



**An owner's manual for  
those who live and travel  
on dirt and gravel roads**

**by Russ Lanoie, Conway, NH**



**Includes a complete Troubleshooting Guide and Quick Tips  
for low cost/no cost things you can do right away to  
improve your unpaved road or driveway**

Russ Lanoie has been a specialty sitework contractor in the White Mountains of New Hampshire for over forty-five years. He has an Associate's Degree in Civil Technology from UNH and has written about and presented programs on energy conservation and solar home design, understanding septic systems, wet basement mitigation and, as in this document, unpaved road maintenance.

His early years in construction were spent building campsites, starting with an old Gravelly hand tractor leveling sand and gravel. He eventually graduated to a skid-steer (Bobcat style) loader and finally to a small articulated loader and a couple of compact diesel tractors.

Most of his work in recent years finds him in the seat of his truck or one of his tractors grading area roads and driveways with the Front Runner grading device that he developed in the late 1980's. He has found that it does not require a large and expensive machine to



be successful at this, but rather an understanding of just what needs to be done to get water off of and safely away from unpaved roads.

Russ is available to conduct road maintenance workshops based on what is presented in this manual throughout northern New England.

**The author and his one ton truck after regrading a local development road during "Mud Season" in the White Mountains**

**Note that most of the photos in this manual were taken during actual grading or maintenance operations by the author.**

**The diagram on page 6 is from the Maine Local Roads Center.**

**The top photo on the cover is of the road to a private home in Madison, NH that required lots of stone added to the surface to make it passable one Spring until the side of the road could be ditched to get rid of melt water. See the Troubleshooting Guide, 11.2 on page 26.**

**The bottom photo is explained on the inside back cover.**

*I'd like to thank my friend, neighbor, client, and ski buddy, Lee Pollock, PhD of Madison, NH for his encouragement and help in editing this manual. Lee is a fresh water biologist who lives on a local pond and recognizes the importance of reducing non-point-source pollution, like that from poorly maintained camp roads, from entering our surface waters. I also thank another long time friend and client, Ed Bergeron, founder of HEB Engineers of North Conway for his help editing section 10, Getting Rid of Stormwater. Finally I thank yet other long time friends, American School administrators, and world travelers Tony & Jenny Simone for their "priceless" photo of the Mongolian road grader on the back cover!*

# A Ditch In Time

**An owner's manual for folks who live and travel on dirt and gravel roads**

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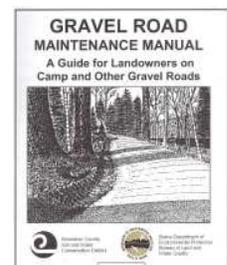
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## Acknowledgements:

This manual is based on the Gravel Road Maintenance Training Workshops presented across Southern Maine in conjunction with the FrontRunner project that placed truck mounted grader/rake attachments in Soil & Water Conservation Districts. It also includes much of what I've learned through the federally and state DOT sponsored Transportation Technology Transfer Centers as well as what I've discovered in over 45 years of building and maintaining "camp" roads and driveway.

Throughout this document you will see references to the GRAVEL ROAD MAINTENANCE MANUAL provided online by the Kennebec, Maine County Conservation District and Maine DEP. It addresses many of the issues relating to rural gravel and dirt roads from the basics of erosion through how to choose a contractor to do the work. I strongly recommend that you also take advantage of this information to round out your understanding of the subject. Download at:

[www.maine.gov/dep/land/watershed/camp/road/gravel\\_road\\_manual.pdf](http://www.maine.gov/dep/land/watershed/camp/road/gravel_road_manual.pdf)



Thanks for reading this manual and feel free to contact me with questions and/or comments

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## INTRODUCTION:

**Ruts, bumps, potholes, mud, washboard and dust** make unpaved rural roads and driveways uncomfortable and sometime nearly impassable for the motorists who use them. It's the washouts that occur along with these inconveniences that create a greater long-term problem, however.



Although only certain roads provide direct access to ponds, lakes, and streams, the runoff from *all* roads eventually finds its way to surface water. Unstable roads become channels through which sediments and nutrients reach sensitive lakes and ponds, causing significant adverse effect on water quality.

In the old days, back before any country roads were paved, landowners often played an active role in their care. They understood that a few minutes work with a hoe at the beginning of a rainstorm could get the water off of a road and keep wheel ruts from turning into deep gullies. **A Ditch in Time**...(with apologies to Poor Richard) implies that there are still basic maintenance steps that can be taken to prevent major damage from occurring to our many remaining miles of "dirt" roads. Most of these steps still have to do with controlling water, from getting it off and away from the road to choosing materials that can work well in the presence of too much water and, at times, in its absence.

This manual is intended to help you learn how to effectively maintain and improve the surface of these roads. A properly planned and

well-executed maintenance program not only makes the road more comfortable to travel on, but also reduces maintenance costs over time. More importantly, it also reduces the impact of erosion on fragile streams, lakes and ponds, helping to preserve these resources and the special qualities that attract us to them.



**Runoff carries sediment and nutrients into surface waters.** The photo at left is of a main road in a second home community in Conway, NH during a Spring rainstorm that happened when the edges of the road were still encased in ice. The above photo is the Saco River downstream from this and many other developments. While the sediment is visible, the nutrients which can pose the greater threat are invisible.

**The concept of "A Ditch In Time" holds as true today as it did in colonial days when a carefully place depression across a road with a hoe, a stick, or even the heel of a boot at the beginning of a rainstorm could keep the traveled part of the road from disappearing. This manual helps to bring this concept into the 21<sup>st</sup> century.**

## 1.0 WHAT IS THE PROBLEM WITH UNPAVED ROADS?

Why do gravel roads present such an erosion problem compared to construction sites? Gravel roads are seldom, if ever, surrounded by “silt fence” or other siltation control devices unlike construction projects that have silt controls installed by law and are ultimately stabilized after construction is finished.



**Road construction site bordered by properly installed silt fence**

Gravel roads, on the other hand, remain unprotected by grass, mulch or pavement for their entire existence. Proper maintenance is critical to keep road surfaces in place through rain events that seem to be increasing in intensity in recent years.

To our benefit, the same techniques used to improve the road surface to reduce erosion also make the road easier and smoother to travel on. This helps to make allies of all road users, helping to win their confidence when we strive to perform other upgrades to reduce sedimentation.

It is important to understand some of the basics of how a road should be built, so we'll briefly start from the beginning.

Unpaved roads are typically made of gravel, and the purchase of gravel is one of the greatest expenses that most home and associations owners make. However, since gravel varies widely from place to place and even within one operator's pit, let's look at what makes *good* road building material.

## 2.0 SOILS 101

Characteristics to consider when examining the soil materials used for roads, or *aggregates*, are: size, shape, durability, and permeability. Each helps determine if a material is suitable for use in some part of a road structure.

**SIZE:** Larger soil materials can range from boulders (used for culvert headers and erosion control) to small stones which make up the *gravel* used in the base of a road. *Sand* consists of smaller particles that can vary from as coarse as rice to as tiny as the eye can see. *Silt* particles are smaller than can be seen with the naked eye. *Clay* is so fine that a moist lump of it feels greasy to the touch.

**SHAPE:** The stones that make up gravel can range from being very *round* to being very *angular*. This factor is most important when considering the type of material to use for the surface of a road. Rounded stones have a tendency to roll out of the roadbed, especially on hills and curves, while angular stones have the ability to lock together for stability. The more angular a material is, the more suitable it is for road surfacing.

**DURABILITY:** As with shape, this factor is particularly important for surfacing material. Different areas of the country and even different soils within the same area can have different types of rock with varying hardness and, therefore, greater or lesser resistance to wear.

**PERMEABILITY:** This defines the soil's ability to allow water to pass through it. The more permeable, or porous that a soil is, the faster water will drain. Clean sand and gravel usually let water pass freely while soil that contains more silt and clay drains slower.

## Where do road materials come from?

Most road building materials are taken from a gravel or "borrow" pit. Without processing of any kind, such material can contain rocks of any size. There are two ways that this *bank-run gravel* can be processed to limit the size rocks and stones in the final product. Screening the gravel removes all rocks and debris that are larger than the holes in the screen. Processing bank run gravel in a stone crusher breaks down the large rocks to a uniform maximum size resulting in *crushed gravel* that is also known as *crusher run*. This crushing process is also done to blasted ledge or bedrock, breaking large pieces of rock down into small pieces and also creating stone dust that is actually particles of sand, silt and clay. Screened and crushed gravel also have stones in it that are no larger than some designated size (such as 1½" 1" or ¾") but also contain all of the smaller sands, silts and clays called "fines".

Screened gravel often has many stones that are rounded due to the way the gravel was formed by nature. Crushing bank run gravel helps to produce more angular material, as all stones that are larger than the designated size are broken down by the crushing process. Crushing ledge results in a product that is the most valuable surfacing material because every bit of it is broken and angular. The durability of the final product depends on the strength of the original rock that produced the gravel.



**The best material starts as solid rock that is drilled & blasted (above) then crushed into smaller pieces and screened to produce specific size aggregate.**



**Besides producing "aggregate" that is uniform in size and, ideally, in content of fines versus stone, this process makes stone that is much more angular than that made just from screening bank-run gravel**

Please note:

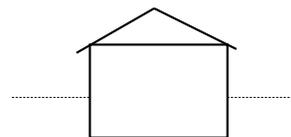
- Architects and engineers usually refer to what those of us in the trades typically call CRUSHED STONE as *GRAVEL*. What they refer to is actually washed & graded stone *only* with no sand and or fines to fill the voids.
- For our purposes, **GRAVEL** is a mix of stones, sand, and "fines" as explained above.

Well-built roads use a variety of materials of different size aggregates and permeability for different parts of their structure. Since there have been many mix-ups by customers ordering one product only to find that something different gets delivered,

***be careful what you order!***

It often helps to understand the structure of a road by comparing it to a house. Both a road and a house require something on top that can withstand the elements and shed water to keep the structure below it dry. Both must contain durable materials throughout.

A road should be like a house:



- A strong foundation to provide support
- A roof to shed water to keep the inside dry

And just like a house, a road needs a foundation that provides support for everything that rests on top of it. A road base must be able to drain well or at least withstand the effects of groundwater through all circumstances or it will cause the structure above it to fail.

### 3.0 GOOD ROADS START AT THE BOTTOM

This document deals primarily with the maintenance of existing dirt and gravel roads that many of us live on and travel daily. There is not space here for a complete discussion of proper road building techniques, and most of those using this manual are faced with maintaining a road that has already been built.

However, it is essential to be able to recognize when a particular problem with a road is caused by inadequate base materials and/or by poor drainage. Patching over existing road base problem is like painting over rotten wood. Note the number of *paved* roads that crumble each spring because they were never properly built from the bottom up.

Just as when building a house, the foundation for a road must be carefully constructed first. All stumps, large rocks, and areas of soft or organic soil must be removed and replaced with well drained, coarse gravel containing less than 10% fines (silt and clay). Porous bank-run gravel with the large rocks removed can work well. Gravel that has been crushed to a maximum size of 6" is more expensive but generally provides an excellent base. Good gravel also has excellent weight bearing capacity and should be very stable when used in a road structure.

**The road base requires a strong foundation:**  
**-Larger “aggregate”** to support the surface and the loads it will have to bear  
**-A minimum of “fines”** to keep water from wicking up into the road and making it unstable

**How strong should it be?**



**One big truck has proximately the same effect as 10,000 cars!**

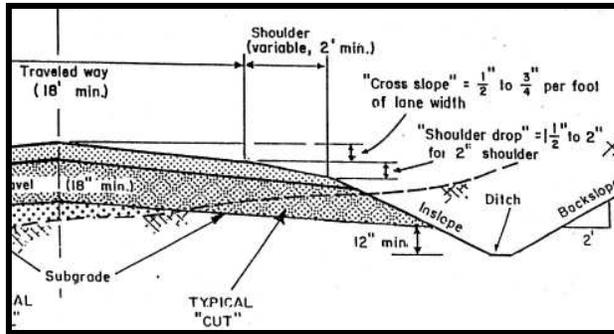
However, even a road base that is made from well-drained material can perform poorly if too much groundwater is allowed into it. Just like a house, there must be some means to keep water out of the road structure.

### Keeping the base dry

**3.1 Surface ditches** built on either the uphill or both sides of a road serve a number of purposes in any road situation.. When properly constructed and maintained they will:

- Drain subsurface water from the base and subgrade, improving the structural qualities of the road.
- Collect surface runoff and channel it away or to a proper crossing point in the road.
- Serve as a storage area for large amounts of rainfall.
- Collect and retain soil particles that normally would be washed into a channel way.

### 3.1 Surface ditches continued



Ditches should be kept clean to allow water to flow freely from the roadway. From there, water should be routed away from the road rather than allowed to settle alongside into depressions where it will cause the road to weaken. Ditches also must drain water away from adjacent property that it might damage.

*Note that it is good practice to discuss changes in drainage patterns with the landowners that receive runoff waters to protect their rights as property owners and avoid unintended impacts..*

See further information on ditching in the [Maine Gravel Roads Manual](#)

Limited rights of way, stone walls, and other restrictive problems with existing camp roads often make it impossible or impractical to achieve a proper road cross-section with adequate side ditches. In these cases it may be necessary to draw the water out of the road base by another means.

