TABLE OF CONTENTS

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The Kennebec County Soil and Water Conservation District's Mitch Michaud originally created this manual in 1987. It was revised in 1995 by Andy Reid and again in 1999 by Rob Mohlar (KCSWCD).

Evaluation Forms: National Science Foundation CREST Intern Pamela Partridge

Illustrations: Brian Kent, Kent Associates; Gardiner, Maine

Editing: Alison Truesdale, LandForms; Brunswick, Maine

Reviewers:
Soil and Water Conservation Districts -
Rob Mohlar (Kennebec County)
Phoebe Hardesty (Androscoggin County)

Maine Department of Environmental Protection -
Karen Hahnel
Kathy Hoppe
Marianne Hubert
Bill Laflamme
Christine Smith
Dave Waddell
Barb Welch

Portland Water District -
Shelly Swanson

Clyde Walton; retired, Maine Department of Transportation

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What is a Soil and Water Conservation District?
Your local Soil and Water Conservation Districts (SWCDs) are quasi - governmental, not-for-profit organizations dedicated to the conservation and preservation of our natural resources. SWCDs are part of a National Association of Conservation Districts. There are almost 3,000 SWCDs nationwide. In Maine, there are 16 SWCDs distributed throughout the state, based on county boundaries. For information on how to contact your local district, refer to the Resource Directory on the inside back cover of this manual.

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
- ❑ New Hampshire Natural Resource and Conservation Service
- ❑ 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 Land and Water Quality
17 State House Station
Augusta, ME 04330-0017
Tel: (207) 287-3901

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, lakeshore owners, town officials, contractors, and lake enthusiasts. Its purpose is to help people maintain and improve camp roads while protecting the quality of water in lakes, streams, coastal areas, and wetlands. How can you do both of these at the same time? Because by doing the former, you will also be doing the latter. Poorly maintained camp roads have been shown to be a major contributor to soil erosion, which in turn, causes water pollution. A camp road in poor shape is not only hazardous, but contributes to the decline of nearby surface waters. This manual will explain the connection between road maintenance and water quality.

The manual is also designed to be a practical tool for maintaining camp roads. The emphasis is on routine maintenance activities, which are far more cost effective than major repair work. The Camp Road Maintenance section includes detailed explanations and diagrams to help you understand your road's problems and how to fix them. A section has been included to help you evaluate your road conditions and determine which problems are most pressing. A checklist is included for road owners to use or give to contractors so they can make sure work is done properly.

Sections on forming a road association, maintenance planning, budgeting, and environmental laws have been included so that people can minimize the work, cost, and liability associated with owning a camp road. The final section of this manual contains a Troubleshooting Guide to evaluate specific road problems. Use it like an index to direct you to more detailed sections of the manual.

Q: How can this manual 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. Proper erosion control can save you time and money by avoiding major road repairs. It also means less gravel hauled in each year to resurface the road or repair chronic erosion problems. Other benefits of proper camp road maintenance include:

- increased property values as a result of better water quality and road conditions;
- 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;
- avoiding regulatory enforcement actions by the Maine Department of Environmental Protection (DEP) (see page 44); 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 my camp road?
A: Pollution from stormwater runoff and soil erosion is one of the most significant prob-lems 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 up to 85% of all 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 my lake or stream?
A: Camp roads change the natural stormwater drainage patterns. Most of these changes increase the potential for soil erosion. These changes include:

- ❑ stripping away the protective vegetative cover;
- ❑ creating a highly erodible pathway of exposed soils in the watershed; and
- ❑ collecting drainage in ditches, which increases the overall volume and speed of surface water runoff.

Q: How does camp road erosion harm our lakes?
A: The most obvious effect of erosion is the brown color that results from suspended soil particles in the water. Less obvious is the fact that these suspended solids irritate the gills of fish, making them prone to disease. Soil particles can smother spawning and feeding grounds as well. Other effects include:

- ❑ gradual filling and the resulting loss of desirable shoreline (due to encroaching weeds, for instance);
- ❑ obnoxious algae blooms which result from excess phosphorus in the suspended soil particles flushed into the lake;
- ❑ depleted levels of dissolved oxygen resulting in fewer cold-water fish (i.e., salmon and trout);
- ❑ 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. These problems include washouts, tire rutting, potholes, and soil erosion. Many camp roads were not properly constructed, are not properly maintained, or both. As a result, the surface and groundwater is not properly diverted away from the road, 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.

UNDERSTANDING 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 raindrop erosion, and then progresses into sheet flow erosion, rill or gully erosion, then stream flow or channel erosion (see Figure 1). 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 to prevent soil from moving in the first place, than to try to stop erosion that has already started.

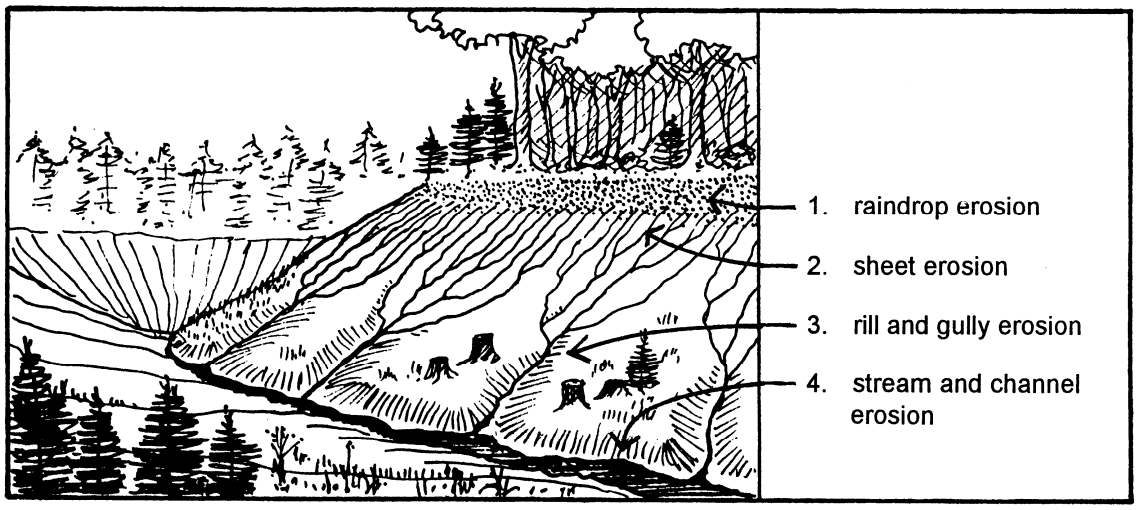


Figure 1. Soil Erosion

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 occurs 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.

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 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 2).

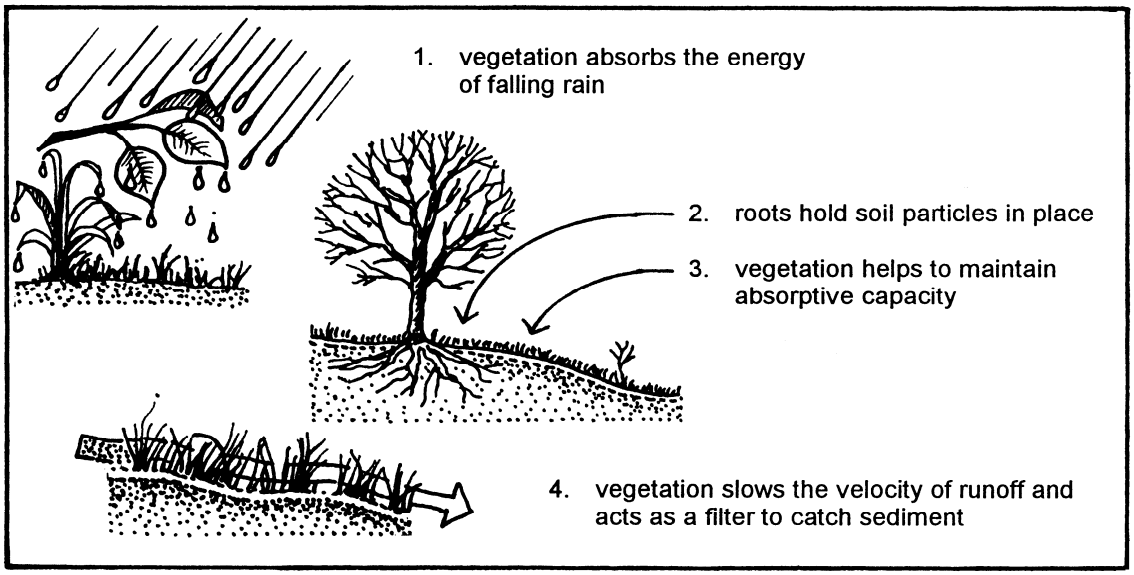


Figure 2. Effect of Vegetative Cover on Erosion

It only takes 16 feet for a raindrop to reach peak free fall speed. Therefore, it is important to limit cutting of lower limbs on trees around shoreline areas to minimize the distance raindrops fall from the limbs.

EROSION CONTROL PRINCIPLES

Up to 85% of all erosion and sedimentation problems in lake watersheds originate from the construction and improper maintenance of gravel camp roads. Camp roads represent a significant environmental problem! 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.

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.
- ❑ 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).
- ❑ 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).

Keep these principles in mind as you read this manual, and use them as you evaluate your own camp road.

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

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 DRAINAGE

Effective drainage is critical to camp road maintenance. It is often said that the three most important aspects of effective road maintenance are "**drainage, drainage,** and **drainage**." This may be overstated, but only slightly. Good drainage requires removing runoff from the road surface and preventing groundwater from infiltrating the road base. These two distinct drainage problems require an understanding of the difference between surface water and groundwater (subsurface water).

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 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.

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

- a well-constructed road with proper crowning and grading;
- 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. With camp roads, the biggest concern is to keep groundwater out of the road base. Groundwater in the road base will make it soft (potentially impassable) and susceptible to tire rutting. Ideally, subsurface water should be drained from the road base and directed to a natural or constructed channel capable of handling the flow without eroding.

Types of subsurface drainage include:

- ❑ subsurface drains of either pervious (slotted) pipe or permeable soil material,
- ❑ stable ditches that are dug sufficiently deep (below the water table) to drain water from the road base; and
- ❑ a well-constructed road foundation of coarse soil materials (i.e., sand and gravel with few fines to allow subsurface water to drain efficiently).

