GRAVEL ROAD
MAINTENANCE MANUAL
A Guide for Landowners on Camp and Other Gravel Roads

Kennebec County
Soil and Water
Conservation District

Maine Department of
Environmental Protection
Bureaus of Land
Resources and Water
Quality

April 2016

For the purposes of this manual, the terms "gravel road" and "camp road" are used interchangeably and are used to describe private and public roads that are typically narrow and unpaved.

- TABLE OF CONTENTS -

CAMP ROAD MAINTENANCE 20

ACKNOWLEDGEMENTS

The Kennebec County Soil and Water Conservation District's Mitch Michaud originally created this manual in 1987 with assistance from the Maine Department of Environmental Protection, Bureau of Land & Water Quality. It was revised in 1995 by Andy Reid, in 1999 by Rob Mohlar (KCSWCD), and in 2010 by the DEP. Contact information and links were updated in 2016.

Funding for this publication was provided by the U.S. Environmental Protection Agency through the Clean Waters Act, Section 319. The Maine Department of Transportation and the USDA Natural Resources Conservation Service provided further assistance.

Original Illustrations: Brian Kent, Kent Associates; Gardiner, Maine

Reviewers:
Soil and Water Conservation Districts -
John Blais, Josh Platt (Kennebec County SWCD)
Chris Baldwin, Heather True, Betty Williams (Cumberland County SWCD)
Susan Gammon (Androscoggin Valley SWCD)

Maine Department of Environmental Protection -
Kristin Feindel, Wendy Garland, Marianne Hubert, Bill Laflamme, Rob Mohlar, Peter Newkirk

Maine Department of Transportation –
Peter Coughlan (Maine Local Roads Center), Clyde Walton (retired)

Maine Department of Agriculture -
David Rocque (State Soil Scientist)

Phil Lowe - Alpha Water Systems LLC, Sebago Lake

A special thanks to Clyde Walton, David Rocque, and Phil Lowe for their devoted review and substantial contributions to this edition.

Document #DEPLW0837A; April 2010.

This manual is a collection of information from many technical journals, handbooks, and other resources, including:

- Erosion Control Guidelines for Highway Crew Leaders
- Maine Environmental Quality Handbook
- Maine Erosion and Sediment Control Handbook
- Massachusetts Unpaved Roads BMP Manual
- New Hampshire Natural Resource and Conservation Service
- Penn State Center for Dirt and Gravel Road Studies
- Road Fundamentals for Municipal Officials
- Seven Islands Land Company Road Manual
- Vermont Back Roads Maintenance Guide

Any errors, omissions, or inaccuracies in this manual should be reported to:

Maine DEP, Bureau of Water Quality
Division of Watershed Management
17 State House Station
Augusta, ME 04333-0017
Tel: (207) 287-7688

www.maine.gov/dep/land/watershed/camp/road/index.html

The manual is intended to be a guide and cannot account for all the possibilities found in any situation. General rules and principles given here can only serve as good sense in most cases, and should be used with discretion. When in doubt, please seek assistance from a resource professional. No warranty, expressed or implied, is made by the authors as to the accuracy and functioning of the suggestions and ideas expressed and outlined.

INTRODUCTION

This manual is intended to be a helpful resource for camp road owners, road associations, lakeshore owners, town officials, contractors, and lake enthusiasts. Its purpose is to help people maintain and improve gravel roads while protecting the quality of water in lakes, streams, coastal areas, and wetlands.

For the purposes of this manual, the terms "gravel road" and "camp road" are used interchangeably and are used to describe private and public roads that are typically narrow and unpaved. While this manual is focused on private roads in lake watersheds, most of the information can be used to guide maintenance on any unpaved road – and some of it (including that on ditching and culverts) for paved roads as well.

This manual is not intended to be used for timber harvesting roads – please refer to the Maine Forest Service's "Best Management Practices for Forestry: Protecting Maine's Water Quality" manual (www.maine.gov/doc/mfs/pubs/bmp_manual.htm) for information on timber harvesting roads.

A camp road in poor shape is not only hazardous, but contributes to the decline of nearby surface waters and wetlands. Poorly maintained camp roads have been shown to be a major source of soil erosion, which in turn, causes water pollution. This manual will explain the connection between road maintenance and water quality.

Lastly, this manual attempts to address the two major classes of privately owned and managed camp roads - the older one-lane and the somewhat newer two-lane gravel roads. Because of the layout, widths, and original degree of engineered design, the options for road work and use of science-based technologies to protect lake water quality of older one-lane camp roads can be much more constrained than the somewhat newer two-lane roads.

A Little History on Camp Roads

Provided by Clyde Walton, Maine Dept. of Transportation, retired

Historically, "camp roads" provided seasonal access to wilderness-type cottages, usually on small lots of 1/4 to 1/2 acre in size. The origins for many of them date back to the early part of the last century. Camp road layout and alignment was based on the positioning of shore lots regardless of land drainage and topography. Construction details were few and

simple: cut a swath of trees and lay down a carpet of gravel. There were many sharp curves and steep hills to travel on. Easement and fee title descriptions for these roads were often vague and varied. But they all had one thing in common. They were very narrow, anywhere from 10 to 30 feet wide. These vestiges of the past are still common in lake watersheds, and they also tend to be plagued by chronic erosion problems due to their lack of planning and poor design.

Today, the majority of these cottages have been converted to year-round use. And, the traffic demand on them has increased at least ten-fold. Back lot development along these same roads is also rapidly growing. This changing land use pattern places more demand on road drainage and lake water quality.

Application of corrective state-of-the-art design and maintenance practices is sometimes difficult to accomplish on these narrow roads. Drainage and traffic safety have to be compromised or improvised down to another level. It becomes obvious that not all public road standards can be applied. For example, it can be very difficult to set a 15" or 18" diameter culvert deep enough for its top to be at least 12" below the road surface. Because to do so would require excavating the ditches on both roadsides deeper, thus increasing the ditch slope areas and possibly encroaching on abutting properties. Many of these small building lots barely have room enough to accommodate a building, driveway, septic system and well, and may not be able to provide the needed space to properly place culverts. Likewise, the use of ditch turnouts could be limited due to these same constraints. There is not enough room to work!

The other class of camp (suburban) roads are those with two travelway lanes. When built properly these roads are far less problematic. They are historically more recent. Much of their origin around lakes can be traced back to the advent of our subdivision laws in the 1970's. This was also the beginning of science-based planning of new road design for lake protection. However, it wasn't until the late 1980's that these roads were being fully built to higher standards with respect to safety, function and environmental protection. Their right-of-way widths ranged from 60 feet to 72 feet so unlike the one-lane roads of years past, there was now room for culverts, ditches and other road improvements.

In addition to the road upgrades, land parcels became larger in size. Also, new regulations specified and limited the amount of land that could be disturbed for new construction projects, which helped reduce stormwater flow and soil erosion off the land and directly into the lake. Road culverts, ditches, turnouts and erosion control are now professionally designed and constructed in terms of the whole subdivision in total. Road alignments are sited more harmoniously with the existing land terrain. Pedestrian and vehicular safety is dramatically improved. And, with a timely maintenance program, road performance is more manageable and cost-effective.

Some Questions and Answers

Q: How is this manual organized?

A: The first section of this manual contains a **Troubleshooting Guide** to evaluate specific road problems and to direct you to the manual sections which discuss the fixes. The **Understanding the Basics** section discusses soil erosion, surface water and groundwater and how they affect roads, general erosion control principles, and the role of vegetated buffers. The **Camp Road Maintenance** section is the main portion of the guide and includes detailed explanations and diagrams to help you properly maintain your road and to understand your road's problems and how to fix them. In the section **Getting the Work Done**, environmental laws that you should be aware of, the role of road associations, and tips on planning and budgeting for road work are discussed. Several **Checklists** are included towards the end of the manual – one to help you evaluate your road conditions and determine which problems are most pressing, one to help schedule inspections and maintenance, and one to help guide you and/or your contractor in some basic specifications for proper road maintenance. Lastly, there is a **Glossary** of many terms used in this manual and a **Resource Directory** to help you find assistance and more information.

Q: How can properly maintaining my road benefit me?

A: Proper camp road maintenance provides many advantages to camp road owners, not the least of which is that it is cost effective. Benefits of proper camp road maintenance include:

- saving you time and money by avoiding major road repairs;
- less gravel hauled in each year to resurface the road or repair chronic erosion problems;
- less wear and tear on your vehicles as a result of an improved driving surface;
- knowing your road is a reliable access for emergency vehicles;
- allowing year round use of the road, even in mud season;
- avoiding regulatory enforcement actions by the Maine Department of Environmental Protection (DEP) or the Land Use Regulation Commission (LURC) (see page 71);
- increased property values as a result of better water quality and road conditions;
- maintenance of cold water fisheries including spawning habitat; and
- the peace of mind that comes from knowing that you are being a good steward for your watershed.

Q: Why are people concerned about camp roads?

A: Pollution from stormwater runoff and soil erosion is one of the most significant problems contributing to the decline in water quality in many lakes, rivers, and streams. **Soil erosion is the single largest pollutant (by volume) to our surface waters, and many of the erosion and sedimentation problems in lake watersheds originate from improper construction and maintenance of camp roads.** Proper camp road maintenance helps prevent this form of pollution and preserves our splendid water resources.

Q: How does a camp road affect stormwater drainage to my lake or stream?

A: Camp roads change the natural stormwater drainage patterns. Most of these changes increase the potential for soil erosion and change the way, the quality, and how fast water gets to the lake and tributary streams. These changes include:

- ❑ stripping away the protective vegetative cover;
- ❑ creating a highly erodible pathway of exposed soils in the watershed;
- ❑ collecting runoff in ditches (and on the road), which increases the speed of surface water runoff, and;
- ❑ if the road or ditch cuts below the water table, increasing the amount of water that is now surface runoff that has to be dealt with. This cool, clean groundwater brought to the surface often becomes warm and sediment laden.

This change in stormwater drainage patterns may overwhelm tributary streams during rain events and then dry them up in summer when they should be nurseries for cold water fish. It may also dry up wetland and vernal pools if natural runoff and groundwater are diverted elsewhere.

Q: How does camp road erosion harm our lakes and streams?

A: The most obvious effect of erosion is the brown color that results from suspended soil particles in the water. Less obvious effects are:

- ❑ algae blooms which result from excess phosphorus in the suspended soil particles flushed into the lake;
- ❑ harm to fish:
  - the suspended solids irritate the gills of fish, making them prone to disease,
  - the soil particles can smother spawning and feeding grounds,
  - in addition, fewer cold-water fish (i.e. salmon and trout) due to:
    - low levels of dissolved oxygen in the water due to decaying lake algae blooms, and
    - episodic bursts of warm, dirty water, depriving fish spawning in tributary streams of the cool, clean continuous flows they need.

- ❑ gradual filling and the resulting loss of desirable shoreline (due to encroaching weeds, for instance);
- ❑ diminished recreational and aesthetic values of the lake because of a decline in water quality; and
- ❑ decreased property values resulting from poor water quality.

Q: What causes camp road problems?

A: Although there is no single cause for all camp road problems, poor management of surface or groundwater is the most common cause. When there were no camp roads, the surface water runoff created its own natural places to run and be filtered before it got to a wetland, stream, or lake. The very presence of a road diverts and concentrates runoff and places it on surfaces that erode and add nutrients and waste to the water. Since runoff is no longer controlled and filtered by the natural landscape, it is the camp owner's responsibility to take care of the issues and the problems that this water creates. These problems include washouts, tire rutting, potholes, soil erosion, and water quality degradation. Many camp roads were not properly constructed, are not properly maintained, or both. As a result, the surface water is not properly diverted away from the road or groundwater is brought to the surface, and the road is not capable of withstanding the wear and tear of the erosion and traffic. Proper identification of the cause of a particular problem requires a careful evaluation of conditions specific to your road. What works for one road may not necessarily work on another, if the cause is different. Take a look at the Troubleshooting Guide to help direct you to the sections of the manual that might help address your road problems the best.

Q: What if our road doesn't have enough funds?

A: If your road doesn't currently have a road association, forming one may help you collect the funds you need. See Forming a Road Association (page 73) for more information. If you do have a road association and collect dues annually, evaluating your road and putting together a detailed maintenance plan and budget may lead to increasing the annual dues, at least temporarily until the road is back in shape. And lastly, if there are still not enough funds to do a major project in its entirety, you should do what you can. Get good guidance from the DEP, your local SWCD, your Water District, your town, or knowledgeable local contractors. Spending even a little towards the right direction can make a significant difference.

Q: What are the basic components of a road?

A: The below profile shows some of the basic names and components of a constructed camp road. Descriptions and details of the components, along with many variations and considerations follow in the 'Camp Road Maintenance' section (page 20) of this manual.

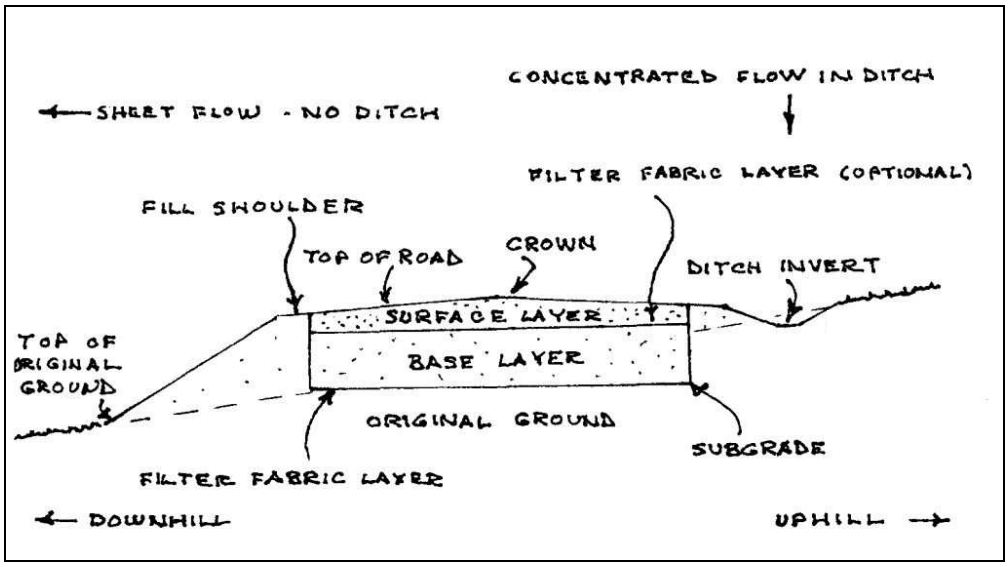


Figure 1. The Anatomy of a Road

TROUBLESHOOTING GUIDE

This troubleshooting guide is intended to be a quick reference to help you understand some common problems on camp roads and to direct you to the relevant manual sections.

ROAD SURFACE PROBLEMS

Problem: Longitudinal (lengthwise) erosion of the road surface
Possible Causes:

- ❑ Flat or u-shaped road. A crown or tilting of the road (super-elevation) is needed to shed water laterally off the outer edge(s) of the road surface (see page 30).
- ❑ Small ridge of soil or grass growth along the outer edge of the road is preventing water from draining off the road surface. Edge needs to be graded to remove this ridge (see page 28).
- ❑ Water is traveling in a wheel rut. Road needs to be regraded (see page 28). This problem often results from soft roads (see "Tire Rutting," below).
- ❑ Road ditch is not large enough and overflows onto road surface. Install more frequent turnouts to get water away from the road (see page 49), or if this is not possible, ditches need to be made larger (see page 42).
- ❑ Snow banks may be preventing water from draining off the road in the early spring. Plow snow wide enough to get the banks off the edge of the road.

Problem: Washboarding
Probable Cause: Poor road surface materials. This most likely results from a lack of fines. Check gradation of road material (see page 21), and adjust as necessary. A grader should be used to remove washboarding and mix road materials (see page 28). Alternative road surface materials may be necessary in certain high stress areas (see page 23).

Problem: Tire rutting on soft roads
Possible Causes:

- ❑ Poor road base material does not drain efficiently (see page 21). Road base needs to be reconstructed with suitable soil materials, or consider using geotextiles (see page 24).
- ❑ Road is too low and the base is in the water table. Build road up above grade (see page 20) and/or install rock sandwiches (see page 63).

- ❑ Poorly drained native soils that may be unsuitable for typical gravel roads. Consider using geotextiles (see page 24) or rock sandwiches (see page 63), or restricting access for seasonal use only.
- ❑ Insufficient road base thickness. Road base should be reconstructed, or consider using geotextiles (see page 24).
- ❑ Insufficient ditching. Ditches need to allow subsurface water to drain out of the road base (see page 39). If road ditch is in a groundwater seep area, ditch may need to be riprapped to prevent slumping (see page 43).

Problem: Muddy or slippery road surface
Possible Causes:

- ❑ Poor road surface material containing too many fines (see page 21). Good surface material needs to be added or blended with existing surface using appropriate grading equipment.
- ❑ Insufficient road tilting (super-elevation) or road crown, which allows water to sit on the road surface. Road needs to be tilted or recrowned to promote drainage (see page 30).

Problem: Dust
Probable Cause: Poor road surface material. Apply new road surface material with the proper soil gradations (see page 21), or use of calcium chloride as a dust suppression agent (see page 35).

Problem: Too much loose gravel
Probable Cause: Poor road surface material that lacks fines due to dusting, winter sand or erosion. New road surface material is needed (see page 21).

Problem: Lateral erosion cutting across the road surface
Probable Cause: This most often occurs at a low spot by the road or where a ditch filled up and no longer functions; water builds up and eventually overflows and erodes the road and sediment that has settled in the ditch. The water needs to be conveyed to the other side of the road by means of a culvert (see page 52), rock sandwich (see page 63), or ford (see page 64).

Problem: Potholes
Probable Cause: Potholes almost always result from road sections on poorly drained soils or from insufficient crown or road tilting. Rebuild the road with proper materials (see page 21), or regrade road to remove potholes (see page 28), then re-crown or super-elevate (see page 30).

CULVERT PROBLEMS

Problem: Water overflows road at culvert
Possible Causes:

- ❑ Culvert is too small. Culverts need to be sized in relation to the drainage area (see page 54), or rock sandwiches (see page 63) or more cross culverts are needed to reduce flow at the culvert. Minimum recommended culvert diameter is 18 inches.
- ❑ Culvert is plugged with sediment or debris. Inspect and maintain on a regular basis. If it is full of sediment, check uphill road and ditches to see where it is coming from. Repair eroding areas.
- ❑ Culvert has been crushed and needs replacement (see page 55).

Problem: Crushed culvert
Possible Causes:

- ❑ Improper installation (see page 55). Culverts should be covered with at least one foot of fill. Poor compaction of surrounding backfill can weaken a culvert (compact soil in "lifts" or layers up to 9 inches).
- ❑ Culvert has been weakened by rust and needs replacement. The average life expectancy of a metal culvert is 25 years (plastic has longer expectancy).
- ❑ Culvert was not designed to handle loads from heavy trucks and equipment.

Problem: Road erodes around the culvert from the middle of the road out
Possible Causes:

- ❑ Improper installation (see page 55). Backfill was likely not compacted sufficiently, which allows water to seep around the culvert.
- ❑ Culvert has rusted through, allowing water to seep around the pipe. Culvert needs to be replaced.
- ❑ Culvert has lifted from frost action; see page 55 for proper installation procedures.
- ❑ Water is seeping alongside the culvert. Install inlet anti-seep collar (see page 59).

Problem: Culvert is eroding around the ends
Possible Causes:

- ❑ Insufficient armoring of culvert ends with rocks (see page 58). Outlet area of the culvert should also be protected with rocks (plunge pool or rock apron; page 59).
- ❑ Culvert is too short and doesn't allow for proper protection of the side slopes (see page 56).
- ❑ Water is seeping alongside the culvert. Install inlet anti-seep collar (see page 59).

Problem: Culvert fills with dirt and debris
Possible Causes:

- ❑ Culvert placed with too little or no pitch (see page 55).
- ❑ Culvert outlet structure clogged and in need of cleaning (see page 59).
- ❑ Culvert inlet basin full or not deep enough.
- ❑ There is upstream erosion that needs to be fixed.
- ❑ Culverts too far apart in areas of steep slopes (see page 55).

DITCH PROBLEMS

Problem: Bottom of ditch is eroding
Possible Causes:

- ❑ Slope of ditch is too steep to handle flow without additional protective measures. Consult an expert or add vegetative protection (page 44), erosion control blankets (page 46), riprap armoring (page 47), ditch check dams (page 48), and/or turnouts (page 49).
- ❑ Ditch is too small to handle the volume of water flowing through it. Consider installing periodic turnouts to get rid of some of the water (page 49) or, if turnouts are not possible, resizing the ditch (page 42) or adding cross culverts (page 52).
- ❑ Bottom of ditch is too narrow (V-shaped) and needs to be widened (parabolic-shaped) (see page 40).
- ❑ Ditch may just need some maintenance to remove debris or accumulated road sand and sediments.

Problem: Sides of ditches are slumping or eroding
Possible Causes:

- ❑ Side slopes are too steep and need to be lessened by digging them back (see page 40).
- ❑ Side slopes need to be stabilized to protect against erosion (page 42).
- ❑ Groundwater seeps are present. Armor ditch side slope with a layer of small rock and then a layer of riprap (see page 47) or reconnect groundwater to other side of the road with rock sandwich (see page 63).

Problem: Uphill side of crown ponds water
Possible Causes:

- ❑ Roadbed is too low from plowing. Add road gravel to permit proper crowning and drainage of roadbed to low areas (see page 20).
- ❑ Drainage path on the lower side is clogged. Clean out clog.
- ❑ Water is trapped by road and surrounding topography. Raise road elevation (see page 20), install a shallow ditch (see page 39), or add a culvert (see page 52) to transport ponded water to lower side of road.

SOIL EROSION

Soil erosion is a camp road owner's worst enemy. It is not coincidence that soil erosion is also the single largest pollutant (by volume) of our lakes and rivers. Erosion typically happens in a sequence that starts with soil becoming exposed through vegetation and/or organic duff removal. The exposed area is eroded by falling raindrops, which progresses into sheet flow erosion, rill or gully erosion, then stream flow or channel erosion (see Figure 2). As the degree of erosion increases, so do the problems that erosion causes; therefore it is very important to try to control erosion in its initial stages. It is always easier and less costly to prevent soil from moving in the first place, than to try to stop erosion that has already started.

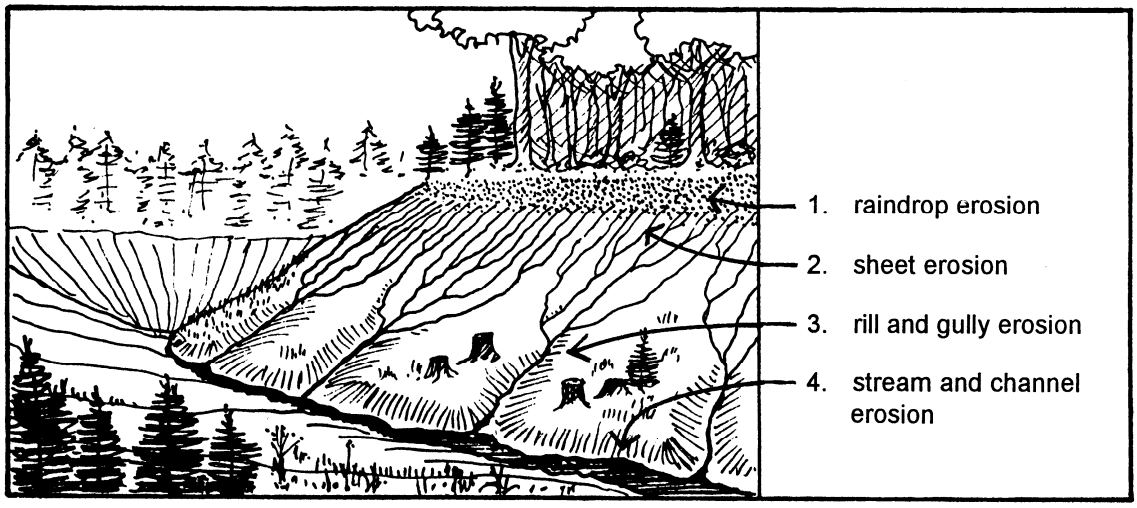


Figure 2. Soil Erosion

Raindrop erosion occurs when falling raindrops hit and dislodge exposed soil particles. The dislodged soil particles are suspended in the stormwater runoff and can easily be transported great distances.

Sheet erosion occurs when surface water runoff removes a layer of exposed soil. This water moves in a broad sheet over the land.

Rill and gully erosion occurs when surface water runoff concentrates in small grooves and then cuts into the soil's surface. These grooves are called rills. If left unrepaired, rills will develop into gullies.

Stream and channel erosion occur when the above described types of erosion are uncontrolled, causing otherwise stable stream banks and channel banks and bottoms to wash away.

Factors Linked to Erosion

The extent to which erosion occurs depends on soil types, slope, climate, and vegetation.

Soil type and condition has a significant effect on the potential for erosion. Coarse-textured sands and gravels are the least erodible, because they are comprised of bigger and heavier particles that are harder to move. Sand and gravel also percolates water at a faster rate, which means there is less stormwater to run off. Silts and fine sands are generally the most erodible soils, due in large part to their small particle size. Smaller particles are lighter and more easily carried away by surface water runoff. Clay soil is generally less erosive than silts and fine sands because it tends to stick together and acts like the larger particles that are more resistant to erosion. Organic matter will also tend to "glue" soil particles together, which helps resist erosion. Natural soil has 50% of its volume as pore space, which can be filled with air and/or water. When soil is compacted, like it is on camp roads, pore space is destroyed and rainfall and snowmelt cannot be absorbed, resulting in runoff and potentially erosion.

