



FOREST ROAD MANAGEMENT GUIDEBOOK



*Maintenance and Repairs
to Protect Fish Habitat
and Water Quality*

Oregon Department of Forestry
Forest Practices Program

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INTRODUCTION

Road Management is Important

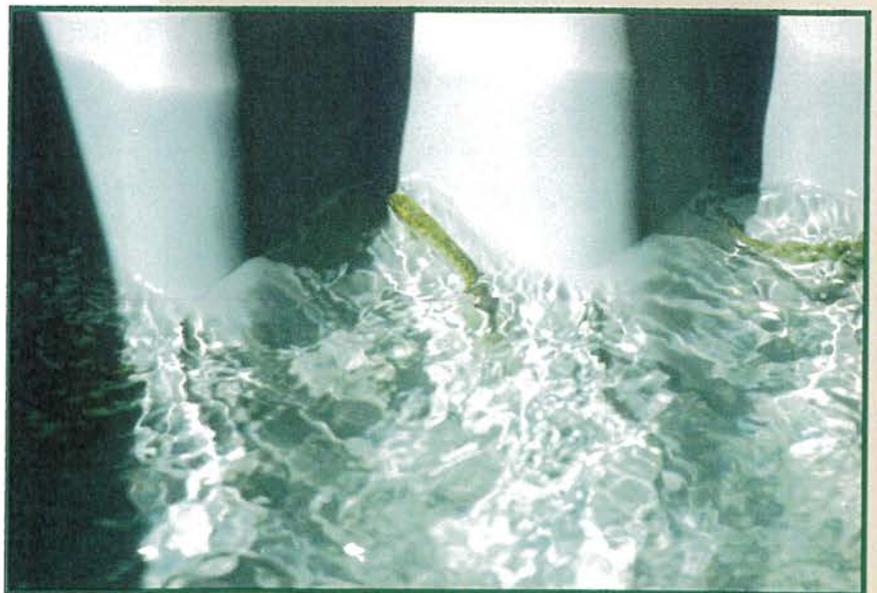
Maintenance and repair of forest roads can benefit fish and fish habitat, protect a landowner's investment in the road system, and reduce the risk to other resources, both natural and human-made. The Oregon Department of Forestry is working cooperatively with forest landowners to identify road-related hazards to streams, fish and other resources. In most cases, regular maintenance is all that is necessary. Proper maintenance means that roads have a stable surface and an operating drainage system. Water should drain from the road as quickly as possible. Surface runoff should be

directed onto the forest floor instead of directly into streams. Culverts should be free of debris and not plugged with sediment or excessive vegetation growth. In addition, where fish may be present, stream crossings should not impede juvenile fish passage. Ditches should only be cleaned when they are full or almost full of sediment. Preventing use of roads during very wet periods or during periods of thaw will greatly reduce both sediment delivery potential and future road maintenance needs. Despite regular maintenance, there are cases where roads may be working well for vehicle use, but are still causing problems for streams and fish.