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: gravel, sand, and fines (listed in order from largest to smallest particle size). Gravel and sand particles are readily distinguishable to the naked eye. Fines (silts and clays) are generally comprised of particles too small for the eye see. Each soil type has specific properties that make it best for different aspects of road building. Gravel is very durable and drains freely. Sand also drains efficiently. Fines pack and bind well and they help shed water, because they do not drain well.

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 types. Some general guidelines are provided below.

Road base material needs to be sturdy and drain freely.

- ❑ Use gravel that is:
  - ■ somewhat coarser than the road surface material (3"-4" maximum particle size); and
  - ■ has 0 to 7 percent fines (this promotes subsurface drainage).
- ❑ The base layer should be 18 inches or thicker.

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

- ❑ Use gravel that:
  - ■ has a maximum particle size of 2 inches (for a smooth ride) and
  - ■ has 7 to 12 percent fines (to pack well and shed water).
- ❑ The surface layer should be about 4 to 6 inches thick.

When you buy gravel, you can ask the pit owner to document the percent fines and the sizes of 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 3. 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.

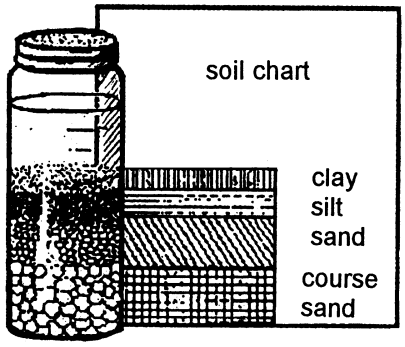


Figure 3. Quantifying Road Material

The desired soil properties for various road components are summarized in the following table.

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

Many camp road problems can be directly related to using improper road materials. Loose surface material generally indicates a lack of fines. Soft roads are generally indicative of too many fines in the base material, or a base layer that is not thick enough to support the road. The Troubleshooting Guide at the end of this manual can help identify problems that might relate to road materials.

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. One alternative is discussed below.

Reclaimed Pavement/Recycled Asphalt (RAP)

Reclaimed pavement is old pavement that has been ground up. It looks similar to road gravel, but it is more granular and darker because of the residual asphalt. The most common and effective use of this material is on steep road segments that have had problems with surface erosion. It is also effective on other high stress areas such as sharp turns and intersections. The residual asphalt in this material acts as a binder, which makes it more resistant to erosion. Many local pavement suppliers produce this type of material. Availability and price may vary significantly, depending on your proximity to a supplier. In the spring of 2000, prices ranged between $6.00 and $14.00 per yard, with delivery charges of approximately $45.00 per hour.

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 RAP 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 RAP, particularly on areas that are heavily traveled. Compacting with a roller or whacker is preferred, but you can also run over the whole area with a passenger vehicle.
- 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 RAP dusty and less likely to bind together.

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 4). 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 significant 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.

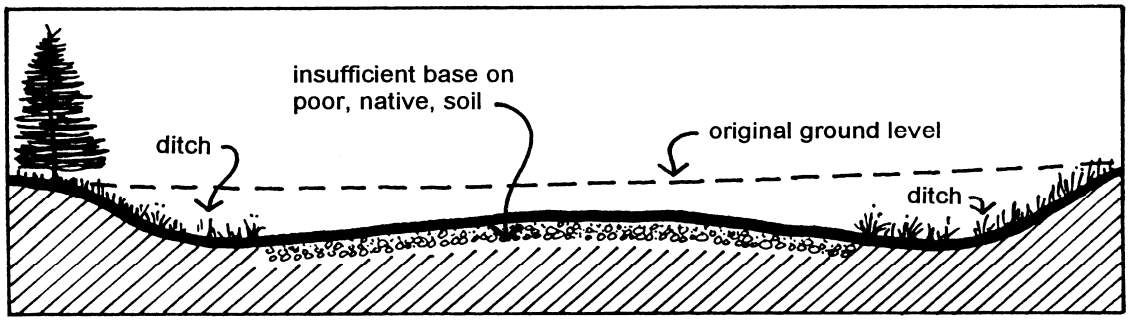


Figure 4. Poorly constructed road: poor base and inadequate ditching.

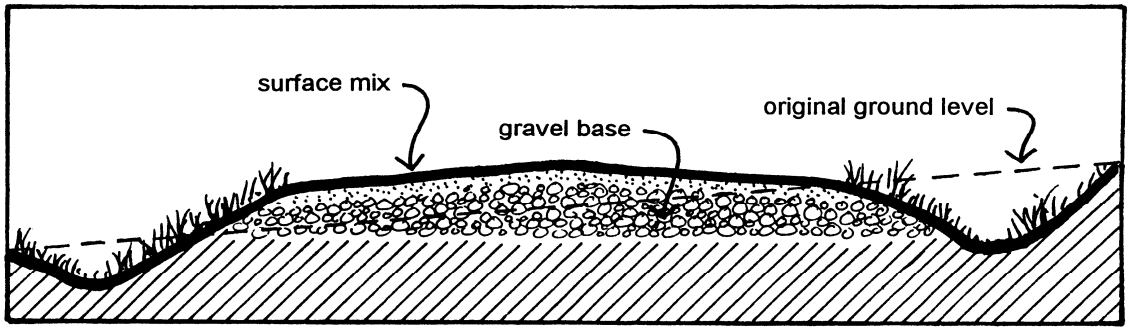


Figure 5. Well-constructed road: high point (crown) above original ground level.

CROWNING AND GRADING

Crowning

Road crowning and grading 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. Crowning is the quickest way to get water off the road, preventing significant erosion of the road surface.

An insufficient crown 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 figure below shows how crowning promotes surface water drainage.

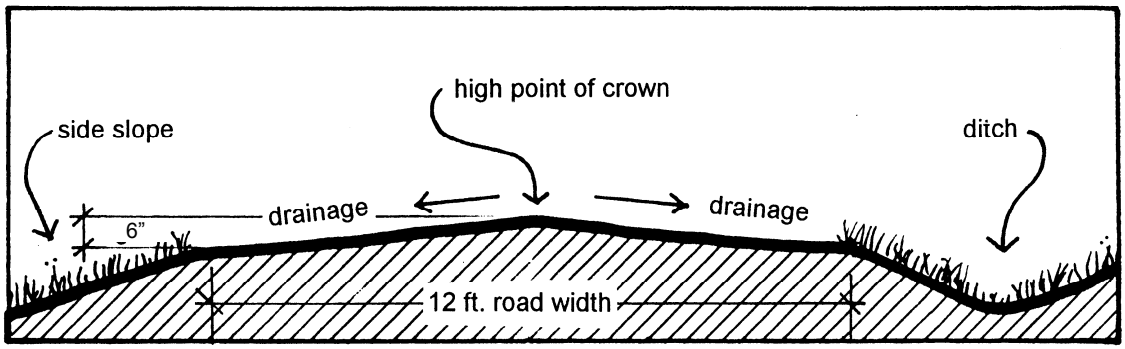


Figure 6. Crown profile: ½ " of crown per foot of road width (e.g., ½ " x 12' road = 6" crown).

A general rule for level or gently sloping gravel roads is ½ -inch of crown per foot of total road width. A crown 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.

Grading

Grading is the process of smoothing and crowning a gravel road. This practice involves using a grader with a steel cutting blade 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 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.***

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 7), 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.

Proper grading is also 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.

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.

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 and more often on year-round roads.

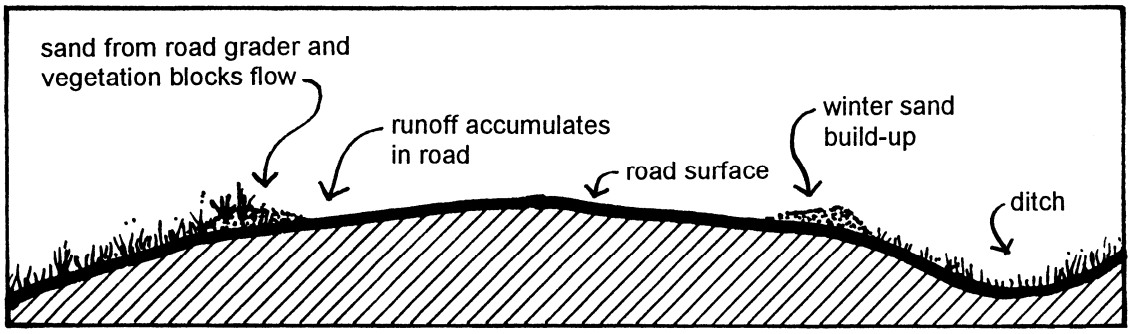


Figure 7. Sand and vegetation build-up prevents drainage to sides of road.

The key to crowning and grading is proper and regular maintenance. Regular grading will allow water to reach ditches efficiently and prevent significant erosion of the road surface.

ALTERNATIVE ROAD MAINTENANCE 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.

A word of caution – job performance is as good as the equipment operator! A trained and experienced contractor may be more expensive, but the job he does 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.

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.

