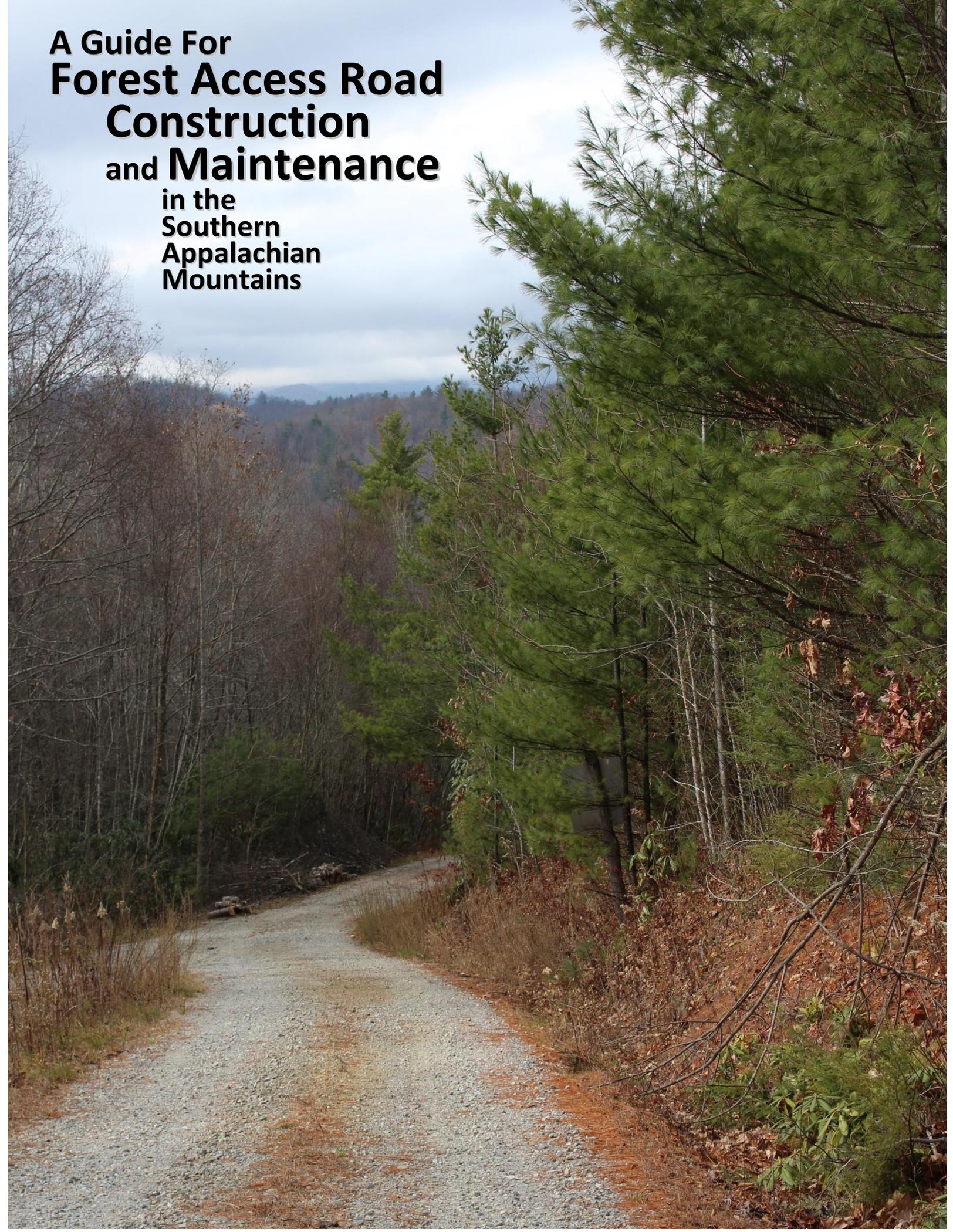


**A Guide For
Forest Access Road
Construction
and Maintenance
in the
Southern
Appalachian
Mountains**



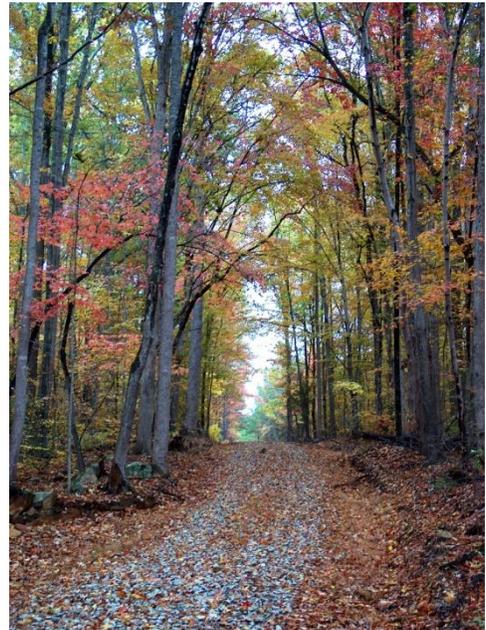
A GUIDE FOR FOREST ACCESS ROAD CONSTRUCTION and MAINTENANCE IN THE SOUTHERN APPALACHIAN MOUNTAINS

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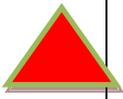
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INTRODUCTION

It is sadly ironic that many of the roads intended to help people enjoy the Appalachian Mountains are inadequately built and often damaging to the beautiful scenery and clear water that make this region so attractive. Poorly constructed and maintained access roads often cause severe soil erosion and sedimentation into streams. Erosion can be disastrous on fragile mountain landscapes, and the landowner must pay dearly for frequent and costly repairs of a poorly designed road.



Ultimately, if you own land, you are responsible for ensuring that your road is properly constructed and maintained. Building an access road in the mountains can be complicated and expensive. Regardless of the advice that you may receive, it is vital to remember that there are no inexpensive “shortcuts” when building a road in the mountains. Admittedly, it is expensive to build a good road. But it is always less expensive to build a good road the first time than to re-build a bad road year after year!



If a road is designed, built, and maintained by using “best management practices” (BMPs), then you will conserve soil, keep the streams clear, minimize the overall environmental impact, and maintain more useful access.

HOW TO GET THE ROAD YOU NEED

First, decide if you really need a road. Can you access your land through a neighbor’s property? How long of a road is really needed? How often will you need to use the road? Can you get by with just having a trail and access your land by all-terrain or off-road vehicle?

Getting the road that you need requires homework. This guide, and other references listed in the back, are useful resources for learning about proper road construction. You will need careful planning, design, and construction supervision is needed, either by you or a reliable professional. You will likely be disappointed if you leave critical decisions in the hands of an un-proven construction contractor or bulldozer operator. Whether you do the planning yourself or hire a professional, some knowledge of your own about planning, layout, and construction of roads is crucial.

This guide provides the basics. For many people and situations, the information provided may be sufficient to design and build a road. For others, professional on-site assistance is necessary. This booklet does not address all of the aspects or possible considerations for constructing a road. You must determine the limits of your abilities, and professional assistance certainly should be obtained for complex projects.

PART 1: PRE-CONSTRUCTION PLANNING

Planning in advance is essential for constructing a safe, reliable, and low-impact access road. Inspect your property to become familiar with the land features, recognizing its opportunities and its challenges. Overlooking this important phase can be an expensive mistake. The factors considered and decisions made in early planning represent the fundamental building blocks of a good road.

1.A. - Get To Know Your Property

This first step involves two main objectives: (1) Referencing different types of maps, and; (2) Verifying that the maps are accurate by going out, and inspecting your property.

1.A.1. - Obtain the most detailed and current maps available for your property.

Listed below are maps that you will find helpful in planning your road, and methods for obtaining the map:

Property Ownership Map or Boundary Survey Plat: *To locate property lines.*

Property boundary maps are available from the County Register of Deeds office or Land Records office. If such maps do not exist, you should hire a registered land surveyor to survey the property boundary lines for you.

Soil Maps: *To identify the types of soils and location of water features.*

Soils maps are usually available at the Soil & Water Conservation District office, the Cooperative Extension Office, or the USDA-Natural Resources Conservation Service (NRCS). Some soil mapping information is available from the USDA-NRCS Web site, <http://soils.usda.gov/survey/>.

Topographic Map: *To determine elevations and important landscape features.*

Topographic maps may be purchased from the U.S. Geological Survey (USGS) directly, or from your state geologic agency, or similar natural resources agency. Current and historical full size maps can also be downloaded from the USGS website: <http://nationalmap.gov/ustopo/index.html>.

Aerial Photographs or Satellite Images: *To see an overhead view of the property, its vegetation, structures, and existing infrastructure.*

Printed aerial photographs are becoming more difficult to locate. This older method of technology has largely been replaced by computer-aided satellite images. Aerial photos may still be available to view and copy at a Soil & Water Conservation District office, a Cooperative Ag-Extension Office, state Forest Service office, or an office of the USDA-Farm Services Agency (FSA). Highly-detailed satellite images may be available from your state's Forestry, or Environmental Protection, or Natural Resources agency. Low-resolution satellite photo images are also readily available from many Internet Web sites.

1.A.2. - Carefully study the maps and identify the property's important features and characteristics.

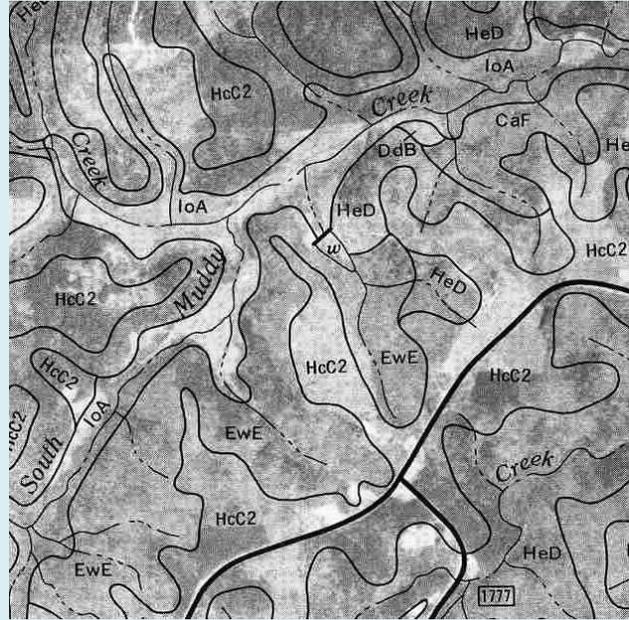
Using the property map, accurately transfer and draw the ownership lines onto the topographic map and the soil map. Once you locate your property upon each map, examine each map to identify problem areas that should be avoided. Areas to avoid include: very steep slopes; streams; wetlands or swamp areas; excessively rocky areas; soils that are shallow to bedrock; highly erosive soils; and soils that have a landslide hazard.

1.A.3. - How to Read Soil Maps

The alphabetic codes on the soil map represent the different types of soils that have been surveyed or estimated.

You will need to reference the soil survey book for the county to decode what the map is showing and to understand the limitations of each soil type.

Creek, streams, and ditches are usually drawn with solid lines or dashed/dotted lines. For example, on this soil map the *South Muddy Creek* is a major waterway in the area. Take note of the numerous smaller feeder creeks that are shown draining into *South Muddy Creek*.



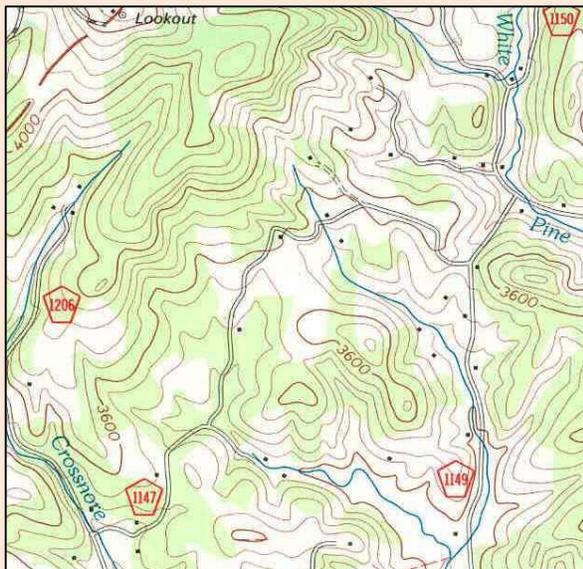
1.A.4. - Using the Soil Map and Survey Book

Written descriptions of each soil in a county are compiled in a county-wide soil survey book, which include the soil maps. The soil descriptions include useful information, such as: the soil's likelihood of eroding; the potential use of the soil for road construction fill material; how well water absorbs into the soil; the amount of sand, silt, and clay in the soil; and the average potential slope of the land where each soil type is commonly found.

1.A.5. - How to Read Topographic Maps

Blue lines on the topographic (or 'topo') map show major creeks. Sometimes these blue lines are drawn as a solid line and sometimes are drawn as a dashed line. In either case, you should avoid crossing streams if at all possible.

The brown-colored 'squiggly' lines on topographic maps indicate the estimated elevation of the land along that contour line. For example, on the topographic shown on page 5, the brown line that has "3600" printed on it means that the land that lays approximately along that line, on the map, is about 3,600 feet in elevation. Each successive line above or below that line represents a certain number of feet change in elevation, either higher or lower.



In addition, where the brown contour lines are more closely spaced together, this indicates the ground is steeper. So for example, look at the topographic map here, in the area of White Pine Creek on the upper-right corner of the map. In the area where the word “Pine” is printed, there are many contour lines tightly spaced together.