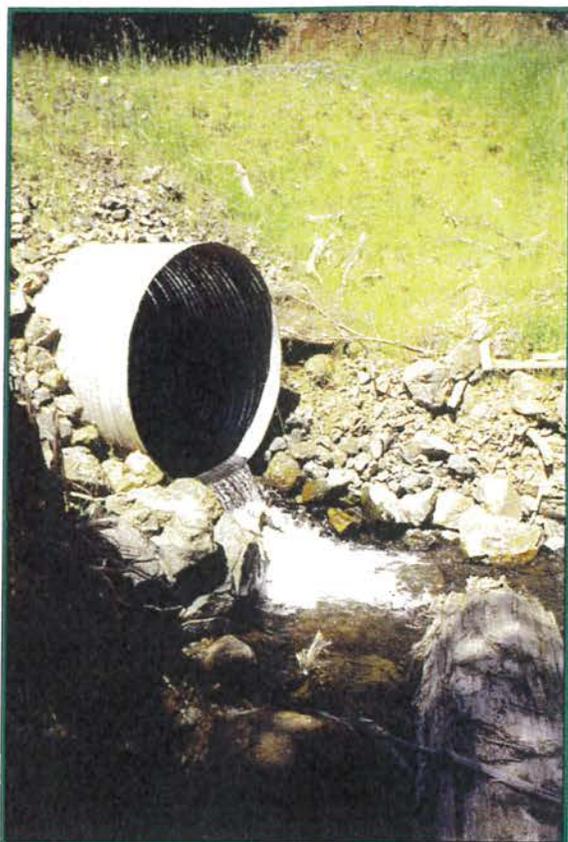
Oregon Plan for Salmon and Watersheds

The Oregon Plan for Salmon and Watersheds (Oregon Plan) is in large part a voluntary effort to protect salmon and steelhead. A major element of the plan is the road hazard identification and risk-reduction project. Members of the Oregon Forest Industries Council (OFIC) have volunteered to implement this project. Other forest landowners have also volunteered to evaluate their roads and see if improvements can be made, since some forest roads, especially older roads, can cause problems. Therefore, the two major elements of this project are 1) a survey of roads to identify sediment and fish passage hazards; and 2) the repair work to fix identified problems. Landowners with only a few roads can walk their road system, looking at culverts and ditches, waterbars and the road prism to identify where water goes, for sources of erosion, and opportunities to filter sediment before it enters streams. Landowners with many roads should conduct a systematic inventory of those roads. After

surveys and repairs are completed, landowners or other responsible parties are strongly encouraged to report these activities to the Oregon Watershed Enhancement Board (OWEB) using forms developed specifically for the road hazard and risk reduction project.



Juvenile fish in culvert



An outlet drop like this one is a barrier to juvenile fish passage

Objectives of this Guidebook

On most private and state forestlands, much of the road system already exists. Therefore, the objective of this guidebook is to help landowners maintain and repair these existing road systems to protect water quality and fish. Design and construction practices for new roads are covered in other publications. (See Useful References, page 32.)

Several factors must be considered when attempting to prioritize repairs. The decision process should consider cost/benefit analysis to evaluate repair priorities. This may be as simple as comparing the amount of habitat (miles of stream) protected or enhanced for the amount of dollars spent.



Roads in flood plains can impact fish habitat and water quality

The most important situations needing repair include:

- Stream crossings and side channel crossings that restrict fish passage
- Stream crossing culverts where overflow water may be diverted down the road during floods or if the crossing becomes obstructed
- Unstable road fills
- Ditches routed over long distances with direct discharge into channels (no cross drainage installed before the stream crossing)
- Log culverts with fills
- Badly damaged or deteriorating culverts

Other considerations when choosing repair priorities include:

- ✓ Risk of impacts to human life, and/or major structures or developments
- ✓ Budget constraints
- ✓ Seasonal restrictions for in-stream work
- ✓ Operational scheduling
- ✓ Critical areas for fish or water quality
- ✓ Traffic intensity

POTENTIAL ROAD RELATED FISH AND WATER QUALITY PROBLEMS

Erosion can occur on all parts of the road prism. Stream crossings are an especially critical location because sediment can directly enter channels, they are easily affected by flood flows, and they can restrict fish passage. Road fills on steep slopes or in other landslide prone locations can turn into debris flows, scouring soil along their paths and moving a great deal more sediment and debris into streams than the size of the road fill would indicate. Roads can also impact wetlands if located adjacent to or through the wetland, or by subsequent erosion from the road into the wetland.

Erosion from all other areas of the road prism can also result in chronic sediment problems. Fortunately, most chronic sediment problems can be readily treated through proper location, maintenance and installation of cross-

drains. Well-managed road surface drainage leaves the road prism quickly and is directed onto stable, vegetated ground for filtering and dissipation. The water can be collected in a ditch and diverted through well-spaced cross-drain structures, and/or it can be drained directly to the outside edge of the roadbed. Table 1 categorizes potential road management problems by the specific area of the road prism.

