8" depth after compaction.
6. The mattress can daylight to natural grade or utilize a gravel diaphragm trench that percolates groundwater safely away.

French Drain:
1. The location of the drain should be placed at the toe of cut slope where groundwater is seeping out of the cut face. The trench should extend the length of the cut slope where the seepage is occurring. The gravel trench should be as wide and deep as necessary to convey the groundwater flow rate.
2. The under drain pipe diameter should be 4 to 6 inches and perforated. A solid pipe is used to daylight the under drain.
3. Install under drain pipe with a 1% minimum slope.
4. The under drain pipe should be wrapped with at least 3 inches of clean stones above and below the pipe with a non–woven geotextile fabric. Provide at least 6 inches of fill cover.
5. Outlet the under drain separately from ditch drainage when possible. Outlet in natural swales or stable filter areas.

Maintenance:
- Remove debris and sediment from the outlet of the under drain pipe or french mattress.

Resources:

- Penn State Center for Dirt and Gravel Road Studies, French Mattress TB. 2013.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Grael Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 2 Subsurface Water
- Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads. April 2010. Maine Department of Environmental Protection. Bureau of Land and Water Quality. Kennebec County Soil and Water Conservation District. Rock Sandwich Pg. 63.
- Kellar, G & Sherar, J. Low–Volume Roads Engineering: Best Management Practices Field Guide. July 2003. USDA Forest Service. Chapter 7 Drainage.

2.8 GEOTEXTILE FABRIC

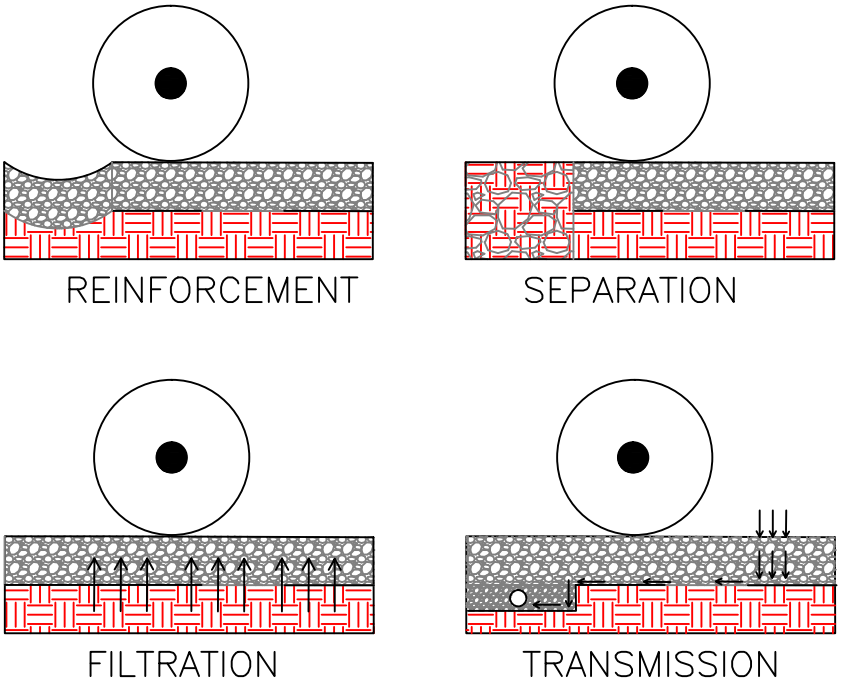


TABLE 1 - REQUIREMENTS FOR WOVEN GEOTEXTILES

Property	Test Method	Units	Class I	Class II
Grab Tensile Strength	ASTM D4632	pounds	247 (min.)	180 (min.)
Elongation at Failure	ASTM D4632	percent	<50	<50
Trapezoidal Tear Strength	ASTM D4533	pounds	90 (min.)	67 (min.)
Puncture Strength	ASTM D6241	pounds	495 (min.)	371 (min.)
Ultraviolet Stability (Retained Strength)	ASTM D4355	percent	50 (min.)	50 (min.)
Permittivity	ASTM D4491	sec^{-1}	0.7 (min.), or as specified	
Apparent Opening Size (AOS) 2/	ASTM D4751	mm	0.22 (max.), or as specified	
Percent Open Area (POA)	USACE CWO-02215	percent	4 (min.)	

