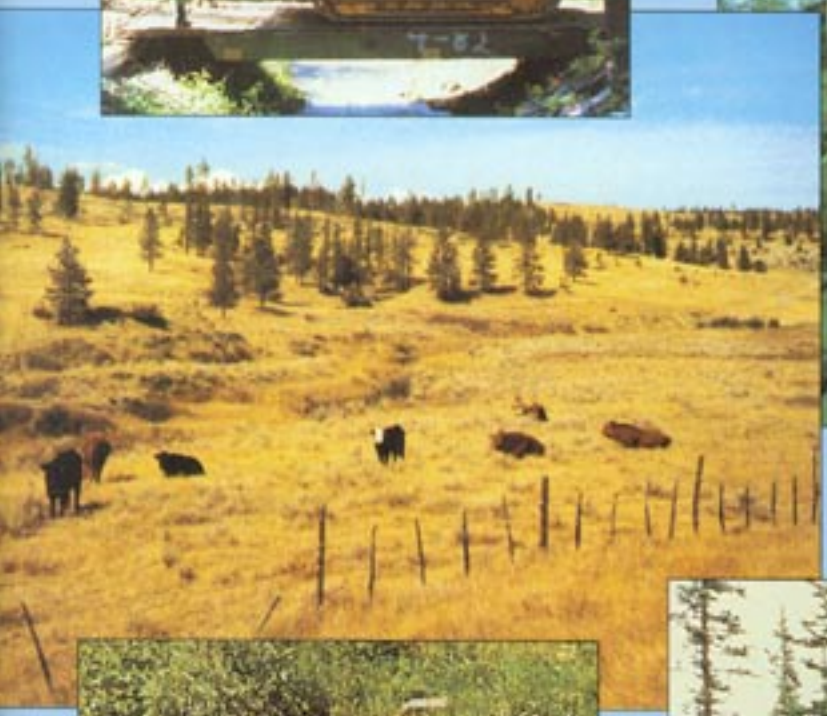
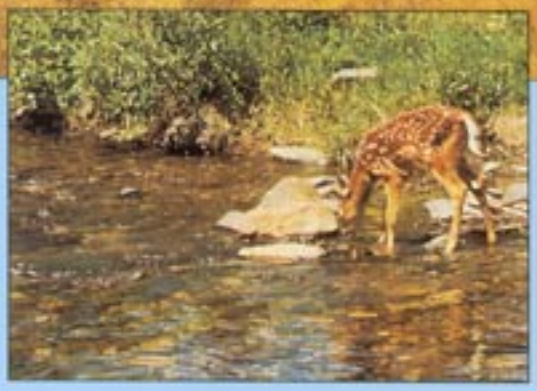
COLORADO FOREST STEWARDSHIP GUIDELINES

TO PROTECT WATER QUALITY





Best Management Practices (BMPs) for Colorado

Developed in partnership by:

Colorado Timber Industry Association

Colorado State Forest Service

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February 1998

Colorado's forest lands supply beauty, clean water, abundant wildlife, minerals, recreation, and renewable resources such as forage and timber which support thousands of jobs. This book is dedicated to the stewardship of those resources – especially clean water. It describes Best Management Practices (BMPs) for the protection of natural resources including water quality.

If you work in the forest, own forest land, or are interested in Colorado's forests, this publication is for you. It contains BMP guidelines and gives reasons for BMPs. An understanding of why to apply these practices along with a good dose of common sense will address most situations you encounter. However, reading these pages is not enough. Maintaining our forests' productivity and benefits can only be achieved by on-the-ground application of BMPs.

How you voluntarily apply BMPs in the forest will require practice and personal judgement. Two notations throughout these pages are intended to help. The "do not" symbol ⊘ indicates practices you should avoid. The black blocks ■ indicate BMPs recommended by the Colorado State Forest Service and the Colorado Timber Industry Association.

Contents

Watersheds

In Colorado, many towns and cities depend on surface water collected from forested watersheds for their domestic public water supply. Throughout Colorado, forest lands act as collectors of clean water. Protecting these sources of clean water is the responsibility of forest landowners, forest managers and timber operators. Best Management Practices (BMPs) are guidelines that should be used to direct forest activities that protect natural resources including water quality.

Areas of land called watersheds (center photo) collect precipitation and funnel it through a network of stream channels. Logging, road construction and other forest activities can disturb vegetation and soil which may cause erosion and release sediment downstream.

Perennial and intermittent streams and ephemeral areas are often found in forested watersheds (note these in photo).

Ephemeral areas drain water to intermittent stream channels, which carry the water to perennial streams, which flow to the watershed outlet. Sediment is fine particles of soil, sand and pebbles carried by moving water and later deposited when the flow slows or stops such as in eddies or where a stream enters a lake or pond. Any sediment created by soil erosion during logging or road building activities can be carried by way of ephemeral, intermittent, and perennial stream channels to the watershed outlet.

Ephemeral areas generally occur above the upper reaches of intermittent streams. Since they can direct water into intermittent stream channels, care should be taken to minimize disturbing soil in these areas.

Roads, skid trails, and landings can act as man made stream channels carrying sediment when improperly planned, located or constructed. If BMPs are not followed, sediment can make its way to the watershed outlet, creating problems downstream.

Wetlands found within a watershed include seeps, springs, wallows, marshes, bogs and riparian woodlands. Some drain into streams, others do not. Even when dry, they can generally be identified by the presence of certain plants. These areas should receive protection when forest activities occur in or around them

EPHEMERAL AREA

Disturbed soils in ephemeral areas can be carried downhill during heavy rainfall or snowmelt.

INTERMITTENT STREAM

Whether wet or dry, intermittent streams generally have gravel or sandy bottoms and identifiable banks. They connect ephemeral areas with perennial streams.

Elk wallows are important water bodies that also need protection.

Across all of Colorado, damage to intermittent beds and banks results in sediment being carried to perennial streams during high flow periods.

Perennial streams are important water sources. They must be kept free of sediment and large woody debris from logging or road construction. Sufficient shade should also be left along streambanks to protect water temperature.

INTERMITTENT STREAM

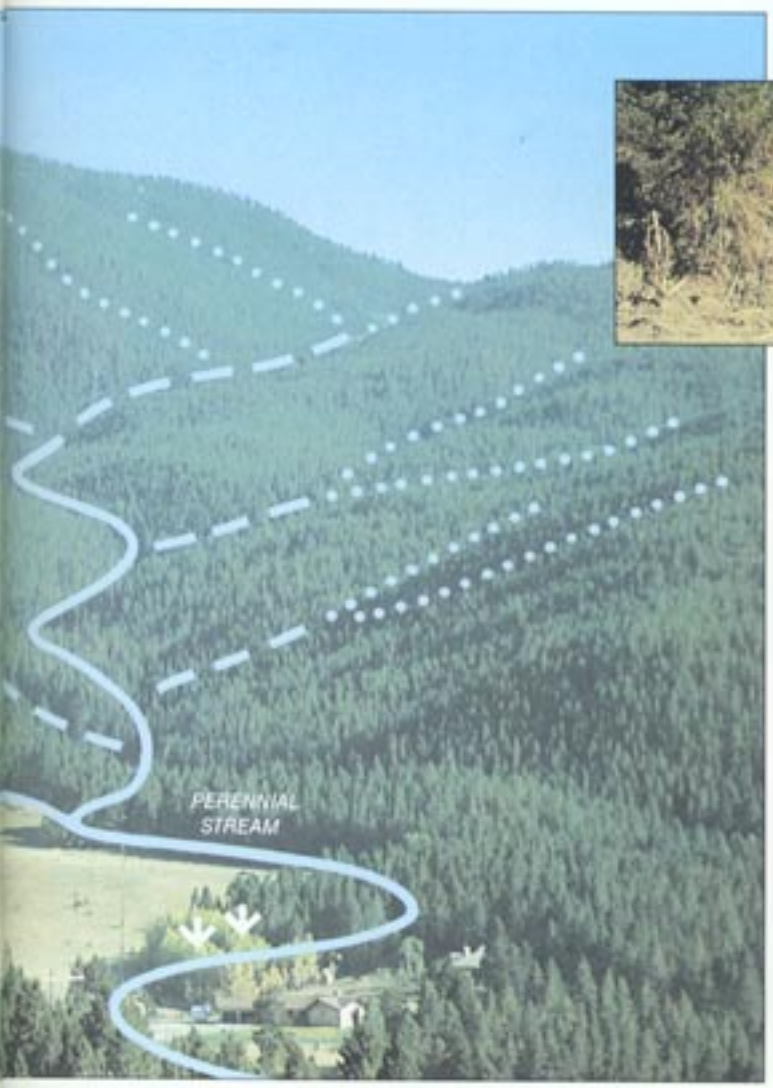
PERENNIAL STREAM

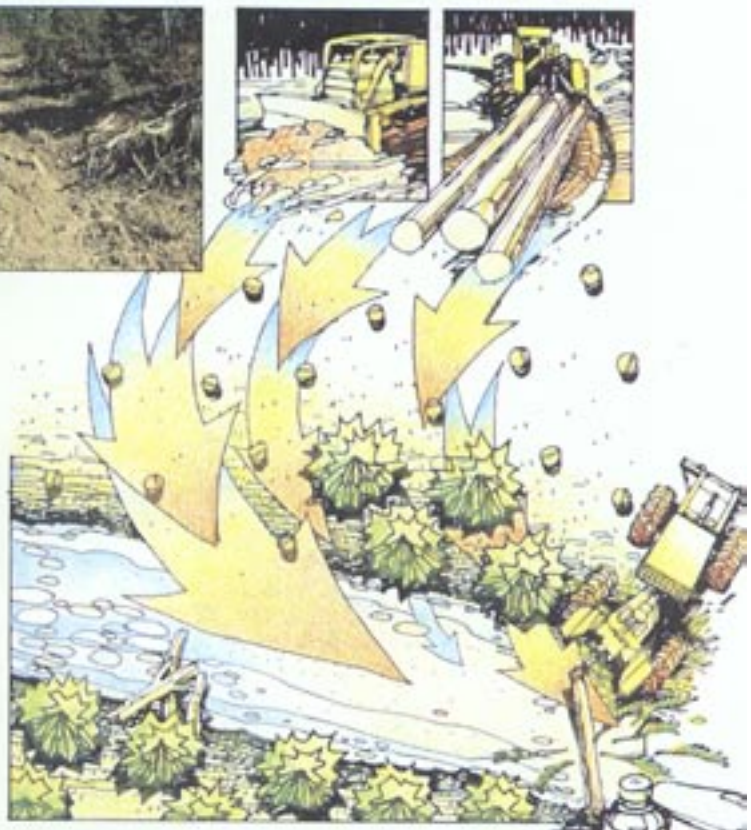
PERENNIAL STREAM

Sediment from ephemeral areas often collects in perennial streams resulting in downstream impacts.

Tree harvesting and other forest management activities such as site preparation and road construction can have minimal impacts to forested watersheds if conducted with careful regard to soil and water resource quality. However, poor logging practices can cause excessive erosion. Excessive disturbance of the vegetation and topsoil on the forest floor destroys its filtering capacity and soil compaction affects surface water infiltration. When surface water is allowed to flow onto roads and trails, they become man-made stream channels. Runoff increases in speed and volume as it flows downstream. Concentrated runoff undermines slopes tearing away the soil, destroying roads, overloading streams with sediment, damaging stream-banks, and destroying aquatic habitat.

Ephemeral areas used as skid roads can contribute to stream sediment. Avoid skidding up or down these areas.





Springs, swamps, seeps, marshes, and bogs all contribute to the watershed collection systems and require protection.

WETLANDS

Ignoring BMPs can result in damaged streams, unhappy downstream neighbors and restoration measures.

Why protect water quality?

Excessive runoff and sedimentation into streams can increase filtering costs for drinking water, interfere with irrigation systems and increase flood potential. Fish eggs laid in stream gravel that are later buried with sediment will suffocate. Removing shade from stream sides can raise water temperatures which affects fish and other aquatic life. Streamside damage also affects stream stability which impacts the wildlife that rely on these habitats.

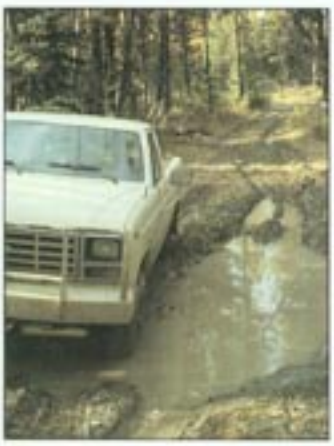
ROADS

Colorado Forest Owners

Riparian areas are important habitat for many types of wildlife by maintaining and enhancing water quality. Design roads around riparian areas and avoid equipment operation in these areas.

In addition to 15.5 million acres of government forestland, there are approximately 5.9 million acres of private forest land in Colorado, owned by more than 100,000 individuals. These landowners are referred to as Non-Industrial Private Forest (NIPF) landowners and are important to Colorado's forest health and productivity. The application of BMPs on NIPF lands is just as important as on other forest ownerships.

NIPF Landowners play a major role in protecting water quality by planning and implementing their forest activities with BMPs.



Unimproved stream crossings (no culvert or bridge) that result in erosion, stream sediment, damage to stream banks, and damage to streambeds are unacceptable.

Plans for permanent stream crossings must include calculations for maximum runoff. When maximum run-off is ignored, flooding and the potential for economic and water quality damage is enormous. Commonly, costs of repair far exceed costs of proper installation.

Timely road grading and restricting road use during wet periods can help insure adequate surface drainage on unimproved road surfaces. Properly designed and spaced waterbars are needed on these roads to divert water from directly entering live streams.

Standards and Use

The need for higher standard roads can sometimes be alleviated through better road-use management and logging system selection.

Forest roads often provide easy access to our favorite recreation areas.

Problems occur when forest roads built to provide access for timber harvesting must also provide for traffic to recreation sites. Such road construction costs may exceed $100,000 per mile.

The alternative to accommodate all these uses is better road use management.

Access control using locked gates is one method of road use management. Seasonal weather conditions may also restrict access.

When access for forest activities requires crossing moist areas with a poor road base, cross only when the ground is frozen. Return during the dry season to do site preparation and slash treatment.

Low-standard roads involve only the clearing of vegetation and minimal construction.

A portable railroad flatcar provides an option for access across streams less than 10 feet wide with minimal disturbance to stream banks or bed.

Along with its portability, this temporary bridge is strong enough for all harvesting activities.

Road restoration includes pulli up roadside berms to prevent channeling water, ripping compacted areas, restoring natural drainage, and reseeding with appropriate grasses.

