

Chapter 5

Runoff Control and Forestland Access

Chapter 5 Layout:

Part 1 - Page 51

**BMP Tools to Control
Runoff**

Part 2 - Page 60

**BMP Tools to Capture
Sediment**

Part 3 - Page 68

Stream Crossings

Part 4 - Page 78

Forest Roads

Part 5 - Page 84

Skid Trails

Part 6 - Page 86

Decks & Landings

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Helpful Hints:

**Remember the four key
elements for
controlling runoff:**

1 - Prevent It

2 - Slow it down

3 - Spread it out

4 - Capture it



Refer to the FPGs
in the Appendix

Take note of how this chapter is organized:

Part 1 describes methods to control runoff, while Part 2 includes practices to capture sediment. These two topics are explained first because implementing these types of ‘BMP tools’ are essential for properly built stream crossings, roads, skid trails and decks.

Also note in this Chapter (and throughout this manual), that the term ‘runoff’ refers to surface runoff that flows atop the ground surface. This term should not be confused with below-surface or groundwater flow.

Water Quality Link

The BMPs in this chapter can help you plan, put into place, and maintain good access in a way that should protect water quality:

- Roads, skid trails, stream crossings and decks are widely considered the most likely source of potential erosion and nonpoint source pollution on a forestry operation.
- Having BMPs correctly implemented can add value to the forestland for its owner and to those who benefit from the land or its resources.
- Not having these features done the right way may lead to prolonged and substantial erosion and water quality problems that will likely cost much more to repair than it would have taken to prevent them in the first place.

‘Getting the Job Done ...’

Your ultimate goal is to protect water quality when working with roads, skid trails, stream crossings, or decks. Preventing runoff, controlling runoff and/or capturing sediment can go a long way towards accomplishing this goal.

Whether it is accomplished by using the BMPs in this manual, or by some other methods, the result must be the same: protecting the water.

Text Box for Rules References

Under each part of this chapter, a text box similar to this one contains references to those rules that may apply to that topic.

- **There are several state and/or federal rules that apply to the features discussed in this chapter, including most of the North Carolina FPGs.**
- **Specific requirements about forest roads in wetlands are briefly discussed in this chapter. Refer to Chapter 6 for detailed information.**

Part 1 -- BMP Tools to Control Runoff

Did You Know?

The type of BMP tools in Parts 1 and 2 have many common names:

- Water control structures
- Erosion control structures
- Water diversions
- Runoff diversions
- Drainage structures
- Drainage diversions

No matter what you call them, they serve the same purpose of controlling runoff and capturing sediment.

Controlling runoff reduces its speed and volume before it can get out of hand, thereby reducing the likelihood of accelerated erosion.

The BMP tools covered in Part 1 are:

- Broad-based dip
- Turnouts
- Cross-drains
- Waterbars
- Inside ditchlines
- Insloping, outsloping and crowning

These different methods of controlling runoff can be used for nearly any suitable forestry application. These may include permanent or temporary roads, skid trails, stream crossings, firelines, access trails and log decks.

Installing these BMP tools usually is best during initial construction. However, they can be successfully retrofitted with proper equipment and techniques.

Locations where these BMP tools are especially useful include:

- Steep slopes or slopes with soil of high erosion and runoff risk.
- Top of slopes or grades to control runoff before it can pick up speed.
- Approaches to stream crossings.

Some Benefits of Controlling Runoff

- Protection of water quality from pollution potential by reducing erosion risk and allowing better water absorption.
- Improved access on your forestland.
- Protection of your financial investment in sustaining forestland access.

Distance Spacing for Runoff Control BMPs

Table 5-1 below provides a range of suggested spacings for installing the different BMP tools used for controlling runoff. *See 'Helpful Hints' to left.*

The spacing ranges are only general guidelines and should be adjusted according to your specific site, soil, groundcover, equipment or other conditions.

Helpful Hints:

Table 5-1 is arranged to focus first on the steeper grades, then recognize their correspondingly shorter spacing ranges, as the slope grade increases.

The layout of this table emphasizes the point that steeper slopes often require more BMPs to control runoff.

Table 5-1: Suggested Spacing Ranges for BMP Tools to Control Runoff

Slope Grade (percent)	Broad-based dips, Turnouts, Cross-drains (feet)	Waterbars (feet)
20 +	60 to 40	40 to 30
16 to 20	100 to 60	60 to 40
11 to 15	140 to 100	80 to 60
6 to 10	180 to 140	100 to 80
0 to 5	250+ to 180	120+ to 100

Helpful Hints:

Broad-based dips are not suitable to provide drainage for Inside Ditchlines or groundwater seeps. Cross-drains should be used instead.

Helpful Hints:

Try to use the native soil from the site, and compact it when forming the reverse-grade hump.

Broad-Based Dip

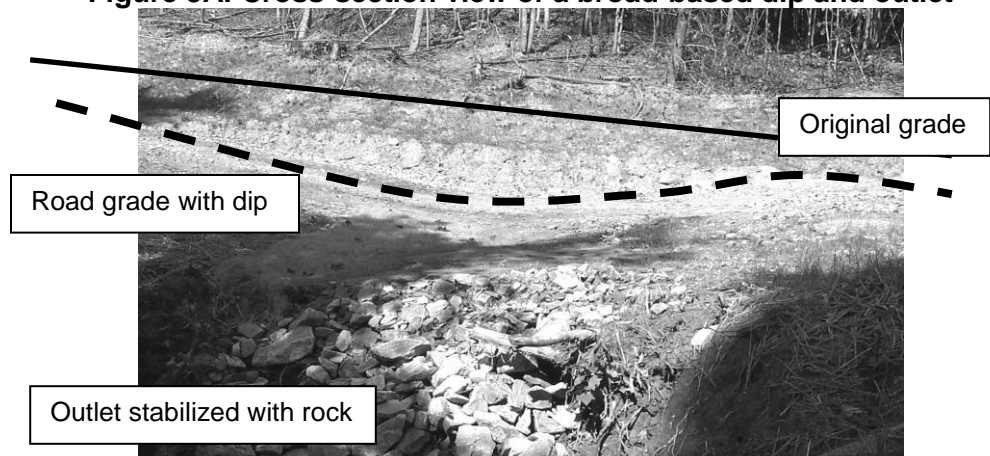
A broad-based dip is a combination of a shallow depression (dip) excavated into the road surface with a slight hump at a reversed grade, formed immediately on the downhill edge of this dip. An outlet area is provided for the runoff to leave the road surface.

The dip works by diverting runoff away from the roadbed and through the outlet. The hump acts as a barrier to continued runoff flow downhill along the road surface.

BMPs for Broad-Based Dip

- Lay out and construct the broad-based dip at right angle to the travel surface and across the full width of the road.
- Excavate a shallow dip approximately 15 to 20 feet long into the uphill travel surface.
- Construct and compact a slight hump across the downhill edge of the dip. The reverse grade of the hump should not exceed 2 to 3 percent slope down toward the base of the dip.
- Outslope the bottom of the dip at enough of an angle to turn away water and runoff, but generally no more than a 2 to 3 percent outslope angle.
- On slopes greater than 8 percent, or when needed, hardening the travel surface of the broad-based dip with stone or other materials can prevent erosion and improve vehicle traction.
- Situate the broad-based dip outlet in a manner that prevents runoff from flowing directly into streams or waterbodies. Take measures to capture the sediment from the outlet as needed.
- Avoid siting the outlet onto soft soil or fill material, unless measures are implemented to prevent accelerated erosion from the outlet.

Figure 5A: Cross-section view of a broad-based dip and outlet



Caption:

In this photo, you can see the dip in the road, and the outlet created for carrying runoff.

It is recommended to only create enough outslope angle within the dip to turn the runoff without creating a hazardous driving condition for vehicles.

Helpful Hints:

Waterbars are usually used when closing off, or 'retiring' skid trails and roads.

It is not recommended to drive over waterbars, since this will wear down the hump and alter the drainage function of the trench.

Watch Out!

Remember: Waterbars are excavated and constructed.

Simply piling soil on the trail or road surface IS NOT the same as installing a waterbar.

Also Refer To...

Table 5-1 provides spacing ranges for waterbars.

Helpful Hints:

Don't set the waterbar backwards, which diverts water into the side / cut slope, unless there is an Inside Ditchline to collect the runoff.

Waterbars

A waterbar can be thought of as an angled 'speed bump' with a shallow trench along the uphill edge that diverts runoff. There are two key points to remember for functional waterbars:

- 1. A waterbar must be constructed to extend completely across the trail or road surface to be fully functional:**
 - Doing so reduces the likelihood of runoff finding its way around the ends of the waterbar and flowing past it.
 - This may require 'tying-in' the waterbar with adjacent side / cut slopes.
 - This may require extending the waterbar well beyond the width of the road or trail travel surface.
- 2. The waterbar is not intended as a trap to block or pool runoff. It should be angled and have a suitable outlet for diverting runoff into an area where sediment will settle and/or filter out:**
 - Proper angling is needed to allow the runoff to drain and not backup.
 - Excavation of a shallow trench along the uphill edge of the waterbar hump helps collect and drain off the diverted water.

BMPs for Waterbars

- Waterbars should be excavated and constructed using equipment and/or techniques that assure proper angles and a firm waterbar hump.
- When building waterbars next to a side / cut slope, tie the uphill end of the waterbar into the side / cut slope, and angle the waterbar downhill towards the outfall edge of the road or skid trail.
- Use an angle ranging from 15 to 30 degrees (downslope) for the waterbar to properly drain while preventing pooling of runoff behind it.
- Excavate the trench with enough gradient to allow adequate flow of water runoff, but generally not to exceed 2 to 3 percent.
- Situate the waterbar outlet in a manner that prevents runoff from flowing directly into streams or waterbodies. Take measures to capture the sediment from the outlet as needed.
- Avoid siting the outlet onto soft soil or fill material, unless measures are implemented to prevent accelerated erosion from the outlet.
- Establish groundcover or harden the waterbar with stone or other material, if needed to maintain long-term function.