1/ All values are minimum average roll values (MARV) in the weakest principal direction, unless otherwise noted.
2/ Maximum average roll value.
Note: CWO is a United States Army Corps of Engineers (USACE) reference.

TABLE 2 - REQUIREMENTS FOR NONWOVEN GEOTEXTILES

Property	Test Method	Units	Class I 2/	Class II 2/
Grab Tensile Strength	ASTM D4632	pounds	202 (min.)	157 (min.)
Elongation at Failure	ASTM D4632	percent	50 (min.)	50 (min.)
Trapezoidal Tear Strength	ASTM D4533	pounds	79 (min.)	56 (min.)
Puncture Strength	ASTM D6241	pounds	433 (min.)	309 (min.)
Ultraviolet Stability (Retained Strength)	ASTM D4355	percent	50 (min.)	50 (min.)
Permittivity	ASTM D4491	sec^{-1}	0.7 (min.), or as specified	
Apparent Opening Size (AOS) 3/	ASTM D4751	mm	0.22 (max.), or as specified	

1/ All values are minimum average roll values (MARV) in the weakest principal direction, unless otherwise noted.
2/ Needle punched geotextiles are required for both class I and class II.
3/ Maximum average roll value.

Description:
Geotextile Fabric is a multi–purpose material common in road construction. The term geotextiles is used to describe a variety of manufactured products used to reinforce earthen structures. The type of Geotextiles described here are those fabrics made of synthetic polymer fibers which are either machine woven together (woven) or heat bonded (nonwoven). Geotextile fabrics have historically been used to enhance many erosion control practices. The discussion in this guide is for using geotextile fabric as a component of the road base layer and as a component of other Road BMPs.

Limitations:
- Geotextile fabrics must be placed by hand in most cases.
- Bedrock and angular rock intrusions can puncture geotextile fabrics
- The type and thickness of the road gravel may also stress the fabric.
- Depending on the type of geotextile fabric and subsoil materials, gravel on steep slopes may slip over the fabric.

Improving Road Strength:
- Reinforcement prevents rotational failure due to soft subsoil or frequent heavy or fast traffic. The geotextile fabric acts to disperse forces accross the failure plane to strengthen subgrade and gravel base material. A Woven fabric is used for its tensile strength.
- Separation prevents the intermixing of soil and gravel. The geotextile fabric reduces the thickness of the gravel base and disperses the applied loads to increase the life of the road. The frequency of adding gravel is reduced. Either a Woven or Nonwoven fabric can be used to separate road layers.

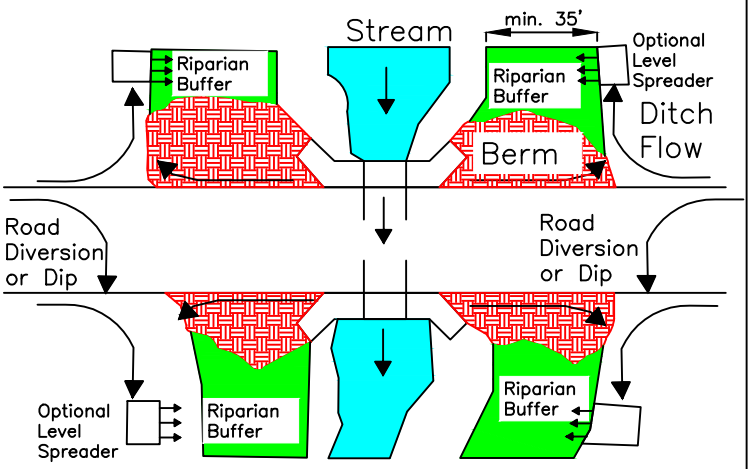
Improving Road Drainage:
- Filtration helps retain soil particles while permitting water to pass through. Use to allow seeps or springs to drain through the gravel, thus reducing hydrostatic pressure associated with a high water table. The amount of water moving through the fabric determines design and selection of the geotextile. A nonwoven fabric is best for transmitting water.
- Transmission allows water and air to be conveyed along the geotextile plane to prevent flow accross the geotextile fabric. Typically used with a subsurface drainage structure to prevent over saturation of the gravel base or underlying subsoil. A woven fabric is usually used as a liner. A nonwoven fabric may be used around the subsurface drain.

