The purpose of this book is to help landowners, loggers, contractors and foresters plan and install a successful forest road system. Success can be measured in several ways such as reduced maintenance costs or year round usage. However another measure that is important in our time is the maintenance or enhancement of the quality of our waters. It is hoped that these pages can help meet this challenge. The intent of this book is the simplification of complex or detailed concepts such as soils, slopes, angles, etc. in order to make them understandable. It also emphasizes the "How-To" over the "Why" type of information in order to get the proper road design installed.

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MILE MARKERS FOR SUCCESSFUL ROAD DESIGN

11. Remember the need for and the intended use of the road.

Consider what effects the type of vehicles used, the seasons of use, the products cut and boundary restraints will have on road location, road width, road grade and stream crossings.

10. Consider the soils on which the road system will be built.

Some soils will absolutely not hold a road. Others may have problems that can either be avoided or taken into consideration during planning.

9. Gather topographic maps and aerial photographs.

Recent aerial photos and topographic maps are essential in designing a road system.

8. Plot the proposed routes on the maps.

Using drainage and slope information from the maps, plot the proposed route watching for: problem soils, streamside management zones, and topography that can keep the road grade on slopes no steeper than moderate.

7. Check the proposed route on the ground.

Flag the proposed route for construction, adjusting for problem areas not identified on the maps.

6. Minimize the number and size of stream crossings.

The cost of changing a route can often be less than that occurred by installing expensive stream crossings.

5. Design adequate stream crossings.

When streams must be crossed, crossings must be properly designed and installed to reduce future maintenance costs and to prevent obstruction of stream flow.

4. Design adequate water control devices.

Get water off the road system with water bars (temporary or limited use roads), or dips and culverts (permanent and high use roads), along with wing ditches.

3. Plan for stable outlets for the water control devices.

Empty water bars, dips, culverts and wing ditches gently onto non-erosive, stable areas.

2. Plan for an adequate right-of-way width.

Allow for a right-of-way that will accommodate the road surface, gently sloping ditch sides, and adequate sunlight for revegetation, when needed.

1. Revegetate

Revegetate problem areas such as steep slopes, ditches and outlets.

0. Plan for maintenance.

SOILS AND SLOPES

Introduction

Sandy Soils

Loamy Soils

Clayey Soils

Slope

SOILS AND SLOPES

This section covers potential road problems associated with soils and slope. These problems are wetness, erosion and sloughing. To determine if these problems can be expected on a site, a check of the soil texture and an estimate of the slope will be needed. Then a reference to a graph for each soil texture will show how severe the problem will be.

Soils

Soil texture will be divided into 3 groups - Sands, Loams and Clays. Sand particles are about the size of table salt, while clays are so fine they cannot be seen with the naked eye.

Soils that will form a ribbon about an inch long when crushed between the fingers are said to be clayey. If they are loose and will not form a roll the size of a pencil when softly rolled between the fingers are sandy. Other soils that will ribbon only slightly are loamy.

Slopes

The landscape is made up of different soils and slopes. In this book slopes are divided into 3 classes - Flat (less than 4%), Moderate (5 - 10%) and Steep (greater than 12%).

The slope can be checked with instruments such as clinometers or estimated with the naked eye, as used in this book. Doing this requires keeping a level line of sight and an ability to estimate distance. This is explained later.

3 problems - wetness, erosion, and sloughing

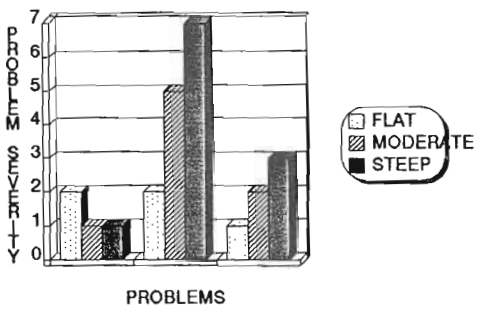
Soil wetness presents equipment problems. Clayey soils can become wet when the slope is too flat or the drainage is blocked.

Everyone knows that water runs faster as the slope increases. Add to this that water runs faster and sooner on clays, and you have a problem. However, whenever water is confined and slopes increase, erosion can be a problem on loams and sands too.

Sloughing of cut banks is a real problem, especially on clayey soils. Avoid leaving vertical slopes in road banks in most situations.

The graphs

Once the soil types and slopes are known, the potential problems on the site and their severity can be determined from the graph on the following pages. If a problem is rated as a 5 or higher on the graph, attention must be given to it.



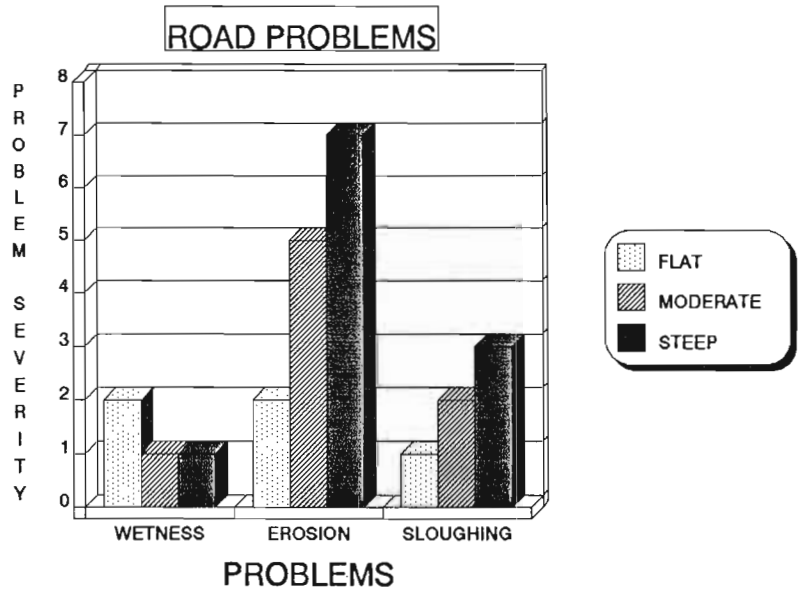
SANDY SOILS

Properties

Sandy soils feel gritty when rubbed between the fingers and will not ribbon when pinched. Sand particles can easily be seen with the unaided eye.

Problems

Sandy soils tend to drain well and therefore wetness generally is not much of a problem. On the contrary, the use of equipment is more restricted when sands are dry than when wet. Likewise sloughing of road banks and cuts are not a serious problem. However, because sands do not bond well together, erosion can be a problem whenever water is confined in channels such as ditches and road surfaces. In fact, compacted sands can be more erosive than clays.



Solutions

- Erosion - As slopes and traffic increase, install necessary water control devices such as water bars, dips and wing ditches. Seeding after use may also be needed.