■ Design roads to the minimum standard necessary to accommodate anticipated use and equipment.

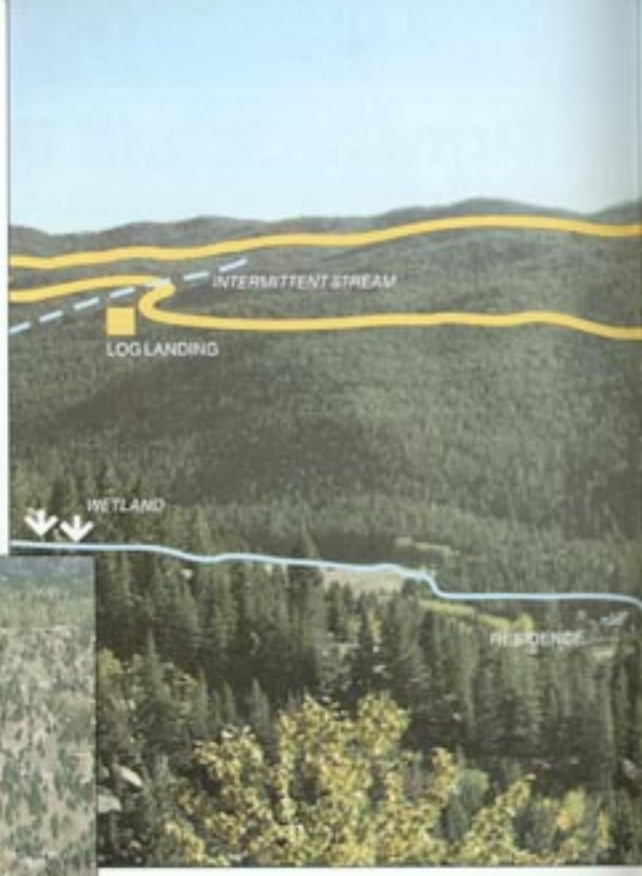
Temporary low-standard roads are designed for short-term minimal use during timber harvesting. They can be constructed, used and reclaimed during seasons when precipitation and erosion potential are minimal.

When stream crossings are needed, portable bridges can be used. These temporary bridges are quick, economical, can be installed with less impact than other alternatives, and can be reused at other locations in the future.

Planning, Design, and Location

- Properly design roads and drainage facilities to prevent potential water quality problems due to road construction.
- Minimize the number of roads constructed in a watershed through comprehensive road planning, recognizing intermingled ownership and foreseeable future uses.
- Using existing roads where practical, unless use of such roads would cause or aggravate an erosion problem.
- Fit the road to the topography by locating roads on natural benches and following contours. Avoid long, steep road grades and narrow canyons where practical.
- Review available information and consult with professionals as necessary to help identify erodible soils, unstable areas, and to locate appropriate road surface materials.
- Locate roads on stable geology, including well-drained soils and rock formations that tend to dip into the slope.
- Attempt to avoid slumps and slide-prone areas characterized by steep slopes, highly weathered bedrock, clay beds, concave slopes, hummocky topography, and rock layers that dip parallel to the slope.
- Avoid wet areas, including moisture-laden or unstable toe slopes, swamps, wet meadows, and natural drainage channels.
- Minimize the number of stream crossings and choose stable stream crossing sites.
- Locate roads to provide access to suitable (relatively flat and well-drained) log landing areas to reduce soil disturbance.
- Locate roads a safe distance from streams when roads are running parallel to stream channels. Provide an adequate streamside management zone (SMZ) to trap sediment and prevent its entry into the stream. (See page 14 for details.)

Attention to these recommendations will reduce road maintenance costs and minimize failures.



Roads produce up to 90% of all sediment from forest activities. That is why forest road planning, design, and location is so critical. Critics of forest roads point to excessive road building, evident on many hillsides.

More cooperation and planning among adjacent forest landowners within a watershed is necessary to reduce sedimentation from roads and to minimize the obvious visual impact.

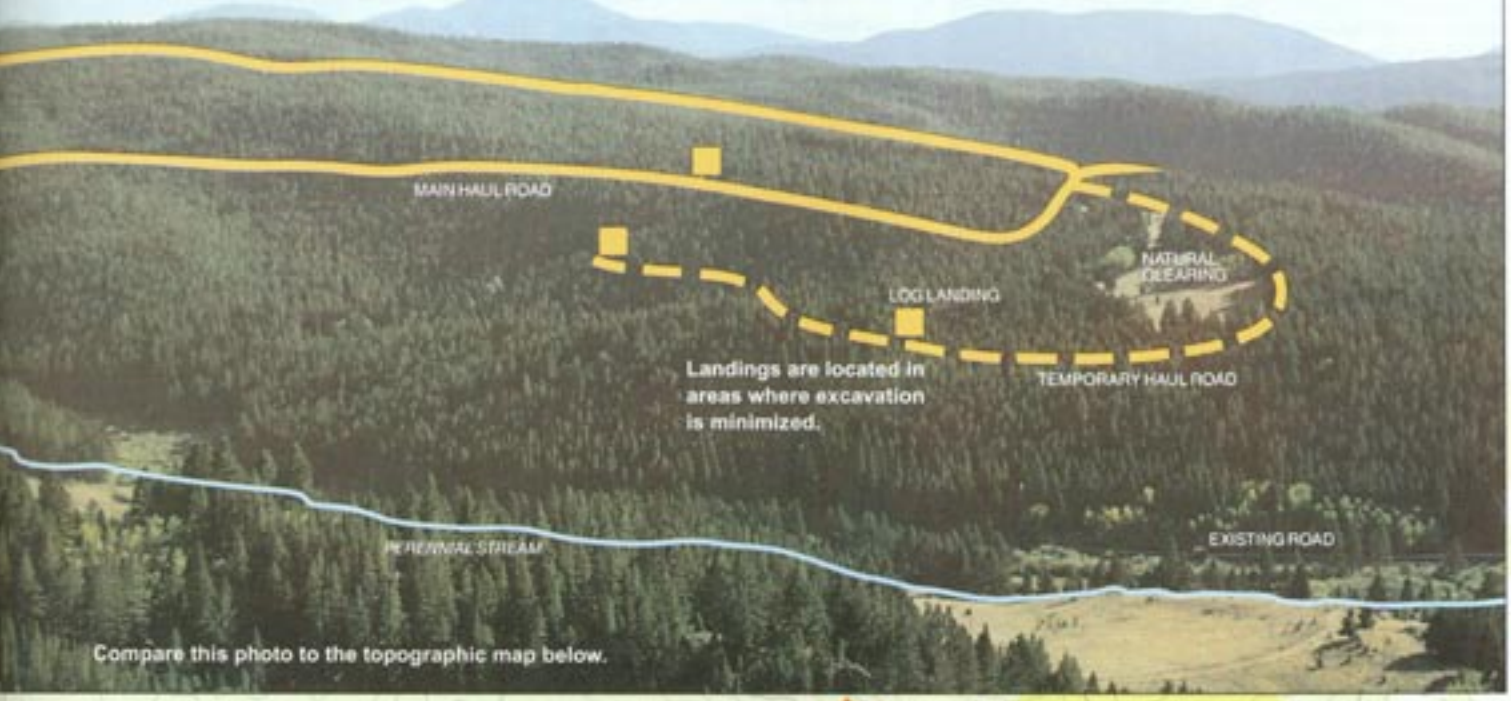
Rock layers that slant with, rather than into, the slope are a clue to potentially unstable bedrock conditions. When planning roads in these locations, get expert advice.

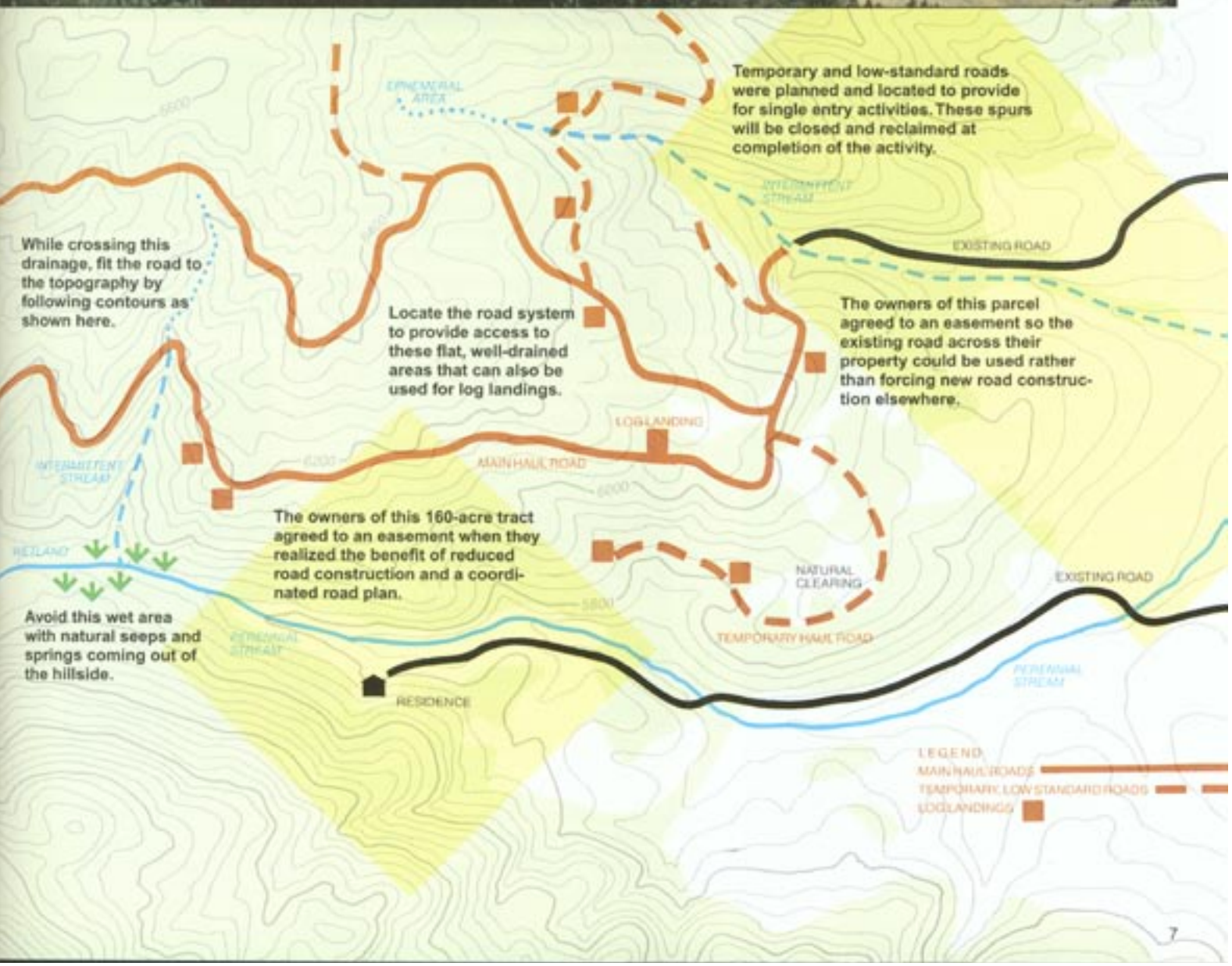
Roads and landing locations, should complement each other so as to provide an efficient transportation system while minimizing logging costs and soil erosion. When roads use natural benches and flat areas, excavation for landings is reduced. Sedimentation from landing construction is also reduced.

Roads located in steep canyons have been common practice for decades. Unfortunately, they require substantial cuts and fills, often increasing erosion potential into the drainage below. Avoid new road construction in such sites whenever possible.

A road system has been designated on the topographic map below for the forested area shown in this photo. The area consists of mixed ownership and has some existing roads.

To comply with BMPs and minimize the number of roads, surrounding landowners should be contacted during road planning. Mutual agreement among all affected landowners could result in the road location indicated on the topographic map and plotted on the photo of the area. On-the-ground problems that influenced road location are indicated.





Road Construction

See also Stream Crossings, pages 30-33.

Once clearing limits and road design features are staked out, road construction begins. Vegetation is removed, piled or buried along the lower side of the right-of-way.

Excavations efficiently dig, swing, and deposit material with accuracy and care. Stumps and other vegetative debris are swept clean from the new road surface.

While pioneering roads, temporary crossings are used to get beyond a stream and continue clearing. Several logs, placed in the stream channel, form a base that water can flow through while protecting stream banks. This is replaced promptly with a permanent crossing (culvert or bridge, page 30).

Forest roads are often built by excavating the road surface out of a hillside. A bulldozer starts at the top of the cut slope, excavating and sidecasting material until the desired road width is obtained.

An experienced bulldozer operator can do many road construction tasks, including drainage features. The inside ditch between the cut slope and road surface, and a catch basin formed just below the culvert inlet, prevents ditch water from bypassing the culvert.

Following up the bulldozer is a grader, providing the final smoothing of the road surface, shaping of ditches and forming drainage features.

Grass seeding of exposed cut and fill surfaces is an important erosion control practice. Proper seed mixtures and timing are important for success. Use seed of know purity, having a high germination rate and that is free of noxious weeds. The local district office of the Colorado State Forest Service, Colorado State University Cooperative Extension Service, Natural Resources Conservation Service or a private forester can assist in recommending an appropriate seed mix for your particular site. Several vendors in Colorado stock native and introduced grass seed.

Seeding stabilizes soil, prevents erosion, and indicates landowner's concern for control of potential erosion.

Control erosion during the construction process:

- When using existing roads, reconstruct only to the extent necessary to provide adequate drainage and safety; avoid disturbing stable road surfaces. Evaluate the integrity of existing roads prior to utilization.
- Minimize earth-moving activities when soils appear excessively wet. Do not disturb roadside vegetation more than necessary to maintain slope stability and to serve traffic needs.
- Keep slope stabilization, erosion, and sediment control work as current as possible with road construction. This includes installing drainage features as part of the construction process.
- Complete or stabilize road sections within the same operating season, insuring that drainage features are fully functional prior to spring runoff and that road sections are not left in an unstable condition over winter.
- If the road is a permanent installation which will experience considerable traffic, consider graveling to minimize erosion and provide a superior running surface.

Stabilize slopes:

- Construct cut and fill slopes at stable angles. A 3:1 slope is the maximum recommended in stable soils. A 1:1 slope may be necessary in sandy soils to avoid slumping.
- Stabilize erodible, exposed soils by seeding, compacting, riprapping, benching, mulching, or other suitable means prior to fall or spring runoff.
- At the toe of potentially erodible fill slopes, particularly near stream channels, pile two feet of slash in a row parallel to the road to trap sediment. When completed concurrently with road construction, this practice can effectively control sediment movement and can provide an economical way of disposing roadway slash. Limit the height, width and length of these "slash filter windrows" so not to impede wildlife movement.
- Avoid incorporating potentially unstable woody debris in the fill portion of the road prism. Where possible, leave existing rooted trees or shrubs at the toe of the fill slope to stabilize the fill.