Resources:

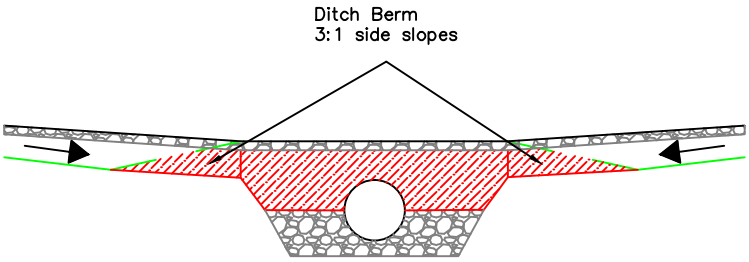
- Wisconsin Transportation Bulletin No 16. Geotextiles in Road Construction/Maintenance and Erosion Control. Wisconsin Transportation Information Center UW – Madison. 1997.
- A Landowner's Guide to Building Forest Access Roads. July 1998. Wiest, Richard. USDA Forest Service. NA–TP–06–98. Geotextiles.
- Va. Construction Specification VA–795 Geotextile. October 2015. USDA Natural Resource Conservation Service.

2.9 CLEARWATER CROSSINGS

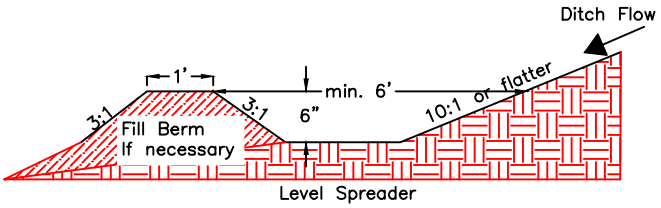
PLAN VIEW



*Use Level Spreader to dissipate and disperse ditch flows into riparian buffer area when slopes are steep or other site constraints.



CROSS SECTION



PROFILE

*Fill Berm should be compacted and stabilize for high flow situations. Otherwise the fill berm may be porous.

Description:
Clearwater Crossings are practices that minimize discharge of sediments and gravel into stream channels. Clearwater crossing disconnects ditches from the stream channel by diverting the ditch flow into a vegetated filter strip or riparian buffer. Disconnecting ditches combines ditch turn outs with vegetated filter strip and helps establish a functional riparian filter.

Limitations:
- Drainage areas greater than 1 acre per ditch outfall should be avoided.
- Riparian Buffer must be at least 35 feet of undisturbed vegetation.
- The slope of the receiving area must be less than 8 percent.
- When the slope or riparian buffer width cannot be met a modified dispersion measure (such as a gravel diaphragm or level spreader) may be needed.

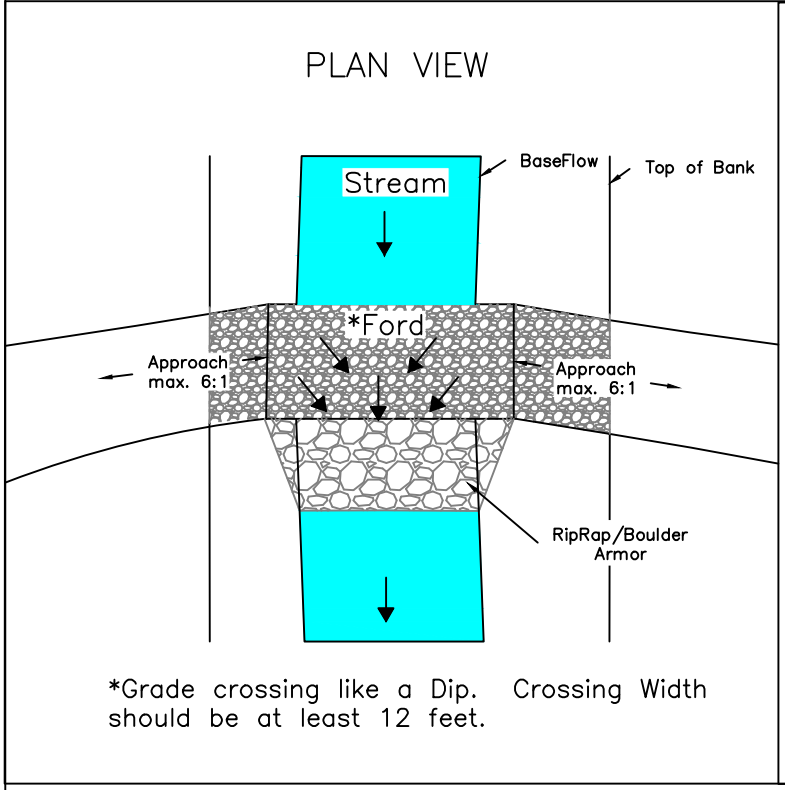
Construction:
1. Regrade ditches in wide flood plains to drain away from stream crossings.
2. Fill ditch outlets and divert ditch flows using turnouts away from the stream into stable vegetation.
3. Construct dips or diversions before the stream crossing to disperse surface and ditch flows before stream crossing.
4. Level spreaders should be used for erosive flows above steep slopes or when large volumes of runoff are concentrated to a single point.
5. Level spreader should be at least 10 feet long and typically no more than 40 feet. Larger level spreaders may be needed depending on the design flows, consult a professional engineer for sizing.
6. Level spreader should be built on contour and tied into the natural grade of the riparian buffer. In some cases, a fill berm may be necessary. The berm should not obstruct floodplain flows. The berms may be porous to promote better drainage. Berms must be compacted and stabilized with matting for erosive flows.