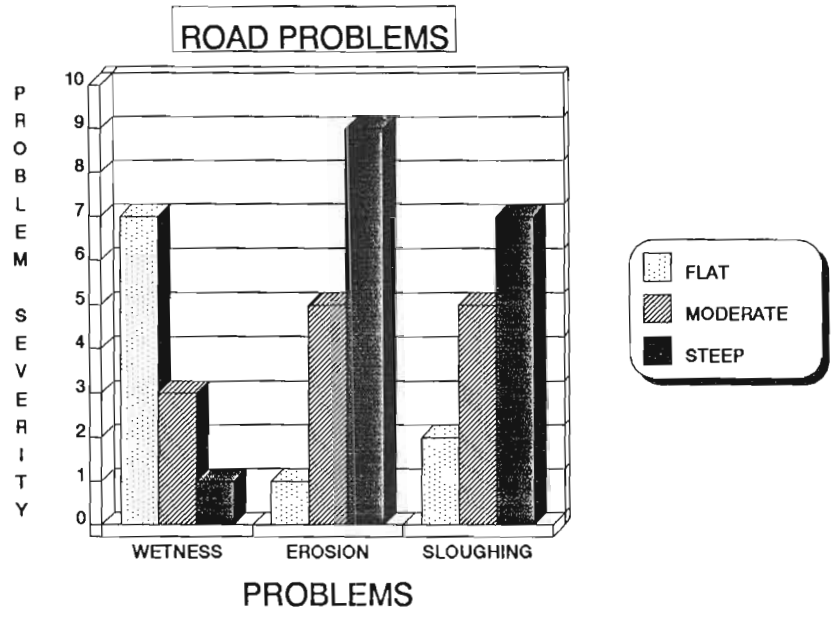
CLAYEY SOILS

Properties

Clays, when moist will form a ribbon or wire of soil that extends for more than an inch when pressed between the thumb and index finger. They tend to form clods when dry and are sticky when wet.

Problems

Because clays hold water well, wetness can be a problem on flat and poorly drained sites. These soils can also be very erosive and subject to sloughing as slopes increase.



Solutions

- Wetness - Avoid excessive rutting and blockage of drainage on flat slopes. Crowning, raising the road bed, and side ditches may be needed. Also, some restriction of use may be necessary during wet periods.

- Erosion - As slopes increase install needed water control devices such as water bars, dips and wing ditches. Seeding may also be necessary.

- Sloughing - Slope banks and cuts to a grade of at least 3 to 1 (3 feet of horizontal run over 1 foot of vertical fall).

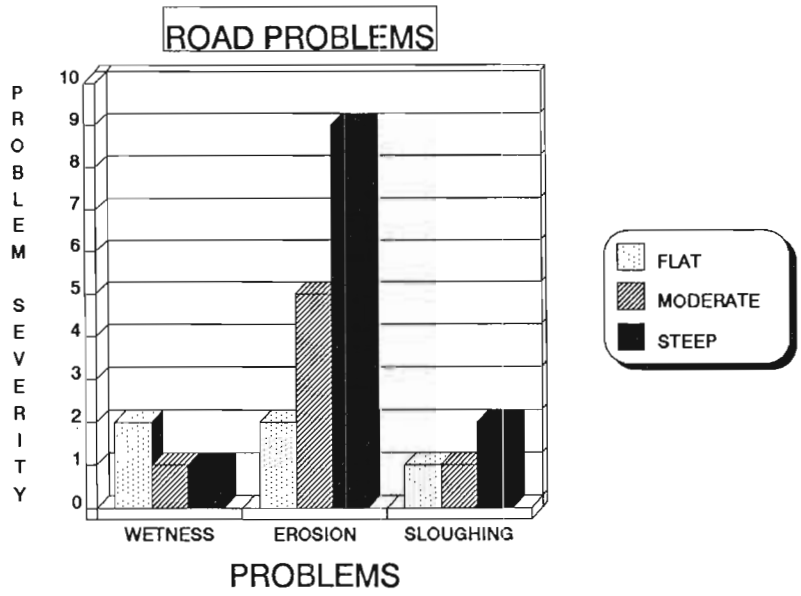
LOAMY SOILS

Properties

Loamy soils are a mixture of sand and clay. Because they are neither excessively sandy nor clayey, they may feel somewhat coarse to floury to sticky. For the purpose of this section, if a soil does not fit the description of sand or clay, it will be called a loam.

Problems

Depending on the amount of clay present, loamy soils tend to drain well enough to make wetness a minor problem. An exception would be on flooded bottomland sites. Sloughing of road banks and cuts should also present little problem. However the possibility of erosion can greatly increase as slopes increase.



Solutions

- Erosion - As slopes increase install necessary water control devices such as water bars, dips and wing ditches. Seeding after use may also be necessary.

SLOPE

Definition

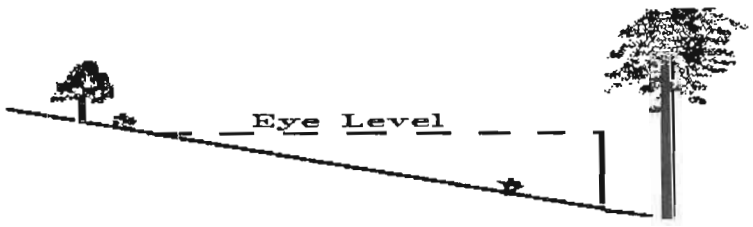
Slope is the steepness of the land expressed as the amount (in percent) of vertical fall per 100' of horizontal run. For example, a 3% slope means that over a distance of 100', the ground drops 3' from the horizontal.

Importance of slope

Slope (usually called "grade" on roads) along with other factors such as soil texture and ground cover, determines how fast water can drain from a road. If water runs off a road surface too quickly, erosion can be a concern. If, on the other hand, water cannot drain due to flat slopes and fine textured soils, wetness can be a problem. Unlike texture though, slope and slope length can be managed during road design and layout.

Estimating slope

Slope can be divided into 3 broad categories: Flat, Moderate and Steep. Putting a slope into one of these categories isn't very difficult. Standing downhill, and facing uphill, try to look level back into the hill. To help keep your line of sight level, face uphill with your arm stretched out in front of you with a pencil (or a rolled up dollar bill) pointing up out of your fist. Looking over the top of the pencil will keep your sight level. Estimate the horizontal, level distance between you and where your line of sight hits the ground. The chart below can help estimate the land's slope:



DISTANCE	SLOPE CATEGORY	SLOPE RANGE
>125'	Flat	<4%
50-125'	Moderate	5-10%
<50'	Steep	>12%

Other sources of slope information

- USGS Topographic Maps
- SCS soil surveys and soils maps

M A P S

Aerial Photos

Soils Maps

Topographic Maps

Determining Drainage Area

AERIAL PHOTOS

Definition

Aerial photographs or "maps" are high altitude photos taken in a very concise and systematic manner. Although maps can be made in color and even infra-red, the most commonly used aerial photos are black and white. The top of the map is usually north.