**3.2 Subsurface drains** provide a means to intercept and divert ground water where it is not possible to provide adequate side ditches. Pervious (perforated or slotted) pipe or some other specially designed drainage product is bedded in porous sand or gravel in a ditch along the edge of a road and directed downhill to a safe outlet. The pipe draws in groundwater, removing it from adjacent areas and preventing it from reaching the roadbed. The deeper the pipe is installed, the more effect it can have on draining a road. The limiting

factors in this type of installation are the need for slope to move water by gravity, and the need for a place to safely outlet the water.

Removing water from under a road is very much the same as installing perimeter drains around a house.



**Installation of an underdrain on the uphill side of a private driveway to remove groundwater**

**3.3 Geotextile, a new alternative** for firming up soft roads has developed in recent years with the advent of burlap-like synthetic fabrics that are being used to solve unstable road base problems. Geotextiles have made it possible to cost-effectively stabilize roads without having to dig up and replace *any* base material *or* provide additional drainage.

These special fabrics are simply rolled out over an unstable section of road and covered with several inches of gravel. The geotextile provides a layer of separation between the surface gravel and the road base, keeping heavy traffic from pushing the road surface down into and mixing with the base even when roads are saturated with water.

The fabric comes in long rolls that are 12.5', 15' and wider. It is inexpensive, readily available, and easy to use. For years it has been simplifying new road construction and solving past problems quickly, easily, and, as far as experience has shown, permanently.

**See more on Geotextiles at the [Troubleshooting Guide](#) at the end of this manual. Also see the [Maine Gravel Road Maintenance Manual](#) for more details about how a road should be constructed from the beginning.**

## 4.0 THE SURFACE

The surface of an unpaved road must, like the roof of the house, be able to shed water to protect the rest of the road below it. It also must be both strong and firm enough to withstand the wear and tear of vehicles driving over it.

### 4.1 Characteristics of good surface gravel

**Durability:** Surface gravel should always contain a considerable amount of stone that is resistant to wear. Also, the more *angular* the stone is, the better, because it is angularity that helps keep stones locked together in the road surface in spite of the action of wheels tearing at it. This is why crushed gravel, and particularly crushed ledge is preferable to screened material.



angular (good)

rounded (poor)

**Size:** The maximum size stone recommended for a finish surface is 1" or *less*. Larger stones, especially if they are rounded, have the tendency to become dislodged from the surface on hills or curves. Many prefer to use ¾" ledge based crushed gravel whenever possible because of the fine finish it provides for cars, bicycles and foot traffic.

**Cohesion:** Road surfacing gravel needs to be able to hold itself together to fight the effects of water and traffic. It requires *binder*, in the form of particles of silt and clay to fill the voids between the larger aggregates and act as a sort of cement. Surface gravel should not allow water to pass through it into the base. Instead, it should shed water to the ditches because of its shape.

Unfortunately, much of the crushed gravel manufactured by large sand and gravel companies is designed to be used as a base layer under asphalt pavement. It needs to be able to bind together only enough to support the paving machine that lays down the permanent surface. For this use it is preferable that the gravel drain so that it does not retain water under the pavement.

Surfacing gravel, on the other hand, needs *lots* of binder to keep it together. Therefore it is necessary to keep any fines that may have been a part of the gravel originally or are the product of a crushing operation, rather than screening or washing them out during manufacture.

Therefore: **The dirtier the better**

**The ideal mix** for surface gravel should contain almost 50% sharp angular stone of a maximum size of ¾" with enough sand, silt and clay to fill up all of the spaces between it and lock it together. When wet it can have almost the consistency of wet cement, to the point of being muddy, and when dry will set up almost as hard to the touch, forming a crust that sheds water rather than allowing it to drain through.



¾" minus crushed gravel with fines washed out so the larger "aggregate" is visible. Note the sharpness of the stone due to this being ledge based gravel and that the stone is approximately the same size as a quarter

## 4.2 Determining the mix:

How do you find out just what percentages of these different materials you have in your existing road or in the gravel someone is trying to sell you? It is easy to estimate the amount of stone and its shape by visual inspection, but figuring how much sand, silt and clay particles are present is quite difficult, especially because the smallest particles are invisible.

Engineers perform this test with a set of precision sieves (fine screens). The percentage and size of soil particles is determined by the size of the sieve mesh opening that the particles are retained on after sifting. As most of us do not have access to these sieves, a simpler test is quite helpful.

**The Veryfine test:** Find a clear container such as an empty juice bottle (glass or plastic) with a fairly wide opening. Fill it half full with the soil material to be tested. Add water to fill the container then shake well. Set the container down and notice that the largest particles settle out immediately while the smallest particles remain in suspension for a long while, the same as they do during the erosion process. After sitting long enough, the water becomes clear again. The different materials in the sample have graded themselves and allow you to see the approximate percentage of each soil type in the sample. The longer it takes for the water to become clear, the more of the smaller fines there are. If the water becomes clear almost immediately, the soil lacks fines.

A simple field test for fines is to grab a small fistful of the gravel to be tested and wet it with a little water. If the whole mass becomes muddy and smears against your skin as you work it around in your hand it contains fines. If its consistency does not change and it fails to become pliable or smear your hand, it does not contain fines. Also remember to look for the size, shape and percentage of stone. Without adequate stone a road surface will not be stable and stand up to wear.

The desired amount of fines in the different parts of a road are listed in the following table.

Surface	7 to 12% fines
Base	5 to 10% fines
Subgrade	0 to 5% fines

These gradations will allow for proper drainage over and throughout your road cross section.

**One simple way to judge whether gravel will pack or not is to observe it in the pile at the gravel pit. If it holds a steep bank as material is being removed it likely has sufficient binder in it to provide a good surface.**



Another way is to see if it flows freely under the tailgate of the haul truck when the driver attempts to “tailgate spread” by hooking the tailgate chains to the body to only allow a certain amount of gravel to run out under the tailgate gate as he drives along. If it does not come out, it probably has good binder, though the truck driver will be quite annoyed at having to break loose the bound up gravel from behind the tailgate before he lengthens the chains!



**Oops! Here the driver set the tailgate spread chains too tight and the gravel bound up because it had lots of binder.**

**In short: the road surface should have...**

- **Lots of small aggregate** (stones) to provide strength with a **shape** that will lock stones together to support wheels
- **Sufficient “fines,”** the binder that will help cement the stones together, to keep them from moving around

**It is usually safe to ask for  $\frac{3}{4}$  MINUS gravel to get the best road surfacing material. Remember that:**

**“Dirty” gravel *packs* but does not *drain***  
**“Clean” gravel *drains* but does not *pack***

Hard packing gravel is critical on hills and the inside of steep corners (switchbacks) because tires tend to tear up loose gravel.

A proper combination of correctly sized broken rock, sand and silt/clay soil materials will produce a road surface that hardens into a strong and stable crust that forms a reasonably impervious “roof” for your road. An improper balance of these materials results in a surface that is loose, soft & greasy when wet, or excessively dusty when dry.

Adding calcium chloride can help stabilize road surfaces while also reducing dust.

(see [Troubleshooting Guide page 29](#))

In some cases the steepest hills may need to be paved to keep them from eroding.

### 4.3 Alternative surface materials

There are other road surfacing materials available, some of which are specific to certain regions and some are gaining wide acceptance universally. The same rules apply to any of these as to good ledge-based gravel:

**Ledge pack:** is usually another name for ledge based crushed gravel

**Rotten Rock-**is ledge that breaks up into small particles as it is dug up. It is a traditional surfacing material in the Mt Washington Valley and a few other places. It packs hard, but continues to break down under heavy traffic, turning it into fines that lack the strength of granite ledge based gravel.

**Crushed concrete-** be careful to be sure it has enough binder (fines) to make it pack.

**RAP (recycled asphalt pavement)** Again, be sure it has enough fines. Pavement is made of clean  $\frac{3}{4}$ " and smaller aggregate with *no* fines. Hot asphalt provides the “glue” that holds it together instead of fines. Asphalt starts at the plant at 360°F and is laid down at 275°F but recycled asphalt never reaches that temperature on the ground to rebind it together. It works well for low volume, flat areas or as base material but DOES NOT USUALLY PACK unless it has had binder added.

## 5.0 GRADING THE SURFACE FOR PROPER DRAINAGE while also getting rid of those Ruts, Bumps and Potholes

**The three most important rules to remember when designing, building and maintaining a road:**

- #1. **Drainage:** keep the water out of the base
- #2. **Drainage:** get the water off the surface
- #3. **Drainage:** get the water safely away



### **Water is the enemy of the road!**

And yet it is essential to have some moisture present in the surface of the road when regrading or smoothing it. The best time to smooth or reshape a road is immediately after a rain. Water helps to loosen the surface, reduces dust during the process, and yet also helps the material to recompact after grading. Never work a dry road, especially if it does contain a large amount of fines. For further discussion on [When to Work the Road](#) see section 9.0 on page 24

The condition of a road surface determines whether a road should be smoothed or reshaped.



**5.1 Reshaping** is generally done late in the spring of the year when the road is still soft but not unstable. Reshaping involves *cutting as deep as necessary to get to the bottom of all ruts and potholes*. In many cases there will be a berm (ridge of gravel or dirt) at the edge of the road that results from previous grading, snowplows pushing aside unfrozen gravel and accumulated winter traction sand, as well as the scuffing action of wheels, especially on curves. This material must be reclaimed by pulling it to the center of the road. Reclaimed material is now blended and reworked as if it were new and properly shaped into a crown. However, too much accumulated traction sand may need to be removed rather than be reworked into the road where it will make the surface unstable.

**5.2 Smoothing** is the process of regular maintenance and involves less penetration into the road surface. It should be done as often as necessary to keep the road from needing to require reshaping.

Neither the reshaping nor smoothing process should ever allow the formation of a berm or ridge beyond the work area at the edge of the road above the ditch. Even the tiniest berm acts as a barrier to surface water drainage, particularly on hills, and prevents water from properly reaching the ditch. It could be the cause of very serious damage in the future. **Also see section 7.6 on page 20**

**5.4 The correct shape or "CROWN"** A gravel road surface that is too flat permits water to puddle in low areas where it softens the surface, weakening the roadbed by encouraging water to seep into it and also by loosening up the surface fines. As traffic splashes water out of the puddles, the fines are carried away and *potholes* begin to form.

Roads should be crowned, or pitched, in the shape of the letter "A" to promote drainage of surface water from the road into roadside ditches (if there are any) to minimize the detrimental effects of water on the traveled way.

But doesn't a crown usually look like:



Yup! But that doesn't make it right! A rounded crown leads to a problem with the center of the road because it's the **only part of the road not pitched** to one side or the other. And it often gets twice as much traffic as either side because traffic going each direction tends to put one wheel down the middle of the road!

**The figure at the bottom of the page shows proper "A" shaped crown, typical parabolic or rounded crown, W shape of many camp roads, and depressed "native soil" road.**

Here's what happens to a road with a rounded crown: (also see back cover)



**Potholes down the middle where the road is the flattest and where most drivers put their left wheels**



**Proper crown**



**Typical rounded crown**



**W shape**



**Depressed road**

## How much crown?

A rule of thumb for gravel roads is 1/2 to 3/4 inches of pitch per foot of width. Roads with greater than 3/4 inches per foot are difficult to maintain and drive over.

This pitch should continue over the *entire road width* from one shoulder to the other. Curved road sections often maintain this single pitch across the whole road by sloping only toward the inside of the curve. Thus this slope on a right hand curve:

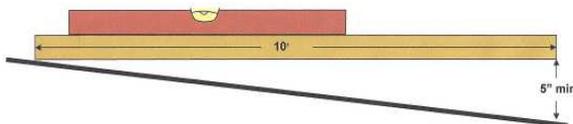


Most roads, however, break the pitch in the middle, which should result in the "A" shaped or "teepee" *crown* and *not* the rounded crown that is so common.



Note that single lane roads and driveways do not require the "A" shaped crown because vehicle wheels seldom touch the center of the road. Although it is still critical to provide a crown, it is acceptable for it to be rounded in the center.

**Measuring the crown:** A crown of 1/2 inch per foot means that a 20' wide roadbed (two 10' lanes) should have a centerline five inches higher than the edge of the road. That represents 1/2" of rise for each foot of width from the center to the edge. The simplest tool for checking this crown is a straight piece of wood or metal ten feet long with a carpenter's level on top. One end of this "gauge" is set in the middle of the road and the other end propped up on a rock or the toe of your boot until it is level. The distance from the end of the gauge to the ground should be five inches.



By contrast, paved roads generally require only half this pitch, or 1/4" per foot or 2 1/2" for a 10' lane. Other paved surfaces like driveways and parking lots require even less pitch to shed water, about one inch per ten feet. The integrity of the paving material is generally adequate to keep potholes from forming, even if there is an occasional "birdbath".

Many gravel roads started as wagon paths and have had little done to them except to add gravel and, perhaps, have a ditch cut on each side. Most are no more than a lane and a half in width. This means that most cars always drive with one set of wheels (the left ones) *in the center of the road*. When a vehicle approaches from the opposite direction, both drivers simply swerve slightly to accommodate the other and then return the left wheels to the center of the road. Even if the road was built as two full lanes, poor ditch maintenance or brush encroachment often pushes drivers toward the centerline. Lack of a yellow line seems to have the same effect.



**Example of proper crown slope at left only and flat at right, with potholes; same road, different slope on each side**

Reshaping, smoothing and restoring crown each require cutting into the road surface and redistributing the gravel. Also, because reclaimed material often contains significant amounts of debris it is important to be able to separate it and maximize the amount of material

reclaimed. Before we take a look at how to actually do the work we need to examine a common problem with rural dirt roads that were never built correctly from the start.