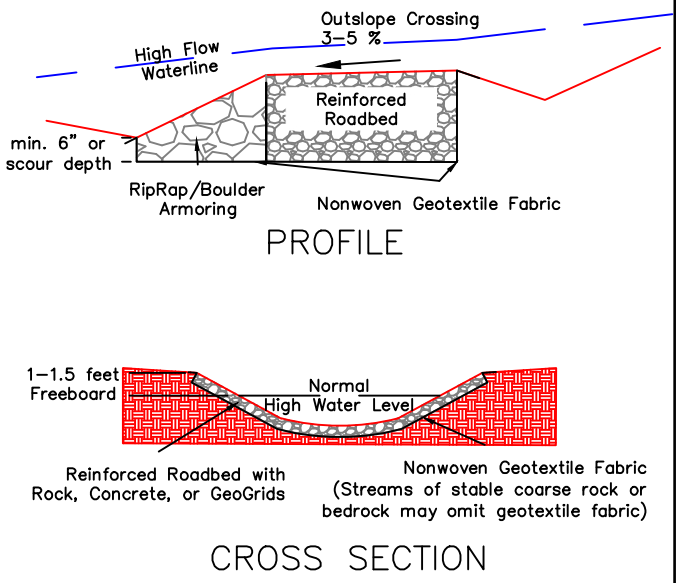
Maintenance:
- Inspect ditch turnouts for clogging or erosion.
- Inspect Level Spreader for ponding of water and erosion of the fill berm.
- Maintain the ditch and level spreader with grass cover by mowing at least once a year.

Resources:

- Penn State Center for Dirt and Gravel Road Studies, Croman Clearwater Crossing TB. 2006.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Grael Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 4 Disconnecting Ditches and Streams.

2.10 LOW WATER CROSSINGS





Description:
Low water crossing is a ford at or near stream bed elevation allowing stream flow over the road. Low water crossings are reinforced with stone aggregate or concrete to hold the channel grade.

Limitations:
- High stream depth and flow velocity limit the use of low water crossings.
- Low Traffic Use only.
- Not appropriate for unconfined channels where cutoff channels are prevalent.
- Not for highly erodible channel materials.