Information provided by aerial photos

These maps show and can be used to illustrate physical features of the land such as:
Boundaries and timber types (pines show up darker than hardwoods)
Drainage patterns
Roads, buildings, etc.

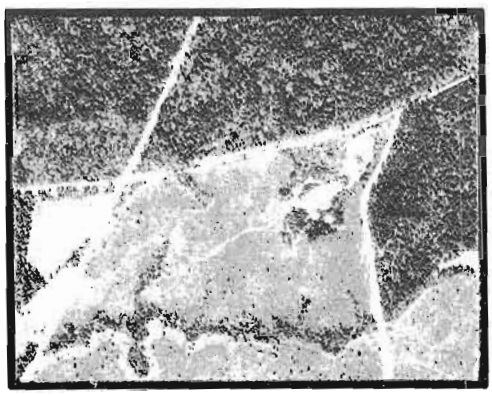
Scale

Aerial photos come in many scales such as 1" = 660', 1320', 1000' or 2000'. It is important to know the scale before a map can be used successfully.

Use in planning

During the road planning and design process aerial photos can be used to:

- Select points that the road must pass through
- Help choose preliminary routes prior to an on-site check
- Find field features that can be used to check progress during layout
- Choose sites for stream crossings



Where to look at maps:
SCS
ASCS
TFS

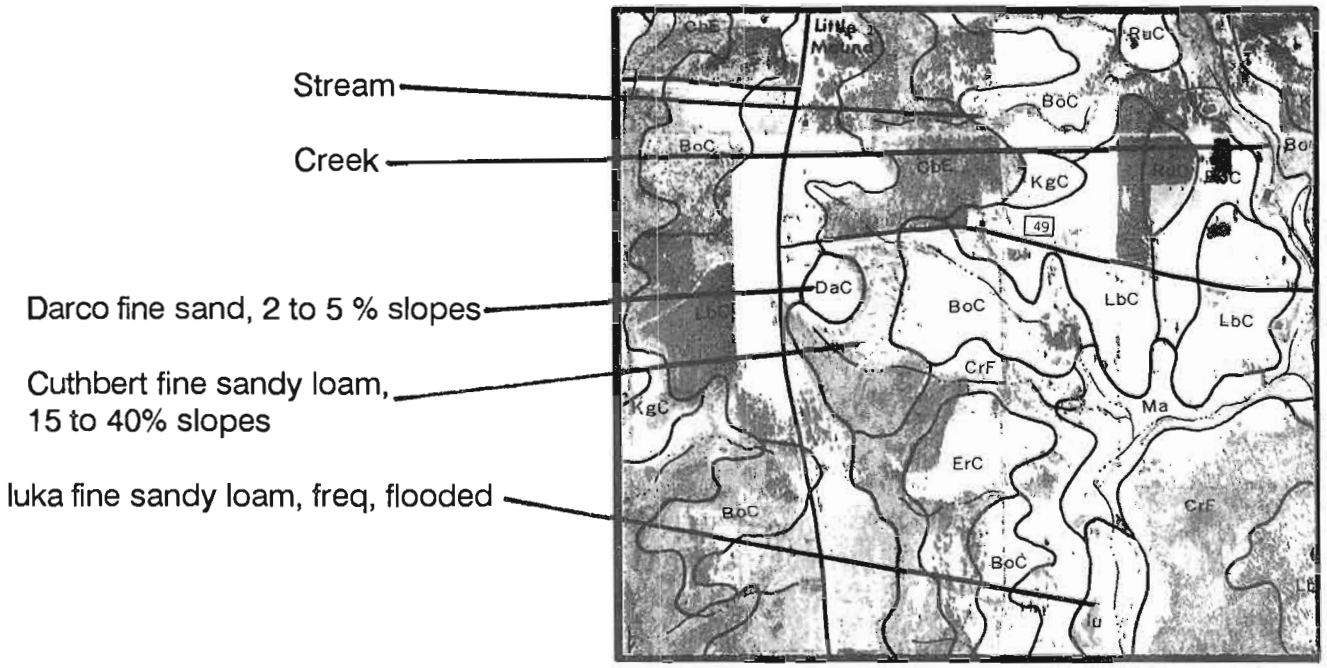
SOILS MAPS

Definition

Soils maps are aerial photographs on which the different soil types are delineated. The soils are classified and the maps are developed by Soil Conservation Service soil scientists. Many counties have a published book of soils maps called a Soil Survey,

Information provided by soils maps

A soils map, along with an accompanying legend, can provide useful basic information. Along with physical features such as roads, buildings, rivers and creeks, the different soil types are drawn and labeled.



Use in planning

During the road planning and design process, soils maps can be used to:

- Plan routes
- Avoid problem areas such as wet areas
- Plan where and how to cross streams
- Estimate slopes that may be encountered
- Determine drainage patterns

Soil surveys/soils maps are important planning tools but an on- site check of the exact soil type and slope may be necessary.

TOPOGRAPHIC MAPS

Definition

Topographic maps or "Quad Sheets" are printed maps that show the relief of the landscape. In addition, they also display physical features such as roads, buildings, rivers, creeks, etc.

Scale

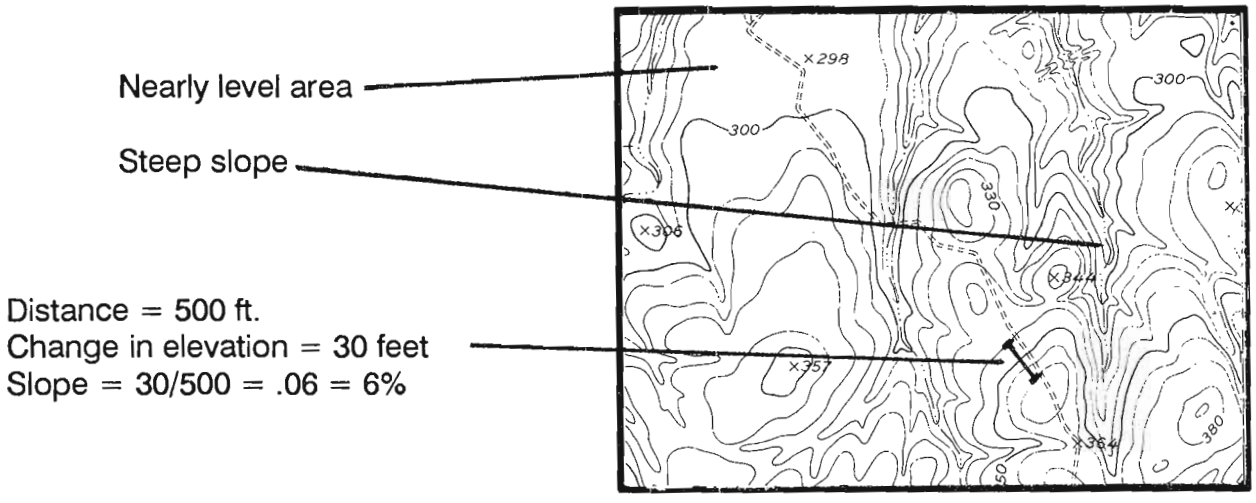
The most commonly used topographic map is the 7.5 minute map which has a scale of 1:24,000 or 1 inch = 2,000 feet. Scale is shown at the bottom of the map.