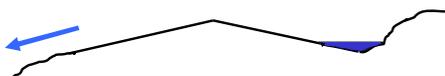
### 5.5 Roads built into native soil

Properly constructed roads are built above the natural ground. Many camp roads, however, were originally built simply by removing the organic layer and cutting into the existing soil. Often there has been little or no gravel added either to reinforce the base or to form a surface. Although not ideal, these "native soil" roads can be satisfactory where local soils are reasonably strong and well drained. Where native soils are not adequate, it is necessary to provide some other means of support or drainage, such as the addition of surface gravel over geotextile.

Often the right-of-way for a camp road is too narrow or the road is cut too deep into the parent soil to allow for the construction of an ideal road cross section that includes proper side ditches. These roads simply rely on the edge of the road to conduct water. While this is not as ideal as having a true ditch system it can often work satisfactorily, especially if the crown of the road is maintained and the "ditch" side is kept clear of leaves and debris. This minimizes the chance of a significant rainstorm causing severe damage to the traveled way.

In extreme cases, as in the heavy rains that we are experiencing more and more, this road edge "ditch" may become washed out. If the ditch has remained clear of debris that can redirect water out into the road, the traveled way will remain intact and the washed out edge can be repaired. If this is a chronic problem, the road edge can be reinforced with stone as outlined in section 8.2.

Many roads have no ditch system, water flows where the edge of the roadbed meets the original ground or off to the side where the roadbed is above original grade



The amount and type of use a road receives determines the type and frequency of grading necessary. For example:

- Trucks carrying heavy loads flatten the crown and create wheel ruts where water can collect and travel.
- Cars traveling too fast blow away light soil particles from the road surface and cause washboarding.
- Heavy summer rains cause washouts.
- Steady rain with lots of traffic on an improperly crowned road results in potholes.
- And snowplows often dig up roads if it snows before they freeze, and particularly, after they begin to thaw in the spring.

The amount and type of use a road receives determines the type and frequency of grading necessary. The condition of the road surface determines whether a road should be smoothed or reshaped.

### 6.0 TOOLS AND TECHNIQUES used

to get rid of the ruts, bumps & potholes and restore crown

#### Why it shouldn't be a drag...

A traditional way to smooth a camp road was to drag a long steel "I" beam or an old bedspring or piece of chain link fence weighted with a log behind a tractor or pickup truck.



While a drag of this type does help to redistribute material, it does little to cut to the bottom of potholes, reclaim material from the shoulder, separate accumulated debris, or restore crown. In fact, indiscriminate use of a

drag can often help to destroy a road by removing a crown and digging out the center of the road. Drags are also difficult to turn around in a dead end road or driveway.

This section examines the proven methods of road surface maintenance and some of the different types of machines used to perform them.

## 6.1 The methods

As already stated, regrading a road usually involves cutting into the road surface and pulling the edge into the center to remove the berm, reclaim material, and reconstruct the crown. Debris must then be separated from reclaimed material and pushed into piles and loaded out or pushed off the side of the road to a place where it will not obstruct the flow of water or infringe on the right of any adjacent landowner. It must also be kept out of delicate wetland areas. Debris can range from rocks and vegetation to discarded rubbish and occasional car parts that have fallen off cars bouncing over potholes.

Where there is little or no surface gravel to work with, regrading can loosen up road base material. Where there is no base gravel, such as in native soil roads, it can dig into the original soil. Either of these materials is likely to contain many stones of varying size. It is possible to reuse much of this stony material by working it into the very center of the road where the new crown will be built up the most. In this way, only the largest stones will have to be separated out with other debris.

When a road is sunken like the native soil roads already discussed, (bottom of page 12) the entire width of the road must be graded right down into the ditch line, taking special care to remove collected leaves and debris from the edge of the road. Failure to remove this debris can force water out onto the traveled way where it is likely to erode a new path around it.

## 6.2 The machines

Machines used for camp and development road maintenance range from road graders built specifically for the purpose to trucks and tractors fitted with various attachments. The actual part of the tool that meets the road falls into one of two categories: a rigid **blade** or a spring tooth **rake**. The tool can be an integral part of the operating vehicle (such as the blade of a bulldozer,) or a separate device attached to a multi-purpose vehicle. Either type can be mounted in front of or behind the operator, depending on the carrying vehicle.

While each device has different features and benefits and must fit individual circumstances, it should also meet the following criteria to be considered suitable.

A device used to adequately restore and maintain a road must be able to:

- cut into the road surface to remove potholes and washboard.
- reclaim material from the shoulder and move it to the center to restore crown
- separate rocks and debris from reclaimed material
- spread new material when necessary
- mix materials into existing surfaces for repairs, and
- provide a means of control to establish a finish grade

In addition to these traditional functions, it is also helpful when the same device can:

- dry out soft and muddy roads in the springtime
- remove snow from unfrozen road surfaces (to reduce snowplow damage)
- cleanout and reshape water turn outs, swales, and rolling dips (to be examined later)
- be easily transported for emergency repairs

## 6.2 The Machines

### Choosing the best system: advantages and disadvantages

The ideal machine for maintaining unpaved surfaces is the road grader. This sophisticated tool is unique in the way it can reposition its blade for a variety of operations. In the right hands it will cut out potholes, reclaim material, restore crown, clean and shape side ditches and do almost everything necessary to maintain a road.



Narrow, winding, and rolling camp roads often present a problem for these machines, however. Graders are usually quite large and expensive and require a skilled operator for good results. Therefore, many other devices have become popular for this purpose, some of which are effective and some little better than the bedspring drag.

**Rigid blades** are the working part of roadgraders and bulldozers, and are used as attachment on the back of agricultural tractors. The advantage of the rigid blade is that it can usually be positioned at an angle that lets it cut out potholes, pull in shoulders, restore crown and also clean side ditches. The disadvantages of a blade are that it requires slow operating speeds because of its rigid attachment to the carrier and also that it has trouble separating out debris. Graders blades also tend to “hop” or chatter when operated too fast.

A "box scraper" that fits behind a tractor is a type of rear blade that is fitted with sides making it somewhat similar to the front bucket on a tractor-loader. While either a loader bucket or a box scraper can cut into surfaces effectively, they cannot easily separate debris or reshape and restore crown.

**Flexible tine rakes** use spring steel tines in place of a blade. They are often mounted on the back of farm or industrial tractors, while tow-



behind rakes are self-contained units designed to be pulled behind trucks or tractors. The advantage that tines have over a blade is that they provide shock load protection to the carrying vehicle, allowing higher operating speeds, and they excel at separating debris. With proper positioning, they can cut potholes and washboard, reclaim material, restore crown, and finish grade. Disadvantages of flexible tines are that they can sometimes individually bend or break when hitting obstructions and are generally more costly than rigid blades to purchase and replace. This cost, however, has to be balanced against their overall efficiency and the protection they afford to the operating vehicle and the frame that attaches them to it.

Many rakes were designed primarily to complement a road grader for removing rocks and debris after blading. Some models are too wide to work each lane of a camp road individually, and unskilled operators are inclined to remove the crown of the road ( if there is one) along with debris during raking.



**This road rake is traditionally towed behind a truck or a road grader to remove rocks but is too wide to be used on many dirt roads and has been known to remove a crown rather than create one...**

## 6.2 The Machines continued

**Front or back mounted:** Where a tool is mounted, along with how easily it is controlled, dictates whether it is suitable for actual grading or strictly for smoothing. The blade of a road grader or bulldozer is in *front* of the operator where he can see both the tool and the work being done. Rear mounted tools are much more difficult for an operator to control, particularly when having to continually compensate for changing topography and conditions. In addition, front mounted grading tools usually penetrate a road surface more readily than rear mounted tools because the operating vehicle pushes them into the road surface rather than pulling them out.

Recently, a heavy-duty attachment with stronger and more aggressive tines has been introduced as a front mounted alternative. (see inside front cover) It has been adapted to the snowplow hoist of pickup trucks, taking advantage of the existing hydraulic lifting and angling controls for its operation. It also mounts in place of the bucket on the front of a tractor where it offers greater visibility and control, providing much the same operating configuration as a road grader. According to a recent USDA Forest Service report, the "Front Mounted Rock Rake" as they call it "is 70% less costly to operate than a road grader" and, because it fits on a multi-use, high mobility vehicle is readily "available when needed."

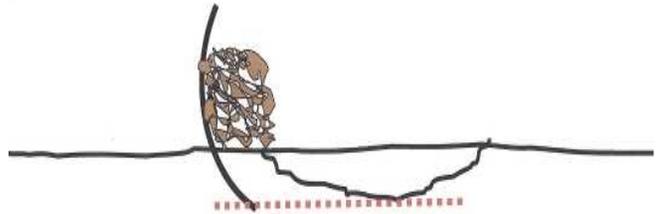
Availability is critical, regardless of the type of equipment used, because it is regular maintenance performed *before* a road surface becomes badly worn, rutted or washed out that helps to reduce long term cost while also reducing erosion and sedimentation. Observing the efficiency of a front mounted grader/rake at work in a Maine State Park several years ago a ranger quipped that the key to maintaining a road with this piece of equipment is to "**go fast and go often!**"



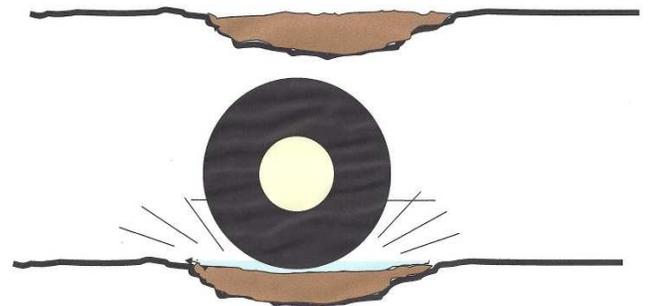
The **FrontRunner** grader/rake mounts in front of a truck in place of the snowplow and uses the snowplow controls to feather, lift and angle it.

Whatever piece of equipment is chosen to do the work, the first and most important criteria for its use is that be able to **penetrate the surface** in order to cut out ruts and potholes. **But why is it necessary to cut into the road surface?**

To get the best results from regrading, it is necessary to cut to the **bottom of the deepest ruts or potholes.**



When a rut or pothole is filled in with loose material, the new material soon compacts down, leaving a depression that fills with water in the next rain. Passing traffic splashes water and soil out to reopen the pothole



Cutting to the bottom of the deepest defect allows all loosened material to be reworked as if it were new gravel. Loosened material is spread and shaped in an even layer just as new gravel would be. **(below)** This prevents potholes and ruts from coming right back in the same spot by eliminating them.



Now that we understand the goal to achieve it's time to start...

## 7.0 DOING THE DIRTY WORK

**Note that the photos in this document feature the FrontRunner as this is the attachment of choice of the author who developed it over many years of road, driveway, and campsite grading and maintenance.**

**The principles shown, however, apply to most equipment whether it be blade or rake, front or rear mounted.**

It is a natural tendency to start grading a road by pulling in the shoulders to rebuild the crown. While this may work in some cases, there are generally two steps necessary before that can happen.

**7.1. Get rid of leaves and debris before starting to grade.** Rakes are particularly helpful for this.

Better still, get rid of leaves when they have just fallen using a backpack or walk behind leaf blower. Tractor mounted blowers are also available to clear debris from road shoulders and are also useful to clear leaves from ditches.

Trees help keep a road from drying out and create a protective canopy, but leaf build-up on the road can make it harder to maintain and lead to washouts in the traveled way as water flows around them, especially if they get caught in fallen tree branches..



**Clear leaves and loose debris to safe disposal areas off the road**

**7.2 Cutting out the potholes;** Once the road is cleared of debris it is time to tackle the potholes which, as we have already seen, are usually most prevalent in the CENTER of the road. Hence, that is the place to start cutting into the surface.



**Start in the middle of the road to cut out those potholes first rather than filling them with material from the sides.**

Only after the middle of the road has been addressed can we start to pull in the shoulders. Start the process by driving up and back on the left side of the road. This affords visibility on the ditch side for the driver if preferred. Then reverse the process by driving up and back on the opposite side (right) all the while bringing material to the center.



This has the advantage of:

- Balancing wear to both ends of grading device since the ditch side is usually set to cut deeper and therefore wears more than the crown side
- Helping to cancel out any roller coaster or chopping that may start to occur when working too fast.

But be careful of those soft shoulders, especially in early Spring



**A moment's inattention during the Spring thaw can quickly mire even the best all-wheel-drive vehicle**

Inevitably there will still be some debris mixed in with the material being reclaimed from the shoulders. Rake tines are very effective at helping to separate this debris from the material to be saved.



After material has been pulled to the center of the road and debris removed from it, the rule to follow is never to straddle the centerline with the wheels of the vehicle to which the rake or blade is attached unless it can be adjusted in the same manner as a road grader. Violating this rule generally means cutting down the centerline crown while attempting to clean and smooth the surface.

**Crossing the centerline will scrape off the crown!!!!**

Keeping to each side will also place a truck wheel in the middle of the road to help compact the newly placed material on the crown. 105

This seems like it would make it difficult or impossible to remove rocks and debris and cast them all the way from one side of a road to the other without destroying the crown., however.

**7.3 Getting rid of the rocks to one side of the road without losing the crown:**

As shown above, always keep the vehicle completely to one side of the center of the road. Angle the tool towards the center of the road, casting rocks and debris toward the opposite side of the crown.