Cutting back an inside slope into the hillside to improve the angle of repose and removing vegetation crowding the roadway are road reconstruction activities that improve vehicle safety and visibility.

Over time, it is often necessary to add culverts for improved drainage. Anticipating the need for additional culverts can avoid drainage problems.

Deep, wide road fills like this can be stabilized with log terraces or cribbing. After installation, the entire fill is seeded with appropriate grass cover.

Slash filter windrows are very effective at keeping sediment from entering stream channels. They consist of compacted slash installed along the base of the fill slope.

■ Design roads to balance cuts and fills or use full bench construction where stable fill construction is not possible.

Most forest roads are built by excavating a road surface. Road design and layout on-the-ground show machine operators the proper cut slopes and indicate cut slope steepness. The bulldozer starts at the top of the cut slope, excavating and sidecasting material until the desired road grade and width are obtained. Material from cuts is often pushed or "drifted" in front of the blade to areas where fill is needed. Road fill is used to cover culverts and build up low areas. Since fill must support traffic, it needs to be spread and compacted in layers to develop strength.

While cut-and-fill road construction is common for gentle terrain, full-bench roads are nearly always built on slopes over 65%. In full-bench construction, the entire road surface is excavated into the hill. The excavated material is pushed or hauled to an area needing fill or to a disposal area.

During the process of cut-and-fill, it is critical to avoid letting sidecast or waste material enter streams or placing it on unstable areas where it might erode. Keeping roads outside of streamside management zones, where possible, will mitigate this problem.

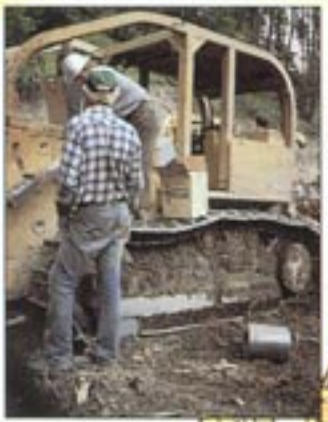
Considerations for borrow pits and overburden disposal:

- Minimize sediment production from borrow pits and gravel sources through proper location, development, and reclamation.
- Place debris, overburden, and other waste materials associated with construction and maintenance activities in a location to avoid entry into streams. Include these waste areas in soil stabilization planning for the road.
- Stockpile topsoil for use in reclaiming borrow pits after construction activities. Avoid excavation into groundwater to decrease possible contamination and decrease operating costs.

Excavators can remove stumps clean and relatively free of soil, minimizing the chance of sediment moving off the construction site.

Be aware of the potential for borrow pits to contaminate surface water. Take precautions to control drainage and escaping sediment.

Surfacing can double the construction cost of a forest road. However, gravel roads provide water quality protection because soil is covered with a more weather resistant surface. Therefore, erosion is reduced and the operating season may be extended.



Machine maintenance in the forest can result in water contamination. Do not allow waste oil and anti-freeze to drain on the soil. Instead dispose of used oils, filters, and parts responsibly – pack it out.

Burning can be used to dispose of root wads, slash and vegetative debris during road construction. To prevent contamination of water, locate burning areas away from water sources.

Drainage from Road Surface

■ Vary road grades to reduce concentrated flow in roadside drainage ditches, culverts, on fill slopes and road surfaces.

■ Provide adequate drainage from the surface of all permanent and temporary roads by using outsloped or crowned roads, drain dips, or insloped roads with cross-drains. Caution must be used in constructing crowned or outsloped road profiles. Excessive crown or outslope may make it impossible to keep trucks on the running surface during icy and other low traction conditions.

■ Space road drainage features so peak runoff on the road surface or in ditches will not exceed the capacity of the individual drainage outlets.

■ **Outsloped Roads:** Outsloped roads provide means of dispersing water in a low-energy flow from the road surface. Outsloped roads are appropriate when fill slopes are stable, drainage will not flow directly into stream channels, and transportation safety considerations can be met.

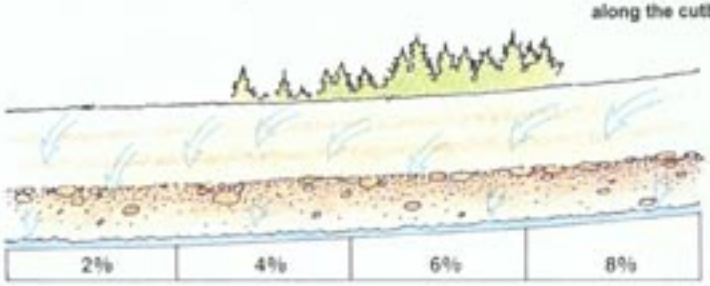
■ **Insloped Roads:** For insloped roads, plan ditch gradients of generally greater than 2%, but no more than 8%, to prevent sediment deposition and ditch erosion. The higher gradients may be suitable for more stable soils but plan for sufficient culverts, drop structures or armor ditches. Use the lower gradients for less stable soils.

Well-designed forest roads with changing road grades, adequate ditches, and crossdrain culverts are important for controlling drainage and protecting water quality.

In contrast, the road drainage problem below is the result of a plugged crossdrain culvert and washed-out catch basin. Periodic cleaning and armoring the catch basin with rock will prevent this.

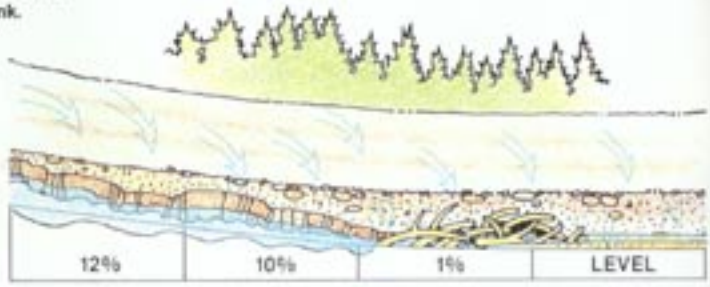
A smooth surface is the key to an effective outsloped road. Smoothing and outsloping (from cutbank to outside edge of roadbed) should be kept current, so water can drain across without creating channels on the road surface.

Insloped roads carry road surface water to a ditch along the cutbank.



Ditch gradients of 2 - 6% are just steep enough to keep collected waters moving to relief culverts without carrying excessive sediments.

An 8% ditch gradient may be too steep for unstable soils.

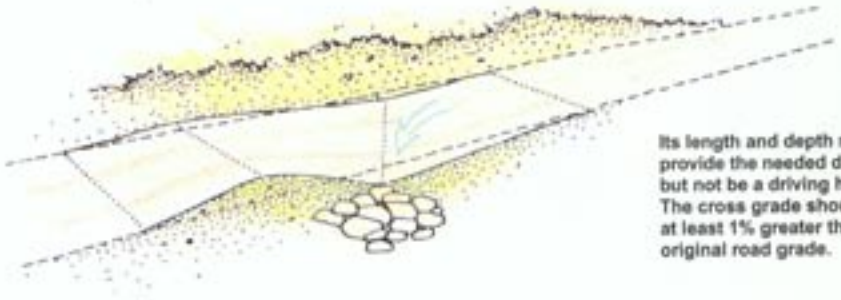


Gradients steeper than 8% give collected waters too much momentum and the ability to carry excessive sediment and debris for great distances.

This erosion leads to filling up the ditch where the gradient is too shallow, clogging culvert inlets and carrying sediments into streams.

■ **Drain Dips:** Properly constructed drain dips can be an economical method of channeling surface flow off the road. Construct drain dips deep enough into the subgrade so that traffic will not obliterate them.

A drain dip is a portion of road sloped to carry water from the inside edge to the outside onto natural ground.

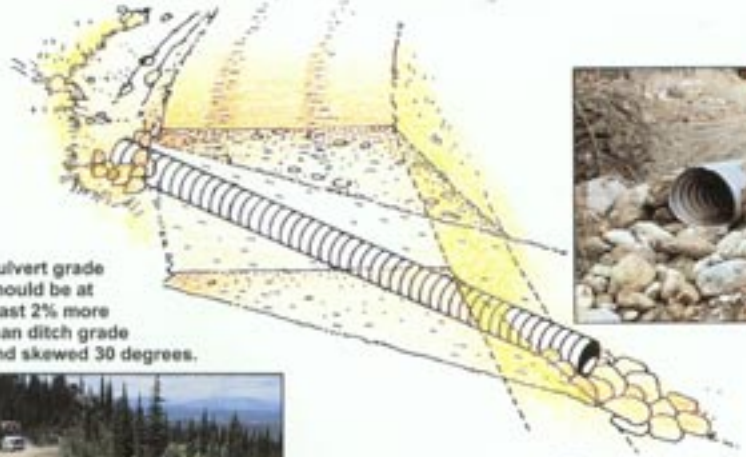


Its length and depth must provide the needed drainage, but not be a driving hazard. The cross grade should be at least 1% greater than the original road grade.

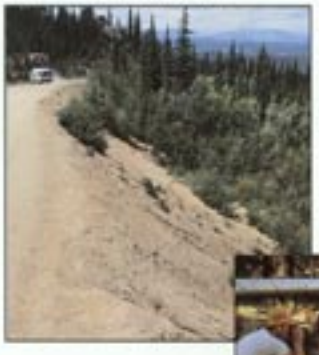
Design roads for minimal disruption of drainage patterns.

- Prevent downslope movement of sediment catch basins, drop inlets, changes in road grade, headwalls, or recessed cut slopes.
- Where possible, install ditch relief culverts at the gradient of the original ground slope; otherwise armor outlets with rock or anchor downspouts to carry water safely across the fill slope.
- Skew ditch relief culverts 20 to 30 degrees toward the inflow from the ditch to improve inlet efficiency. Protect the upstream end of crossdrain culverts from plugging.
- Provide energy dissipaters (rock piles, logs, etc.) where necessary at the downstream end of ditch relief culverts to reduce the erosion energy of the emerging water.
- Crossdrains, culverts water bars, dips, and other drainage structures should not be discharged onto erodible soils or fill slopes without outfall protection.
- Route road drainage through SMZs, filtration fields, or other sediment settling structures which are large enough to accommodate the anticipated volume of water. Install road drainage features above stream crossings to route discharge into filtration zones before entering a stream. Runoff should always be diffused through these filters rather than concentrated so as to avoid creation of new gullies.

Drop inlets (left photo) installed at the head of a ditch relief culvert slow the flow of water, help settle-out sediment, and protect the culvert from plugging. Rock armored inlets (right photo) prevent water from eroding and undercutting the culvert and flowing under the road.



Culvert grade should be at least 2% more than ditch grade and skewed 30 degrees.



Poor road surface drainage caused this fill slope erosion.

To avoid soil erosion reduce the outlet speed of culvert water by running outlet water over a bed of energy dissipaters of rocks or logs.

Ditch relief culverts transfer water from a ditch on the uphill side of a road, under the grade and release it onto a stable area. They prevent water from crossing the road surface and softening the road bed. Install culverts at a 30 degree angle to enhance flow. Insure proper slope of at least five inches in every ten feet (4%).
Seat the culvert on the natural slope. Bedding material should be free of rock or debris that might puncture the pipe or carry water around the culvert. Cover with soil, avoiding puncture from large rocks. Compact soil at least halfway up the side to prevent water from seeping around the culvert. Rule of thumb for covering culverts: minimum of one foot or one-third the culvert diameter, whichever is greater. Be sure outlet end extends beyond any fill and empties onto an apron of rock, gravel, brush, or logs.

One of the most common road drainage problems is allowing ditch drainage to flow directly into a stream. Always route ditch drainage into a filter (SMZ, slash filter windrow, etc.) so sediment can be removed before water reaches the stream.

The ditch in the right photo is a direct route to the stream. Avoid such ditch design.

Maintenance

■ Maintain erosion control features through periodic inspection and maintenance, including cleaning dips and crossdrains, repairing ditches, marking culvert inlets to aid in location, and clearing debris from culverts. It is advisable to keep small water collection points drained with a shovel to dry up potential mud holes and to remove ice dams in drainage ditches during winter operations.

■ Avoid using roads during wet periods if such use would likely permanently damage the road drainage features.

Hand, shovel, and chainsaw work are usually all that culvert maintenance requires. But don't delay! Delay in cleaning a blocked culvert or ditch can result in a damaged road which requires costly reconstruction.

Road grading precautions:

■ Grade road surfaces only as often as necessary to maintain a stable running surface and to retain the original surface drainage.

■ Avoid cutting the toe of cut slopes when grading roads or pulling ditches.

Road surfaces usually have a crown or slope (inslope or outslope). Vehicle traffic and freezing and thawing can damage road surfaces and reduce drainage effectiveness. Grading repairs the drainage by smoothing surface ruts and potholes. However, avoid grading sections of road that don't need it. It creates a source of sediment from the newly disturbed surface. Raise the blade where grading is not needed!

Before grading, it may be necessary to loosen hardened or deep rutted road surfaces. Ripper shanks on a road grader are effective. Road repairs should occur before the wet season. Special attention is needed on steep slopes or curves where greater road surface wear occurs.

Grader damage to inside ditch toe slopes exposes an easily erodible surface and is a source of sediment. Slow, controlled grading is often the solution, and it can also avoid damage to ditches, culverts, and cutbanks.

Road surfaces can be protected with the use of water or chemicals. Significant amount of road surface can be lost as dust. Dust abatement materials serve to decrease rutting. However, they can also be pollutants and caution should be used in their application near streams or drainages.

If grading produces excess sidecast material, feather it out. Never sidecast material into streams. Avoid leaving a berm that channels water down the road.

Preventive maintenance can reduce the need for culvert cleaning. In recently logged areas, floatable debris should be cleaned from drainage ditches that direct water to culverts.

Traffic control on forest roads can be an effective way to reduce road maintenance costs, and provide protection of other forest resources. Traffic control can include: full road closure, temporary or seasonal closure, or road open but restricted to only light use. Any degree of control still requires inspection for maintenance needs.