Relief

The relief of the land (the way it lies) is shown by a series of contour interval lines. These lines represent a point's elevation above sea level and so, any point along a line is the same elevation as any other point on the same line. The closer together the lines are, the steeper the slope. The interval between the lines is usually 5 or 10 feet. This information is given at the bottom center of the map. The elevation is frequently printed along several of the contour lines.

Determining Slope

Determine the elevation change between 2 points from the contour lines, being sure to use the proper contour interval. Divide this change by the distance between the 2 points, using the scale at the bottom of the map. Multiply by 100 to get the percent slope.



DRAINAGE AREA

Definition

Drainage area is that part of the topography that has its runoff waters drain through a point. It is the watershed for that point. Being able to determine the acreage in the watershed is important in sizing culverts, locating stream crossings, etc.

Using topographic maps

Topographic maps provide the best means for determining drainage areas. Because topo maps show changes in elevation by a series of concentric lines, they can be used to determine which slopes drain through an area of concern. To determine the watershed, it is helpful to remember 2 things: Hill tops are identified where a contour line forms a small circle Where contour lines form finger-like projections, the fingers point uphill

By drawing arrows to show which way the water runs toward the point of interest, the watershed can soon be found.

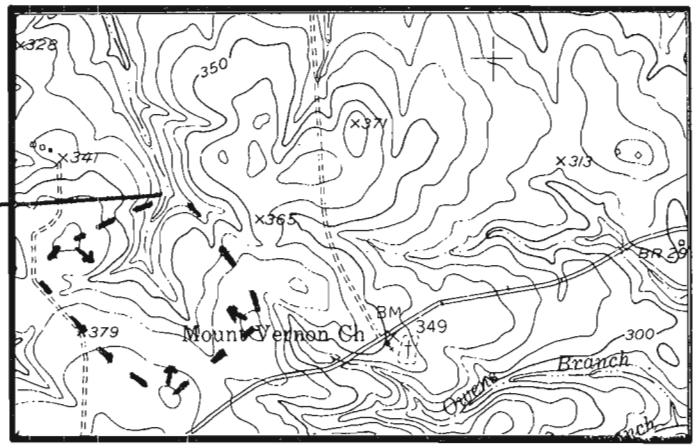
Determining areas

After the drainage area is drawn, the number of acres in the area can be estimated. For a topographic map with a scale of 1:24,000 (a 7.5 minute map) the following can be used as a quick quide

The head of a pencil's eraser =	5 acres
A dime =	40 acres
A nickel =	50 acres
A quarter =	70 acres
A square of 1" x 1" =	90 acres

Point of interest such as a stream crossing site

The outlined drainage area is about the size of a quarter



WATER CONTROL DEVICES FOR ROAD DRAINAGE

Guidelines

Water Bars

Broad-Based Dips

Rolling Dips

Wing Ditches/Water Turnouts

Other Devices

WATER CONTROL DEVICES

Guidelines for getting water off and away from a road.

Road Design

- Don't use natural drains as road ways.
- Don't locate roads directly on the tops of ridges. Side hill locations, just off the crest, are generally best.
- Avoid flat areas that can pond water.
- Break the grade occasionally and avoid long, straight grades.
- Take advantage of natural, small cross-drains.
- Additional drainage can be obtained by taking advantage of turns and curves.

Road construction

- Avoid in-sloping and inside ditches (ditches on the uphill side of the road) whenever possible.
- When inside ditches are used, provisions must be made to divert the water across the road at regular intervals.
- When slope can not be regulated, use water control devises to reduce the slope length.
- Use curves when possible to shed water from the road.
- Avoid expensive and elaborate drainage structures such as stonework.
- Rolling and broad-based dips in the road surface are very effective in gathering water and tipping it safely off the road.
- Water bars and traffic are not compatible.
- Install wing-ditches as frequently as possible.
- Empty water control devices onto stable outlets.
- Outlets should be as level and wide as possible.

WATER BARS

Purposes

- To gather and shed surface water off a road, trail, firebreak etc.
- To divert water from an inside ditch
- To prevent excessive erosion until revegetation can be established

Where suitable

- Roads and trails that will have no or very limited traffic
- Abandoned or retired roads and trails
- Firebreaks

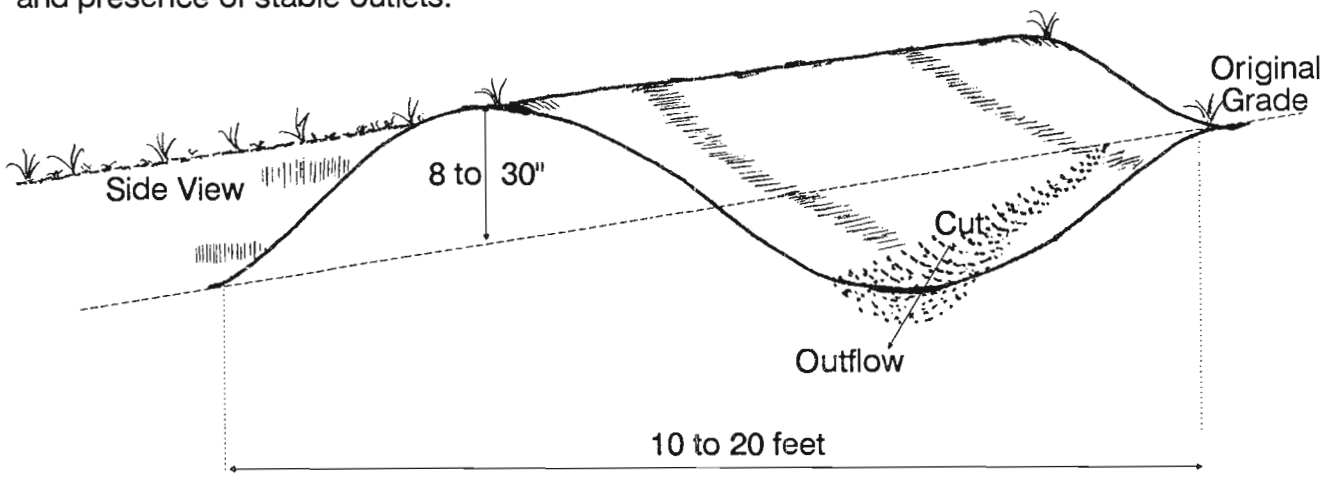
Construction guidelines

- Angle across the road in the down-grade direction
- Tie the upper end into the inside ditch's bank (when present)
- Empty onto stable outlets
- Can be constructed mechanically or by hand

Distance guidelines*

Slope Range	Distance between W.Bars
Flat	250 feet 185 160
Moderate	135 105 80
Steep	75 60

* In addition to distance, consider taking advantage of factors such as slope changes, curves and presence of stable outlets.