Caption:

The waterbar shown here is properly angled diagonally across the skid trail, to allow runoff to flow off the surface.

A shallow trench can carry the runoff.

The waterbar and trench extends past the edge of the skid trail to prevent passage of runoff around the waterbar mound.

Figure 5B: Waterbar constructed across a skid trail in Wilkes Co., N.C.



Figure 5C: View of the trench along the uphill face of the waterbar

Caption:

The trench that is excavated along the uphill face of the waterbar allows water to flow off the trail surface and through the outlet.

This outlet extends into a well-vegetated area that provides good infiltration and sediment capturing effectiveness.

NOTE -- Be sure to minimize any curvature of the waterbar across the road or trail. The waterbar shown here would be best if it were a little less curved, but it appears that it should function satisfactorily.



Caption:

The waterbar in this photo demonstrates some good BMPs to remember:

- Angled across the path
- Mounded soil waterbar
- Tied into side / cut bank (right side of photo)
- Outlet onto stable soil

NOTE -- A trench should be excavated along the uphill base of the waterbar, to carry runoff and keep the soil mound from getting 'blown out.'



Figure 5D: A waterbar tied in to the adjoining side / cut bank

Did You Know?

The word **turnout** can also be used to describe a wide section of forest road that allows vehicles to pass each other.

Also Refer To...

Table 5-1 provides spacing ranges for turnouts.

Helpful Hints:

Remember, there are two angles on a turnout:

- The outlet gradient angle is the slope needed to drain runoff from the road surface.
- The turnout angle describes how wide apart the turnout veers away from the roadside or trail.

Turnouts

A turnout is a type of shallow trench or pathway that diverts runoff from the surface of a road, skid trail or fireline.

A wing-ditch or lead-off ditch is a specific type of turnout used for controlling runoff within roadside ditches.

In both cases, the turnout should be constructed as a continuous offshoot of the road, skid trail, fireline or roadside ditch. This helps maintain an uninterrupted connection for runoff to flow.

BMPs for Turnouts

- Begin the inflow of the turnout at the same grade level as the road, skid trail, fireline or ditch so runoff can flow easily without being interrupted.
- Excavate the turnout with enough outlet gradient angle so runoff can drain in a controlled manner, generally from 1 to 3 percent is adequate.
- Construct using a turnout angle between 15 to 30 degrees downslope.
- Situate the end of the turnout outlet in a manner that prevents runoff from flowing directly into streams or waterbodies. Take measures to capture the sediment from the outlet as needed.
- Avoid siting the outlet onto soft soil or fill material, unless measures are implemented to prevent accelerated erosion from the outlet.
- For use in roadside ditches, take action to minimize erosion within that ditch so the inflow of the turnout does not create a gully.

Figure 5E: A turnout used together with a waterbar on a skid trail

Caption:

This turnout was pushed out into a vegetated area so water can soak into the ground and sediment will settle out.

Note the use of additional waterbars further down the skid trail.



Figure 5F: A turnout, used as a wing ditch alongside a forest access road in Henderson County, N.C.

Caption:

The turnout in this photo is used as a wing ditch, which carries surface runoff from the roadside inside ditchline (see next section for explanation).

The wing ditch or turnout outlets to a well-vegetated area.

Also note the slight hump in the road surface, which helps divert runoff into the wing ditch or turnout.



Did You Know?

Other names for this:

- Inside ditch
- Grader ditch
- Shoulder ditch

Helpful Hints:

Ditchlines are most often needed in sloping terrain where roads have a side / cut slope.

Additional BMP tools are often needed so the ditchlines don't become deep gullies or constant sources of potential erosion or pollution.

Ditchlines can be useful, though, when managing groundwater seeps along side / cut banks.

Watch Out!

The further apart you set turnouts or cross-drains, the more volume and speed you will have to handle within each section of ditchline.

Caption:

In this photo, the inside ditchline is located at the base of the hill slope, at the left edge of the roadbed.

The inside ditchline appears to be stabilized, with no accelerated erosion or down-cutting within the ditchline.

Inside Ditchlines

An inside ditchline provides a place to collect runoff that comes off the surface of an insloped or crowned road. The ditchline carries this runoff for a short distance until a cross-drainage technique is used to move the runoff from the inside edge of the road to the outside edge of the road, where the runoff drains.

Inside ditchlines can be difficult to correctly construct and maintain. While BMPs are provided below, you are encouraged to consider the alternative of installing an outsloped road surface, which does not need inside ditchlines.

BMPs for Inside Ditchlines

- Excavate the ditchline to the minimum depth and width needed to carry the expected runoff from the road surface drainage area:
 - The cross-sectional area within the ditchline should be matched to the cross-sectional area of the pipe to be used for cross-drainage.
 - A conservative rule of thumb is to approximately match the ditchline cross sectional area to the same cross sectional area as a 15-inch diameter pipe (1.25 square feet).
- Control runoff speed and volume to reduce the likelihood of creating a high-risk and long-term erosion hazard.
- Avoid allowing the ditchline to down-cut or become an erosion gully. Where appropriate, install geotextiles, matting, stone or other suitable material to reduce the potential for accelerated erosion.
- Install turnouts or cross-drains at intervals adequate to carry the expected runoff from each uphill section of ditchline and/or road surface.
- Situate the ditchline outlet or cross-drainage outlet in a manner that prevents runoff from flowing directly into streams or waterbodies. Take measures to capture the sediment from the outlet as needed.
- Avoid siting the outlet on soft soil or fill material, unless measures are taken to prevent accelerated erosion from the outlet.

Figure 5G: A forest road with an inside ditchline in Ashe County, N.C.



Helpful Hints:

Cross-drains should use culvert pipes. The pipe must be large enough to carry the runoff, but small enough to fit within the roadbed.

Open-top drains or trenches are not suitable for forestry applications.

Also Refer To...

Table 5-1 provides spacing ranges for cross-drains.

Watch Out!

Smaller pipe sizes can easily get clogged with debris and/or sediment.

If smaller pipes must be used, perform more frequent regular inspection and maintenance to remove blockages.

If plastic culverts are used you may need more substantial fill material atop the pipe to provide vehicle support.

Cross-Drains

Cross-drains move water and runoff from one side of a road or trail to the other, usually under or through the roadbed.

Cross-drains can be used to:

- Carry runoff out of an inside ditchline.
- Drain water and runoff along grades.
- Provide drainage for groundwater seeps or springs.
- Direct runoff away from log decks.

BMPs for Cross-Drains

- Set cross-drains on a 2 to 4 percent downslope angle to provide good drainage and help prevent debris from clogging the drain.
- Install cross-drains at an approach angle suitable to allow free flow of runoff into and through the cross-drain.
- Match the base level of the cross-drain inflow to the base elevation of the ditchline so runoff can flow into and through the cross-drain uninterrupted.
 - A drop-inlet can improve inflow at places where the elevation of the cross-drain inlet is lower than the ditchline.
- If culvert pipe is used, cover the pipe with at least one foot of fill and harden the crossing location as needed to protect the pipe from traffic:
 - Use at least a 15-inch diameter pipe on heavy flow areas.
 - Use at least a 12-inch diameter pipe if only needed for groundwater seeps or for locations where minimal runoff volume and/or debris is expected.
 - The cross-sectional area of the pipe should be matched to the cross-sectional area of the ditchline being drained.
- Minimize erosion on both ends of the cross-drain so the ditchline does not down-cut and create a gully or produce accelerated erosion.
- Where needed, harden the inflow headwall of the cross-drain with stone, sandbags, geotextiles, vegetation, drop-inlet, or other suitable materials to avoid headcutting or accelerated erosion.
- Situate the cross-drain outlet in a manner that prevents runoff from flowing directly into streams or waterbodies. Take action to capture the sediment below the outlet as needed.
- Avoid siting the outlet onto soft soil or fill material, unless measures are implemented to prevent accelerated erosion from the outlet.

Figure 5H: View of the outlet end of a cross-drain installed underneath a permanent forest road in Wilkes County, N.C.

Caption:

This cross-drain provides drainage of runoff that flows within the inside ditchline (which is located at the base of the slope in background, alongside road edge).

Note that the cross-drain is installed diagonally through the roadbed, to provide improved flow of the water.

Also note that the culvert pipe extends well past the travel surface of the road, to protect it from being damaged by vehicles.



For Forest Owners:

Insloped roads may be suitable on steep grades with slick soils and/or sharp curves, but require the excavation and maintenance of an inside ditchline, with cross-drains.

Outsloped roads, with appropriate water control measures, are the preferred road design in steep terrain. This design eliminates the need for an inside ditchline and allows for better control of runoff.

Watch Out!

Use whatever surface drainage method is best to meet your safety needs for slick soils, steep grades, sharp curves, vehicle type(s) and traffic frequency.

Insloping, Outsloping and Crowning

The degree to which a road surface is tilted or angled can determine a lot about runoff flow. By insloping, outsloping or crowning a road surface, you are creating a tilt or angle that naturally moves water and runoff from the surface.

Insloping allows runoff to drain into an inside ditchline. Because the ditchline is between the uphill side / cut bank and the roadbed, the ditchline must be drained with a turnout or cross-drain.

Outsloping allows runoff to drain from the road surface towards the outside (downslope) edge of the road, where the runoff can be controlled or allowed to absorb into the ground. This method generally requires less maintenance than insloped roads because there are no, or very few, ditchlines or cross-drains.