Now, compare this area to where the word “White” is printed, in which there are not as many contour lines, and they are spaced further apart. This tells you that the land is steeper near where the word “Pine” is printed, when compared with the area where the word “White” is printed.

Contour lines that are drawn in the shape of a “V” are good places to look for a possible creek, stream, or springhead. On the example map shown above, notice how *Crossnore Creek* is drawn so that it stops well below the *Lookout Tower*. But, the brown contour lines continue to be drawn in a sharp “V” shape pointing upwards. There is a very high probability that this creek, or smaller feeder creeks, actually exist further up the slope from where this map has stopped showing the blue-line drawing of *Crossnore Creek*.



There will almost certainly be more creeks or streams upon your land than what is drawn on topographic or soil maps. Do not rely upon maps to show where all creeks are located. You need to walk your land, and investigate for yourself to verify the location of creeks or wetland areas on your property.

1.A.6. - Using the Topographic Maps

You can begin to draw possible locations for your road on the topographic map, which will help you to determine the road length. This may be done as follows:

Step 1: Locate the control points: These are places where you need the road to pass through, to meet your needs. Examples of control points could be: a building site; a fishing pond; a hunting stand; an area of timber that is to be harvested; the entrance from the public road; and the highest and lowest elevation points along your new road’s path. Choose points to avoid crossing streams and excessively steep areas.

Step 2: Determine the total elevation difference between each consecutive control point. You can read the contour lines to estimate the land’s elevation. A well-designed road should be located along the side ridge of a hill slope, not directly up and down the face of the slope.

Step 3: To check for the maximum allowable steepness of your road, multiply each change in elevation difference by 12.5 to determine the minimum length of road required between each control point. Using this 12.5 multiplication factor assumes that the road will be constructed at an average slope grade of 8% (see Section 2.A.). If you plan a road that will be shorter and steeper than this approximation, you may be headed for trouble!

1.A.7. - Using Computer Technology: GPS and GIS

Computer-based software programs have made much of this work easier. But you must have the correct equipment and knowledge to use the computer programs correctly. Most engineering and natural resource professionals today use a Global Positioning System (GPS) data collection unit to record latitude and longitude earth coordinates. These coordinate points can then be downloaded into a computer and used to accurately draw a map. The GPS points often are used together with a computer program known as a Geographic Information System (GIS). A GIS is a comprehensive tool to produce detailed maps that can incorporate aerial photos, soils data, streams, elevation change, and other land features.



The use of GPS and GIS is beyond the scope of explaining in this guide book for most landowners who wish to build a new road. The availability of these powerful technological tools is another good reason to hire a professional who can assist you with the design and construction of your road.

1.B - Points to Ponder As You Plan

1.B.1.- Know the state and local laws, ordinances, and regulations.

Rules vary from state to state, and county to county. Permits may be required. Regulations may include land use zoning, subdivision ordinances, sediment and erosion control, stream crossings and stream buffers, or other requirements. An erosion control plan for construction sites may be required.



Sedimentation, erosion, or water quality damage that results from your road construction could bring costly fines, penalties, or even legal action against you.

The process of understanding the multiple layers of rules, laws, and ordinances will be frustrating and will likely require that you speak with many different government agencies. Be patient, take good notes, and if possible, have face-to-face meetings when you identify a person who can assist you.

1.B.2. - Plan ahead for possible future maintenance.

If you plan for the state, county, or town highway department to assume responsibility for maintaining your road, then you must verify this agreement with the appropriate agency supervisors, and prepare to construct your road according to the proper standards. This booklet is not intended to provide guidance to meet highway department standards.

1.B.3. - Be prepared to pay the cost of constructing a good road.

The cost of constructing a road will vary greatly from site to site. The cost may increase due to the following:

- Steep land: costs increase due to more earth-moving on steep slopes.
- Winter construction: costs increase because it takes longer to build.
- Rocky land: the costs of drilling, excavating, moving or blasting rock are high.
- Drainage needed: surface and subsurface water must be managed.
- Unstable soil: extra precautions are required to prevent erosion or landslides.
- Site clearing required: wooded areas must be cleared before construction can begin.



Don't give your land away! Erosion and sedimentation control measures need to be implemented before, during, and after road construction to keep your soil from washing away. Using appropriate Best Management Practices (BMPs) will help to prevent erosion and keep sediment from polluting nearby creeks and ponds.

1.C. - Deciding Where To Put The Road

After you mark on the maps where you think a road should go on your property, get to know the road's potential pathway by walking over it several times. Make notes of any features that are different or are not as indicated on the maps. Walking in a downhill direction may provide you with a better view of the terrain.

Step 1: Identify property boundaries and try to keep the road's location at least 50 feet from any boundary line. Doing so will avoid unintended trespassing or damage onto your neighbor's property.

Step 2: Choose a starting point elevation on the existing road as close as possible to your destination's elevation to minimize your proposed access road's length and grade.

Step 3: Choose an entrance onto the public road where there is good visibility from all directions. Avoid entering onto the public road in a curve or at the top of a hill. A driveway or access permit from the state, county, or town highway department may be required to connect to the public road. The entrance point will need to be constructed according to their standards for public access points.

Step 4: Avoid streams, creeks, and springs whenever possible. If streams must be crossed, make crossings at right angles to the stream channel. Maintain an undisturbed buffer strip of land that is at least 100 feet wide alongside creeks or streams. On flatter ground, this buffer may be reduced in width, but should be no less than 50 feet wide. Keep your road well away from springs and wet areas. Route the road above wet areas where possible. Refer to your state's forestry BMP manual for more guidance on protecting streams.

1.C.1 - Inadequate Subsurface Soil Drainage

Inadequate subsurface drainage refers to excess water that exists within the soil, below the normal ground surface. This may be a natural condition or it may result from failure to properly remove surface water.



**Avoid placing the road atop of poorly drained soils.
Poorly drained roads fall apart in wet weather with even minimal traffic.**

Gravel that is applied for road surfacing atop wet soils will quickly sink into the soil and require repeated replenishing unless geotextile underlayment is applied.

**Erosion control and stability of fill slopes and cut banks
are impossible to maintain on poorly drained soils.**

Identify poorly drained soils on the soil map. Examine the road's pathway for signs of subsurface drainage problems. The following may be signs of subsurface drainage problems:

- ✗ Soil that is grayish in color, when you dig a hole and look at the soil clods
- ✗ Areas with numerous springs or seeps
- ✗ Low areas or ground with a perpetual soft, mushy surface
- ✗ Standing water even during the growing season
- ✗ Areas predominated by water-tolerant plants

1.D. - Assistance Is Available

If by this point, road construction already seems like an overwhelming task for you, don't give up! Help is available, but do not expect someone else to plan and construct your road for you unless you are willing to pay for it. Free assistance may be available, on a limited basis, from several public service agencies that have technical expertise in forestry or road construction Best Management Practices (BMPs). The services of each agency will vary on a state-by-state, or county-by-county basis. Some agencies that may be able to assist include:

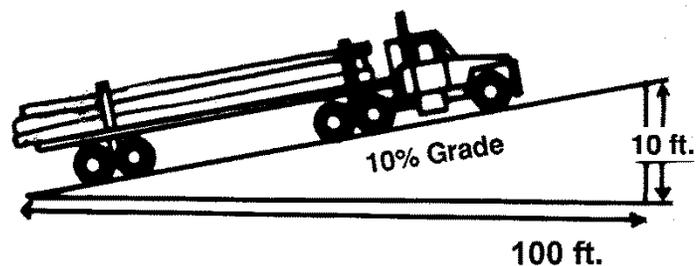
- State Forestry Service, Division, or Commission
- Town, County, or State Highway Department
- Soil & Water Conservation District
- Town or County Erosion Control Department
- USDA Natural Resources Conservation Service
- State Cooperative Extension Service

PART 2: DESIGN GUIDELINES

This chapter can help you understand the basics of designing roads before trying to locate or position a road on the land.

2.A. - Road Grade

The maximum grade of the roadbed should be less than 10% for best results (10 feet vertical change of elevation across 100 feet horizontal distance).



Maximum sustained grades should never exceed:

- 6 percent for natural soil and grass surface
- 10 percent for gravel or crushed stone surface
- 16 percent if paved

Where no other alternatives exist, these grades may be increased up to 15 percent on gravel roads (if crushed stone is applied) and 20 percent on paved roads for short segments of 200 feet or less.



Steep grades should always be avoided at road curves or intersections.

2.B. - Road Width

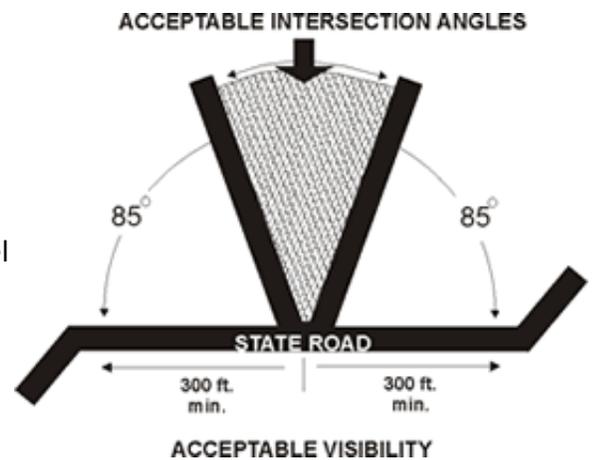


The minimum width of the roadbed should be 14 feet wide for one-way traffic and 20 feet wide for two-way traffic. The minimum tread width is 10 feet for one-way traffic and 15 feet for two-way traffic.

The minimum shoulder width is 2 feet on each side of tread width. Increase all widths by 4 feet if traffic from towed trailers of any kind is expected.

2.C. - Public Road Entrances

For safety, the angle of intersection of your access road and a public road should be no less than 85 degrees, and the clear sight distance to each in direction of travel should be no less than 300 feet.



2.D. - Curves and Switchbacks

The minimum radius of curvature for the centerline of the road should be as follows:

- 35 feet for short-bodied vehicles
- 50 feet for tractor trailers

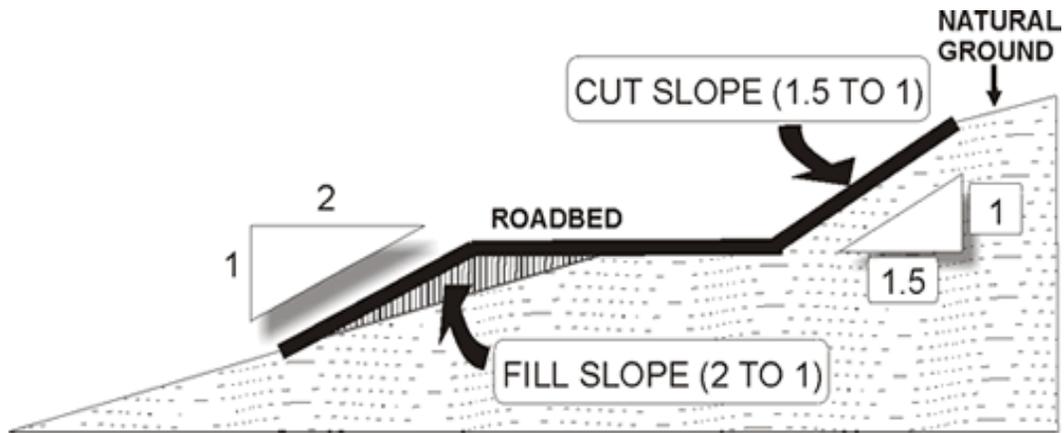
In recreational areas, the radius may need to be increased to accommodate long recreational vehicles. Refer to page 26 on how to lay out and stake a road curve.



Plan switchbacks and curves on grades as flat as possible.

2.E. - Side Slopes

All road-cuts and road-fills should have slopes that are stable for the particular soil and conditions. Cut slopes may be vertical when less than 3 feet high. Cut slopes should not be steeper than 1.5 to 1 where the cut slope is greater than 3 feet. Fill slopes should not be steeper than 2 to 1 unless an analysis of the soil shows steeper slopes to be stable. Where mowing of slope banks is expected, cut and fill slopes should be no steeper than 3 to 1.



This photo shows a fill slope that has been seeded with grass. The road is surfaced with gravel. The old stumps that were removed for the road are piled along the bottom toe of the slope. This debris at first is unsightly, but over time vegetation will grow up and obscure their view. These stumps help to capture any sediment that may wash off the road and are a good tool to use.

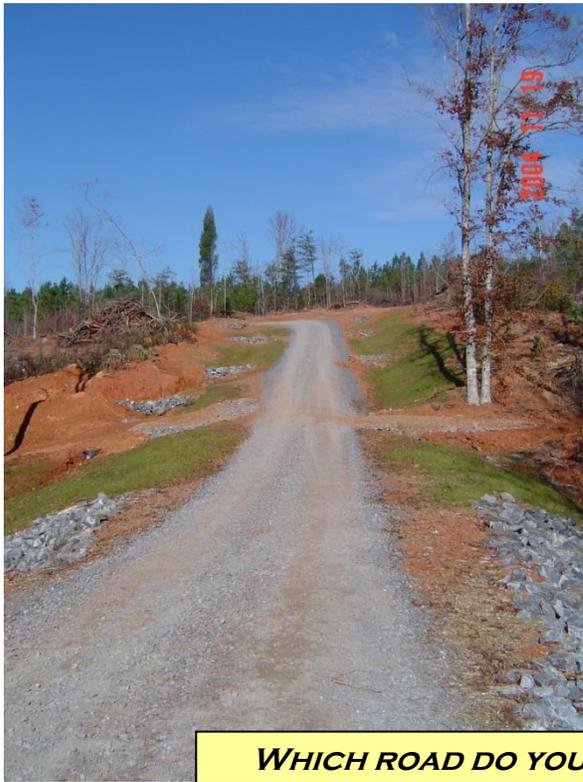
PART 3: SURFACE DRAINAGE

No other aspect of road design is more important and less understood than surface drainage along the road. Unfortunately, this is where road-builders sometimes may try to “save time and money,” which will lead to an expensive and long-term mistake!