Soil depth and groundwater level can greatly affect the ability for water to absorb into the ground, and therefore the amount of runoff that can cause soil erosion. Soils with a shallow depth to hardpan (a dense layer of naturally compacted soil), bedrock, and/or the seasonal groundwater table can not store much rainfall or snowmelt so they generate more runoff which can cause erosion. When ditches go below the groundwater table, they intercept the groundwater flow, causing increased water in the ditches and exacerbating erosion.

Topography has a significant effect on soil erosion. The size and shape of a watershed affects the amount and rate of stormwater runoff. Longer slopes are more likely to erode than short slopes, because they will collect larger volumes of stormwater runoff. Likewise, steep slopes are more likely to erode than flat ones, because runoff travels faster down

steeper slopes. The key to controlling erosion on slopes is to reduce the volume and speed of runoff.

Climate affects the potential for erosion through the frequency, intensity, and duration of rainfall. Maine soils are particularly prone to erosion due to climatic conditions. Maine receives a lot of precipitation annually: between 41 and 44 inches. In addition, in northern climates, soil erosion is often worst in the spring due to the compounding effects of frozen ground, saturated soil, snow melt, and spring rains.

Vegetative cover and organic duff layer in forests is important because it shields the soil from the impact of raindrops and protects the soil surface from scouring. Vegetation helps reduce the speed and amount of surface water runoff and it acts as a natural filter to help remove pollutants. Plants also aid in aerating and removing water from the soil, thus maintaining the soil's capacity to absorb water. Plant root systems also help hold soil particles in place (see Figure 3).

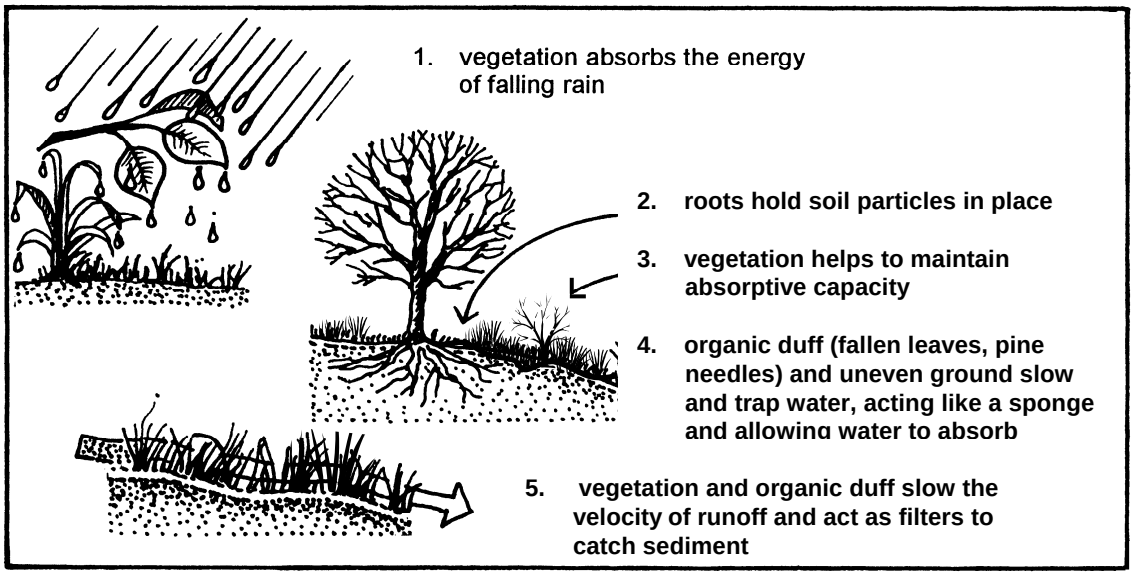


Figure 3. Effect of Vegetative Cover on Erosion

WATER AND YOUR ROAD

Effective drainage is critical to camp road maintenance. Good drainage consists of keeping water off of the road surface and preventing groundwater from infiltrating the road

base. Reducing the effect your camp road has on the natural distribution of water is also very important for maintaining your road drainage system and for the health of nearby lakes and groundwater. Maintaining good drainage requires an understanding of the difference between surface water and groundwater.

Surface Water

Surface water is water that is flowing or standing on the top of the ground. On camp roads, the biggest concern is to get water off the road surface as quickly as possible and to direct it as sheet flow to a vegetated buffer. If this is not possible, direct it to a natural or constructed drainage channel that is capable of handling the flow without eroding. When surface water is not drained off the road, it can lead to washouts, muddy conditions, and potholes.

It is also wise to minimize runoff from developed camp lots to roads and road ditches. If possible, divert runoff from camps, lawns, and driveways to a vegetated buffer as sheet flow. Reducing the amount of water in road ditches reduces the potential for erosion in them and the road.

The following measures are used to help drain water off the road surface:

- a well-constructed road with proper grading and crowning or super-elevation;
- stable road ditches;
- diversions (e.g., water bars); and
- turnouts and buffers that return runoff to natural drainage areas.

Any road (even properly constructed ones) will alter natural surface water drainage patterns. The trick is to recognize these changes and to prevent them from causing problems.

Groundwater

Groundwater (subsurface water) flows and is stored under the earth's surface. It is an essential source of drinking water, and keeps streams running and replenishes lake water during the dry season. With camp roads, the biggest concern is to keep groundwater in the ground and out of the road base. Groundwater in the road base will make it soft (potentially impassable) and susceptible to tire rutting. Groundwater in ditches causes your drainage system to deal with more water and can turn clean cold groundwater into warm sediment-laden surface water.

To keep groundwater out of the road base:

- ❑ build the road above the groundwater table;
- ❑ if the road is built just above the water table, have a geotextile base (see page 24);
- ❑ if the road is not above the water table, pass groundwater through the road frequently using rock sandwiches (see page 63) or cross culverts where needed; or
- ❑ as a last option, groundwater can be drained from the road base and directed to a natural or constructed channel capable of handling the flow without eroding, except in vernal pool areas.

EROSION CONTROL PRINCIPLES

Many of the erosion and sedimentation problems in lake watersheds originate from the improper construction and poor maintenance of gravel camp roads. Camp roads represent a significant environmental threat! These erosion problems also create ruts, bumps, and potholes that can destroy a car's suspension. Mud and washouts can make roads impassable. Each year, road associations have to spend precious dollars to 'fix' these problems. Clearly, improper camp road maintenance is a problem for the road users as well as for the environment.

Do You Refill Sections of Road Every Year?

Refilling sections of a road that continue to wash out every year is a waste of money, does not effectively address the problem, and harms nearby bodies of water. Effective maintenance should prevent or minimize recurring problems.

During “mud season,” early spring water cannot percolate down due to the frozen layer under ground. This saturated soil becomes “mud” and is very easily rutted and eroded, destabilizing the road surface gravels until the frost is out completely. Traffic, especially heavy loads, will cause severe and costly damage at this time. Mud season is over when frost is out, roads drain out and gravels dry and repack.

Restrict Road Use Seasonally To Protect Road

Joy riders and unsuspecting property owners trying to get an early start on things often do damage to seasonal roads by creating tire ruts. Further, tire ruts often cause future erosion problems. Restricting access to the road during the sensitive times of the year (spring and fall) can be the simplest and most cost effective way to prevent major damage. The cost of a simple gate can easily offset the cost of repeated road repairs. There may be some legal issues related to blocking off traditional access, and you may want to seek advice from a lawyer. For safety's sake, make sure your gate is highly visible to snowmobilers and ATV users.

It is difficult to control erosion once it has started, which is why emphasis should be placed on prevention and regular maintenance. Effective erosion control can be best accomplished by observing the following guiding principles:

- ❑ Monitor and maintain your camp road on a regular basis. The best time to inspect your camp road is on a rainy day, when problems are more apparent.
- ❑ Thoroughly plan improvement projects before starting.
- ❑ Work with nature whenever possible – let the natural features and forces help you accomplish the end site design.
- ❑ Drain stormwater off the road surface at frequent intervals, and as quickly as possible.
- ❑ Keep runoff velocities slow.
- ❑ Avoid concentrating runoff (promote dispersion).
- ❑ Avoid discharging runoff directly into natural surface waters.
- ❑ Discharge stormwater runoff into vegetated areas (buffer strips) as sheet flow.
- ❑ Minimize areas of exposed soil on side slopes and ditches.
- ❑ Stabilize and cover bare soils with vegetation or other protection (i.e., mulch or riprap).
- ❑ Limit heavy loads and minimize traffic during early spring (mud season), until frost is out and road is dry.

Keep these principles in mind as you read this manual, and use them as you evaluate your own camp road. If you have a chronic erosion prone section of road, ask for help in addressing it properly. It is causing great harm to nearby bodies of water, is inconveniencing camp road users and is costly to continually repair.

Work with Nature

Working with nature and letting natural forces help you accomplish the end site design can result in several benefits.

- ❑ Less runoff is created.
- ❑ Balancing cuts and fills creates less hauling, may eliminate some excavating and over-the-road hauling, and generally reduces the impacts to neighbors and others in the area.
- ❑ Getting water courses and runoff back to where they once were as quickly as possible reduces impacts and costs.

While working with nature may be easier to do when working with a new road, compared to the often limited options when working with an existing camp road, the principle is good to keep in mind when doing any road work.

The greatest cause and the degree of failure regarding site work and roadways is directly proportional to the degree which you underestimate what mother nature can and will throw at you. Working with the natural topography and the way the water wants to flow as much as possible improves the site's design and its longevity.

WHERE TO DRAIN TO: VEGETATED BUFFERS

Vegetated buffers are areas of undisturbed trees, shrubs, and other vegetative groundcover located between developed areas (such as a camp road) and a lake, stream, wetland, or coastal waters. Vegetated buffers are excellent at removing sediment and nutrients from stormwater runoff if they are maintained and used properly.

As pointed out earlier, it is critical to get water away from the road. However, getting water away from the road is only part of the problem. You still need to make sure this water doesn't cause a problem away from the road site. Road runoff should be directed as sheet flow (spread out with shallow-depth, slow-velocity flow) into an undisturbed vegetated buffer to help remove the pollutants in it. **Remember – never direct road drainage into a lake or stream!**

Figure 4. Vegetated buffers filter and absorb camp road runoff.

Types of Buffers

Fortunately, many of our camp roads still have plenty of vegetated buffers (in the form of forests) along the edges. Forested areas make the best buffers, because the uneven ground and the leaves, needles, and twigs trap and absorb water before it reaches lakes or streams. Tree and shrub roots also absorb the nutrients dissolved in the runoff, using them to grow.

Thick grassy areas can be used as vegetative buffers, too, but they are not nearly as effective at removing nutrients as forested areas. In order to promote thicker growth and maximize the benefits of grass buffers, they can be mowed a couple of times per year. However, they should not be mowed shorter than four inches. Occasional haying or bush-hogging is acceptable.

A smooth, mowed lawn is not an effective buffer since it does not effectively trap and absorb runoff. Also, poorly drained soils are not equal in their absorptive capacity to well drained soils and this should be taken into account when determining the runoff to be directly to it. The effectiveness of a vegetative buffer is directly proportional to its type, quality, use, and maintenance.

How to Have an Effective Buffer

It is important to note that buffers are only effective when runoff is flowing through it as sheet flow. Directing too much water into a buffer creates a channel, which defeats the

purpose. Turnouts need to be located frequently enough to prevent this type of overloading. In addition, when using vegetated buffers:

- ❑ Don't allow large amounts of sediment to smother the vegetation (this indicates an erosion problem further up the road that needs attention).
- ❑ Don't rake the duff layer! Those decomposing needles and leaves soak up the runoff.
- ❑ Don't fill in the natural depressions that trap the runoff and allow it to soak into the ground slowly.
- ❑ Match how much water is directed to a buffer with the quality of the buffer – don't overwhelm a small, young buffer with too much water.
- ❑ Remember, wider is better. Buffers should be as wide as possible, and wherever possible, a minimum of 50 feet wide.

A buffer needs to be sufficiently well drained to absorb runoff sent to it. Water should be directed as sheet flow in areas of uniform soil/site and surface conditions. If one place in a buffer is lower than the rest, all of the water will likely collect there. Take that into account when directing water to that area. The effectiveness of the buffer can be improved by installing level spreaders (see page 50) or erosion and control mix berms (see page 46) to further slow down and spread out the water into sheet flow prior to entering the buffer. The more water directed to a buffer, the greater the importance of buffer quality and use is.

Buffers: Cost-Effective, Low Maintenance, and Good for the Lake

Proper use of vegetated buffers is the most efficient and effective way to treat road runoff. It is also the most cost-effective, because buffers require very little construction and maintenance. In addition, by directing water bars and road ditches to undisturbed vegetated buffers, you feed trees and shrubs rather than algae in the lake.

Generally, when water is encountered on any site, it is easier and less costly to work with the forces of nature than against them. Camp roads often consist of many sites and changing conditions from one end to the other. If you start at the lowest point (often that is where the biggest problem is) and walk to the highest point in both directions, you will have covered the watershed for that drainage. Often the goal is to get water off the road and out of the ditches to vegetated buffers as quickly as possible. The better this is done the smaller the problems will be downstream, particularly in small drainage areas. You should use all of the resources that you can to do as good a job as you can. The town, the DEP, the Soil and Water Conservation districts, and various water districts, and this booklet, are some of the resources available to you. Use them to your benefit.

CAMP ROAD MAINTENANCE

Now that we understand the basics of how erosion occurs and the keys to controlling erosion, it is time to tackle specific aspects of camp road maintenance.

ROAD SURFACE

Road Level

Properly constructed roads are built above the natural ground. This creates a high point, which is essential for effective surface drainage. Unfortunately, many older camp roads were built by pushing material away from the roadway (as depicted in Figure 5). This results in a road surface that is lower than the surrounding land, which is hard to drain. This situation can cause heavy road damage during larger rainstorms. Heavy runoff will tend to overflow the limited ditch capacity and run over the road, which is likely to cause significant damage. This type of road is also prone to subsurface drainage problems, because the road base often consists of poor (native) soil materials that may be in the local water table.

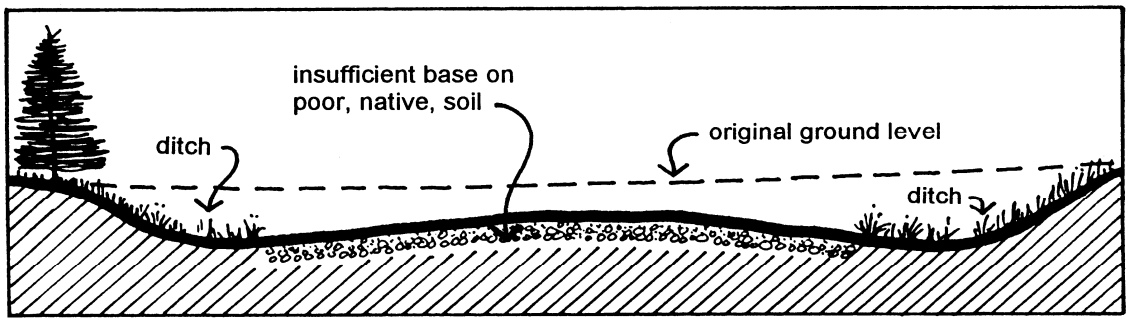


Figure 5. Poorly constructed road: poor base, inadequate ditching and built below original ground level.

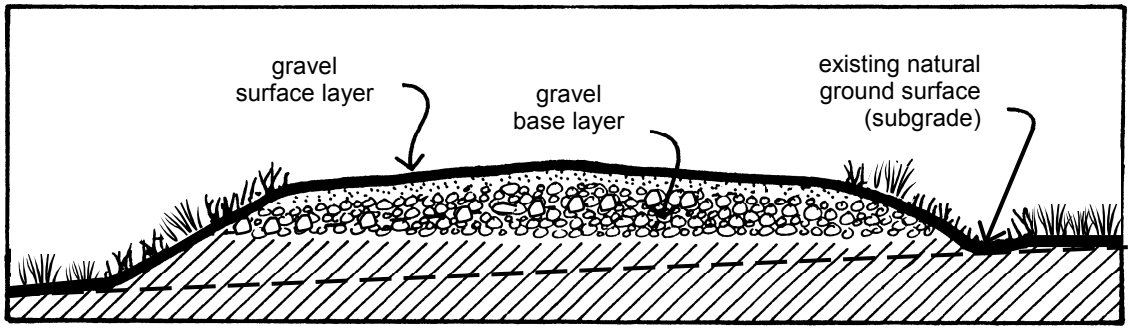


Figure 6. Well-constructed road: entire road built above original ground level.

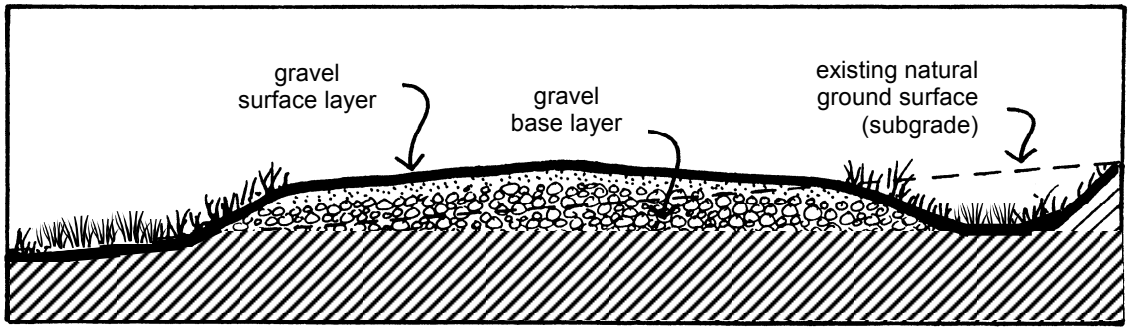


Figure 7. Well-constructed road: high point above original ground level.

Road Materials

"Dirt" is a misleading term often used to describe camp roads. The truth is that "dirt" (we'll call it "soil" from now on) is comprised of varying amounts of different types of materials.

There are three basic types of soil materials used for building camp roads: gravel, sand, and fines (listed in order from largest to smallest particle size). Gravel and sand particles, coarse material, are readily distinguishable to the naked eye. Fines (silts and clays) are generally comprised of particles too small for the eye to see. Each soil material has specific properties that make it useful for different aspects of road building. Coarse material provides strength and has large voids between the particles that provide good drainage. Fines fill the voids between the coarse material particles holding them together, and on the road surface, decrease infiltration of water into the road.

As mentioned earlier it is critical to keep water out of the road bed. An ideal road bed should have two layers; a base layer that provides strength and is free draining and a surface layer that is strong and dense, shedding rainfall and preventing it from infiltrating into the bed.

When selecting road bed material, it is important to have a range of different size gravel and sand so that the particles "lock" together. This is called well-graded. If they are all the same size, they are more apt to move around, causing rutting. This is called poorly-graded.

Road Material Composition

The specific composition of soil materials used in camp road construction will make a big difference in terms of performance and durability. Good road material should contain portions of each of the soil materials. Some general guidelines are provided below.

Road base material needs to be sturdy and drain freely.

- Use gravel that (see table or equivalent to MEDOT Aggregate for Base Type A, Spec. No. 703.06):
  - is somewhat coarser than the road surface material and consists mainly of well-graded gravel smaller than 3" in size;
  - may have few large stones but no greater than 6"; and
  - has no more than 7 percent fines (silt-clay particles), to allow for subsurface drainage.
- The base layer should be 12-18 inches thick when compacted.

Road surface material needs to pack well, be durable, and shed water.

- Use gravel that:
  - is well-graded with the majority of gravel smaller than 1/2" in size;
  - has a maximum particle size of 2 inches; and
  - has 7-12% fines (silt-clay particles), so it packs well and sheds water.
- The surface layer should be about 4 to 6 inches thick when compacted.

Recommended Specifications for Well-Graded Gravel Material for Roads			
Road Base Material		**Road Surface Material**	
All material less than 6" in size		*All material less than 2" in size*	
% by Weight	Is Smaller Than	% by Weight	Is Smaller Than
78-100	1 ½"	85-100	¾"
55-75	¾"	70-100	½"
30-55	¼"	55-85	¼"
8-22	#40 (sand)	20-35	#40 (sand)
0-7	#200 (silt)	7-12	#200 (silt)

When you buy gravel, you can ask the pit owner to document the percent fines and the sizes of materials. Be sure to buy crushed gravel, rather than bank run gravel, since the crushed material has edges that can lie flat and pack well. Bank run gravel is rounded and tires can easily roll the rounded stones out of the road surface, leaving holes that start ponding water and cause pothole problems.

Many camp road problems can be directly related to using improper road materials (and to the base being below the groundwater table, as discussed earlier). Loose surface material generally indicates a lack of fines. Soft roads are generally indicative of too many fines in the base material that hold water, the road base being below the water table, and/or a base layer that is not thick enough to support the road. The Troubleshooting Guide (see page 7) can help identify problems that might relate to road materials.

How to Test Your Road Materials

To start, fill a large, clear container (glass or plastic) half full with soil from your road. If possible, try sampling soil from the source of the road material (i.e., the gravel pit). Then fill the container with water and shake it well. Allow the container to sit for a period of time until the water becomes clear again. The different types of soil materials in the sample should have settled out in layers, which allows you to see the relative percentage of each type as shown in Figure 8. Fines will be in the top layer, because they are lighter and take longer to settle out. Coarser, heavier particles will settle out first and be on the bottom. In order to calculate the percentage of each soil type, you must first measure the height of the entire soil sample and then the height of each individual soil type. Next, divide the height of each soil type by the height of the entire sample, and multiply by 100.

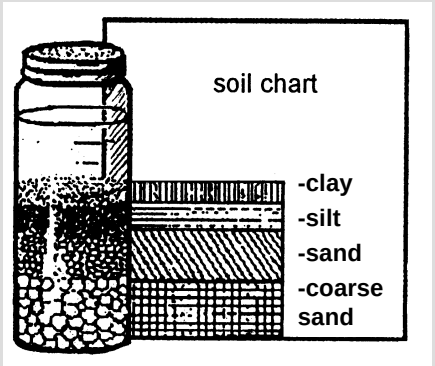


Figure 8. Quantifying Road Material

The desired soil properties for various road components:

Road Layer	Percent Fines (clay and silt) by volume
Surface	7 to 12% fines
Base	0 to 7% fines
Roadside seeding material	5 to 10% fines

DETERMINING HOW MUCH ROAD MATERIAL TO ORDER

To figure out how much road material to order, first calculate the volume needed in cubic feet (road length x width x depth), then convert to cubic yards. You also have to account for compaction. For example, to get 3 inches of compacted gravel on the road surface, you might need to multiply by 1.11. Round your estimate up or down depending on the

capacity of the delivery truck. A compacted cubic yard of gravel usually weighs around 1.6 tons.

Example – 3 inches (0.25 feet) to your road surface equals:

> [150' (length) x 12' (width) x 0.25' (depth)] divided by [27 cubic feet to cubic yards] = 16.6 cubic yards
>
> 16.6 cubic yards x 1.11 (compaction adjustment) = 18.5 cubic yards to order

Alternative Road Surfacing Materials

Gravel is the material of choice for most camp roads, in large part because it is affordable. However, there are certain situations where a typical gravel surface may not be sufficient to resist erosion or traffic wear. Such situations include sections of steep slopes, sharp corners, or intersections with heavy volumes of turning traffic. Alternative materials generally cost more up front, but can be more cost effective, given their longer life cycle. Alternative materials can also lessen or eliminate some chronic maintenance problems. Some alternatives are discussed below.

Geotextiles as Road Base

Geotextiles (also known as filter fabrics) are water permeable membranes that are made of industrial grade fabrics in a variety of synthetic materials (polyethylene, polypropylene, and nylon). Geotextiles are sold in big rolls of fabric, which makes installation relatively easy and cost-effective.

When the fabric is placed under the gravel base layer, it separates the lower layers of fine poorly-drained soils and reduces upward water siphoning movement of fine soils up into the new "clean" gravel base layer to protect the road's integrity.

Properly placed fabrics may reduce thickness of the gravel base as well as the amount of side slope fill against the road shoulder. This is both cost-effective and provides more room for ditching.

Woven and Non-woven Geotextiles:

There are two types of geotextiles commonly used in road construction applications: woven and non-woven. Woven geotextiles generally have a glossy finish with a distinguishable woven pattern. Non-woven geotextiles generally have a flat finish with no distinguishable pattern, and a felt-like appearance. The primary advantage of woven geotextiles over non-woven is that they are much stronger. However, non-woven geotextiles are highly

permeable and softer (which allows it to conform to soil surfaces better). There are many different types, grades, lengths, and manufacturers of both woven and non-woven geotextiles. Proper material selection and installation is the key to success. Some products may look similar, but have very different characteristics. It is important to call the manufacturer or consult their literature when you have questions about which material to use or how to use it.

Stabilization Using Geotextiles:

Stabilization using geotextiles is a way to firm up soft roads that are prone to tire rutting. This situation results from a road base or subgrade that is poorly drained. Repair the road during a time of year when it has stiffened up some. The first step is to grade and crown the existing road surface. Then, roll out the geotextile fabric over the full road width, covering the entire problem area. The final step is to cover the geotextile with at least 6 inches of compacted road surface material. If you have placed the geotextile directly on the natural ground surface (not on road fill), you will want to cover the geotextile with at least 6 inches of road base material, then the 4-6 inches of road surface material.