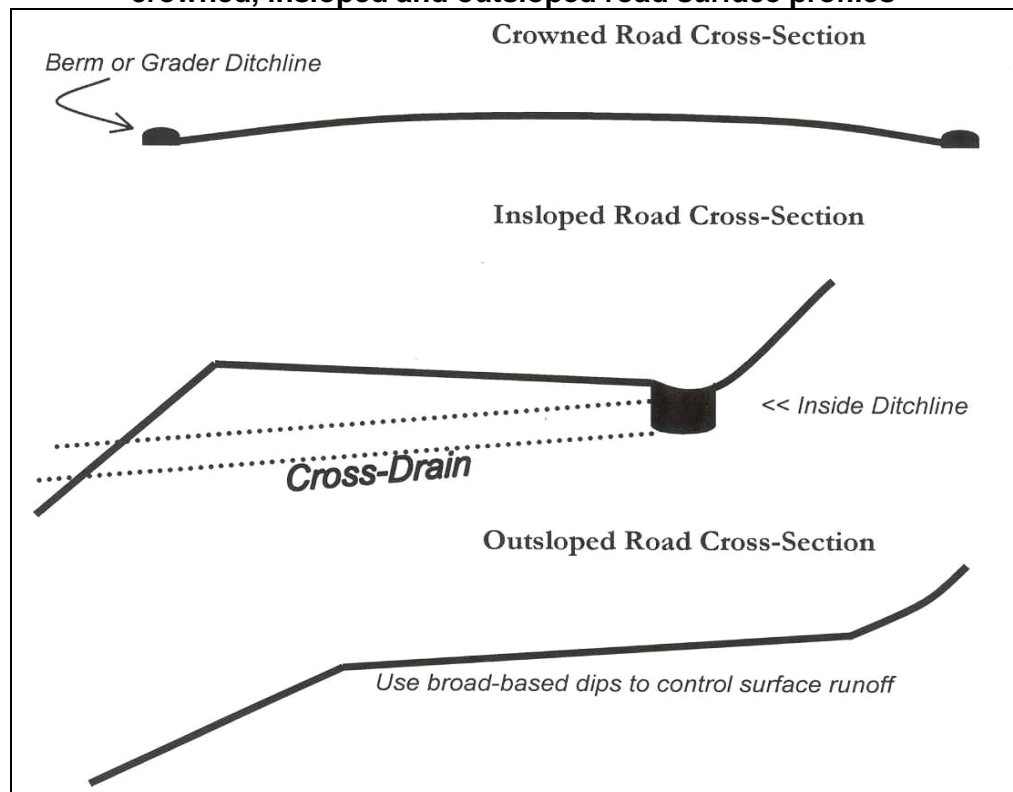
Crowning creates a slight hump across the road's cross section, by having the centerline of the road higher than both roadside edges. If a road is to be crowned, other BMPs tools to collect and/or capture runoff may be needed. Crowning is usually used on wider, permanent access roads or in flat lands with a ditch on at least one side to collect runoff.

BMPs for Insloping, Outsloping and Crowning

- On insloped roads, excavate and maintain inside ditchlines and cross-drains in order to carry runoff. Refer to the BMPs for inside ditchlines.

- For freshly graded outsloped or crowned roads, a temporary low berm along the outside (downslope side) edge of the road may prevent washing away of the soft soil and fill material:
 - If a temporary berm is installed, provide outlets or gaps so runoff can move away from the road surface in a controlled manner.
- Maintain the road surface as needed to minimize or repair ruts, holes, or depressions that hold water, which can weaken the roadbed or create concentrated runoff with sediment transport.

Figure 5I: Schematic cross-sectional sketch of crowned, insloped and outsloped road surface profiles



Caption:

A crowned road may need slight berms and/or grader ditchlines alongside either edge to control runoff.

An insloped road needs appropriate inside ditchlines to collect runoff. A cross-drain (dotted line) is also needed to drain the inside ditchline.

An outsloped road can effectively use broad-based dips to manage surface water runoff.

Part 2 -- BMP Tools to Capture Sediment

Capturing or containing sediment is the second part of using BMPs related to roads, skid trails, stream crossings and decks.

Your first goal should be to prevent or halt accelerated erosion once you have controlled the runoff. When those efforts are not adequate, capturing the sediment before it reaches a stream is the last option you have:

- Stop or prevent sediment transport at its source.
- If that doesn't work, keep the sediment on site.
- Above all else, keep the sediment out of the streams and waterbodies.

The BMP tools discussed in Part 2 are:

- Filter Areas
- Silt Fences
- Brush Barriers
- Sediment Traps / Pits
- Straw Bales
- Check Dams

Consider the long-term potential for effectiveness and maintenance when deciding which BMP tools to use when capturing sediment.

Locations where these BMP tools are especially useful include:

- Disturbed soil areas near streams or other waterbodies.
- Approaches to stream crossings.
- Steep slopes or slopes with soil of high erosion and runoff risk.
- Along slopes or grades to periodically capture sediment in runoff.
- As a catchment for collected or diverted surface runoff.

Some Benefits of Capturing Sediment

- Protection of water quality from pollution potential by containing sediment in runoff before flow picks up speed and volume or enters a waterbody.
- Improved access on your forestland.
- Added value of your financial investment in sustaining forestland access.

Figure 5J: Temporary sediment capture alongside a forest road



Caption:

This temporary holding area, reinforced with stone, is successfully capturing runoff and sediment.

The stone provides good support and backing.

Filter Areas

Filter areas are usually a long-term, low-cost option to capture, slow, and contain runoff so sediment and other potential pollution can settle out before reaching a waterbody.

Filter areas can be differently shaped or sized, depending upon the application and needs of the soil and site.

FPG

Refer to FPG .0201 as it relates to SMZs, which are a type of required filter area.

The DWQ riparian buffer rules are also a type of mandatory filter area that must be applied in certain parts of North Carolina.

Did You Know?

Other names for these include:

- Sediment basins
- Settling pit
- Silt trap or silt pit
- Tank traps

Helpful Hints:

Traps or pits are effective to collect runoff that is diverted by a broad-based dip, waterbar, cross-drain, turnout or ditchline.

BMPs for Filter Areas

- Permanent groundcover should be retained or established that allows runoff to slow down and soak into the soil:
 - Natural, relatively undisturbed groundcover and/or vegetation is usually the best choice for a filter area.
 - Established groundcover can also be effective, but may require additional BMPs and/or maintenance.
- Intensive soil disturbance should be minimized.
- Use stable, well-drained soils for filter areas when available.
 - If unstable soils must be used for a filter area, install treatments such as erosion matting or other methods to stabilize the soil.

Sediment Traps or Pits

Sediment traps are excavated holes that trap and store runoff, and are usually installed where runoff is concentrated nearby streams and other waterbodies.

Traps or pits can be used for either temporary runoff control, or long-term installation. Permanent use of traps / pits will require more substantial construction and periodic maintenance.

BMPs for Sediment Traps or Pits

- Excavate the pit with a suitable opening and depth to capture the expected sediment runoff while minimizing soil disturbance to the adjacent area. Refer to Appendix 14 for suggested sediment pit sizing dimensions.
- Locate the pit within stable, well-drained soils when available.
 - If the pit must be situated within unstable soils, install additional measures to provide soil stabilization around the pit.
- Dispose or stabilize the excavated spoil material to keep it from washing away. Avoid using the spoil to build up the sides of the pit, since this loose spoil material can easily wash away or fall back into the pit.
- For sediment pit installations intended to be permanently functional:
 - Create a reinforced outlet for overflow capacity that will reduce the likelihood of the pit walls being washed away or 'blown out'.
 - Harden the walls of the pit to minimize the risk of structural failure.
 - Revegetate exposed soil around the perimeter of the pit.
 - Periodically clean out accumulated sediment. A useful rule is whenever the pit is half full, remove and stabilize the accumulated sediment.

Caption:

This sediment pit is located in a good position to capture sediment that flows off of this graveled, outsloped forest road.

The pit is positioned well away from the stream (in background).

NOTE -- The headwall on this pit may need reinforcement, or have to be sloped back, to keep soil from falling into the pit after being saturated from precipitation.

Helpful Hints:

Silt fences are usually man-made materials.

Think of a silt fence as similar to a coffee filter - - the idea is to capture the sediment in the runoff, while allowing the water to still trickle through.

Figure 5K: A functioning sediment pit excavated alongside a forest road



Silt Fence

Silt fence is a geotextile or fabric that is supported with stakes, with the bottom partially buried into the ground and is for temporarily capturing runoff.

A silt fence is most effective for temporarily capturing sediment and delaying runoff that occurs across the ground surface, before reaching a channel or forming gullies and erosion trenches in the land.

Silt fence cannot effectively capture mass movement of sediment or capture runoff for an extended period of time.

Silt fencing may be useful to capture sediment in areas of exposed bare soil until vegetation can be established. Due to the natural roughness and uneven terrain on forestry job sites, a silt fence can be very difficult to correctly install and still remain effective.

BMPs for Silt Fence

- Additional measures upslope and downslope of the silt fence may be required to slow, control and capture sediment.
 - If there is considerable sediment build-up along the silt fence, determine the sediment source and adjust or add BMPs accordingly.
- The suggested drainage area limit is 100 feet of fence for every one-quarter acre of land. Refer to Table 5-2 below for further reference.
- Set fencing along the land contours and extend the fencing far beyond the expected pathway(s) of runoff flow. The ends of the fencing should be gently turned like a sideways 'J', with the hook facing uphill.

Watch Out!

Silt fence should never be used as the only BMP tool on the job site.

Additional BMPs are needed to control runoff and capture sediment.

You should expect silt fencing to fail during heavy precipitation - - plan accordingly.

If you observe a heavy sediment accumulation, look up-slope and re-evaluate your BMPs.

Table 5-2 was adapted from N.C. Division of Land Resources' Erosion and Sediment Control Handbook "Practice Standards and Specifications."

Caption:

This sketch depicts the proper installation of silt fence.

Note the bottom of the silt fence along the upslope side is buried into the soil, and the fence is securely staked.

Consider setting multiple rows of fencing to provide additional protection.

Avoid using silt fence to divert water - - it should be used only as a temporary sediment filter.