The surface water from all sources must be conveyed from off of the roadway at frequent locations to control soil erosion, maintain a stable road surface, reduce future maintenance, and avoid repairs.

Surface drainage is needed to manage water from the following sources:

- Rain and other precipitation upon the roadbed, as well as cut and fill slopes
- Overland storm runoff flow from the watershed above the road
- Springs, seeps or streams that are intercepted by the road



WHICH ROAD DO YOU WANT ON YOUR LAND?

| Out-sloped road with broad-based dips | In-sloped road with or without broad-based dips | Out-sloped or crowned bed with roadside ditch and culverts | In-sloped with roadside ditch and culverts |
|---|--|---|---|
|  |  |  |  |
| Cross-section view of road | | | |
| Most acceptable design for most roads | Only for short distances | Most commonly found design in most situations | Where road grade is too steep for broad-based dips |
| Only requires culverts for crossing streams or seeps | Only requires culverts for crossing streams or seeps | Requires additional periodic culverts to drain the ditch | Requires additional periodic culverts to drain the ditch |
| Road water flows freely off the roadbed | Road water will flow along the road surface, and will need a place to drain-off the edge | Road water flows freely off the outside edge and within the ditch | Road water flows almost entirely within the ditch |
| Where overland flow from above the road during storms is insignificant | Where overland flow from above the road during storms is slight | Where overland flow from above the road during storms is expected; or where groundwater seeps are intercepted | Where overland flow from above the road during storms is expected; or where groundwater seeps are intercepted |
| Usually requires least amount of construction | Safer on roads that are often frozen, wet, icy, or slippery | A compromise between out-sloping and use of ditches | Safer on roads that are often frozen, wet, icy, or slippery |

If possible, shape the surface of the road to drain itself by means of out-sloping and broad-based dips. Out-sloping refers to the purposeful shaping of the road, at a slight downward tilt, from the cut slope bank outwards to the fill slope. The out-sloping technique allows surface water to gently flow across and off of the road, rather than down along the length of the road. Out-sloping should be less than a one-half inch drop for every 1-foot of road width, or about a 6-inch drop for a one lane road. Refer to the chart on the previous page.

3.A. - Broad-Based Dips

Broad-based dips are an inexpensive and proven method to divert runoff from the road surface. Properly constructed broad-based dips allow smooth vehicle passage without bumping or bottoming out. On sections of a road where broad-based dips are the primary means of surface drainage, construct the dips at the following spots:

- ✓ At the crest of each downgrade, to reduce surface runoff flow along the roadway.
- ✓ About 20 to 30 feet away from either side of each stream crossing, to prevent storm runoff from entering into the stream.
- ✓ At side ridges, to displace surface runoff from the roadway.
- ⊗ Do not use broad-based dips to drain roadside ditches or groundwater seeps from a slope; and do not place them in draws.



*This is a side view of a broad-based dip. The dotted line shows the original road grade.
The curved solid line shows the new, gently rolling grade of the roadbed.
Runoff that flows off of the road surface will exit the broad-based dip atop of the large stone.*

Install a sufficient number of broad-based dips so that none are more than 100 feet apart. On steeper road slopes, you will need to install more broad-based dips at closer intervals. Refer to your state's forestry BMP manual for additional guidance on installing and spacing broad-based dips.

Sediment may collect within the bottom of a broad-based dip. Remove accumulated sediment. Identify where this sediment is coming from and stabilize those areas. Adding gravel to the broad-based dip will reinforce the structure and prolong its usefulness. For the outlet of the broad-based dip, install rip-rap or anchor some erosion control matting to avoid eroding the soil where the runoff water exits from the broad-based dip.

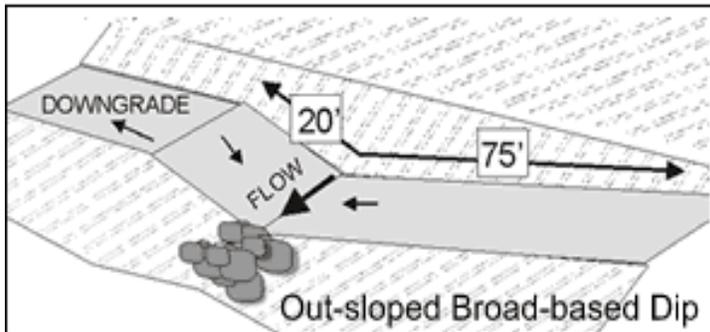


Photo at right shows a vehicle parked on a broad-based dip, along a steep road. Installing a series of multiple dips within a long, steep road grade is like building a set of stairs, for the stormwater runoff to slowly stair-step down hill, instead of rushing uncontrollably atop of the road surface. Take note of the ample gravel surface and groundcover.



3.B. - Roadside Ditches

Construct roadside ditches along the inside edge of a road where overland flow will occur from above the road during rain storms. Minimize the length, width, and depth of the ditch construction.

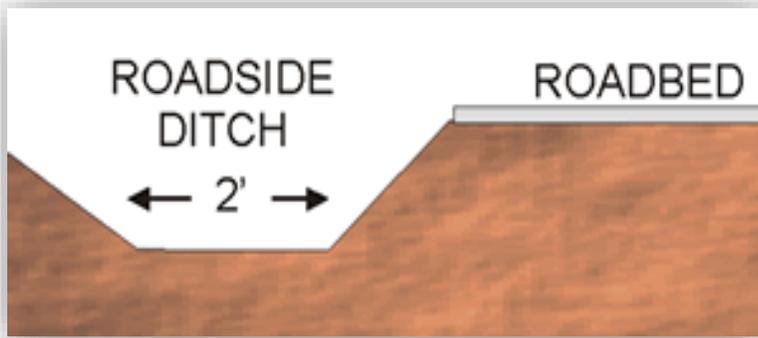


If not properly installed or maintained, the ditch that you construct will quickly and easily become an eroding gully that can undermine your road and wash away the hill slope.

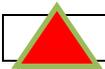
Flat bottom ditches with flat areas two feet or more in width provide for greater driver safety and reduced maintenance than do deeper V-shaped ditches.

Line the ditch with rip-rap, and/or install check dams to slow down water within the ditch and prevent scouring of the soil. Installing firmly-anchored erosion control matting may also prove effective, as well as installing straw logs (often called straw wattles or coir logs).

Only clean out ditches when they fill with sediment that is sufficient to block or divert runoff back onto the roadway surface. Identify the source of sediment and take actions to stabilize the sediment source.



Drain the ditch with culvert pipes, or turnouts (also known as wing-ditches). A turnout is an elongated, side extension of the ditch that diverts runoff water away from roadside ditch, and dead-ends into a sediment pit or onto undisturbed soil.

 **Do not empty a ditch or turnout directly into a stream, draw, or steep gully.**

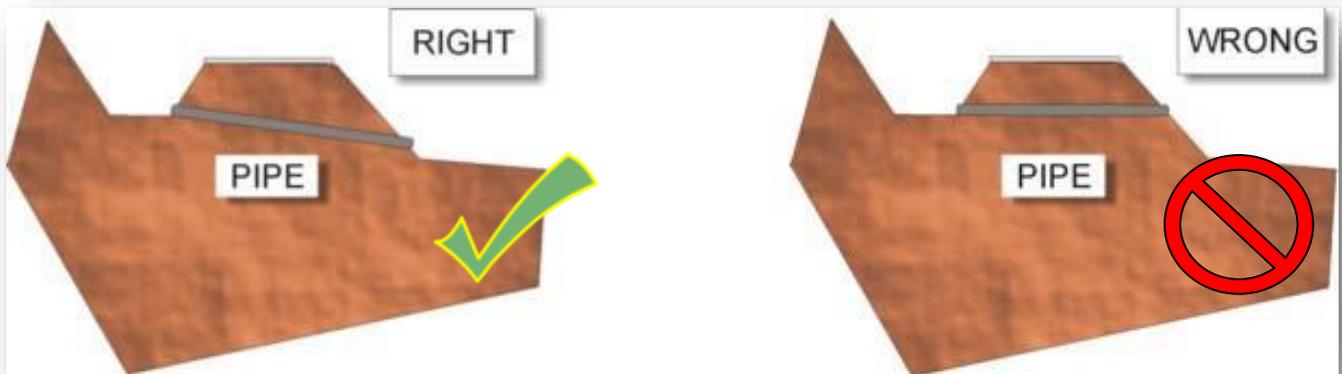
3.C. - Cross Drain Culvert Pipes

To effectively remove runoff water from the roadside ditch or from groundwater seeps on a cut slope, install a cross drain culvert through the roadbed.

 **Debris will periodically clog the inlet of cross drain culverts. This debris must be promptly removed to prevent the runoff from blowing-out the ditch or washing away the road.**

Steps for using culverts for draining roadside ditches and groundwater seeps:

- Use a culvert that is no smaller than 15-inches in diameter.
- Install a cross-drain culvert no further apart than 150 to 200 feet.
- Align the elevation of culvert inlet with the roadside ditch elevation.
- Set the culvert at a slight downslope grade to aid in water flow and self-cleaning.
- Avoid perching the outlet of the culvert above the road's slope bank.
- Stabilize the outlet of the culvert to avoid scouring of the soil from the runoff.
- Frequently inspect the inlet and outlet of each culvert and remove built-up debris.





*These two photos show the same cross drain culvert through a curve in a road.
The culvert is placed within a dry gully that only carries water after rainfall.
The photo at left is the uphill inlet end. The right photo is the downhill outlet end.
Each headwall is armored with native stone obtained on the property -- a good way to save money!*

3.D. - Road Surfacing

A road surface that is left as bare soil will not provide adequate vehicle access; provides poor surface drainage; will accelerate sedimentation and erosion; and require higher maintenance costs.

Choose the type of road surfacing material by considering traffic needs, frequency of usage, grade of road, soil type of the natural roadbed, available materials, cost, and aesthetics.

Crushed rock or gravel surfacing should be applied as soon as possible after construction (while soil surface is still freshly disturbed) to reduce soil erosion, and insure a good bond between the soil and surfacing material.



Laying down filter fabric cloth/geotextile underlayment is a worthwhile investment to keep the gravel atop of the roadway surface.



Geotextile filter fabric installed on the left, and gravel being applied atop of the geotextile on the right.

Examples of Road Surfacing Materials

Grass or Other Permanent Ground Cover Vegetation



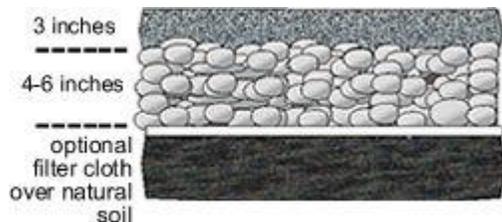
- Not for daily use or wet weather use.
- Well-drained, relatively dry soils.
- On grades less than 8%.
- Least expensive.
- Requires lime, fertilizer, mowing, etc.

Crushed Rock Only



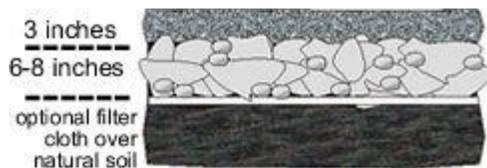
- Medium to high traffic.
- For use on naturally sandy or gravelly roadbed soils.
- On grades of 15% and less.
- Specify "ABC" or "Base Course".
- Requires periodic grading.

Crushed Rock Over Washed Gravel



- Medium to high traffic on soft soils.
- On grades of 15% and less.
- Specify "ABC over washed gravel".
- Requires periodic grading.
- Use fabric filter cloth/geotextile on poorly drained areas.

Crushed Rock Over Large Stone (3-inch stone)



- For wet sections of roads with soft mushy soil.
- For all traffic conditions.
- On grades less than 16%.
- Specify "3-inch washed stone" or "ballast stone".
- Requires periodic grading.
- Use filter fabric cloth/geotextile on poorly drained areas.

3.E. - Dealing with Poor Soil Drainage

If drainage problems are encountered in the roadbed, it is recommended that the road be relocated to a drier site. If relocation is not feasible, consider taking these actions to reduce the impact of poor drainage:

- Improve the roadbed's surface drainage.
- Remove nearby over-shading trees to allow more sunlight for drying the road.
- Apply geotextile filter-fabric underlayment cloth atop of the roadbed surface, prior to applying stone gravel. This cloth will keep the stone from sinking into the soft soil.
- Use large (3-inch) stone for the road surface along with smaller crushed stone.
- Install subsurface drainage tile (called weeping drains, or French drains).



Large stones are placed into a catch basin for draining stormwater runoff off the gravel road.

PART 4: STREAM CROSSINGS

Crossing a stream requires substantial planning and careful execution. Check with state, county, and local agencies to determine if you need to obtain permits for your crossing(s).



Avoid having to cross a stream or creek when laying out and constructing your road.

Crossing a stream will only require further maintenance and invites trouble from potential sedimentation into the water.

