Chapter 5
Runoff Control and Forestland Access

Chapter 5 Layout:

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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.

Helpful Hints:

Remember the four key elements for controlling runoff:
1 - Prevent It
2 - Slow it down
3 - Spread it out
4 - Capture it

'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.

FPG
Refer to the FPGs in the Appendix

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.

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.

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.

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

Broad-Based Dip

Helpful Hints:

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

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

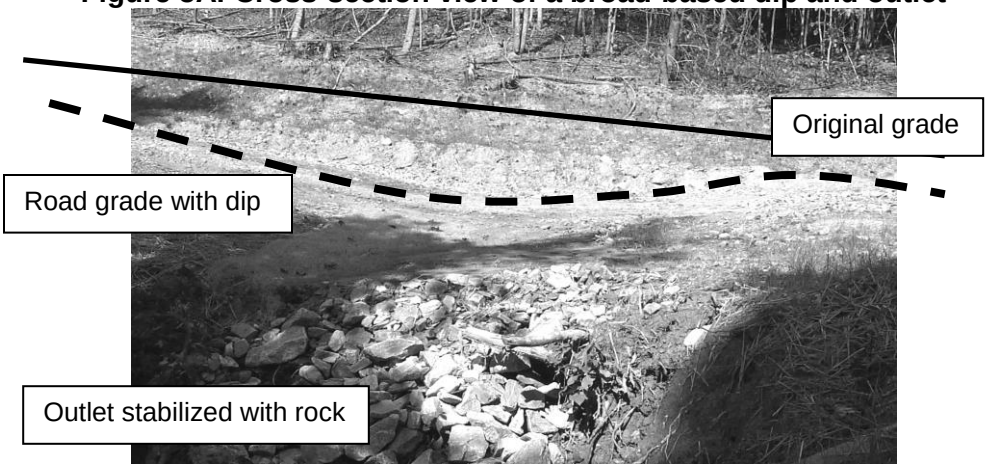
- Lay out and construct the broad-based dip at right angle to the travel surface and across the full width of the road.
- Excavate a shallow dip approximately 15 to 20 feet long into the uphill travel surface.

Helpful Hints:

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

- 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.

Waterbars

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.

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.

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.

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 is 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.

Also Refer To…

Table 5-1 provides spacing ranges for waterbars.

- 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.

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.

- 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.

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

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.

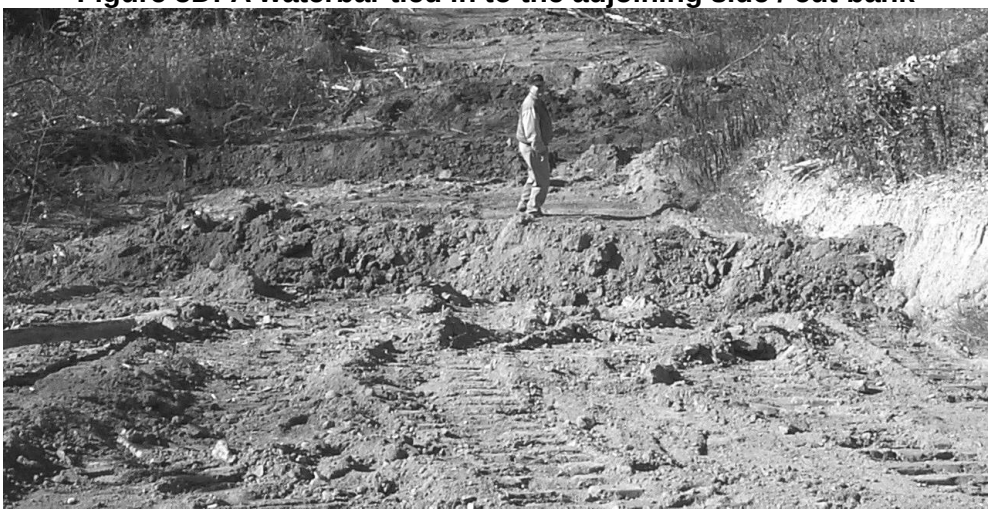
Figure 5C: View of the trench along the uphill face of the waterbar

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.

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



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.'

Turnouts

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.*

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 continous offshoot of the road, skid trail, fireline or roadside ditch. This helps maintain an uninterrupted connection for runoff to flow.

BMPs for Turnouts

Also Refer To…

Table 5-1 provides spacing ranges 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.

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.*

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.

Inside Ditchlines

Did You Know?

Other names for this:
- *Inside ditch*
- *Grader ditch*
- *Shoulder ditch*

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

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.

- 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.

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.

- 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.

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.

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.

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.

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.

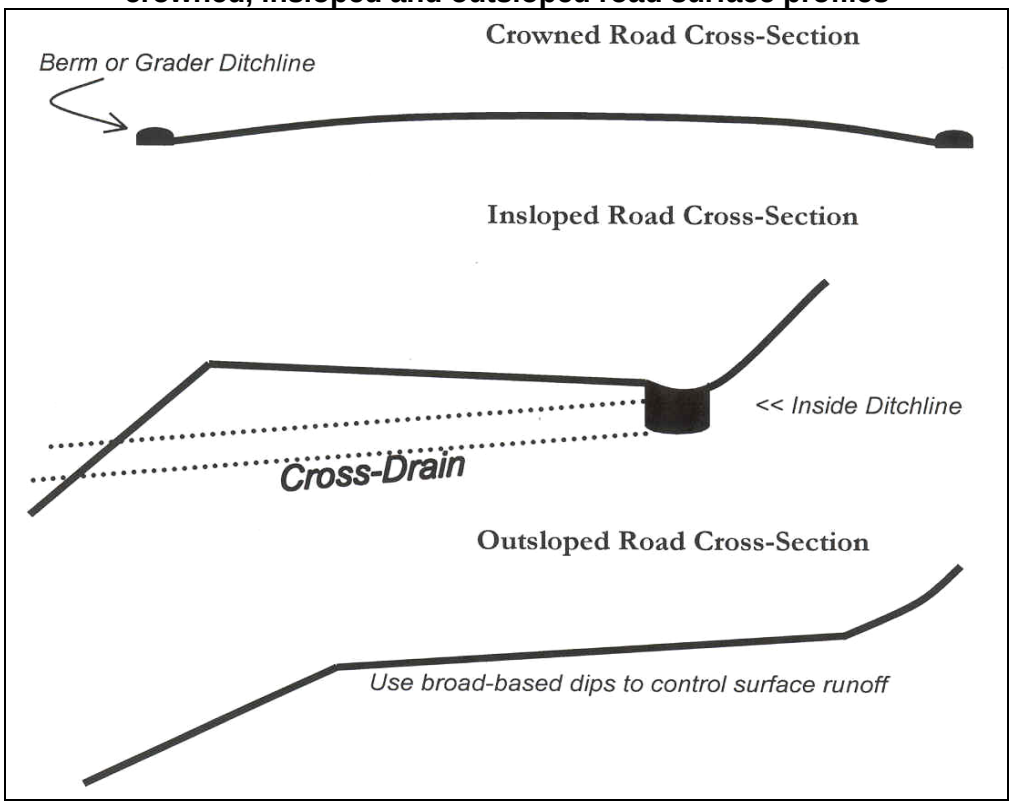
BMPs for Insloping, Outsloping and Crowning

- 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.