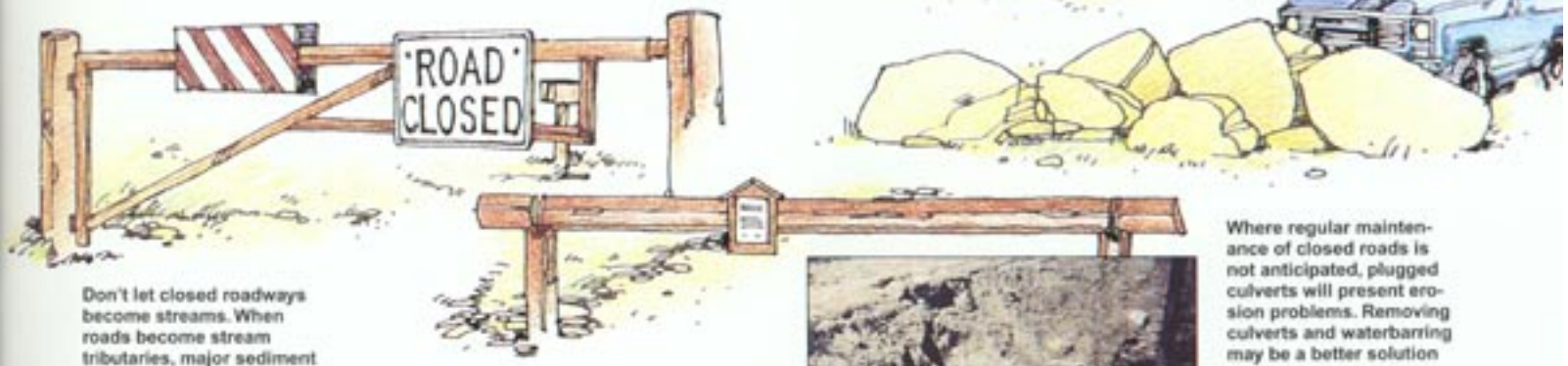
The unauthorized use of traffic-controlled roads continues to be a problem for forest land owners. Damage to road surfaces can occur as easily by a pickup as it can by a log truck. Voluntary traffic control only works if everyone understands the reasons why and agrees to comply.

Road Closures

- Upon completion of seasonal operations, the road surface should be crowned, outsloped, insloped, or water-barred. Remove berms from the outside edge where runoff is channeled.
- Leave abandoned roads in a condition that provides adequate drainage without further maintenance. Close these roads to traffic; scarify if required and reseed. If necessary, recontour and provide waterbars or drain dips.

Complete road closures may appear to be a solution to continued road maintenance, but they also require the most preparation. Remember, water still runs on closed roads. The drainage system of closed roads needs careful thought and attention (see illustrations below).

In many cases, physically blocking the access to roads may be necessary. Gates are used because they can provide temporary closure along with quick access if needed. Alternatives to gates include large berms or trenches, logs, stumps, and boulders. To prevent removal by vandals, gates and other barriers need to be well anchored. For safety reasons, it is advisable to provide good visibility and signage for road closures with adequate space for turn arounds.



Don't let closed roadways become streams. When roads become stream tributaries, major sediment pollution can be the result. Outsloping the surface of closed roads can avoid this problem.

Bridges may present special problems to road closures. Unless plans include regular inspections of abutments for erosion and other potential problems, it may be best to remove all bridge structures.

Where regular maintenance of closed roads is not anticipated, plugged culverts will present erosion problems. Removing culverts and waterbarring may be a better solution to diverting water on abandoned roads. Space waterbars more closely in areas that are more likely to erode (see page 24). When removing culverts, stockpile earth from the removal in a safe place where it can be recovered and won't erode. Reshape banks to a stable slope.

If the decision is to remove bridges and pull all culverts, it is also necessary to restore all drainage features to their natural condition. This includes reseeding the road surface and all cut and fill slopes.

STREAMSIDE MANAGEMENT ZONE

The SMZ is a recommended 50-foot minimum slope distance from a stream, lake, wetland area or other water body that must be protected because of its special importance.

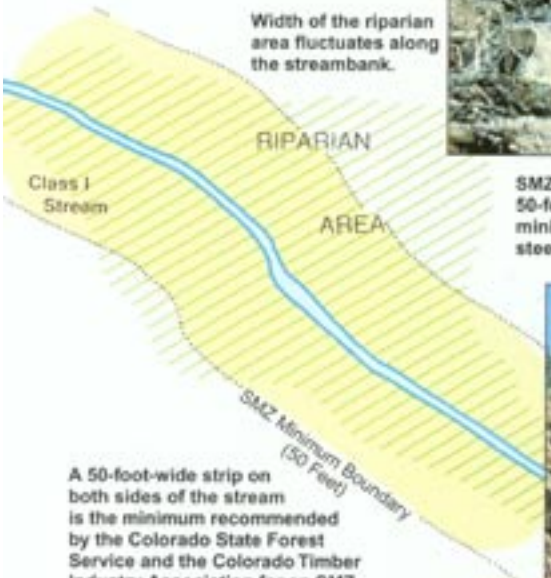
What is an SMZ?

The function of an SMZ is to protect water quality along streams, lakes, and other water bodies by maintaining a natural sediment filter. The riparian area "green zone" around streams, lakes, reservoirs, springs, and seeps represents an area that stays green long into the summer months. Riparian areas usually have wet soils, high water tables, and can be identified by the presence of water-loving plants such as alder, willow, and cottonwoods. Recognizing these areas and knowing where they are in the forest will make protecting water quality with an SMZ much easier.

The 50-foot minimum SMZ often extends beyond the riparian area "green zone." This is important when slopes near streams are steep and soils are unstable, or when the riparian area is narrower than 50 feet. Details concerning identification of a stream, how to mark an SMZ, and when the SMZ should be more than the minimum are covered on page 18.

Riparian vegetation adjacent to this stream provides important shade. This helps maintain stream temperature.

SMZ extends beyond the 50-foot recommended minimum where there are steep slopes or erodible soils.



A 50-foot-wide strip on both sides of the stream is the minimum recommended by the Colorado State Forest Service and the Colorado Timber Industry Association for an SMZ. Even when the riparian area is narrow, the SMZ should be 50 feet.

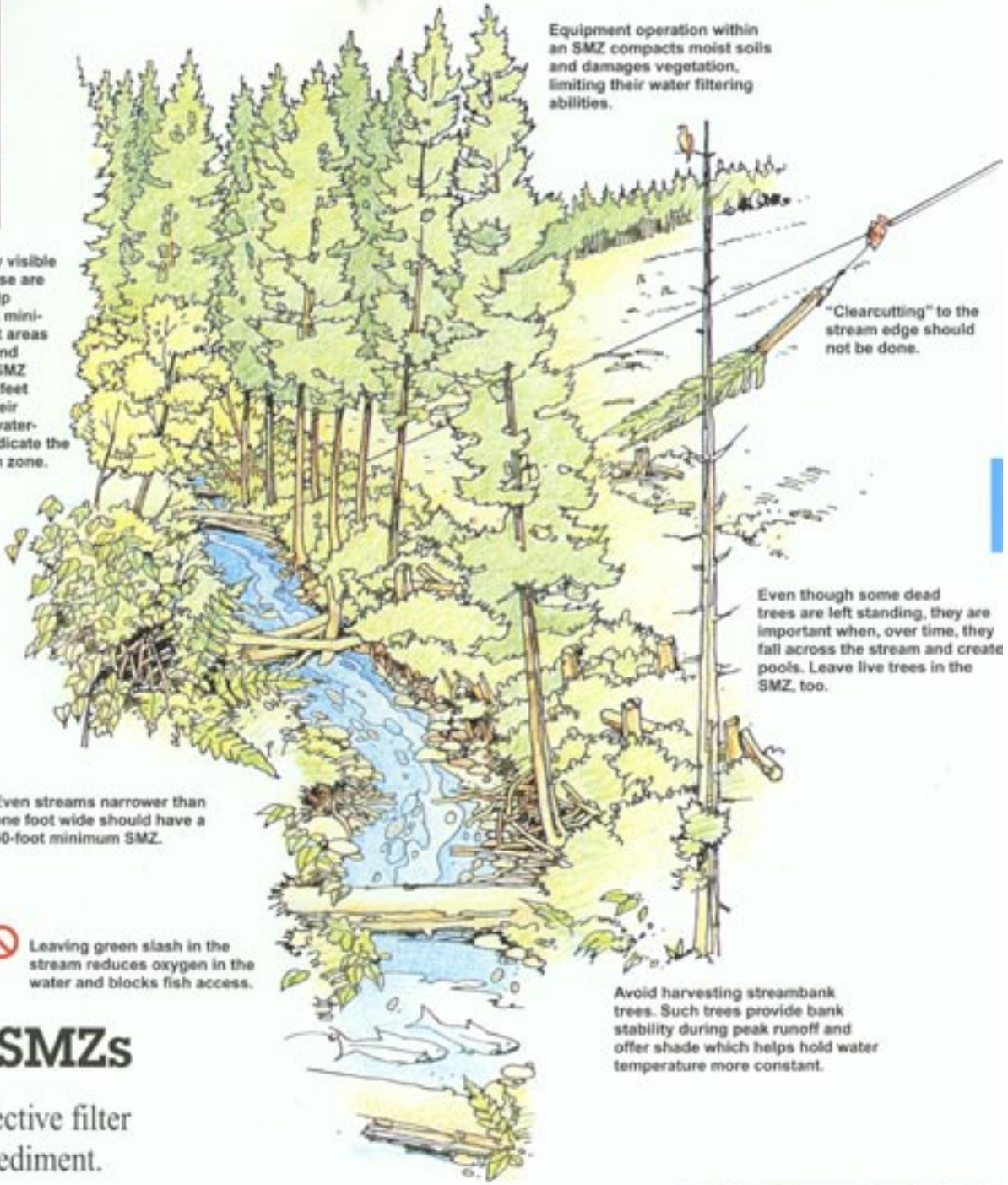
The forest harvesting scene on the next page presents some of the decisions facing loggers and forest landowners. Some decisions were made correctly. Others were not. (See captions.) Proper on-the-ground application of BMPs requires practice, personal, and often, professional judgment.

Legal Requirements

In some cases it is necessary to secure certain permits prior to altering a stream channel or wet area. Compliance with Section 404 of the Clean Water Act is necessary if the activity has the potential to impact any water area considered "waters of the U.S." Only consultation with the appropriate agency will determine the actual need for a 404 permit. The consequences for operation without a permit, if needed, could be significant, including work stoppage and possible monetary fines. The landowner and/or operator should consult with their local U.S. Army Corps of Engineers regarding 404 permit information.

Inadequate SMZ for this stream because the riparian area extends beyond the recommended 50 foot minimum

Photo above - Highly visible markers such as these are recommended to help delineate the 50-foot minimum SMZ. When wet areas next to streams extend beyond 50 feet, the SMZ should reach out 50 feet beyond to protect their integrity. Watch for water-loving plants that indicate the extent of the riparian zone.



Benefits of SMZs

The SMZ acts as an effective filter and retention zone for sediment.

1. The SMZ, with its thick plant growth creates a mat of decomposing material on top of the soil. It is often damp because the water table is at or near the soil surface. The topsoil, covered with organic material, aids in conserving moisture. The sponge-like qualities of the SMZ control the quantity of water flowing into the streams. Soils in this area absorb water during the wet seasons and slowly release moisture into the stream. This minimizes the effects of peak runoff and keeps streams from drying out sooner than usual.

2. The SMZ provides filtering of surface runoff. SMZs act as a trap, blocking sediment and other debris from entering the stream, lake, or reservoir. It catches and holds sediment in the mat of plants and duff. When this last line of defense isn't working, sediment ends up in the stream, causing water quality problems, loss of habitat and potential flooding.

Since logging activity occurs in many of Colorado's watersheds, it is important that water quality is protected by a healthy SMZ. Healthy SMZs control the amount and quality of water coming from a watershed. We all depend on sediment-free water for household use, irrigation, and healthy fisheries.

This thick, spongy SMZ carpet is the last line of defense, protecting stream water.

STREAMSIDE MANAGEMENT

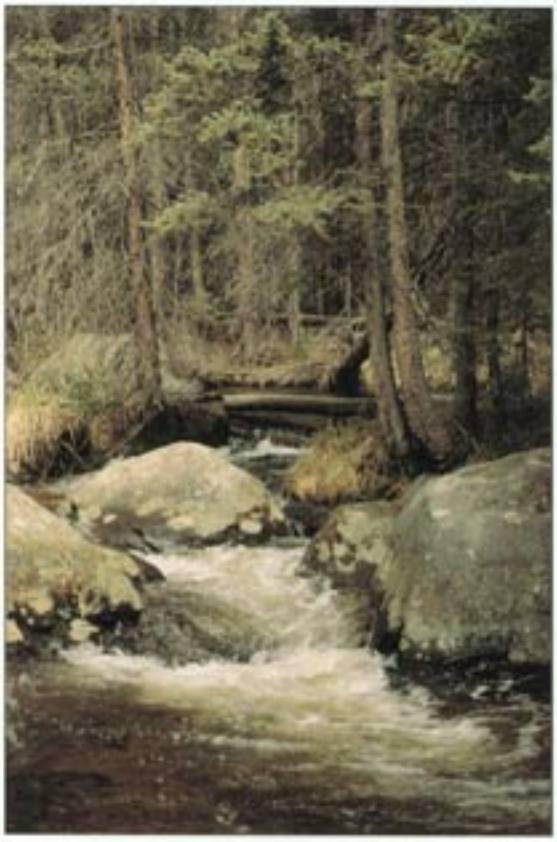
The SMZ maintains shade; conserves aquatic and terrestrial riparian habitats; protects the stream channel and banks; and promotes flood plain stability.

An adequate SMZ protects the absorptive and filtering action of the riparian area. The absorbent mat of forest humus, litter, and duff helps to trap sediment before it reaches the stream, ensuring good water quality.

What's wrong with sediment in the streams?

Trout and other fish reproduce by burying their eggs in stream-bottom gravel. The eggs develop in the gravel and hatch into "sac fry." When the yolk is absorbed, the young fish emerge from the gravel.

Sac fry and young fish can be choked by sediment. When too much sediment falls to the stream bottom it fills the gaps between the gravel and suffocates the eggs and fish. The stream bed becomes cemented over. This tomb of sediment traps the young fish without clean water, oxygen, or food. For those fish that survive, the sediment has an abrasive effect on their sensitive gill tissue.



Sediment also kills aquatic insects and algae, fills in resting pools, interferes with recreation, reduces light penetration, and increases thermal energy absorption.

Sport fishing is enjoyed by thousands of Coloradans, and generates substantial revenues for the state. Fish losses due to timber harvesting activities can be minimized with healthy SMZs.

Other SMZ Benefits:

SMZ's and stream shade.