**Getting rid of the rocks from the reclaimed gravel after grading**

### 7.3 Getting Rid of the Rocks continued

Usually this means running one side of the vehicle and the attachment's supporting wheels right down the centerline while forcing rocks and debris over the crown. Then come back with the vehicle just to the other side of center (again without straddling it) and angle the rocks toward the shoulder. This has the added advantage of helping to compact the gravel that has been pulled in from the sides to build up the crown.

Rocks and debris can also be worked toward either shoulder for removal without taking off the crown simply by keeping the operating vehicle to either side of the middle and treating each side as if it were a completely separate grade, which, in fact, is the goal of the entire operation unless the road is pitched to only one side.

A rake works best for this finishing process, though a blade can also work if set just slightly above the road surface.



**Treat each side as an entirely different drainage surface!**



### 7.4 Saving the material that the road is made out of

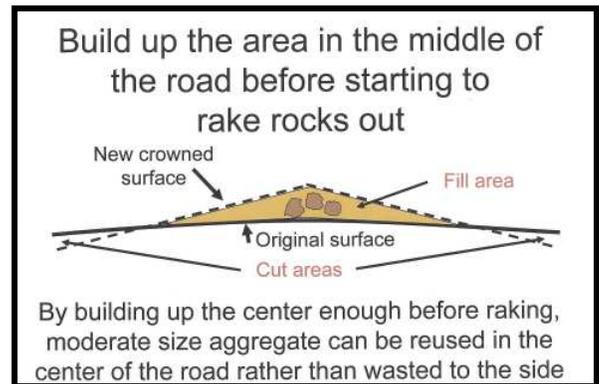
Many, in fact, most gravel roads do not have a sufficient layer of processed gravel on the top to allow them to be worked without digging up some of the rocks that form the road base. It is counterproductive to dig up

too many of these larger rocks and have to rake them to the side of the road and waste them.

It is possible to save much of this "aggregate," however, by bringing as much of it as possible to the middle of the road to create a substantial "lift" or layer that is thick enough for these rocks to be re-embedded in the road surface.



**For this driveway reconstruction, shoulders have been pulled in with a tractor to form a substantial "lift" in the middle of the road and grading has begun**



Only after the crown has been established should the larger stones be raked off to the side and lost. Much of the appropriate size aggregate will remain in the new crown.

**Only the largest stones are being raked out to the edge during finish grading & cleanup**



7.4 Saving material continued



**Finished crowning and grading**

Speaking of crown, here's a convenient way to determine degree or percent of slope when constructing the crown. This crown gauge mounts right on the tractor and allows the operator to determine just what percent of crown he is holding during the grading process.



**8% equals 1" per foot (a little too much crown!) 4% is the desired percent**

**Remember that the process is the same regardless of the equipment used.**

**7.5 Compaction:** essential to road surface stability

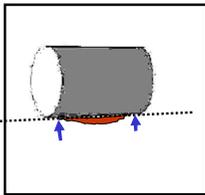
Once a road has been properly graded with shoulders pulled in, debris separated out and crown restored, it is essential to compact the surface to consolidate the aggregates and help keep rainwater from soaking in. Cars and truck wheels can do a reasonable job rolling loose gravel. However, the best tool for this purpose is the steel drum vibratory roller, that thing you pass on the highway that grumbles along on freshly laid asphalt, beating it down as hard as it possibly can. This machine is optimum for good compaction, especially when reworking several inches of the road surface or laying down a heavy layer of new processed gravel or preparing for paving. A vibratory roller will compact a layer of gravel that is 6" to 8" deep where wheel traffic only compacts 3" to 4."

Because most of us have limited access to such equipment it is typical to depend on wheel traffic for compaction. Any compaction is certainly better than none especially if the road is moist. There is another consideration regarding compaction and potholes that enters into this discussion.

It is not always possible to cut to the bottom of the deepest potholes on a road, especially if the surface has been allowed to deteriorate beyond normal smoothing and reshaping and there is little processed gravel. Trying to cut to the bottom of 6" deep potholes will likely dig up rocks that should have remained as road base, and many of these will be wasted.

In this case it is recommended to cut as deep as reasonably possible, recognizing that loose material will collect in the pothole and be compacted by wheel traffic as already explained. Rolling with a loaded one-ton truck can compact this material fairly well into the pothole following grading, and regrading again after that compaction can help fill them in incrementally until they are nearly as hard as the surface surrounding them.

A steel drum roller can “bridge” a filled in pothole or low spot, where a truck wheel will compact these spots more effectively



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This eliminates the effect of the roller “bridging” a pothole that is too deep to be completely cut out

7.5 Compaction continued



Cutting too deep into the surface of many roads can dig up rocks from the base that might be too big to reincorporate in the crown of the road and would better off left in place rather than lost to the side of the road during cleanup

The alternative:

- **Work the surface to just a few inches deep**, even though you will be filling rather than cutting some of the potholes
- **Compact the surface** with the grading vehicle and let traffic compact it also
- **Regrade again soon**, cutting to the new bottom of the compacted potholes

This may take more than a couple of visits before potholes are completely gone but experience shows that the technique works! Also see [Troubleshooting Guide 11.1](#)

A loaded dump truck, even a one-ton, makes an excellent compactor- lots of weight concentrated on small “footprints.” Try to roll

steep hills soon after grading, especially if there is threat of rain. While compacting hills, it is important to help direct water to the side of the road rather than have it run straight down the wheel tracks, no matter how slight they are. Use the truck wheels to make tracks from the traveled way across the shoulder to the side, *carefully* backing down the hill toward the ditch in a herringbone pattern. The back end of an empty 4 x 4 truck typically weighs less than the front since the engine is over the front wheels. This allows the truck to pull itself back onto the road when the operator feels the back wheels hit the soft shoulder.



This slight wheel depression will direct water to the side of the road



DOWN GRADE



7.6 Beware of berms that prevent proper surface water drainage!

Remove grader berms if they were already there from previous grading and don't ever leave them yourself, especially on hills.



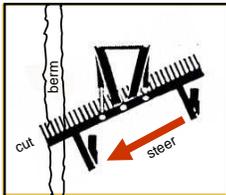
Grader berm left during grading



**Permanent grader berm left during years of poor grading practices. Note the ditch at right, but water is forced to traveling IN the road. (arrows)**

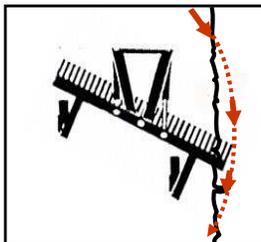
**7.6 Removing grader berms continued**

With a front mounted device such as a FrontRunner or a bucket on a tractor you can make holes or “turn outs” through grader berms by driving downhill and turning toward the ditch (or shoulder,) penetrating the berm as often as possible.



**Drive downhill and turn toward the ditch, penetrating the berm and forming a water turnout**

Another way to remove grader berms with a front mounted rake is to drive toward the ditch and sweep the berm material back toward the middle of the road, allowing the rake to reach out farther than if the truck was running parallel to the ditch.



With a rear mounted rake or blade you can usually raise it then back over the berm, drop the attachment and pull the berm back into the road where material can be reclaimed.

Sometimes it is necessary to more aggressively remove material buildup along

the road shoulder(s) either before grading is begun or after it is completed to remove material spilled into the ditch during grading.



**Using a loader front bucket to clear ditch of debris and remove grader berm**



**Switch to backhoe where ditch becomes more defined and deeper than the road shoulder. This backhoe bucket is equipped with a 4' wide blade that pins onto the bucket providing extra width and eliminating teeth marks, leaving the bottom of the ditch smooth.**

Material cleaned from the shoulder and ditch may be able to be reused on the road, but often has to be disposed of because it contains too much vegetation and debris.

**Ice dams** that form at the sides of roads during icy winters can also cause severe damage by keeping melting snow and rain water on the road rather than allowing it to run the road ditch.





**This development road washed out because water could not reach the ditch at left and required some emergency repair.**

7.6 Grader berms continued



**The emergency repair required re-directing the stream back to the ditch to prevent further road damage and allow traffic to pass.**



**Breaking ice dams is difficult. Sometimes all that can be done is to plow or scrape the snow off the top of the ice and let the sun hit the ice in hopes that it will melt and allow water to run off before spring rains wash the road out. The above situation called for hand chipping the ice to allow water to get to the road ditch and culvert.**

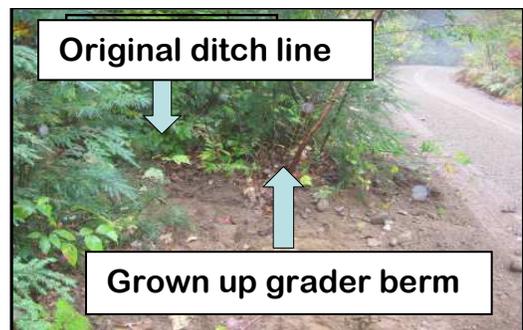
**8.0 WATER CONTROL**

Proper drainage includes not only getting water off the road but getting it safely away.

**8.1 Turnouts** Water turnouts are openings through whatever is obstructing flow at the side of the road in order to get water away from the road. Obstructions include grader berms, upgrades, ledge outcrops, trees or stone walls (be careful of these, they can have historical and legal significance.)

**Because they carry water away from the road, the more turnouts, the better to reduce the volume of water that the ditch has to carry.**

In order to get water to the *original* ditch line, sometimes it's necessary to make turnouts through grader berms that have "matured" into windrows of trees. Ideally, the vegetation should be completely removed and the berm eliminated, but this is often not possible because of budget constraints. In this case, create openings through the berm as often as possible, especially on slopes, to get water off the traveled way before it gains in volume and velocity.



**The down arrow at left points to the original ditch line while the up arrow points to the trees and debris that have grown up in the grader berm due to lack of maintenance over many years.**

**Make turnouts as far as possible from water bodies so that silt can be deposited before it reaches the water**

For further information on Turnouts see:  
[Maine Gravel Roads Manual pg 49](#)

**8.2 Water crossings** Often it is necessary to get water from one side of the road to the other because there is:

- An existing stream crossing the path of the road,
- Too much water for the capacity of the ditch,
- Something blocking the flow from continuing down on the same side, or
- An appropriate place to outlet the water on the other side of the road

Different structures are used to move water across or under roads:

- Large streams require bridges
- Small streams, seasonal flows, and storm water generally use culverts

**And what's so good about culverts?**

**Nothing!!!!**



**Several problems can plague culverts even if they are installed properly which happens less often than it should.**

Over time culverts are prone to:

- Collapsing or rusting out
- Plugging or freezing up
- Pushing up due to frost
- Washing out due to poor installation or the action of frost or both

Although culverts are essential for many applications, particularly on higher volume roads or larger flows, other structures can be used to send water harmlessly across low volume roads.

Water bars, stone fords or “rolling dips” refer to structures that can be easily built and maintained and eliminate many of the problems that plague culverts.



**Constructing the Rolling Dip- digging a low spot across the road with bucket or, in this case, the backhoe blade**



**Adding “ditch mix” that consists of several sizes of crushed stone from several inches down to small stone and some fines to hold it together. “Tailings” from a gravel producer can work very well for this purpose. Otherwise, mix several sizes of stone together, sometimes as large as 6” depending on the application. This particular crossing was lined with tailings.**



**Grading and backblading to obtain final shape**

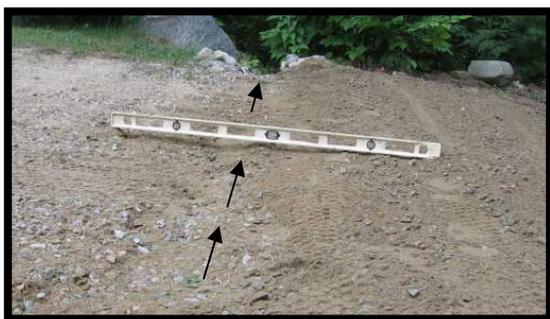
### Completed rolling dip

- Carries lots of water
- Can't plug up, etc.
- Allows easy passage of traffic
- Needs no headers
- Is easily maintained during regular maintenance



Another dip at the side of a development road across a private driveway with a substantial springtime flow across it, before surface gravel was added. Note the largest stone is 6" with 3" and 1.5" stone filling the voids.  $\frac{3}{4}$ " gravel forms the final surface, filling remaining voids, so that the stone disappears and the surface is smooth and firm to walk and drive on, but running water cannot erode the stone.

## 8.2 Water crossings continued



A smaller version, called a water bar, that directs water to one side at the top of the slope on a private driveway. It intercepts water from the parking area before it can run down the driveway. It is similar to structures often built across hiking trails. This small diversion needs touch up after snowplows damage it occasionally, but is a simple and effective way to keep the driveway from washing out.

For a good description of "broad based dips" for moderate slopes and other water control measures see the [Maine Camp Roads Manual](#)

## 9.0 WHEN TO WORK THE ROAD

Moisture in the road plays a key role in successfully maintenance. Too little water can make it nearly impossible to break into the surface of well compacted high quality surface gravel. Too much water can make a road grading project turn the road to gumbo.