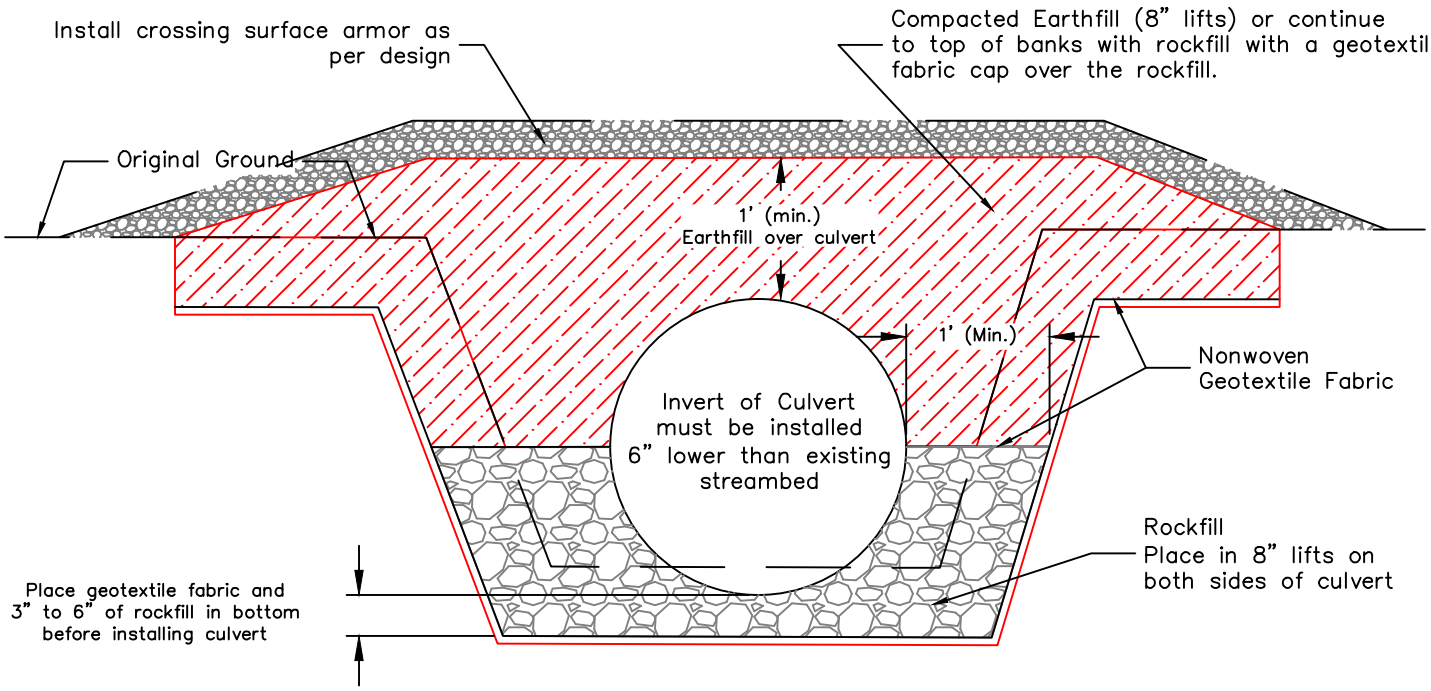
Construction:
1. Contact the Army Corp of Engineers and Virginia Department of Environmental Quality for stream permits when installing a new crossing.
2. Perform the work in the dry whenever possible and divert the stream base flow with a diversion or pump around.
3. Excavate soft erodible materials from stream bed and approach. Excavate down to non–erodible materials or bedrock.
4. Provide a 3 to 5 percent outslope to the crossing to reduce debris accumulation. Shape of the low water crossing will be similar to a dip.
5. Key in large boulders at downstream edge of the crossing so that no more than 4 to 6 inches of each boulder is visible.
6. Backfill the crossing with non–erodible material. Use large rocks to build up to the desired road crossing elevation. Use smaller aggregate to fill voids and create a cohesive matrix.
7. Grade the approach to 6:1 (~15%) or flatter.
8. Create dips or grade breaks above approaches to reduce hydrologic connectivity. See Clearwater Crossing.
9. Install flood warning sign and flood stage in public view for incoming traffic.

Maintenance:
- Maintain flood warning sign and flood stage meter.
- Remove debris that collects in the crossing.
- Periodically maintain and replace smaller aggregate.
- Inspect downstream edge of the crossing and repair scour areas.

Resources:

- Kellar, G & Sherar, J. Low–Volume Roads Engineering: Best Management Practices Field Guide. July 2003. USDA Forest Service. Chapter 9 Fords and Low–water Crossings.
- Low–Water Crossing: Geomorphic, Biological, and Engineering Design Consideration. October 2006. USDA Forest Service. 0625 1808 SDTDC.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Grael Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC.Chapter 6 Imprvoed Fords and Low–Water Crossings.

2.11 CULVERT CROSSINGS



Description:
Stream Crossings have the greatest impact on water quality and aquatic habitat. Culvert crossings are used to pipe stream flow under the road. The pipe may be corrugated metal (CMP), high density plastic (HDPE) or reinforced concrete (RCP).

Limitations:
- Bedrock may affect culvert placement.
- Stream depth and flow may require more then one culvert or an alternative stream crossing such as a bridge or bottomless-arch culvert.