A landowner typically has a choice of three different methods to cross streams: culvert pipe, hardened improved ford, or a bridge. Each method comes with its own pro's and con's. This guide book cannot describe all of the measures that may be appropriate to design and install a suitable stream crossing. Even if you decide to design and build your access road yourself, you should seek professional assistance when needing to cross a stream and refer to your state's forestry BMP manual.

| <i>Pro's</i> | <i>Con's</i> |
|---|--|
| Culvert Pipe | |
| Readily available to buy | Difficult to transport to the site and set into place correctly |
| Can be a long term or short term solution | Short lengths require connecting multiple pipes |
| Made in different materials to match the needed use | Requires a lot of fill material to be placed in the channel and valley of the stream |
| | Can restrict stream flow during storms |
| | May block passage of fish and other aquatic life |
| Hardened Improved Ford | |
| Less likely to block the stream's flow | May not be suitable at crossings with steep approachways or where stream banks are high and straight-walled (known as being "incised") |
| Does not require soil fill material, but will need clean stone | Requires that vehicles drive directly through water |
| May need geotextile or filter fabric underneath the stone that is set upon the bottom of the stream channel | Access may be restricted by high water flow after storms |
| Offers a permanent solution once installed correctly | Needs clean stone applied atop of each approachway |
| Can be used to drain groundwater seeps and draws | |
| Bridge | |
| Will not block the stream's flow | Requires substantial engineering and planning |
| Provides for vehicle access during high water flow | Generally the most expensive option |
| Can be designed and built as an aesthetic feature for the property | Surface may be slick during snow or icy conditions |
| Offers a permanent solution once installed correctly | Cannot easily be widened if road width is expanded in the future |

4.A. - Culvert Pipe



Poorly installed culverts, under-sized culverts, and unstable fill material are the most common problems that are observed on access road culvert stream crossings.

If installing a culvert, be sure to follow all needed steps to design, install, and maintain it. Refer to your state forestry BMP manual for additional specifications.

4.A.1. - Comparing Culvert Pipe Material

Culverts are manufactured of different materials, and each one has different capabilities.

| Corrugated Steel | Corrugated Aluminum | Corrugated Plastic | Concrete (Round Tiles) |
|---|---|--|--|
| Most commonly available | Lighter and easier to handle than steel | Also commonly available | Typically most expensive |
| Heavy-duty and can take rough handling | Easily damaged by rough handling | More prone to crushing from heavy vehicle traffic if fill material is inadequate | Difficult to connect sections together without proper heavy equipment |
| Can be coated to prevent rusting | Rust-resistant | May be less expensive in smaller diameters than metal culvert | Heavy and difficult to handle without heavy lifting equipment |
| Can be purchased in arch-shaped, bottomless forms | | Double-wall plastic is recommended | Large concrete "box culverts" can be custom-sized to match the specific need |
| | | Rust-resistant | Rust-resistant |

4.A.2 - Determining Culvert Diameter

Many factors influence the proper diameter of culvert to use. These factors include:

Size of drainage area into the crossing: Larger drainage areas will produce higher volumes of runoff.

Upstream watershed land use: Forested land will absorb more rainfall than ag lands, pastures, or developed areas. Fewer trees in the watershed will result in increased "pulse" of storm-triggered flows.

Local rainfall patterns: Areas with more frequent or heavier rainfall patterns will produce greater and more frequent runoff, thus requiring larger and/or more culverts.

Soil type: Some soils absorb water better than others. Refer to the soil survey information.

Size of the stream channel: Closely match the cross-sectional area of the culvert to the same cross-sectional area of the stream channel.



No culvert less than 18-inches in diameter should ever be used.

4.A.3 - Culvert Sizing Chart

The chart below is a starting guide to determine what size diameter of culvert can be used. Seek guidance from the county Soil & Water Conservation District, state forestry office, or local highway department for a second opinion on what diameter of culvert is suitable.



This is an oval, steel culvert that was installed in this stream for a road crossing. The flat bottom provides better water flow and allows improved fish passage.

How to Read This Culvert Sizing Chart:

Determine the amount of upstream land area that drains down to the point at where you wish to cross the stream. Read that acreage figure down the left column. Round-up the acreage to the next largest number.

Then, estimate the slope, soils, and vegetation cover of the overall upstream watershed area, and read down that column of the table.

The numbers in the column represent the minimum diameter (in inches) of round culvert.

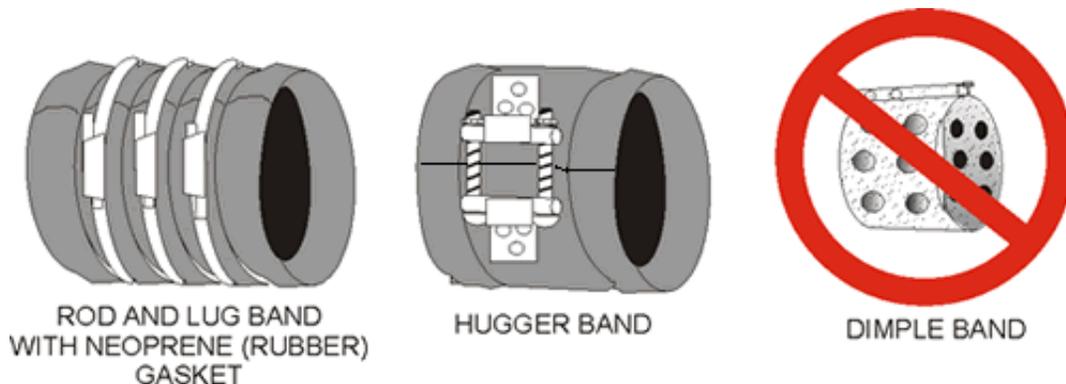
This table is based upon Talbot's formula modified to estimate a 2.5-inches-per-hour rainfall.

| <p style="text-align: center;"><i>The letter 'C' indicates the amount of runoff to expect. High value C means more runoff and heavier streamflow volume Low value C means less runoff and lighter streamflow volume</i></p> | | | | | | | | |
|---|---------------------------------------|--|-------------------------------------|---|-------------------------------------|---|-------------------------------------|--|
| | <i>Impervious 100% runoff</i> | <i>Steep slopes, heavy soils, moderate cover</i> | | <i>Moderate slopes, heavy to light soils, dense cover</i> | | <i>Gentle slopes, agricultural-type soils and cover</i> | | <i>Flatland pervious soils</i> |
| | <i>C = 1.00 Bare soil</i> | <i>C = .80 Higher Runoff</i> | <i>C = .70 Lower Runoff</i> | <i>C = .60 Higher Runoff</i> | <i>C = .50 Lower Runoff</i> | <i>C = .40 Higher Runoff</i> | <i>C = .30 Lower Runoff</i> | <i>C = .20 Normal runoff</i> |
| Acres | | | | | | | | |
| 2 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| 4 | 18 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| 6 | 24 | 18 | 18 | 18 | 18 | 18 | 18 | 18 |
| 8 | 24 | 24 | 18 | 18 | 18 | 18 | 18 | 18 |
| 10 | 30 | 24 | 24 | 24 | 18 | 18 | 18 | 18 |
| 20 | 36 | 30 | 30 | 30 | 24 | 18 | 18 | 18 |
| 30 | 42 | 36 | 36 | 30 | 30 | 24 | 18 | 18 |
| 40 | 48 | 42 | 36 | 36 | 30 | 30 | 24 | 24 |
| 50 | 48 | 42 | 42 | 36 | 36 | 30 | 24 | 24 |
| 60 | 36+36 | 48 | 42 | 42 | 36 | 36 | 30 | 24 |
| 70 | 30+30+30 | 48 | 48 | 42 | 42 | 36 | 30 | 24 |
| 80 | 36+36+24 | 30+30+30 | 48 | 48 | 42 | 36 | 30 | 30 |
| 90 | 48+48 | 36+36 | 48 | 48 | 42 | 42 | 36 | 30 |
| 100 | 48+48 | 36+36+24 | 30+30+30 | 48 | 48 | 42 | 36 | 30 |
| 150 | | 48+48 | 36+36+36 | 36+36+24 | 30+30+30 | 48 | 42 | 36 |
| 200 | | | 48+48 | 36+36+36 | 36+36+36 | 30+30+30 | 48 | 36 |

A Note About Multiple Culverts: It is recommended that if a crossing requires an opening greater than 48 inches, that you use bridging, arch-culverts, or multiple round culverts. Some options for multiple round culverts are offered in this table. There may be other combinations that can work. Consult with an expert if you are unsure.

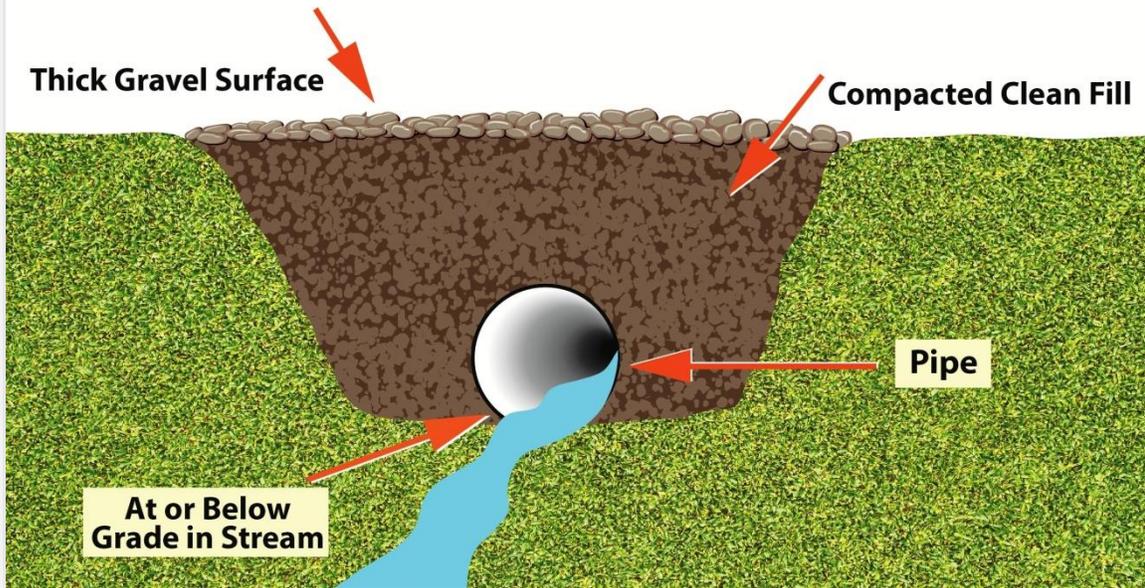
4.A.4. - Culvert Crossings

- Use arch-shaped, (oval) bottomless culverts on perennial (permanent) streams, especially where fish are known to exist in the stream.
- Consider using water pumps and temporarily piping the stream water around the crossing location during culvert installation, to prevent creating muddy water downstream and avoid having to work in wet, sloppy conditions.
- Install the culvert in the centerline of the expected water flow, to maximize flow through the pipe.
- Place the bottom of the culvert directly upon, or slightly buried, into the streambed.
- Assure that the inlet of the culvert is slightly below grade, so the stream can freely flow into and through the culvert, and not bypass underneath.
- Set the culvert at the same grade as the stream, or slightly angled downslope, to aid in flow.
- When connecting multiple pipe sections together, use water-tight bands such as the “rod and lug” band with a neoprene gasket; or a “hugger band.” **Do not use a “dimple band.”** They will not hold the sections together for a long time.



- Compact the backfill soil material that is placed around the pipe to secure it. Apply the backfill in layers, tamping each layer until firm. Ensure that soil is packed all of the way around the pipe.
- Stabilize the road fill material that is placed atop of the culvert pipe, by applying gravel or seeding in groundcover vegetation.
- Apply ample rip-rap, stone, erosion-control matting, and/or groundcover vegetation on each headwall of the culvert (the inlet side and outlet side).
- Frequently inspect the culvert and remove blockages. Repair erosion from the road.

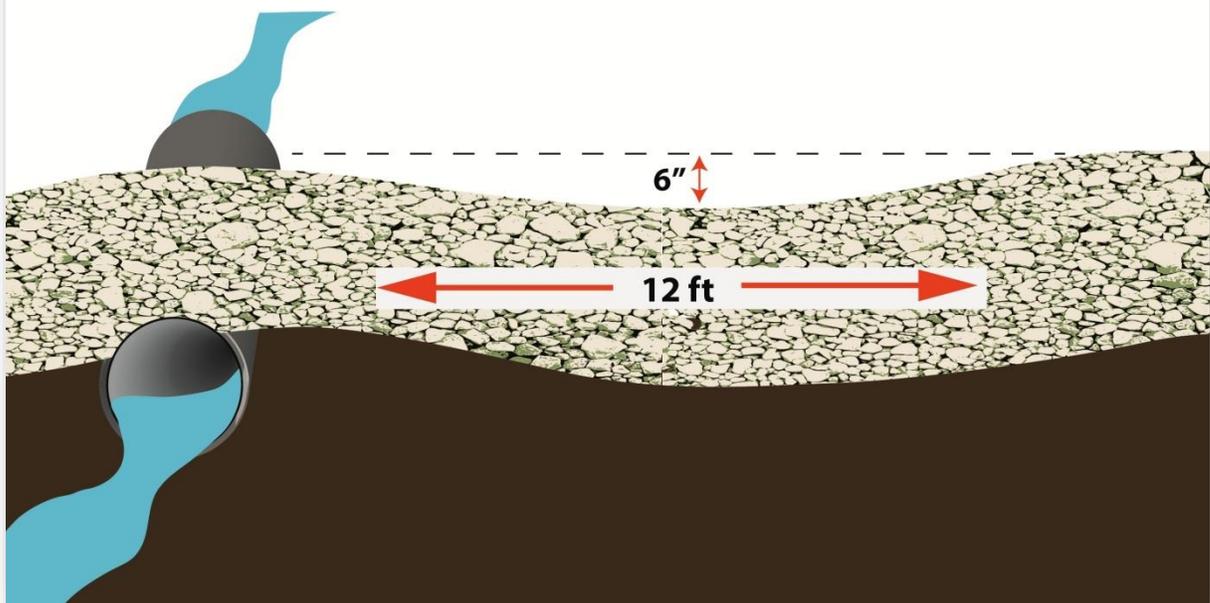
Culvert Cross Section



In large watershed drainage areas, in low-lying flatlands, and whenever a smaller diameter culvert must be used, create overflow bypass channels (see drawing below) within each approachway.