Follow these tips:

*Stay off of it...*

- **When too dry:** takes extra effort to grade if possible at all, road material will not repack after it is loosened; excessively dusty and hard on equipment
- **When too wet:** it's possible to make more soup than already exists
- **If there is a threat of heavy rain** while you are grading or shortly after, but before the surface is compacted, especially on steep hills

Ideal conditions for grading

- Springtime after most frost has left. The road may still be soft but tine rakes can help dry it out if not too wet
- Late Spring or Summer after road is fully stable- wait until just after rain to soften the surface
- Fall is easiest because sun is low, not drying the surface as you work it

If you must grade when it's dry and sunny

- **Do only one short section** of the road at a time, completely finish before moving onto another section to avoid drying out the surface unnecessarily
- **Add water** to the surface if possible; it doesn't take much moisture to make a big difference

**FINAL CONSIDERATIONS**

There is an increasing impact of development on existing road systems as more homes are built and seasonal homes become year round residences. There's

- More stormwater to dispose of
- More traffic on the roads
- Fewer places to safely dispose of water

Consider that one **inch** of **rain** falling on **1 acre** of ground produces more than **27,000 gallons of water**. Roofs and driveways shed water, and lawns do not accept nearly as much water as forest land. Black roofs and driveways heat up water in thundershowers on sunny days and *fish don't like hot water!*

There are few dirt and gravel roads and driveways that are built to ideal specifications. The few that may have been many years ago typically have had little proper maintenance to keep them in ideal condition. Following the suggestions outlined in this manual can help get them back into shape and keep them there.

**Paving as an alternative to gravel for road surfaces...**

Note that paving has been mentioned as being the best solution for the steepest hills that

cannot hold gravel well. While a good paving job can be an effective long term solution it is essential to consider that you should

- Pave only when the road is ready
- That means providing a strong, well drained base
- Adequate drainage must be addressed before or in conjunction with paving

**Or Else:...**



**These two photos show water damages to the edges of paved roads due to poor ditch stabilization at the side.**

\* \* \* \* \*

The key to success with any road maintenance program is to address problems *before* they become major issues, in the true tradition of **A Ditch In Time.**

## 10.0 GETTING RID OF STORMWATER

This manual makes it clear that rain, or stormwater, should always be directed away from roads and driveways. However most roads and driveways, as well as parking lots, inevitably have some low areas where water collects with no place to go. Whenever possible, underground pipes, called culverts, should be installed to carry this water away from these areas.

Stormwater systems are quite evident in municipal areas as displayed by storm drain grates on the side or in the middle of roads. These storm sewers or catchbasins usually tie to a subsurface collection and disposal system of pipes that leads the runoff to a river or stream, or to a roadside ditch or simply to “daylight,” meaning onto the surface of the ground or, in some cases, to a manmade settling area where the water and eventually soaks into the ground.



This homeowner's driveway was flooding during winter when snowbanks froze to the ground keeping rain and melt water from running off the pavement on the surface drain that was blocked by ice. The custom poured concrete structure at left (55 gallon drum as an outside form, 18" builder's tube as an inside form) being dropped into the hole has an outlet pipe cast through it near the bottom that connects to a pipe that extends to a daylight outlet. This catches water through the grate and carries it safely away under ground. (right arrow)



Other times it is necessary to collect stormwater runoff from a roof or other area and send it harmlessly away through an underground pipe rather than have it add to other roadway rainfall.



Left photo shows a light duty catch basin made of a short section of 18" plastic culvert pipe standing on end. It is installed in an unpaved area that collects runoff from a roof and parking area. Right photo shows the outlet pipe (before backfilling) that carries water away to a safe outlet in the woods. This keeps it from adding to the runoff at the side and in places, across the road. This catch basin is backfilled flush to the ground. Note the light duty grate covering the 18" culvert. (arrows)



This section deals with stormwater that cannot be directed away from a road, driveway, or parking lot. This situation occurs all too often and can be difficult and expensive to address. A structure usually has to be built to collect runoff and to provide a way for it to soak into the ground nearby. The structures we look at here typically collect runoff in the same manner as storm sewers, but use techniques similar to septic leaching systems to return the water directly into the ground.

As with much of what has been discussed in this manual, soil characteristics, especially permeability, have everything to do with how easily water can be absorbed by the ground. Highly permeable, or porous, material like coarse sand and gravel often absorbs water so quickly that little has to be done to address stormwater except to get it off the surface of the road and to the side where it can soak into the ground quickly. Less porous soils, such as fine sand, silt, and clay, absorb water more

slowly and require more elaborate drainage systems to dispose of it. Roads, driveways and parking lots built on such soil usually require one or more supplemental structure(s) to collect runoff during a storm and let it soak in after the storm has stopped.

### 10.1 Surface soakaways

The easiest way to dispose of runoff that has no place to go is simply to dig a hole next to the road, driveway, or parking area. Water collects in the hole and soaks away in time. Drainage holes like this are very common on the low volume rural roads here in the mountains where a loader or backhoe simply dug into the side of the road leaving a depression where water can collect off of the traveled way. While these are cost effective and extremely simple to construct, they require the use of property frontage that cannot be used for anything else and can tolerate being somewhat unsightly.

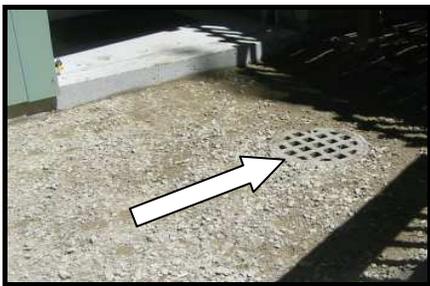
The other concern about soakaway areas is that they generally fill up with debris and sediment over time, rendering them less and less effective. This is particularly true for those that serve unpaved roads where traffic and moving water loosen the fine material that holds the surface together and carries it downstream as shown in the introduction of this manual. Soakaways that become plugged with silt can cause surface water to stagnate and become a breeding ground for mosquitoes if not cleaned out. The good thing about roadside soakaways is that they can easily be cleaned out with a loader or backhoe. The cleaning or restoration process becomes much more difficult, if not impossible, for the more complex subsurface structures used to dispose of storm water.

A simple alternative surface drainage technique that is gaining in popularity is the use of rain gardens. They serve the same purpose as soakaways and are an attractive green alternative when planted with native vegetation. When properly constructed, they can also help filter out silt that would plug an open hole and can reduce the need for maintenance.

### 10.2 Collecting stormwater:

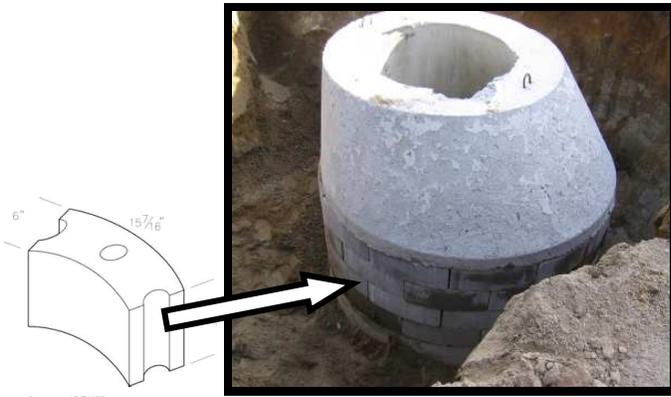
Catchbasins are open top subsurface structures that collect surface water and either allow it to soak into the ground below or be conducted away via a below ground culvert pipe. They generally have some sort of cover, grate or guard over the top to protect people, animals, vehicles and other things from falling into them. Many, such as the ones under highways, are built strong enough to support any type of traffic.

A catchbasin must be constructed at a low point, or a point that can be made lower than its surroundings to draw runoff into it. This can be in a road, driveway, parking area or even in a walkway or just beside it where access to it can be maintained during winter months. The ground surface needs to be sloped gradually to direct water to the inlet.



This small and simple leaching basin is next to the front door of this house where water used to collect. The cast iron grate is flush to the ground surface.  
(arrow)

Highway type catchbasins are usually constructed of a heavy duty precast concrete cylinder or stack of concrete rings, often used in conjunction with special solid concrete “barrel” blocks that can be stacked in layers to adjust the catchbasin to any height. On top of the rings is either a thick, flat, steel reinforced concrete cover with a hole in it for the iron or steel grate or a tapered cone that fits the ring at the bottom and the grate at the top.



10.2 B

This offset tapered cone is the type used under a highway to allow the top of the cone to be close to the edge of the highway next to the curb.

The lower section rests on barrel blocks (LEFT) which stack to form a circle the same size as the base of the cone while the heavy duty frame and grate will set on top of the cone as shown in photo 10.2.D below.

Disposing of the water once it gets into the catchbasin depends on soil and topography. It remains preferable to pipe water away to a “daylight” outlet because this allows any volume of water to be disposed of. If that’s not possible, the catchbasin will have to connect to or be part of a leaching system that allows water to soak directly into the ground around it. This requires some planning to be sure the leaching structure can handle excessive storm water without filling up faster than water can soak into the ground, causing water to back up and leave a puddle on the surface long after the rain has stopped. This is only possible where the ground water table is lower than the bottom of the catchbasin and there is sufficient dry soil to accept the runoff.



The catch basin in the middle of this large parking lot has been plugged for years making the lot extremely difficult to maintain in winter as well as a challenge for those who have to drive through it when there is over a foot of standing water and ice chunks. Arrow points to the submerged catch basin in late March 2014.

It looks like the snowplow contractor gave up trying to clear around the basin after the last snowstorm since it is impossible to plow!!

Also see last page

### 10.3 Leaching basins

Catchbasins that do double duty of collecting runoff and returning it into the ground are often called “leaching basins.” The way catchbasins disperse water is the same way that dry wells do for septic systems. Backfill around the basin can range from reusing the material that was excavated from the hole if it is very porous, to constructing a large storage and distribution system below a parking lot that can rival or surpass the most elaborate septic systems. A low ground water table and porous soil are necessary for leaching basins to be successful.

#### 10.3.1 Drywell basin

The drywell basin is constructed with holes, slots or some means of letting water get through its walls. The whole basin is simply surrounded with clean backfill or, more effectively, washed crushed stone that increases the volume of the structure in proportion to the amount of stone used. Because typical crushed stone is 40% voids, the spaces in the stone provide additional water storage, but, more importantly, they provide more surface area against the original soil in order to disperse water into the

soil.

Catch basins that do double duty as leaching basins are often built with barrel block as shown in photos 10.2 B above and 10.2 D below. Water seeps out between the spaces in the blocks into the surrounding stone. If a precast concrete cylinder is used instead of barrel block it has several small holes through it and spaced around it making it into a “drainage ring,” designed to allow water to soak into the ground around it. Similarly, precast rings can have a large hole or holes cast into their side) to allow culvert pipe(s) to be placed through them if they are simply collection structures connecting to a culvert system rather than leaching basins.

Time has shown that the barrel blocks in the center leaching basin shown below may have been placed a little too close together so that debris that washed into the catch basin plugged up the spaces between the blocks as well as the bottom sand. These spaces can be cleaned with a pressure washer and, though the blockage has caused some aggravation, the porosity of the sand and stone soil interface outside of the leaching basin has been protected from plugging up which would result in the paved driveway having to be dug up to replace the plugged up soil surrounding the basin. It would be helpful to trap this debris before it ever gets into the basin as discussed later in this chapter.



10.2 C



10.2 D



10.2 E

These two leaching basins are designed to both collect water and to return it to the very porous sandy soil in which they are constructed. The center basin (above) consists of a round ring about one foot high (left photo) set on the original sand at the bottom with barrel block stacked on the ring and a precast concrete cone on top of the barrel block. It tapers up to the size of the heavy duty cast iron frame and grate that ends up flush with the ground surface in a slight depression in a parking lot. The spaces between the barrel block allow water to leach through to the outside of the structure.

The above right photo shows two perforated drainage rings stacked on one another with a heavy duty flat cover and frame and grate. This is a much simpler and less costly structure that was installed in a residential driveway. [see *below*]

*A few years ago I installed a simple heavy duty combination catch basin-drywell (right photo above) for a local homeowner whose driveway, in spite of being in an area of porous sand, used to flood with water during winter rainstorms due to snowbanks freezing and impounding the rainwater. A year or so later his wife approached me at a local gathering and gave me a big hug. She said that, after thirty years of having to put a sump pump in the middle of their driveway during winter rainstorms, I had finally solved their problem. Although I was amazed it took so long for someone to come up with such a simple solution, I was more than happy to receive her show of appreciation!*

Each of the above structures is backfilled with washed crushed stone almost to the surface. The stone is covered with a layer of geotextile “filter fabric” before the driveway surface gravel, and in some cases, pavement, is placed or replaced.

It is sometimes preferable to set the bottom of these structures on sand rather than stone because if the bottom should become plugged with debris it is easier to remove the debris from a sandy surface rather than a stone surface.

Where soils are porous and there is only a moderate amount of stormwater to be disposed of, a combination catch basin-drywell can be very effective. When soils are dense, slow draining, or the ground water table is shallow, and/or there is considerable water to be disposed of, the disposal system must be much larger. In fact, major stormwater treatment systems have begun to rival or surpass septic systems in their complexity. All storm water disposal systems carry some pollutants washed in from the surface of the area drained. Here we are less concerned with that type of pollution and more concerned with the sediment that gets carried by stormwater from unpaved roads that can plug up a water infiltration system.



This is an example of a large scale storm water storage and infiltration system being installed under a municipal or a large mall parking lot to return stormwater to the ground

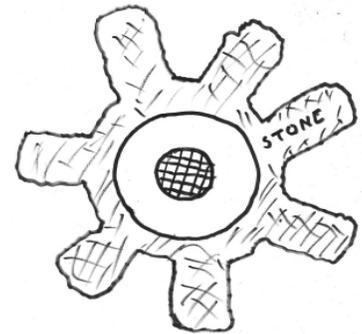
### **Silt, the leaching basin killer-**

Unlike catch basins that connect to culverts, combination catch basin/drywells, or leaching basins, are subject to plugging up with stormwater borne silt. This is why it is essential to construct them with as much surface area against the original soil as possible. The more surface a leaching area has, the more silt it can tolerate before totally plugging up and stopping water absorption.