Using geotextile will enhance the road stability in two ways:

- ❑ It preserves the integrity of the road base material by preventing mixing with the poor soils beneath it.
- ❑ It disperses the vehicle weight over a broader area.

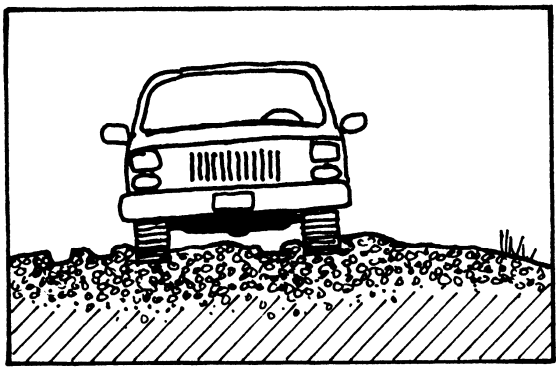


Figure 10. Soft road with no geotextile.

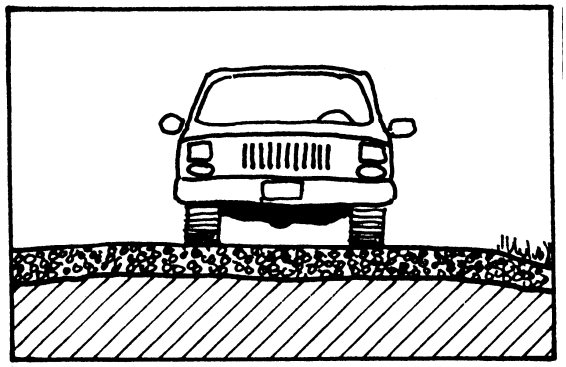


Figure 11. Soft road with geotextile.

General Installation Recommendations:

- ❑ Use woven geotextiles for stabilization because of their superior strength. Some heavier weight, non-woven types may suffice. Check with the product manufacturer for their recommendations.
- ❑ Always overlap sheets of geotextile by as much as 2-3 feet.
- ❑ Fill large holes and remove protruding rocks and other debris from the road before putting down geotextile to prevent punctures and tears.
- ❑ Homeowners and road associations may be able to purchase these materials from their town's public works departments and gain their volume pricing.

Reclaimed Pavement/Recycled Asphalt (Reclaim)

Reclaimed pavement is old pavement that has been ground up. When combined with fines, it is known as "brown pack." Before it is installed, Reclaim looks similar to road gravel, but it is more granular and darker because of the residual asphalt. However, once installed and compacted, the residual asphalt and fines bind the material into a very resistant road surface. The most common and effective use of this material is on long, gradual sloping road segments that have had problems with surface erosion. It is also effective on other high stress areas such as short, steep hills, sharp turns and intersections - as long as it isn't an area where people excessively spin their tires, since this will cause the material to be thrown around.

Many local pavement suppliers produce this type of material, but quality of the mix varies greatly, so be sure the mix includes fines to bind the material together. Availability and price may vary significantly, depending on your proximity to a supplier.

Tips for Using Reclaimed Pavement

- ❑ Reclaimed pavement can be spread in the same way as gravel; no special equipment is required.
- ❑ If you are placing Reclaim on problem slopes, start from just beyond the crest (top) of the hill and work down.
- ❑ The recommended depth is approximately 3-4 inches. Thin layers (less than 2 inches) may be prone to erosion.
- ❑ Compact the Reclaim, particularly on areas that are heavily traveled. Compacting with a roller is strongly recommended and provides much better results. If this is not possible, however, the material should be compacted by making several runs over the entire road surface with a loaded pickup truck. Many users report that compaction makes a big difference in results.

- ❑ Verify the quality of the product before delivery. Make sure the supplier doesn't mix in any waste products such as sheet rock and gravel that can make Reclaim dusty and less likely to bind together.

Reclaim appears to last up to 10 years on seasonal roads. Generally, after you have done the original grading and compaction, you should not have to re-grade Reclaim that often, but if you do, it is important to re-compact the material in order to keep asphalt fines from washing into nearby bodies of water and having harmful effects.

Pavement

While camp roads are not often paved due to the cost of paving and traditional views and uses of camp roads, sometimes paving is the best option. This is often true with particularly steep, high-use, or intersection portions of the road. Paving these chronically eroding sections of the road can often be the most effective method of stabilizing them. Paving may also be the best option for difficult, chronically soft or eroding roads as well. When paving a road or section of the road, a good base is required (see page 21). While the cost of paving can be prohibitive, the overall cost of the current road, including the maintenance and repair costs, should be considered when determining the best option. For areas that are already paved, do not use coal tar sealants on them, as runoff from them have a very high concentration of toxic compounds like PAHs.

Other Alternative Surface Materials

Sometimes a good gravel pit is far away from the job site and the price for the material reflects the high delivery charge. When other surface materials are locally available, such as crushed stone, crushed bedrock, or ripped shale, they may be used in place of gravel as long as they meet the particle size and fine percentage requirements discussed above to ensure the material sheds water and binds together. For many of these materials you may also need to use a base layer of geotextile (as described on page 24) to ensure it doesn't sink into the natural ground layer below. Also, since different pits and contractors often use different names for different products, be sure what you are asking for meets the correct description of what you are looking for, not just the name. You can also ask contractors or suppliers for local examples of places where alternative surface materials have been used to see first-hand how it looks and holds up over time.

More data is needed on alternative surface materials relative to possible resulting pollution, life cycle performance, required frequency of compaction and grading, and use on seasonal versus year-round roads.

A Few Notes on Alternative Surface Materials

- **Bank Run Gravel** – Bank run gravel is rounded while crushed gravel (more common and the better option) has edges that can lie flat and pack well. Tires can easily roll the rounded bank run gravel stones out of the road surface, leaving holes that start ponding and pothole problems.
- **C&R** – Available from CPRC Recycling. This 'crushed and recycled' product reuses demolition waste and is made of crushed bricks, concrete, asphalt, and shingles. This 1" minus product has a high percentage of fines. Usually less expensive than Reclaim and comparable in price to gravel.
- **Crushed Brick** – Made out of clay fines. Good for driveways that aren't very steep.
- **Crushed Cement** – This product can work well and stay in place well if it's added to a road surface that's already crowned. It can also be blended in with crushed gravel. It can get dusty, however.
- **Crushed Rock/Bedrock** – A mix of various sized rocks, but without fines. The large variety of rock sizes allows for packing. This product may be useable without adding fines if it binds on its own.
- **Crushed Stone** – Uniform in size and without fines, this doesn't pack well and moves around a lot under tires. Good for road base material and to stabilize soft, flat parking areas.
- **Reclaim/Brown Pack** – Crushed old pavement. This can be a very good product although there is a range in the mixes available. Some pits mix their reclaim with sand and gravel. See section above for more information.
- **Ripped Shale** – Can break down quickly and can be very dusty.
- **Stone Dust** – Can become muddy in the spring since it doesn't provide good drainage. However, it does pack very well and can be used effectively as a surface coat over driveways.

Grading

Grading is the process of smoothing and crowning or super-elevating a gravel road. This practice involves using a grader with a steel cutting blade or tines to redistribute soil material. The grader is the most frequently used piece of equipment for general camp road maintenance. It can be very versatile when used by an experienced operator.

Bulldozers are not generally recommended for road grading, because it is very difficult to get a good crown or to super-elevate with them. The same can be said for dragging a bedspring or other similar device. They tend to flatten the crown, which restricts effective surface drainage.

Key to Crowning, Super-Elevating, & Grading

= Proper and Regular Maintenance

Regular grading will allow water to reach buffers (preferably) or ditches efficiently and prevent significant erosion of the road surface.

Regular grading is an effective means of redistributing ridges of road material that has either been washed to the road edge or has been pushed to the edge by vehicle traffic. These little ridges will defeat the purpose of crowning by catching water before it can drain off the road (see Figure 12), and channeling it along the outer edge of the road surface. This problem has the potential to cause severe damage to a road surface during periods of heavy rain. **Always make sure that water can get off the road by smoothing the edge of the road with the grading blade.** Usually, camp roads are regraded by scraping this material from the outer edge of the road, and pulling it back into the center.

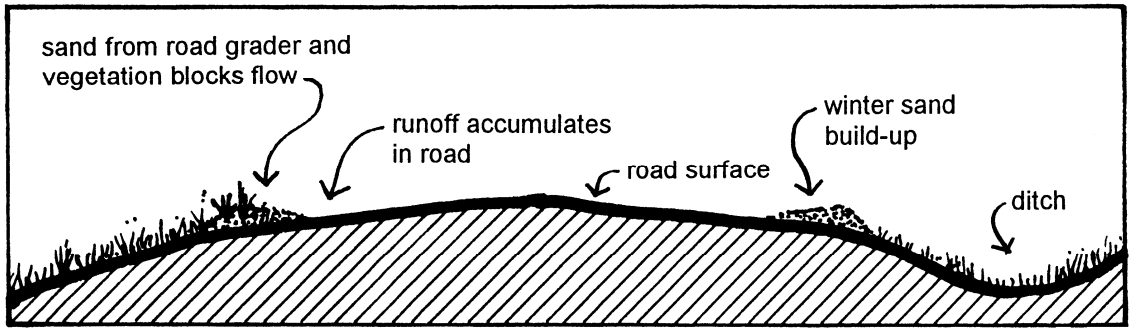


Figure 12. Sand and vegetation build-up prevents drainage to sides of road.

Grading Tips

- ❑ Proper grading is the most effective means of removing potholes. The grader should cut to the full depth of the potholes. Otherwise, they will tend to reform very quickly.

- ❑ After the grader makes a pass along the road, pick up large rocks that get pulled up out of the road and throw to the sides of the road.

- ❑ If there is a lot of sandy material on the road surface from winter sanding, try to pull this material off the road or blend it into other areas.

- ❑ Grade the road first and then add new crushed gravel to the surface to keep it separate from the poorer mix underneath. You don't want to mix the good material with loose, sandy material.

Grading Timing

The best time to grade a road is when the road is moist (in the spring, or after a rain). Water helps to loosen the gravel and fines and makes the road easier to reshape. Dry conditions can create a dust storm. If you need to work when it's dry – either to fit into a contractor's schedule or if there is a long dry period of weather – see if residents can spray down the road in front of their houses. You could also apply calcium chloride (see "Dust Control" section for more information on the use of calcium chloride).

Compaction after Grading

All grading practices loosen and re-sort the soil particles, which is needed to get the proper mix of particle size in the surface layer of the road. Although often overlooked, it is critical that the graded surface be compacted into place before it rains in order to "lock" in the fine particles with the coarser ones. If not they can be easily eroded. For best results a large roller should be used for compaction. If a roller is not available, a loaded pickup truck should be driven over the entire road surface several times to ensure that the surface is firm and not erodible. Simply driving passenger vehicles over the road will not provide adequate compaction.

Grading Frequency

The amount and type of use a road receives will determine how often grading should be done. For example, trucks carrying heavy loads will flatten the crown and create wheel ruts much faster than typical passenger vehicle traffic. Cars traveling too fast will blow away light soil particles from the road surface causing washboarding. In general, roads receiving heavier use will require more frequent grading. Grading is typically done at least once a year on seasonal roads. Year-round roads should be graded 3-4 times per year – in May to reshape the road after being flattened and bermed by plowing, 1-2 times in the summer to remove washboarding, and in the fall to prepare the road for winter.

Crowning and Super-Elevating

Road crowning or super-elevating are the primary means by which surface water is drained off the road surface. To crown a road means to create a high point that runs lengthwise along the center of the road. Either side of this high point is sloped gently away from the center toward the outer edge of the road. To super-elevate a road means to tilt the entire

road surface (except the uphill shoulder) in one direction so that water from the entire width of the road flows off as sheet flow to the side of the road. Super-elevating or crowning are the quickest ways to get water off the road, preventing significant erosion of the road surface. Depending on the road width, super-elevation has the advantage of being easier to maintain during grading and plowing.

A Job Well Done is Worth the Price

Job performance is as good as the equipment operator! A trained and experienced contractor may be more expensive, but the job will be better, and last longer. If a contractor's quote seems very low, be careful. Check the contractor's references, and make sure he or she understands the nature of the work you need done.

A flat road will allow water to puddle on the road surface; this will create potholes or erode the road surface. The potholes will continue to grow each time a vehicle splashes through them, resulting in the loss of fine clay particles that are necessary for a good road surface. Standing water will also seep into the roadbed, weakening the road and making it susceptible to tire rutting. Proper grading will prevent potholes from forming and provide a safer surface for travel. The figures below show how crowning and super-elevation promote surface water drainage.

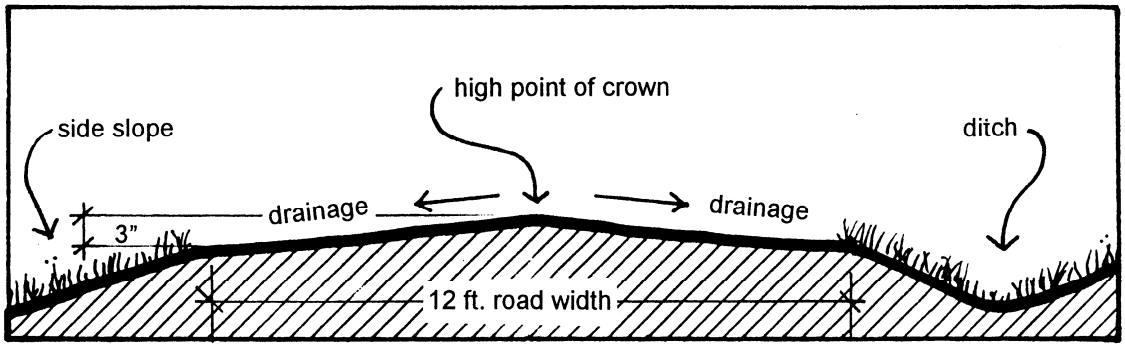


Figure 13. Crown profile: ½ " of crown per foot of road width (e.g., ½ " x ½ x 12' road = 3" crown).

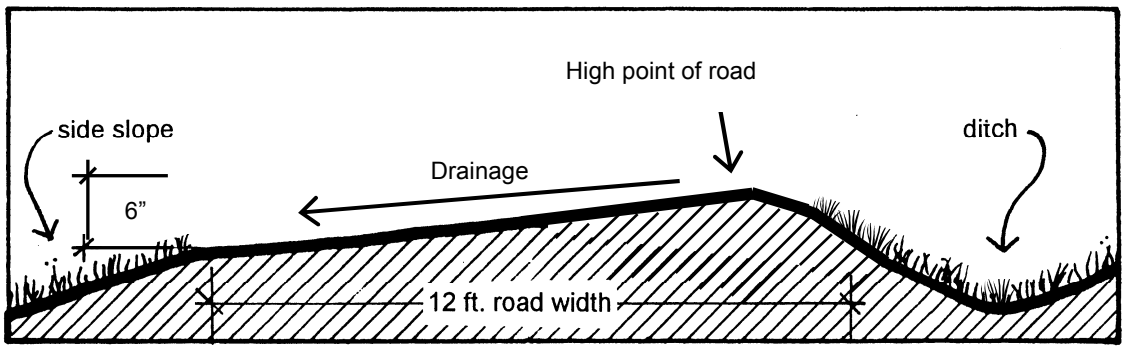


Figure 14. Super-elevation profile: ½ " of super-elevation per foot of road width (e.g., ½ " x 12' road = 6" crown).

A general rule for level or gently sloping gravel roads is ½ -inch of crown or super-elevation per foot of road width. A slope of ¾ -inch per foot of road width may be necessary for steeper sections to counteract the tendency of water to travel downhill over the road surface. Crowns greater than ¾ -inch per foot are not generally recommended, as they can be difficult to maintain and difficult to drive over. Crowning should be done annually because snow plowing and normal use flattens the road over the course of a year.

While super-elevation of the road was traditionally done on curves for safety reasons, super-elevating the road in any section is also a way to direct water off the road as non-erosive sheet flow. Following the natural contours of the landscape is a good way to determine which direction to tilt the road.

Out-sloping is preferred if possible since it avoids the collection or concentration of water in a ditch, resulting in less water to deal with, and less to cause erosion. Out-sloping is useful on roads where concerns about winter icing are minimal or side slopes are gentle. For out-sloped sections, if there is sufficient area for the road to drain off into, ditches are not needed on the downslope side of the road, and they may not be needed on the upslope side either.

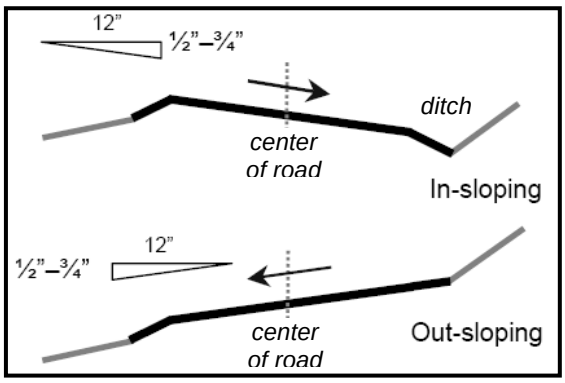


Figure 15. Super-elevation tilting options

In-sloped sections direct water to the ditch and are useful on steep side hills or where speed requires a banked curve to lessen the probability of vehicles sliding on a steep side-

slope. Since in-sloped sections will increase the amount of water in the ditch, be sure to turnout out the ditch water as frequently as possible.

Alternative Equipment

Typical equipment used in camp road maintenance consists of graders, excavators, and dump trucks. This type of equipment is generally too expensive and not used often enough for most camp road owners to consider buying. This is why contractors are usually hired to perform camp road maintenance work.

Steel Tine Rake

One affordable and effective piece of maintenance equipment is a steel tine rake, or York rake. This device consists of a row of strong metal tines that work in much the same manner as a grader blade. They are made to be towed behind, or mounted in front of, a pickup truck or tractor.

However, the steel tine rake may do more harm than good unless the treated road surface is properly compacted. As grading is done, these devices loosen fine material and can allow the material to wash into nearby waterbodies. That is why it is critical that roads treated with these devices be properly compacted. See discussion on compaction after grading (page 30).

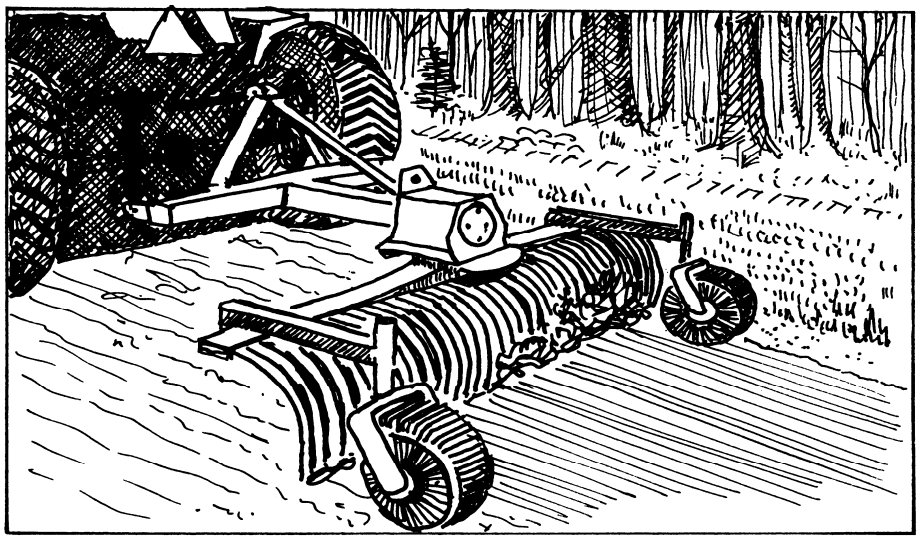


Figure 16. Steel tine drag rake used for light grading work of loose soil materials.

Steel tine rakes can be used to:

- ❑ remove potholes and washboarding;
- ❑ maintain or establish proper road crown;
- ❑ remove ridges of road material or vegetation from the road shoulder; and
- ❑ mix road materials to achieve proper distribution of particle sizes.

Advantages associated with this type of device include:

- ❑ Cost. Rakes are much less expensive than typical road maintenance equipment, primarily because they can be used with a standard pickup truck or tractor.
- ❑ Reduced maintenance expenses. It is best to use a steel rake frequently. This corrects minor problems before they become major ones.
- ❑ Ease of use. A rake doesn't require special training to use and can be done by a volunteer instead of paying a contractor.
- ❑ Shortened grading time and improved road condition. For best results, use to grade only when the road surface material is moist or wet. And, schedule re-grading of year-round roads at least 4 times a year during mid May, late June, late August and mid October. This use frequency will shorten the time required for each grading operation while improving the road performance to the satisfaction of the users and cash investors.

A Good Tilt or Crown is Key

It is very important to maintain a proper road crown or super-elevation. Often too much emphasis is placed on the smoothness of the road, with the result that the crown or tilt is removed.

Flat roads are prone to drainage problems.

Frontrunner Device

Another device to maintain gravel roads is called a Frontrunner grader/rake. The Frontrunner is similar to the steel tine or York rake except that it is mounted on the front of the vehicle on an existing snow plow mount, rather than towed behind it. The advantage over the drag rake is that the Frontrunner rake can be angled or pivoted similar to a snow plow and the tines dig into the road surface better to cut out potholes, washboard rills, wheel rut ridges, and shoulder berms. Its simplicity of operation helps make possible the timely maintenance or re-establishment of a proper road crown.

However, as with the steel tine rake, the device may do more harm than good unless the treated road surface is properly compacted. As grading is done, these devices loosen fine material and can allow the material to wash into nearby waterbodies. That is why it is

critical that roads treated with these devices be properly compacted. See discussion on compaction after grading (page 30).

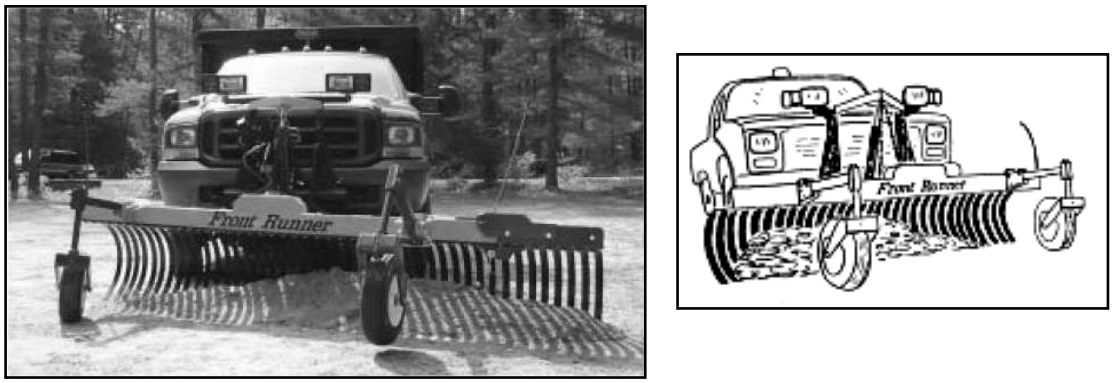


Figure 17. Frontrunner grader/rake.

Frontrunners are available for rent from several Soil and Water Conservation Districts. To rent the device, most Districts require attendance at a Frontrunner training. A ¾ ton or one ton vehicle with a 8 foot Fisher 25" push tab snowplow mount is required. Contact your local Soil and Water Conservation District for more information (see back Resource list).

Dust Control

Calcium chloride is a commercial chemical product used to control dust on gravel roads. Road dust is a nuisance, and it also hastens the deterioration of a gravel road and can make it prone to erosion. It has been demonstrated that a gravel road can lose as much as a ½ inch of surface material (primarily fines) per year because of dusting.

Road dust problems result in:

- Road surface loss that will require periodic replacement. A ½ inch loss of surface material per year on 5280 feet of a 12 foot road results in an annual loss of about 100 cubic yards of road material.

- A loss of soil fines, which are essential in maintaining the integrity of a gravel road surface. Soil fines are the binders that hold the road surface material in a tight, hard mass. The fewer the fines, the looser the gravel, which adversely affects traction and can result in washboarding.

Dusty conditions occur when a road surface has dried out. Soil fines can actually shrink due to moisture loss which, in turn, loosens and weakens the road surface. Calcium chloride helps to control dusting by preserving the moisture level in the road surface materials.

Calcium chloride is sold in liquid and dry (flake) forms. The flake form is most commonly used on camp roads because it does not require special equipment (i.e., a tanker truck) to apply. However, liquid applications are more cost-effective on large sites. The application rate varies, depending on the relative quality of materials in a given road surface. Some calcium chloride suppliers may require a road sample before recommending an application rate. Generally, 30% calcium chloride is recommended for most gravel roads.

Suggestions for using calcium chloride:

- ❑ While the initial application rate should be around 1 lb of calcium chloride per square yard, abide by the supplier's recommended application rate. More is not always better!
- ❑ It is best to apply calcium chloride when the road surface is somewhat moist. Watering the road from a tanker truck will suffice during dry times of the year.
- ❑ Scarify the road surface with a rake or grader before applying the calcium chloride; this assures a better bond.
- ❑ Regrade or rake the road surface after applying the calcium chloride to mix it uniformly with the surface material.
- ❑ Compact the road surface with a roller or a vehicle.
- ❑ Reapply calcium chloride as necessary. Successful applications can remain effective for 2 to 3 years.
- ❑ Flake calcium chloride can be applied by a garden spreader, but remember to adjust the spreader so that you achieve the right amount of material per square foot of road.
- ❑ Use of these and other chemical treatments, even salt, must be limited or not used at all in areas near water wells and in the shoreland zone.