The bypass will allow high stream water from storms to flow over top of the road, and around the culvert. Apply a heavy layer of gravel in the overflow bypass, similar to a ford.

Overflow Bypass



4.B. - Ford Crossings

Fords can be a cost-effective and low-impact alternative on infrequently-used stream crossings, and for crossing streams which do not flow during the entire year, or only flow with minimal water.



Fording a stream with strong, permanent water flow is possible, but extra safety precautions should be taken to avoid being swept away by strong currents.



This ford crossing was installed to replace an improper crossing of logs, boulders, and soil. The stream is now open and free to flow, without excessive fill material blocking the channel.



Allow for stream water flow through the ford crossing, even during dry seasons of low-flow.

4.B.1. - Steps for Installing a Ford:

- Pick a location where the stream channel is narrow, straight, on relatively flat ground and the stream banks have a relatively low profile.
- Grade the road approachways at a gradual slope angle.



Avoid creating steep approachway slopes leading down directly into the stream.

- Install broad-based dips or other diversions along each approachway to divert storm runoff away from the ford crossing.
- Apply geotextile filter fabric atop of the bare soil on each approachway, prior to applying crushed stone gravel. Apply the stone gravel atop of each approachway for at least 50-feet back from each side of the ford crossing.
- Apply clean stone atop of, or slightly below, the stream's natural surface bottom in a way that will not block or alter the stream flow, even during low-flow (dry season) conditions.



**Do not use broken-up asphalt, concrete, or scrap-metal debris in a ford.
Use only clean & washed hard stone aggregate.**



Fords are ideal for streams that have an existing, hard bottom surface.

However, in places where the stream bottom is soft, you can install expandable honeycombed-shaped geotextile material which retains clean gravel inside of the honeycomb. This system can then be installed slightly below-grade of the stream's natural bottom to create a firm foundation for a ford.

- Maintain the road surface and approachways to prevent loose soil or mud from being tracked into the stream from vehicle tires. This may require additional ground cover vegetation or stone gravel to be applied atop the road surface, well beyond the ford crossing location.

4.C. - Bridge Crossings

Specifications and designs for bridges are beyond the scope of this guide book. You should enlist the services of a civil engineer who can design a bridge that will handle the intended traffic load.

Some companies sell old railroad flatcars, or former military portable bridges to the public. While these options may at first seem appealing, the transportation and installation costs may not result in much cost savings, when compared with construction of a new, on-site bridge structure. Often a large crane is needed to set those structures in place.

To temporarily cross a stream or ditch, many loggers are now using portable bridge panels, also known as bridgemats, for their logging tractors and/or log trucks.

Such bridgemats are often not structurally designed or approved by an engineer, but in many cases the steel bridgemats are rugged and can carry typical logging equipment and trucks across narrow channel spans.

A set of portable bridgemats installed over a creek for temporary access by logging trucks.



PART 5: LAYING OUT THE ROAD ON THE LAND



After becoming familiar with the property and the design concepts of road construction, it's time to lay out the road.

Laying out a road consists of staking or flagging the center-line of the road, identifying locations for broad-based dips, turnout diversions, stream crossings, and possibly staking cut and fill slopes.

5.A. - Tools to Use

The following tools are needed:

- Clinometer or Abney level: A handheld angle gauge used to measure slopes and heights. These can be purchased from forestry or surveyor equipment suppliers.
- 100 foot measuring tape: To measure road width, length, distance between dips, cut/hill slopes, etc.

- An axe, hatchet, machete, or brush-ax: To clear away vegetation so that you can more easily see the pathway, and keep track of your route. Also helpful for driving wooden stakes.
- Compass: To determine aspect and to keep yourself oriented.
- Notepad, maps and/or aerial photo: To make useful notes about the location of the road and potential problems. Maps and photos can keep you going in the right direction.
- Different colored flagging tape, surveyor pin flags, wood stakes, spray paint, and permanent markers: Use these tools to locate the road centerline, road right-of-way edge, stream crossings, location of broad based dips or other runoff control diversions, roadway curves, edge of cut & fill slopes, and other roadway features such as pull-offs or turn-around spots.

5.B. - Methods to Lay Out a Road

Laying out a road can be done alone, or with multiple persons. Both methods are explained.

5.B.1. - The One Person Method

1. Tie colored flagging tape at eye-level to a tree, bush, or limb at the starting point of the road.
2. Walk a short distance along the proposed route of the road. Using a clinometer or Abney level, sight backwards to your colored tape with the Abney/clinometer pre-set at the desired road grade slope angle.
3. Move up or down the hill until the desired grade is reached, and then flag this position, again at eye-level.
4. If a road construction obstacle (such as a large rock outcrop, wet area, property line) is encountered between your two newly established points, it may be necessary to adjust the planned grade to avoid the obstacle.
5. Walk further out along the proposed route and repeat the procedure above, always sighting back on your previous point. Set your flagging no further than 30 to 40 feet apart. Set them close enough together so that you can see at least the previous two points behind you. This will help you to stay on course.

5.B.2. - The Two Person Method

1. This method is similar to the above procedure except that instead of sighting backwards to the previous point, the person with the clinometer or Abney level (the “instrument person”) sights forward, out ahead to another person (the “flag person”) who is standing on the proposed road pathway.
 - Before using this two-person method, the instrument person should locate his/her eye level on the flag person, and always sight at this same spot on the flag person during the survey, no matter what elevation they are standing upon.
2. The instrument person directs the flag person to move up or down the hill and flag a position marking the desired road grade.
3. The flag person may mark the position (to be the centerline of the road) with flagging tape, wooden stakes, or spray paint on trees.



If the desired end of the road is missed while following your planned grade, or as a result of making adjustments to avoid obstacles, then the road locators should work backward from the endpoint and connect the two surveys at the most convenient point. It may be necessary to repeat earlier surveys several times working in both directions to find the best route. Nobody said it would be easy!

5.B.3. - Laying Out and Staking a Curve

1. Set a stake at beginning of curvature (end of straightaway)—point A.
2. Decide spacing of stakes in curve (distances from 25 to 100 feet are suitable for logging roads, with the closer spacing applicable to sharp curves).
3. Measure selected distance from A to C, in line with B.
4. At right angles to CA, set stake at D and mark distance CD on measuring stick.
5. Lay off same distance from D to E, and distance AC from A to E. Set temporary stake at E.
6. Double selected distance to F in line with AE and set stake at F.
7. Pull up temporary stake at E and set it at G by using measuring stick and tape in same way as at E.
8. Set stake H in same manner as that by which F was located.

This procedure is repeated around the curve. As long as all measurements are the same each time, the curve will be smooth. If it does not end at the right place for the next straightaway, either increase or decrease length marked on measuring stick and reset the stakes.

By using 25-foot distance A-C, a 2-foot measuring stick C-D will produce a curve with a radius of approximately 157 feet;
3-foot stick produces radius of 106 feet,
4-foot stick produces radius of 80 feet,
5-foot stick produces radius of 65 feet, and
6-foot stick produces radius of 55 feet.

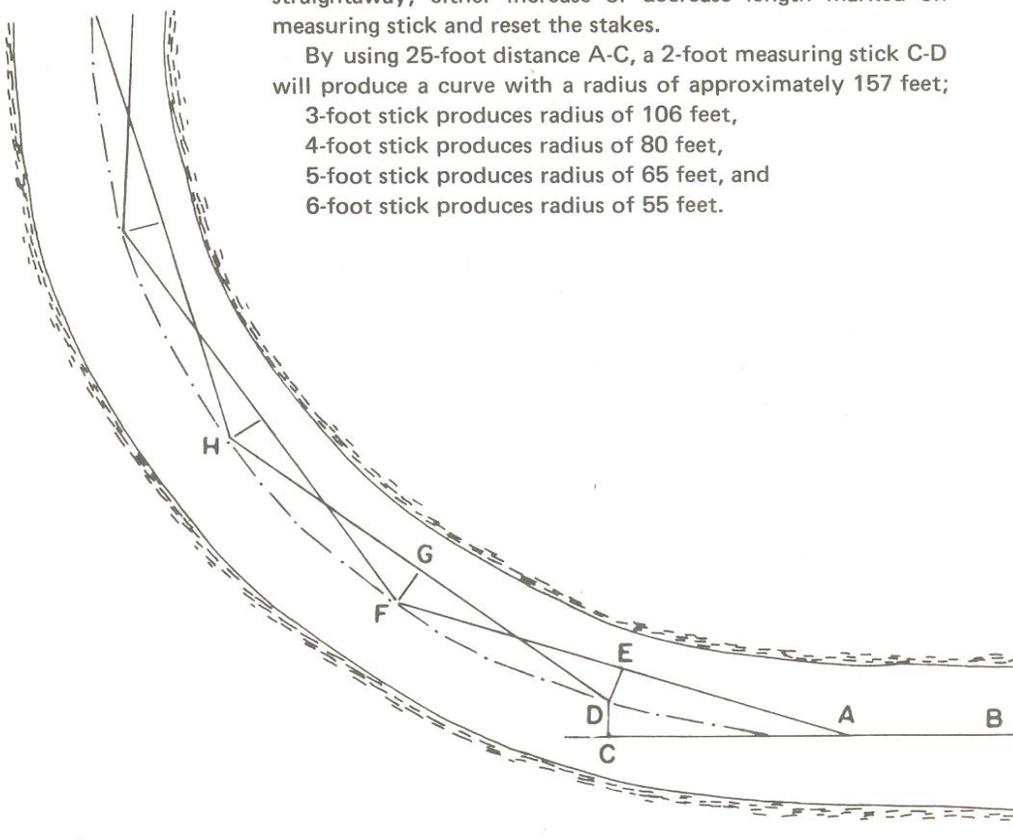


Illustration above excerpted from Figure 37 of "Permanent Logging Roads for Better Woodlot Management". USDA-Forest Service, 1978.

PART 6: GETTING READY FOR CONSTRUCTION

Now that you have planned and laid out the road, your homework is not complete. There is still vital planning to accomplish to prepare for road construction.

6.A. - Scheduling Road Construction

Road construction should occur during the milder, drier seasons of the year in the Appalachian Mountains. Working on a new road during the winter only invites problems, since the soil will either be frozen and too hard; or will be soft, soggy, and unmanageable.

Road work should be done in small increments, with short sections completed at one time.

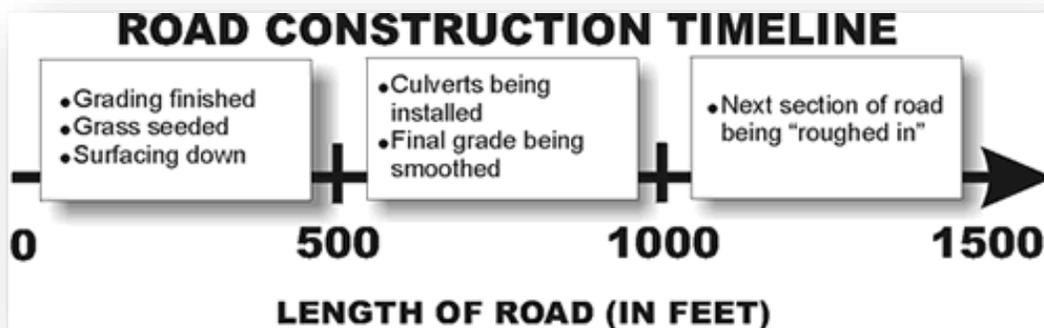
6.A.1. - Time of Year

The chart below illustrates a general schedule for road work. These seasons vary according to elevation, aspect, rainfall patterns and soils. Consult with local experts from the Soil & Water Conservation District, the state forestry agency, or local highway department.

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|--------------------------------|---|-----|--|-----|-----|---------------------------------------|-----|---------------------------------------|-----|--|-----|-----|
| TIMING FOR CONSTRUCTION | BAD TIME | | EXCELLENT TIME | | | BAD TIME | | GOOD TIME | | BAD TIME | | |
| REASONS | Snow and ice slows construction Too cold for seeding | | Good weather Excellent time for seeding | | | Too hot and dry for permanent seeding | | Good weather Good time for seeding | | Cold weather approaching Too late for permanent seeding | | |

6.A.2. - Road Work Timeline

Establish a construction schedule that requires the road to be completely finished in segments of 500 feet or less. Do not allow the road construction operator to advance too far ahead. If the weather conditions change, or a heavy rain falls, then the exposed soil will wash away and pollute the streams with sediment. In addition, maximum effectiveness is ensured when stone surfacing and seeding are performed while cuts and fills are still fresh.