The simplest way to increase this surface area and thereby extend the life of the leaching basin is simply to excavate a larger hole and add more stone. There are other methods, however, that can add surface area in much the same manner that septic systems increase their absorption area.

#### 10.3.2 Extended leaching systems

The easiest of these techniques is simply to modify the shape of the area of crushed stone used to surround the catch basin by digging several trenches that lead from the catch basin out into the surrounding soil. These trenches, when filled with stone, provide much more surface area against the original soil for the same amount of stone used. While this technique does not increase the storage capacity of the stone, it can help the structure last longer when the runoff is silt laden.



#### 10.3.4 Leaching basin connected to a leaching system

This technique can include the design of a conventional dry well leaching basin but depends more on the addition of a septic leachfield type of structure. It can include perforated sewer pipes in crushed stone or one of the many plastic leaching chambers now available.

The idea is to provide as much surface area as possible along with a method of conveying the water from the catch basin to the additional leaching area. When it is possible to locate the catch basin portion of the system off to the side of a traveled area, it is very cost effective to build the catch basin

portion of the system with plastic culvert as shown in the following photos. Most use 18" smooth wall plastic culvert standing on end with holes in the side if the basin is to be used for leaching, as well as one or more larger holes for pipes to lead out of the basin to the additional leaching area. Medium duty 18" grates are available to top off the catch basin. These typically come with a frame that surrounds them for support and rests easily on the top end of the basin. These frames and grates are not suitable for highway traffic but will support light weight foot traffic and lawn mowers.

In areas where there will be no foot traffic catch basin, bar guards can be more effective than standard flat grates as they are less likely to plug up with debris because of their vertical structure shown in the photos.



Photo at left shows several "Infiltrator" plastic leaching chambers typically used in septic systems installed in a trench that was dug deep enough to place it in the most porous soil layer available above water table. Stormwater is picked up by the vertical 18" culvert (arrow) and flows into the Infiltrators through the two 4" pipes.



The chambers are covered with 1½" washed crushed stone to complement the storage and leaching area provide by the open bottom and slotted sides of the plastic chambers. (above left)

Filter fabric covers the stone and the trench is backfilled to the surface next to the unpaved road. (right) The wood post is for winter protection/location and the bar guard keeps large debris from building up as it might on a flat grate and blocking the flow of water. The bar guard can easily be wrapped with filter fabric to keep out finer debris and silt.



Photo at left is of a heavy duty bar guard that covers the intake of a catch basin. This basin is flush with the ground surface and directs water into a culvert that crosses a road. The bar guard keeps large objects that might block the culvert from falling in while letting smaller debris flow into the catch basin and out through the culvert with stormwater. While it is stronger than the above bar guard, it is less able to keep out smaller debris by design, and its inverted funnel shape helps to keep it from plugging up with leaves as did the flat grate that it replaced.

Photo at right is of another Infiltrator and stone installation in very clean porous sand collecting substantial amounts of water from an unpaved road. This installation also uses 18" plastic culvert as a catch basin (arrow at bottom left of photo) with two pipes leading from catch basin into the Infiltrators.



Lower two photos show a low cost addition to an existing catch basin constructed in very porous river gravel. The trench was excavated, the rocks raked out of the excavated material and placed back in the trench with two distribution pipes run out of the catch basin on top of the rocks which are then covered with filter fabric and backfilled.

Due to the amount of debris that this catch basin is subject to collecting, septic tank outlet filters were installed on the inlet end of each pipe inside the catch basin. These filters can be cleaned and reused over and over.

Similar to the other catch basins shown, this one is also constructed from 18" plastic culvert because it is off to the protected side of a parking lot.



### 10.3.5 Remote leaching systems

This technique is similar to a catch basin connected to an expanded leaching system but is used primarily under paved areas. A pipe leads water away from the catch basin to a leaching system that is not under the pavement. This allows the catch basin to be installed where it will be most effective but also simplifies future repair and cleaning or replacement of the leaching system without having to tear up pavement. This can reduce the pressure to make the initial catch basin large enough to work forever without repair, which is practically impossible and seldom cost effective. Again, the infiltration areas of remote systems are similar to those for many septic systems and share many of the same products as shown above.

As pointed out at the beginning of this chapter, simple dugout “soakaways” can be scraped clean of silt buildup with a backhoe bucket. Subsurface structures, however, cannot be cleaned without being dug up. Therefore, it is necessary to provide as much protection for a leaching basin as possible to prevent silt as from entering in the first place.

### 10.4 Preventing silt from reaching the catch basin

If a leaching basin is not located in a direct foot or vehicle traffic area but off to the side, several options can be used. Simply making a circle of silt fence keyed into the ground on several stakes around the leaching basin inlet can be very effective, but also is unsightly for the long term. A filter sock consisting of a woven mesh tube that is filled with filter material can be placed around the leaching basin inlet without being as unsightly as a silt fence, though high water flows can go over the top of the sock.

Silt fence or hay bales are often used in newly constructed roadside ditches to help trap sediment to keep it from plugging up a leaching basin. Check dams consisting of piles of angular stone regularly spaced in the bottom of a roadside ditch can also help catch sediment.

The finer that the filter used to trap silt and debris is, the more effectively it will protect the catch basin. However, as the filter material clogs, water may be backed up for longer on the surface of the road or parking lot, causing passing vehicles to stir up more sediment and compounding the silt problem. Therefore, regular maintenance by a road steward can help reduce the problem and extend the life of the leaching basin.

This grate is surrounded by a fiber filled sock to trap sediment that might otherwise go down the drain. If this grate sits on a leaching basin the filter will help extend its life. If it is on a catch basin that drains to daylight it will help to trap silt that would end up in ponds, lakes, or streams.



### 10.5 Restoring existing catch basins that have become plugged with silt

The typical solution to restore an existing catch basin is to dig out around it, remove the layer of sediment clogged soil and replace it with clean stone. This both restores the soil’s ability to absorb water and increases the surface area in contact with the original soil. Reducing the amount of sediment that reaches a catch basin as explained above is the most effective way to forestall this repair, especially if a leaching basin is located under pavement.

### **In conclusion, a little help as well as hindrance from Mother Nature...**

Coincidentally, those areas where it is difficult to dispose of water because they are too flat to run a culvert to daylight often are blessed with soils that are more porous and sandy than the soils in hilly areas where water is less likely to remain on the surface or can be drained to daylight. This is a gift of the departed glacier that makes it practical and successful to install leaching basins on flat areas with sandy soil.

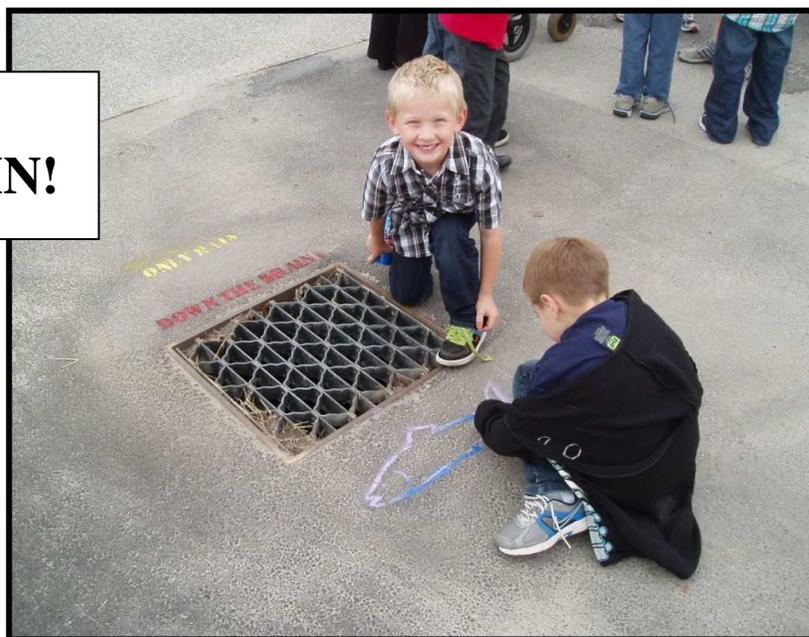
On the other hand, Mother Nature can make it more demanding to maintain catch basins as well as culvert openings during winter and early spring when ice and snow can cover the openings. Therefore, it is important to place them where they can easily be reached either by snow removal equipment or by hand to keep the inlets open. If structures are to be kept clear of snow by heavy equipment or plow trucks, they need to be of the heavy duty type shown at the beginning of this chapter.

Another consideration when constructing catch basins in cold climates is to make them deep enough into the earth to help protect them from frost penetration. Here in the White Mountains it is typical to place the bottom of a leaching basin at least six feet below the ground surface for frost protection. If a remote leaching area is used, locating it under ground that will not be plowed can usually keep even a shallow system from freezing.

Finally, because leaching basins are not intended or permitted to dispose of potentially dangerous or hazardous liquids, they should be treated carefully. Petroleum products, hydrocarbon solvents and other hazardous liquids can travel quickly through the soil and, once they reach the ground water, can easily contaminate drinking water wells. Putting any hazardous liquids down a catch basin that drains directly to daylight amounts to the same thing as dumping those liquids directly on the ground or in a river or stream. Used motor oil, anti-freeze, paints, cleaning chemicals and such should be disposed of at permitted hazardous waste disposal sites.

**Remember:**

**ONLY RAIN  
DOWN THE DRAIN!**



**Local school kids stenciling this motto onto the pavement next to a catch basin**

Please note that much of the information on catch basins shown here is appropriate for *private* roads and driveways. For information regarding public highway and municipal drainage practices check local and state regulations or your state's Technology Transfer Center.

For information on culvert installation for private unpaved roads please refer to the Maine Gravel Roads Maintenance Manual at the address shown on page one of this manual.

Note that several of the water control products in this section such as the Grade Gauge shown on page 19, the light duty grate on page 26, the tall bar guard on page 31, the heavy duty bar guard on page 32, and the fiber filled sock on page 33 are available from:  
Agri-Drain, Adair, Iowa [www.agridrain.com](http://www.agridrain.com)

Smoothwall plastic culvert used for many of the light duty catch basins in section 10 are generally available at a farm supply store.

Check your local Yellow Pages for suppliers of septic system leaching chambers and precast concrete products.

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# 11.0 TROUBLESHOOTING GUIDE

There are several defects and problems that can plague unpaved roads. The following is a guide to maintenance issues that can help improve your road using simple techniques that have been proven over time.

## 11.1 PROBLEMS CAUSED BY WATER

### 11.1.1 POTHOLES: depressions or holes in the road surface

**Cause:** water and traffic on a road surface that is too flat

**Solution:** reshape or regrade to cut out the potholes and restore A shaped crown

Although potholes can also be caused by weak spots in the road base due to pockets of organic matter, rotting stumps or other base defects, the most common cause is lack of pitch causing water to puddle on the road. Restoring crown through regrading the surface is generally required for repair.

If there are just a few potholes here and there, not enough to tear up the whole road to fix: It can be OK to fill potholes if you follow these rules:

- OVERFILL the potholes just like an auto body repairman overfills a dent in the car
- Compact the gravel with the truck that's hauling the gravel or
- Let traffic compact it

Then, after the gravel fill has been thoroughly compacted, grade the excess off just as the body man shaves off the excess Bondo (body filler)

Remember that a bump (the overfilled pothole) will not get larger as will a pothole filled with water!

For filling potholes...Use crushed gravel that has lots of  $\frac{3}{4}$  stone for extra strength, with just enough sand and fines to lock it in place\

see >>4.0 THE SURFACE and 7.0 DOING THE DIRTY WORK <<

### 11.1.2 DEEP MUD: that can be severe enough to close the road in the spring

**Cause:** poor base materials or drainage, or a combination of both

**Solution:** add stone, improve drainage or reinforce base with well-drained gravel or install geotextile



If a road turns to impassible mud in the spring, the only practical way to return it to service immediately is to add crushed stone (not gravel) to strengthen it. Use larger (1½" stone) until road firms up. It's generally cheaper and stronger than  $\frac{3}{4}$  stone. Stone is worked into the mud until the road is able to support passing loads. Though expensive, this scheme is very effective for emergency repairs.

If the repair can wait for dry weather, drainage can be added or the road base can be reinforced with strong, well-drained gravel. A lower cost solution is to install a geotextile layer over the existing road and cover it with 8 inches or more of surfacing gravel.



Geotextiles keep the gravel on top from being pushed down into the soil underneath, compensating for a poor road base

- Earlier requirement was for only 4" of gravel over geotextile fabric
- Present recommendation is for 8" minimum
- Use woven fabric under roadways, non-woven under rip rap

### 11.1.3 MUD HOLES: small areas of deep mud or quicksand-like gravel

**Cause:** Springs or pockets of organic matter under the road

**Solution:** Add stone or drain



Small pockets of mud or mudholes can usually be repaired with the addition of crushed stone in the same manner as deep muddy roads (11.1.2). If the source of the problem is an active spring, however, it is preferable to install a subsurface drain to remove the water from the roadbed

>>see: 3.2 Subsurface Drains<<

### 11.1.4 SURFACE MUD or slick surface. Road is firm but "greasy" on top:

**Cause:** Surface gravel lacks stone

**Solution:** Resurface with better gravel or add stone to existing surface

If the surface gravel is too thin it may be worthwhile to add gravel to a greasy surface to firm it up. If there is adequate depth of surface gravel but it lacks sufficient stone aggregate to provide strength, it can be cost effective to add crushed stone only and work it into the surface. Angular 3/4" stone is preferable for this purpose. Experience and an understanding of the interaction of soil and water are essential to determining the true reason for roads becoming soft and muddy and are the essential first step in choosing a solution.