Notes on a Few Alternative Dust Control Treatments

In 2003 a study was conducted to test several road dust control treatments. Four different treatments were used and following are the results for each treatment (contact DEP for more information):

- ❑ Dried granular asphalt – This recycled asphalt shingles product did not protect against the formation of potholes, the washing away of finer particles, or the

formation of dust. This product, as produced at the time of the study, is most useful as a binder and filler under pavement.

- Liquid asphalt penetration – This "old-fashioned" way of paving consists of spraying with liquid asphalt, adding a coating of sand blotter, and then rolling to compact. This product held the road together well, kept the road somewhat smooth, kept dust down, and was anticipated to hold up for several years. A concern with this product is the toxic compounds that make up the material and the effect the washing of such toxics could have on the nearby body of water.
- TDS (lignin sulfonate) – This liquid by-product of the paper industry is biodegradable and not harmful to plants, humans, or animals. This product did not protect against potholes, washboards, or the formation of dust on the test road but may be useful for roads where there is a better road base and slower and less traffic.
- Liquid calcium chloride – This product has been used for dust suppression at construction sites, and for snow and ice management on roads during the winter. This product resulted in a stable, dust-free road surface and as a result was the recommended treatment to control dust on roads.

Winter Maintenance

Roads that are used year-round and plowed in the winter require more maintenance than those that are only used in the summer. Besides the actual plowing and sanding that needs to be done in the winter, summer maintenance is increased because plowing often removes the road crown, creates plow berms on the side of the road, and allows for access when the road is not stable and especially prone to damage.

Plowing and Sanding Tips

- Winter Sand – avoid excessive sanding during winter storms since it can break down the quality of the road surface gravel mix by adding more fine or coarse materials over time and mixing them into this layer during seasonal grading operations. For example, too many fine soil materials will create a greasy condition on the travelway surface during wet weather and increase dust during dry conditions. On the other hand, too many coarse gravels and sands will cause a loose surface that will not compact well and hold its road crown. In either case, potholes, wash-boarding, soil erosion, shoulder berming, ditch/culvert clogging and stream/lake sedimentation will increase. All of which adds more costs!

- Plow all the way to the sides – Avoid snow banks along the road to prevent water runoff from washing out and icing over the road during winter thaws and early

spring melt. Be sure to plow the snow wide enough away to keep the banks off the road shoulder, especially during the first storm and thereafter.

- ❑ Rubber razors (see page 67) and open top culverts (see page 69) should have their locations well marked to help prevent damaging these drainage devices and the plow unit. Be sure to review this with the operator in advance!

- ❑ Mark culvert ends and ditch turnouts (see page 49) with long strips of red flagging hanging off tree limbs high above snow bank and plow truck. These locations may have to be opened up to handle heavy storm water flows during winter thaws. Have an emergency plan in place to deal with this problem.

- ❑ Limb up evergreen tree branches and/or remove trees that cause winter shading on the road. This should be done selectively to add another 1 to 2 hours of winter sun exposure to the road to reduce shade-induced icing. For example, during December and January, a sun exposure window between 10:30 AM and 2:30 PM will provide 4 hours of melting on the part of the road running downhill southerly. This will not work well on those parts of the road running downhill northerly.

- ❑ Each spring, be sure to remove plow berms and excess winter sand, and to recrown the road.

ROAD DRAINAGE

Any alteration to drainage patterns should be carefully considered. Be sure to get permission from landowners who may be affected by the change in drainage prior to beginning work.

Ditches

The best roads are built above grade without ditches and water sheds off them as sheet flow. Unfortunately, sometimes this is not an option due to the local topography. For these roads, installing good ditches with turnouts and cross-drains is the next best option. Properly designed and constructed ditches serve a number of essential purposes:

- ❑ They collect runoff flow from the road surface as well as from abutting properties and drain it away from the road.
- ❑ When connected to proper turnouts and buffers, they keep pollution from reaching sensitive water resources.
- ❑ When water flows through and out of them, ditches can help drain road base materials to reduce frost heaving, mud season problems, etc.

Evaluating your Existing Road Ditches:

1. Are they necessary? If not, can you get rid of them and allow road runoff to sheet flow into buffers?
2. Are they below the water table? If so, can you reconnect the groundwater back into the ground? (see rock sandwiches, page 63)
3. Can turnouts or more frequent turnouts be installed? (see page 49)
4. Do they need armoring to stabilize them? (see page 42)
5. If cross-drainages and turnouts and super-elevation are not possible, are the ditches big enough? (see page 42)

Proper ditching involves careful consideration of many factors, including watershed size, degree of slope, width of right-of-way, ditch size and shape, and native soil type. If your road ditches receive significant volumes of stormwater runoff, have an experienced and qualified individual design the ditch. Improperly designed or constructed ditches can make a bad situation even worse.

Ditch during a time of year when there will be sufficient time and moisture for a new vegetative cover to take hold. Late fall and mid- to late summer are not good times to do road ditching if you plan to establish grass cover in the ditches.

As with roads, ditches should be regularly inspected and maintained. It is critical to keep ditches free of large obstructions to allow water to flow as designed. Accumulation of leaves and debris can decrease the capacity of a ditch and restrict the ability to establish and maintain a vegetative cover. Leaves should be cleaned out of ditches in the fall – one good way to do this is to use a leaf blower to blow out the dry leaves. For more major ditch maintenance, a truck to haul off the debris being removed and a backhoe or excavator are recommended. Also, consider hiring a machine with a hydraulic tilt ditching bucket. This allows the operator to shape the ditch much more evenly and cleanly.

Where NOT to Drain To

When routing water away from a road, it is important to think about where it will end up. Road drainage should not be channeled directly into wetlands, lakes, streams, or coastal waters because it contains nutrients and sediments (regardless of how well your road is maintained) that can be very harmful to water quality. Also, never channel road runoff to wells or septic systems.

Be a good neighbor – discuss drainage options with landowners whom may be affected by the runoff water. When possible, avoid future problems by establishing written drainage easements. For a copy of a sample drainage easement, contact your local Soil & Water Conservation District.

Water should be routed away from the road and turned out frequently, so that it can be discharged into a stable vegetated area a little at a time (see page 49). This practice allows the water to filter and absorb into the surrounding vegetation and prevents large volumes of water from accumulating in the ditch.

The following information on ditch design is provided as general guidance. **If there is any question about proper design, consult with a qualified individual from your local Soil and Water Conservation District Office.**

Ditch Shape

Parabolic (U-shaped) ditches are preferred over V-shaped ditches. The flatter bottoms of parabolic ditches spread water out over a wider surface area. This slows the water down and greatly reduces its erosive potential. Ditch side slopes should not be steeper than 50

percent (2:1; see figure below), if possible. Steeper side slopes are unstable and have a tendency to collapse, which erodes soil and creates maintenance problems.

SLOPE VALUE EQUIVALENTS		
Ratio	**Percent Slope**	**Degrees**
1:1	100% slope	45°
1.5:1	67% slope	34°
2:1	50% slope	27°
4:1	25% slope	14°

Figure 18. Slope value equivalents

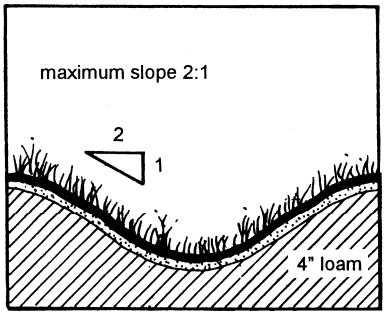


Figure 19. Parabolic (U-shaped) ditch, grass-lined.

Steepness of slope can be a difficult concept to understand. It is easiest to visualize slope as the long side of a triangle with horizontal "run" and vertical "rise" being the other two sides (see diagram below). Slope expressed as a ratio is "run" : (to) "rise." To express slope as a percentage, simply divide rise by run and multiply by 100: (rise/run) x 100.

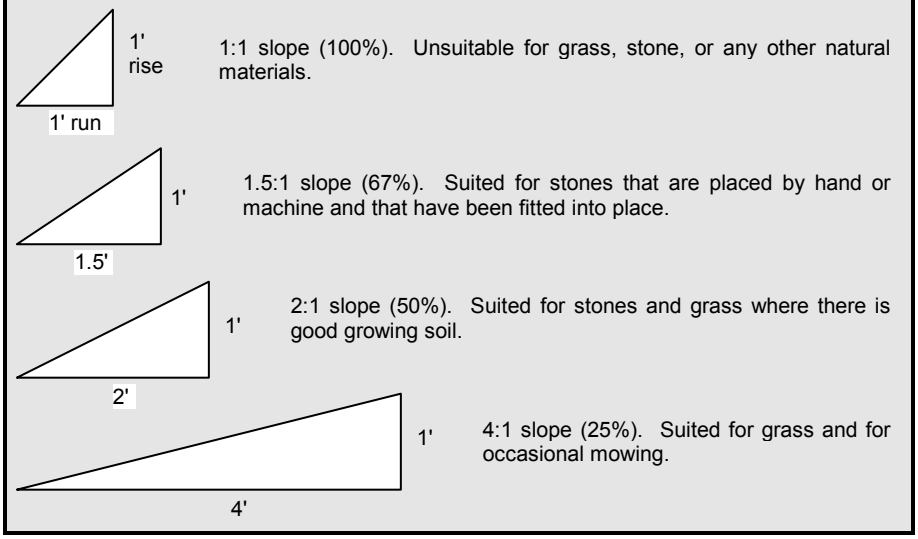


Figure 20. Slope

Ditch Size and Depth

The size of a ditch should be based on the volume of runoff it receives. This volume is determined by calculating the surface area draining into the ditch and factoring in the amount of rainfall it receives during a major storm. Ditches which are in or near the water table should also take into account groundwater that may end up in the ditch. Unfortunately, ditches are more commonly squeezed to fit into limited right-of-way space. Undersized ditches can overflow onto the road surface and cause severe road damage.

As a rule, when the ditch is full with stormwater, the water should never be higher than 1 foot below the top of the ditch (see Figure 21). This will provide enough room for ice buildup in the winter and runoff from the occasional heavy rainstorm.

Ditches ideally should not extend below the groundwater table. The road, including the bottom of the ditches, should be built above the water table. If this is not possible, groundwater that ends up in the ditches should be crossed under the road and spread out frequently to reconnect the hydrology and to get the water out of the ditch. The drier you can keep a ditch (while still having it do its job), the better – a "dry" ditch needs very little maintenance.

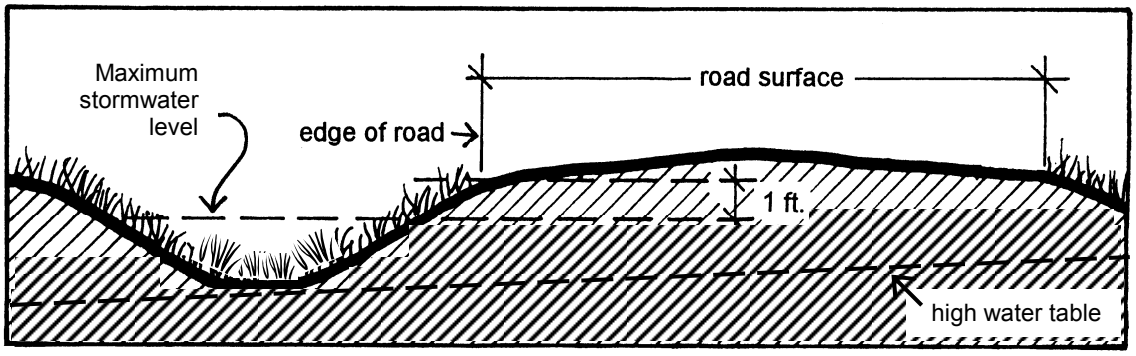


Figure 21. Ditch above groundwater level and with sufficient depth.

In cases where all other options to get groundwater out of the road base (see page 14) have been explored and determined to be unfeasible for a particular situation, road ditches can be designed to help stabilize the road by draining the groundwater from the road base by digging the ditch deeper than the high water table. However, this will create more water in the ditch that must be dealt with. The ditches should be cross-drained frequently with culverts or rock sandwiches (see page 63).

Ditch Erosion and Stabilization

Erosion in Ditches

The best way to evaluate an existing road ditch is to inspect it during a heavy rainstorm. Muddy water or water overflowing the banks of the ditch means you have an improperly sized ditch. If the ditch appears to be large enough, but the water is still muddy, it probably cannot handle the speed of the water or it has active groundwater seeps and needs further armoring to protect it from eroding, or it could be receiving muddy water from the road or other areas.

Ditch erosion is often the result of side slopes that are too steep, scoured channel bottoms (inverts), groundwater seeps, or concentrated runoff flow from uphill development sites. Steep slopes are prone to collapsing and are difficult to keep covered with vegetation. In general, side slopes should not exceed a 2 to 1 ratio (not more than half as high as they are wide). Seep areas are also difficult to stabilize with vegetation due to soft muddy soil and moving groundwater and need to be stabilized with rock.

An eroding ditch will continue to erode until one of two things occurs:

- ❑ All erodible material is washed away, eventually finding its way into a lake; or
- ❑ The channel widens until the speed slows to a point where erosion stops. This may entail washing out road shoulders and driveway entrances.

If a ditch is eroding, there are several things you can do to halt it:

- ❑ Stabilize the ditch bottom by lining it with grass, erosion control blankets, and/or stone (riprap). See the following pages for more information.
- ❑ Reduce the amount of water going to the ditch by installing ditch turnouts (see page 49), upland diversions, or detour culverts (see page 52) across the road.

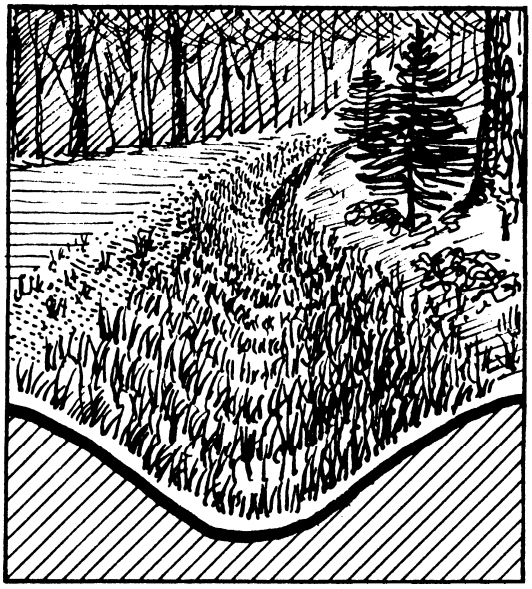


Figure 22. Plant grass to control erosion in ditches with less than 5% pitch

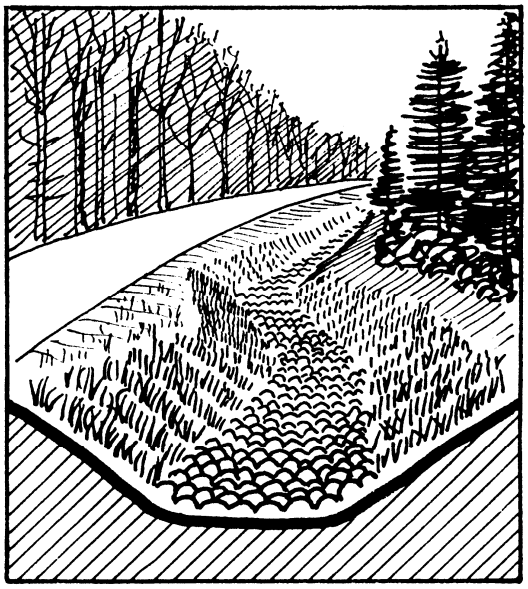


Figure 23. Grass and stone to control erosion for ditches with more than 5% pitch

Seeding and Mulching

A good vegetative ground cover is critical to controlling erosion and water pollution. Seeding and mulching is an effective and affordable way to prevent erosion on exposed soil areas such as ditches and roadside construction areas, provided the soil is not poorly drained, in full shade or over a groundwater seep or on a hardpan. For those situations, you may need to use rip-rap, erosion control mats, or erosion control mix (see following sections).

Temporary Erosion and Sedimentation Control

If you have a break in your road work and will be leaving disturbed soil for more than a day, or if it is forecasted to rain before you will finish your work, you need to temporarily stabilize the area with mulch or erosion control mix (not seed and fertilizer), or cover the area with a tarp or erosion blanket. See the Erosion and Sedimentation Law (page 71).

Whenever you disturb the soil (such as when you are digging or maintaining ditches) and wherever there is exposed soil, seed and mulch the area to prevent the soil from washing away in the next rainstorm. Seeding and mulching should be done before the fall, so there is sufficient time for the grass to become established before cold weather hits.

Suitable seed can be bought at most agricultural and hardware supply stores. Standard "Conservation Mix" is recommended, because it provides a blend of grass seeds that will help to ensure a good growth in a variety of situations. Read the seed label to make sure there is an adequate mix of annual and perennial seed. Do not use old seed because it will cause reduced germination. Follow the manufacturer's recommendations regarding application rates. The soil must be raked just before seeding to allow the young grass a chance to root. Then:

- ❑ Apply ground limestone, if necessary (140 lbs. per 1,000 square feet in lieu of a soil test).

- ❑ Do not apply fertilizer, unless it is necessary. If you need to apply fertilizer, minimize the amount of phosphorus in the fertilizer (the amount of phosphorus is represented by the middle number in fertilizer designations; for example 10 – **10** – 10). Most soils in Maine have enough naturally occurring phosphorus to grow healthy grass. New grass may require a small amount of added phosphorus to help with initial root development, but most established grass does not require additional phosphorus. Phosphorus-free fertilizers are recommended for most applications within lake watersheds.

- ❑ If using fertilizer, work the fertilizer and lime into the soil before seeding. **Fertilizer and other chemical amendments should be used carefully. Adding twice the amount with the thought that it will grow twice as much or twice as fast does not work!** Seeding, fertilizing, or liming more than the recommended amount may actually decrease your chances of success.

- ❑ Annual maintenance is sometimes necessary. Remember that you are growing grass, not a harvestable crop. Recycle the clippings into your lawn or compost pile.

- ❑ For somewhat steep banks where vegetation has been determined to be preferable to rip-rap or other erosion control methods, prior to seeding, first add loam and mix it into the natural soil 18" deep to encourage the roots to grow deep and provide more stabilization. Then mix seed into the very top layer.

Grass is not always effective. For example:

- ❑ If a ditch with a good grass cover still erodes, it indicates that water is traveling faster than the grass can handle. Further protective measures are necessary (i.e., riprap or manufactured erosion blankets).

- ❑ The soil may be too wet or on a hardpan. Grass won't grow in a ditch that is wet throughout most of the year. This generally indicates that groundwater is draining into the ditch. Try other protective measures (i.e., riprap).

- ❑ The area is too shaded for seed establishment. This is a common problem with camp roads under tree canopies. To control erosion, a layer of stone riprap may be required to protect steep slopes and excessive channel flow drainage. Erosion control mix may be used in flat areas of lesser stormwater flow.

- ❑ It may be that the soil has insufficient nutrient levels to establish a good grass cover and you need to fertilize. Proper fertilization requires knowledge of your soil's deficiencies. If you question your soil's nutrients, contact your local University of Maine Cooperative Extension office for a simple, low cost soil test kit. But remember that unnecessary fertilization can be harmful to a lake.

Mulching with Hay or Straw:

After you seed the ditch, mulch the area with hay or straw to temporarily protect the exposed soil and seeds. Mulching should be done just after seeding to protect the seed from washing away and to provide a better growing environment by regulating the soil's temperature and moisture level. When you spread mulch, cover **all** the soil. Walking over the mulch or cutting it into the soil with a shovel blade will help to anchor it in place and prevent it from blowing away. Mulch should be inspected and reapplied, if necessary, after rains or high winds.

Erosion Control Mix

Erosion control mix is a kind of mulch made of stump grindings, sand, gravel, stone, and wood fragments. It is much heavier than other types of mulch and its mixture of elongated fibers, gravel, and soil lock together to protect the underlying soil from erosion. Like other mulches, it also retains moisture, controls weeds, and improves the soil as it decomposes. Erosion control mix can be used to stabilize the upper sides above the riprap line in ditches and other appropriate areas, including shaded sites.

The following are general guidelines:

- ❑ Apply to bare areas to a thickness of no less than 2 inches.
- ❑ Place evenly and provide 100% soil coverage, with the soil totally invisible.
- ❑ Do not apply in areas that will have concentrated flows within the ditch invert area or below culverts ends, on backslopes that have groundwater seepage, or on slopes that are steeper than 2:1.

Mulched areas should be inspected regularly and after each large rainfall. Mulch should be immediately added to washed out areas to maintain the desired thickness. Erosion control mix should be left in place, and new plant growth should be promoted to more permanently stabilize the area.

To locate erosion control mix vendors, visit the website www.maine.gov/dep/land/training/suppliers.pdf for a list of suppliers, or contact your local contractor or gravel pit and ask for erosion control mix. Make sure to be clear that you are not looking for landscaping bark mulch because it is not the same product and will not be as effective.

Erosion Control Blankets

Erosion control blankets (also known as erosion control mats) are manufactured combinations of mulch and netting designed to slow down water flow, protect soil underneath from erosion, and promote vegetative growth by retaining the soil's moisture and modifying the soil's temperature. Erosion control blankets are useful to stabilize ditch sides and bases before grass is fully established. They are also useful to stabilize steep slopes (15% or greater).

The most critical aspect of installing mats is obtaining firm continuous contact between the mat and the soil. Without such contact the mat is useless and erosion occurs. Be sure to install mats and staples in accordance with the manufacturer's recommendations. And, always seed the bare ground area under the blanket (like with hay mulch).

Riprap and Geotextiles

Riprap can be used to stabilize steep sections, in ditches with lots of water flow, or if there are groundwater seeps in the ditch side-slope.

- Riprap should consist of angular stone of varying sizes. The different sizes help lock the stones in place. Round shaped, uniformly sized riprap stone tends to be very loose and does not key well together, causing sliding and undercutting.
- Sometimes, you can tell what size rocks you need by looking at the size of stones remaining in the ditch naturally.

Geotextile material should be used to prevent soil erosion beneath riprap armoring. Erosion can occur under and around riprapped ditches, particularly if the side slopes are steep. Water flowing over the riprap can actually lift soil out from underneath the stones. This undercutting can be curtailed by using a geotextile layer between the riprap and the native soil. The geotextile covers the soil surface and protects it from erosion. For more information about geotextiles, see page 24.

General Installation Recommendations:

- Use non-woven geotextiles for this type of application because they are more permeable and they conform to the soil surface better.
- Anchor the upper ends of geotextile in a small trench to prevent it from slipping when the riprap is lain in the ditch.
- Overlap multiple sheets of geotextile by 1-2 feet (upslope fabric should overlap the downslope fabric, just like shingles on a roof).
- The soil surface should be relatively smooth and free of protruding rocks and debris that can puncture and tear the fabric.

For ditches with groundwater seeps in the side-slope, geotextile should not be used since it will likely get clogged up by the soil. To stabilize these areas, first put a layer of pea stone sized rock then add a layer of rip-rap sized rock on top. This allows the water to drain through while stabilizing the area.

Ditch Check Dams

Stone check dams can be installed in ditches along steep sections of camp roads where the ditches are not armored with riprap and never seem to get fully vegetated. Stone checks dams slow down the velocity of water flowing through the ditch, which can reduce ditch erosion and force sediment to settle out behind the dams. Stone check dams have traditionally been installed as temporary devices, but have recently been installed with success as structures that are a 'permanent' part of the ditch without plans for removal.

Check dams should be no more than 2 feet high and are generally built with 2 to 3 inch stone. Keep in mind that the rock must be large enough to stay in place given the expected flow through the ditch. Place the rock across the entire ditch and make sure the center of the dam is 6" lower than the edges, so that water does not flow around and erode the edges. Ideally, the dams should be spaced so that the toe of the upstream dam is at the same elevation as the top of the downstream dam. Make sure to remove sediment from behind dams when half-full or at least once a year.