6.B. - Obtaining Materials

You may wish to obtain the needed materials yourself. If you are not comfortable doing this, then you will need to have the road contractor obtain materials for you. In those cases, make sure the contractor provides you receipts for the purchases, and come to an agreement that you will only pay for the materials that are actually used on your job.

6.B.1. - Develop a Bill of Materials for each road segment.

Check early with suppliers about availability, shipping times, price, terms, and other specifics. Be sure to specify the details on the type of materials desired. Some items that may be needed include: culverts, drop inlet boxes, silt fence, erosion control matting, geotextile fabric filter cloth, crushed stone, riprap, seed, fertilizer, lime, and mulching materials.

6.B.2. - Stage the materials on site BEFORE they are needed.

Have you ever started a job only to find that you didn't have everything needed to finish? Failure to have materials on hand when they are needed results in unnecessary delays. Such delays are expensive.

6.B.3. - Inspect materials when they arrive.

Make sure that what you received is what you ordered. If materials are damaged or do not meet your specifications, then have them returned and replaced right away.

6.C. - Hiring A Quality Contractor

Discuss your plans and specifications with a contractor. Consider inviting multiple contractors to visit your site all at the same time, so that they are all given the same information. Afterwards, you can request that each contractor submit a written bid for their cost to build the road; or you can negotiate separately with each person.

Communicate your goals and expectations. Walk over the site with the contractor. Provide a copy of the specifications you have developed for your road and discuss each point. Resolve any questions. Consider the contractor's ideas and suggestions, but do not allow the contractor to change the specifications in order to save time or costs at the expense of a quality road.

| Quantity | Item |
|-----------|---|
| 3 | 15" Corrugated Steel Culverts - 30 ft. long |
| 1 | 18" Corrugated Steel Culvert - 40 ft. Long |
| 4 | Drop Boxes for Culvert Inlets |
| 8 tons | Rock Riprap for Culvert Outlets |
| <hr/> | |
| Seeding | |
| 1 ton | Agricultural lime |
| 500 lbs | 10-10-10 Fertilizer |
| 30 lbs | Ky-31 Tall Fescue |
| 40 bales | Straw Mulch |
| <hr/> | |
| Surfacing | |
| 40 tons | Washed gravel |
| 30 tons | Crusher run stone |

Always use a written contract when hiring a road contractor, or any other contractor who will work on your property. A written contract need not be long and complicated. A thorough contract can protect you and the contractor.

If a contractor refuses to use a written contract, then use another contractor! Don't take chances.

6.C.1. - Experience

Hire a contractor experienced in mountain road building. Just because a contractor has a bulldozer, backhoe, and dump truck does not mean that they are good at building roads. Check around, obtain references, and ask for examples of their previous work:

- Get out and look at some roads built by contractors.
- Talk to landowners who have hired the contractor in the past.
- If possible, work with a contractor that has obtained specialized training.

If the contractor has any objections to the above, be suspicious!

Determine if the contractor is familiar with Best Management Practices (BMPs) related to road construction. BMPs are actions that can be taken to reduce the likelihood of sedimentation, erosion, and pollution from entering into streams, creeks, and ponds. Each state forestry agency has BMPs for roads. Obtain a copy of the road BMPs and get familiar with them, prior to hiring the contractor. That way, you can test the contractor to see how familiar they are with BMPs!

6.C.2. - Avoid Bad Attitudes

Hire a contractor with an attitude toward high quality and customer service. Find another contractor if the one you are thinking of choosing says:

- × *I'm too busy to do the work in the months you want it done... but I can do it after Christmas (or New Years)*
- × *I know a lot of shortcuts to save you money*
- × *The standards you want just aren't needed for a good road*
- × *I don't need or want anybody's help... I already know all there is about building roads*
- × *I don't like to be supervised... I'll let you know when you should stop by*
- × *I'm not supposed to give you the names of people we worked for in the past*

6.C.3. - Payment for Road Work

The method of payment and total cost should be included in the written contract. It is commonplace to pay construction contractors 'by the hour'. These hourly rates can sometimes be separated into labor time and machine time. Machine rates are sometimes based upon the "tach hour" (the number of hours shown on the machine's "tachometer") which records the number of hours the engine operates, instead of the number of miles, as your car odometer records.



**Never pay "in full" for the road work prior to construction.
And never pay the contractor more than 50% of the total cost,
until the road is completed and you are satisfied with the quality of the work.**

6.C.4. - Contractor Supervision

Plan to have someone knowledgeable of your road specifications to supervise or periodically check the progress of construction. This is one of the most neglected aspects of any type of construction. Supervision is imperative to assure that you receive a quality road. If you have no one capable of providing construction supervision, ask your local Soil and Water Conservation District, county Erosion Control office, or state forestry agency. They may be able to offer assistance to periodically check on the work's progress.

PART 7: CONSTRUCTING THE ROAD

With ample planning completed, the road's route properly designed and laid out, and a quality contractor hired, now it's time to build the new road.



Above all else, the contractor should utilize appropriate Best Management Practices (BMPs) during all phases of road construction to control erosion risks and keep sediment out of the stream. Obtain a copy of road BMPs from your state forestry agency or local erosion control department.

7.A. - Appropriate Construction Equipment

Earth-moving equipment comes in all shapes, sizes, models, and colors. The exact type of equipment is not as important as is matching the size and capabilities of the equipment with the degree of work that will be needed. Some examples of construction equipment capabilities are shown below, for your general reference.

| Capability for Road Construction | Typical Equipment Needed |
|---|--|
| Lifting and moving large boulders | Medium to large tracked-excavator; with thumb/claw on the bucket |
| Loading rock, boulders, dirt into a dump truck | Medium to large tracked-excavator; or a front-end loader |
| Carrying dirt, rock, and fill material | Medium to large dump truck |
| Roughing-out road corridor, with small stumps and/or few rocks, and few cut banks or fill slopes | Small to medium bulldozer, with either a fixed blade or "6-way" blade |
| Roughing-out road corridor, with large stumps and/or abundant rock, and abundant cut banks or fill slopes | Medium to large bulldozer, usually with a fixed blade; and/or a ripper shank mounted on the rear |
| Digging roadside drain ditches | Small backhoe; or mini-trackhoe |
| Installing culverts | Tracked-excavator; or mini-trackhoe; or a tracked skid-steer loader; and small bulldozer for pushing fill atop the culvert |
| Installing ford stream crossing | Small bulldozer with "6-way" blade; or mini-trackhoe; or a tracked skid-steer loader |
| Installing broad based dip or turnout | Small to medium bulldozer with "6-way" blade |
| Spreading gravel and grading the finished road | Small to medium motor grader; or for short sections, a medium farm tractor with a pull-behind blade; or bulldozer with "6-way" blade |



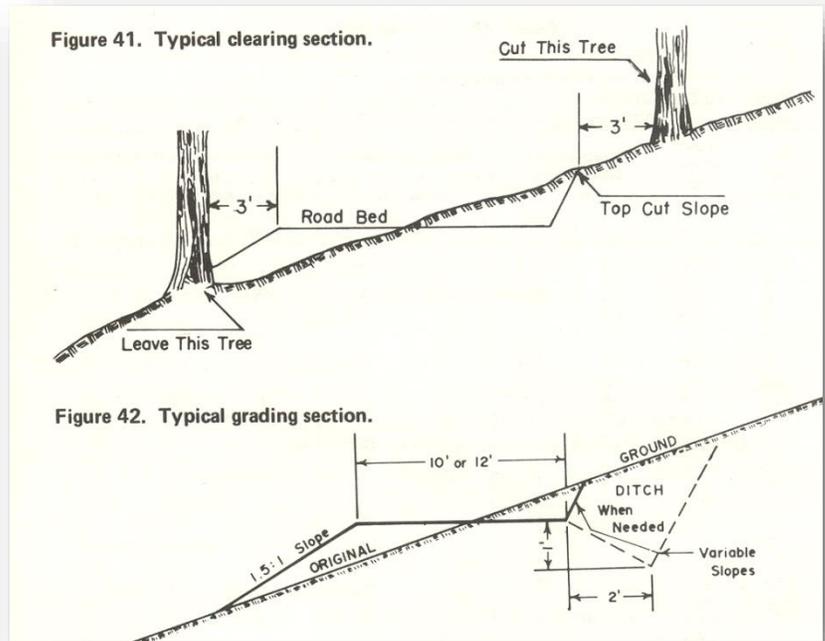
Left: A medium bulldozer with a 6-way blade. Center: A mini-trackhoe. Right: A medium, tracked-excavator with mechanical thumb, and a dump truck.

If possible, give preference to hiring a contractor that uses tracked-mounted equipment, instead of rubber-tired equipment. The tracks will more easily support the machinery on soft soil and reduce soil compaction, rutting, and churning. The cleats of the tracks can also be useful for roughening-up the finished soil surface prior to seeding and mulching.

7.B. - Clearing the Way

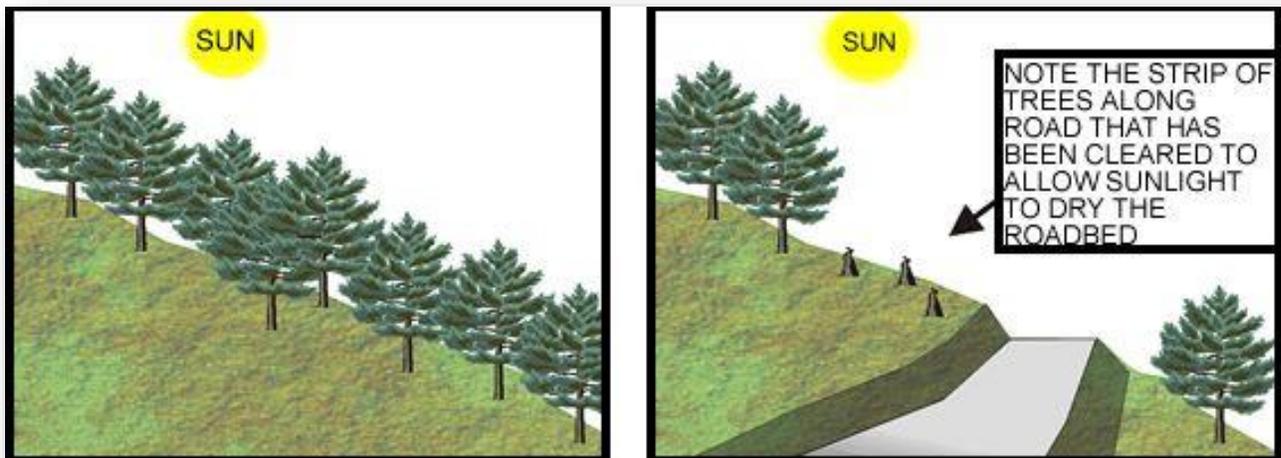
Access roads in wooded areas require that trees be removed prior to pushing in the road. Make plans well in advance of road construction to have the usable timber or firewood harvested and removed from within the road's right-of-way. To aid in removing stumps, some bulldozer operators prefer to have the trees cut 3 or 4 feet above the ground, rather than at ground level.

Illustration excerpted from Figures 41 and 42 of "Permanent Logging Roads for Better Woodlot Management". USDA-Forest Service, 1978.



There is no need to waste good trees! Selling the timber from the right-of-way can help you offset the cost of building the road. Consult with a reputable forester who can estimate the timber value and sell it for you, if that is a viable option.

Clear vegetation from the right-of-way at least wide enough for the roadbed, cut banks, and fill slopes. Where deep cuts or high fills are required, it will be necessary to clear a wider path. At curves, the area cleared should provide good visibility of traffic from both directions. Where snow and ice on the roadbed may create travel hazards, it is a good practice to cut away more trees and tall shrubs to allow maximum sunlight onto the roadbed. This practice is known as “daylighting” the road; or cutting out a “sun strip”.



7.C. - Roughing-In the Road

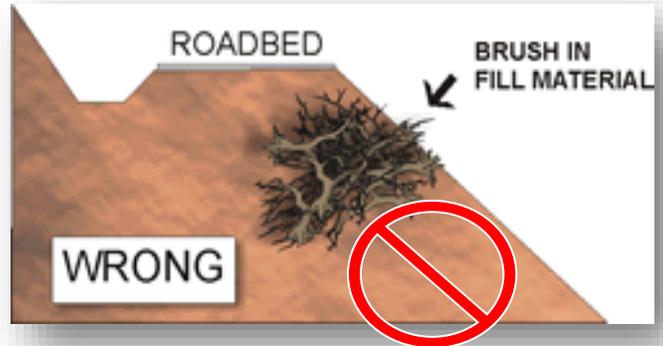
Do not allow the equipment to “rough-in” more than 1,000 feet of road, until the first 500 feet are completed. Surface drainage structures and stream crossings should be installed, fill material properly compacted, and surfacing material put down as construction progresses. Seeding should begin on segments as soon as the grading on that segment is completed.



Do not bury trees, stumps, or brush into the roadbed, or into areas that will be covered by soil fill material! Do not burn excess woody debris.

Remove all trees from the area to be filled with soil. It is impossible to satisfactorily compact soil around woody debris, resulting in future unstable roads, banks, and fill slopes.

Stumps, trees, and leftover brush should be either piled below the toe-slope of the embankment; or ground up with a wood chipper; or removed from the site and disposed properly in a landfill; or piled elsewhere on the property.