Soft road surfaces can be reinforced with the addition of clean crushed stone, not crushed gravel (see text 4.1). (see photos next page)



Here ¾" stone is being added and worked in with the grader/rake to form a strong surface that resists rutting

see>> 4.0 THE ROAD SURFACE<<

### 11.1.5 DOUBLE RUTS, one on each side of the center of the road

**Cause:** Normal wear and tear over time with wheels traveling in the same track, especially on hills, or on an unstable base. This can result in erosion that will become more severe if left unattended. (see Washouts below)

**Solution:** Regrading and/or regravelling if the ruts are a result of normal wear and tear that is aggravated by erosion. If ruts are the result of an unstable base, follow suggestions for deep mud above.

Road rutting can be only a minor problem or can signal the start of the breakup of the road. Heavier traffic, additional rain, or melting snow can contribute to this breakup.

### 11.1.6 WASHOUTS: rills or gullies where the soil has disappeared and been deposited downstream on the road, in the ditch, or into a waterway.

**Cause:** too much water flowing in too narrow a channel over unstabilized soil, usually the result of poor crown or traffic driving in the same track (as above) or barriers to water flow off of and away from the road surface.

**Solution:** Restore crown, slow the water down, spread it out, or stabilize the soil in its path.

Washouts that occur on road surfaces themselves are generally a result of inadequate grading that allows water to channelize rather than staying spread over the whole surface. To avoid this, roads should be properly crowned, road shoulder grader berms should be removed or never allowed to form, and cross drainage (culverts and dips) should be kept free and clear of debris or deposited soil. Road surfaces need to be good quality stable gravel that resists the forces of water and traffic. see >> 4.0 THE SURFACE << and >> 5.0 GRADING <<,

Trying to reclaim soil that has washed from the road and reuse it as road surface material is folly. Whatever fines were present in the gravel to hold it together have left with the stormwater, leaving little more than washed sand and coarse gravel behind. It is reasonable to replace reclaimed material back into a gully, compact it and cover it with good gravel and restore the crown or the same situation will reoccur.

In extreme situations it may be necessary to pave the road with asphalt which, if properly installed over a well-drained, stable base should provide a near permanent solution. If asphalt is installed over an inadequate base it can become a liability because it cannot be regraded as can a gravel surface if it should break up under heavy loads when the road below is soft.

Culverts or ditches can wash out because of inadequate design, installation or maintenance.



These washouts are the result of lack of maintenance in time to smooth out the wheel tracks caused by everyone driving in the same location (double ruts). Heavy rains followed the tracks even though this is only a gradual slope.

The repair included filling and compacting the washouts and restoring crown. It also included an admonition to the road owners to not wait until it's obvious that the road needs help but to keep it maintained to prevent this from reoccurring and also ask drivers to vary their path each trip.

**11.2 PROBLEMS ASSOCIATED WITH TOO LITTLE WATER:** Although water is the enemy of the road, some moisture is necessary to hold a road together

**11.2.1 WASHBOARD:** the series of evenly spaced bumps that make a vehicle chatter

**Cause:** Road surface is tearing apart through the action of passing vehicles because the surface gravel lacks fines or adequate angular stone or moisture or a combination of the three.

**Solution:** Regrade the road surface to cut out the washboard and add good quality gravel with adequate sharp stone and fines. Treat with Calcium Chloride

Washboard is a direct function of traffic, especially fast moving traffic, usually on a dry road, regardless of whether it is upgrade or flat. Providing as hard and compact a surface as possible will help eliminate washboard. Good gravel with considerable fines helps to hold moisture. Calcium chloride increases the road's ability to retain moisture in dry seasons consolidating it to help prevent washboard and other problems.

**11.2.2 DUST** is the result of surface fines being sucked out of the road by passing vehicles.

**Cause:** Too little moisture in the surface of the road and traffic moving too fast

**Solution:** Slow traffic through the use of speed bumps, add water to the surface, or treat with Calcium Chloride or Magnesium Chloride or one of the other surface stabilizers but *DO NOT USE OLD MOTOR OIL!*

As dust lifts out of the road, it not only creates a nuisance for motorists and adjacent land-owners but also, as it blows away it, means a loss of the binder that helps hold the road together which can contribute to problems like washboarding. This can amount to many tons of soil loss each year per mile of road. Dust also contributes to silt and nutrient pollution because after it settles on nearby foliage or other surfaces, it can be washed off by rain and carried into surface waters .

Calcium chloride (CaCl) attracts water and holds it in the surface of the road even when applied in moderate amounts. As mentioned under Washboard, CaCl also helps to consolidate a road surface, helping to prevent other defects. In more substantial applications it can actually help reduce total maintenance costs by reducing the necessity for grading. In many situations, the cost of calcium chloride treatment can easily offset the cost of soil loss and the environmental effects of having that soil enter surface water.

- Apply Calcium or Magnesium Chloride in moderate amounts to settle dust
- In heavier amounts it can also harden the road surface to save on maintenance
- CaCl can be applied as 77% flake by hand or by push spreader

### 11.2.2 Dust:



Here calcium chloride (CaCl) flakes have simply been spread right out of the bag after the driveway has been regraded and graded. The CaCl is then raked into the surface with a plastic leaf rake to distribute it evenly. It can also be spread by hand with a salt spreader. Apply right after rain or on a humid day if possible. Otherwise, wet it down with a hose after spreading to help it dissolve into the soil rather than letting traffic carry it off or rain wash it away. Regardless of what's used to spread it, avoid contact with leather and wash steel implements thoroughly to avoid corrosion.



Calcium chloride can also be applied as a 35% liquid when mixed with water by a delivery truck with a built-in distribution system. For a first time application the rate is .3 gallons per square yard with follow up applications of .2 gallons. Many towns now do this regularly and report significant savings on road maintenance.

Find out when CaCl is being delivered to other customers in your area to help save on delivery costs.

As for environmental concerns about calcium chloride application, it appears that the advantages of treating roads outweighs any negative effects there may be. Calcium chloride stays locked in the soil unlike sodium chloride that is also used as an ice melter but goes more readily into solution in water and washes into surface water.

### 11.2.3 AGGREGATE SEPARATION, particularly on corners and hills :

**Cause:** stone aggregate that is too large and/or rounded

**Solution:** rework stone into surface and topdress with good surface gravel. Stabilize with CaCl

Crushed gravel with stone that is larger than 1" has the tendency to have the stone "kick out" on hills and curves due to wheel action, especially when the surface is dry. These "rolling stones" can also help start a washboard effect.

Reclaiming loosened stone and working it back into the surface can help save it from being lost, but in more extreme conditions the only way to keep this loss from reoccurring is to cover this larger aggregate with at least a couple of inches of good 3/4" or similar gravel and recompact.

see >> 4.0 THE SURFACE <<

### 11.2.4 LOOSE SURFACES: the "squirrely" road

**Cause:** Lack of fines

**Solution:** Cover with good surfacing gravel or mix in additional binder

While loose gravel on flat surfaces can create a headache, loose gravel on hills can be a detriment to travel, especially for light rearwheel drive vehicles such as empty pickup trucks or muscle cars. Sometimes even good gravel becomes loose when fines are lost to wind or to water such as the material that collects at the bottom of a washout. With care, fines can be added to this material and mixed in to reclaim it, or it can be left as base and covered with good surface gravel.

see >> 4.0 THE SURFACE <<

### 11.3 PROBLEMS WHERE GRAVEL MEETS PAVEMENT

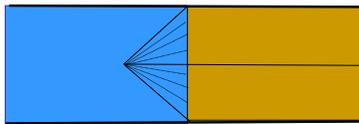
**Cause:** Different crown criteria for pavement and gravel

**Solution:** Carry crown of graveled section slightly over pavement so wheels ride up on gravel in the center of road during transition from gravel to pavement.

The typical way to transition between pavement and gravel is to taper the crown of the gravel section down to the level of the pavement. Paved surfaces require much less crown than gravel surfaces. This results in the center of the gravel section becoming too flat to shed water properly, inevitably allowing potholes to develop in the center of the gravel section right where pavement meets gravel. By carrying the gravel in the center of the road several feet onto the pavement this condition can be greatly reduced.

#### Preventing potholes where paved road turns to gravel

Taper gravel onto pavement rather than stopping where pavement begins



Gravel road should have more crown than paved section

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By carrying the gravel crown several feet onto the pavement, wheels in the center of the road climb up the slight incline onto the crown before the right wheels of the vehicle leave the pavement. Gravel (on right) tapers down in a "V" shape over the center of the pavement (left).

This is most effective using finer aggregate gravel (3/4") that's treated with Calcium Chloride to consolidate the gravel over the pavement.



Though having some gravel cover the asphalt in a V or "hip roof" configuration may look like a mistake, it is an effective technique to reduce potholes at the gravel to pavement transition.

Another cause for defects in a gravel road surface where it meets pavement occurs at intersections where drivers have to accelerate while turning to merge with oncoming traffic, or crossing the paved road while avoiding it. This acceleration often results in potholes or "digouts" in the section of the apron where the gravel road meets the pavement. There are two possible treatments for this condition:

- Treat apron heavily with CaCl or
- Pave the apron

### 11.3 Problems where gravel meets pavement

For either solution, the pavement or calcium chloride treatment should extend far enough back from the main road to ensure that most vehicles, particularly light rear wheel drive pickup trucks and muscle cars, are completely on the apron when beginning to accelerate. In some cases it may be necessary to incorporate a swale into the apron for storm water control. This could be done with a stone base or pavement as shown here, killing two birds with one stone.

As described above, drawing some of the gravel crown of the unpaved road onto the paved apron will help avoid potholes caused by vehicles passing from pavement to gravel.



## 11.4 WINTER WOES:

### 11.4.1 SNOWPLOW DAMAGE: dug up roads, plow berms, crowns removed, etc

**Cause:** Overeager or careless snow removal before roads have frozen in the Fall, and particularly, after they have thawed in the Spring

**Solution:** Exercise care when plowing, have prearrangements to not have roads plowed under certain conditions, or plow with front mounted grader-rake instead of a conventional snowplow.

Snowplows, especially the trip-edge type so common here in the Northeast, are designed to cut under the snow and cannot distinguish between snow and gravel. Plowing one late winter snowstorm can undo a whole season's improvements to a road, especially if plow damage goes unrepaired before spring rains take advantage of new channels made by the snowplow.

Ironically, many of these early or late season snows would melt within a day if left alone. Therefore, the option exists for a road association to establish an agreement between road users and maintenance personnel as to when to avoid plowing because resulting damage may outweigh benefits.

Many of the towns and contractors who use front-mounted grader rakes for summer maintenance have found these units to be well suited to clear snow and slush from soft roads. Because the units are even useful for breaking up winter ice, the demand for traction sand can be reduced along with its detrimental effects on road surfaces and surface water.



**Snowplow trip edges dig into soft roads. Front mounted rakes are an effective alternative for plowing early and late winter storms when roads are not frozen. Heavy, wet snow sticks together rather than running through the tines.**



Rake tines not only remove most snow, especially if it is wet and sticky, but also mix a little remaining snow with the road surface to make a high traction surface

**The best alternative , whenever possible, is to avoid plowing soft roads and let the snow melt!**

**11.4.2 ICE DAM WASHOUTS: late winter or early spring gullies along the traveled way**

**Cause:** unusual buildup of ice in the snowbanks alongside the plowed road keeping water from being able to run to the road ditches

**Solution:** Although there is no practical way to eliminate such ice dams, their effects can be reduced by cutting slots through the ice to the road ditch. These slots should be placed as often as possible, especially on steeply sloping roads.

This particular problem seems to be the result of changes in our winters that bring more icy rains. If, before channels are opened up through the ice, ice dams do start water washing down the road rather than to the road ditches, it is important to create small dams in the water formed channels to force water into the new turn-outs or it will continue to wash down the road.