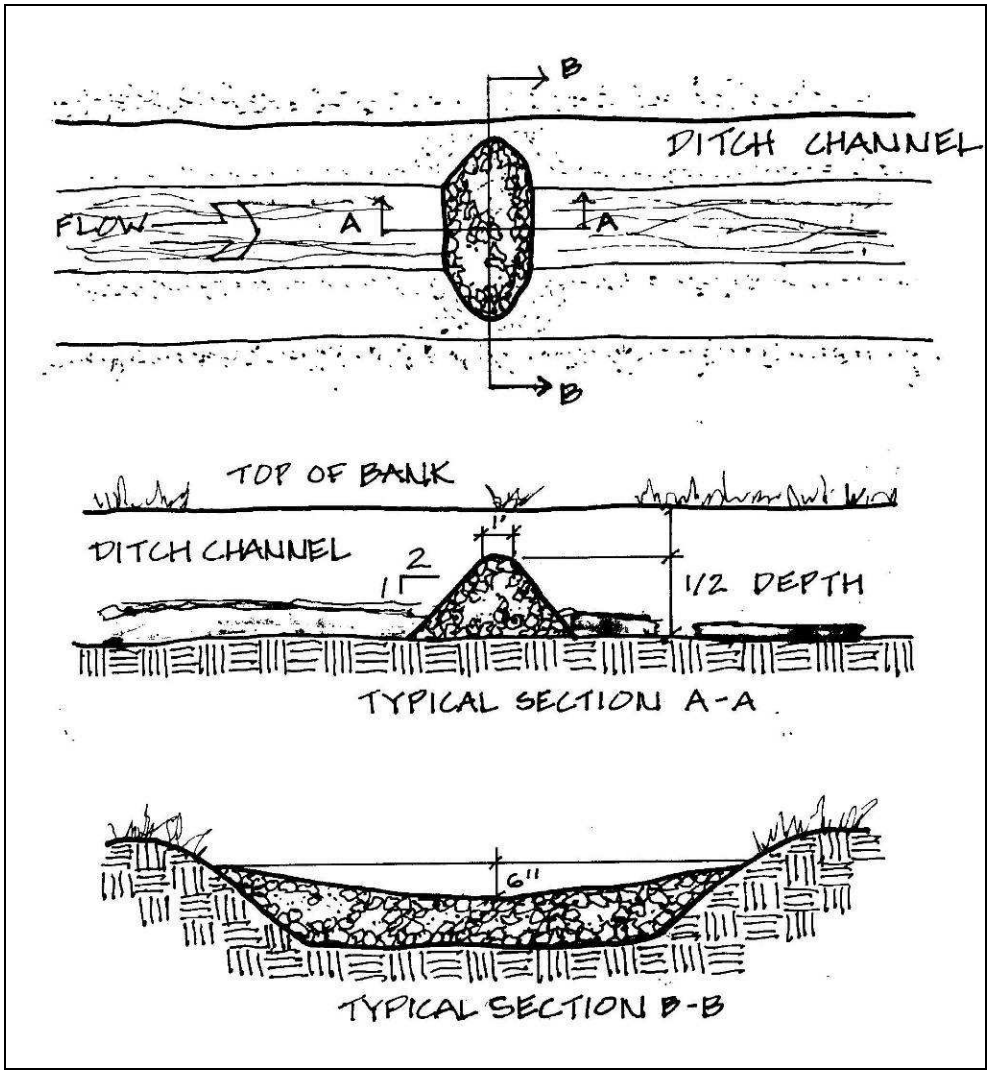


Figure 24. Ditch Check Dams: 3 Views – plan view, side section view, cross section view

Ditch Turnouts

Ideally, road runoff should be discharged uniformly off the road surface and into a grassed or wooded area where it will gradually percolate into the ground. In reality, this is generally not the case. Usually, road runoff accumulates in a ditch before it is discharged, often into a stream or lake. Instead, every effort should be made to discharge ditch water into vegetated

areas capable of handling the runoff without the water creating channels or causing erosion. This is what turnouts do.

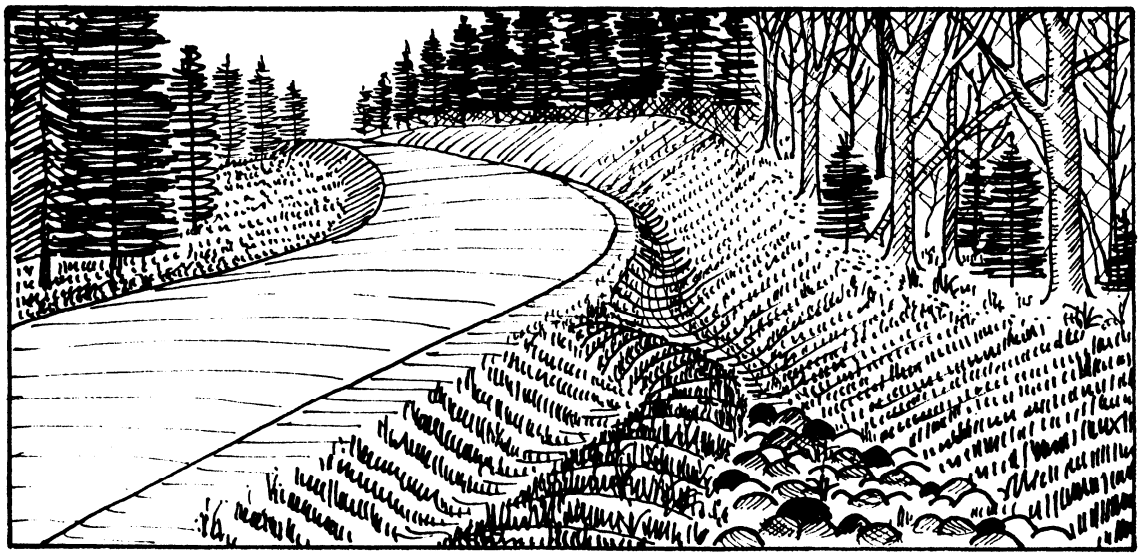


Figure 25. Ditch turnouts channel water away from the road into vegetated buffers.

Turnouts are used to direct ditch water into a vegetated buffer so less concentrated runoff reaches the bottom of the hill and less of it ends up in the lake or stream. Turnouts are beneficial, because they:

- ❑ disperse runoff before it can cause erosion (if located frequently enough);
- ❑ allow eroded soil particles to settle out of the runoff; and
- ❑ use natural filtration to remove the nutrients and fine sediments in stormwater runoff.

Turnout Specifications:

- ❑ Outlets/Level Spreaders - The turnout should have a flared end section that is level and lined with 4"-6" crushed, angular stone to spread out the flow. This level spreader or rock dam converts the channeled flow into slower, shallow sheet flow just before it discharges into the vegetated area. Do not outlet turnouts into existing stream channels or drainage ways. They should be discharged to vegetated buffers.

- ❑ Location and Spacing - Turnouts should be located so that they use the natural contours of the land and should be installed frequently enough to prevent large volumes of runoff from accumulating in the ditches. As it is easier to disperse smaller volumes of water at a time, turnouts should be constructed as often as possible. For very steep slopes, turnouts may need to be placed every 50 feet to counteract the

effect of fast-moving water. Turnouts may not be possible or useful in very wet, flat areas.

- Neighbors - Be sure to check with abutting property owners to ensure this water will not adversely impact their property.

- Stabilization - Turnouts should be stabilized so as not to create additional soil erosion. Turnouts with less than a 5% slope can be seeded and stabilized with a conservation mix and mulched with hay or an erosion control blanket until the seed germinates. Alternatively, on steeper slopes or areas receiving greater flow, 3"–6" angular rip-rap placed over non-woven geotextile fabric can be used to line the structure.

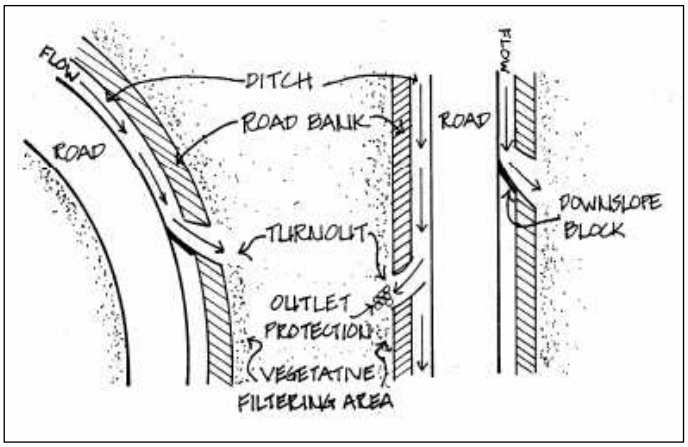


Figure 26. Detail of ditch turnouts.

- Maintenance - Because the turnout may have a secondary function as a small sediment trap, maintenance is critical to ensure excessive sedimentation from storm events does not fill the structure and render it nonfunctional. Check turnouts during and after large storm events for erosion or accumulation of debris. Any turnout will fill with sediment over time, and it is critical to remove this material for the structure to function properly. Confirm that water flows evenly into the vegetation, and does not form an erosive channel. Shift stone, as needed to stop any channelized flow. Have a post-storm plan in place for checking damage and determining maintenance needs.

Road Shoulders

The road shoulder is the area between the edge of the road travelway surface and the ditch. They range anywhere from 18" to 48" wide and are increased in size for vehicular turnout parking. Shoulders can serve the following purposes for camp roads:

- Transfer surface drainage as sheet flow from the travelway to the ditch and provide a snow bank zone
- Provide a safety visibility zone for two-way traffic on road curves and space for emergency parking

- ❑ Help provide structural support of the road surface and base layers as well as protecting ditch side slopes
- ❑ Help separate the travelway edge from the top of the ditch slope for driver and pedestrian safety

Camp road shoulders are usually either gravel or grass covered. Steeper shoulders should be rip-rapped. An important aspect is to stabilize the shoulder either with vegetation (such as grass), erosion control mulch, or rock. To allow water to drain from the road, the shoulder should be sloped to about twice that of the roadway surface or about ¾" to 1 foot per foot of shoulder. For a 2 foot shoulder, the drop minimum should be 1.5"-2". For a 4 foot shoulder, the drop minimum should be 3"-4". The shoulder should be shaped from the road surface edge, making sure there is a seamless transition so a "false ditch" does not form between the roadway and the shoulder.

Maintenance of shoulders should include:

- ❑ Mowing (if vegetated) and removing brush from the shoulders
- ❑ Removing winter sand and other debris
- ❑ Grading to ensure the shoulder is flush with the road surface

Culverts

Culverts and cross drainage channels are used to convey water from one side of a road to the other. This is accomplished by conveying water under the road through the culvert, or by allowing water to flow over the road using a ford, waterbar, or dip. The following pages provide general information on culvert selection and installation. Improper selection or installation can result in severe damage to your road and pollution of downstream bodies of water. **If there is any question as to what is appropriate, consult with a qualified individual.**

When to Install a Culvert

Culverts should be installed when:

- ❑ a stream, brook, seasonal runoff channel, or subsurface drainage way must be directed under the road. This keeps the road from disrupting the natural drainage system. If there may be fish in the stream, you must consider ease of fish passage – contact your local Soil and Water Conservation District or the DEP if there may be fish.
- ❑ surface and subsurface water flows reach volumes that are difficult to contain in a roadside ditch and need to be turned out on the opposite side of the road.
- ❑ a driveway crosses a road ditch.

Culverts should reconnect streams, brooks, or seasonal runoff channels. Other culverts transporting groundwater or runoff should disperse the water into vegetated buffer areas capable of handling the water without eroding. When you need to cross groundwater under a road or driveway, narrow rock sandwiches or rock cannolis (see page 63) can be used in place of culverts.

Culverts are frequently overlooked during camp road construction and maintenance. Often, culverts are the most critical, but most expensive, part of maintaining camp roads. Because culverts are expensive to buy and install, it is best to maximize the useful life of these structures by installing them properly, and inspecting and maintaining them regularly. Be sure to keep culverts clear of any debris – branches, sand, leaves, etc. – that could clog the culvert and cause it to be overtopped. One way to clear leaves is to use a leaf blower to blow the dry leaves out in the fall.

Culvert Types

There are three basic types of culverts used in camp road construction: corrugated metal, plastic, and concrete. There are advantages and disadvantages to each type, as shown in the following table. For non-stream crossings, smooth line plastic culverts (corrugated on the outside but smooth on the inside) are recommended due to the advantages noted below. However, for streams with fish, smooth interior culverts are not recommended since they speed up the flow of the water and can make fish passage extremely difficult.

Culvert Type	Advantage	Disadvantage
metal (corrugated)	❑ inexpensive for sizes < 24” ❑ easy to install ❑ 25-year life	❑ expensive for sizes > 24” ❑ easily crushed and permanently deformed
plastic (HDPE)	❑ inexpensive for sizes < 18” ❑ >25-year life ❑ less freezing ❑ easily cut with power saw ❑ smoother interior bore surface for heavier water and debris flow velocity ❑ lightweight ❑ bounces back from frostheaves	❑ easily broken if not handled carefully ❑ more difficult to install to grade with respect to envelope backfilling operations
concrete	❑ 50-year life ❑ smoother surface for heavier water flows ❑ handles heavier truck weights with shallow gravel cover	❑ expensive ❑ heavy

Sizing Culverts

Culvert sizing is probably the most important aspect of culvert selection. Proper sizing can eliminate washouts and plugging. Money spent for a larger culvert often results in net savings because of reduced maintenance and repairs when properly fitted to the site.

In general, you should consult with a qualified individual when dealing with culverts greater than 24 inches in diameter. Following are some general guidelines.

- Inspect other culverts that drain to your crossing. If the local highway crew installed a 3-foot diameter culvert that drains water toward your camp road, you probably need that size, or larger.
- For cross drainage, culverts that are a minimum of 18 inches in diameter are recommended. If space constraints do not allow for an 18 inch culvert, a 15 inch culvert (or two 15 inch culverts side-by-side) may be necessary. For example, 15" minimum size culverts are recommended for placement in roads with right-of-way widths of up to 30 feet, and 18" minimum size culverts are recommended for right-of-way widths in excess of 30 feet. Do not install cross drainage culverts that are smaller than 15 inches as they plug easily and are difficult to clear.
- For stream crossings, contact expert to ensure fish passage.

The following table can be used as a general guide for sizing culverts. Another good rule for sizing culverts in small watersheds (less than 14 acres) is to have a culvert diameter of at least 8 inches plus the watershed acreage – keeping in mind that a minimum diameter of 18 inches is recommended for maintenance purposes.

Channel Width (inches at normal high water mark)	**Channel Depth** (inches at normal high water mark)	**Culvert Size** (inches diameter)
≤ 9	≤ 9	18
12	6	18
12	9	22
12	12	24
18	9	30

Culverts for streams that may have fish in them may have additional sizing regulations. Contact an expert if dealing with a stream that may have fish in it.

Culvert Installation

LOCATION

Place culverts where there are existing water channels crossing the road and wherever needed to control the volume and velocity of water. Steep slopes will need more culverts to control water flow.

PITCH

Most culverts should be set at a 2% grade (¼-inch of drop per foot of length). Pitches less than 2% can cause water to pond in the culvert, resulting in freezing or pipe corrosion. It is very difficult to eyeball a 2% slope, so use a string line level or a pop level.

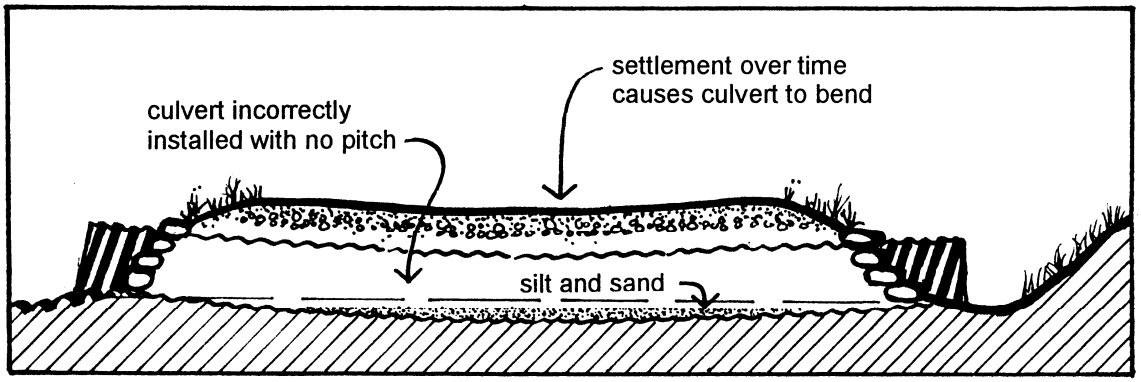


Figure 27. Incorrect way to set a culvert: center too low; silt freezes and plugs culvert.

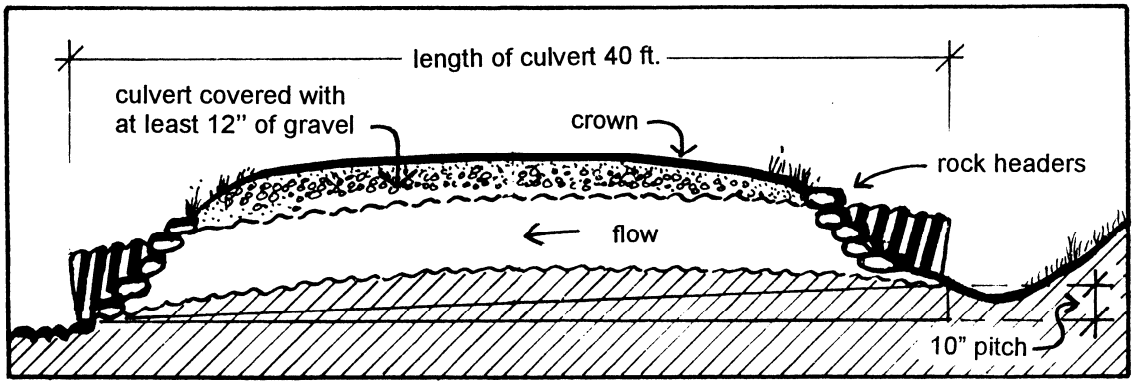


Figure 28. Correct way to set a culvert: rise allows for settling (note: bow is exaggerated for illustration purposes).

ANGLE

Culverts should be set at an angle 30 -35 degrees downslope from a line perpendicular to the road's centerline. Setting culverts on an angle improves their hydraulic efficiency and lessens the chance of erosion at the inlet. Culverts installed in a natural drainage channel (e.g., streams) should be installed at the same angle as the channel.

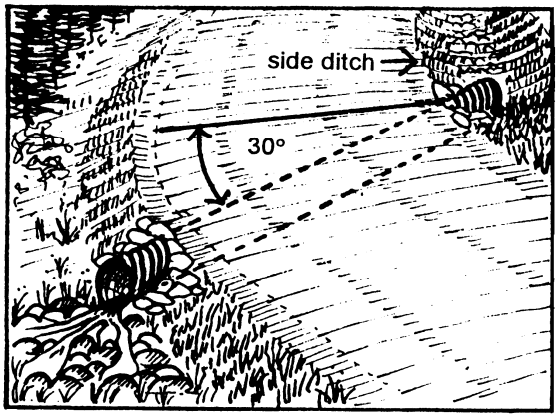


Figure 29. Set culvert at 30° downslope.

CULVERT LENGTH

It is very important to have the proper culvert length. All too often, people install culverts that are too short, causing road shoulder washouts and culvert collapse that ultimately plugs the end openings. Culverts are manufactured in standard lengths, so when determining the proper length for your situation, it is better to estimate a little long rather than a little short. The culvert can be cut to length later, if necessary, but extending it with couplings is expensive and prone to failure.

When determining the culvert length, be sure to account for the following factors:

- the travelway shoulder width,
- the length and steepness of side/fill slopes (measured horizontally), and
- the length of culvert needed to compensate for the downhill pitch angle and the road cross angle (if any).

<u>If you account only for the width of the road surface, you will always end up with a culvert that is too short!</u> Measure from toe of slope to toe of slope plus add for the angle and add length if deepening ditches makes them farther from the road. Don't sell yourself short!

CULVERT INSTALLATION

Most common cause of ***CULVERT FAILURE*:**

<u>Lack of proper compaction around culvert</u>

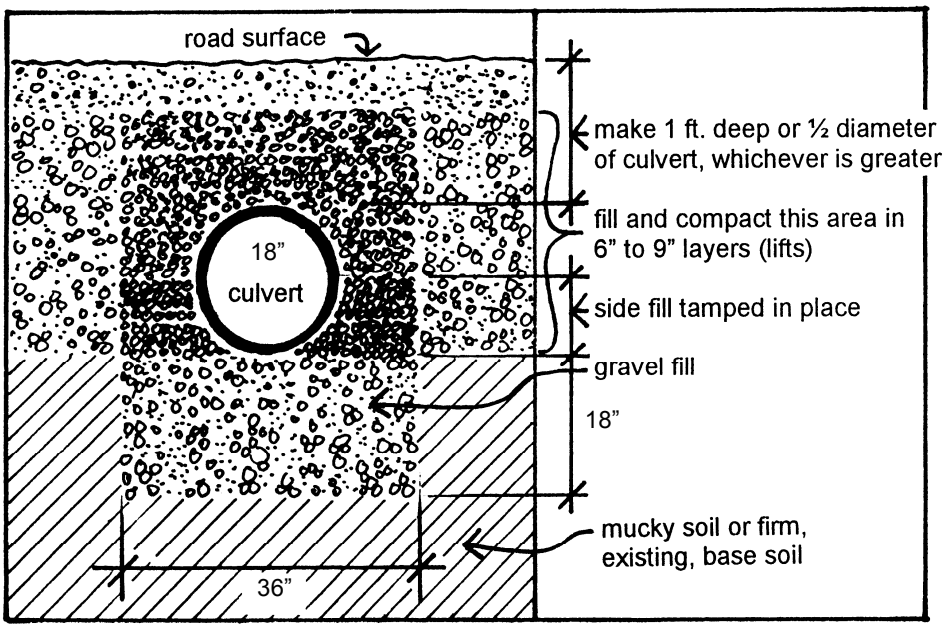


Figure 30. Culvert Installation

- It is critical to set a culvert on a firm base consisting of gravel material containing rocks no larger than 2½ inches. If mucky soil is present, it should be removed and replaced with good backfill in an area twice as wide as the diameter of the culvert, and about the same depth as the diameter of the culvert. The backfill should be as close to the surrounding soil as possible so there will not be differential heaving.
- On sites with ledge and rock, set the culvert onto a gravel base measuring 1/3 of the culvert's diameter. For example, set a 18-inch pipe on a 6-inch base. Next, backfill the sides with good gravel, and tamp by hand.
- **It is essential to cover the culvert with a minimum of 1 foot of soil.** An adequate covering will reduce frost heaving, the potential for crushing the culvert, and sagging. If the culvert is over 2 feet in diameter, the amount of fill placed on top of the culvert should equal ½ the diameter.
- If you don't have enough space for an adequate amount of fill to prevent frost heaving, or to further protect against frost heaving, you can put insulation over the top and sides of the culvert. While the thickness of 1 inch of Styrofoam insulation replaces one foot of soil in terms of insulation against freezing, it does not provide the same protection against crushing. Whenever at all possible, use a minimum of one foot of road surface or road base on top of the culvert to allow the weight of vehicles to be dispersed and protect the culvert from crushing and sagging and to prevent the Styrofoam from being exposed and lifting out.

- ❑ Always compact soil around the culverts in lifts (or layers) no greater than 9 inches. **Good compaction around the pipe is very important**, since it provides the structural strength necessary to resist crushing.
- ❑ Culverts installed in natural streams should be set into the streambed to allow fish to travel freely through the culvert. Contact an expert if dealing with a stream that may have fish.

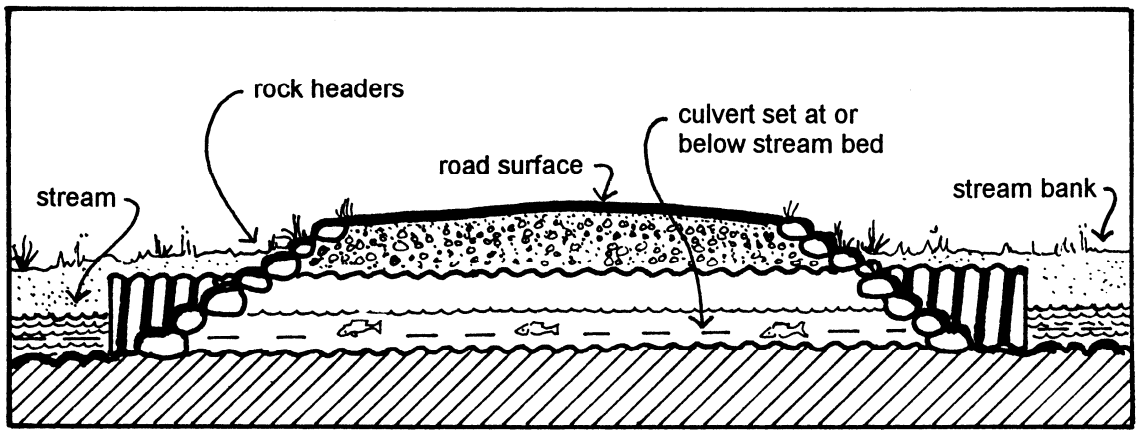


Figure 31. Culvert installed in a stream to allow fish passage.

Culvert Inlet and Outlet Banking Stabilization

The banking around the culvert inlet and outlet should be stabilized the width of the culvert with large, angular rip-rap, (e.g. 18" width of rock all around a 18" culvert) with non-woven geotextile underneath. This helps hold the road base and protects the area around the culvert in case the stream or ditch water backs up. Try to use larger rocks as headers, as they will stay in place better and hold back more material. In addition, the slope above the culvert must be stabilized as follows:

- ❑ For banking slopes steeper than 2:1, armor with riprap with non-woven geotextile underneath. The rip-rap should consist of angular stone of varying sizes to help lock the stones in place. Round shaped, uniformly sized riprap stone tends to be very loose and does not key well together, causing sliding and undercutting. For more information about rip-rap and geotextiles, see page 47.
- ❑ For banking slopes 2:1 or less, place erosion control mat and seed to establish vegetation.