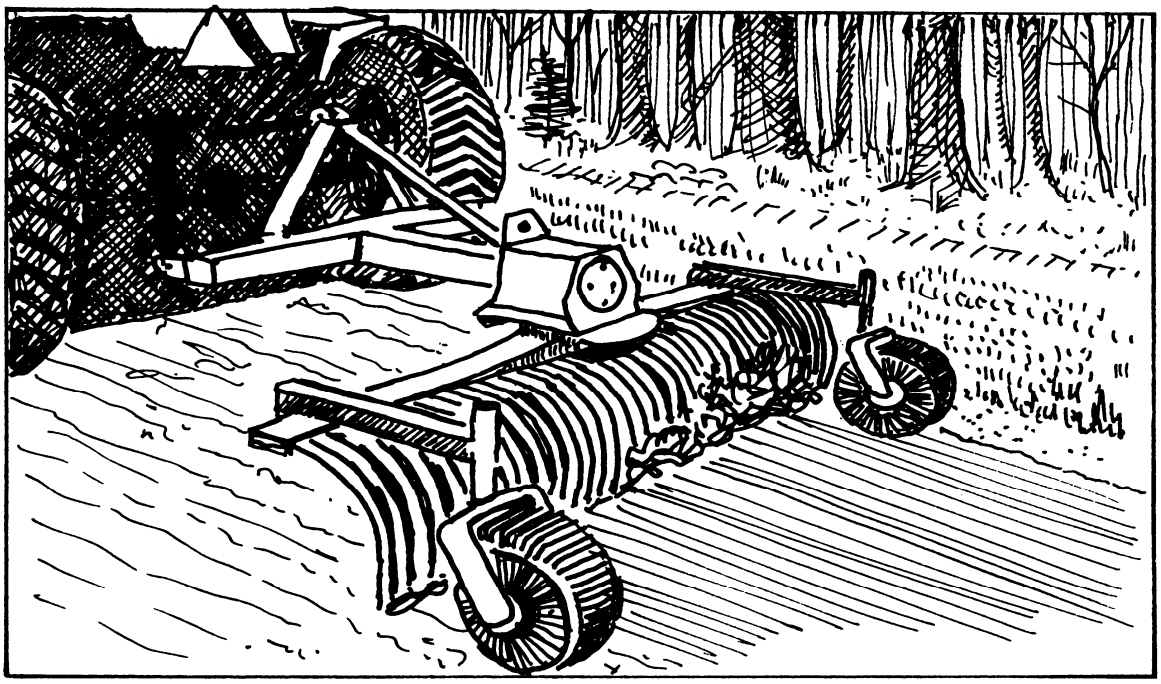


Figure 8. Steel tine rake used for maintenance.

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.

> ***It is very important to maintain a proper road crown. Often too much emphasis is placed on the smoothness of the road, with the result that the crown is removed. Flat roads are prone to drainage problems.***

DITCHES

Good ditches make good roads. Properly designed and constructed ditches serve a number of essential purposes:

- ❑ They collect road surface run-off and drain it away from the road.
- ❑ They store large amounts of rainfall.
- ❑ With proper turnouts and buffers, they keep pollution from reaching sensitive water resources.
- ❑ They collect and drain subsurface water away from the road's base and subgrade soil materials.

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.

> ***When routing water away from a road, it is important to think about where it will end up. Road drainage should never 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.***

As with roads, ditches should be regularly inspected and maintained. It is critical to keep ditches free of obstructions to allow water to flow freely. 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 30). 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 or trapezoidal ditches are preferred over V-shaped ditches. The flatter bottoms of parabolic and trapezoidal 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 page 19), if possible. Steeper side slopes are unstable and have a tendency to collapse, which erodes soil and creates maintenance problems.

Figure 9. Trapezoidal ditch, stone lined.

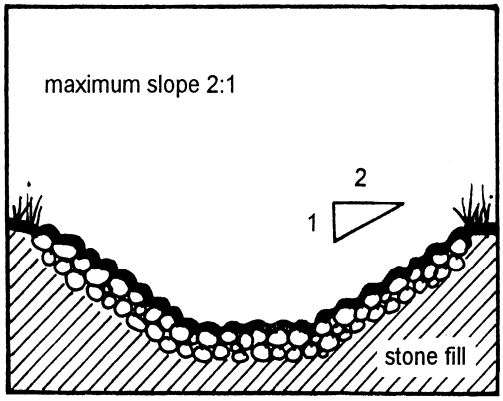
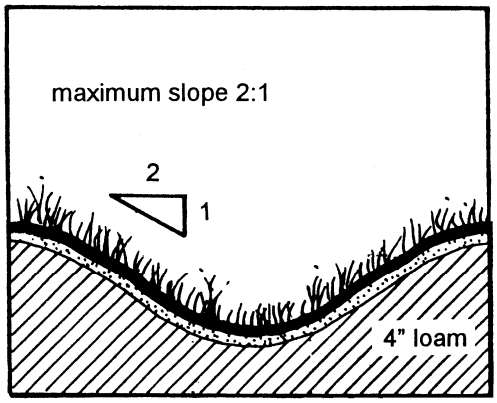


Figure 10. Parabolic ditch, grass lined.



Ditch Size

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. 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.

Road ditches can also drain groundwater from the road base, which stabilizes the road. To drain groundwater, a ditch must be dug deeper than the high water table. As a rule, water in a ditch should never be higher than 1 foot below the top of the ditch (see Figure 11). This will provide enough room for ice buildup in the winter and runoff from the occasional heavy rainstorm.

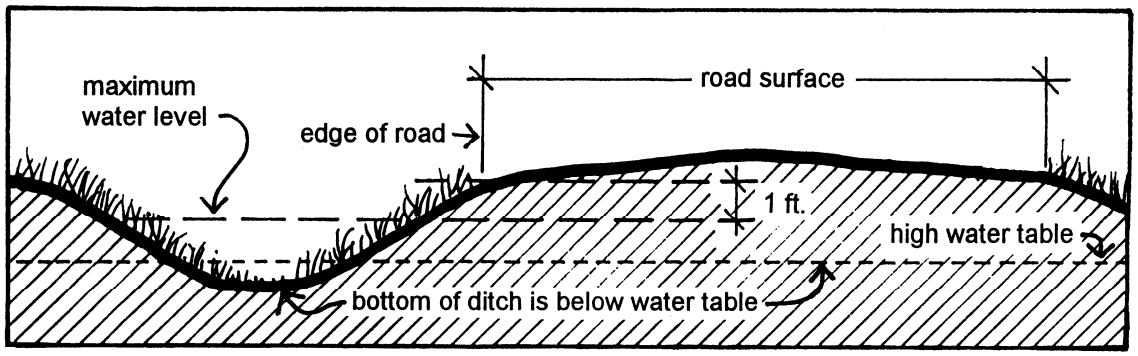


Figure 11. Ditch that drains groundwater from road base.

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 can't handle the speed of the water and needs further armoring to protect it from eroding.

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

- ❑ all erodible material is washed away; or
- ❑ the channel widens until the speed slows to a point where erosion stops.

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

- ❑ Widen the channel. The wider and flatter the channel is, the more volume it can handle at a slower speed. And,
- ❑ Stabilize the ditch bottom by lining it with grass or stone (riprap).

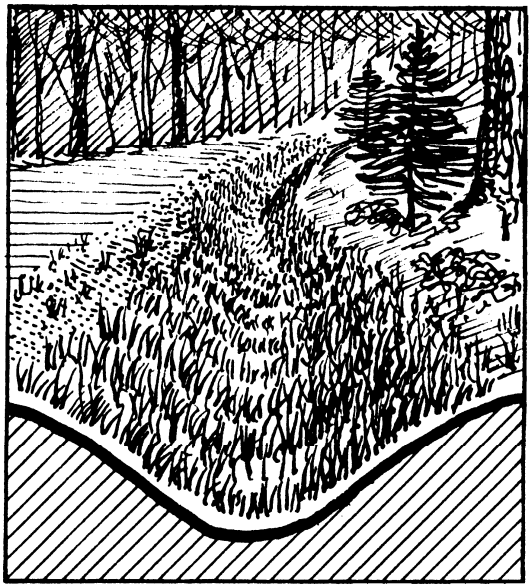


Figure 12. Plant grass to control erosion in ditches with less than 5% pitch

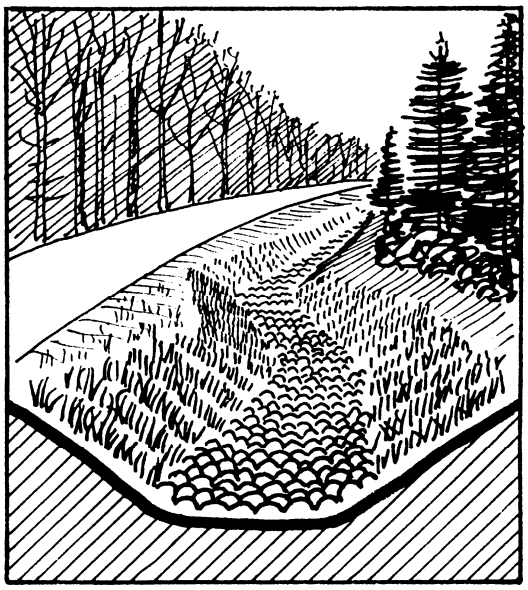


Figure 13. Grass and stone to control erosion for ditches with more than 5% pitch

Riprap should consist of angular stone of varying sizes. The different sizes help lock the stones in place. Uniformly sized riprap tends to be very loose and prone to sliding and undercutting. Often, you can tell what size rocks you need by looking at the size of stones remaining in the ditch naturally.

Ditch Side Slopes

Ditch erosion is often the result of side slopes that are too steep. 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).

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.

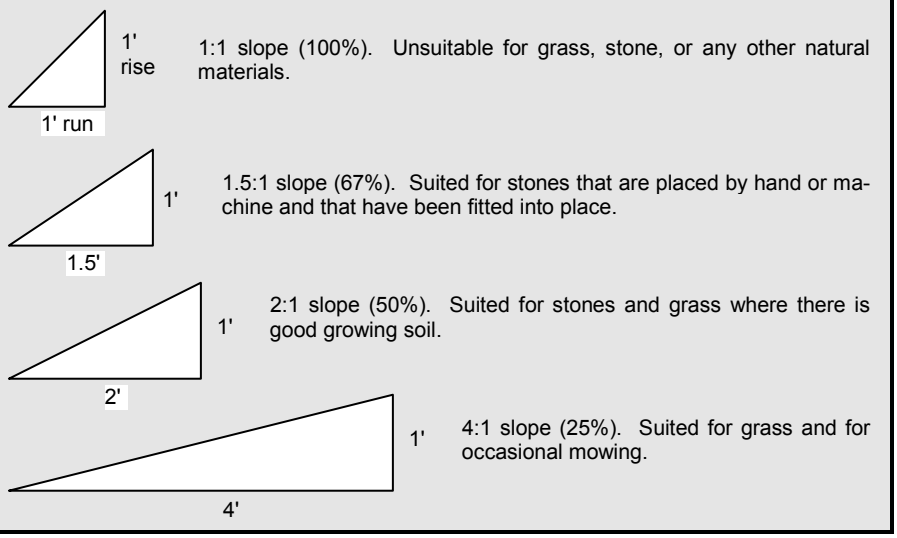


Figure 14. Slope

Slope Value Equivalents		
Ratio	**Percentage**	**Degrees**
1:1	100%	45°
1.5:1	67%	34°
2:1	50%	27°
4:1	25%	14°

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, or seasonal runoff channel must be directed under the road. This keeps the road from disrupting the natural drainage system.
- ❑ 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 discharge water into stable ditches or disperse it into vegetated buffer areas capable of handling the water without eroding.