7.D. - Fill Material

Suitable soil fill material for building up the road bed or fill-slopes should consist of soil that is well-drained and tightly compacts. Avoid fill material that includes abundant sand or clay. This type of material cannot be suitably compacted and will not support vehicle traffic. The fill material should be free from large rocks, chunks of wood, and other debris.



Do not use broken-up concrete, asphalt or other scrap junk as fill material.



7.E. - Monitoring Construction

Maintain close supervision and make sure your plans are followed. Ask a question if something does not look right.

Make sure after clearing the right-of-way, that all of your flags and stakes remain and are understood by the contractor. You may need to reinstall your control point flags or stakes.

Be alert for problem areas, such as wet or unstable soils, and take corrective action immediately as described in Chapter 3.

Have an agreement with the contractor that he will check with you before applying any surfacing material (gravel or pavement). Before surfacing the road, be sure that drainage structures are installed properly; that adequate erosion and sediment control measures are implemented; and that the roadbed surface grading (in-sloping, out-sloping, crowning) is satisfactory.

Consider taking a series of photos throughout the progression of construction, from the start. Photos can demonstrate what actions were taken during the work, if you are challenged later regarding off-site sedimentation or runoff from the road.

PART 8: ESTABLISHING GROUNDCOVER

This phase of construction is often over-looked or taken for granted. If the contractor presents you with an opportunity to “save money”, usually it is related to the establishment of groundcover vegetation. ***Don’t fall for that trap!***

Promptly establishing groundcover vegetation atop of exposed, bare soil is critical to prevent accelerated erosion, keep sediment from washing into streams, and soften the visual impact of this new “scar” upon the landscape.



Left: A new road being constructed. Right: Same road, after gravel surfacing and groundcover vegetation was applied. Remember: A good appearance leads to good perceptions, and an ugly appearance will leave a long lasting bad impression with the neighbors.

8.A. - Roughen the Soil Surface

The surface of the soil may need to be scarified, or “roughened up”, to break up a dry, crusty top layer. The work need not penetrate too deeply, just enough to break up the surface layer. This work can be accomplished by a farm tractor pulling a set of disks; or a soil tiller; or from the metal cleats (grousers) of walking a bulldozer back and forth; and even the trusty hand-rake. On steep cut banks, fill slopes, or next to streams, hand tools may be the only way to scarify the soil and prevent sedimentation into the water.

8.B. - Lime and Fertilizer

Prior to the road construction, take samples of the soil and obtain a soil analysis to determine how much lime and fertilizer may be needed to establish vegetation. If lime or fertilizer is applied, these amendments should be broadcast across the bare soil and then incorporated into the soil by disking, tilling, raking, or tracking-in with a bulldozer.

In the mountains, soils are often acidic, and the addition of ample lime will promote enhanced growth of groundcover erosion-control vegetation. A general recommendation is to apply dolomitic or agricultural lime at a rate of 2 tons per acre (this equals approximately 90 pounds for every 1,000 square feet).

Fertilizer may or may not be needed, depending upon the results of a soil analysis and previous land use. If necessary, a general recommendation for fertilizer is to apply 1,000 pounds per acre (which equals about 25 pounds for every 1,000 sq.ft.) of the following:

- For grass, apply 10-10-10 fertilizer
- For legumes, or a grass/legume mixture, apply 5-10-10 fertilizer

8.C. - Seeding of Vegetation

Seed should be applied promptly after the soil is prepared. After reviewing the seeding options in this booklet, you should seek advice from your local Soil & Water Conservation District, Ag-Cooperative Extension Service, or state forestry agency. These professionals may have better solutions that work for your specific location and soils.



Do not rely upon throwing out seed by hand. This will not sufficiently cover the area uniformly with seed, creating gaps and clumps of vegetation. Instead use a rotating seed spreader, a seed drill or hydroseed slurry.

You need to use a mixture of seed when establishing groundcover:

1. One part of the mix should be temporary, quick “green up” vegetation that will help to immediately resist soil erosion, but not become a nuisance plant.
2. The other part of the mix should be permanent vegetation that will germinate and take hold after the temporary vegetation dies off.



A Note About Hydroseeding

On large areas of cut banks, fill slopes, or long roads, you may consider hydroseeding as a way to establish groundcover. Hydroseeding often results in a faster germination of vegetation, and may be an ideal alternative if the work is being conducted during a dry period, or during a cold (dormant) period. The added water that comes with hydroseeding can jump-start the new seed and help it get established during less-than-ideal conditions.

The hydroseed mixture can also contain a tackifier which binds the loose soil together to resist erosion while the seed germinates and vegetation becomes established.

Consult with landscaping contractors, the local highway department, and erosion/sediment control department to identify hydroseeding contractors in your area. This is a specialized line of work, and often a road construction contractor does not have the equipment or expertise to do hydroseeding.

The following two pages contain suggestions for establishing groundcover vegetation.

Key to Table Abbreviations:

(G) : means that the seed is a grass vegetation

(L) : means that the seed is a legume vegetation

@ : means “to be applied at a rate of”

: means “pounds per acre”

[+] : indicates a seed mixture, and that multiple seed components should be used

For example, *(G) - Tall Fescue @ 50#, [+] (L) - White Clover @ 4#*, means that this is a seed mix consisting of grass seed Kentucky-31 Tall Fescue, to be applied at a rate of 50 pounds per acre, mixed in with seed of legume White Clover applied at a rate of 4 pounds per acre.

Conversions: To convert “pounds per acre” to “pounds per 1,000 square feet”, multiply by 0.023. For example, a rate of 40 pounds per acre shown in the two seeding tables would equal $(40 \times .023) = 0.92$ pounds/1,000 Sq.Ft., so round it up to 1 pound of seed per 1,000 Sq.Ft. (abbreviated as TSF in the conversion chart).

8.C.1. - Traditional Groundcover for Critical Erosion Areas

The seeding options in this section have traditionally been used for insuring soil stabilization on critical areas that are at-risk of erosion. These seed choices, over time, are now viewed by some as being less friendly to bird and wildlife habitat considerations; and in some cases certain species of vegetation have been known to become invasive and a nuisance. **The shaded blocks indicate the preferred time of year for using each seed mix option.**

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Temporary, Seasonal "Green Up" | | | | | | | | | | | | |
| (G) - Oats @ 90#, or (G) - Rye @ 120# | | ■ | ■ | | | | | | | ■ | ■ | |
| (G) - Ryegrass @40# | | ■ | ■ | | | | | | | ■ | ■ | |
| (G) - Sudangrass @ 45# | | | | | | ■ | ■ | ■ | | | | |
| (G) - Browntop Millet @ 40# | | | | | | ■ | ■ | ■ | | | | |
| Sunny, Dry Sites | | | | | | | | | | | | |
| (G) - Kentucky 31 Tall Fescue @ 60# | | | | ■ | ■ | ■ | | | ■ | ■ | | |
| (G) - Tall Fescue @ 50#, [+] (L) - White Clover @ 4# | | | | ■ | ■ | ■ | | | | | | |
| (G) - Weeping Lovegrass @ 5# | | | | ■ | ■ | ■ | | | | | | |
| (G) - Crownvetch @ 15#, [+] (G) - Tall Fescue @ 20#, or (G) - Lovegrass @ 3# | | | | ■ | ■ | ■ | | | | | | |
| (L) - Latchco Flatpea @ 20#, [+] (G) - Tall Fescue @ 20#, or (G) - Lovegrass @ 3# | | | | ■ | ■ | ■ | | | ■ | ■ | | |
| Shady, Dry Sites | | | | | | | | | | | | |
| (G) - Creeping Red Fescue @ 50# | | | | ■ | ■ | ■ | | | | | | |
| Partial Shade | | | | | | | | | | | | |
| (G) - Tall Fescue @ 30#, [+] (G) - Creeping Red Fescue @ 20# | | | | ■ | ■ | ■ | | | | | | |
| (G) - Creeping Red Fescue @ 30#, [+] (L) - Latchco Flatpea @ 20# | | | | ■ | ■ | ■ | | | | | | |
| Wet Sites | | | | | | | | | | | | |
| (G) - Reed Canarygrass @ 20# | | | | ■ | ■ | ■ | | | | | | |
| Dormant Season: Complete Mulch Coverage | | | | | | | | | | | | |
| | ■ | | | | | | | | | | | ■ |

Conversion Chart: Pounds Per Acre (#/ac) to Pounds Per 1,000 Sq.Ft. (#/TSF)

| | | | | |
|--------------------|--------------------|--------------------|--------------------|---------------------|
| 5#/ac = 0.11 #/TSF | 20#/ac = 0.46#/TSF | 40#/ac = 0.92#/TSF | 70#/ac = 1.61#/TSF | 100#/ac = 2.30#/TSF |
| 10#/ac = 0.23#/TSF | 25#/ac = 0.57#/TSF | 50#/ac = 1.15#/TSF | 80#/ac = 1.84#/TSF | 120#/ac = 2.75#/TSF |
| 15#/ac = 0.34#/TSF | 30#/ac = 0.69#/TSF | 60#/ac = 1.38#/TSF | 90#/ac = 2.07#/TSF | 140#/ac = 3.21#/TSF |

8.C.2. - Wildlife Friendly and Non-Invasive Alternatives for Groundcover Vegetation

Consider one of the options in this table on areas that are not as critical for erosion control or in places where you wish to enhance bird or wildlife habitat. *The shaded blocks indicate the preferred time of year for using each seed mix option.*

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Temporary, Seasonal "Green Up" | | | | | | | | | | | | |
| (G) - Oats @ 80 to 100# alone, or 30# in a mix | | | | ■ | ■ | ■ | | | | | | |
| (G) - Foxtail Millet @ 30# alone, or 20# in a mix | | | | ■ | ■ | ■ | | | | | | |
| (G) - Buckwheat @ 50 to 75# alone | | | | | | ■ | ■ | ■ | | | | |
| (L) - Crimson Clover @ 30# alone, or 10# in a mix | | | | | | | | | ■ | ■ | | |
| (G) - Wheat @ 80 to 100# alone, or 40# in a mix | | | | | | | | | ■ | ■ | | |
| Full Sun, Droughty Soil | | | | | | | | | | | | |
| A seed mix for dry cut banks or fill slopes. | | | | | | | | | | | | |
| (G) - Deertongue "Tioga" variety @ 5#, [+] | | | | ■ | ■ | ■ | | | | | | |
| (G) - Creeping Red Fescue @ 10#, [+] | | | | ■ | ■ | ■ | | | | | | |
| (L) - Korean Lespedeza @ 10# | | | | ■ | ■ | ■ | | | | | | |
| If left un-mowed, will grow 1 to 3 feet in height, providing seed forage and refuge cover for birds. | | | | | | | | | | | | |
| NOTE: Deertongue may take 1 to 2 years to fully establish, so do not rely solely upon this species to provide groundcover. Use only in a mix. | | | | | | | | | | | | |
| Dry Shady Sites | | | | | | | | | | | | |
| Suitable for road surfaces and road banks that are underneath shade. | | | | | | | | | | | | |
| (G) - Creeping Red Fescue @ 20# | | | | ■ | ■ | ■ | | | ■ | ■ | ■ | |
| If left un-mowed, can grow 1 to 3 feet in height and take a weeping form. | | | | | | | | | | | | |
| Sunny to Partial Shade with Normal Soil Moisture | | | | | | | | | | | | |
| A seed mix suitable for roadside edges, and gentle to moderate slopes. | | | | | | | | | | | | |
| (G) - Orchard Grass @ 6#, [+] | | | | ■ | ■ | ■ | | | ■ | ■ | ■ | |
| (L) - Red Clover @ 4# | | | | ■ | ■ | ■ | | | ■ | ■ | ■ | |
| If left un-mowed, can grow 2 to 4 feet in height, providing forage and cover for small wildlife. May be mowed once in mid-summer if needed. | | | | | | | | | | | | |
| Sunny, Open, Wet Sites | | | | | | | | | | | | |
| Choose one of the following for ditch outlets, stormwater runoff basins, swales or moist stream banks. | | | | | | | | | | | | |
| (G) - Eastern Gamagrass @ 8# | | | | ■ | ■ | ■ | | | ■ | ■ | ■ | |
| Grows in clumps, with grass reaching 3 to 6 feet in height. Does not require mowing. | | | | | | | | | | | | |
| (G) - Switchgrass @ 8# | | | | ■ | ■ | ■ | | | ■ | ■ | ■ | |
| Grows in clumps, with grass reaching 4 to 6 feet in height. Does not require mowing. | | | | | | | | | | | | |
| Dormant Season: Complete Mulch Coverage | | | | | | | | | | | | |
| | ■ | ■ | ■ | | | | | | | | ■ | ■ |

Conversion Chart: Pounds Per Acre (#/ac) to Pounds Per 1,000 Sq.Ft. (#/TSF)

| | | | | |
|--------------------|--------------------|--------------------|--------------------|---------------------|
| 5#/ac = 0.11 #/TSF | 20#/ac = 0.46#/TSF | 40#/ac = 0.92#/TSF | 70#/ac = 1.61#/TSF | 100#/ac = 2.30#/TSF |
| 10#/ac = 0.23#/TSF | 25#/ac = 0.57#/TSF | 50#/ac = 1.15#/TSF | 80#/ac = 1.84#/TSF | 120#/ac = 2.75#/TSF |
| 15#/ac = 0.34#/TSF | 30#/ac = 0.69#/TSF | 60#/ac = 1.38#/TSF | 90#/ac = 2.07#/TSF | 140#/ac = 3.21#/TSF |

8.D. - Mulching Over the Seed

Mulch is needed over top of any new seed that is broadcast onto the site. The mulch retains moisture in the seed and prevents birds from feasting on the seeds. Straw is the most readily available and commonly used mulching material. Some contractors use a mechanical blower to shred the straw and spread it across a site.