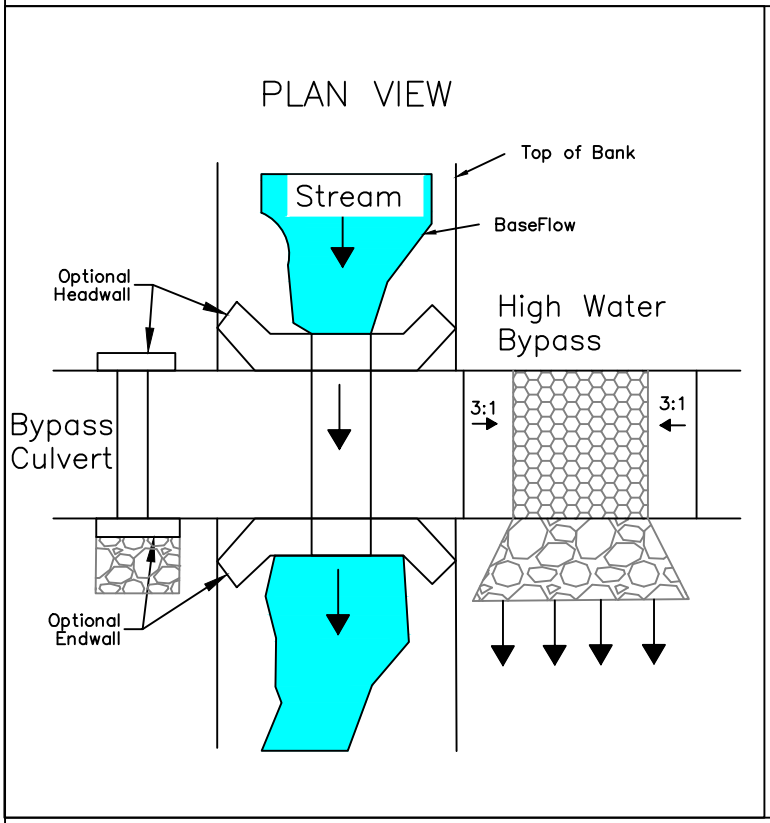
Construction:
1. Contact the Army Corp of Engineers and Virginia Department of Environmental Quality for stream permits when installing crossing.
2. Do not use culverts where large flows of sediments or large woody debris are expected or where the stream gradient is greater than 6 percent.
3. Stream crossing should be placed in an area where the stream bed is stable or where it can be stabilized. Preferably a riffle.
4. Place stream crossing perpendicular to the stream flow and not a bend in the stream channel.
5. Stream crossing must accommodate out-of-bank flows by safely bypassing without damaging the structure or eroding the stream bank or fill material.
6. Width of the stream crossing shall be at least 12 feet, but not more than 30 feet as measured from the upstream end to downstream end of the crossing, not including the side slopes.
7. The approach must be stable and no steeper than 6:1 (~15%).
8. Excavate soft material and backfill with suitable rock aggregate for a firm base.
9. The invert of at least one culvert must be installed at least 6 inches below the existing streambed to maintain stream baseflow and provide fish passage.
10. Place a minimum of one foot of backfill over the culvert. Make barrel length adequate to extend full width, including side slopes, plus one foot on each side.
11. Downstream side slope of fill shall be protected from erosion. In some cases this may require riprap armoring of the downstream side slope around the culvert outlet or an endwall.
12. Earthen fill side slopes shall be no steeper than 2:1. Rock fill side slopes shall be no steeper than 1.5:1.
13. Headwalls and endwalls should be provided for all culverts with diameter of 48 inches or larger or when more than one culvert is installed. Flared wingwalls should be used when the side slopes are steep and unstable.