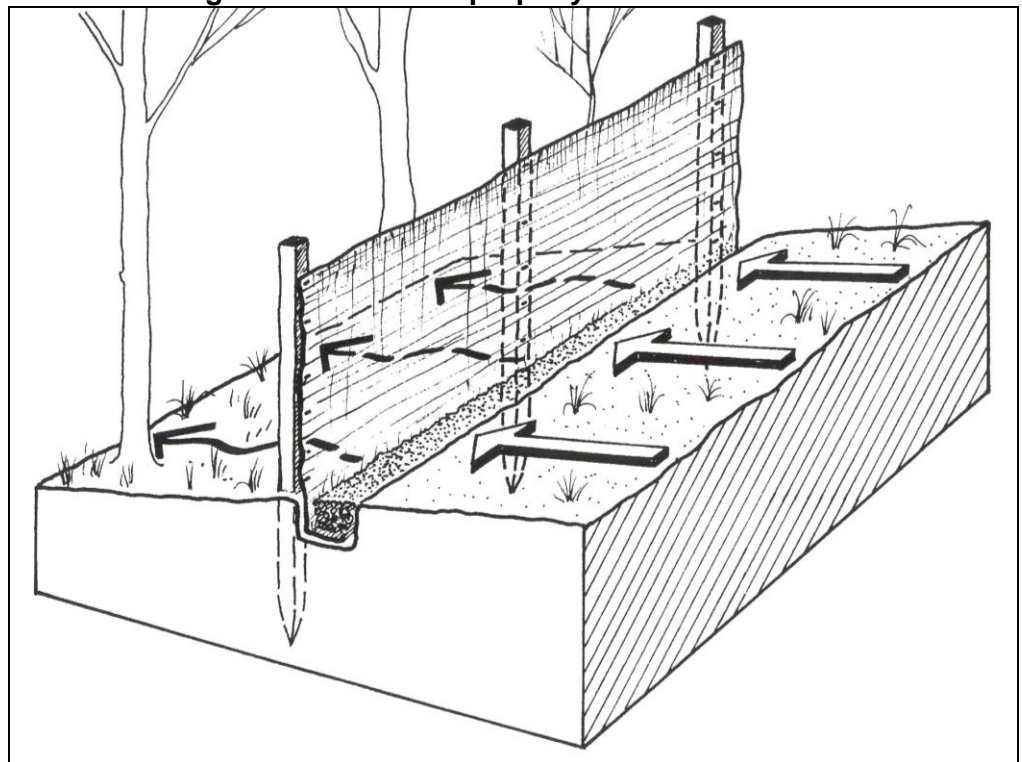
(Illustration provided with permission and courtesy of Maine Forest Service).

- Bury the bottom 4 to 6 inches of silt fence securely into the ground to keep runoff from flowing underneath:
 - Install the fence so that the buried portion is along the upslope face of the fence, to prevent the fence from getting washed over by sediment.
- Adequately reinforce the silt fencing from being knocked over or blown out. Wire fencing backer or additional staking can be used.
- Frequently monitor the silt fence after installation. Promptly take action to maintain or improve the filtering effectiveness.

Table 5-2: Recommended Applications for Every 100 Feet of Silt Fence

Slope	Maximum Slope Length Between Fence-rows (feet)	Maximum Drainage Area (acres)
0 to 2%	100	0.23
2% to 5%	75	0.17
5% to 10%	50	0.11
10% to 20%	25	0.06
20% +	15	0.03

Figure 5L: Sketch of properly installed silt fence



Helpful Hints:

Places where bales may be helpful:

- Outlets of water diversion tools described in Part 1
- Stream crossing approachways
- Alongside freshly graded outsloped roads
- Around edges of log decks
- Supporting or supplementing silt fence installations

Straw Bales

Straw bales, or a bale of other natural fibers, can be a low-cost and effective tool to slow runoff and capture sediment. Bales often are better than silt fence or brush barriers since they can conform better to the ground surface.

Bales can be placed around the perimeter of an area with exposed soil, or across the pathway of runoff flow. The bales will help control the runoff, and act as a sediment filter.

However, since they are natural fibers, the bales will eventually decompose and breakdown. As a result, they should be used for temporary runoff capture and control.

BMPs for Straw Bales

- Additional measures upslope and downslope of the bales may be needed to slow, control and/or capture sediment.
 - If there is considerable sediment build-up along the bales, determine the sediment source and adjust your BMPs accordingly.
- Set bales tightly against the ground surface and anchor the bales firmly into the soil if the bales are likely to wash away.
- If square bales must be stacked, stagger the joints between bales so they do not line up over the joints in the previous layer, similar to brick laying.
- Frequently monitor bales after installation. Promptly take action to maintain or improve effectiveness.

Caption:

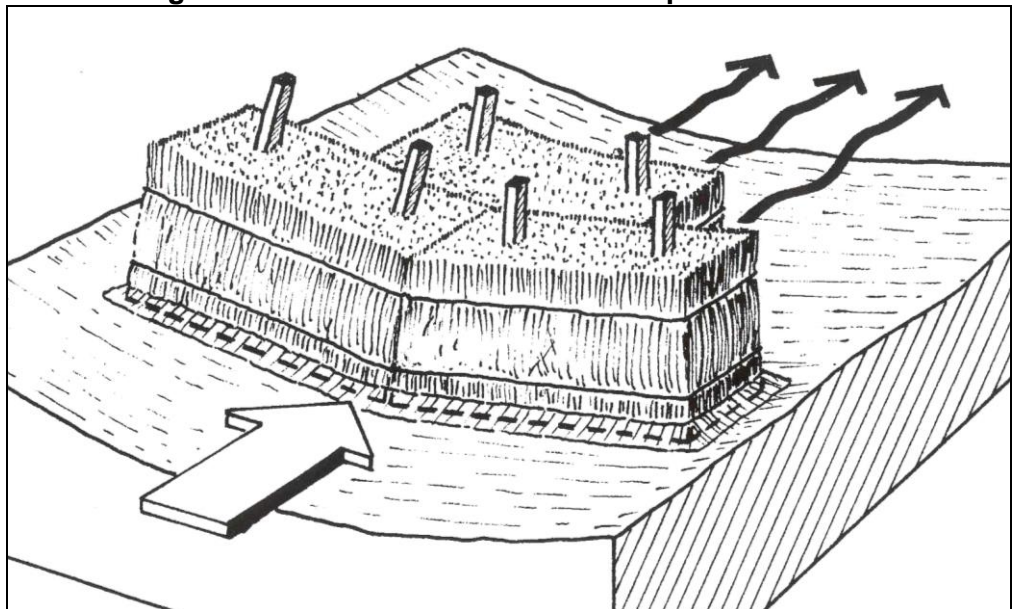
When bales are used to capture sediment, you should make sure that:
-- Bottom of the bales conforms to the ground surface to prevent leakage.

-- Bales are secured if needed to prevent them from being washed away.

-- Joints between successive bales are staggered like bricks.

(Illustration provided with permission and courtesy of Maine Forest Service)

Figure 5M: Sketch of bales used to capture sediment



Helpful Hints:

Places where brush barriers may be helpful:

- Alongside newly constructed or graded roads
- Alongside and on top of skid trails
- Around edges of log decks
- Stream crossing approachways

Brush Barriers

Brush barriers are piles of leftover, unusable tree and vegetation debris that is carefully piled and packed down to act as a temporary filter barrier to slow runoff and capture sediment.

Creating brush barriers is a productive use and disposal for debris that is generated by road or skid trail construction and can be a low-cost method of temporary sediment capture.

BMPs for Brush Barriers

- Pile and pack down brush to achieve close contact with the ground surface.
 - This may require breaking or cutting large pieces of material into smaller chunks that more easily conform to the surface of the ground.
- Use additional BMP tools such as silt fences, bales, filter areas or other methods to improve trapping effectiveness where brush barriers fail to capture enough sediment because of their loose configuration.
- Avoid removing the brush barrier once it is established.

Figure 5N: A brush barrier alongside a closed road in Caldwell Co., N.C.



Caption:

The brush barrier installed along the right edge of this stabilized forest road will help capture sediment before it can move downslope.

Figure 5O: A brush barrier at the base of an active road



Caption:

Brush has been laid down at the base of the roadbed, in the center of the photo. Also note the well-vegetated roadbed and side / cut bank.

(Photo figure 5O provided courtesy of Coweeta Hydrologic Laboratory, Southern Research Station, USDA-Forest Service.)

Helpful Hints:

While usually constructed of stone rip-rap, check dams can also be built from sandbags, sacks of concrete, logs or other suitable hardened materials.

Watch Out!

Check dams are not appropriate for installation within streams.

Caption:

These small check dams provide sediment capture within a turnout that drains a graveled forest road.

Note the sediment accumulation captured by the front two check dams.

The rear two check dams appear to not have any sediment accumulation yet, but provide good reinforcements.

The area is well vegetated and stabilized.

Check Dams

Check dams are short, hardened barriers established within inside ditchlines to slow the speed of runoff and capture sediment. Check dams can also be useful to control the runoff that comes from the outlets of water diversions (such as those described in Part 1 of this chapter.)

BMPs for Check Dams

- Consider laying down geotextile fabric before placing the check dam's construction material. This keeps material from sinking into the ground.
- Provide ample support at the base of the check dam in order to hold back and contain the sediment.
- Tie-in the base of the check dams with the soil to keep runoff from seeping under or 'blowing out' around sides of the the dam location.
- The center of the check dam should be lower than each outer edge to provide overflow capacity of water during heavy flows.
- The total height of the check dam should not exceed 3 feet. Taller structures are more prone to failure.
- Space the check dams within the channel so the top of each downslope check dam matches the same elevation as the base of the next higher dam.
- If check dam effectiveness is compromised by sediment buildup, periodically remove built-up sediment from behind the dams. Dispose of or stabilize this material to keep it from washing into waterbodies.