Monitoring Results

The Oregon Department of Forestry has been monitoring the effects of roads on streams over the past few years. Some findings from this monitoring effort include:

- Most roads were designed for optimum water delivery to stream channels. Cross-drainage culverts were not located to filter drainage water before it enters streams.
- Areas with old roads on slopes steeper than 70% should receive a priority for upgrading (by removing unstable fill slopes and through improved surface water drainage).
- Damaging landslides are unlikely for roads constructed on slopes of less than 50% if these roads have frequent and properly sized drainage structures and use balanced excavation practices that minimize cuts and fills.
- Slope, landform and fill depth should be evaluated prior to relocating cross drainage structures. Even a small length of road draining to a marginally stable slope appears to greatly increase the likelihood of a landslide.

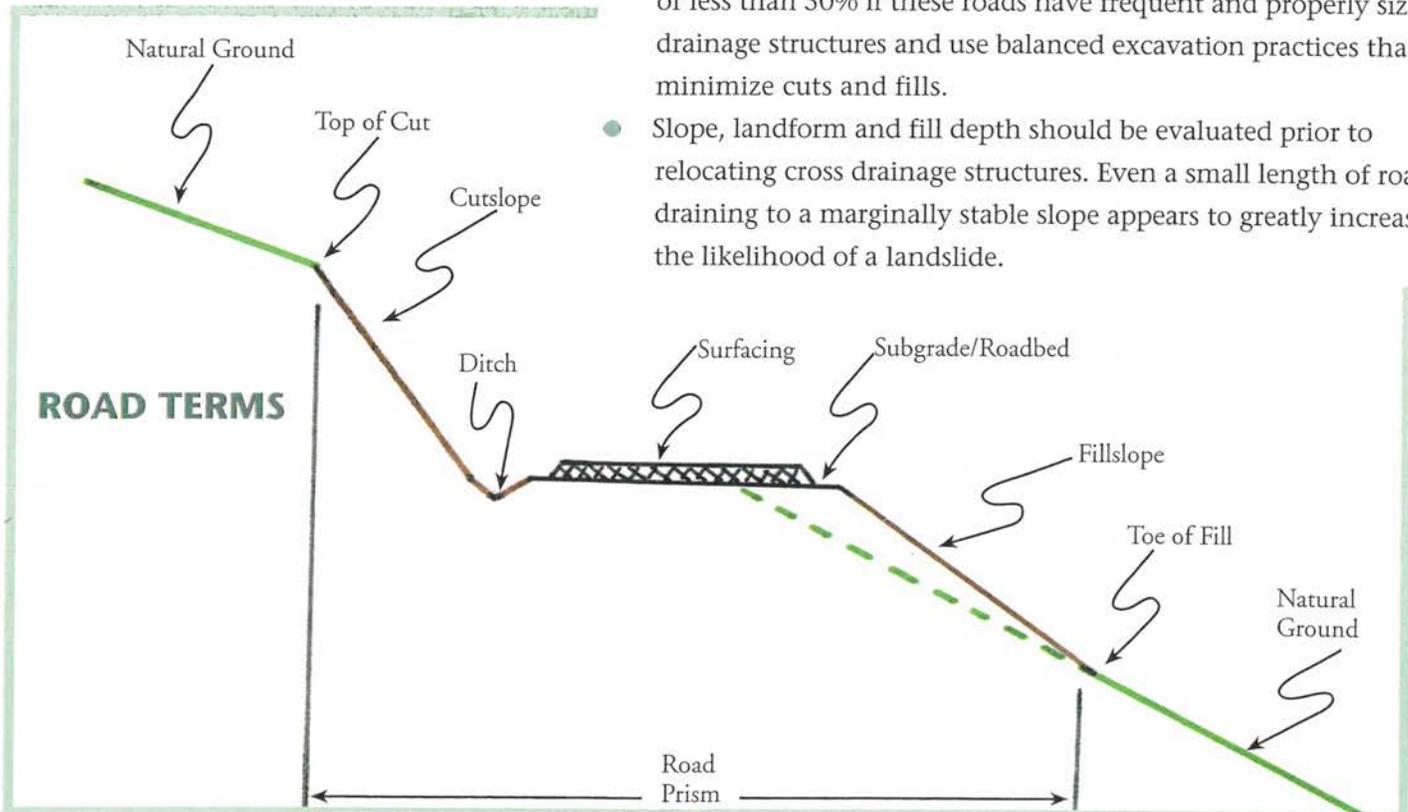


Table 1

POTENTIAL ROAD-RELATED FISH AND WATER QUALITY PROBLEMS

Source of Problem	Potential Impact on Resources			
	Water Quality	Fish	Road Damage	Logging Costs
Road Surface Erosion and Live Streams	Significant source of fine sediment and related turbidity	Fine sediment produces turbidity and fills gravel	Erosion and loss of parts of road prism	Can lead to road closures during wet periods if not properly drained
Wet Weather Use	Generates additional turbidity during rainy or snowmelt periods	Fine sediment more likely to deposit in spawning gravel during low flow periods	Accelerated loss and wear of gravel - especially if inadequately maintained	Inadequate surfacing can result in increased haul costs
Stream Crossing Structures	Failures and washouts are major sources of stream channel impacts	Can block fish passage and fish use of stream segments above culvert	Loss of fill, culverts, and extensive gullying down roads	Washouts can close road until the following construction season
Surfacing	Poor quality or limited depth of surfacing is a source of much sediment during wet periods or thaw cycles	Source of fine sediments	Premature replacement of surfacing and increased grading costs	Poor quality or limited depth of surfacing can increase haul costs