BROAD-BASED DIPS

Definition

A carefully outsloped section of road which acts as a water catchment and drainage channel

Purposes

- To gather surface water and tip it safely off the road
- To provide cross drainage of inside ditches

Where suitable

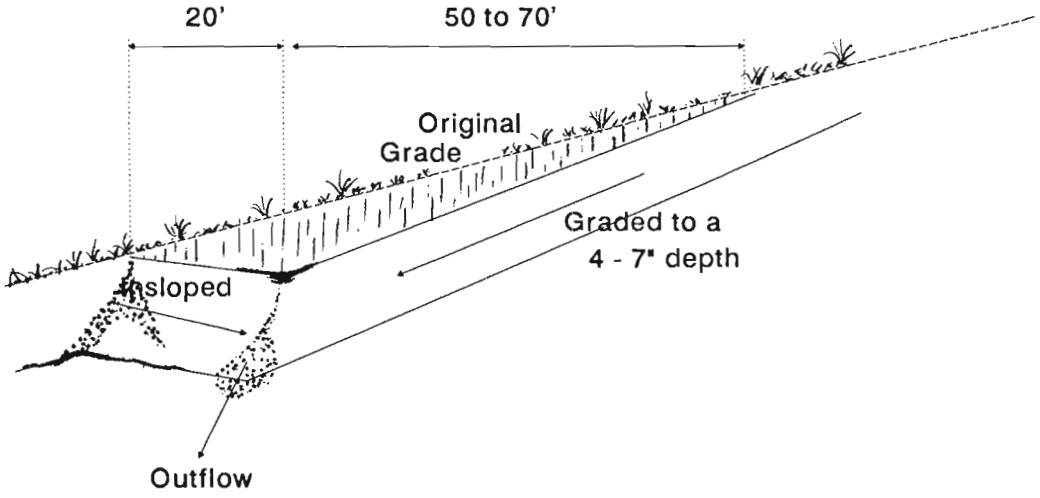
- Not for handling live (constantly flowing) water
- On roads and trails that will be used
- On flat and moderate grades only

Construction guidelines

- Only outslope the dip. Outsloping the road between dips probably will not turn water out of wheel tracks
- Place dips across the road in the direction of flow

Distance guidelines

Slope	Distance between BB-Dips
Flat	300 feet 220 195
Moderate	180 160 140



ROLLING DIPS

Definition

Rolling dips are a cross between water bars and broad-based dips. Like broad-based dips they have a reverse grade (except its shorter) and they tip water off the road. Like water bars they may also rely on a mound of soil at the down-hill side.

Purposes

- To gather water and tip it safely off the road
- To provide cross drainage of inside ditches

Where suitable

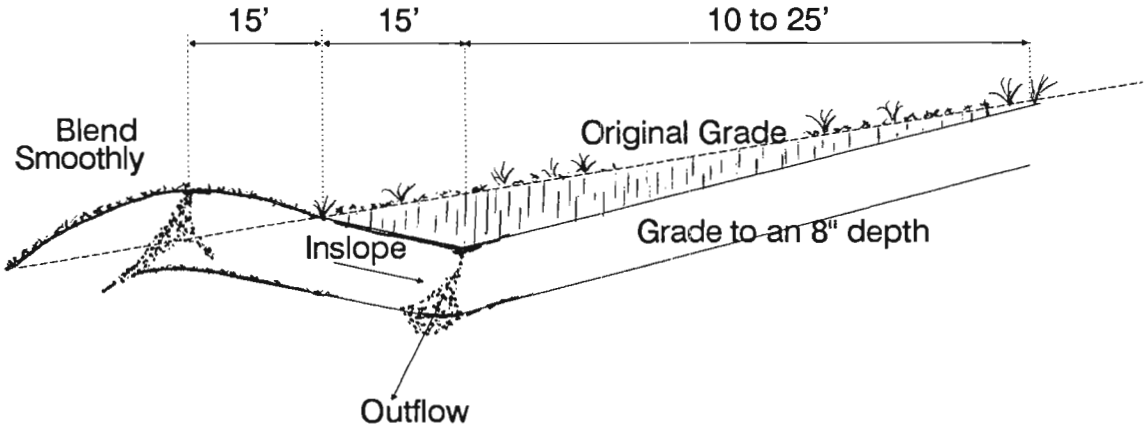
- Not for handling live (constantly running) water
- On roads that will be used
- Can be used on steeper grades than broad-based dips

Construction guidelines

- Place across the road in the direction of flow
- Outslope the dip only, not the road
- Mound excavated material from the dip on the down-hill side
- Blend the mound to as gentle a slope as possible to make travelling over it easier

Distance guidelines

Slope Range	Distance between Rolling Dips
Flat	180 feet 160
Moderate	150 135 130
Steep	120



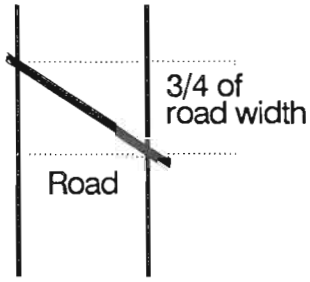
OTHER WATER CONTROL DEVICES - CULVERTS

Purpose

To provide cross drainage of inside ditches. These devices are not for stream crossings.

Installation guides

- Whenever possible, install in low points and small cross drains along the road.
- Avoid excessively long ditch spaces.
- Space culverts at about the same distance as broad-based dips. But take advantage of opportunities such as low points and ideal outlets whenever possible.
- Place culverts at a downhill angle to aid the charging of the culvert. The lower end of the culvert should be the equivalent of about three-fourths the road's width down-slope from perpendicular with the upper end.
- Seat culverts onto firm ground.
- The culvert's inlet should be at the same grade as the ditch.
- Protect the outlet end from excessive erosion.
- Size the culvert to handle ditch flow, allowing for storm occurrences
- Plan on sufficient culvert length to extend it beyond the road fill on both ends.



Types of culverts

- Pipes, such as corrugated metal - These are the most expensive form of ditch relief structures.

  Compact the fill at least half way up the side of the culvert.
  Pipes should be no smaller than 12 inches.
  Cover the culvert with at least 1', and preferably 2', of fill.

- Open-Top box culverts - These are 3-sided boxes constructed of lumber.

  Box culverts must be well made and the open end must be adequately reinforced to prevent their collapsing.
  These may not be as self cleaning as pipe culverts, but are less expensive. Hand tamp the fill to the top of the box.

- Open-Top pole culverts - These are made of two or more poles laid side by side, with a space between, in a ditch dug across the road.

  Reinforce the top to prevent them from rolling together.
  In East Texas these are, at best, temporary measures.