\* \* \* \* \*

## GLOSSARY & INDEX

- Aggregate** p.3, sec. 2.0 The soil materials- stone, sand, silt and clay that make up the gravel that roads are made of
- Bank Run Gravel** p.4, sec.2.0 The material that is taken from a “borrow” pit (sand or gravel bank) without any screening, crushing, or other processing
- Berm** p.20, sec.7.6 A row or “windrow” of road surface material that rolls off the end of a grader blade or rake that often stops water from reaching the road ditch
- Binder** p.9, sec 4.2 The fine particles that help hold the road surface together (see Fines)
- Blade** p.14, sec.6.2 A rigid device fitted under a road grader or in front of or behind a tractor used for leveling and grading
- Calcium Chloride** p.29, sec.11.2.2 A chemical available in liquid or as bagged flakes used to reduce dust from leaving the road surface and, in heavier applications, to help stabilize road surfaces
- Catch basins**, p. 27 sec 10.2 Manmade structures below ground with some sort of opening to the ground surface used to intercept water and either let water soak away into the ground (leaching basin) or go into a culvert to be carried away across a road or downhill to daylight
- Cohesion** p.7, sec.4.1 The process of sticking together tightly, typically applied to road surface materials
- Compaction** p.19, sec.7.5 The process of squeezing road materials together to eliminate all voids to keep water out of the road material. Typically done by mechanical means
- Crown** p.10, sec. 5.4 The pitch given to one side or the other or to both sides of the surface of a road to shed water and reduce potholes
- Crushed Gravel** p.4, sec. 2.0 Material that has been mined from natural deposits and run through a crushing machine to break larger rocks down to a specified size. Can also apply to material that has been blasted from solid rock and crushed to a maximum size (see Ledge Pack). Typically contains stone, sand and “fines.” Can Often referred to by the maximum size of the stones along with the word “minus” as in “3/4 minus” meaning nothing larger than 3/4” but including everything down to microscopic clay particles.
- Crushed Stone** p.4, sec.2.0 For our purposes, washed and graded stone of a specific size with minimal stones larger or smaller, such as 1 1/2”, 3/4”, or 3/8” “peastone”
- Culvert** p 23, sec.8.2, & Quick Tips A pipe generally made of steel, plastic or concrete buried in the ground to allow water to pass across a road or driveway from one ditch or catch basin structure to another.
- Ditch** p.5, sec.3.1 Open depression that runs along the side of the road to collect and channel water beside and, ideally, away from the road
- Dust** p.29, sec.11.2.2 The fine particles of silt and clay (fines) that get sucked out of the surface of the road from passing vehicles when the road surface is too dry
- Fines** p.5, sec. 3.0 Tiny particles of silt and clay that help bind the larger pieces of road surface material together. Too many fines and a road surface is greasy when wet, too few and the surface is loose. Can leave the road surface as Dust (above) when road surfaces get too dry.
- Geotextiles** p.6, sec.3.3 Synthetic fabrics that are used under rip-rap in ditches (non-woven) and also under a layer of surface gravel to stabilize roads that suffer from an unstable base (woven type)
- Gravel** p.4, sec.2.0 Naturally occurring deposits or processed material that contains many different sizes of stones, sand, silt and clay particles NOT CLEAN AND GRADED CRUSHED STONE (see note on p.4)

- Ice dam** p.21, sec.7.6; p.26 sec.11.1.2 A ridge of ice along the shoulder of a road that keeps water from reaching the ditch, especially harmful on hills, similar to roof ice dams on buildings
- Leaching basin** p.28, sec 10.3 A catch basin that returns stormwater directly to the ground like a dry well
- Lift** p.18, 7.4 A layer of backfill or fill material generally placed so that it can be compacted before the next layer is placed
- Ledge pack** p.9 sec. 4.3 A road surfacing material typically made of blasted and crushed ledge, sometimes locally called Hard Pack or similar name.
- Permeability** p.3, sec 2.0 A soil's ability to allow water to pass through, more permeable means water passes more easily.
- Potholes** p.10, sec. 5.4; p.26, sec.11.1.1 Holes in either a paved or unpaved road surface. On unpaved roads they are the result of water and traffic on surfaces that are too flat. (On pavement they are typically the result of failure of the road base or water penetrating the pavement and freezing.)
- RAP recycled pavement** p.9, sec. 4.3 A road surfacing material made from ground asphalt with or without added gravel or binder
- Rake** p.14, sec.6.2 A device used for maintaining road surfaces that is comprised of several flexible steel tines in a row that can dig into a road surface for grading while also helping to separate debris from the road surface. Can go in front of or behind a truck, tractor or grader.
- Reshaping** p.10, sec.5.1 Involves digging into the road surface to cut out potholes and rework material into a crown to shed water to prevent potholes from reforming
- Rolling dip** p.23, sec. 8.2 A constructed depression across a road for the purpose of carrying water from one side to the other. (see Stone Ford)
- Rotten rock** p.9, sec. 4.3 A natural material consisting of soft ledge that has broken down into small pieces. Available only in some areas, sometimes screened, and often used just as it comes from the ground.
- Shoulder** p.6, sec.3.1 Diagram The edge of the road between the traveled way and the ditch, if there is one
- Sieve** p.8, sec.4.2 A fine screen with small openings that is used to determine the percentage of different size soil particles
- Smoothing** p.10, sec.5.2 The process of regular maintenance that cuts only slightly into the road surface with the grading or maintenance tool
- Steward, road** p.46 Quick Tips The person who keeps watch over road, ditch, and culvert conditions to report any conditions that could cause further damage to the road if not taken care of soon
- Stone ford** p.23, sec.8.2 A stone bottomed depression across a road that carries water across the road or driveway
- Subsurface drain** p.6, sec.3.2 A structure installed under or next to a road to remove ground water to a safe place away from the road. Usually a perforated pipe bedded in washed stone or sand
- Underdrains** (see Subsurface Drains)
- Washboard** p.29 sec. 1.2.1 Repeating ripples or ridges in a road surface typically due to dry conditions and heavy footed drivers
- Washouts** p.28, sec.11.1.6 Channels in road surface caused by heavy rain, poor crown, drivers driving in the same ruts and lack of maintenance
- Water bar** p.23, sec. 8.2 See Rolling Dip and/or Stone ford
- Water turnout** p.22; 8.1 An opening through any obstruction next to a road to allow water to flow away from the road

## QUICK TIPS: THINGS THAT CAN BE DONE NOW TO IMPROVE YOUR GRAVEL ROAD OR DRIVEWAY

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**Every private road should have a steward, someone to watch out for the things that can cause greater problems if not taken care of NOW! If it's your own driveway, YOU are the steward. Knowing when to take action yourself or to notify whoever can take action might save a road or driveway from disappearing needlessly. As a steward you should watch:**

**Water drainage patterns** on the surface of the road. If water is beginning to flow where it should not, even a hasty scratch mark with a hoe, shovel, stick or heel of a boot to redirect water to where it *should* go might divert disaster. Catching this in time is the key. Hence the title of A Ditch In Time.

**Culvert inlets and outlets as well as ditches** to be sure they are not blocked. A stick or two across a culvert



or a ditch can dam water flow just like a beaver dam, especially if other debris snags on and builds up. This is especially important as leaves fall in autumn. The dammed water will find another path across or out into the road, most likely causing a washout. When you are out for a walk, throw those errant branches back into the woods.

**This culvert was blocked by a small piece of brush that had been trimmed at the side of the road but left where it fell. It got caught at the entrance to the culvert and caught leaves and other debris, blocking the culvert and resulting in the loss of the driveway when water washed down the road instead of through the culvert.**

**Water bars (sometimes known as “rolling dips.”)** Be sure they are not losing their shape due to mechanical damage from snowplows or normal wear and tear and therefore allowing water to jump over and run down the wheel tracks in the road. A little handwork can often make them serviceable again.

**Water turnouts and grader berms.** Keep turnouts open and look for areas where more turnouts might be added. Cut slots through grader or snowplow berms to let water off the roadbed, especially on hills. This is true even for paved roads with regards to snowplow berms.

### **Other helpful and preventative actions:**

**Remove leaves** when they first fall and are light and dry. Backpack or walk-behind blowers work well on leaves that have not yet been beaten down by traffic or winter.



**Grade out potholes *WHEN THEY FIRST SHOW UP!*** This is possibly the only time that dragging the old bedspring might actually work! If potholes get too deep, overfill them, especially if there are only a few here and there.

**Keep snowplows off the road** when they are soft and traffic is light, especially if snow is going to melt in a day or two in the Spring. An overeager snowplow operator can quickly destroy even the best drainage pattern and, at the same time, relocate much of the road surface to where it shouldn't be. Many folks now have all-wheel drive vehicles if they are on a private road anyway.

**Have roads sanded only as much as absolutely needed.** Winter sand washes into waterways, covers leaves and weighs them down at the side of the road and “dilutes” the road surface as it gets worked into it.

**Don’t be like lemmings or a flock of sheep, particularly on hills.** Following the same track as everyone else, especially on steep hills, helps create wheel ruts in which water tracks, creating washouts. Simply drive all over the road whenever possible to help avoid starting or deepening those tracks.

Also learn the tricks of driving on a dirt road. Put the power to your vehicle BEFORE you get to a hill and gradually back off on the throttle as you travel up. This can help prevent washboard and the beginning of ruts that turn to washouts. Front wheel drive cars are actually more of a problem on hills than rear wheel drive cars because weight shifts to the rear of the car as it starts up a hill.



*Easy does it.*

\* \* \* \* \*

Besides the Maine Gravel Roads Maintenance Manual mentioned at the beginning of this document: [www.maine.gov/dep/land/watershed/camp/road/gravel\\_road\\_manual.pdf](http://www.maine.gov/dep/land/watershed/camp/road/gravel_road_manual.pdf) there are several other resources available for download at:

### **Maine Guide to Forming Road Associations**

[http://www.maine.gov/dep/land/watershed/road\\_association\\_guide.pdf](http://www.maine.gov/dep/land/watershed/road_association_guide.pdf)

### **Gravel Roads Design & Maintenance Manual**

[http://water.epa.gov/polwaste/nps/upload/2003\\_07\\_24\\_NPS\\_gravelroads\\_gravelroads.pdf](http://water.epa.gov/polwaste/nps/upload/2003_07_24_NPS_gravelroads_gravelroads.pdf)

### **Vermont Better Backroads Pocket Guide**

[ftp://ftp-fc.sc.egov.usda.gov/VT/RCD/BBR%202008/pocket\\_guide.pdf](ftp://ftp-fc.sc.egov.usda.gov/VT/RCD/BBR%202008/pocket_guide.pdf)

### **Answers to Frequently Asked Questions about Gravel Roads**

(Franklin County, Massachusetts)

<http://www.frcog.org/pubs/transportation/GravelRoadsFAQ/roads.PDF>

### **Problems Associated With Gravel Roads (print version only)**

*Federal Highway Administration, Pub # FHWA-SA-98-045, May 1998*

## Parting Shot:



This photo by photographer **Jamie Gemmiti** appeared on the cover of our local Conway Daily Sun newspaper on April 2, 2014. It is a different view of the same parking lot shown on page 28 of this manual that was taken on March 20<sup>th</sup> before much of the snow melted! The leaching catch basin in the middle of this lake (yes there actually is one) was repaired in spring of 2014

The part of the parking lot where the catch basin is located is paved but the new leaching system was installed under the adjacent gravel surfaced section and connected back to the existing catch basin as explained in chapter 10 Section 10.3.5: Dealing With Stormwater.

*Russ Lanoie*

Most people who see a “landscape rake” mounted on the front of a pickup truck in place of a snowplow are extremely skeptical of its ability to actually regrade a road. Here’s a response to demonstration at a Camp Road Workshop in Hope Maine in 2005:

*“ Our class knew what had to be done to fix the road as a result of the morning lectures, but we were unanimously skeptical that the Front Runner would be able to accomplish the task under the very dry and hardened condition of the road. Much to the contrary, it was able to dispatch the ruts and build a crown that perhaps is the first real crown that road has seen in 57 years.”*

Dr. Tom Eastler, State Certified Geologist # 158,  
University of Maine at Farmington



For more information and videos of this innovative road grading attachment please visit:

[www.RuralHomeTech.com](http://www.RuralHomeTech.com)

For those folks who want to try using their own snowplow equipped pickup truck for road maintenance, here’s a low cost option. It is similar to several of the rakes that Russ Lanoie adapted to fit on the front of his truck on the way to developing the FrontRunner:



**This tractor style three point hitch rear mounted landscape rake was retro-fitted to the plow hoist of a truck as a low cost alternative to a FrontRunner. While it does not have power angling and is not as rugged as the Front Runner, it can perform regular maintenance duties without the owner having to have a tractor solely for that purpose and has the added advantage of being *ahead* of the operator.**

The circuit rider from the Maine DOT Local Roads Center who co-presented with me at the Camp Road Maintenance Workshops for several years throughout southern Maine always preached that,

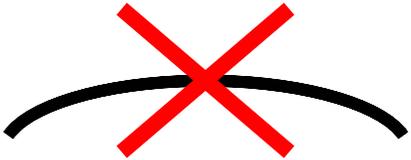
*“A grader operator will grade a road flat nine out of nine times.”*

Several years ago I came upon a big grader working on a well-traveled gravel road locally. It was ripping the road up and it was clear that the operator was preparing the surface for reshaping, or so I thought. Late that winter I happened to travel the road again, only to find that it was as full of potholes as ever. In spite of the full-scale firepower unleashed on the road to rework it the previous Fall, it was still just as flat as the circuit rider said it would be. That observation prompted me to write the following...

### The Perfect Crown

I think that I shall never see, a dirt road shaped as it should be.

Not graded flat the way some do, or rutted like a dubble-u,  
Nor rounded like a baby’s rear, but pointed like a Martian’s ear



To keep the surface of the road from looking like a horny toad  
With bumps and craters on its back, and slippery mud, due to a lack  
Of drainage, shaped so it can’t shed all water off its back, instead.

The trouble with a rounded road, is that it’s flattest where the load  
Is double that of either side, because it’s where more tires ride,  
‘Cause cars both going to and fro, crowd toward the middle, don’t ya know?  
New England dirt roads narrow be, from ditch to wall and rock to tree.

The simple rule to keep your road from looking like that horny toad  
Just make it look like letter “A” and you will find that it will stay  
As smooth as that new baby’s ass, because it’s shaped so *it can last!*



©Russ Lanoie 2001, Conway, NH



At the other end of the spectrum from the road grader mentioned above, and on the other side of the earth, a world traveler from the White Mountains spotted this Mongolian road “grader” on the Chinese border, “a million miles from nowhere.” It appears that the tank in the back of the truck is probably for water which is helpful, but the grading device is even less likely to provide any sort of crown than did the big grader that prompted the poem.

**The tips in this manual will help you understand the importance of proper crown and how to achieve it along with other maintenance procedures and show you how to put them into practice on your road or driveway.**