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.

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.

Culvert Type	Advantage	Disadvantage
metal (corrugated)	❑ inexpensive for sizes < 24” ❑ easy to install ❑ 25-year life	❑ expensive for sizes > 24” ❑ easily crushed
plastic (HDPE)	❑ inexpensive for sizes < 18” ❑ >25-year life ❑ less freezing ❑ easily cut with power saw ❑ smoother surface for heavier water flows ❑ lightweight	❑ easily broken if not handled carefully ❑ more difficult to install
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.

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 small flows, install culverts that are a minimum of 15 inches in diameter. Smaller culverts plug easily and are difficult to clear.

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 15 inches is recommended for maintenance purposes.

Stream Width (inches at normal high water mark)	**Stream Depth (inches at normal high water mark)**	**Culvert Size (inches diameter)**
6	6	15
9	6	15
9	9	18
12	6	18
12	9	22
12	12	24
18	9	30

Culvert Installation Tips

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.

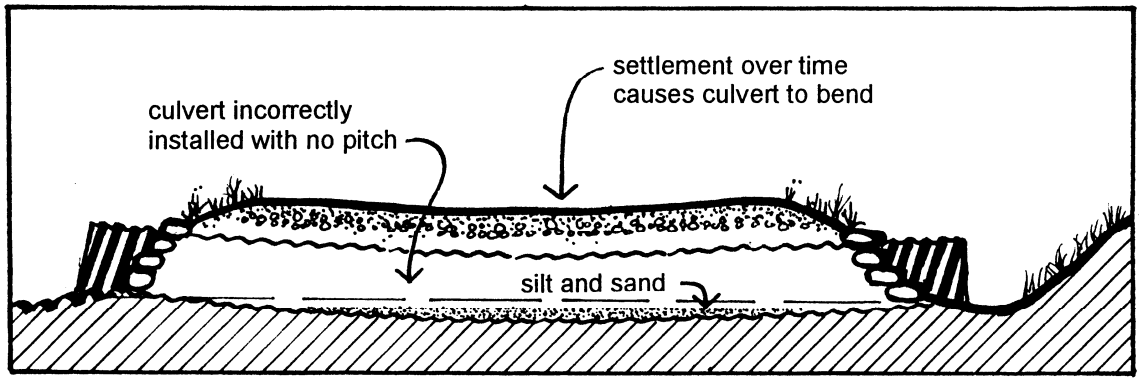


Figure 15. Incorrect way to set a culvert: center too low; silt freezes and plugs culvert.

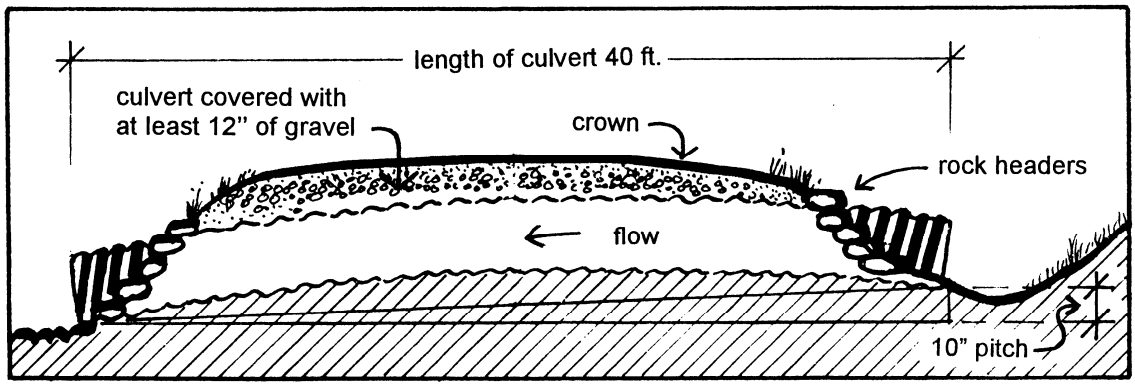


Figure 16. Correct way to set a culvert: rise allows for settling (note: bow is exaggerated for illustration purposes).

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. Culvert outlets should drain into rocks and a vegetated buffer.

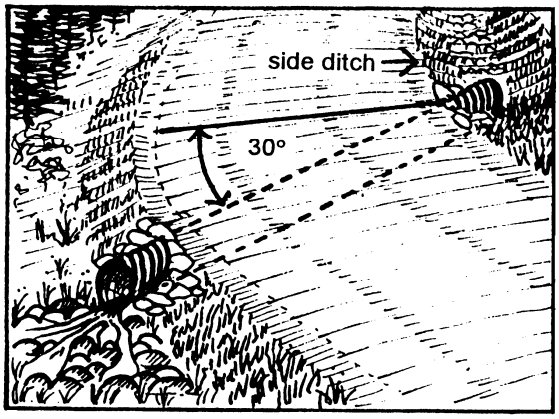


Figure 17. Set culvert at 30° downslope.

Culvert Length

It is very important to have the proper culvert length. All too often, people install culverts that are too short, causing the road shoulder around the culvert to collapse and plug the 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, and extending them with couplings is expensive and prone to failure.

When determining the culvert length, be sure to account for the following factors: the road and shoulder width, the length of side slopes (measured horizontally), and the length of culvert needed to compensate for the pitch angle and the cross angle (if necessary). If you account only for the width of the road surface, you will always end up with a culvert that is too short.

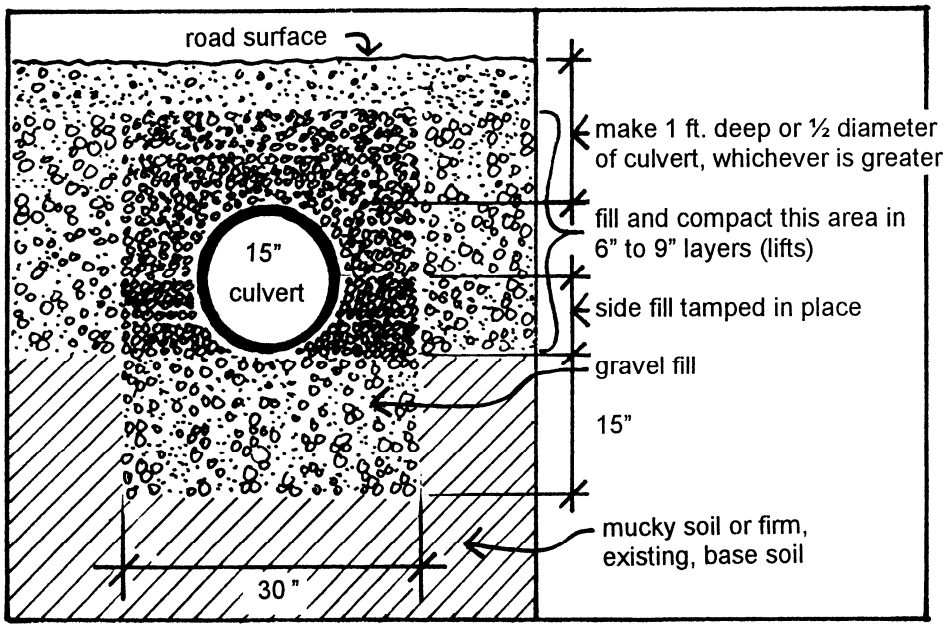


Figure 18. Culvert Installation

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 gravel in an area twice as wide as the diameter of the culvert, and about the same depth as the diameter of the culvert.

- ❑ 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 15-inch pipe on a 5-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.
- ❑ 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.

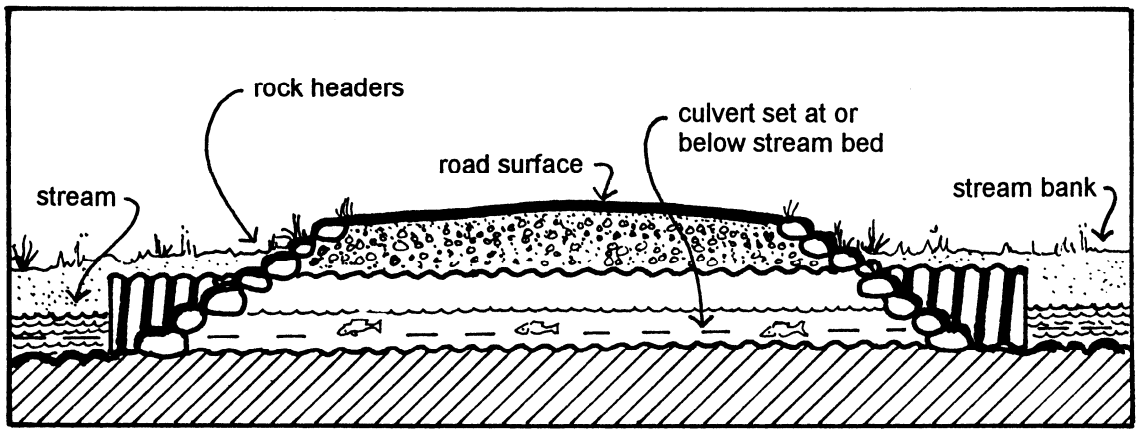


Figure 19. Culvert installed in a stream to allow fish passage.

Outlet Protection

Stabilizing the receiving area at the culvert outlet is important to prevent erosion. Two common ways to do this are by installing a plunge pool or by simply armoring the area with stone (riprap).

Both these methods help to slow the force of the water as it flows out of the culvert, and thus prevent scouring. Plunge pools also trap sediment that may be carried in the water and, therefore, must be cleaned out periodically.