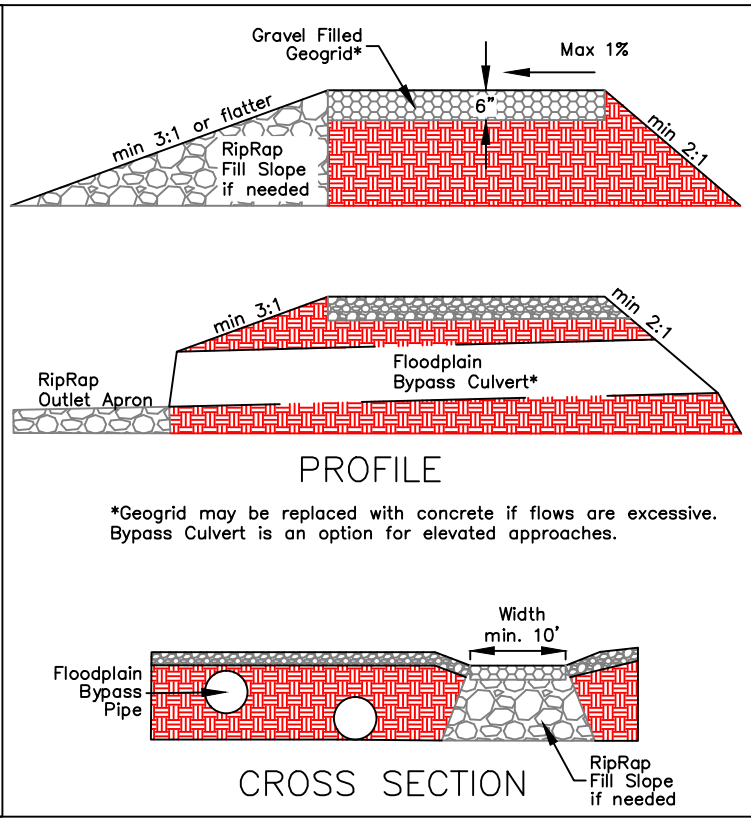
Maintenance:
- Remove debris and sediments clogging the culvert.
- Inspect for scour below the culvert outlet and at the upstream side slopes and stream banks.
- Inspect for sedimentation of the culvert inlet.
- For metal pipes ensure the pipe maintains an adequate coating of anti-corrosion sealant.
- Inspect pipes for damage and corrosion.

Resources:

- Environmentally Sensitive Road Maintenance Practices for Dirt and Grael Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 6 Improved Stream Crossings.
- Va. Conservation Practice Standard CODE 578: Stream Crossing 578. Natural Resource Conservation Service (NRCS). April 2012.
- A Landowner's Guide to Building Forest Access Roads. July 1998. USDA Forest Service. NA-TP-06-98. Stream Crossing Methods. Sizing Table 8&9.
- VDOT Road and Bridge Standards: Volume 1; section 100 Drainage. Endwall Treatments pg. 101.01 to 102.04. 2016 or latest edition. http://www.virginiadot.org/business/locdes/2016_road_and_bridge_standards.asp

2.12 HIGH WATER BYPASS





Description:
High Water Bypass are intentionally designed flat, low–lying section of reinforced road bed that serves as an emergency spillway to allow high water to flow over the road with minimal damage to the road and stream crossing. High Water Bypass can also be provided within elevated bypass culvert set at the floodplain elevation. High Water Bypass can be provided by a stone–filled geogrid, concrete weir or culvert bypass pipe.

Limitations:
- Use for high flows not regular flows
- Used for low volume roads where periodic flooding of road will not impact emergency services.
- Bypass Culvert provides limited capacity compared to an overland bypass.

Construction:
1. High Water Bypass is to be the lowest point of a stream crossing approach, set at an elevation that connects to the floodplain.
2. All surface flows from road approaches should be diverted away from bypass area using dips, diversions or turnouts. See Clearwater Crossing practice.
3. Width should be at least $\frac{1}{3}$ width of floodplain or a minimum of 10 feet.
4. Excavate to a depth suitable for placement of a geotextile and geogrid. Backfill with 6 inches of 1"–3" stone and top dress with road aggregate.
5. Ensure that the bypass is level along width and the approaches are sloped at 3:1 or flatter.
6. Armor the downstream fill slope with rip rap if needed.
7. Headwalls and Endwalls on the stream culvert and bypass culvert should be considered when the high flows produce headwater elevation greater than 1.5 times the culvert diameter. Headwalls and Endwalls can be concrete, gabion baskets, or natural stones stacked. See Stream Crossing and resources for more details.
8. Install flood warning sign and flood stage in public view for incoming traffic.

Maintenance:
- Maintain flood warning sign and flood stage meter.
- Inspect High Water Bypass for erosion and vegetation blocking flow paths.
- Inpsect Geogrid for buoyancy uplift, scour or loss of material.
- Inspect bypass pipe for clogging, scour or uplift.
- Replace stone backfill as needed.

Resources:

- Penn State Center for Dirt and Gravel Road Studies, High Water Bypass TB. 2006.
- Penn State Center for Dirt and Gravel Road Studies, Headwalls & Endwalls TB. 2004.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 6 High Water Bypass.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 5 Headwalls and Endwalls.