Maintaining water temperatures helps fish spawning. Without trees and overhanging shrubs, stream temperatures would be higher in the summer and colder in the winter. Some fish species and aquatic organisms would then be unable to live in the streams. In the summer, cold water from shaded streams eventually flows into larger rivers and helps maintain their fish and aquatic life by keeping these waters cool all the way downstream.

SMZs and food.

Leaves and insects drop into streams from overhanging trees and shrubs. In fact, 90% of the food in forested streams comes from bordering vegetation. Even in large rivers, over 50% of the food consumed by fish is from streamside trees and other vegetation.

SMZs protect streambanks.

Many streambanks are stabilized by shrubs and trees. They anchor banks and prevent erosion during periods of high water. Removing trees and shrubs and substituting shallow-rooted grasses can lead to streambank collapse and stream sedimentation.

Bank tree roots also supply important cover for fish.

Bank overhang is created by stream flows undercutting the stream bank and tree roots. Fish can rest, hide from predators, and feed in these naturally occurring protected areas.

SMZs and humans.

We like SMZs too for a lot of reasons. The recreational activities that we enjoy in and around streams are many. The financial value of healthy SMZs to the people of Colorado is sizeable. All of us should be careful when we are in and around them.

Hundreds of animals and birds rely on SMZs.

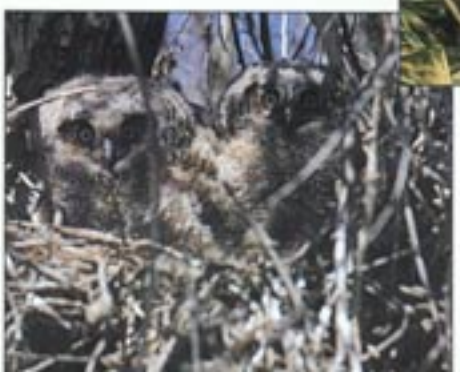
In the Rockies, 59% of the land birds use SMZs for breeding. Of those birds, 39% can breed only in SMZs. Others hunt in healthy SMZs where food and cover are abundant. The reason is that SMZs supply a great variety of plants needed by birds and other wildlife. Grasses, shrubs, vines and trees, all grow well in the moist fertile soil. Turtles, beaver, muskrats and water snakes thrive in SMZs. Deer, wood duck, and bear feed and seek cover in the thick vegetation. Eagles, owls, and songbirds occupy the trees. Pools supply breeding sites for frogs, toads and insects. SMZs are also well-traveled wildlife corridors connecting one area with another.

SMZs and timber production.

For those who grow and harvest trees, the fact is that trees often grow best in riparian areas. Trees respond to those deep, fertile and moist soils. SMZs are not timber harvest "keep out" zones. But they are locations where timber harvesting activities must be modified to protect the many benefits mentioned above.

SMZs and floods.

Healthy SMZs stabilize floodplains. During times of high water, SMZs reduce the velocity of floodgates. Their dense vegetation and deep humus slow down racing waters. Forest flood plains suffer less damage when SMZs are protected during logging activities.



SMZ Boundaries

- Designate streamside management zones to provide stream shading, soil stabilization, sediment and water filtering effects, and wildlife habitat.
- "Stream" means a natural water course of perceptible extent with defined beds or banks which confine and conduct continuously or intermittently flowing water.
- Defined beds have a sandy or rocky bottom which results from the scouring action of water flow.
- The SMZ encompasses a strip at least 50 feet wide on each side of a stream, measured from the ordinary (yearly average) high-water mark or definable bank.
- The width of the SMZ extends beyond the 50 foot suggested minimum to include riparian areas along the stream bottom and to provide additional protection in areas of steep slopes or erodible soils.
- Consult with forestry professionals, soil and water conservation specialists, or biologists if assistance is needed in setting appropriate SMZ boundaries.

Setting SMZ Boundaries

To be sure equipment operators have no question about the SMZ boundary, it should be clearly marked. Plastic flagging, degradable paint, or signs should be used at frequent intervals. A walk through may also be appropriate before operations commence.

The purpose of marking an SMZ is to be sure everyone working around a stream, lake or other body of water knows the extent of the protected area.

Perennial streams are easy to identify. Intermittent streams can be more difficult to identify during dry periods. Whether wet or dry, perennial or intermittent, during drought or wet years, streams should be protected with an SMZ.

One reason for a wider SMZ is when a riparian area lies adjacent to a stream. Individuals must be aware of wetlands by watching for water loving plants. In these cases, the SMZ should loop out to include any wetlands and provide protection. Proper SMZ location requires practice and personal judgement.

What is a riparian area?

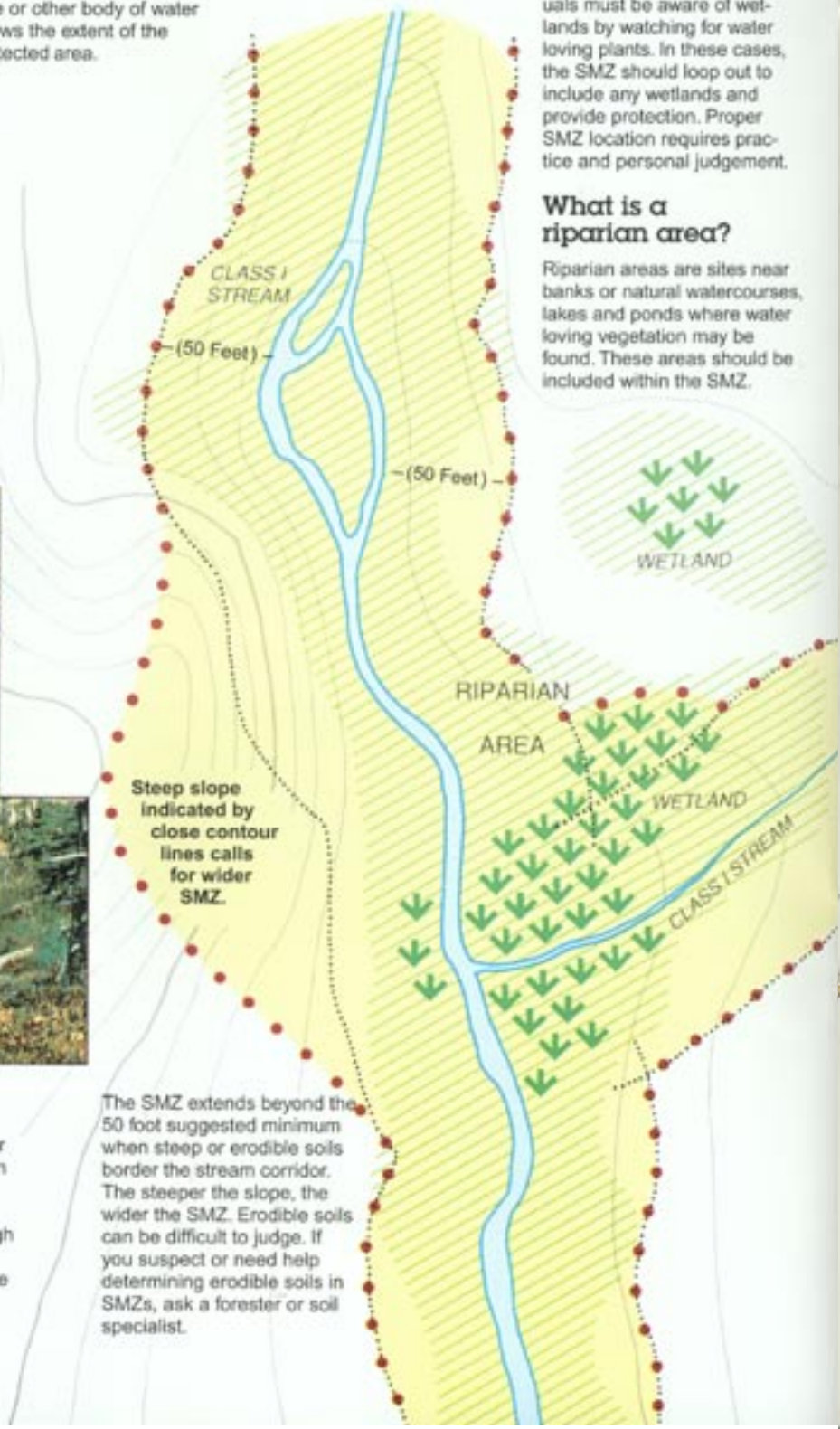
Riparian areas are sites near banks or natural watercourses, lakes and ponds where water loving vegetation may be found. These areas should be included within the SMZ.

What is a stream?

A stream can be identified in one of two ways. A stream must have a sandy or gravel bottom, which is the result of flowing water. Or a stream must have definite banks that restrict water.

Is this a stream?

No. There is no rocky bottom or identifiable banks. But this is an ephemeral area, part of the watershed collection system, that may carry water during high flows. Disturbed soils in these areas can create sediment (see page 2). Care should be taken when logging.



The SMZ extends beyond the 50 foot suggested minimum when steep or erodible soils border the stream corridor. The steeper the slope, the wider the SMZ. Erodible soils can be difficult to judge. If you suspect or need help determining erodible soils in SMZs, ask a forester or soil specialist.

Harvest Activities

Consider the following practices when harvesting timber in the Streamside Management Zone.

The SMZ is not a "keep out" zone. But because of its values, timber harvesting in the SMZ should be done with special care.

Trees are important to a healthy SMZ.

■ Leave the following adjacent to streams: hardwoods, unmerchantable conifers and shrubs. Merchantable trees must also be left where there is insufficient other vegetation to adequately stabilize stream banks.

Protect SMZs

■ Maintain or provide sufficient ground cover to trap sediment.

SMZ vegetation works as a filter to keep sediment from reaching the stream. If disturbed during harvesting, it cannot do the job. Skidder and tractor operators should stay out of SMZs.

Harvesting in the SMZ

■ Use directional falling for harvest operations in the SMZ or wetlands. Avoid falling trees in streams or water bodies. Limb or top trees above the high-water mark.

Especially important are streambank trees and shrubs. They anchor the bank, shade the stream, provide food, supply cover for fish and habitat for birds and other wildlife.

Leave snags, and unmerchantable trees in SMZs. They are habitat for many birds and animals.

■ Suspend the lead end of the log during skidding whenever possible, and use cables to end the line logs out of SMZs and wetlands when ground skidding systems are employed. Logs should be fully suspended when skyline skidding across a stream and immediately above streambanks.

■ Whole-tree or tree-length yarding can reduce the need for slash disposal in the SMZ.

Directional falling and/or mechanical feller-bunchers allow removal of some SMZ trees without damaging the SMZ.

Site preparation near SMZs

■ Steep slopes containing material that could roll down-slope and fall into a stream during controlled burning should receive special attention.

■ Protect the SMZ with a slash free strip along the border.

■ High stumps along the SMZ border keep debris from rolling down steep slopes and reaching the stream.

Keep slash out of water bodies by removing limbs and tops well above the stream high-water mark. Rotting slash uses up oxygen, robbing it from fish and other aquatic animals.

Eventually, bank trees fall across the stream, helping to create a stair-step of pools in the stream channel, providing an essential fish habitat component. The larger the bank trees, the better.

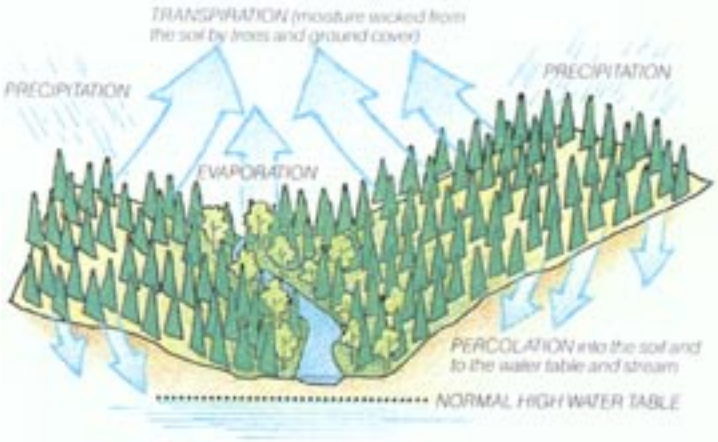
■ Retain trees necessary for bank stabilization and as a future source of large woody debris to the stream channel and habitat for cavity nesting birds and other snag inhabitants.

Conifer Regeneration

■ Recognize that in some soil and drainage types, clearcutting can cause marked increases in the water table, cold-air ponding and grass/shrub competition. All of these factors can inhibit conifer regeneration.

■ To avoid potential regeneration problems, leave some mature trees.

Trees act as a buffer. Except for times of extreme precipitation and runoff, trees help maintain the normal water table along streams. They are like wicks, pumping water from the soil and releasing it onto the air through leaves and needles (transpiration). Of course some soil moisture seeps (percolates) underground, slowly reaching the stream channel.



Below is the same drainage after hillside trees are harvested. The "wicks" have been removed, transpiration is reduced and percolation is increased, at least until vegetation recovers.

To avoid the following consequences, always leave some mature trees in the SMZ.

1. **Removing trees can lead to cold-air ponding. This extends winter's cold temperatures into early spring and hinders conifer regeneration in the SMZ.**
2. **Removing trees can raise the streamside water table which may create soil moisture conditions adverse to conifer regeneration.**

WILDFIRE

Firelines And Roads

■ Stabilize all areas that have significantly increased erosion potential or drainage patterns altered by suppression activities.

■ Treatments for damage include but are not limited to:

A. Installing waterbars and other drainage diversions in fire roads, fire lines and other clear areas.

B. Seeding, planting and fertilization to provide vegetative cover.

C. Spreading slash or mulch to protect bare soil.

D. Repairing damaged road-drainage facilities.

E. Clearing stream channels of debris deposited by excessively burned soils.

F. Scarification may be necessary to encourage percolation on excessively burned soils.

Fire Camps

■ Protect surface and sub-surface water resources from nutrients, bacteria and chemical associated with solid waste and sewage disposal.

■ Fire camps, spike camps and logging camps may cause adverse effects if care is not taken to properly design and locate sewage facilities and wastewater disposal facilities.

■ Garbage and other solid waste is also a concern and these materials should be disposed of at a properly designated, operated and permitted landfill.

Reclamation

■ Minimize soil and site productivity loss, threats to life and property and deterioration of water quality both on and off site by:

A. Seedling grasses or other vegetation to provide a protective cover as soon as possible.

B. Fertilizing

C. Fencing to protect new vegetation

D. Clearing debris from stream channels

E. Constructing channel-stabilization structures and debris-retention structures.

TIMBER HARVESTING

Harvest Design

■ Use the logging system that best fits the topography, soil type, and season, while minimizing soil disturbance and economically accomplishing silvicultural objectives.