WING DITCHES/WATER TURNOUTS

Purpose

To safely divert water from a side ditch and disperse it onto a stable outlet.

Construction guidelines

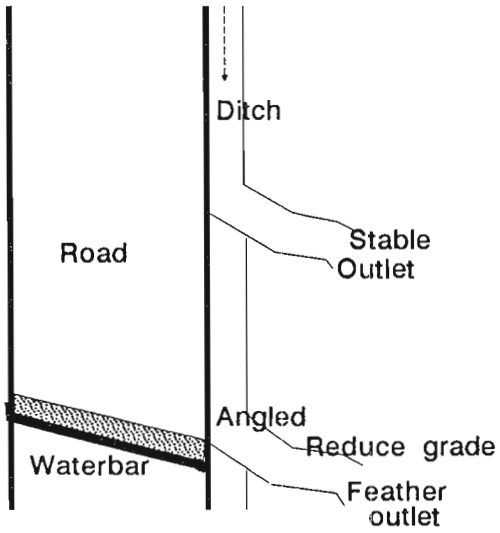
Constructing wing ditches or water turnouts with as flat a bottom as possible:

- Begin the ditch with its bottom at the same depth as the road ditch.
- Angle the turnout away from the road to direct all the water from the road ditch.
- Then curve the wing ditch across the hill to flatten out the grade in the ditch. However, be careful not to turn it back uphill.
- Blend or feather the end onto a stable outlet to spread the water as much possible.
- Avoid building turnouts that release water directly into streams.

Distance guidelines

Water turnouts or wing ditches may often be needed to provide stable outlets for other water control devices such as water bars and dips, but additional turnouts may also be needed along stretches of road where water is expected to collect.

Slope Range	Maximum distance between Wing Ditches/Turnouts
Flat	250 feet 185 160
Moderate	135 105 80
Steep	75 60



STREAM CROSSINGS

Culvert Guidelines

Estimating Storm Runoff

Culvert Sizing

Culvert/Spillway Installation

Examples of Culvert Design

Other Stream Crossings

GENERAL CULVERT DESIGN AND INSTALLATION GUIDELINES FOR STREAM CROSSINGS

Definitions

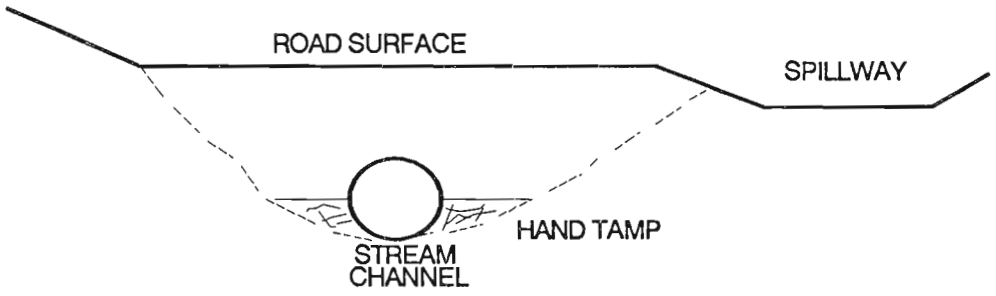
Peak Runoff is the accumulated amount, in cubic feet per second, of a storm's runoff from an entire drainage area. Factors that affect runoff include vegetative cover, slopes and soils. The design guidelines included in this section are calculated on a 5 inch, 24 hour, storm occurrence.

Head is the vertical column of water that is temporarily stacked over the culvert's entrance. Head provides the energy needed to force water through the culvert. The greater the head, the more water can be forced through the pipe.

Spillway is the flat bottom channel that leads across the road to the downstream side of the culvert installation. Its purpose is to protect the culvert and road by safely handling runoff that is in excess of the culvert's capacity. A spillway should be considered in all culvert installations.

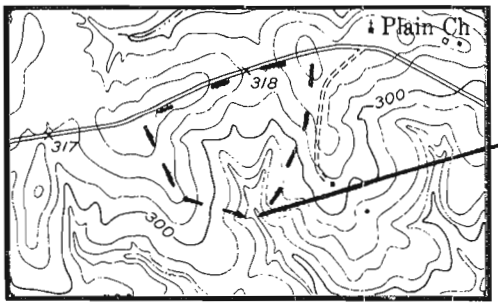
Guidelines

- Culverts should be placed in straight sections of stream channels.
- The stream should have as straight an entrance and outlet as possible.
- The inlet should be placed on the stream bed, not above it.
- The approach to the stream crossing should be at right angles to the stream.
- Seat the culvert on firm ground, not fill, and compact the earth at least halfway up the side of the culvert.



ESTIMATING STORM RUNOFF FOR CULVERT SIZING

1. Using appropriate maps, estimate the drainage area for the stream crossing site.



2. Using either a soils map or testing the texture by feel, determine if the drainage is predominantly sandy, loamy or clayey.

3. Determine the average slope class (flat, moderate, steep) of the drainage area.

Do not consider the crossing site only, but the whole drainage area.
Most drainage areas will be either flat or moderate

4. Using the table below, determine the runoff for a 5", 24-hour storm for the appropriate drainage area, soil type and slope class.

Table 1 - Peak Runoff From A 5" Storm in Cubic Feet Per Second (CFS)

Acres	Flat Slopes			Moderate Slopes			Steep Slopes		
	Sand	Loam	Clay	Sand	Loam	Clay	Sand	Loam	Clay
5	4	9	15	6	12	19	8	14	20
10	7	14	24	11	21	35	15	27	40
15	9	19	32	14	29	47	21	39	57
20	11	23	40	17	35	60	26	50	75
25	12	26	47	20	42	70	30	60	92
30	14	30	52	23	47	80	35	70	110
35	15	32	60	25	52	90	40	77	125
40	17	35	65	27	57	100	43	85	140
45	18	37	70	30	62	120	47	95	150
50	19	40	75	32	67	140	50	100	165
75	25	52	100	42	87	160	67	130	230
100	30	65	120	50	110	190	80	170	290

5. Choose a culvert(s) or culvert/spillway combination that will handle the runoff.

CULVERT, CULVERT/SPILLWAY SIZING

1. Estimate, either from topographic maps or on-site inspection, how much fill can reasonably be used at the site.

2a. Choose a culvert size and associated head from the table below that closely matches the estimated runoff and fits the site.

Table 2 - Culvert Capacity (In Cubic Feet Per Second) By Diameter and Head

CULVERT DIAMETER	FEET OF HEAD OVER THE TOP OF THE CULVERT						
	1	2	3	4	5	6	7
18	6	9	11	12	14	15	16
21	9	13	15	18	20	22	23
24	13	18	21	24	27	29	31
27	17	24	30	33	37	38	40
30	22	31	37	42	45	49	52
36	33	45	55	62	68	74	78

2b. -OR- Choose a culvert size/head figure and calculate a spillway width to accommodate the extra runoff.