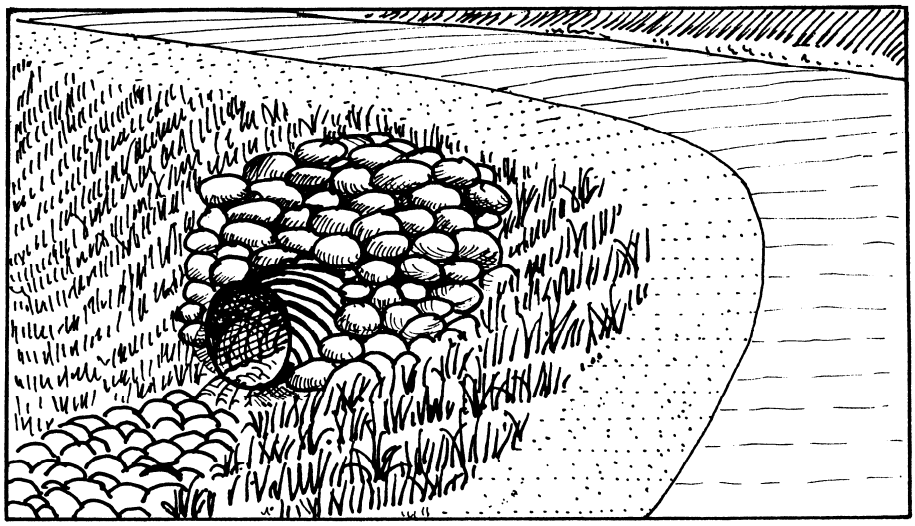


Figure 32. Rock headers on culvert outlet: headers (on 2:1 slope) at both ends prevent erosion.

Culvert Inlet Anti-Seep Protection

To ensure water does not bypass the culvert by seeping alongside the culvert (through the road), and then causing the road to collapse, the area around the culvert inlet must be protected. If around the inlet is rip-rapped with geotextile underneath, be sure the geotextile forms a protective collar around the inlet. If around the inlet is not rip-rapped with geotextile underneath, it needs to be protected with an anti-seep collar. Place the collar (you can make one using geotextile or any non-permeable material) around the culvert inlet for at least the width of the culvert.

Shallow Culverts

Please Note: This information about shallow culverts is taken from Penn State's Center for Dirt & Gravel Roads. It is a new practice to Maine – please let us know if you try it and have results either way.

Oftentimes, to get enough cover over a culvert, a ditch needs to be excavated at the culvert outlet. As an alterative, a drainage culvert can also be installed as a 'shallow culvert' so that it is placed at the natural ground elevation rather than below it. For year-round roads, the key to protecting the culvert from being pulled up by the snowplow is to have a gradual enough hump over the culvert. For all roads, having enough fill on top of the culvert and properly compacting the fill is imperative (see culvert installation section see page 56 above).

Benefits of Shallow Culverts:

- Less maintenance. No tail-ditch (deep, long ditch from outlet) to maintain.
- Less problems. No tail-ditch means no standing water to saturate road or breed mosquitoes.
- Less pollution. Outletting drainage quickly on natural ground gives maximum opportunity for infiltration.
- Shallower inlet. A shallower pipe means a shallower inlet that is less likely to plug or need maintenance.
- Potential water bar or broad-based dip. The material imported to cover a shallow culvert can sometimes be used to create a water bar or broad-based dip to prevent water from flowing down the road by forcing it off the road (see page 66).

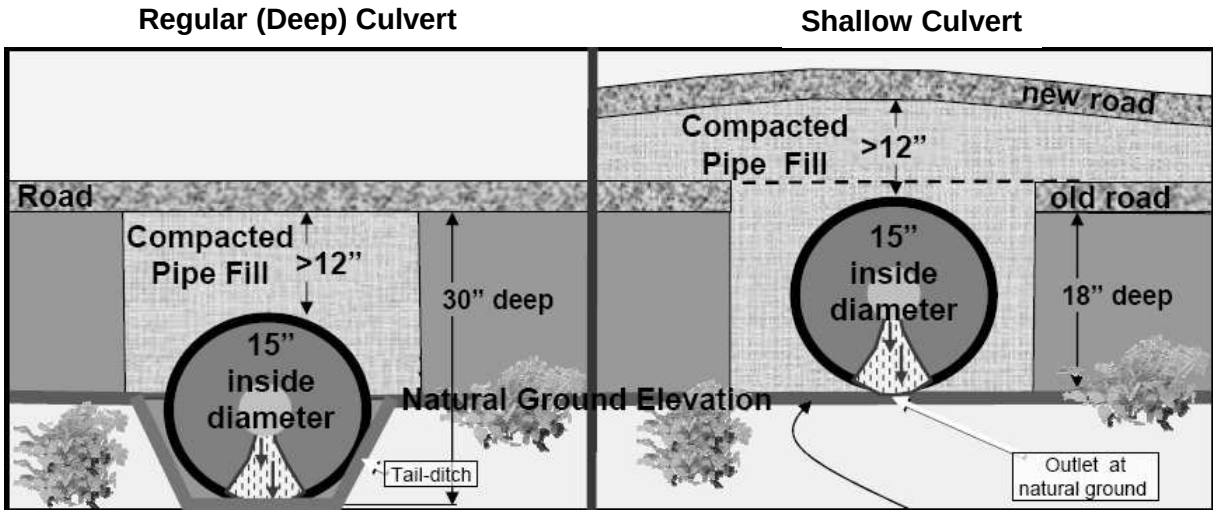


Figure 33. Side View, looking through culvert from outlet, comparing regular and shallow culvert placements.

Installing a Shallow Culvert:

1. Determine proper outlet elevation. Ideally, bottom of pipe outlet should rest on natural ground. Shallow culvert elevation should be determined by the elevation of the existing ground at the culvert outlet, not the elevation of the road surface.
2. Dig pipe trench. Pipe trench should be excavated based on outlet elevation. Ideally, pipe inlet should be placed in existing ditch line. Insure minimum ¼ inch per foot fall across trench. Also, you should have 18" of storage area from the bottom of the ditch to the top of the bank.
3. Install pipe. Use guidelines in culvert installation section (see page 56) above.
4. Cover culvert. Shallow culvert installations typically require 30 to 60 tons of fill to obtain necessary pipe cover. Proper compaction is critical to avoid settling and pipe

strain. Pipes should be covered with a minimum of 12 inches of compacted material (not including surface aggregate) before allowing traffic on the road. The fill should be tapered into the exiting road elevation on either side of the culvert. The amount of till needed and length of fill taper will depend on site conditions such as road slope and culvert depth. Transitions should be sufficiently long to accommodate expected traffic. In some cases, a water bar or broad-based dip can be created with fill that forces water off the road and into the ditches and culvert.

Emergency Spillway

If a culvert commonly overflows, the runoff that drains to the culvert can be reduced through turnouts (see page 49) or should be replaced with a larger, appropriately sized culvert (see page 54). If these options are not realistic given lack of spacing or funds available, and if the culvert only overflows infrequently, an emergency spillway can be installed. An emergency spillway allows for infrequent overtopping to pass over the road without causing any damage to the road or sedimentation downstream.

To install an emergency spillway, excavate the soil over the culvert and then place a layer of filter fabric on the culvert and soil beside it. Then place clean 3" – 6" rock on the filter fabric in a slight "U" shape, creating an elongated dip in the road. The shape should be moderate enough that it will allow vehicles to travel over it without bottoming out, but enough of a "U" that any overtopping water will stay in the rocked area. The filter fabric layer keeps the soil from below from moving up into the rock. The rock layer should extend down to the stream channel (on both sides of the road) so that no erosion or sedimentation occurs.

Culvert Outlet Protection

Stabilizing the culvert outlet is important to prevent erosion. This can be accomplished by installing a plunge pool or by simply armoring the area with stone (also called a rock apron). Both methods help slow the force of the water as it flows out of the culvert, and thus prevent scouring. Plunge pools have the added benefit of trapping sediment that may be carried in the water; but the accumulated sediment needs to be cleaned out regularly.

If the culvert is located at a stream crossing, consult the Department of Inland Fisheries and Wildlife to determine the design needed for fish passage. Otherwise, follow the guidance below. Both types of outlet protection should use only hard, angular stones.

Rock Apron

Rock aprons are commonly installed to armor the slope below the culvert outlet end as well as to dissipate and spread flow over gently sloping terrain. The size and placement of riprap

in the apron depends on the diameter of the culvert as well as the expected water flow through it. Construction specifications for 18 and 24 inch diameter culverts are listed in the table below.

Armor with properly sized crushed or quarried stone over a geotextile membrane. Do not use in streams where fish passage is an issue. Avoid installing in deep channels.

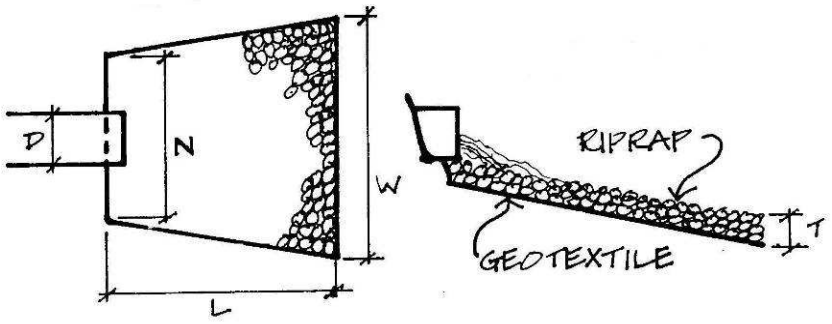


Figure 34. Rock apron dimension diagrams.

Rock Apron Rock Size and Dimensions					
Culvert Diameter (inches)	**Riprap Size** (inches)	**T** (inches)	**N** (feet)	**W*** (feet)	**L** (feet)
18	3 - 6	18	4.5	14.5	10
24	6 - 12	18	6	20	14

*Note: If the culvert flows into a ditch, the apron width should extend across the channel bottom and up the banking to armor to the top of the bank or a foot above the typical flow depth.

Plunge Pools

Plunge pools are used to take the energy out of fast flows at culvert ends in seasonal channel flows; i.e., ditches, drainageways. Do not use in streams since fish passage is an issue

1. For culverts less than 36 inches in diameter, excavate a pool that will be four culvert diameters long by two culvert diameters wide by one culvert diameter deep. For example, the finished plunge pool for an 18-inch culvert would be six feet long, three feet wide, and 18 inches deep. Since these are the finished dimensions of the pool, your initial excavation would need to be about two feet longer, two feet wider, and one foot deeper to make room for the stone lining.

2. Smooth the surface of the excavated pool and remove any protruding rocks and roots. The sides of the plunge pool sloping to the pool's center should be no steeper than 1 Vertical : 2 Horizontal, or a slope that rises one foot for every two feet of level distance.
3. Line the pool with a non-woven geotextile and cover with a 12-inch layer of six to twelve inch stones.
4. Finish by hand, filling voids and gaps to provide an interlocking, uniform surface.
5. Plunge pool outlet must be 6 inches lower than the lowest point of the culvert invert.

Inspect the plunge pool yearly or after severe storms. Reposition stones to restore the pool's original dimensions and uniform surface. Clean any accumulated sediments and debris from the plunge pool once a year or when it is one third filled. Cut or remove any woody vegetation growing in the pool.

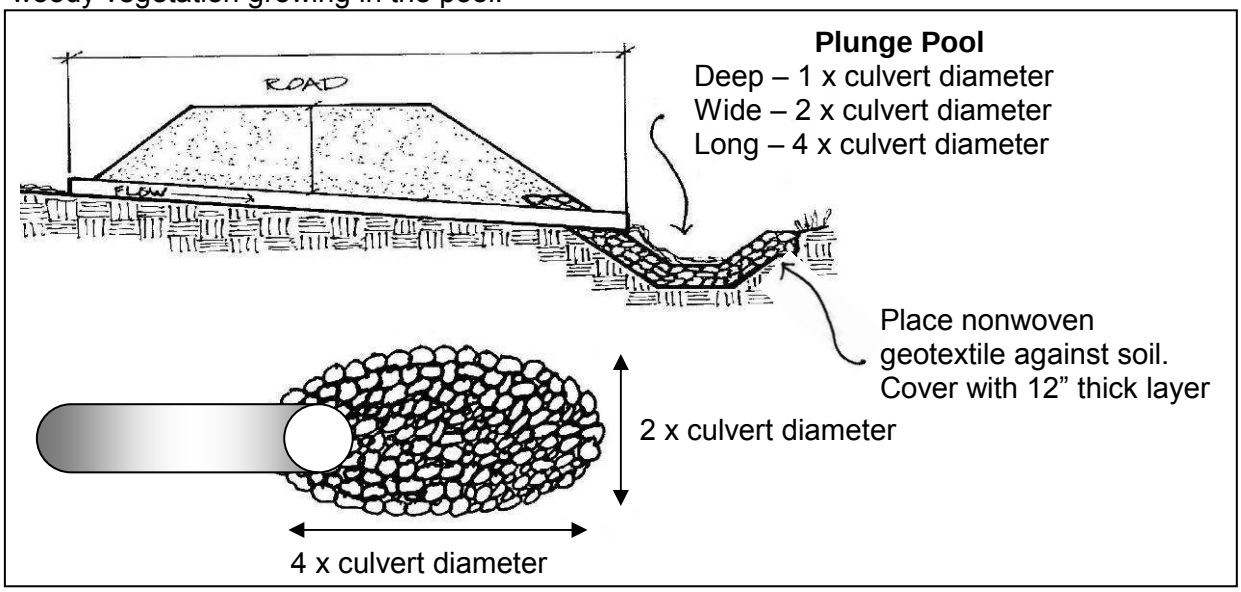


Figure 35. Plunge pool dimension diagrams.

Culvert Alternatives

Not all circumstances require or allow for culverts. Here are a few alternative ways to direct water across a road without causing erosion. These structures require careful thought and sound advice.

Rock Sandwiches

Used in combination with or in lieu of culverts, rock sandwiches, also known as French mattresses, can be used to improve drainage by passing groundwater from one side of the

road to the other, and as a support foundation for the road during mud season. They are also useful in passing wetland water under the road in either direction without altering natural water elevations and riparian character on either side. They should not be used solely for regular surface runoff since winter ice can build-up and cause vehicular safety problems. This is not a concern for groundwater however, since it has latent heat which prevents freezing.

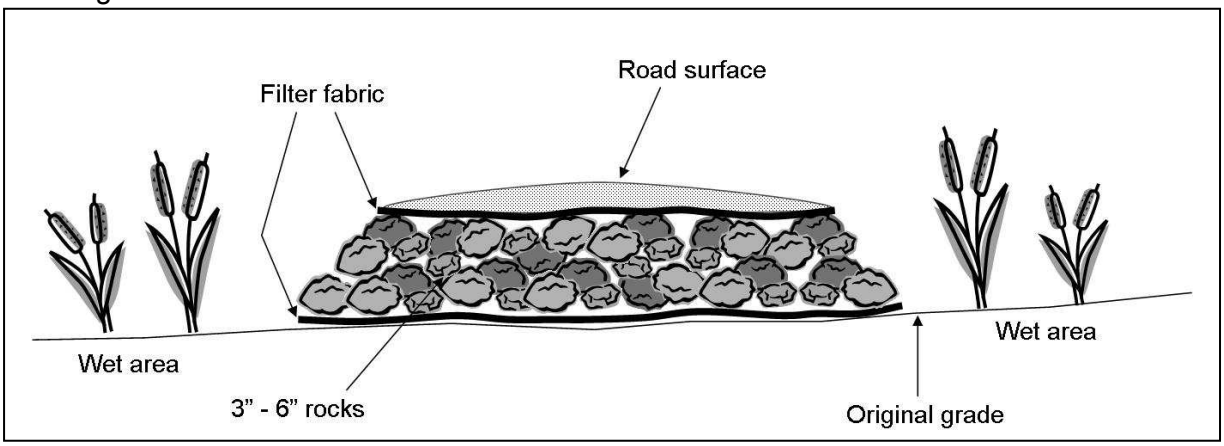


Figure 36. Rock sandwich

A rock sandwich consists of stones "sandwiched" between two layers of filter fabric, allowing water to pass freely through the spaces between the rocks, and therefore from one side of the road to the other.

To construct a rock sandwich:

- ❑ Remove road fill material (to natural ground level) the width of the wetland or seeping road cut. Minimize ground disturbance beyond the removal area and avoid excavating ditches.
- ❑ Place non-woven filter fabric on the full width of the cleared roadway area. If the rock sandwich is crossing a small area, have enough fabric to line the sides and overlap with the top layer. Lining the crossing with the filter fabric creates a barrier between the rock and surrounding soil, thereby preserving the permeability of the rock. If there are multiple sheets of filter fabric, overlap them by at least 1-2 feet.
- ❑ On top of the first filter fabric layer, place at least a foot of large, clean 3" to 6" rock.
- ❑ Place a layer of filter fabric on top of the rock. Then, place the road surface material (and road fill, if desired) to a minimum of 6" depth after compaction.

Rock Cannolis

Rock cannolis are a smaller version of the rock sandwiches except they are cylindrically round and shaped like a length of culvert (cannoli). They consist of 3-6" angular rock

wrapped in filter fabric all the way around, leaving just the inlet and outlet ends open. They can be used in situations like those of a rock sandwich where you want to cross groundwater or wetland water, but since they are smaller, there are often several spaced along the wet area instead of just one large rock sandwich. Follow the above construction guidelines for the rock sandwich, except make it smaller and wrap the filter fabric all the way around the rocks.

Stone Fords

Stone fords are sometimes used on roads with limited use and infrequent traffic. They are stone blanket armoring over a road surface, usually located at the bottom of a long sag grade where stormwater naturally overflows. Stone fords allow water to flow over and through stones placed on the road surface, without significant erosion. Angular stone should be used. Five-inch diameter stones allow vehicles to cross with little difficulty. Larger stones may be used below the surface layer to allow the water to flow more freely, and along both sides to keep the smaller stone in place. During times of high water, the water passes over (and through) the ford, and passing vehicles actual drive through the water. The following figure depicts a ford.

Figure 37. Stone ford crossing over low-lying channel: suitable only on limited use camp roads.

In-Road Surface Water Diversions

While some year-round roads have had success using in-road surface water diversions, others have not. It is not recommended to install surface water diversions (except the broad-based dip) on roads that are plowed unless you mark the location of it annually and the plow driver lifts the plow slightly before going over it. Otherwise, when the ground is still soft in the spring and fall, there is a good chance the surface water diversion will be pulled up or ruined if it is in the path of the plow.

Water Bars and Broad-Based Dips

Water bars and broad-based dips can be used on roads and driveways to divert water off the road surface during a storm. They are most useful on long continuous slopes. A water bar is a ridge (like a speed bump) that runs diagonally across the road, typically at a 30-degree angle. The ridge stops water from running down the road, and diverts it to the side. Place water bars at frequent intervals to prevent significant water flow on the road surface (see table below). For a smoother ride and more durability, the "dip" can be filled with stone.

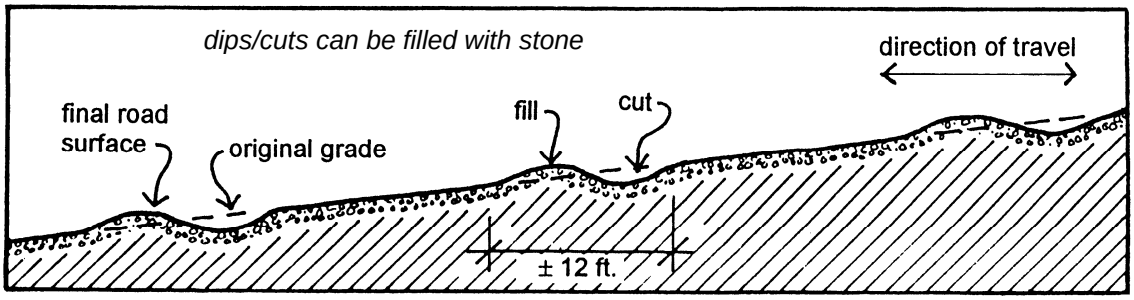


Figure 38. Water Bars

A broad-based dip accomplishes the same result as a water bar by using a shallower depression. These devices can be an economical means of getting water to drain off the road. Water bars are easy to construct, but may be inappropriate for roads with frequent daily traffic. Broad-based dips are more appropriate for use on year-round roads but they can't be used on steep slopes.

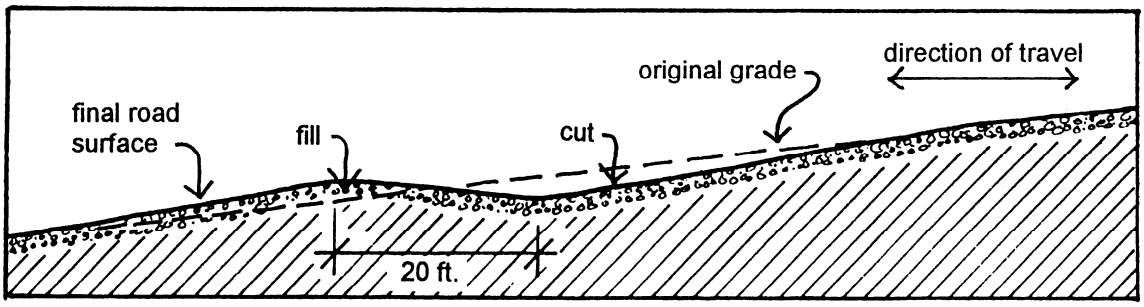


Figure 39. Broad-based Dip

Spacing For Water Bars And Broad-based Dips	
Road/Trail Grade (%)	**Water Bar Spacing (feet)**
2	250
5	135
10	80
15	60
20	45
30	35

Rubber Razor Bars

Rubber razor bars can also be used to divert water off sloping sections of a road and can take the place of a water bar. The rubber bar protrudes above the road surface high enough to intercept and collect water, while allowing traffic to pass over it.

While this device is used generally on seasonal roads or driveways, it can be used on roads that are plowed as long as its location is flagged and the snowplow driver is instructed to lift the plow at the rubber bar location. The rubber for this type of device can be constructed using new or used conveyor belts. These may be obtained at no or low cost from industrial sources or can be found in some hardware stores. Contact your local Soil and Water Conservation District for additional sources. Lumber can be purchased at any local hardware store.

Figures 40 and 41 show the basic construction and placement of a rubber bar. Install the rubber razor at a 30 degree angle to the road edge and point the outlet toward a stable vegetated area. Pack gravel around the rubber razor to make sure it is securely installed. Armor the outlet with a flared grouping of stones to slow down the water before it enters the buffer. To maintain these structures, periodically remove accumulated debris from behind the razor.

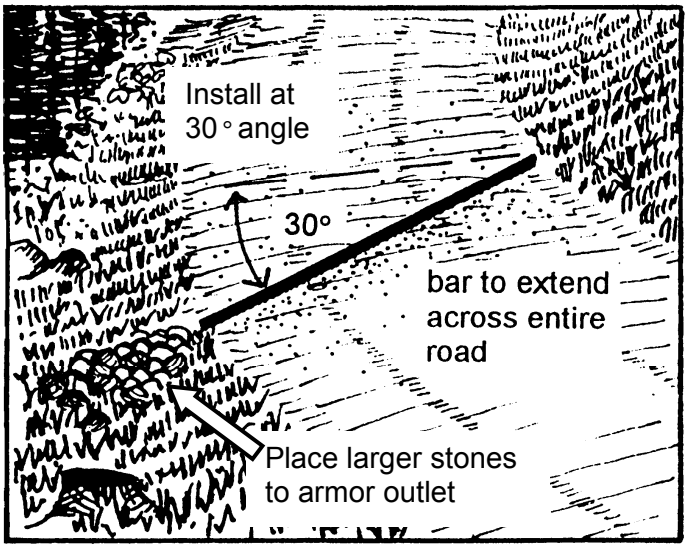


Figure 40. Set Rubber Bar at 30° downslope.

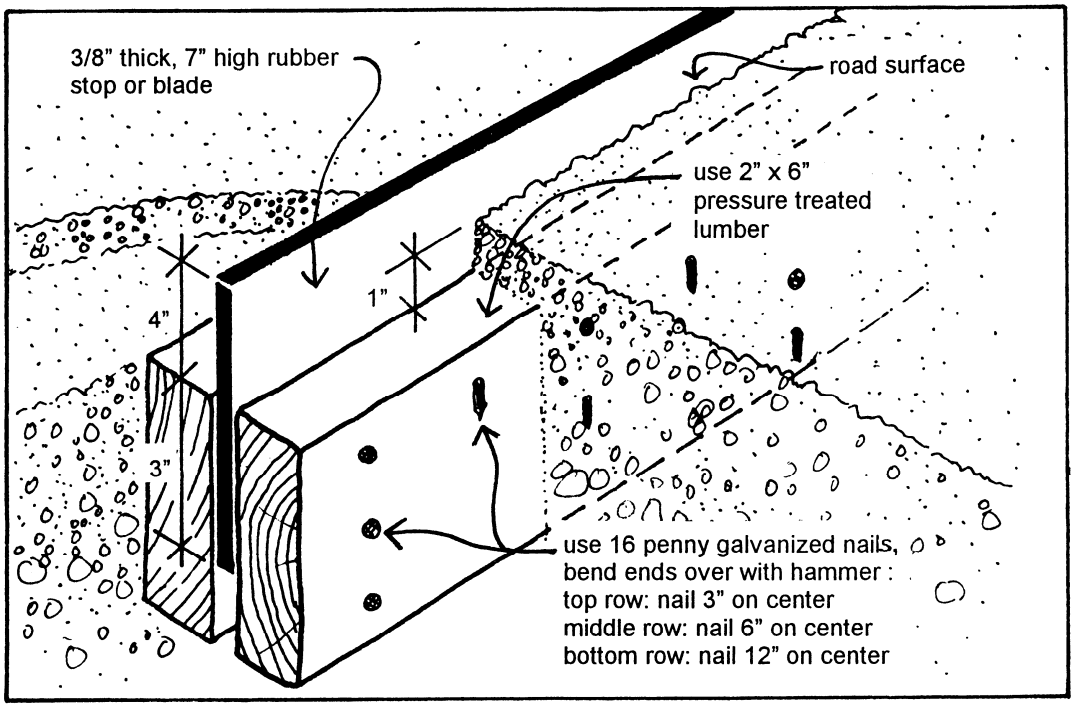


Figure 41. Rubber Bar Construction

Open-top Culverts

Open-top culverts are an alternative often used in logging operations, but can also be used on camp roads. These box-like structures collect and divert road surface runoff away from the road.