Analyze the effects of harvesting on the watershed.

Protect wildlife habitat.

Plan for a new forest.

Timber harvest planning is more than deciding how to cut trees. The harvest design must consider the long-term effects of harvesting on increasingly important resources.

Watershed analysis.

What are the effects of this harvest when combined with other activities in the same watershed? Will there be a combined detrimental effect on water yield and sediment? Work with neighboring landowners to maximize everyone's opportunities while protecting the watershed.

What are the potential effects of the harvest on water quality?

Soil erosion hazard: Some soils are more prone to erosion or slumping. Help is available to identify erosion and slumping hazards.

Rainfall: its seasonal pattern and total amount.

Topography: Where are slopes, drainages, streams, and other physical features located? Are there critical areas that will require special attention?

Wildlife habitat protection.

How will the harvest affect wildlife habitat? Eliminating elk habitat, for example, may displace elk use of the area.

Plan for a new forest.

Are there other plants, in addition to trees, that indicate special precautions about the harvest area? What kind of forest will be grown after the harvest and how quickly will the site be reforested?

Trees left for future harvest must be of sufficient vigor and acceptable species to ensure continuous growing and harvesting. They must also be protected from damage, to enhance their survival and growth.

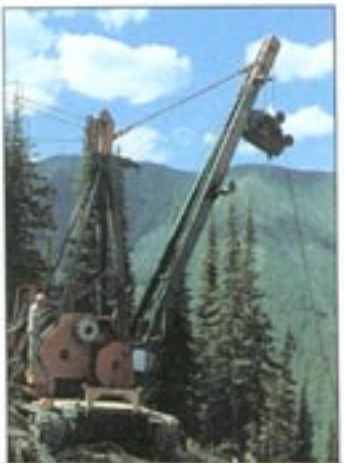
Characteristics of the harvest site — in particular, terrain — influence the choice of a logging system. On gentle terrain, tractors and skidders, or even horses, are a logical choice. In Colorado forests, ground based skidding equipment is common.

Left: Whatever the harvest system — skidders or skyline — skilled operators are crucial.

Below: Feller-bunchers are mechanical harvesters that move through the forest and harvest trees and pile them in bunches. They can reach into sensitive areas and thin individual trees with minimal damage to remaining trees, water, soil, or wildlife habitat.

Above: Slide-boom delimbers begin the manufacturing process right in the forest. They quickly snip off the branches and cut the stem into exact lengths.

Skyline and cable harvesting (below) are used on steep slopes where ground-based equipment cannot operate. These machines are capable of reaching out a quarter mile, lifting logs off the ground and moving them to a landing where they are hauled away.



Whatever the chosen harvest system, it must protect the long-term resource values of the forest.

■ Use the economically feasible yarding system that will minimize road densities.

■ Consider the potential for erosion and possible alternative yarding systems prior to planning tractor skidding on steep or unstable slopes.

The topographic map (above) indicates steep terrain. A skyline harvest system is a good choice. This system eliminates the need for skid trails because the logs are moved to the landing by an aerial cable (skyline). By suspending logs in the air, skyline systems reduce soil disturbance. This harvest system is more expensive than ground skidding, but is used where long, steep slopes are common. When harvesting is completed, skyline harvest areas are easily recognized by the skyline corridors. Once the timber is removed the area can be regenerated and a new forest is free to grow.

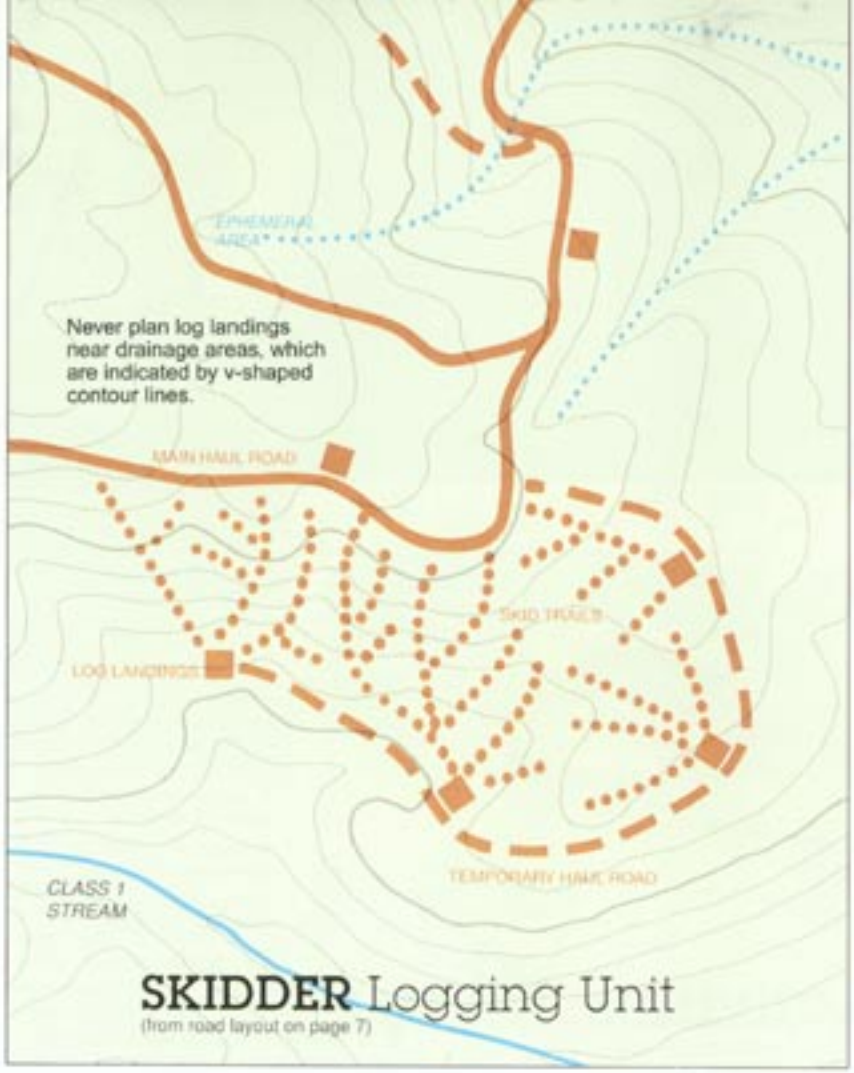
The forest land pictured in the topographic maps above is the same land pictured on page 7. Here, it is used to illustrate timber harvesting BMPs. Looking back at the map on page 7, you can see the steep canyon pictured above and in the mountain top bench shown on the topographic map on the next page. The contour lines indicate the contrast between the two locations. Terrain differences like this call for harvest techniques that consider the potential for erosion and its impact on water quality.

A small skyline harvesting system is planned for the steep canyon above. A perennial stream runs down the canyon and drains into a wetland at the toe of the slope. The skyline will operate from the road, using an overhead cable to reach down the hillside and pull suspended logs up to the road (dotted lines indicate the planned cable settings). Log landings are planned along the road. These small landings reduce the need for extensive excavation to carve out flat areas to pile logs. Notice that the harvest plan shows the boundary of the SMZ along the perennial stream, and includes the wetland at the toe of the hillside. The small skyline makes it possible to harvest timber in the SMZ without disturbing the soil. Individual trees can be removed from the SMZ without the risk of damage to water quality.

When the terrain is more gentle, like that shown in the topographic map on the next page, other harvesting options are available. The harvest plan for this mountain bench calls for ground-based skidding equipment, pictured in the far right photo. The slope is less than 30% and well suited to skidding equipment. A temporary access road (dashed line) is planned to come off the main haul road. It skirts around the outer edge of the bench and allows downhill skidding to the marked log landings along the road.

Designated skid trails are planned for this unit (dotted lines on the map). Pre-planned skid trails limit soil disturbance and potential soil compaction. They should also be designated to avoid natural drainage areas. Skidding equipment is limited to these designated trails rather than "go-anywhere" trails (see diagram, page 23). Try to confine the area covered by skid trails and landings to less than 15% of the total unit.

Regardless of the harvest system you choose, being able to grow the next forest depends on protecting the soil.



SKIDDER Logging Unit
(from road layout on page 7)

■ Design and locate skid trails and skidding operations to minimize soil disturbance. Using designated skid trails is one means of limited site disturbance and soil compaction.

When designated skid trails are compared to "go anywhere" skid trails, there is little difference in winching, but a large difference in the area covered by skid trails

Research and field experience indicate that designated skid trails may be only slightly more expensive, than "go anywhere" skid trails.

As much as 40% or more of any area may be covered with skid trails if they are not planned and marked in advance.

This may be desirable in certain situations such as when attempting to expose mineral soil to improve germination and survival of tree seedlings or to disturb aspen root systems which encourages coppice regeneration. However, it is generally wiser to limit ground disturbance by pre-planning skid trails so as to minimize erosion potential.

■ Minimize the size and number of landings to accommodate safe, economical operation.

■ Avoid locating landings that require skidding across drainage bottoms.

■ Locate skid trails to avoid concentrating runoff and provide breaks in grade.

■ Locate skid trails and landings away from natural drainage systems and divert runoff to stable areas.

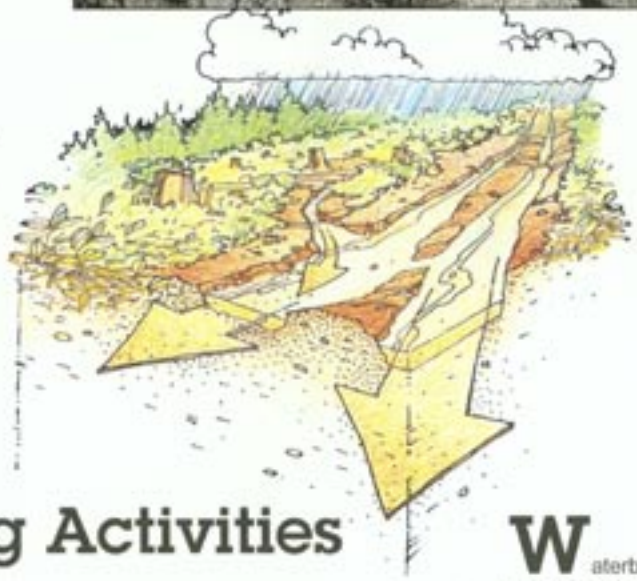
■ Limit the grade of constructed skid trails on geologically unstable, saturated, highly erodible, or easily compacted soils to a maximum of 30%. Use mitigating measures, such as waterbars and grass seeding, to reduce erosion on skid trails.

Poor location of log landing. Logs are being skidded across drainage.

Right: Planning can help avoid steep skid trails on slopes greater than 30% with highly erodible soils. Always install waterbars (see page 24) on skid trails as needed.

- Tractor skid when compaction, displacement and erosion will be minimized.
- Avoid tractor or wheeled skidding on unstable, wet, or easily compacted soils and on slopes that exceed 40% unless operation can be conducted without causing excessive erosion.
- Avoid skidding with the blade lowered.

Forest soils on steep slopes are often shallow. Scalping off the litter layer removes the soil's protective cover, leaving it exposed to erosion. Don't use the blade as a brake or to improve traction for skidders on steep slopes.



What happens when the forest litter layer is scraped off?

- **Nutrients for the next crop of trees are removed.**
- **Mineral soil is exposed to erosion by rainfall and surface flow.**
- **Soil does not retain moisture as well.**
- **Ability of the soil to grow trees is reduced.**
- **Runoff and sediment transport increase.**

Other Harvesting Activities

Drainage Management

- Stabilize or reclaim landings and temporary roads on completion of use. Logging slash and other natural debris may be scattered on them and these disturbed areas reseeded to grass.

Ditches, waterbars, or outsloping can prevent water accumulation on landings. Be sure to waterbar skid trails leading down to landings.

- For each landing, skid trail, or fire trail, provide and maintain a drainage system to control the dispersal of water and to prevent sediment from entering streams.
- Install necessary waterbars on tractor skid trails. Appropriate spacing between bars is determined by the soil type and slope of the skid trails. Timely implementation is important.
- When natural revegetation is inadequate to prevent accelerated erosion before the next growing season, apply seed or construct waterbars on skid trails, landings and fire trails. A light ground cover of slash or mulch will retard erosion.

Waterbars divert surface water from bare soil to areas where it will not cause erosion. They should be constructed on roads, landings, and skid trails (pictured). Waterbars can be constructed with a shovel, but mechanical equipment is most common. Cut the waterbar into solid soil, at least eight inches deep. Shape the berm, parallel to the cut, at least twelve inches above the skid trail grade. Construct the cut downward, but not more than at a 45 degree angle, so water runs to the outlet. Be sure the waterbar is open at the lower end so water runs out. Water should flow onto slash, vegetation, or rocks. When temporary spur roads are waterbarred, be sure to connect the waterbar into "cutslope" to intercept all surface flow.

Suggested Waterbar Intervals for Different Soils

Recommended Waterbar Spacing Distance for Roads and Skid Trails

Grade of Road or Trail (%)	Unstable Soils (High Erosion Hazard)	Stable Soils (Low Erosion Hazard)
2 -	135'	170'
5	100'	140'
10	80'	115'
15	60'	90'
20	45'	60'
25+	30'	40'

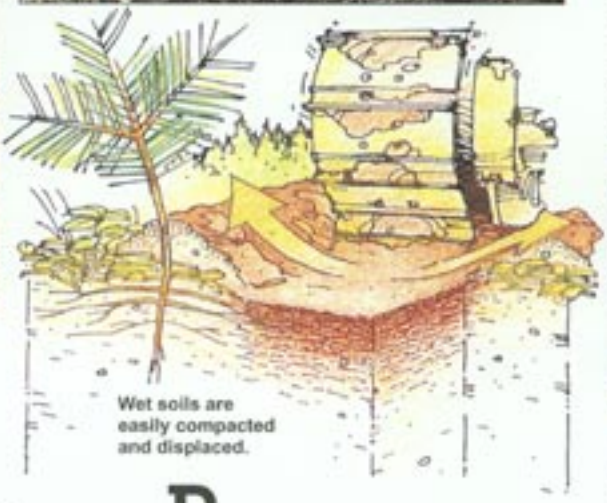
Intervals in feet.

Slash Treatment and Site Preparation

The question "How much soil exposure is enough?" is common when preparing a site for a new forest. Clean as a parking lot (below) is too much. New forests need the nutrients and protection supplied by logging slash. Soil compaction is another problem with sweeping the forest clean.

When you pick up a handful of forest soil, half of it is solid material. The rest is empty pore space that holds water and air. Heavy equipment can squeeze soil pores, reducing the space for water and air. Since trees need water and air for growth, the start of the next forest can suffer from soil compaction.