- Mulch the seeded areas with 60 to 80 bales of straw (or hay) per acre. This equals about 1 or 2 bales per 1,000 sq.ft.
- About 25% of the ground surface should be visible after mulching.

Hay is an alternative to straw, but may contain noxious weed seeds.

On steep ground, mulch needs to be anchored to prevent it from slipping or slumping off the slope. Netting can be applied over top of the mulch, but use this netting sparingly; small animals and birds can become entrapped within it. Another solution is to spray emulsion tackifier solution atop of the mulch. Use caution when spraying tackifiers close to streams or ponds. Keep the solution mix out of the water.

8.E. - Erosion Control Matting



This matting is made from small fibers of wood, straw or coconut husks. It works well to stabilize and create a seeding foundation upon slopes, within roadside ditches, and along stream banks. Erosion control matting should not be used in a location where vehicle traffic is expected. Do not drive over the matting. Apply lime, fertilizer, and grass seed prior to laying down the erosion matting. Firmly anchor the matting

with metal-wire staples. Follow the manufacturer's instructions for installation.

8.F. - Stone Aggregate (Gravel)

Ample stone aggregate is vital to create a suitable travel surface on your road. Choose material and apply to a thickness depth according to your needs. For timber harvesting access, the road will require thicker and larger stone. For less frequent road use with smaller vehicles, a thinner layer of stone may be acceptable. Table 8.F.1 on the next page provides estimates of how much aggregate may be needed for certain applications.

Table 8.F.1: Volume of Stone Aggregate (in Cubic Yards) Required for 1 Mile of Road

| Road Surface Width (feet) | Square Yards per Linear Foot | Square Yards per Mile of Road | 1" deep loose layer | 2" deep loose layer | 3" deep loose layer | 4" deep loose layer | 5" deep loose layer | 6" deep loose layer |
|--|------------------------------|-------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| 10 | 1.11 | 5,867 | 163 | 326 | 489 | 652 | 815 | 978 |
| 12 | 1.33 | 7,040 | 196 | 392 | 587 | 783 | 978 | 1,174 |
| 14 | 1.55 | 8,213 | 229 | 457 | 685 | 913 | 1,141 | 1,370 |
| 16 | 1.77 | 9,387 | 261 | 522 | 783 | 1,044 | 1,304 | 1,565 |
| Note 1: Above Cubic Yards are for loose aggregate. When compacted, increase the volumes +15% to 30%. | | | | | | | | |
| Note 2: 16.30 Cubic Yards equals a 1"-deep layer that is 1-foot wide and stretches for 1-mile. | | | | | | | | |
| Note 3: A typical 10-wheel dump truck has a capacity of approximately 10 Cubic Yards (equal to about 15 tons), depending upon the size of the dump body and size of the material being hauled. | | | | | | | | |
| Table adapted from Figure 48 of "Permanent Logging Roads for Better Woodlot Management." USDA-Forest Service, 1978. | | | | | | | | |

PART 9: MAINTAINING YOUR ROAD, PROTECTING YOUR INVESTMENT

You have invested substantial money and time into building your new access road. Maintaining the road will protect this investment while being a good steward of the land.

9.A. - Inspect and Monitor

Conduct periodic inspections of the entire road at least twice per year; once during the wet season and once again during the dry season. Also, inspect your road after any significant heavy rainfall storms. Examine the roadbed, the road surface, cut banks, fill slopes, stream crossings, and surface drainage structures. Get out and walk the road; don't rely upon a "drive by" inspection in a vehicle, ATV, or golf cart. Use the inspection checklist on the rear cover of this booklet as a guide to assess your road.

9.B. - Examples of Maintenance Concerns

The following photos show a few examples of where proper attention to maintenance will pay dividends to keep your newly constructed road in place and fully functioning.

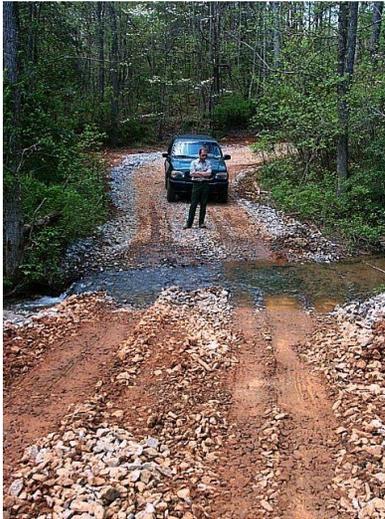
The photo at right shows gravel washing off the road surface. What is the root cause? Rainwater runoff is getting out of control. A broad based dip or other diversion structure is needed to control the water. If not fixed, this small erosion eyesore will grow into a deeper and wider gully that will require major re-work.



This road needs re-grading, installation of water control diversions, and significant groundcover establishment work.



Gravel is starting to get pushed down into the soft soil. Ruts are forming near the bridged stream crossing. Applying more gravel and/or re-grading will help.



This ford crossing needs work. Gravel is getting pushed into the soft ground. Mud is being pulled into the creek.

Geotextile underlayment may have prevented this from happening.

More gravel is needed on the road to keep dirt out of the water!

This road needs runoff control and is getting entrenched below the natural grade.

This happens when a road is used when wet, and the sloppy surface mud is scraped off down to harder road-bed. Don't let that happen! Stay off until it dries. Geotextile and gravel may have prevented this.



This culvert is on a lightly used road. The outlet, shown here, looks okay. But look at the next photo on the right...



...This is the inlet of the same culvert, clogged with leaves and branches.

If nothing is done, this culvert and road will wash out, dumping tons of soil into the creek.

Since this is a lightly used road and a small creek, a well built ford crossing would be better. A ford will not clog like a culvert does.

Reference Sources

Much of the content in this booklet was drawn freely from many of the sources listed below. The reader is encouraged to consult these references and a road design professional if detailed information is needed.

Building Water Pollution Control Into Small Private Forest and Ranchland Roads. 1981.
USDA-Forest Service, Portland, OR.

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

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

Environmentally Sensitive Maintenance Practices for Dirt and Gravel Roads. April 2012.
USDA-Forest Service, San Dimas Technology and Development Center. Publication Number 1177-1802P.

- **NOTE:** *This is a highly recommended, well-illustrated handbook and this publication can be downloaded from the USDA-Forest Service website linked below. However the Adobe®-PDF file is very large (25 MB) and will take substantial time to download:* <http://www.fs.fed.us/eng/pubs/pdf/11771802.pdf>.

Erosion Control on Logging Roads In the Appalachians. 1970.
USDA-Forest Service, Northeastern Forest Experiment Station. Research Paper NE-158.

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

Low-Volume Roads Engineering Best Management Practices Field Guide. July 2003.
USDA-Forest Service and US Aid. By Gordon Keller and James Sherar.

- **NOTE:** *This is a highly recommended, detailed handbook and this publication can be downloaded from the website below. However each chapter's Adobe®-PDF file is very large and will take substantial time to download:* http://ntl.bts.gov/lib/24000/24600/24650/Index_BMP_Field_Guide.htm

Permanent Logging Roads for Better Woodlot Management. September 1978. USDA-Forest Service, State & Private Forestry, Northeastern Area. Pub.No. NA-FR-18. By Richard Haussman and Emerson Pruett.

Acknowledgements

The original guide that served as the basis for this publication was entitled "The Layman's Guide to Private Access Road Construction in the Southern Appalachian Mountains - Plan Now or Pay Later"; and was prepared by Howard Tew and Lane Price of the USDA Soil Conservation Service, and Lloyd Swift, Jr. of the USDA Forest Service. It was published in July 1985 and reprinted October 1996. A Second Edition was published in 2005 after having been revised, updated, edited, and amended by staff of the N.C. Forest Service, N.C. Wildlife Resources Commission, and the N.C. State University Extension Forestry Department. This 2014 version was adapted from those earlier publications and was prepared by staff of the N.C. Forest Service with support from USDA-Forest Forest. This booklet is N.C. Forest Service publication number WQ-02-14. 6,000 copies were printed at an estimated cost of \$5,958 by the N.C. Dept. of Agriculture & Consumer Services. This booklet is in the public domain; reproduction and free distribution is allowable. It can be downloaded from the N.C. Forest Service website: <http://ncforestservice.gov>. The North Carolina Forest Service is an equal opportunity / affirmative action employer. Its programs, activities and employment practices are available to all people regardless of race, color, religion, sex, age, national origin, handicap or political affiliation. Funds for preparation and printing were provided by:

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- Virginia Department of Forestry

The Problem



Solutions

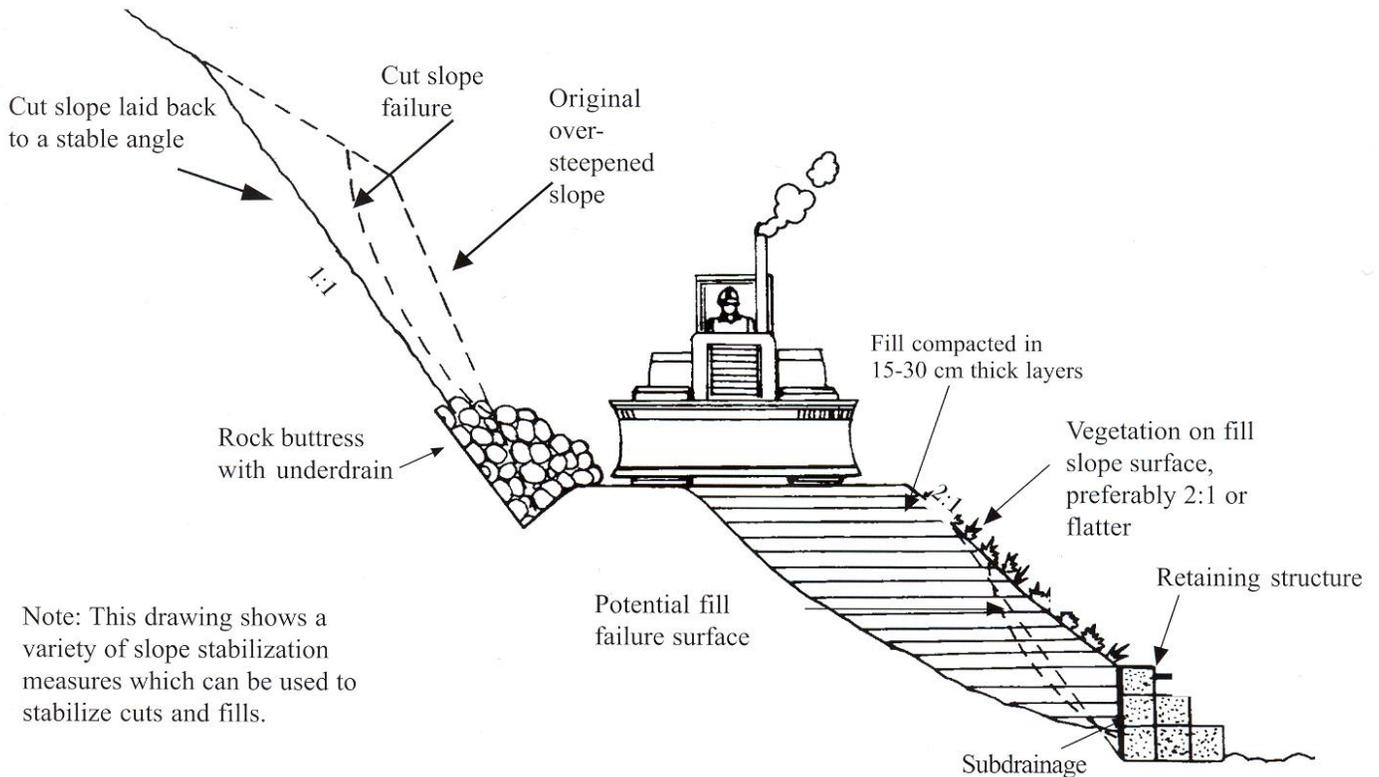


Illustration excerpted as Figure 11.3 from "Low-Volume Roads Engineering Best Management Practices Field Guide," 2003.

**A GUIDE FOR FOREST ACCESS ROAD CONSTRUCTION AND MAINTENANCE
IN THE SOUTHERN APPALACHIAN MOUNTAINS**

Forest Road Maintenance Inspection Checklist

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

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

Segment of Road Inspected: _____ Date: _____

Roadway Structure

Yes No

- Soil slumping or eroding down the face of cut banks and fill slopes
- Spots in the road that remain soft and wet through the year

Stream Crossings and Cross Drains

- Clogged culverts
- Caving-in atop of a culvert pipe
- Streamflow water undermining the culvert
- Ruts in the stream bottom at a ford crossing; or stream flow dammed up at the ford

Surface Drainage

- Erosion of the road surface; or sediment washed into streams, ditches, or waterways
- Rutting of the surface or displacement of surfacing gravel
- Sediment being washed away into the woods or onto neighbor's property
- Sediment build-up within broad based dips, turnouts, diversions, or roadside ditches
- Down-cutting of soil within roadside ditches or turnouts
- Bare spots of soil lacking groundcover vegetation or gravel

Roadway Corridor

- Groundwater seepage coming out from cut bank slopes
- Over-hanging trees and limbs that cast abundant shade onto the road surface
- Tree limbs and shrubs that obscure a driver's vision at the public road entrance
- Soil is being tracked or washed-out onto the public roadway