Figure 5P: Check dams installed within a turnout from a forest road



Part 3 -- Stream Crossings

Helpful Hints:

BMPs for the four most common types of stream crossings are provided:

- *Bridgemats*
- *Culverts*
- *Fords*
- *Pole Crossings*

Stream crossings are often necessary for roads, skid trails and firelines to gain access to forestland for management. Permanent crossings usually are for roads, or in some cases, firebreaks. Temporary crossings are most common for timber harvesting or other short-duration forestry operations, such as site prep, tree planting, fertilization or herbicide application.

Because of the obvious potential for water quality impacts at stream crossings, there are several rules that require practices be used or actions taken. Since the North Carolina FPGs were enacted in 1990, stream crossings have been the most frequent location on a job site where sediment may get into the water.

Rules Related to Stream Crossings

FPG

Forest Practices Guidelines Related to Water Quality (FPGs)

North Carolina General Statute 77-13 and General Statute 77-14

DWR riverbasin and watershed 'Riparian Buffer Rules'

These 'buffer rules' for specific river basins and watersheds set limitations on stream crossings within the 50-foot buffer zone

North Carolina Dredge and Fill Law

This state law requires that permits be secured for discharges of dredged or fill material in certain locations within the 20 Coastal Area Management Act (CAMA) counties. Refer to Chapter 6 for more information on this law.

Planning Stream Crossings

Stream crossings should be carefully planned in advance of their need to determine how water quality can be best protected. This section provides suggested BMPs when planning crossings.

BMPs for Planning Stream Crossings

- Avoid having stream crossings if possible. Take note of the FPGs.
- Use maps, photos and/or on the ground examinations to determine the minimum number of crossings needed to efficiently access the property while protecting water quality.
- Designate the location of the proposed stream crossing on the ground to avoid confusion about where to construct the crossing.
- When conditions allow, give preference to locations for crossings where:
 - The stream is relatively straight so crossing distance is minimized.
 - Approaches to the stream are relatively flat to better control runoff.
 - The crossing can be installed at a right-angle (90°) to the stream channel so crossing distance is minimized.

FPG

Helpful Hints:

Recommendations on stream crossings are available from:

- *Consulting Foresters*
- *N.C. Forest Service*
- *Soil & Water Conservation Districts*
- *USDA-Natural Resources Conservation Service (NRCS)*



Caption:

The BMPs noted here:
- Properly sized culvert.

- Culvert installed to handle low flow stream conditions.

- Sloped road fill, reinforced with a side support log/timber.

- Ample fill material over the culvert.

- Headwall reinforced with large rock.

A Note on Permanent Bridges:

Permanent bridges require professional engineering expertise. Specifications are beyond the scope of this Manual. Some generic BMPs to consider:

- Use bridges on deep, wide streams with heavy streamflows.
- Minimize soil disturbance during construction.
- Avoid placing a bridge in the curve of a stream or road.

- Select the type of stream crossing(s) based on site characteristics and the ability to best protect water quality while providing safe, efficient access.
- Maintain as close to normal (pre-construction) streamflow by maintaining depth, width, gradient and capacity of the stream channel at the crossing.
- Perform construction, installation, and removal work during low-water flow if circumstances allow.
- Stabilize the approachways and/or stream crossing locations so sediment is not transported into the stream as prescribed in the FPGs.

Figure 5Q: A permanent stream crossing on a forest road



Bridgemats

Bridgemats are heavy wood or steel panels placed over a stream or ditch channel, usually for temporary crossing. Other names include dragline mats, skidder bridges or pontoons. When bridgemats are carefully installed, used, and removed, they typically do a very good job of protecting water quality.

BMPs for Bridgemats

- When site conditions allow, select a stream crossing location that has these characteristics:
 - Narrow channel width.
 - Firm, stable streambanks.
 - Solid footing on either side to support bridgemats and equipment.
 - High, level ground on each side.
- Create a solid-surface crossing that provides a barrier over the channel to minimize debris, soil, and other materials from falling into the water.
- Keep equipment out of the channel during installation and removal of the crossing unless doing so is necessary for handling the bridgemats.

A Note on Log Bridges:

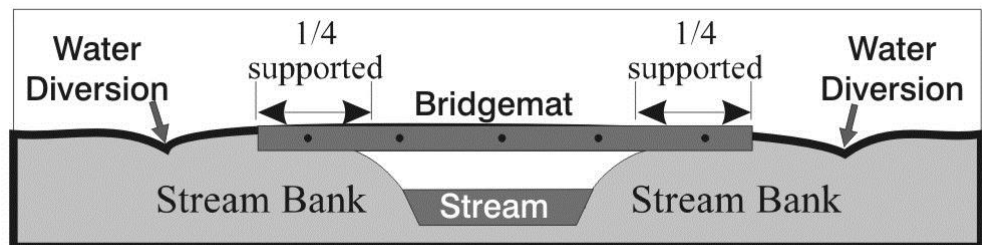
Temporary crossings constructed of de-limbed logs may be suitable in certain cases.

A log bridge is not the same as a 'pole crossing', which is explained later in this Chapter. A log bridge should completely span the watercourse:

- Avoid gouging or damaging stream channel with the logs as they are installed and removed.
- Keep logs butted tight to each other to minimize debris and soil from falling between.
- Keep equipment out of the stream when placing and removing logs.

- Minimize the amount of over-hang from logs, trees, or trucks/trailers that may disturb the channel or approachways.
- Control runoff and/or capture sediment on the approachways. See Part 1 and Part 2 of this Chapter for possible options.
- As needed, periodically inspect the crossing and take action to provide for safety while protecting water quality from runoff, debris, soil, or other potential pollution factors.
- Stabilize the approachways and crossing location in accordance with **FPG .0203** and **.0209**.

Figure 5R: Schematic drawing of proper bridgemat installation



Bridgemat for Stream Crossing

Caption:

BMPs noted here include:

- Good support on each end of the bridgemat.
- Adequate clearance between the stream flow and bridgemat.
- Three panels are used to create full-width crossing, with no gaps.

Figure 5S: Side view of a wooden bridgemat skid trail crossing



Figure 5T: Steel bridgemat installed for a skid trail stream crossing

Caption:

BMPs noted here include:

- A full-width panel crossing is used, with no center gap that could allow debris to fall into the stream.
- A straight section of stream is used for the crossing location.
- The bridgemat ends are well supported to prevent damaging the stream banks.



Culverts

Culverts are typically used for forest road stream crossings but can also be used for skid trail crossings. While culverts are readily available and can be a relatively inexpensive method, a major disadvantage of culverts is that they require disturbance in the stream channel. That includes placing fill material in close proximity to the water.

For Forest Owners

Smaller diameter culverts (less than 15 inches) can get clogged or blocked too frequently and create potential water quality problems.

A single larger diameter culvert is usually better than multiple, smaller diameter culverts since the smaller culverts may be more prone to blockages.

The cross-sectional area of a culvert opening cannot simply be added together to determine multiple culvert needs. Two 24 inch diameter pipes DO NOT provide the same volume as one 48 inch diameter pipe.

BMPs for Culverts

- Use a culvert sized to meet your needs that can carry the expected amount of runoff and streamflow from the upstream watershed:
 - Take into account the volume of heavy runoff that can result from precipitation and storms.
- Use a culvert long enough to extend at least 12 inches beyond the edge of the fill material:
 - If a shorter culvert is required, then protection should be added to the inlet and outlet headwalls. Examples include rip-rap, stone, sandbags, drop-inlets, or other erosion-preventing material.
- For forestry stream crossings, it is recommended to use culverts that are at least 15 inches in diameter.
- For temporary culvert installation, refer to Table 5-3 as a quick-reference table of suggested culvert diameters.
- For permanent culvert installation, refer to Table 5-4 for recommendations of culvert diameters.

Helpful Hints:

If a culvert is partially imbedded into the streambed, a larger diameter pipe may be needed to make up for this loss of open area within the pipe itself.

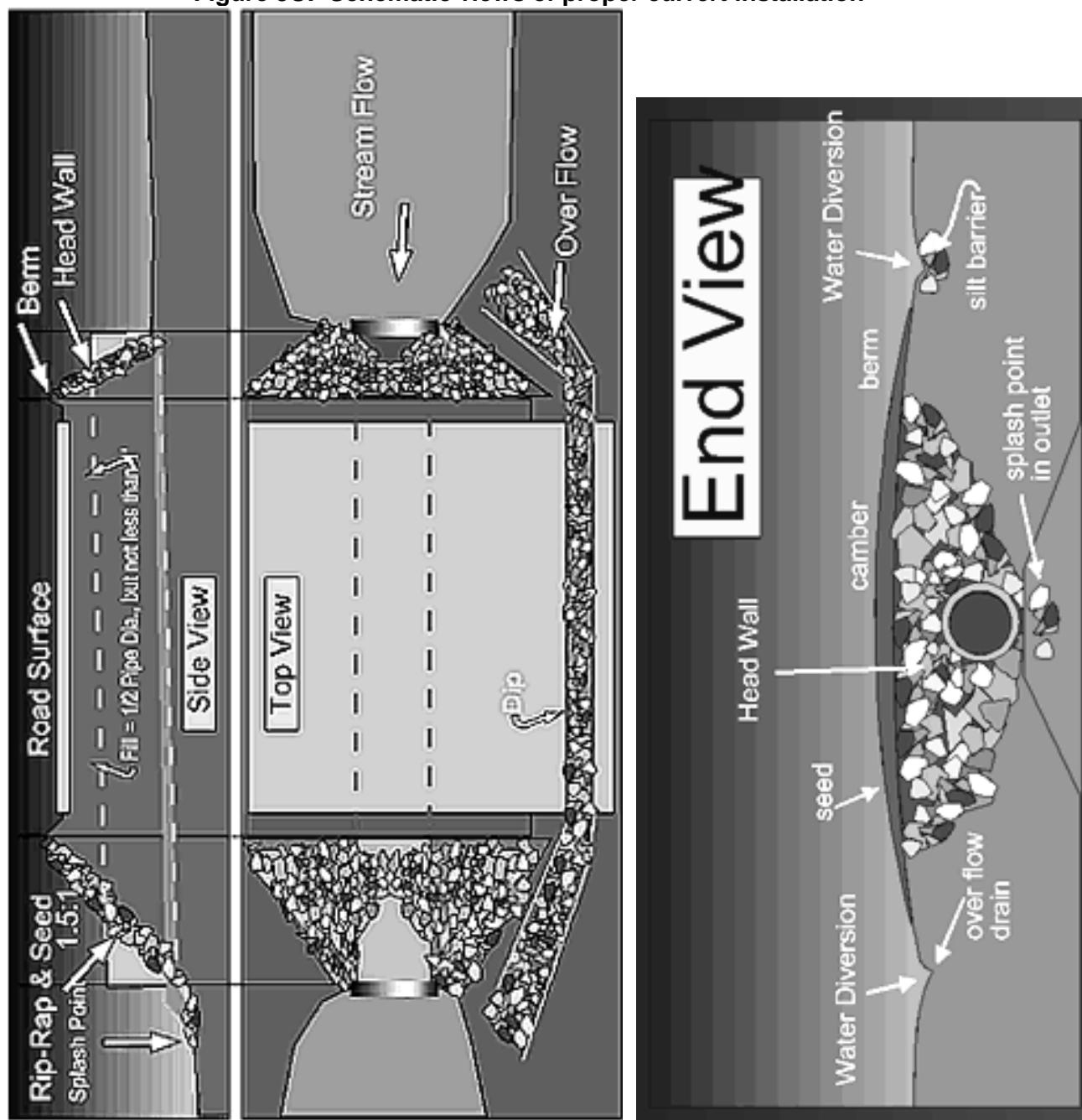
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Avoid backfill with debris or large rocks that could create air pockets within the backfill or damage the culvert.