Certain soil conditions are more likely to lead to compaction. Wet soils are more compactible than dry. The most severe compaction occurs within a few inches of the surface. Unfortunately, that is where seed germination occurs and where most of the water-absorbing tree roots are found.



Wet soils are easily compacted and displaced.

Regeneration of a new forest may require the removal of some logging slash. Seed from nearby trees germinates best in exposed mineral soil. Surface scarification activities must expose bare soil for new seedlings, while avoiding erosion. The three scenes below show mechanical scarification; inadequate (top), acceptable (middle), and excessive (bottom).

Reduction of slash to decrease fire hazard is recommended. In the two scenes below, one shows acceptable slash reduction (top); the other is not acceptable because too much fire hazard was left.

- Use brush blades on equipment when piling slash.
- Scarify the soil only to the extent necessary to meet the reforestation objective of the site. Site preparation equipment producing irregular surfaces is preferred. Care should be taken to preserve the surface soil horizon.

Slash from log processing should never be cast into the SMZ.

- Low slash and small brush should be left to slow surface runoff, return soil nutrients, and provide shade for seedling.

Work around existing small trees and low brush.

- Carry out brush piling and scarification when soils are frozen or dry enough to minimize compaction and displacement

Stay clear of wet areas during scarification. Results like this create compaction and water quality problems.

- Carry out scarification on steep slopes in a manner that minimizes erosion.

Machine-made ruts on hillside soils can easily become channels for surface water erosion.

Broadcast burning can be used to prepare a site for a new forest, even on steep slopes. By carefully monitoring moisture conditions, a fire can be set that consumes only part of the material, leaving the soil humus and large logs relatively undisturbed. Afterwards, the site is either planted or allowed to seed-in naturally.

Reforestation

- Remove all logging machinery refuse to a proper disposal site (tires, chains, chokers, cable, and miscellaneous discarded parts).
- Limit water quality impacts of prescribed fire by constructing waterbars in firelines; not placing slash in drainage channels; and maintaining the streamside management zone. Avoid intense fires unless needed to meet silvicultural goals.
- Broadcast burning and/or approved selective herbicide application are preferred means for site preparation, especially on slopes greater than 40%. Herbicide and insecticide use requires special training and state licensing of applicators. For additional information contact the Colorado Department of Agriculture.
- Rapid reforestation of harvested areas is encouraged to re-establish protective vegetation.

Site preparation techniques — mechanical or broadcast burning, are designed to get the new forest off to a vigorous start. When combined with healthy tree seedlings, either planted or naturally seeded, the result is the next generation forest.

Generally, throughout Colorado, natural regeneration provides more than adequate restocking of harvested areas.

Winter Activities

Winter Harvesting Considerations

Colorado's winter freeze-up brings the opportunity for low impact logging. With proper precautions, even work in sensitive areas can be done without affecting water quality. This is often the best time to log these sites.

Trying to rely on memory can be expensive when it comes to maintaining culverts. Mark them before the snow falls to avoid logging activity damage.

SMZs can be totally obscured by heavy snow. Avoid confusion by marking boundaries ahead of the first snow.

Consider snow-road construction and winter harvesting when logging sites that are characterized by wet meadows, high-water tables, sensitive riparian conditions or other potentially significant soil erosion and compaction hazards.

- Consult with operators experienced in winter logging techniques.
- Conduct winter logging operations when the ground is frozen or snow cover is adequate (generally more than one foot) to minimize site disturbance.
- Before logging, mark existing culvert locations. During and after logging, make sure that all culverts and ditches are functional.
- Prior to felling in wet unfrozen soil areas, use tractors or skidders to compact the snow for skid trail locations. Avoid steeper areas where frozen skid trails may be subject to erosion the next spring.
- Do not leave slash and tops in streams.
- Be prepared to suspend operations if conditions change rapidly and when the erosion hazard becomes high.
- Return the following summer and build erosion barriers on any trails that are steep enough to erode.

Compact skid trail snow before skidding logs. This avoids damage to soils that are still wet or not completely frozen.

Winter thaws can happen quickly. Don't take chances with soil disturbance and possible erosion. Expect to shut-down temporarily.

Waterbar all skid trails prior to spring runoff. If prohibited by frozen ground, install waterbars during dry summer months. Temporary erosion control barriers consisting of slash can be used until waterbars are installed.

Road and Drainage Considerations

■ For road systems across areas of poor foundation, consider hauling only during frozen periods.

To provide a winter road grade capable of heavy hauling, always remove snow cover. Deep-frozen road surfaces have tremendous strength. Don't let snow cover insulate and weaken the road — plow during cold weather.

■ During cold weather, plow any snow cover off of the roadway to facilitate deep freezing of the road grade prior to hauling. Use compacted snow for road beds in unroaded, wet or sensitive sites. Construct snow roads for single-entry harvests or for temporary roads.

■ Following completion of snow road use, restore stream crossings to near pre-road conditions to prevent ice dams. Do not use the stream channel for the roadway except for crossings. Water-bars placed on winter roads just above drainage crossings will divert snowmelt onto vegetative filters instead of directly entering streamcourses.

■ Be prepared to suspend operations if conditions change rapidly and when the erosion hazard becomes high.

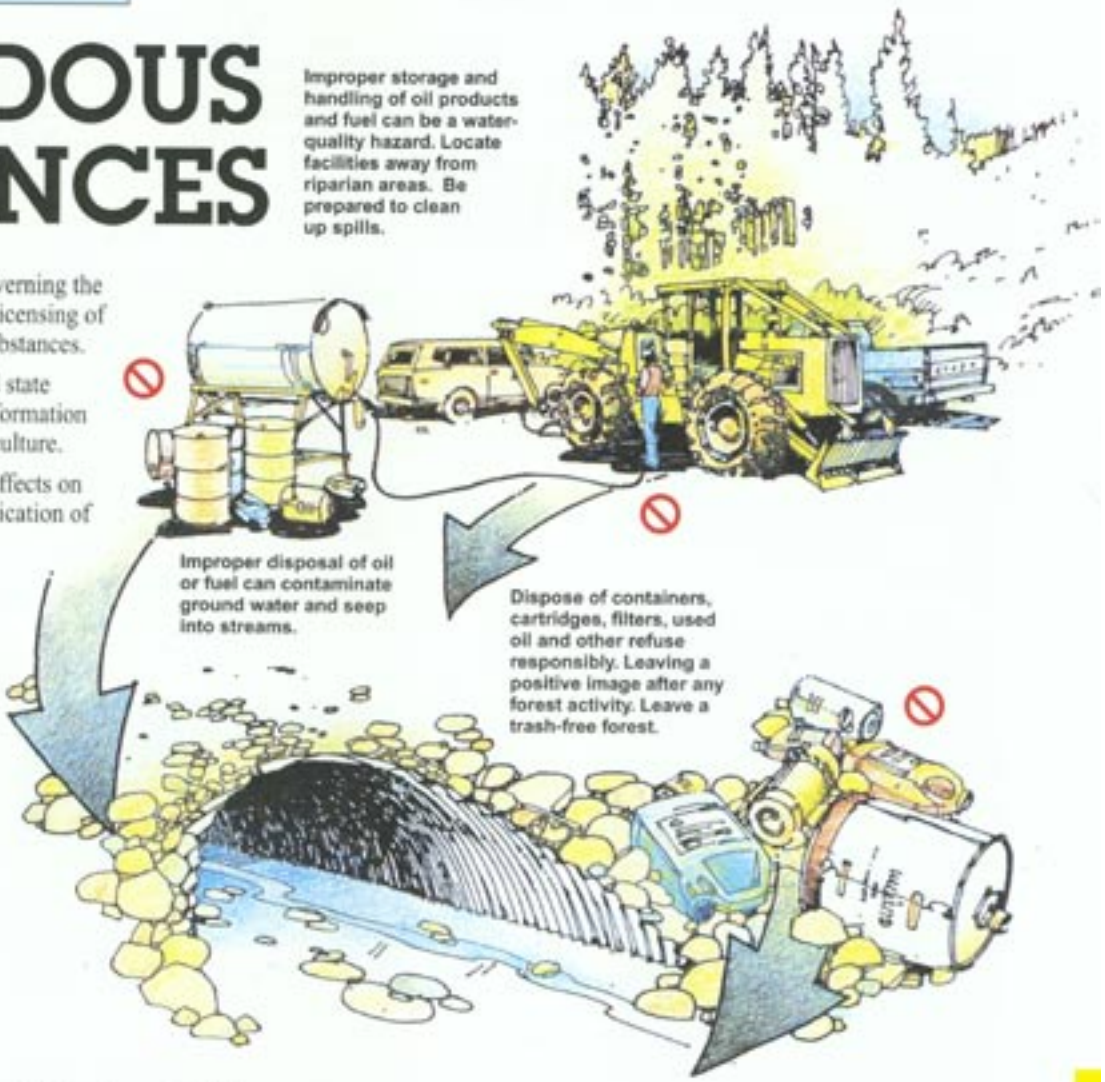
This is an inadequate job of restoring a temporary snow road stream crossing. This work should be completed before stream flows begin. In addition to the streambed, it appears that stream bank and SMZ damage is occurring.

Road surfaces deteriorate rapidly under heavy hauling and thawing temperatures. This road surface is starting to break up. Hauling should be suspended, or limited to colder portions of the day.

■ When plowing snow for winter timber harvest, prior to spring breakup, provide breaks in snow berm to allow road drainage.

Snow berm breaks allow for spring drainage without damaging the road surface.

HAZARDOUS SUBSTANCES



■ Know and comply with regulations governing the storage, handling, application (including licensing of applicators), and disposal of hazardous substances.

Pesticide use requires special training and state licensing of applicators. For additional information contact the Colorado Department of Agriculture.

■ Reduce or eliminate possible adverse effects on water quality by proper handling and application of fertilizers.

■ Prevent water contamination and risk to humans and aquatic life from cleaning and disposal of pesticide containers.

■ Cleaning and disposal of containers and equipment must follow federal, state, and local laws. Records should document how and where containers are disposed.

Pesticides and Fertilizers

■ To prevent the entry of hazardous substances into surface waters:

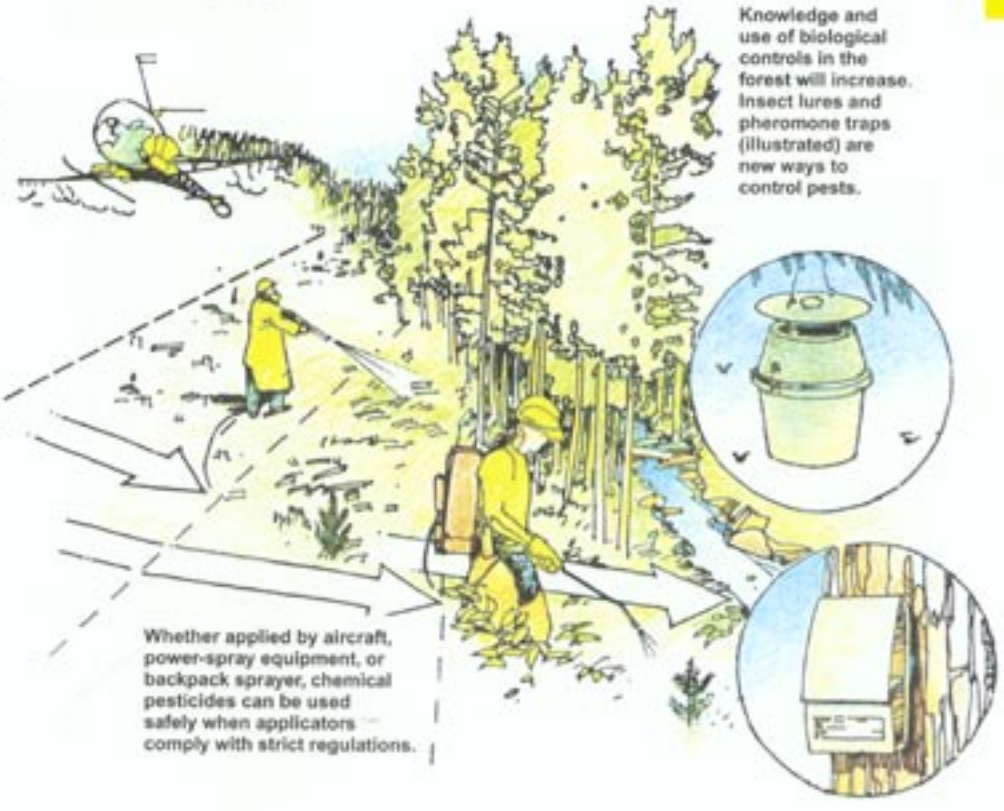
A. An adequate vegetative buffer zone is needed to insure that the chemicals are not sprayed, or drained into any surface water either directly or carried by water runoff. Generally, a buffer area of at least 150 feet wide is recommended for most applications.

B. If aerial application of pesticide is required, check the label for restrictions on aerial application.

C. A spill contingency plan to handle accidental spills, including clean up, should be developed.

D. Always refer to chemical label instructions for additional guidance on use near water and required buffer zones.

■ To enhance effectiveness and prevent transport into streams, apply chemicals during appropriate weather conditions (generally calm and dry) and during the optimum time for control of the target pest or weed.



STREAM CROSSINGS

Concrete planks, fastened together and stretched across the streambed, provide an improved ford crossings.

Legal Requirements

■ In some cases it is necessary to secure certain permits prior to altering a stream channel. Compliance with Section 404 of the Clean Water Act is necessary if the activity has the potential to impact any water area considered "waters of the U.S." Only consultation with the appropriate agency will determine the actual need for a 404 permit. The consequences for operating without a permit, if needed, could be significant, including work stoppage and possible monetary fines. The landowner and/or operator should consult with their local U.S. Army Corps of Engineers regarding 404 permit information.

Limited traffic on this improved ford crossing has minimal impact on the streambed and on sediment production.