Table 3 - Calculating Spillway Width and Depth

1. Determine the runoff in excess of the culvert size/head figure in Table 2
2. Multiply the excess runoff by the appropriate factor below to determine the spillway's bottom width.
3. Add 1.0 feet to the appropriate Depth of Flow(DOF) to determine the spillway's depth below the road surface..

	Spillway Width Factor	DOF
Sandy or Loamy Spillway	2.0 Feet per CFS of runoff	0.5'
Clayey Spillway	1.0 Feet per CFS of runoff	0.7'
Gravelled Spillway	0.7 Feet per CFS of runoff	0.8'

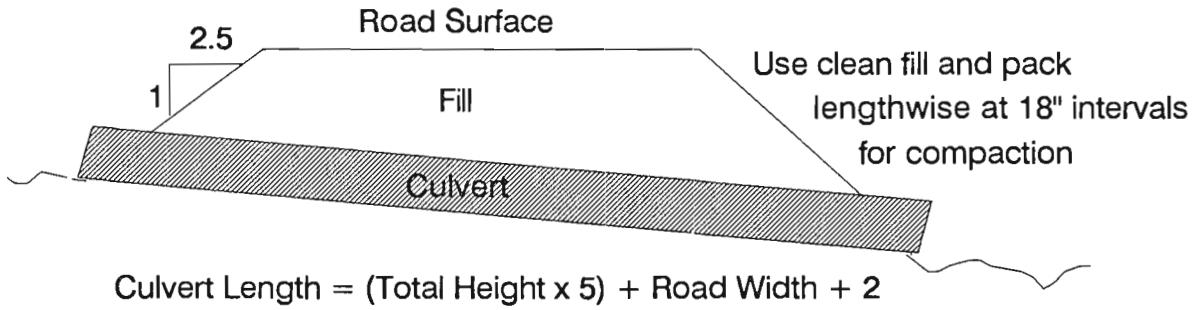
- If the site is in a flat bottomland situation, spillway construction may not be needed.
- If the site is so steep that constructing a spillway would mean excessive cutting into the slopes, choose a larger culvert/head figure.

2c. -OR- Choose multiple culverts of same size and head to fit the runoff and site.

CULVERT AND SPILLWAY INSTALLATION

Culvert installation guidelines

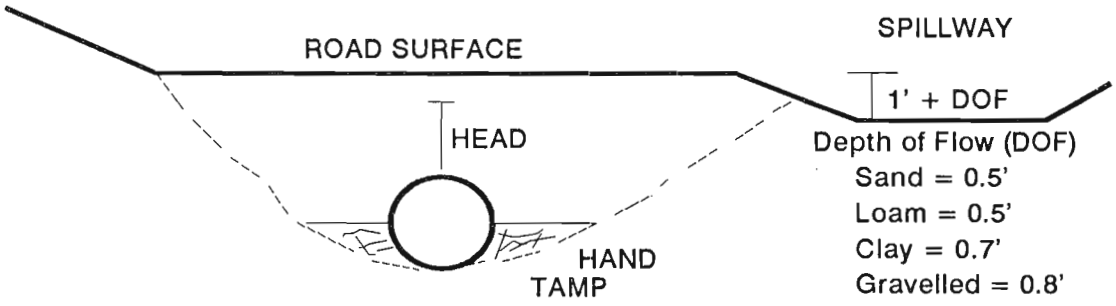
- Place the culvert in the bottom of the stream channel.
- Hand tamp the fill along the culvert to a height of at least one-half of the culvert's diameter.
- Slope the fill no steeper than 2.5:1 (2.5 feet horizontal over 1 foot of fall).
- Allow for about 1 foot of culvert to extend beyond the fill both upstream and downstream.



Culvert Length = (Total Height x 5) + Road Width + 2

Spillway construction guidelines

- Plan on including a spillway, even if the culvert will handle the runoff.
- Install water bars or dips above the spillway to divert outside water.
- Grade the slopes leading into the spillway to 3:1 or flatter.
- Keep the spillway flat across the road and never directly over the culvert.
- Grading the spillway back down to the stream may be necessary to avoid drop-offs.
- Either seed or gravel the spillway to control erosion and to improve wet weather use.



Total Height

= Stream bed to top of road
= Culvert diam.(in feet) + Head + 1'

EXAMPLES OF CULVERT DESIGN

Situation: 20 acres of drainage on sandy soils with moderate slopes.

The spillway will not be gravelled.

Runoff for 20 acres, sandy soil, moderate slope = 17 cu. feet/second (CFS) (Table 1)

Solutions:

1. Installing a 24" culvert with 2' of head and no spillway needed (but one should be added, if practical, for emergencies anyway) will handle 18 CFS of runoff (Table 2).

2. Install an 18" culvert with 2' of head + a 16' wide spillway.

Runoff handled by the culvert = 9 CFS (Table 2)

Excess runoff = Storm runoff less runoff handled by culvert
17 CFS - 9 CFS = 8 CFS

Spillway width needed to handle excess runoff
Width = Excess runoff x Width Factor for sandy soils (Table 3)
Width = 8 CFS x 2.0 ft./CFS = 16 ft.

Total Height* = Diam. of pipe (ft) + Head (ft) + 1'
Height = 1.5' + 2' + 1' = 4.5'
* Height from stream bed to road surface

Spillway Depth* = 1' + Depth of Flow (DOF) for sands (Table 3)
Depth = 1' + 0.5' = 1.5'
* Depth of spillway from the road surface

3. Installing two 18" culverts with 2' of head and no spillway needed (but one should be added, if practical, for emergencies anyway), will handle 18 CFS of runoff.

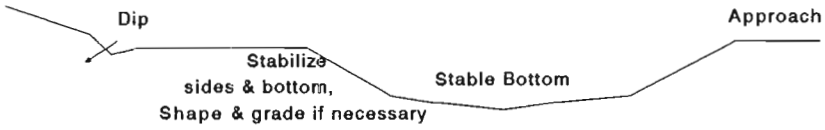
CFS = 2 x CFS handled by one 18" culvert with 2' of head (Table 2)

OTHER STREAM CROSSINGS

Low water crossings or fords

If low water crossings or fords are used:

- Look for stream crossings that have low banks and solid stream beds.
- Look for stream sections that can accommodate approaches of about 50' (on both sides) and that are reasonably level. Stabilize immediately.
- Make crossings at right angles to the stream and only in straight sections, never in bends.
- Stabilize, if necessary, the crossing with heavy applications of gravel.
- Install wingditches, waterbars or dips before the crossing. This will drain water off the side of the road rather than into the stream.
- Use other stream crossing methods such as culverts or bridges if water quality is important for domestic use, livestock water, fishponds, etc
- Never use during high water periods.