Sidecast and Steep Fills	Most road associated landslides that enter streams originate here	Typically result in larger debris flows than other landslides and can greatly alter channel morphology	Repair or replacement can be major reconstruction projects	Failures can close roads until the following construction season
Cutslopes	Ravelling or sloughing can block ditches and divert water onto road surface	Diverted drainage can cause landslides below the road	Extra ditch repairs, landslides can narrow or remove road	Can cause temporary road closures

Best Management Practices

Most states have a set of Best Management Practices (BMPs) for forest roads. In addition to BMPs, states have water quality standards. These often include standards for turbidity (muddy water), which can be related to roads. Roads can affect water temperature where they are located in riparian areas parallel to streams

and therefore prevent growth of shade producing vegetation. When water quality standards are not met, a stream may be subject to additional regulations through a total maximum daily load (TMDL) related to a specific water quality standard. Special practices may be required to meet these load reductions. Proper road management is even more important in these watersheds.

Be Aware of Regulations

Oregon and most other western states have regulations that may affect all or some road maintenance and repair activities. Using this guidebook alone **will not ensure compliance with applicable regulations**. In Oregon, the Forest Practices Act and rules apply to all forest road maintenance and repair activities on state and private lands. Washington, California, Alaska, British Columbia and Idaho also have comprehensive forest practice regulations. In addition, most western states (except Oregon) require permits from the fish and wildlife agency for certain in-stream activities, or activities in riparian areas. It is essential that you know local regulations, or contact the appropriate agency prior to conducting certain road use, maintenance and repair activities.



Hauling on a very wet road produces muddy runoff

INSPECTING FOREST ROADS

Timely inspection and subsequent maintenance or repair activity on forest roads will benefit fish and fish habitat. All roads and drainage structures should be inspected, especially older or little-used roads. Frequent inspections are important in areas known to have past landslides, washouts and undersized culverts.