Streams can be crossed with culverts, bridges or fords. Culverts are the most common stream crossing structure. Bridges are best for large streams and areas plagued with floatable debris problems. Bridges also have less effect on fisheries than other methods. Fords are less desirable because of continued disturbance to the stream bed. Choice of the stream crossing method depends on the following:

Stream size

Cost of construction and maintenance

Amount of road use and years of use

How the road approach lies with respect to the stream

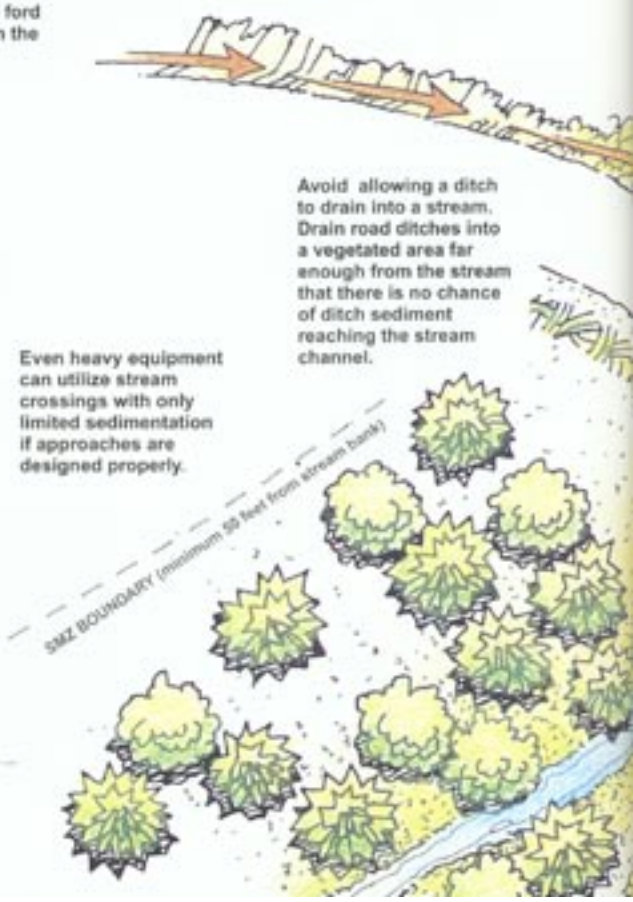
Soil foundation conditions

Available equipment and materials

Applicable permit requirements

A wrong choice of stream crossing method or improper sizing can result in major damage to both the immediate site and down-stream water uses.

Even heavy equipment can utilize stream crossings with only limited sedimentation if approaches are designed properly.



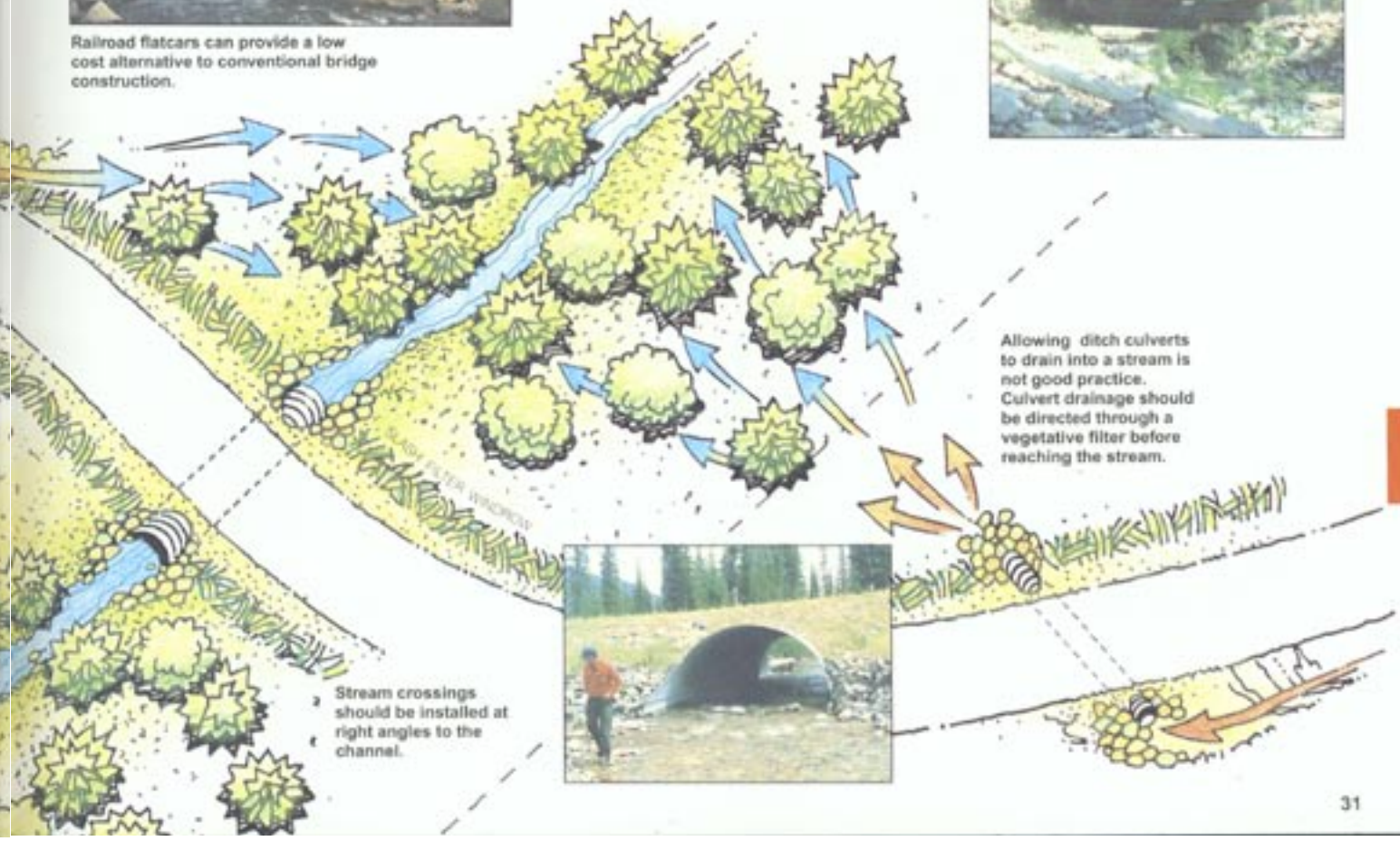
Avoid allowing a ditch to drain into a stream. Drain road ditches into a vegetated area far enough from the stream that there is no chance of ditch sediment reaching the stream channel.

Design Considerations

- Design stream crossing for adequate passage of fish, minimum impact on water quality and to handle peak runoff and flood waters.
- Cross streams at right angles to the main channel if practical.
- Culverts must be adequately sized for the application. For most applications use culverts with a minimum diameter of 18 inches for permanent stream crossings and cross drains.
- Adjust the road grade to reduce the concentration of water carried by drainage ditches to stream crossings.
- Direct drainage flows through an SMZ and away from the stream crossing site.
- Avoid unimproved stream crossings. When a culvert or bridge is not feasible, locate drive-throughs on a stable, rocky portion of the stream channel.

When short-term access to forest land is cut off by a stream, portable bridges are one solution. They offer the flexibility of convenience and relatively low cost. A timber harvest or other forest activity can be carried out over a short period of time and the crossing easily restored to its original condition. This railroad car portable bridge provided access to an eight acre sale. An appropriate crossing, approximately ten feet wide, with firm soil banks, level grade, and requiring minimal vegetation clearing, was selected. The twenty-foot-long bridge was hauled into place with a flatbed truck, stretched across the stream and set into place in one day. Cribbing for the bridge consisted of ten-foot-long timbers laid on the ground approximately four feet away from the bank. A small crawler tractor finished the installation by building the road approaches to the bridge. This durable bridge crossing was used over a three-week period. Approximately twenty-five 80,000 lb. log truck loads were hauled across it. When the harvest was completed, all logging and skid trail roads were restored and the temporary bridge removed.

Railroad flatcars can provide a low cost alternative to conventional bridge construction.



Allowing ditch culverts to drain into a stream is not good practice. Culvert drainage should be directed through a vegetative filter before reaching the stream.

Stream crossings should be installed at right angles to the channel.

Installation of Stream Crossings

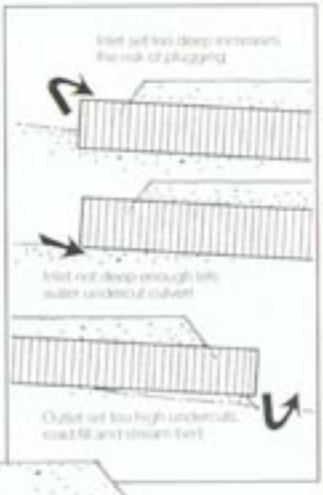
- Minimize stream channel disturbances and related sediment problems during construction of road and installation of stream crossing structures.
- Time construction activities to protect fisheries and water quality.
- Do not place erodible material into stream channels. Remove stockpiled material from high water zones.
- Locate temporary construction bypass roads in locations where the stream course will have minimal disturbance.
- When using culverts to cross small streams, install those culverts to conform to the natural stream bed and slope on all streams that support fish.
- Place culverts slightly below normal stream grade to avoid culvert outfall barriers. Do not alter stream channels upstream from culverts, unless necessary to protect fill or to prevent culvert blockage.
- Install culverts to prevent erosion of fill. Compact the fill material to prevent seepage and failure. Armor the inlet and/or outlet with rock or other suitable material where needed.
- Consider dewatering stream crossing sites during culvert installation.
- Use one foot minimum cover for culverts 18 to 36 inches in diameter, and a cover of one-third diameter for larger culverts to prevent crushing by traffic.

Construction of stream crossings has the greatest potential to cause immediate sediment pollution. Complete the work as fast as possible during a time of year when the least damage can occur. This photo sequence shows a typical culvert installation.

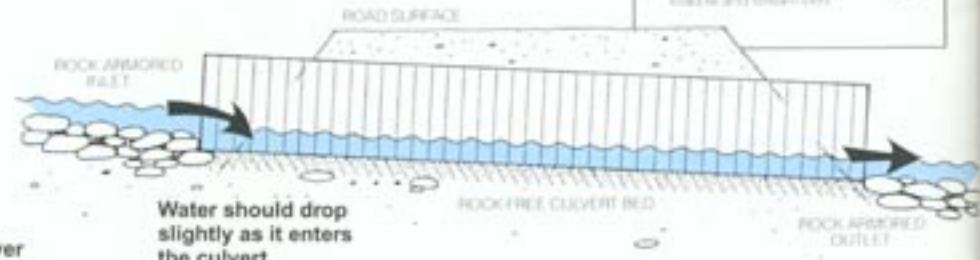
The temporary channel in the foreground carries stream water. The dewatered stream channel is being cleared for the culvert. The culvert foundation and trench walls must be free of logs, stumps, limbs, or rocks that could damage the pipe.

The culvert bed is graded to the appropriate slope to conform with the natural stream bed. The bed is either rock-free soil or gravel. Bedding should provide even distribution of the load over the length of the pipe.

Alignment is critical for the culvert to function properly. Culverts set at an angle to the channel can cause bank erosion. Skewed culverts can develop debris problems. Culvert alignment must fit the natural stream channel.

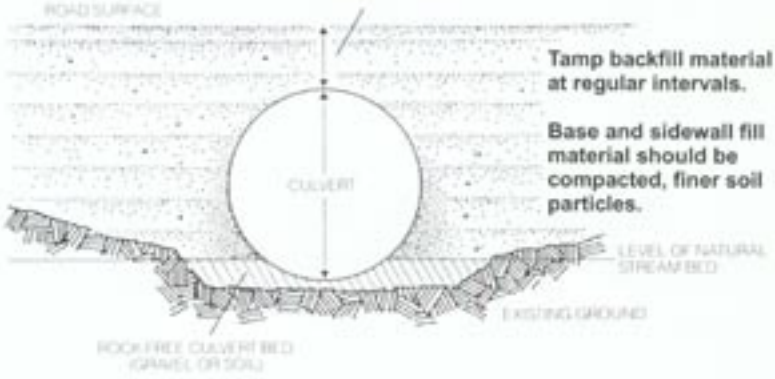


Place culvert slightly below the natural stream bed. Water should drop slightly as it enters the culvert. The natural rock bed of this stream serves to control water velocity and protect the culvert as water enters the inlet.



Water should drop slightly as it enters the culvert.

At least one foot of cover or one-third of diameter for larger culverts.



Tamp backfill material at regular intervals.

Base and sidewall fill material should be compacted, finer soil particles.

Start to backfill over one end of the culvert. Then cover the other end. Backfill material must be free of limbs, rocks, and other debris that could dent the pipe or allow water to seep around the culvert.

Once the ends are secured by backfill, the center is covered. Pour backfill material over the top of the pipe. This allows finer soil particles to flow around and under the culvert sides. Larger particles roll to the outside. Fine soil particles close to the culvert compact more easily.

Tamping fill material throughout the entire backfill process is important. The base and sidewall material should be compacted first. This reduces seepage into the fill.

Both the culvert inlet and outlet should be armored. Rocks, logs or grass seeding can be used to protect these locations against erosion.

When the new culvert is opened to water, watch for the need to add more rock armor. Be sure that a minimum of one foot of compacted soil covers the top of the culvert.

After checking to be sure the new culvert is working, the dewatering channel is closed.

Road approaches to the new crossing are the next phase of construction.

Layers of fill are pushed into place and carefully compacted to build up and maintain a consistent road grade.

As a final precaution against sediment entering the stream, a slash filter windrow is constructed around the culvert outlet.

The need to safeguard the future of our water resource is essential. With the cooperation of all forest users, and the application of the information on these pages, we can protect the water quality of Colorado's forest lands.

Please be aware that BMPs will improve as our knowledge of the forest increases over time. Forest managers and timber industry professionals are continually developing new techniques and equipment to meet different needs.

Thank you for doing your best to put BMPs to work in the forest.

"Colorado's forests are essential to the lifestyles of people in our state. Forests provide jobs, recreation, and sources of clean, high quality water that support aquatic resources, drinking water supplies and aesthetic needs. Stewardship of our forests comes through education and commitment, not coercion. Everyone wants to be a good steward by protecting Colorado's water quality. This guidance provides the tools to do a better job."

Greg Parsons,
Watershed Section Manager
Colorado Water Quality
Control Division

"This booklet, and subsequent training sessions, will benefit the environment by outlining practices which will minimize potential impacts from timber management. We commend the Colorado Timber Industry Association for its initiative to enact these voluntary practices in Colorado, and look forward to the opportunity to support the training sessions and distribution of the booklets."

Clint Kyle, Chair
Colorado-Wyoming Society
of American Foresters

The Colorado Tree Farm organization works to help forest landowners create and/or maintain healthy and productive forests. Best Management Practices for Colorado is one of the best tools yet produced to supply that kind of information. It not only provides clearly written and illustrated guidelines on how to best carry out various forest management practices, it explains why these guidelines produce superior results. This publication will be of great benefit to forest landowners and the general public because it will ultimately benefit what they have in common...one of our greatest natural resources, Colorado's forests.

Wes Rutt, Chair
Colorado State Tree Farm
Committee