Moist mineral soil usually works best.

- If multiple culverts are used, provide adequate cross-sectional opening area of the culverts to handle the expected streamflow. Refer to Table 5-4 for suggested diameters of multiple culverts.
- Install the culvert crossing during low-flow periods in the stream, if possible.
- Place culvert approximately in the center of the existing or expected water flow within the channel.
- Set the culvert(s) with a downslope grade so streamflow is not impeded and to prevent debris from clogging the pipe.
- Minimize the height that water drops from the outlet of the culvert:
 - For temporary installation, placing the culvert immediately upon the stream bottom is usually suitable.
 - For permanent installation, it may be appropriate to place the culvert partially imbedded into the stream bottom to allow better passage of fish and other water-living organisms.
- Backfill over the culvert with at least 12 inches of suitable material. Culverts larger than 30 inches diameter should have backfill thickness equal to at least one-third of the culvert's diameter.
- Use backfill material that will pack down tightly. Secure the culvert in place and provide adequate support for vehicle traffic:
 - Tamp down the backfill along the length of the culvert to block seepage that may flow around the culvert and wash it out.
- Protect the inlet and outlet of the culvert and the fill material to minimize erosion from the streamflow and runoff.
- Construct the crossing so it allows floodwaters to flow around the crossing location to minimize water backups and the potential of the culvert from being washed away (commonly called 'blowing out'):
 - Elevating the backfill over the culvert and creating a very slight crown can help divert floodwaters around the crossing location.
 - Creating a low depression area within the approachways can provide a flow-way for floodwaters to bypass around the crossing.
- Use surface hardening materials on the culvert crossing and approachways as needed to provide vehicle support and minimize erosion potential.

Figure 5U: Schematic views of proper culvert installation



Caption:

The top illustration (side view) shows proper culvert layout along the contour, with a slight downslope gradient to promote good streamflow and minimize back-ups or blockages.

The middle illustration (top view) shows the overflow dip that should be installed to allow floodwaters to flow around the culvert location and reduce the likelihood of the culvert blowing-out.

The bottom illustration (end view) shows how the road should be crowned over the culvert, with rock used to stabilize the inlet and outlets. Also note the water diversions on each approachway.

Culvert Sizing Diameters for Temporary Installation

The information on this page can be used for temporary installations of round culvert. Table 5-3 is based upon streamflow that could normally be expected from a '1 to 3 year' interval storm-flow event.

You should consider the recommendations found in Table 5-3 for sizing culverts:

- When needed for temporary access.
- During dry periods.
- On sites with low soil moisture.
- No precipitation has occurred or is forecast to occur while the crossing is needed.

Table 5-3: Suggested Diameter Sizes of Round Culverts for Temporary Installations

Average Channel Width (inches)	Average Channel Depth (inches)						
	6	12	18	24	30	36	42
12	15	18	18	24	24	30	36
18	15	18	24	24	30	30	36
24	15	24	30	30	36	36	48
30	18	24	30	30	36	48	48
36	18	24	30	36	48	48	48
48	24	30	36	48	48	48	60

FIGURE 5V: Sketch of a stream channel cross-section for determining temporary culvert size

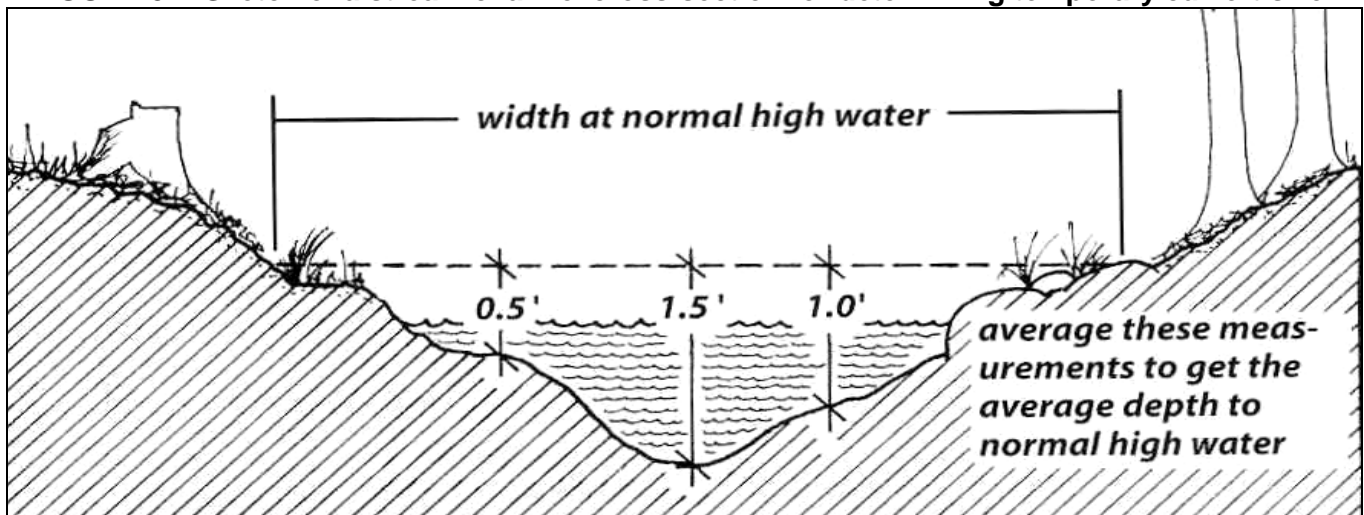


Figure 5V is reproduced with permission from "Best Management Practices for Forestry: Protecting Maine's Water Quality". Maine Forest Service, 2004.

Determining Average Channel Width for Table 5-3:

Measure how wide the channel is at the point of normal high water mark. Take several measurements and average them together to get the Average Channel Width for Table 5-3.

Determining Average Channel Depth for Table 5-3:

Measure how deep the channel is from the point of normal high water mark. Take several measurements and average them together to get the Average Channel Depth for Table 5-3.

NOTE: *In each case, do not simply measure how deep the water is. Instead, you need to measure the average stream channel dimensions at the point of normal high water mark.*

Table 5-4: Suggested Diameter Sizes of Round Culverts for Permanent Installations

The recommended culvert sizes on Table 5-4 should be considered for crossings that are expected to be in place for more than one year. Table 5-4 is adapted from Talbot's formula for a 2.5-inches-per-hour rainfall. The complete Talbot's formula table is in Appendix 9 for further reference.

	Impervious 100% runoff	Steep slopes, heavy soils, moderate cover		Moderate slopes, heavy to light soils, dense cover		Gentle slopes, agricultural-type soils and cover		Flatland pervious soils
Acres	<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>							
	C = 1.00 Bare soil	C = .80 Higher Runoff	C = .70 Lower Runoff	C = .60 Higher Runoff	C = .50 Lower Runoff	C = .40 Higher Runoff	C = .30 Lower Runoff	C = .20 Normal runoff
2	15	15	15	15	15	15	15	15
4	18	18	15	15	15	15	15	15
6	24	18	18	18	15	15	15	15
8	24	24	18	18	18	15	15	15
10	30	24	24	24	18	18	15	15
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
250	A Note About Multiple Culverts:					36+36+36	48	42
300	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 culverts are offered in this table. • There may be other combinations that can work. • Consult with someone who has experience if you are unsure.					36+36+36	30+30+24	42
350							30+30+30	48
400							36+36+24	48
450							36+36+30	48
500			36+36+36	30+30+30				

Caption:

This culvert installation exhibits these BMPs:

- Properly sized to accommodate stormflow.
- Situated at, or just below grade to allow low-flow conditions.
- Headwall stabilized with rock.
- Vegetation established on bare soil near the water's edge.

Figure 5W: Culvert installed on a forest road in Montgomery Co., N.C.



For Forest Owners:

When properly built and maintained, fords can provide efficient and inexpensive road access.

Watch Out!

Because a vehicle drives directly in the water, fords are usually the least preferred method of crossing for protecting water quality.

FORDS ARE NOT RECOMMENDED for use on skid trail crossings.

DO NOT BLOCK the natural flow of water in the stream channel.