Plunge pools should be constructed in the following manner (provided the culvert is no more than 30 inches in diameter):

- ❑ Length (parallel to the culvert) = 4 times the pipe diameter

- ❑ Width (perpendicular to the culvert) = 2 times the pipe diameter
- ❑ Depth (from the base of the culvert to the bottom of the pool) = 1 times the pipe diameter

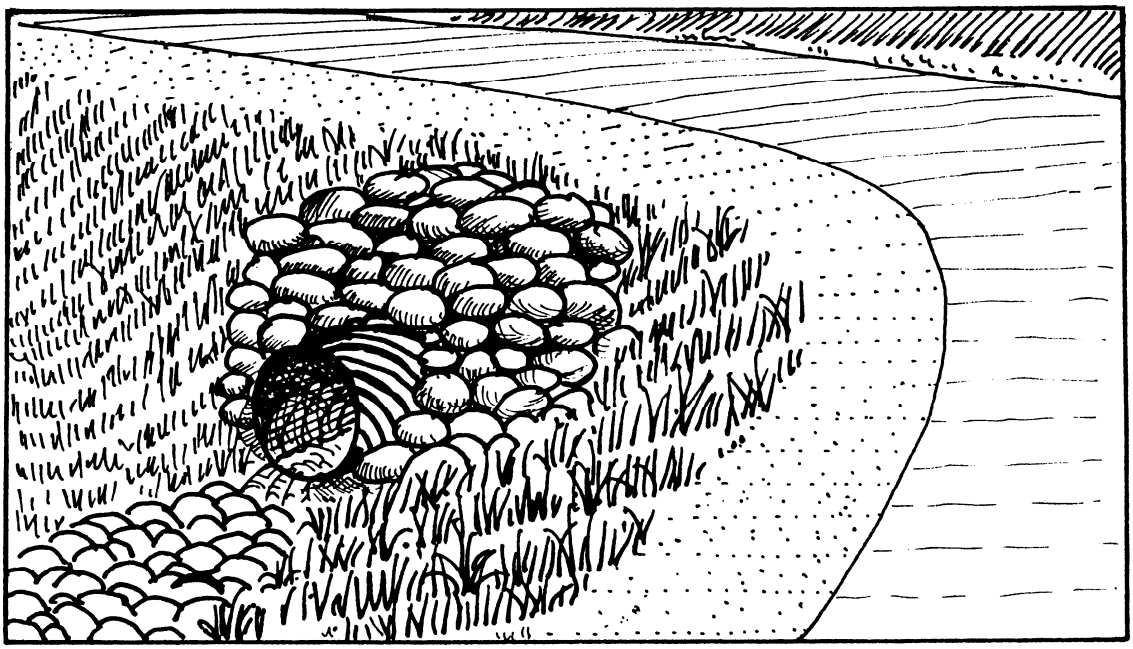


Figure 20. Rock headers on culvert outlet: headers (on 2:1 slope) at both ends prevent erosion.

Use rocks to stabilize the banking around the inlet and outlet of the culvert. This helps hold the road base and to fill around the culvert. Try to use larger rocks as headers, as they will stay in place better and hold back more material.

On the low end of any culvert, where there is a fall of 6 or more inches, place rocks in the channel to break up the force of the falling water and prevent erosion of the lower end of the pipe base. However, culverts in streams should be embedded in the streambed. Hanging the outlet above the stream prevents fish from swimming upstream.

DRAINAGE ALTERNATIVES

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

Stone Fords

Stone fords are sometimes used on roads with limited use and infrequent traffic. 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. The following figure depicts a ford.

Figure 21. Stone ford crossing over low-lying channel: suitable only on limited use camp roads.

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. 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 on the next page).

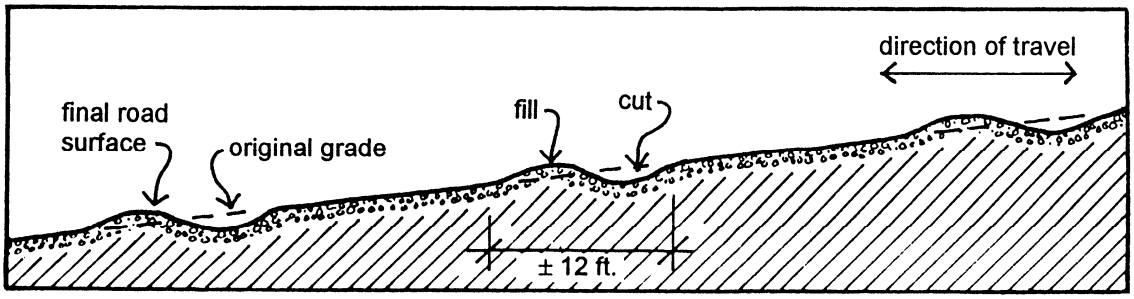


Figure 22. Water Bars

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.

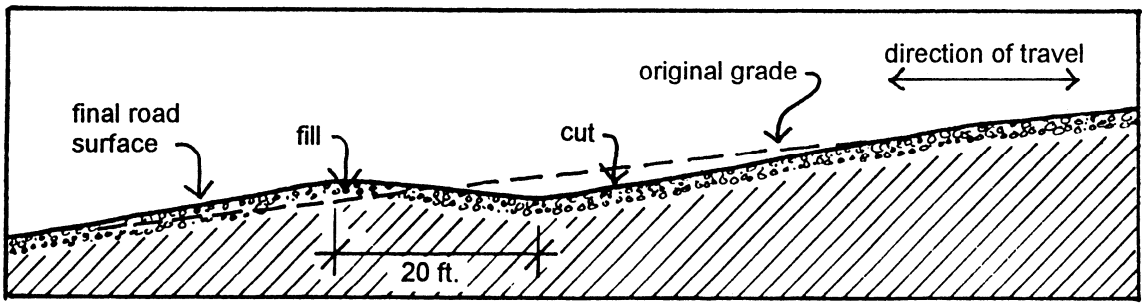


Figure 23. Broad-based Dip

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 Bars

Rubber bars can also be used to divert water off sloping sections of a road and can take the place of a water bar. Figures 24 and 25 show the basic construction and placement of a rubber bar. The rubber bar protrudes above the road surface high enough to intercept and collect water, while allowing traffic to pass over it. This device is used generally on seasonal roads or driveways because the bars are prone to snowplow damage. The rubber for this type of device can be found in some hardware stores and is typically cut from an old conveyor belt.

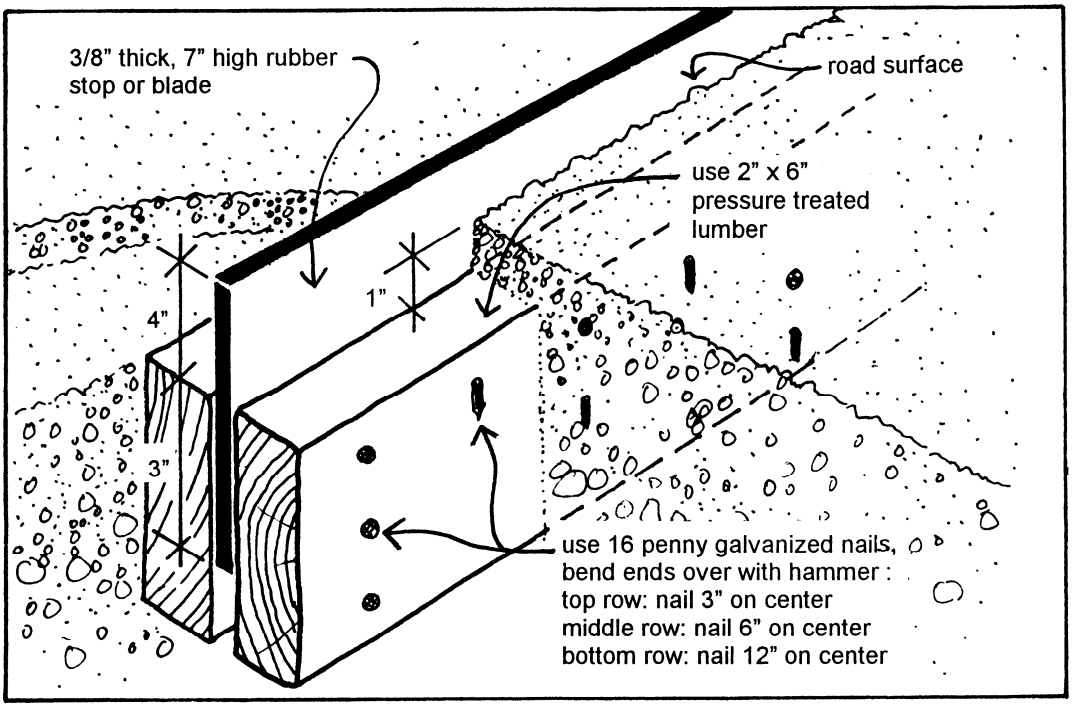


Figure 24. Rubber Bar Construction

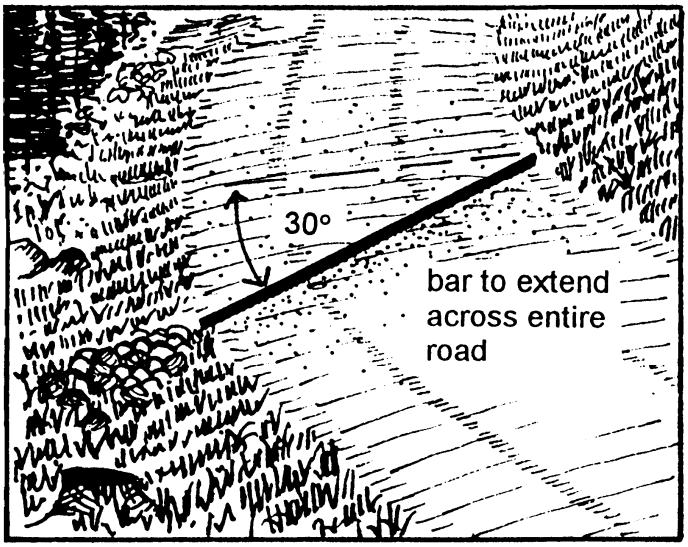


Figure 25. Set Rubber Bar at 30° downslope.

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. They are seldom recommended for year-round roads due to the likelihood of snowplow damage.