Bridges

If bridges are planned because stream crossings are too large for culverts or because maintaining high water quality is important for domestic use, livestock water, etc.:

- Consider alternate road locations first.
- Make crossings at right angles to the stream and only in straight sections.
- Choose a site with approaches that will allow for adequate visibility, turnouts, and a relatively constant grade to the bridge. The bridge should maintain the grade of the approaches to avoid abrupt rises or falls in grade at the ends of the bridge.
- Install abutments that are parallel to the stream and imbedded into good foundation material.
- Get technical help in designing the bridge to handle the intended traffic.

Temporary crossings

Temporary crossing must be designed to handle the intended traffic and not impede stream flow. Remove temporary crossings immediately after use and stabilize the site. Avoid crossings made of brush and fill that pushed into the stream.

REVEGETATION

Adapted Plants

Planting Dates and Rates

Seedbed Preparation and Planting

Mulching

APAPTED PLANTS FOR REVEGETATION OF ROADS, TRAILS, AND LOG SETS

Vegetation Type	Species	Sands	Loams	Clays
Annual grasses/crops***	Millet			
	Brown Top	x	x	x
	Fox Tail	x	x	x
	Pearl	x	x	x
	Ryegrass		x	x
	Oats	x*	x	x
	Elbon Rye	x	x	x
	Wheat	x*	x	x
Perennial grasses	Bahia**		x	x
	Bermudagrass			
	Alicea	x	x	x
	Coastal	x	x	x
	Selection 3	x	x	x
	Sheffield	x	x	x
	Common**		x	x
	NK-37		x	x
	Tall Fescue**		x	x
	Lovegrass**			
	Weeping	x	x	x
	Wilman	x	x	x
	Alamo Switchgrass		x	x
Legumes	Singletary Peas		x	x
	Hairy Vetch	x	x	x
	Arrowleaf Clover		x	x
	Subterranean Clover		x	x

* Not adapted to very deep sands

** Most shade tolerant of listed plants

** * Used as a temporary clover, in mixes, or for wildlife plantings

REVEGETATION - PLANTING INFORMATION

Vegetation Type	Species	Season of Growth	Planting Dates	Rates*
Annual grasses/crops	Millet			
	Brown Top	warm	4/15 - 8/1	40 lbs
	Foxtail	warm	4/15 - 8/1	30 lbs
	Pearl	warm	5/15 - 8/1	40 lbs
	Ryegrass	cool	9/1 - 11/30	24 lbs
	Oats	cool	9/1 - 11/30	128 lbs
	Elbon Rye	cool	9/1 - 11/30	112 lbs
	Wheat	cool	9/1 - 11/30	120 lbs
Perennial grasses	Bahia (Pensicola)	warm	***	30 lbs **
	Bermudagrass			
	Alicea sprigs	warm	1/15 - 6/1	48 bu
	Coastal sprigs	warm	1/15 - 6/1	48 bu
	Slection 3 sprigs	warm	1/15 - 6/1	48 bu
	Sheffield sprigs	warm	1/15 - 6/1	48 bu
	Common seed	warm	3/15 - 5/15	2 lbs **
	NK-37	warm	3/15 - 5/15	2 lbs **
	Tall Fescue	cool	9/15 - 11/15	20 lbs **
	Lovegrass			
	Weeping	warm	3/1 - 5/1	4 lbs **
	Wilman	warm	3/1 - 5/1	4 lbs **
	Alamo Switchgrass	warm	3/1 - 5/31	7 lbs **
Legumes ****	Singletary Peas	cool	9/15 - 11/30	70 lbs
	Hairy Vetch	cool	9/15 - 11/30	40 lbs
	Arrowleaf Clover	cool	9/15 - 11/30	20 lbs
	Subterranean Clover	cool	9/15 - 11/30	20 lbs

* Planting Rates are in lbs. per acre or bushels per acre
1 acre = 43560 sq. feet

** Pure Live Seed (percent purity x percent germination = Pure Live Seed)

*** Bahia can be planted nearly year round if it is planted with an appropriate temporary cover plant.

**** Inoculate seed before planting

SEEDBED PREPARATION AND PLANTING

Seedbed Preparation Guidelines

- If the soil is loose, or even firm (but not compacted), is smooth enough for planting, and has not been sealed by rainfall, no seedbed preparation may be needed.
- Some grading, shaping, smoothing, and water bars may be needed on some sites.

Seedbed Preparation Methods

Condition	Method
Soil still loose and not compacted Newly constructed roads (not graded to clay)	None
Soil compacted after use Soil sealed by rainfall Newly constructed roads graded to clay	Use disk or similar equipment to loosen to a 3-4" depth

Planting Guidelines

- Select the best adapted plants for the soil, intended use and season of growth.
- When temporary plants (annual grasses/crops) are used, a follow-up to determine the need for permanent vegetation is needed.
- When possible, use mixes. Legumes should always be used in mixes with grasses.
- Permanent grasses may be seeded or sprigged into dead cover provided by temporary cover plants.

Planting Methods

Situation	Method
Planting seed	Broadcast and lightly drag into soil Broadcast and firm with a roller Drill seed
Sprigging	Sprig by machine Sprig by hand with a dibble Broadcast, disk in and firm with a roller

Fertilizing

- Apply 600 to 650 lbs. of 13-13-13 per acre (43560 sq. ft.) either at the time of planting or mixed into the top 2 to 3" during seedbed preparation.

MULCHING

Definition and Purpose

Mulching is the application of plant residues or other suitable materials to the soil surface for the purpose of reducing erosion and helping establish a plant cover. It may be particularly useful on steep or problem areas where erosion is likely to occur before vegetation can be established.

Mulching with hay

- Spread, either by hand or mechanically, at a rate of approximately 100 pounds per 1,000 square feet.
- Anchor mulch by either light disking or by tucking it into the soil with a spade.

Mulching with wood chips and bark

- Do not use this method in water flow areas such as ditches.
- Spread either by hand or mechanically.
- Do not spread deeper than 1" if revegetation is planned.

Mulching with slash

- Logging slash can be used to provide sufficient erosion prevention until native or planted vegetation can be established.
- Spread, either by hand or mechanically, placing as much of the slash as possible in contact with the soil surface.

Other forms of mulching

- Hydro-mulching
- Manure
- Rock or gravel
- Jute mesh or similar material

THE DIRTY DOZEN

Twelve common mistakes in road construction and maintenance

1. Improperly sized culverts (too small)
2. Poor location (wet spot, SMZ, loose soil)
3. Not enough wing ditches
4. Hills too steep (over 10 percent grade)
5. Use of fill material taken from SMZ to cover culvert
6. Improperly maintained road crown
7. Blocked culverts
8. Failure to stabilize erosive soils with grass on shoulder
9. Leaving ditches clogged with logging debris
10. Narrow planning which fails to consider management objectives present and future
11. Inadequate soil compaction or "set-up" time before heavy use
12. Failure to discuss road uses, plans and BMPs with logger or timber buyer.

- From - Steven J. Milauskas
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