**Safety 1st - - -
Never drive through a ford during high water or rapid currents.**

Caption:

This sketch drawing of a ford includes:

- Water diversions.
- Short fording distance.
- Hardened stream bottom.

Fords

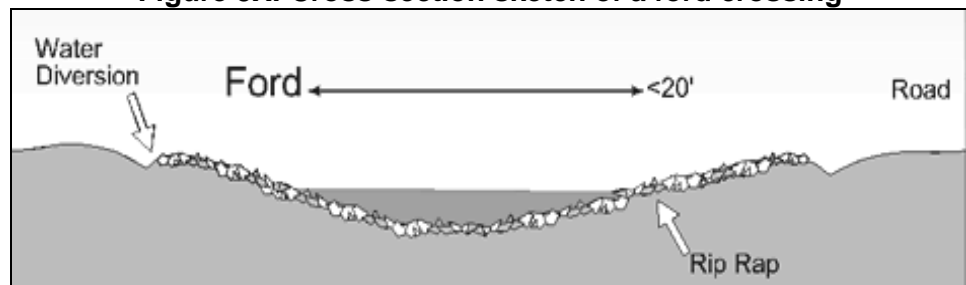
Fords are hardened-surface, low water crossings in which a vehicle drives directly through and across the stream channel. Places where a ford crossing may be appropriate include:

- A stream that has an existing rocky bottom surface.
- Streams that are too wide for bridgemats or multiple culverts.
- Areas prone to beaver activity that could dam-up a culvert crossing.

BMPs for Fords

- Minimize the grade slope of the approachways into the ford crossing. Control runoff and capture sediment along and/or from the approachways.
- When site conditions permit, give preference to crossing at a:
 - Low streambank.
 - Solid and level bottom.
 - Straight section of stream channel.
- If the stream bottom is soft and unstable, consider laying down geotextiles as underlayment for the added rock or hardening material.
- Use clean hardening materials to create a firm vehicle traffic surface. Avoid using asphalt-based materials.
- Spread the material as even as possible across the channel to avoid dips or humps that could alter the streamflow:
 - Leave a low trough within the centerline of the channel so streamflow can continue during low-flow or dry periods.
- Within the first 50 feet of the ford crossing, establish permanent groundcover covering at least 80 percent of the approachway area, or spread stone (or other suitable materials) atop each approachway.
- When driving through the ford, you may need to:
 - Maintain a slow speed to avoid damaging the crossing location.
 - Stagger the tire-tracks through the ford to minimize creation of tire ruts.
- Inspect the crossing to insure safe usage, proper water flow, and water quality protection. Take action as needed to protect water quality.

Figure 5X: Cross-section sketch of a ford crossing



Caption:

Note the BMPs on this ford crossing:

- Gentle grade on the approachways so runoff can be controlled.
- Substantial stone is used to stabilize the road approachway and provide a firm base.
- A shallow trough is left within the centerline of the stream channel to allow continued stream flow during low-flow periods.

FPG

Read and understand the requirements of FPG .0202, FPG .0203, N.C. GS 77-13 and N.C. GS 77-14.

Helpful Hints:

To provide water flow, one possible option is to place one or more culverts on the base of the channel so water can still flow through.

Figure 5Y: A ford crossing in Henderson County, N.C.

**Pole Crossings**

Pole crossing is the name used to describe a temporary channel crossing that is made by stacking logs that are free of limbs and soil within the channel high enough so equipment can travel across.

Pole crossings are usually appropriate for temporary access across ditches or ephemeral drainages.

Pole crossings are not suitable for either an intermittent stream that has water, or for any perennial stream.

BMPs for Pole Crossings

- Establish the pole crossing in a way that:
 - Allows water to flow through the crossing location.
 - Does not contribute to accelerated erosion, runoff or sediment transport.
 - Protects the integrity of the channel's structure.
- Use only topped and de-limbed logs that are free of soil and excess debris.
- Use logs of a large enough diameter so they do not pack too tightly together. Logs of 'pulpwood' size or larger usually work best.
- Do not place soil within or on top of the pole crossing.
- Build up the pole crossing to an elevation higher than the adjacent channel or bank. That way, when the logs settle, the channel is still protected.
- Pack down limbs, slash, or other woody material atop the approachways to the pole crossing to protect the channel structure.

- Immediately remove the pole material after the crossing is no longer needed, or when precipitation is forecast for the watershed area.
- Stabilize the crossing location to prevent accelerated erosion or sediment transport.

Figure 5Z: A pole crossing installed within a dry ditch for temporary log road access in northeastern North Carolina



Caption:

This pole crossing uses adequately sized logs to provide support and are free of soil, limbs, or excessive debris.

Instead of placing soil atop the pole crossing, wooden road pallet/mats are used here to provide a running surface for the log trucks.

Part 4 -- Forest Roads

Roads are necessary for the sustainability of working forests in North Carolina. The ability to utilize renewable forest resources, enjoy the visual beauty of the forest, and provide efficient and effective property access are among the most common needs for forest roads.

However, roads that are poorly planned, constructed or not well maintained are among the most common origins of sediment within nonpoint source pollution from forestry activities.

Because of the high potential for sediment problems from forest roads, there are several state and federal rules or laws requiring that certain practices be implemented, or actions be taken, to protect water quality.

NOTE: A summary and further explanation of the rules or laws are provided in Chapter 2 and Appendix 1. Forest roads in wetlands are discussed in Chapter 6.

FPG

The FPGs are detailed in Chapter 2 and the Appendix

Also Refer To:

The Forestry Leaflets and rules citations for DWR buffer rules are in the Appendix 3.

Both U.S. Army Corps of Engineers' documents are in Appendix 1 and further discussed in Chapter 6.

For Forest Owners:

Good forest roads provide many benefits, including:

- Adding economic value to your property.*
- Making property access more efficient, with no unnecessary roads.*
- Reducing or eliminating the number of stream crossings.*
- Minimizing or preventing potential long-term and significant erosion risks.*
- Providing wildlife corridors and firebreaks.*

Rules Related to Forest Roads

Forest Practices Guidelines Related to Water Quality (FPGs)

North Carolina General Statute 77-13 and General Statute 77-14

DWR riverbasin and watershed 'Riparian Buffer Rules'

These buffer rules for specific river basins and watersheds set forest road limitations within the mandatory buffer zone.

U.S. Army Corps of Engineers 15 mandatory best management practices for forest roads in wetlands as cited within 33 CFR Part 323

Construction of access roads in jurisdictional wetlands for the production of forest products does not require a Corps' permit if these 15 best management practices outlined by the Corps of Engineers are implemented.

U.S. Army Corps of Engineers Information Regarding Compliance with the Federal Clean Water Act Section 404(f)(1) Provisions for the Construction of Forest Roads within Wetlands, in North Carolina

This information should be used when planning for and constructing new forest roads and maintaining existing roads within waters of the U.S. including streams and wetlands subject to regulation under the Clean Water Act.

North Carolina Dredge and Fill Law

This state law requires that permits be secured for discharges of dredged or fill material in certain locations within the 20 Coastal Area Management Act (CAMA) counties. Refer to Chapter 6 for more information on this law.

Forest Road BMPs

The following three sections within this Part 3 provide BMPs for planning roads, constructing roads, and maintaining roads.

- **Planning:** This allows you to establish a road that is best suited for the site conditions and intended usage while minimizing impacts to the forest landscape and water quality.
- **Constructing:** Roads should include BMP tools that are outlined in Part 1 and Part 2 of this chapter, or other suitable methods, so water quality is protected and erosion is controlled.
- **Maintaining:** Roads should be maintained to assure that the variety of BMP tools you use are still functioning, water quality is protected, and your investment in the road retains its value.

BMPs for Planning Roads

- Consider using maps, aerial photos, and your own on-the-ground site examination to help determine where roads should be placed.
- When feasible, plan to construct roads at least one year before usage to allow the roadbed to stabilize and settle prior to use.

- Minimize the number of stream crossings. Avoid crossings when possible.
- Minimize soil disturbance and road placement within ephemeral drainages:
 - If roads are needed within an ephemeral drainage, you should consider using BMPs to control runoff and capture sediment.
- Establish roads along the land contours when conditions allow:
 - In steep terrain, try to establish roads along gentle hill slopes, just below the ridgeline. This allows better runoff control and keeps the road from downcutting into the ridgeline, which creates an erosion channel.
- Try to keep the road atop firm and well-drained soils. Avoid wet-natured soils, loose soils, or highly erodible soils if possible.
- Plan the road to minimize the amount of cut and/or fill needed.
- Look for opportunities to naturally drain runoff from the road, but never directly into streams or other waterbodies. Avoid placing outlets within ephemerals where possible.
 - Often the best solution in steep terrain is to construct an outsloped road with broad-based dips or other suitable BMP tools to control runoff.
- Plan adequate right-of-way widths to provide ample sunlight for drying the road surface.

Did You Know?

Providing sunlight to a road or trail surface is known as '**daylighting**.'

BMPs for Constructing Roads

- Construct roads at the minimal width that meets your safety and traffic needs while protecting water quality and allowing adequate runoff control:
 - Travel surfaces of 10 to 14 feet, with intervals of wider road for passing, are usually suitable for light-duty roads.
 - Travel surfaces from 14 to 20 feet, or slightly more, may be needed for frequently used roads.
- Keep grade slopes to 10 percent or less when conditions allow:
 - For steeper grade slopes, limit road-segment lengths to 200 feet or less when possible. This allows improved runoff control and capture.
- Limit height of side / cut banks to 5 feet or less if possible:
 - For loose soils, the side / cut bank should be sloped at a ratio no steeper than 2:1 where site conditions allow.
 - For tight soils, a steeper side / cut bank may be acceptable, but generally should be no steeper than a ratio of 1/2:1.
 - Roads with side / cut banks steeper than 1:1 or more than 5 feet tall should only be constructed when no other practical alternative exists.
- Minimize soil disturbance and the amount of road at any stream crossings in accordance with **FPG .0201** and **FPG .0203**. Also see Part 5 of this Chapter for BMPs on stream crossings.