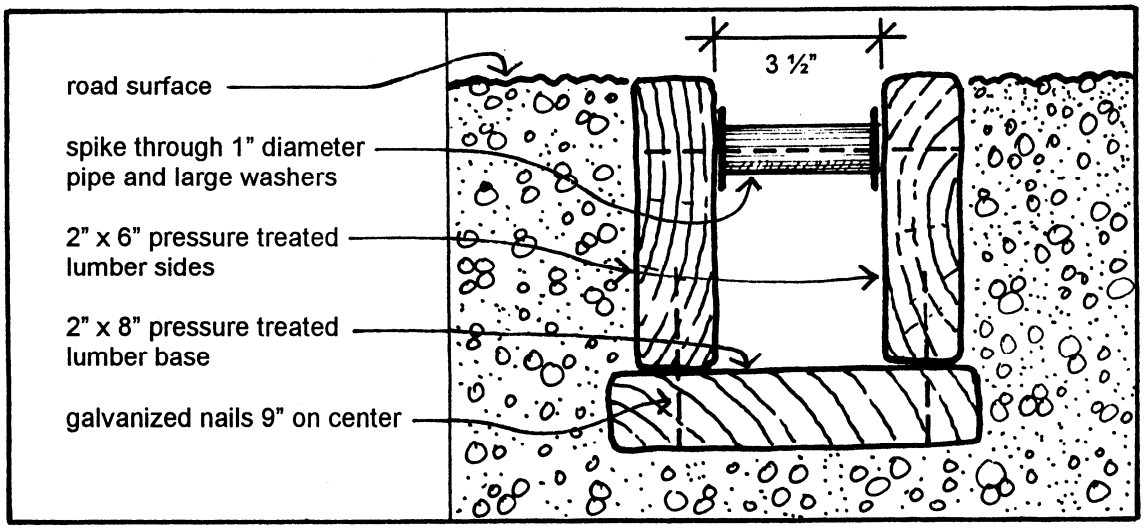


Figure 26. Open Top (Box) Culvert

Open-top culverts can be constructed of logs or from sawn lumber, as shown in the figure. If constructed of pressure treated lumber, they can last for many years. Drain open-top culverts into stable vegetated areas (see Figure 27). Open-top culverts need to be cleaned regularly to remove sediments, gravel, leaves, and twigs. Remember that winter snowplowing can easily destroy this type of culvert and result in even greater erosion problems in the spring.

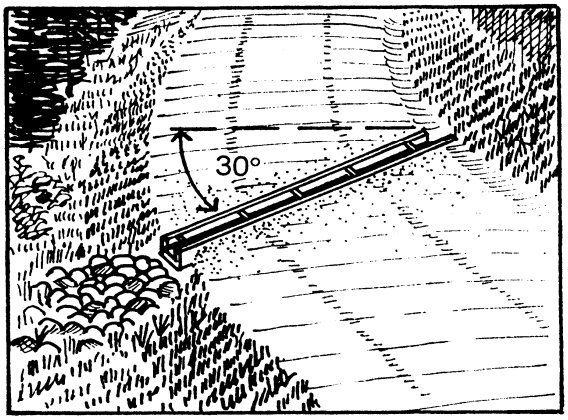


Figure 27. Open-top culvert set 30° downslope.

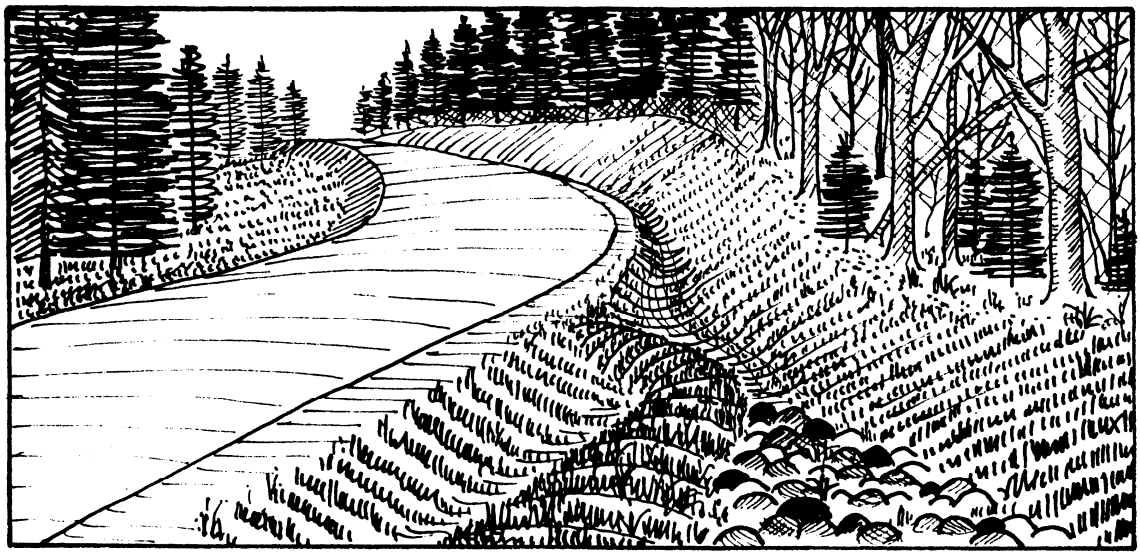
DITCH TURNOUTS

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. Instead, road runoff accumulates in a ditch before it is discharged. It is important to avoid discharging ditches into streams or the lake. Instead, every effort should be made to discharge them into vegetated areas capable of handling the runoff without the water creating channels or causing erosion. This is what turnouts do.

Turnouts are used to direct ditch water away from the road into a vegetated buffer area. The turnout should have a flared end section that is level and lined with rock to spread out the flow. The level lip of this device converts the channeled flow from the ditch into shallow sheet flow just before it discharges into the vegetated area. (Sheet flow has far less erosive potential than channeled flow, because the water is moving more slowly.) 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.

Figure 28. Ditch turnouts channel water away from the road into vegetated buffers.



The main purpose of turnouts is to reduce the quantity of channeled stormwater reaching the bottom of the hill. 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. More turnouts are necessary on steeper slopes to counteract the effect of fast-moving water.

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.

As pointed out earlier, it is critical to get water away from the road (remember, “drainage, drainage, drainage”). 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 into an undisturbed vegetated buffer to help remove the pollutants in it. **Remember – never direct road drainage into a lake or stream!**

Figure 29. Vegetated buffers filter and absorb camp road runoff.

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.

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 sediments 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.
- ❑ Remember, wider is better. Wherever possible, buffers should be a minimum of 50 feet wide.

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. So for your lake's sake, turn water bars and road ditches into undisturbed vegetated buffers as frequently as possible. Wouldn't you rather feed trees and shrubs than algae?

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. 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.

Seeding

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. 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).

- ❑ Apply fertilizer, if necessary (20 lbs. per 1,000 square feet in lieu of a soil test).

- ❑ 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.

- ❑ 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. Fertilize with nitrogen when needed, avoiding blended fertilizers with high phosphorus content.

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. 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 or manufactured blankets).

- ❑ The area is too shaded. This is a common problem with camp roads. If erosion is a problem, riprap may be required.

- ❑ The seed may not germinate well. 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

$10.00 soil test kit. But remember that unnecessary fertilization can be harmful to a lake.

Mulching

Mulching is the placement of hay or straw over exposed soil to protect it against erosion. 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.

GEOTEXTILES

Geotextiles (often called "filter fabrics") have gained widespread acceptance in the construction industry. Geotextiles are permeable industrial fabrics that are made from a variety of synthetic materials (polyethylene, polypropylene, and nylon). They have proven to be a cost-effective solution to some common road construction and maintenance problems. Specific applications include:

- ❑ Stabilization and material separation. Geotextiles can be placed between different layers of soil to keep them from mixing.
- ❑ Drainage enhancement. Geotextiles can be wrapped around perforated drain pipes to filter out fines that can clog them.
- ❑ Erosion control. Geotextiles are often placed underneath riprap to prevent underlying soil from eroding away.

Geotextiles are sold as big rolls of fabric, which makes installation relatively easy. 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, softer (which allows it to conform to soil surfaces better), and less expensive.

There are many different types, grades, 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.

Geotextiles used for Stabilization and Material Separation

Stabilization 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 10-12 inches of good road gravel. Using geotextile will enhance the road stability in two ways:

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

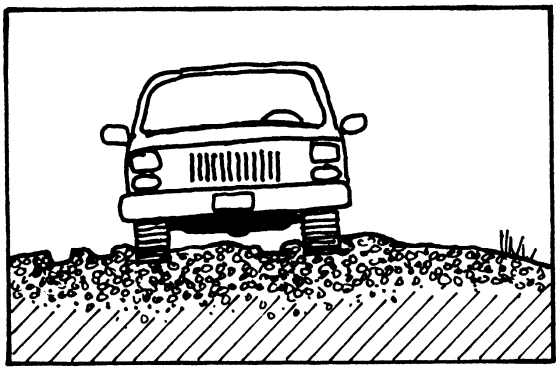


Figure 30. Soft road with no geotextile.

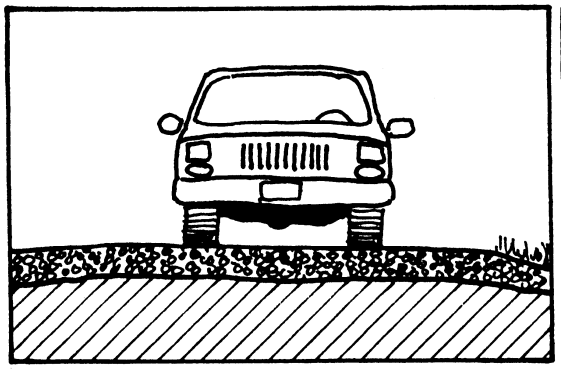


Figure 31. Soft road with geotextile.

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.
- ❑ Remove protruding rocks and other debris from the road before putting down geotextile to prevent punctures and tears.

Geotextiles used for Drainage Enhancement

Geotextiles can be used to improve subsurface drainage by removing groundwater from chronically soft, muddy sections of a road. Typically, this type of drain consists of a trench filled with gravel and/or perforated plastic pipe. The trench is designed to intercept the groundwater and drain it to a lower spot. Lining the trench with a geotextile prevents the pipe from clogging and extends the life of the drain. The geotextile also acts as a barrier between the gravel and surrounding soil, thereby preserving the permeability of the gravel.

General Installation Recommendations:

- Use non-woven geotextiles because they are more permeable, less expensive, and material strength is not a significant concern.
- Lay the geotextile in the trench with the ends extending up over both sides of the trench. Once the trench has been filled with gravel, the ends can be folded over the top and then covered with soil.
- Overlap multiple sheets of geotextile by at least 1-2 feet.
- Make sure the drain has a continual downhill pitch and discharges into a stable area.
- See that the soil surface is free from rocks or other protrusions to ensure good contact between the soil and the geotextile.