Similar to rubber razor bars, open-top culverts are usually used on seasonal roads and driveways that receive little or no winter plowing. They are generally not recommended for camp roads that get plowed in winter since snowplowing can easily destroy this type of culvert and result in even greater erosion problems in the spring. However, some people have had success with open-top culverts if the road is not plowed until the ground is frozen and they have an attentive plow driver. If you choose to plow a road with an open-top culvert, you may want to flag both ends of the culvert to alert the snowplow drivers.

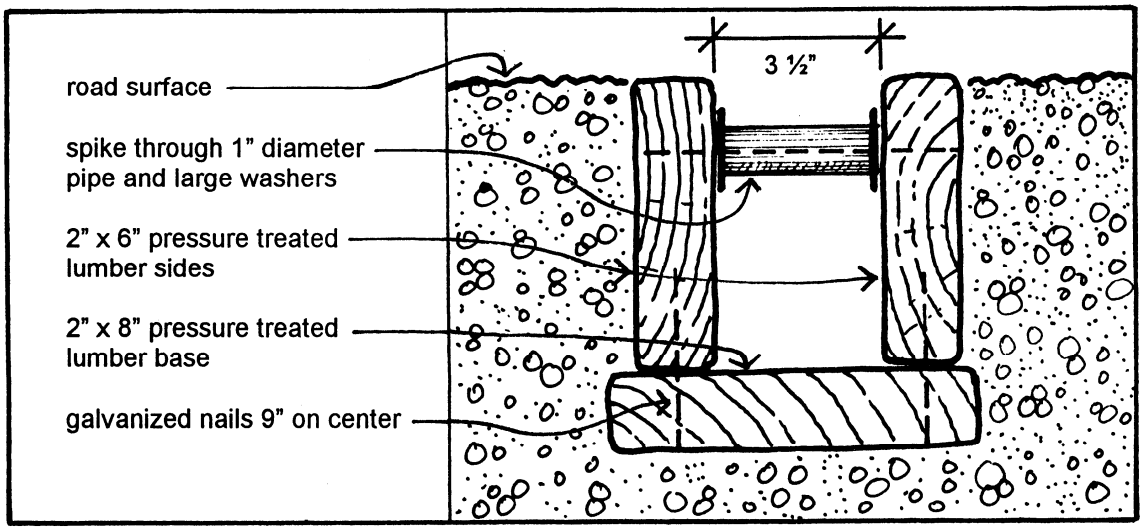


Figure 42. Open Top (Box) Culvert

Open-top culverts can be constructed of logs or from sawn lumber, as shown in the figure. If constructed of slow-decaying wood like cedar or pressure treated lumber (be sure not to use lumber treated with creosote due to its toxicity), they can last for many years. Drain open-top culverts into stable vegetated areas (see Figure 43). Open-top culverts need to be installed at an approximately 30 degree angle down slope. Be sure to take this added length into consideration when purchasing materials.

Install the culvert flush with the surface of the road. If placed too high, stormwater will not enter the structure; if placed too low, it may quickly fill with road material and sediment loosened during installation.

The outlet of the open-top culvert should extend beyond the edge of the road. Remove any plowing berms or other debris that could interfere with water flowing from the outlet. Diverted water should flow into a stable area away from the road or open water to allow for infiltration. A stone-lined outlet or vegetated area is an acceptable way of reducing erosion at the culvert outlet.

Open-top culverts need to be cleaned regularly to remove sediments, gravel, leaves, and twigs. Check after storm events for accumulated sediment. A child's toy hoe fits easily into the culvert and can be used for cleaning. Remember that winter snowplowing can easily destroy this type of culvert and result in even greater erosion problems in the spring.

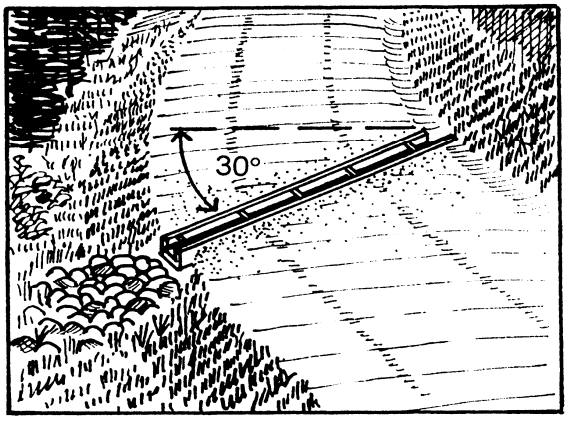


Figure 43. Open-top culvert set 30° downslope.

GETTING THE WORK DONE

LAWS AFFECTING CAMP ROAD OWNERS

If your camp road is in an organized municipality, there are three environmental laws that may apply to its maintenance: the Erosion and Sedimentation Control Law, the Natural Resource Protection Act, and the Mandatory Shoreland Zoning Act (with associated local ordinances). If your camp road is in a township, plantation, or unorganized area, contact the Land Use Regulation Commission for information on the environmental laws that may apply to maintenance of your camp road.

The Erosion and Sedimentation Control Law requires that erosion control devices be installed before any activity begins that will disturb the soil, and that the devices be maintained until the site is permanently stabilized. The law also requires that **existing** areas eroding into a lake, stream, river or wetland be stabilized by July 1, 2010. If the eroding area is in a watershed of a water body "most at risk" (contact the Department of Environmental Protection (DEP) or your local Soil & Water Conservation District to find out which water bodies these are), it must have been stabilized by July 1, 2005. This means you must follow erosion control procedures when your camp road maintenance or construction disturbs the soil, and you must ensure that the disturbed area is permanently stabilized.

Do I Need a Permit?

The following laws require a permit to do some kinds of road work so that state and local officials can ensure that our lakes, streams, coastal areas, and wetlands are protected. Read this section, then call the proper agencies to find out if a permit is necessary, and if so, how to obtain one.

The Natural Resources Protection Act (NRPA) regulates activities in, on, over, or within 75 feet of lakes, ponds, rivers, streams, brooks, and wetlands. Regulated activities include filling, disturbing the soil, building permanent structures, removing, or displacing vegetation, dredging, or draining. A permit is required from the DEP before starting any of these activities. Two types of permits are available: a Permit-by-Rule (PBR), and a full permit. A

Permit-by-Rule only requires that you file notice and follow a set of prescribed standards; a full permit involves a formal project review by the DEP. Most camp road-related activities can be done under the Permit-by-Rule program. Replacing existing culverts does not require a permit, provided the culvert is no longer than 75 feet or no more than 25% longer than the original culvert. Replacing existing bridges is also exempt from the permitting process, provided the new bridge has the same dimensions, does not block fish passage, and does not intrude any further into the water body or wetland than the old bridge.

<table>
<tr><th colspan="4">DEP-Related Permits for Certain Camp Road Work Near Water</th></tr>
<tr><th></th><th>In or within 75 feet</th><th>Within 250 feet</th><th>Contact</th></tr>
<tr><td>Lake, Pond, River, Wetland, Tidal area</td><td>Required permits:
• NRPA
• Shoreland zoning</td><td>Required permits:
• Shoreland zoning</td><td rowspan="2">NRPA – DEP

Shoreland zoning – Town Code Enforcement Officer</td></tr>
<tr><td>Stream</td><td>Required permits:
• NRPA
• Shoreland zoning</td><td></td></tr>
</table>

The Mandatory Shoreland Zoning Act (and associated municipal ordinances) regulates development along the immediate shoreline of lakes, rivers, tidal areas, wetlands, and some streams. The law requires towns to zone all areas within 250 feet of these resources with the exception of streams, where the zoned area need only be 75 feet. Each town's ordinance may be different, but the ordinance must be at least as stringent as the state's minimum guidelines. As a camp road owner, you must check with the Town's Code Enforcement Officer to determine if the work you plan for your camp road requires a permit from the town. Generally, maintenance activity on existing roads does not require a permit. However, if you plan to fill, disturb soil material, or widen the road, a permit may be required.

In addition to the above laws, construction of **new** camp roads may require permits under either the **Stormwater Management Law** or the **Site Location of Development Law**. Contact the DEP if your project involves 20,000 square feet or more of road construction.

FORMING A ROAD ASSOCIATION

Managing maintenance on camp roads that serve multiple users can be difficult. Questions about ownership, liability, and maintenance costs can become very complicated and cause hard feelings between neighbors. Forming a road association can be an effective means of avoiding or addressing these problems. By establishing a road association you can:

- ❑ centralize decision-making;
- ❑ open lines of communication among members;
- ❑ legitimize the collection of membership dues;
- ❑ set up an impartial means for managing money;
- ❑ establish legal authority (if necessary); and
- ❑ potentially avoid personal liability.

A Guide to Forming Road Associations contains step-by-step guidance on how to form a road association and implement a successful road maintenance program, as well as electronic templates of legal forms you may need. Download the guide and forms at www.maine.gov/dep/land/watershed/roadassociation.htm or contact your local Soil and Water Conservation District or DEP Watershed Management to obtain a copy.

PROPERTY BOUNDARIES AND EASEMENTS

Whenever you are assessing what road work is needed where, the location of property boundaries, right-of-ways, and drainage easements need to be considered. If there are concerns among landowners as to where these lines are located and proposed road work, a lawyer should be contacted.

When there are restrictions as to the width and location of the road and its drainage and slopes, these need to be considered when planning for road work. See Figure 44 for an example of how these boundaries can overlap with planned work.

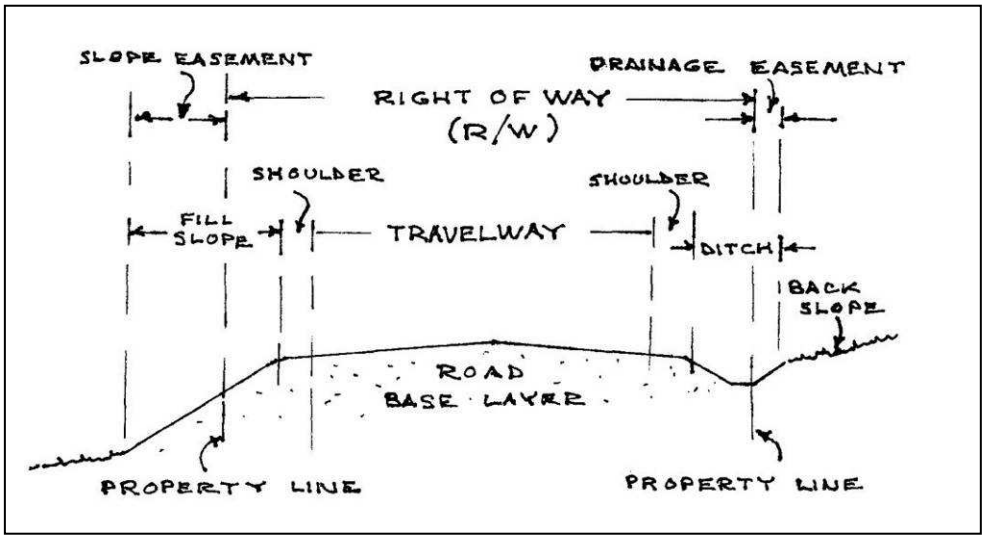


Figure 44. Sample road profile of space needs vs. design minimums.

Any possible alteration or drainage impacts on land of others should be carefully considered. Be sure to get permission from landowners who may be affected by any change in drainage patterns, now or in the future. For example, more development, over time, along the road may require enlarging an existing culvert of adding another nearby. This could progressively over time cause washouts and flood damage on downhill properties. Also, wells could gradually become polluted and septic systems saturated and failing. These kinds of damages are very divisive and litigious among individuals. It is recommended, at a minimum, that all landowners along the road corridor be notified of the work in advance of construction, asking for comments.

HIRING A CONTRACTOR

Contact local contractors and ask to see other gravel roads which they have worked on. This will give you a good idea of what you can expect for your project and whether the contractor uses proper road maintenance techniques. Use the 'Contractor Maintenance Checklist' (see page 91) to help evaluate the contractor's work and consider hiring a DEP certified contractor (see page 76).

Getting a Good Quote

It is a good idea to request quotes from competent contractors in advance of work for both budget planning and immediate needs.

Tips for Requesting Estimates:

- ❑ Request estimates from more than one contractor. Remember, a good, certified contractor may charge more, but a job well done is worth the price in the long run.
- ❑ Provide contractors with a detailed description of the work you want done and request itemized estimates in return. The quotation request presented to a contractor should be conceptual, clear and brief. State what is to be done, where it is to be done, and when it will be done. The more exact it can be, the more likely you will be able to compare quotes and to get what you want.
- ❑ Ask for a "not to exceed quote" to ensure that the job stays within your budget.
- ❑ Ditch by the day. If your road needs to be ditched, plan on at least a day's worth of ditching at a time because of equipment transportation costs. It is easy for a contractor to quote you for a day's worth of ditching. You will still want to prioritize which sections of road you will want to ditch first.
- ❑ Plan ahead! Available contractors can be very hard to find as the construction season approaches.

Sample Estimate Request:

"300 linear feet of light, round bottom ditching on easterly side of Blue Jay Lane, 2 feet deep and 3 feet wide as staked by the owner. Rolled, 3 feet wide, erosion control blankets (with plastic enveloped mesh on both sides) to be laid and pinned over seeded bare ground in the ditch invert. All other bare ground work shall be seeded and hay mulched at the end of each work day. Work to commence on 6/15/10 and be completed by 6/30/10. Payment in full shall be made lump sum in full upon acceptable completion of work."

If a contractor offers another proposal, allow it to be considered along with the solicited one. Experienced contractors may have equal or superior alternatives and may have other suggestions to save money and make a better road.

If in doubt about the quality of material being proposed for the intended purpose, ask the contractor to submit a sample. To avoid confusion among soil samples for base and surface materials, contact your local SWCD or soil scientist for help.

DEP Certified Contractors

Consider hiring a "certified contractor." The Maine Department of Environmental Protection has developed an incentive program to recognize competent contractors who make an ongoing effort to learn about erosion control practices. This program, called the Voluntary Contractor Certification Program, provides contractors with training in environmental laws and erosion control practices that relate to working near sensitive natural resources. A certified contractor is not necessarily more qualified to work on private roads, but does have more training in erosion control measures and understands the relationship between eroded soil and lake water quality; thus requiring little or no supervision with these skills to do the work. See DEP's Nonpoint Source Training and Resource Center website at www.maine.gov/dep/land/training/index.html or call Bill Laflamme at 215-9237 for a list of certified contractors.

PLANNING AND BUDGETING

Planning and budgeting is another important aspect of camp road maintenance, but it is often overlooked. Frequently, planning is done only after the road has washed out. Planning should be proactive. Proper planning can prevent recurring problems and save money over the long term. Proper budgeting can help ensure that money is available to perform necessary maintenance and repair work when it is needed – before small problems turn into large, expensive ones. While there are often not enough funds to do major projects in their entirety, putting together a phased plan is great way to get started on doing what you can. Spending even a little, as long as it is in the right direction, can make a significant difference.

$1 spent in regular maintenance is estimated to save **$15** in capital repairs.

Long-term planning helps avoid or spread out the cost of more expensive repair items over time:

Culverts may seem costly (example: $660) when viewed from any given year, but not nearly as costly when they are paid for over the culvert's 25-year life span (example: $26 per year).

Develop a Maintenance Plan and Budget

Your maintenance plan should establish a schedule for surveying the road, grading and ditching, cleaning out structures such as culverts and detention basins, and for replacing culverts. The maintenance plan (and budget) should also include some provision for addressing unforeseen problems in a timely manner.

It is a good idea to earmark some funds for capital improvement work on a yearly basis. A general rule is that it costs 60 to 90 cents per foot of road for yearly maintenance (using estimates from 2009). Using the higher figure may provide contingency funds for major improvements or natural disasters.

Steps to Develop a Maintenance Plan and Budget:

1. **Inventory the roads.** Determine the size and geographic extent of the road network as best you can.
2. **Assess the condition of the roads.** Each year, assess the condition of your road using this manual and the *Camp Road Evaluation Score Sheet* (see page 82). Maintain a continuing record of the assessed condition of each road or road segment so that changes in condition can be noted easily and quickly.
3. **Determine specific road repairs.** Consult with your local Soil and Water Conservation District and/or contractor to select the most appropriate treatment to repair the road and get bids or estimates for the needed work (see page 74).
4. **Determine overall costs.** Add up the costs of each repair job to get a total estimate. When road surface problems are extensive, it is often necessary to select priorities and phase the project over a number of years.
5. **Establish priorities.** Determine criteria to use for selecting priorities and clearly state them in the maintenance plan. Assessment criteria could include the potential of the problem site to impact water quality, safety concerns, property value concerns, and nuisance factors, etc. You should plan to keep good roads in good shape (preventive maintenance) and establish a separate budget (or request a temporary increase) to reconstruct roads in poor condition. The maintenance plan should consist of the established priorities and a timeline, including any recommendations for phasing and their target dates.
6. **Create inspection schedule and checklist.** Using the *Inspection and Maintenance Schedule* (see page 89) as a guide, create one for your road and incorporate it into your maintenance plan.
7. **Establish a yearly budget and itemize costs.** This will make membership dues easier for others to understand, and possibly make funds easier to collect and distribute.
8. **Keep track of road work.** Be sure to keep track of what work has been done on the road where and when. This 'journal of work', or 'straight line map' (see page 78) of

what has been done and what is planned is very helpful when it comes time to do more work on the road and during maintenance planning. One way to keep track of it is to use a town tax map as a base and then mark what has been done where and when.

Record Road Work on Map or Plan

A site map or plan of the road, with appurtenant features, is an important messenger of information. It can:

- ❑ illustrate maintenance history
- ❑ pull together relevant factors that influence design and construction
- ❑ serve as a way to record location inventories of culverts and related drainage activities
- ❑ be used as a long-range budget planning tool
- ❑ be a way to note storm-related damage sites

If subdivision plans are unavailable, simple plans can be developed from town tax maps or computer generated Google maps. However, one of the easiest ways to create a simple plan is to make a "straight line map" (see figures 45 and 46 for examples).

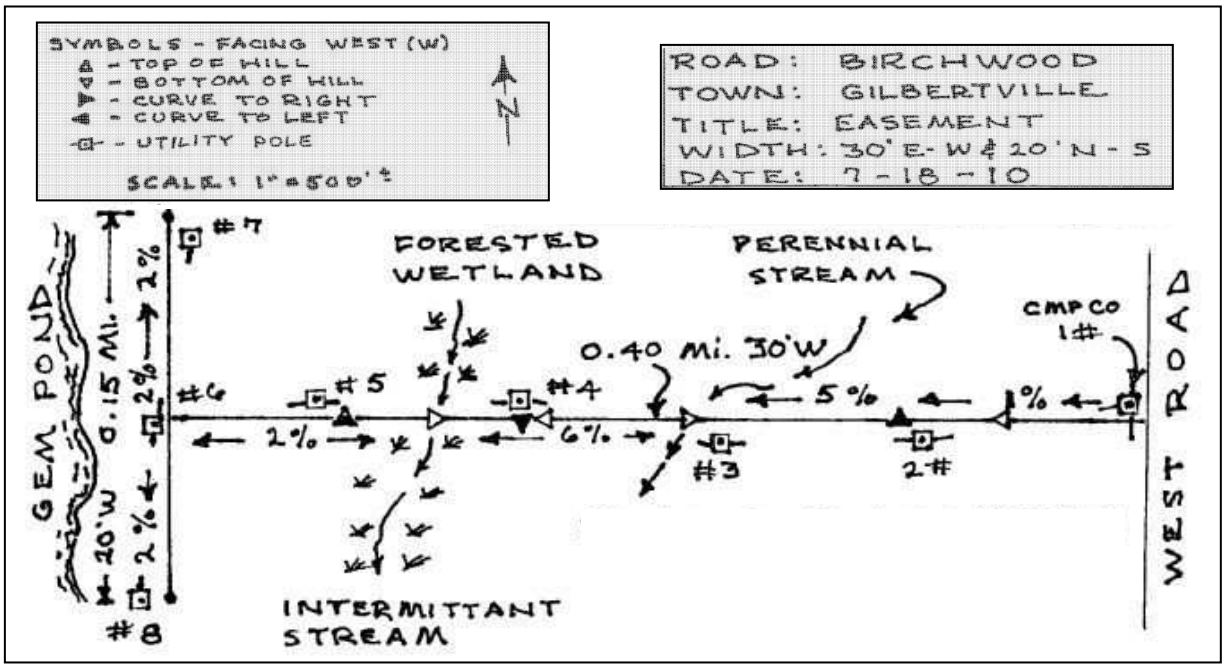


Figure 45. Sample straight line map: Inventory of existing natural features, road alignment, and utility pole locations.

How to Make and Use a Straight Line Map:

1. Draw a straight line across the mid-section of a sheet of 8½ " x 11" paper to represent the road (don't worry about not showing wiggly road curves).
2. Plot on this line existing reference points such as utility poles, culverts, tops of hills, streams, and road bends or curves. This becomes part of your base plan.
3. Make copies of this base plan and add other things that occur or are planned. Including the year culverts are installed, turnouts are created, a section of road is washed out, etc., is very helpful as a record-keeping activity and to help plan for future work.
4. Keep all the plans together and protected from the elements when you bring them outside. One way to do this is to place each original copy in a transparent plastic sheet and store them all in a 3-ring binder notebook.
5. Make plenty of spare copies for handouts. NEVER give out your only copy!

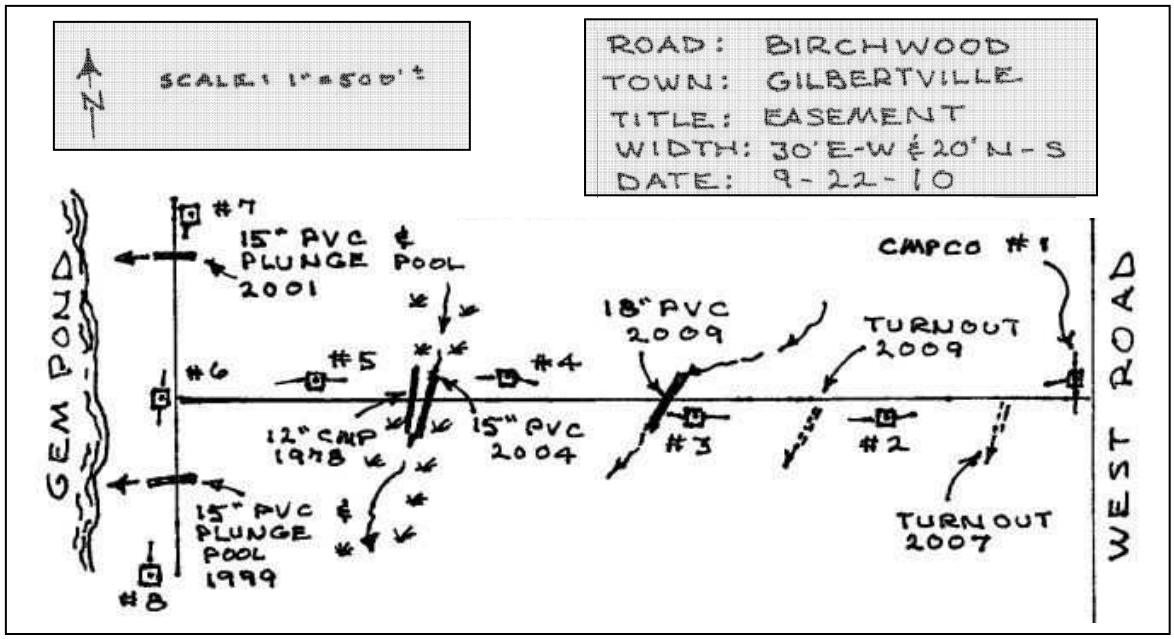


Figure 46. Sample straight line map: Culvert and ditch turnout inventory.

Sample Budget Calculations

Example costs are 2009 estimates. Prices can fluctuate widely and often, and you must get current prices for your area and work needed.

Culverts

(number of culverts x cost) ÷ expected lifespan of culvert = annual cost (See the table on page 53 for the expected lifespan of different types of culverts.)

Metal culverts typically last 25 years. Begin systematically replacing the damaged ones as funds accumulate.

Example: 6 metal (18") culverts x $660 ÷ 25 years = $160/year

Surfacing

Surface loss from dust, use, and snowplowing:

Note: 0.015 yards represents an average loss of ¼ inch of road surface per year due to use. If you think you are losing ½ inch of surface material per year, double the figure to 0.03.

(road length) x (number of yards of gravel lost per year, per foot of road length) x (cost per yard of gravel) = annual cost

Example: 2,000 ft. x 0.015 yd x $17/yd delivered = $510/year

Grading

Have a contractor give you a dollar estimate or an estimate of the number of hours to do the job.