Helpful Hints:

To learn how to measure slope ratio, and how it differs from percent (%) slope, refer to Appendix 6.



FPG

FPG

Also Refer To...

Recommendations on using geotextiles and gravel are in Appendix 4 and 5.

Watch Out!

Full bench construction may require side / cut banks steeper than 2:1.

Caption:

This forest road has many BMPs, including:

- *Outsloped road with broad-based dip (under the rear wheels of the vehicle).*
- *Well vegetated road shoulders and graveled road surface.*
- *Silt fence and roadside berm to capture sediment.*

- Establish access entrances to public roads in accordance with **FPG .0204**.
 - Use rock, stone, wooden mats, or other suitable materials for a distance of at least 50 feet from the public road, if soil conditions require.
- Stabilize bare soil areas in accordance with **FPG .0209**. Also see Chapter 11 for suggestions on establishing groundcover.
- In low-lying areas, especially areas prone to flooding, keep the roadbed as close to the original ground level as possible, to minimize potential blockage of natural overland surface water flow:
 - When fill material is needed, provide adequate cross drainage.
- Use insloping, outsloping and/or crowning techniques as appropriate to provide drainage from the road surface and control runoff:
 - This may require the excavation of an inside ditchline to carry runoff.
- Control and capture runoff.
- Stabilize and/or harden the road surface as needed to provide runoff control and vehicle access. Consider using geotextile fabric as underlayment.
- Consider using full-bench construction in sloping terrain where soil is loose and prone to sliding or accelerated erosion:
 - A full bench road is cut entirely into the side / cut bank, with all excavated spoil material hauled away. No spoil is side-cast over the downslope edge, therefore the roadbed sits entirely upon a solid, undisturbed soilbank.

Figure 5AA: A forest road with broad-based dip



Figure 5BB: A forest road and stream crossing

Caption:

Note the BMPs used on this road:

- Gentle sloping grades.
- Turnout (on right) to divert runoff upslope of the stream.
- Solid-surface panel crossing of bridgemats at the stream crossing.
- Graveled road surface.
- Open daylight corridor for rapid surface drying.

NOTE -- Shallow ruts are beginning to appear in the road surface; these may require attention if runoff begins to concentrate and flow within them.



Caption:

While flat terrain roads may seem simple to construct and manage, take note of the BMPs found on this road:

- Open daylight corridor for rapid surface drying.
- Road width only as wide as needed for vehicles.
- Well-vegetated road shoulders that can capture sediment.
- Slightly crowned road surface to promote controlled drainage.
- Stone surfacing on the road to allow better drainage and trafficability.

Figure 5CC: A permanent forest access road in Montgomery Co., N.C.



Figure 5DD: A public road entrance from a forest road

Caption:

This entrance onto a public roadway from a forest road is well stabilized.

It appears that the graveled surface of the forest road is adequately stabilizing the road, and providing a rough surface that 'kicks off' dirt and mud from truck tires, before entering the public road.

NOTE -- Some type of runoff control may be needed near the curve in the forest road, to control runoff before it flows toward the public road.



BMPs for Maintaining Roads

- Rehabilitate and stabilize the road and side / cut banks according to the standards of **FPG .0209**.
- Monitor the condition of the road and its BMPs to see if runoff is being controlled and captured as intended. Take prompt action to protect water quality if BMPs are not properly functioning.
- Clean out built-up silt and sediment as needed from sediment traps, silt fences, bales, check dams, brush barriers or other places where sediment poses a risk to water quality.
- Maintain an open daylight corridor that provides suitable drying for the road surface.
- Maintain a road surface that provides good runoff control, water quality protection, and vehicle access.
- Close access to roads when suitable to minimize unnecessary use.
- If practical, perform road and ditch maintenance during times when heavy precipitation is not expected, so freshly tilled soil is less likely to be exposed to runoff flows.

For Forest Owners:

Limiting access protects the road and its BMPs from damage, and protects your investment.

Consider reconstructing, relocating, or 'retiring' a road section that proves difficult to maintain, or shows signs of repeated heavy erosion.

Part 5 -- Skid Trails

Skid trails are pathways used to transport trees, logs, and other forest products from the woods to a deck, landing or roadside. Skid trails are usually for temporary use. However, if they are not constructed or used correctly, skid trails can have long-lasting impacts on water quality and site conditions.

Rules Related to Skid Trails

Forest Practices Guidelines Related to Water Quality (FPGs)

North Carolina General Statute 77-13 and General Statute 77-14

DWR riverbasin and watershed 'Riparian Buffer Rules'

These 'buffer rules' for specific river basins and watersheds set limitations on skid trails within the mandatory buffer zone.

North Carolina Dredge and Fill Law

This state law requires that permits be secured for discharges of dredged or fill material in certain locations within the 20 Coastal Area Management Act (CAMA) counties. Refer to Chapter 6 for more information on this law.

FPG

Figure 5EE: A skid trail and stream crossing in Durham County, N.C.



Caption:

Note the BMPs on this skid trail and stream crossing:

- Good use of leftover logging debris to mat the skid trail surface.

- Full-width, solid-surface panel stream crossing using bridgemats.

- Skid trail width is kept to a minimum.

- Skid trail curves (background) as it approaches the stream crossing from upslope, creating a 'break in the grade' before the stream.

Figure 5FF: A curving skid trail in western North Carolina

Caption:

Note these BMPs -- Skidding is going uphill, which allows for better control of runoff.

The skid trail curves along the slope contour, rather than simply straight up/down.

Skid trail width is kept to a minimum, despite the long timber turning radius.

NOTE -- While the trail appears to be soft, there are no intensive ruts, gouges or trenches that might funnel runoff.



Helpful Hints:

The BMPs offered in this Part 4 may also be suitable for temporary roads that are needed for forestry use. If a road is likely to become permanent, then it is suggested you use the BMPs provided in Part 3 of this Chapter.

Minimizing the width of skid trails is especially important on thinnings and other partial harvests.

A switchback, or zig-zag pattern, may be useful when laying out skid trails in steep terrain.

BMPs for Skid Trails

- Minimize disturbance to the soil such that surface runoff does not result in sediment transport into waterbodies. Where conditions warrant:
 - Concentrate skidding on as few skid trails as needed.
 - Limit primary skid trails to 10 percent of the total working area.
 - Avoid widespread or random skidding patterns with repeated passes.
 - Minimize placement and use of skid trails in ephemeral drainages. If skid trails must be within or cross an ephemeral drainage, additional BMPs are needed to protect water quality.
 - Create skid trails only as wide as necessary to safely operate your equipment and conduct the forestry operation. Avoid creating two-lane skid trails, which disturb more soil area.
 - Minimize the extent of gouges or trenches upon the ground surface that are created by the skidding of trees or logs.
- On sloping terrain, skid trails should follow along the land contours and should be kept to 25 percent grade or less when practical:
 - If trails must be located on steeper slopes, more BMPs than usual are needed to control and capture runoff to protect water quality.
- Install waterbars, brush barriers, turnouts or use other methods as needed to control and capture runoff.
- When forest management goals and site conditions warrant, frequently pack down leftover logging debris atop primary skid trails to minimize further disturbance to exposed soils:

Did You Know?

This debris is commonly called 'slash' or 'laps.'

- To be most effective, this should be done as the skidding is taking place, not simply after the job is completed. As the equipment operates on the debris, it helps break down the debris with each pass.
- Packing down logging debris is often an effective and affordable BMP to install at the approaches to stream crossings.

Part 6 -- Decks and Landings

Did You Know?

Other names for decks include: landings, ramps, setouts and docks.

Log decks are locations where trees, logs or other forest products are removed from the forest and temporarily placed so they can be loaded onto trucks and transported from the job site. Because of the disturbance to exposed soil and repeated equipment traffic in a concentrated area, decks have the potential to produce significant runoff and erosion. As a result, there are rules that determine certain actions and practices that must be undertaken to protect water quality. These rules are noted below:

Rules Related to Decks and Landings

Forest Practices Guidelines Related to Water Quality (FPGs)

FPG

North Carolina General Statute 77-13 and General Statute 77-14

DWR riverbasin and watershed 'Riparian Buffer Rules'

These 'buffer rules' set limitations on the location of decks and landings.

North Carolina Dredge and Fill Law

This state law requires that permits be secured for discharges of dredged or fill material in certain locations within the 20 Coastal Area Management Act (CAMA) counties. Refer to Chapter 6 for more information on this law.

BMPs for Decks & Landings

FPG

- Minimize the number and size of decks.
- Establish decks at locations where soil disturbance is minimized.
- Site your deck with these factors in mind, as conditions allow:
 - Outside of the SMZ. If a deck must be sited within the SMZ, read and understand the requirements outlined within **FPG .0201**.
 - Outside of ephemeral drainages.
 - On flat terrain or gentle slopes.
 - Upon stable soils.
- Control runoff and/or capture sediment that flows off of the deck site.
- During use of the deck, maintain groundcover materials on exposed bare soil areas that may pose a risk to accelerated erosion.

For Forest Owners:

Deck locations should provide the most efficient access for the site, to minimize the number that are needed.

Consider using the BMPs in this Part 6 for portable in-woods sawmills, wood chippers, and debris processors.

- If decks must be placed in steep terrain:
 - Select side-ridge locations as high on the slope as practical, to provide as much room as possible for controlling runoff and/or capturing sediment before it reaches a waterbody at the bottom of the slope.
 - Use more BMPs than usual to control runoff and capture sediment.

Caption:

This active logging deck has some BMPs worth noting:

- Flat terrain so runoff is easier to control.
- Open sunny area to promote drying of the soil after precipitation.
- Wooden road pallets / mats promote soil stabilization.
- Crushed gravel minimizes soil disturbance and provides good traction for log trucks.

Figure 5GG: Active logging deck