Geotextiles used for Erosion Control

Geotextile material is often 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.

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.

DUST CONTROL

Calcium chloride is a commercial chemical product used to control dust on gravel roads. Road dust is a nuisance, but 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 dusting results in:

- Road surface loss that will require periodic replacement. A ½ inch loss of surface material per year results in an annual cost of approximately $500.00 per mile.

- 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 will vary, 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:

- 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.

CAMP ROAD EVALUATION

The purpose of this section is to help you to evaluate your road conditions, and to decide where your road maintenance and repair money is best spent. Below are eight tables that address all major aspects of proper road maintenance. Fill in the tables with the scores appropriate for your road. The final table is for summarizing these scores and evaluating them so that you can determine where the most critical problems are. Certain items are difficult to

alter (for instance, road slope segments), but are covered in the evaluation to help you understand why problems may exist.

ROAD EVALUATION

Name of road:	Date:
Estimated road length:	Avg. road width:
Number of homes total:	Number of year-round homes:

ROAD SURFACE	RATINGS	SCORE
Crown	1 (excellent), 2 (good), 3 (fair), 4 (poor - potholes), 5 (problem rutting)	
Surface when dry	1 (hard, no dust), 3 (hard, dusty), 4 (loose cobbles), 5 (dusty with loose cobbles)	
Surface when wet	1 (hard), 2 (hard & slick), 3 (slick & loose), 5 (muddy)	
Edge	1 (no berms or ridges), 5 (berm or ridge prevents runoff)	
Base	1 (gravel), 2 (gravel/sand), 3 (dirt), 4 (sand/clay)	
	Sub-total of above	(a)
Type of usage	1 (summer/seasonal), 2 (year-round)	(b)
Overall condition	1 (100% good), 2 (75% good), 3 (50% good), 4 (25% good), 5 (0% good)	(c)
	TOTAL SURFACE SCORE (a) + (b) x (c)	(d)

DITCHES	RATINGS	SCORE
Ditching	1 (ample ditching, or none needed), 3 (some needed), 5 (badly needed)	
Depth/Width	1 (ditches all functioning well), 3 (at least one ditch not functioning), 5 (nonexistent or all not functioning)	
Vegetation	1 (good turf, wooded, or riprap), 2 (grass), 3 (weeds), 4 (brush), 5 (bare ground)	
Sediment accumulation	1 (none), 2 (1 inch), 3 (2 inches), 4 (4 inches), 5 (6+ inches)	
Shape	1 (parabolic), 2 (trapezoidal), 3 (round), 4 ("V" shaped), 5 (square)	
	Sub-total of above	(e)
Overall condition	1 (100% good or none needed), 2 (75% good), 3 (50% good), 4 (25% good), 5 (0% good or none present but needed)	(f)
	TOTAL DITCH SCORE (e x f)	(g)

CULVERTS	RATINGS	SCORE
Culverts	1 (ample number or none needed), 3 (some not working), 5 (culverts needed)	
Number of culverts needed? Size of culverts needed:		
Condition	1 (new), 2 (aging/some rust), 3 (old/rust holes), 4 (bottom gone)	
Size	1 (2 foot), 2 (15 inches), 3 (1 foot), 4 (< 12 inches)	
Pitch (inside culvert)	1 (clean), 2 (some rock and/or water), 3 (1 inch of silt), 4 (2+ inches of silt)	
Cover	1 (1 foot or ½ culvert diameter if culvert > 2 feet), 3 (<1 foot), 4 (bent inside), 5 (visible on road surface)	
	Sub-total of above	(h)
Overall condition	1 (100% good or none needed), 2 (75% good), 3 (50% good), 4 (25% good), 5 (0% good or none present but needed)	(i)
	TOTAL CULVERT SCORE (h) x (i)	(j)

DIVERSIONS	RATINGS	SCORE
Outlets and turnouts	1 (ample number or none needed), 5 (needed)	
Number of outlets and/or turnouts	number of outlets recommended based on slope (see page 27)	
Diverted into what?	1 (woods), 2 (field or lawn), 3 (gully in woods), 4 (stream), 5 (lake)	
Sub-total of above (sum of 1st and 3rd row)		(k)
Overall condition	1 (100% good or none needed), 2 (75% good), 3 (50% good), 4 (25% good), 5 (0% good or none present but needed)	(l)
TOTAL DIVERSION SCORE (k) x (l)		(m)

SLOPE EVALUATION

To fill out the evaluation table on the following page, measure the angle of incline and distance (by pacing off) for each distinct segment of road. For the purposes of this evaluation, a segment is considered a length of road with a uniform slope.

1. Put a check in the appropriate box for each segment of road.

2. When you have surveyed the entire road, multiply the number of checks in each box by that box's value (in parentheses) to get a box total.

3. Add all of the box totals to get a total for the entire road.

4. Divide the road total by the total number of identified road segments (checks), which will give you the road segment average for the entire road.

Gray areas of the table represent segments with high erosion potential; the darker the gray shading, the greater the erosion potential.

Grade (%)	Length of Road Segment (feet)				
	50	**100**	**200**	**500**	**1000**
0-5	_____(4) Total	_____(5) Total	_____(8) Total	_____(12) Total	_____(17) Total
6-10	_____(10) Total	_____(14) Total	_____(19) Total	_____(31) Total	_____(43) Total
11-15	_____(16) Total	_____(23) Total	_____(33) Total	_____(51) Total	_____(73) Total
16-20	_____(29) Total	_____(41) Total	_____(58) Total	_____(91) Total	_____(129) Total

Total of all boxes = _____ ÷ total number of checks _____ = segment average ____ (n)

ACCESS EVALUATION

Access to Main Road	Ratings	Score
angle of approach to main road	1 (90°), 3 (45°-89°), 5 (0°-44°)	
water from main road onto camp road	1 (none), 2 (a little), 3 (some), 4 (a lot)	
length of landing access to main road	1 (20+ ft.), 2 (10 ft.), 3 (5 ft. or less), 4 (none)	
view of traffic	1 (excellent), 2 (look 4 times), 3 (be quick when pulling out), 4 (none)	
Is fire road name visible?	1 (yes), 2 (no)	
	Total Access Score	(o)

FINAL ROAD EVALUATION SUMMARY

Summarize and evaluate your scores in the following table by entering the scores from the previous tables that correspond with the letters. The comparison scores in the table below represent the "best" to "acceptable" totals for each aspect of the road that was evaluated. In general, the lower your total the better; however, having a low or acceptable score does not mean your camp road does not require maintenance. A high score indicates the need for work, and should help to guide you in making decisions about where and what type of work is needed. As a rule, any single item worth more than two points should be part of your road maintenance plan.

FINAL ROAD EVALUATION SUMMARY					
Evaluation	**Surface (d)**	**Ditches (g)**	**Culverts (j)**	**Diversions (m)**	**Total**
Actual					
Best	7-8	5	5	2	19-20
Acceptable	20	20	16	6	62
Road Segment Average (n)					
Actual					
Desired					25
Access To Main Road Total (o)					
Actual					
Best					5

QUICK REFERENCE CHECK LIST

Use this checklist as a quick reference when you are hiring contractors to perform maintenance on you 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 pages 8 through 10)

- ❑ Base material (needs to be strong and free-draining)
  - ■ Gravel can be up to 3- to 4-inch maximum dimension (prefer somewhat angular stones).
  - ■ 0 to 7% fines (the less the better for drainage).
- ❑ 18-inch recommended thickness.
- ❑ Surface material (needs to pack hard and firm, and shed water)
  - ■ Gravel stones no larger than 2 inches (for smooth ride).

- 7 to 12% fines (for binding and shedding).

- ❑ 4-inch recommended thickness

Crowning and Grading
(See pages 11 through 13)

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

Ditches
(See pages 15 through 19)

- ❑ 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 Spreaders
(See page 30)

- ❑ Disperse water 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 pages 19 through 29)

- ❑ Sized appropriately, based on the amount of upstream drainage area (minimum of 15-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 riprapped area at outlet to protect against erosion.
- ❑ Culvert pitch of 2%

Erosion Control

- ❑ Discharge water in a dispersed manner, to a well vegetated area (buffer) (see pages 5, 30, and 31).

- ❑ Minimize areas of exposed soil on side slopes and ditches (see page 32).
- ❑ Stabilize exposed areas with vegetation or other protection (i.e., mulch or riprap) (see pages 18 and 34).
- ❑ Apply fertilizer and lime based on a soil test. Do not over fertilize (see pages 32 through 34).
- ❑ Maintain and monitor areas until they have been permanently stabilized (see page 34).

LAWS AFFECTING CAMP ROAD OWNERS

DO I NEED A PERMIT?

There are three laws that may apply to camp road maintenance: the Erosion and Sedimentation Control Law, the Natural Resource Protection Act, and the Mandatory Shoreland Zoning Act (with associated local ordinances). All of these 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 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 be 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.

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.

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.

Road associations can be loosely formed or highly organized. Generally, the more organized the association, the easier it is to maintain the road and share the cost. A good option for road associations is to incorporate as a non-profit corporation with the State of Maine **and** to develop a set of rules by which you will do business (by-laws). The primary purpose for incorporating is to avoid lawsuits involving association activities against individual members.

INCORPORATING AS A NON-PROFIT

Following are some steps to follow to form a non-profit corporation:

- ❑ Discuss incorporating ahead of time with all the landowners that benefit from the road. This gives people an opportunity to ask questions, express concerns, and it gives you the opportunity discuss the benefits.

- ❑ Notify landowners at least 30 days ahead of time – preferably in writing – of the meeting to discuss and vote for incorporation.

- ❑ Hold the meeting. Be sure to have a clear agenda and stick to it. Set aside plenty of time for discussion, and take accurate minutes.

- ❑ Vote. A majority vote is necessary to pass a motion to form your non-profit corporation.

- ❑ If a majority of the landowners vote for incorporation, complete the form entitled "Non-Profit Corporation, State of Maine, Articles of Incorporation." This form can be obtained from the Bureau of Corporations, Elections and Commissions at 101 State House Station, Augusta, Maine 04333-0101 (Tel: 207-624-7740). There is a $20 annual filing fee. You'll be required to name a Registered Agent (this person has to be a Maine resident), and five incorporators. The Registered Agent must also fill out the form "Acceptance of Appointment as Registered Agent."