(# of hours estimated by contractor to grade road) x (cost/hr.) = annual cost

Example: 2 hours to regrade 2,000 ft. (without fill) x $80/hr. = $160/year

Ditch Maintenance

(time estimated by contractor to clean out ditches) x (cost/time) ÷ (how often needs to be done) = annual cost

Example: (1 day x $1,000/day) ÷ 5 years = $200/year

Capital Improvements (Wish List)

(estimated cost of improvements today) x 1.04 ÷ # of years to reach goal = annual cost

Example: Rebuild 100 feet of properly drained road in the next 2 years.
(100 ft. of road x $12/ft.) x 1.04 ÷ 2 years = $624/year

Erosion Control and Miscellaneous

(culverts + surfacing + grading + ditches + capital improvements) x 0.1 = annual cost

Example: ($160 + $510 + $160 + $200 + $624) = $1654 x 0.1 = $165/year

Total Annual Cost to Maintain the Road

culverts + surfacing + grading + ditch maintenance + capital improvements + erosion control and miscellaneous = total annual cost

Example: $160 + $510 + $160 + $200 + $624 + $165 = $1819/year

Cost per Road User or Association Member

total annual cost to maintain the road ÷ the number of road users

Example: If there are 15 users:
$1819 ÷15 = $121/user/year

To help with general planning, here are a few more estimates from 2009:

Asphalt paving: $5 per square foot, not including road base preparation
Conveyor belt: $5 - $7 per foot
Frontrunner: $10 - $100 per day, depending on the District and the length of rental
Hand compactor: $60 per day
Reclaim: $16 - $18 per yard, with delivery charges of $50 - $65 per hour
Vibratory roller: $150 - $200 per day
Woven and non-woven geotextile: $1 per square yard
Completely reconstructing or building a new road: $12 per linear foot for 14 foot wide access road

CHECKLISTS

CAMP ROAD EVALUATION SCORE SHEET

The purpose of the following score sheet is to help you to evaluate your road conditions, and to decide where your road maintenance and repair money is best spent. The score sheet is available for download and printing on the website at: www.maine.gov/dep/land/watershed/camp/road/eval_gravel_rds_score_sheet.pdf

Score Sheet Evaluating Gravel Roads For Drivability, Stability And Maintenance of Water Quality

Road Name or Fire Lane Number: _____

Municipality: _____

Book and Page number of deed for road: Book: _____ Page: _____

Road is seasonal _____ Road is year round_____
If year round, is it plowed in the winter? _____

Are winter and/or "mud season" use prohibited by owners or the Road Association? _____

Right of way width if known: _____

Approximate Road Length: _____

Number of culvert crossings: _____

What Lake Watershed is the road located in: _____

Is the road in the Shoreland Zone? _____
If yes, be sure to follow Shoreland Zoning and NRPA regulations
(Refer to page 71 of the Gravel Road Maintenance Manual for more information)

Is there an active Road Association for the road? _____
If yes, Contact Person: _____
Telephone number: _____

Name of Evaluator: _____

Date of Evaluation: _____

Weather conditions: _____

The procedure developed to evaluate roads includes the following 7 steps:

NOTE: It is strongly recommended that a road be evaluated during a rain event (especially if soils contain a lot of silts and clays) so that you can observe the quality of the runoff and where it is discharged in addition to water flow on the road surface in culverts and in ditches.

1) Walk or drive entire length of road to determine location of culverts, ditch turnouts and steep slopes. Locate any potential erosion sites, seepage from road cut banks or ditch slopes and any ponded water in back of upslope side of road. Also locate discharge points for culverts and ditches along lakes or streams. Note length and width of road.

2) Evaluate using Section 1 and 2, establish a sample station at every other telephone or power pole on the road. If few or no poles are present, establish sample stations at approximately 10%, 20%, 40%, 60%, and 80% of road length. Use the small boxes on the score sheet to record ratings at each station.

3) When evaluating for Section 1, at each sample station, measure crown, and evaluate the road surface within 25 feet of either side of the pole or sample location. For Section 2, rate shoulders and ditches in these areas.

4) Evaluate using Section 3, locate each culvert crossing and rate each culvert. Note if there are locations that culverts need to be installed. Use the small boxes on the score sheet to record ratings at each culvert location.

5) Average ratings for each criterion and assign score. (Round up to the highest score if .5 or greater)

6) Add all scores and come up with the final score for each section evaluated. Each section's score must meet or exceed score indicated "to qualify" to meet standards for that section.

7) If a section or sections do not meet or exceed the score indicated "to qualify", use the lowest scores for the criteria to develop a repair plan for the road component (surface/base; ditches/shoulders; culverts/bridges). Obtain quotes for the repair work from local contractors and develop a timeline for completing the work.

Section 1. Road Base and Surface Areas

					SCORE	
					Stations	Average
1. Road constructed above original ground level to facilitate drainage/structural integrity of road base materials.	0 None	1 Some	2 Most	3 All		
2. Gravel road surface is at least 4 to 6 inches, is compacted, and is composed of a firmly packed aggregate. ***(Refer to page 21 of the Gravel Road Maintenance Manual for road material information)***	0 None	1 Some	2 Most	3 All		
3. Gravel road surface provides good traction and is not highly erodible and dusty (too many fines).	0 None	1 Some	2 Most	3 All		
4. Level or low slope road surfaces are crowned to shed water at ½ inch of rise per foot of road width, or contain alternative drainage structures, such as waterbars, or are otherwise designed to direct stormwater as sheet flow off of the road surface (insloped /outsloped). ***(Refer to page 30 of the Gravel Road Maintenance Manual for information on road crowning)***	0 None	1 Some	2 Most	3 All		
5. Steep sloped road surfaces are crowned to shed water at ¾ inch of rise per foot of road width, or contain alternative drainage structures or are otherwise designed to direct stormwater as sheet flow off of the road surface or are paved. ***(Refer to page 30 of the Gravel Road Maintenance Manual for information on road crowning)***	0 None	1 Some	2 Most	3 All or N/A		
6. Stormwater flow from the road surface is directed to stable ditches, a vegetated buffer or stable vegetated areas (that are not wetlands) of at least 50 feet in width between the road and a waterbody.	0 None	1 Some	2 Most	3 All		

7. Dust from the road surface is effectively controlled using materials to keep road surface intact.	0 Never	1 Controlled only in response to complaints	2 Occasionally	3 Regularly			
Total Available Points = 21	**14 to qualify** **If score is 14 or better, road base and surface meets these standards, and other than regular maintenance, no significant repair is currently needed.**				**Total = _____**		

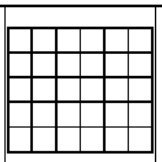
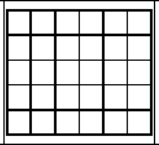
Section 2. Road Shoulders and Ditches

					SCORE	
					Stations	Average
1. Road shoulders are stabilized with vegetation or have a firmly packed gravel surface.	0 None	1 Some	2 Most	3 All		
2. Road shoulders are sloped to promote surface drainage away from the road and into adjacent ditches or buffer areas. A "false ditch" or berm of road material is not present which might prevent runoff from draining off the road surface.	0 None	1 Some	2 Most	3 All		
3. Ditches are stabilized with vegetation and/or rock riprap that is shaded with vegetation, and have no signs of excessive erosion.	0 None	1 Some	2 Most	3 All		
4. Ditches are U shaped (versus V-shaped) with side slopes less than 2 to 1 (50% slope) that are properly sized. ***(Refer to page 39 of the Gravel RoadMaintenance Manual for information on ditches)***	0 None	1 Some	2 Most	3 All		
5. Ditches do not discharge directly into the lake or tributary streams but discharge from a stable outlet into a vegetated buffer (that is not a wetland) of at least 50 feet in width between the outlet and receiving waterbody.	0 None	1 Some	2 Most	3 All		

6. Ditches have appropriately located and spaced turnouts that direct water into stable vegetated buffer areas (that are not wetlands) of at least 50 feet in width between the turnout outlet and any waterbody.	0 None	1 Some	2 Most	3 All
Total Available Points = 18	**12 to qualify** **If score is 12 or better, road shoulders and ditches meet these standards, and other than regular maintenance, no significant repair is currently needed.**			**Total = _____**

Section 3. Culverts and Bridges

					SCORE	
					Stations	Average
1. Culverts are large enough to accommodate flow, properly installed, and covered with at least one foot of fill or half the culvert diameter (if over 24 inches). ***(Refer to page 52 of the Gravel Road Maintenance Manual for information on culverts)***	0 None	1 Some	2 Most	3 All or N/A		
2. Culvert inlets are stable with properly installed rock riprap or vegetation.	0 None	1 Some	2 Most	3 All or N/A		
3. Culvert outlets are stable with properly installed rock riprap or vegetation.	0 None	1 Some	2 Most	3 All or N/A		
4. Culvert bore shows no signs of crushing, bowing or obstructions that could impair water flow.	0 None	1 Some	2 Most	3 All or N/A		
5. Appropriate number of culverts installed and located to accommodate flow and there is no sign of road topping, and/or erosion occurring.	0 None installed but needed	1 Some	2 Most	3 All or N/A		

6. Evidence indicates that culverts are working to maximum capacity and are not plugged and in need of cleaning or subject to ice jams in winter.	0 None	1 Some	2 Most	3 All or N/A		
7. Bridge abutments and wing walls are stable with no visible signs of erosion occurring.	0 None	1 Some	2 Most	3 All or N/A		
Total Available Points = 21	**14 to qualify** **If score is 14 or better, culverts and bridges meet these standards, and other than regular maintenance, no significant repair is currently needed.**				**Total = _____**	

INSPECTION AND MAINTENANCE SCHEDULE

Camp road maintenance is an ongoing task. Regularly checking on and repairing any issues found is vital to maintaining a good road. The following schedule can be used as a guide for creating your own inspection and maintenance checklist.

	In the SPRING	In the FALL	After Every MAJOR STORM	Inspection Date & Condition
CULVERTS				
Remove accumulated sediment, leaves, and debris at the inlet, at the outlet, and within the culvert	X	X	X	
Repair any erosion damage at the culvert's inlet and outlet	X	X	X	
DITCHES				
Inspect ditches and swales	X	X	X	
Remove any obstruction and accumulated sediments, leaves, or debris	X	X	X	
Stabilize any erosion	X	X	X	
Mow grass ditches		X		
Remove woody vegetation growing through riprap		X		
Repair any slumping side slopes	X	X	X	
Replace riprap where underlying filter fabric is showing or where stones have dislodged	X	X	X	
ROADWAYS				
Clear accumulated winter sand along the roadway and remove false berms	X			

	In the SPRING	In the FALL	After Every MAJOR STORM	Inspection Date & Condition
Grade and crown/super-elevate the road surface and shoulder *(year round roads should be graded and crowned 4 times per year – spring, 2 times in summer, and fall)*	X X	X X		
Clean out sediment within waterbars and open-top culverts, and behind rubber razor bars	X	X	X	
VEGETATED SLOPES				
Inspect all slopes and embankments	X		X	
Replant bare areas or areas with sparse growth	X		X	
If you find areas with erosion, armor the area or divert erosive flows to areas that can withstand concentrated flows	X		X	
BUFFERS				
Inspect roadside buffers for evidence of erosion, concentrated flows or encroachment	X	X	X	
Mow vegetation in non-wooded buffer no shorter than 6 inches and less than 3 times per year		X		
Repair any sign of erosion	X	X	X	
Inspect and repair down-slope of all spreaders and turnouts for erosion	X	X	X	
Install more level spreaders or ditch turnouts if needed for a better distribution of flow		X		
Clean out any accumulation of sediment within the spreader bay or turnout pool	X	X	X	

CONTRACTOR MAINTENANCE CHECKLIST

Use this checklist as a quick reference when you are hiring contractors to perform maintenance on your camp road. The checklist will help ensure that your money is well spent. See the pages listed for more details about each item.

Road Materials
(See page 21)

- ❑ Base material (needs to be strong and free-draining)
  - ■ Well-graded gravel with the majority of gravel smaller than 3" in size.
  - ■ May have few large stones but no greater than 6".
  - ■ 0 to 7% fines (the less the better for drainage).
  - ■ 12-18 inch recommended thickness when compacted.
- ❑ Surface material (needs to pack hard and firm, and shed water)
  - ■ Well-graded gravel with the majority of gravel smaller than 1/2" in size.
  - ■ Gravel stones no larger than 2 inches (for smooth ride).
  - ■ 7 to 12% fines (for binding and shedding).
  - ■ 4-6 inch recommended thickness when compacted.

Crowning and Grading
(See pages 30 and 28)

- ❑ ½ - to ¾ -inch of crown per foot of total road width (¾-inch necessary on steeper hill sections).
- ❑ No grader berms or other ridges along outer edge of road.

Ditches
(See page 39)

- ❑ Shape should be parabolic or trapezoidal (flat bottomed), not V-shaped.
- ❑ Side slopes no steeper than 50% (2:1) for stability.
- ❑ Sized such that water is never less than 1 foot from road surface.
- ❑ Surface stabilized to prevent erosion (typically with vegetation or riprap).

Turnouts and Level Spreaders
(See page 49)

- ❑ Disperse water as sheet flow into an area capable of handling the flow without eroding (forested buffers preferred).
- ❑ Do not discharge directly to lake or stream.

Culverts and Cross Drainage
(See page 52)

- ❑ Sized appropriately, based on the amount of upstream drainage area (minimum of 18-inch diameter).
- ❑ Minimum of 1 foot of soil cover over culvert (cover should equal ½ the diameter for culverts larger than 2 feet in diameter).
- ❑ Good compaction of fill material. Should be compacted in lifts (layers) no greater than 9 inches.
- ❑ Stone lined plunge pool or rock apron at outlet (see page 59) to protect against erosion.
- ❑ Culvert pitch of 2%.

Erosion Control
(See page 42)

- ❑ Discharge water as sheet flow to a well vegetated area (buffer) (see page 17).
- ❑ Minimize areas of exposed soil on side slopes and ditches (see page 44).
- ❑ Stabilize exposed areas with vegetation or other protection (i.e., mulch, blankets, or riprap) (see pages 42 through 47).
- ❑ Apply fertilizer and lime based on a soil test. Do not over fertilize (see page 44).
- ❑ Maintain and monitor areas until they have been permanently stabilized.

GLOSSARY

Anti-Seep Collar: Geotextile or non-permeable material placed around a culvert inlet to keep water from seeping alongside the culvert.

Armoring: Stabilizing an area with stone rip-rap.

Broad-Based Dip: A broad, shallow ridge that runs diagonally across the road, stopping water from running down the travelway by diverting it over the side of the road.

Brown Pack: See Recycled Pavement / Reclaim.

Buffer: An area of undisturbed trees, shrubs, and other vegetation located between a developed area (such as a dwelling or camp road) and a lake, stream, wetland, or coastal water.

Calcium Chloride: A commercial chemical product used to control dust and stabilize the travelway surface of gravel roads.

Check Dam: Stone dam constructed in an accessible ditch to slow down the velocity of water in the ditch, reducing ditch erosion and forcing larger sediment particles to settle out behind the dam.

Crown: Creating a high point that runs lengthwise along the center of the road so that either side of this high point is sloped gently away from the center toward the outer edge of the road.

Culvert: A plastic, metal, or concrete pipe used to convey water from one side of a road to the other.

Culvert Inlet: The end of the culvert that water flows into to go under the road.

Culvert Outlet: The end of the culvert that water flows out of after going under the road.

Ditch: A “U”-shaped, narrow, stabilized excavation channel alongside the road that collects and carries water downhill.

Drainage Easement: A legal right for others to use someone else’s land to allow (road) drainage flow and to construct and maintain appropriate drainage devices in perpetuity.

Easement Road Title: A legal right for others to use someone else’s land for a road in perpetuity.

Erosion Control Blanket/Mat: A manufactured combination of mulch fibers and netting that is installed over seeded areas to slow down water flow, protect soil underneath from erosion, and promote vegetative growth.

Erosion Control Mix/Mulch: A heavy mulch made of stump grindings, washed sand, gravel, stone, and unprocessed wood fragments; these components in a mixture lock together to protect the underlying soil from erosion and restore an organic soil cover as it decomposes; an excellent erosion control tool for winter work; available in a variety of textures and spread in different layer thickness for performance needs.

Fee Road Title: Legal use and ownership of the land under the road in perpetuity.

Filter Fabric: See Geotextile.

Fines: Very fine sand, silt and clay particles too small for the eye to see; they hold lots of water which causes roads to heave during mud season, keeping them in a semi-liquid state under camp roads for 3 to 4 weeks; however, when mixed properly with sand and gravel they bind and pack well for use as a surface layer on the road travelway and this surface compactness helps shed water off the top of the road.

Frontrunner: A piece of grading equipment consisting of a row of strong metal tines that is mounted on a snow plow ram attached to the front of a pickup truck or tractor; it is very versatile and an inexpensive way to grade and shape road surfaces during spring, summer, and fall; the front mounted feature enables it to dig out potholes and surface ripples; like most graders it should not be used to move large stones and tree roots.

Geotextile: (aka filter fabric) An industrial fabric developed for silt fence barriers and below ground drainage separation; made from a variety of synthetic materials (polyethylene, polypropylene, and nylon); there are 2 types, woven and non-woven, both of which allow water to pass through but reduce many fine soil particles from moving into the road base gravels and out through stone wall and riprap joints, thus protecting the drainage of road bases and the stability of structural stone work.

Grader Berms: (similar to plow berms) An earth berm, or long small pile of sediment or surface material, on the edge of the road resulting from incomplete grading or snow plowing; they cause surface water runoff to get stuck or stranded on the travelway rather than draining off to the side slopes and ditches.

Grading: Spreading and shaping road base layers using a dozer, blade grader, or tine rake.

Grantee: A person or persons who receive real estate interests (fee or easement titles) from a grantor.

Grantor: A landowner who conveys real estate interests (fee or easement titles) to a grantee.

Gravel: Road material (mixture of sand and stones with very few fines) that is readily distinguishable to the naked eye, very durable, and drains freely.

Ground Water: (aka subsurface water) Water that flows and is stored below the soil surface.

Gully Erosion: Erosion that occurs when surface water runoff concentrates and then cuts into the soil's surface; erosion that is large enough to step into.

Invert: The bottom portion of a culvert or constructed ditch.

Level Spreaders: (aka level-lip spreaders) A natural or constructed rise above the ground which evenly disperses or spreads water from a ditch turnout (or other concentrated flow) thinly over a wide enough area so that erosion of the surrounding area does not happen; commonly constructed with stone.

Open-top Culvert: An invert or box-like structure that is placed into and across the road surface to collect and divert water runoff away from the road travelway.

Plow Berms: (similar to grader berms) An earth berm, or long pile, of sediment or road surface material on the edge of the road resulting from winter snowplowing; causes surface water runoff to be blocked on the road rather than draining off to the sides or into the ditches.

Plunge Pool: Rock-lined oval bowl that helps slow the force of the water as it flows out of the culvert, thus preventing scouring and trapping sediment.

Recycled Pavement / Reclaim: (aka Brown Pack) Old pavement that has been ground up and combined with fines to allow it to bind together.

Right of Way: (aka R/W) Legal width of the road between abutting property lines on each side.

Rill Erosion: Surface water runoff that concentrates in small grooves and then cuts into the soil's surface. If left unrepaired, rills will develop into gullies.

Rip-Rap: Large angular stone of varying sizes; used to armor and stabilize steep terrain, flood prone areas, riparian sites, concentrated channel/ditch flows and structures.

Road Association: A formal organization of road users that oversees road maintenance and the collection of fees for relevant road work.

Road Base: Constructed layer under the road which sits on top of the natural ground (or subgrade) and beneath the road surface layer; it needs to be sturdy and drain freely.

Road Shoulder: The area between the travelway edge and top of the ditch or fill slope.

Road Surface: A constructed layer of the road travelway which sits on top of the road base; needs to pack well, be granular, and shed water.

Rock Apron: (aka rip-rap apron) A rock-lined, widened area that armors, spreads the flow, and helps slow the force of the water as it runs out of the culvert, thus preventing erosive scouring.

Rock Cannolis: A below-ground stone drain used under roads to slowly move water from one side to the other; they function like rock sandwiches but are cylindrically round and culvert-like in shape (cannoli); not designed to be used for concentrated flow.

Rock Headers: Large rocks or gabions (aka smaller rocks encased in a wire mesh block-like basket) used to buttress or hinge-up fill slopes over culvert ends; they should be elevated about 6" below the shoulder grade to avoid snowplow damage.

Rock Sandwich: (aka French mattress) Used to allow water to pass under a section of road base, from one side to the other; consists of a 12" layer of 3"-6" stone 'sandwiched' between two layers of filter fabric, allowing water to pass through the spaces between the rocks.

Rubber Razor Bar: A road surface drainage diversion used on sloping road sections; consists of a rubber belt supported by wood planking and protrudes above the road surface high enough to intercept and detour water, while allowing traffic to pass over it; often used on driveways and one lane, low-traffic summer roads.

Sag Grade Profile: A long downhill decrease in road elevation to its lowest point (aka the sag) before rising uphill; usually the sag is located across streams and wetlands.

Sediment: Eroded soil or dirt moved by water.

Sheet Erosion: Occurs when surface water runoff moves in a broad sheet over the land and removes a layer of exposed soil.

Sheet Flow: Non-erosive dispersed flow of surface water runoff in a thin, slow-moving layer over the land.

Signs and Symbols:

> = greater than

$\geq$ = not less than; is equal to or greater than

< = less than

$\leq$ = not greater than; is equal to or less than

Slope: The amount of surface incline or decline as measured by slope ratio (e.g. 2:1, 4:1, etc) or % slope (e.g. 1%, 10%, etc).

Soil and Water Conservation Districts: (aka SWCDs) Quasi-governmental, not-for-profit organizations dedicated to the conservation and preservation of natural resources; organized primarily by county.

Steel Tine Rake: A row of strong metal tines much like a grader blade that is towed behind (aka York rake) or is a portable front mounted unit (aka Frontrunner) on a truck or tractor; can be used to grade, crown and maintain gravel roads.

Stone Ford: Large stones placed as road surface in low sections to allow water to flow over and through the stones without significant erosion; used on roads with limited use and infrequent traffic.

Subgrade: The grade elevation under the road base layer, usually on excavated or original ground surface elevation.

Super-Elevation: The tilting of the entire (except the uphill shoulder) travelway surface and downhill shoulder in one direction; often used on road curves where crowning is difficult; allows for draining most of the surface in one direction; the uphill shoulder is graded in the opposite direction to keep snow bank melt draining in the other direction.

Surface Water: Water that is flowing or standing on the top of the ground.

Swales: A shallow trough-like vegetated depression that carries water mainly during rainstorms or snow melts.

Travelway: That portion of the road surface located between the shoulders on each side of the road that is dedicated for vehicular traffic; travelway + road shoulders = road surface.

Turnouts: (aka ditch turnouts) Used to direct ditch water into a vegetated buffer so less concentrated runoff reaches the bottom of the hill and less of it ends up in the lake or stream.

Vegetated Buffer: An area of undisturbed trees, shrubs, and other vegetation located between a developed area (such as a building site or camp road) and a lake, stream wetland or coastal water.

Washboarding: Creation of a rough and bumpy road surface, resembling a corrugated surface.

Water Bar: A ridge (like a raised speed bump) that runs diagonally across the road, stopping water from running down the road by diverting it to the side and off into the ditch or roadside.

Watershed: All the uphill land that surrounds a body of water (e.g. a lake) that sheds its water into that body of water through streams, ditches, sheet flow, or groundwater.

RESOURCE DIRECTORY

Maine Soil & Water Conservation District (SWCD) Offices

SWCDs are quasi - governmental, not-for-profit organizations dedicated to the conservation and preservation of our natural resources. They provide:

- Site evaluations to assess erosion and/or drainage concerns.
- Best Management Practice design.
- Grant project planning and development.
- Education and training on a variety of lake-related issues, including camp roads.

Androscoggin Valley	753-9400
Central Aroostook County	764-4153
Cumberland County	892-4700
Franklin County	778-4279
Hancock County	667-8663
Kennebec County	622-7847
Knox/Lincoln County	596-2040
Oxford County	743-5789
Penobscot County	990-3676
Piscataquis County	564-2321
Somerset County	474-8324
Southern Aroostook County	532-2087
St. John Valley	834-3311
Waldo County	338-1964
Washington County	255-4659
York County	324-0888

Contact the office for your particular region
www.maineswcds.org

Maine Department of Environmental Protection (DEP)

Bureaus of Land Resources and Water Quality licensing, enforcement, water classification, shoreland zoning, and field services
Division of Watershed Management (DWM) – nonpoint source pollution control, watershed surveys, BMP training, technical assistance

www.maine.gov/dep
(800) 452-1942 (in state only)
(207) 287-7688

DEP Offices – BLWQ & DWM

Augusta	287-7688 (main office)
Bangor	941-4570
Portland	822-6300
Presque Isle	764-0477

List of **contractors certified** by the DEP in erosion and sedimentation control:
www.maine.gov/dep/land/training/ccec.html

Maine Local Roads Center at MaineDOT
(207) 624-3263
www.maine.gov/mdot/csd/mlrc/index.htm

Land Use Planning Commission (LUPC)
(207) 287-2631 www.maine.gov/dacf/lupc/

This publication and other camp road related information and resources are available at the **DEP Camp Roads website:**
www.maine.gov/dep/land/watershed/camp/road/index.htm

There are other resources, such as local watershed groups, private lake associations, and municipal code enforcement officers, available to assist with camp road issues. The DEP and your local SWCD representative will help you to find other local resources.