BY-LAWS

Your next step is to adopt by-laws and elect officials. Topics covered by the by-laws should include items such as:

- ❑ a purpose statement (describe the location of your private road and that you have formed for the purposes of maintaining the road);
- ❑ membership (who is eligible to be a member and vote);
- ❑ dues;
- ❑ election of officers;
- ❑ duties of directors and officers; and
- ❑ meetings.

By-laws should be tailored to each association's needs, so you may want to consider hiring a lawyer experienced in private road agreements to help you set up your by-laws.

The State of Maine Private Way Law (MRSA Section 23, Part 3101, Chapter 305, Subchapter II) allows landowners to underwrite necessary maintenance costs and establishes an enforcement process for collecting dues. To qualify under this law, a private road must:

- ❑ provide access to four or more parcels of land;
- ❑ benefit three or more different landowners;
- ❑ have three or more parcel owners who agree to file; and
- ❑ not be a road constructed or primarily used for commercial or forest management purposes.

Essentially, this law allows for the recouping of maintenance costs, **but** specific procedures **must** be followed so landowners have the opportunity to vote on proposed maintenance projects.

This description is not intended as a legal reference, and the reader should refer to the actual statutory text for the specific details of the law. They can be obtained on the State of Maine Internet Home Page at http://www.maine.gov. Go to the Legislature Home Page, then Revisor of Statutes, publications, Maine revised statutes, and look up the law by title and chapter. Be sure to read the disclaimer, since recent amendments to any law do not show up on the Internet site for several months after the changes have been accepted by the legislature. You may also call the State Law Library at 287-1600.

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/blwq/docwatershed/roadassociation.htm or contact your local Soil and Water Conservation District or DEP Watershed Management to obtain a copy.

CAMP ROAD 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. It has been estimated that $1 spent in regular maintenance will save $15 in capital repairs. Furthermore, 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. Maintenance should not be viewed as a liability, but as an improvement. The old adage "an ounce of prevention is worth a pound of cure" holds true for camp roads.

The key to effective budgeting is to establish a realistic long-term maintenance plan. Proper planning should anticipate routine (annual) maintenance work, such as grading, culvert re-

placement, and ditching. Long-term planning helps ensure a safe road and lower maintenance costs. It can also avoid or spread out the cost of more expensive repair items over time. For instance, culverts may seem costly ($600.00) when viewed from any given year, but not nearly as costly when they are paid for over the culvert's 25-year life span ($24 per year).

Road Budget - (Sample Items)

Calculate the road's replacement cost. Estimates of $10 to $50 per foot to build a camp road are common.

Example: 2000 feet of road at $10 per foot costs $20,000 to construct.

Calculate the yearly maintenance cost of the road. Consider the life span of the materials.

Example: Assume the 2000 feet of road has 5 culverts. The cost of installing 1 culvert is $500, including excavation, proper pipe length, and gravel bedding.

Thus, 5 culverts at $500 each equal $2500. The life span of a properly installed culvert is 25 years. This means that, each year, $100 is needed just for culvert replacements.

Gravel roads can lose ¼ to ½ inch of surface material per year. In this example, this amounts to approximately 30 yards of gravel per year. The value of this material is $300 to $400. Therefore, the yearly wear and tear on a properly constructed road of 2000 feet is $500 in materials. The cost of labor is not included in this example.

It is a good idea to earmark some funds for capital improvement work on a yearly basis. A general rule is that it costs 25 to 50 cents per foot of road for yearly maintenance. Using the higher figure may provide contingency funds for major improvements or natural disasters.

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. The following few pages provide some useful tools and information to help you get a start on your camp road budget.

SAMPLE BUDGET CALCULATIONS

Culverts

(number of culverts x cost) ÷ expected lifespan of culvert = annual cost (See the table on page 20 for the expected lifespan of different types of culverts.)

Example: 6 metal culverts x $600.00 ÷ 25 years = $144.00/year

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

Surfacing

Surface loss from dust, use, and snowplowing:

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

Example: 2,000 ft. x 0.015 yd. x $6.00/yd. = $180.00/yr.

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.

Grading

Have a contractor give you an 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 $60/hr. = $120/yr.

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 $10/ft.) x 1.04 ÷ 2 years = $520/yr.

Erosion Control and Miscellaneous

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

Example: ($144 + $225 + $120 + $520) = $1009 x 0.1 = $100.90/yr.

Total Annual Cost to Maintain the Road

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

Example: $144 + $225 + $120 + $520 + $100.90 = $1109.90/yr

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:
$1109.90 ÷15 = $73.99/user/yr.

Budget Worksheet			
Length of Road (feet)			feet
Number of Culverts (#)			
Costs	**Estimated Unit Cost (if actual is unknown)**	**Actual Unit Cost (if known)**	**Total Annual Cost**
Annual Grading Cost ($/1000 ft.)	$50.00/1000 feet		$
Surface Material Cost ($/yd.)	$6.00/yard		$
Cost to Purchase & Install Culvert ($/culvert)	$600.00/culvert		$
Capital Improvements	$10.00/foot		$
Erosion Control and Miscellaneous	10% of total annual cost		$
TOTAL ANNUAL COST			$

TROUBLESHOOTING GUIDE

This troubleshooting guide is intended to be a quick reference to help you understand some common problems on camp roads.

ROAD SURFACE PROBLEMS

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

- ❑ Insufficient road crown. A proper crown should shed water laterally off the outer edges of the road surface (see page 11).
- ❑ 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 12).
- ❑ Water is traveling in a wheel rut. Road needs to be regraded (see page 12). This problem often results from soft roads (see "Tire Rutting," below).
- ❑ Road ditch is not large enough and overflows onto road surface. Ditches need to be made larger (see page 16), or there are not enough turnouts to get water away from the road (see page 30).
- ❑ 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 8), and adjust as necessary. A grader should be used to remove washboarding and mix road materials. Alternative road surface materials may be necessary in certain high stress areas (see page 9).

Problem: Tire rutting on soft roads
Possible Causes:

- ❑ Poor road base material does not drain efficiently (see page 8). Road base needs to be reconstructed with suitable soil materials, or consider using geotextiles (see page 35).
- ❑ Insufficient ditching. Ditches need to allow subsurface water to drain out of the road base (see page 15).
- ❑ Poorly drained native soils that may be unsuitable for typical gravel roads. Consider using geotextiles (see page 35), or restricting access for seasonal use only.
- ❑ Insufficient road base thickness. Road base should be reconstructed, or consider using geotextiles.

Problem: Muddy or slippery road surface
Possible Causes:

- ❑ Poor road surface material containing too many fines (see page 8). Good surface material needs to be added or blended with existing surface using a grader.
- ❑ Insufficient road crown, which allows water to sit on the road surface. Road needs to be recrowned to promote drainage (see page 11).

Problem: Dust
Probable Cause: Poor road surface material. Apply new road surface material with the proper soil gradations (see page 8), or use of calcium chloride as a dust suppression agent (see page 36).

Problem: Too much loose gravel
Probable Cause: Poor road surface material that lacks fines due to dusting or erosion. New road surface material is needed (see page 8).

Problem: Lateral erosion cutting across the road surface
Probable Cause: This most often occurs at a low spot by the road; water builds up and eventually overflows and erodes the road. The water needs to be conveyed to the other side of the road by means of a culvert (see page 19) or ford (see page 26).

Problem: Potholes
Probable Cause: Potholes almost always result from insufficient road crown. Regrade road to remove potholes (see page 12), then re-crown (see page 11).

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 21). Minimum recommended culvert diameter is 15 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 21).

Problem: Crushed culvert
Possible Causes:

- ❑ Improper installation (see page 21). 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 21). 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 21 for proper installation procedures.

Problem: Culvert is eroding around the ends
Possible Causes:

- ❑ Insufficient armoring of culvert ends with rocks (see page 21). Outlet area (plunge pool) of the culvert should also be protected with rocks (see page 24).
- ❑ Culvert is too short and doesn't allow for proper protection of the side slopes (see page 22).

DITCH PROBLEMS

Problem: Bottom of ditch is eroding
Possible Causes:

- ❑ Ditch is too small to handle the volume of water flowing through it. Consider resizing the ditch (page 16), and/or periodic turnouts to get rid of some water (page 30).
- ❑ Bottom of ditch is too narrow (V-shaped) and needs to be widened (parabolic-shaped) (see page 16).
- ❑ Slope of ditch is too steep to handle flow without additional protective measures. Consult an expert or add vegetative protection (page 32), riprap armoring (page 17), and/or turnouts (page 30).
- ❑ 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 18).
- ❑ Side slopes need to be vegetated (page 17), or riprapped (page 17) to protect against erosion.

RESOURCE DIRECTORY

Maine Soil & Water Conservation District Offices

Androscoggin Valley	753-9400 x 3
Central Aroostook County	764-4153
Cumberland County	892-4700
Franklin County	778-4279
Hancock County	664-7496
Kennebec County	622-7847 x 3
Knox/Lincoln County	273-2005x101
Oxford County	743-5789 x 3
Penobscot County	990-3676 x 3
Piscataquis County	564-2321 x 3
Somerset County	474-8324
Southern Aroostook County	532-2087 x 3
St. John Valley	834-3311 x 3
Waldo County	338-1964 x 3
Washington County	255-4659
York County	324-0888x214

Contact the office for your particular region

Maine Department of Environmental Protection (DEP)
17 State House Station
Augusta, ME 04333-0017
(800) 452-1942 (in state only)
287-7688

Bureau of Land and Water Quality (BL&WQ) – licensing, enforcement, water classification, shoreland zoning, and field services 287-3901

Division of Watershed Management – nonpoint source pollution control, watershed surveys, BMP training, technical assistance 287-3901

Regional DEP Offices – BL&WQ

Augusta	287-3901
Bangor	941-4570
Portland	822-6300
Presque Isle	764-0477

This publication and other related materials are available at: www.maine.gov/dep/blwq/docwatershed/materials.htm.

There are other resources, such as local watershed districts, private lake associations, and municipal code enforcement officers, available to assist with camp road issues. Your local Soil & Water Conservation District representative will help you to find other local resources.