The inspections should identify road surfaces that have:

- ✓ *drainage problems, such as downcutting in ditches*
- ✓ *drainage onto very steep slopes*
- ✓ *drainage structures that do not work properly, are damaged, or blocked*
- ✓ *evidence of erosion or failure of the road surface or fill- and cutslopes*
- ✓ *rutting, gullies, or potholes in the road surface*
- ✓ *arc shaped cracks in fills*
- ✓ *direct sediment discharges to streams*
- ✓ *any other potential sources of drainage and stability problems*

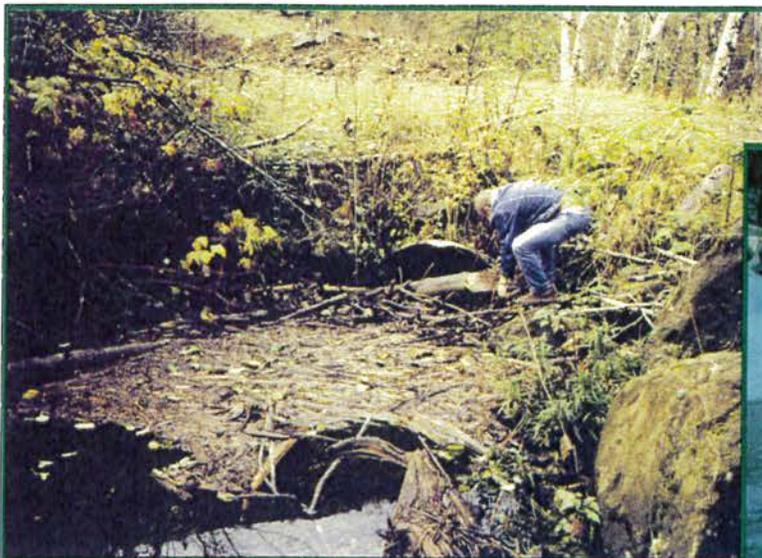
Inspections of drainage structures should be made prior to the onset of wet weather to ensure the structures are functioning properly. Also, inspect road surfaces prior to operations to ensure there is adequate drainage and a stable surface. Additional inspections should be made during periods of heavy traffic use, and during heavy use in wet

weather to watch for drainage and road surface stability problems. Another good time for inspections is during heavy rainfall or rapid snow melt and runoff events. This provides an opportunity to check drainage structure capacity during peak flow, and to mitigate any damage that may occur from a non-functioning structure (e.g. plugged cross-drain or stream crossing).

To obtain useful information, on-the-ground inspection of the road system is necessary. Priority information includes:

1. Looking at general road characteristics;
2. Identifying symptoms of erosion along the road;
3. Noting the conditions of culverts and bridges; and
4. Evaluating the risk of sidecast fill landslides entering streams.

A forest road hazard inventory protocol has been developed for surveying the condition of road systems (see Useful References, page 32). Periodic inventories—every 5-10 years—are important to track improvements in the road system. It also is possible to maintain a continuously updated road inventory.



Inspecting for culvert blockage



Culvert at beginning of snow melt

ROAD MAINTENANCE

Timely road maintenance will protect roads and reduce the risk of impacts to streams and fish. Components of a good maintenance program include on-the-ground inspections, surface shaping, ensuring drainage structures are working, and disposing of waste materials where they will not enter streams. The capacity to respond quickly to emergency events like storms and accidents also is critical.

“Routine” maintenance includes regular inspections, and maintaining the road surface and drainage structures so that they function properly. Routine maintenance most often occurs during the drier months, and includes, but is not limited to:

- ✓ Cleaning culvert inlets
- ✓ Grading the road surfacing to maintain drainage
- ✓ Replacing and/or adding cross-drainage structures
- ✓ Adding surfacing
- ✓ Controlling roadside vegetation that interferes with drainage or vehicle use

Non-routine maintenance includes emergency road repairs during major storms that are essential to prevent washouts and landslides and includes:

- ✓ Unplugging culverts and ditchlines
- ✓ Installing temporary overflows
- ✓ Redirecting floodwaters to less damaging locations

When Roads Need Maintenance

In general, road systems that have a higher level of use will require more maintenance activities. Road systems that have a lower level of activity generally require less maintenance unless they are in high risk locations, for example, steep slopes that are next to streams. Roads with high cutslopes will require more catch basin and ditch cleaning. Some new roads also need



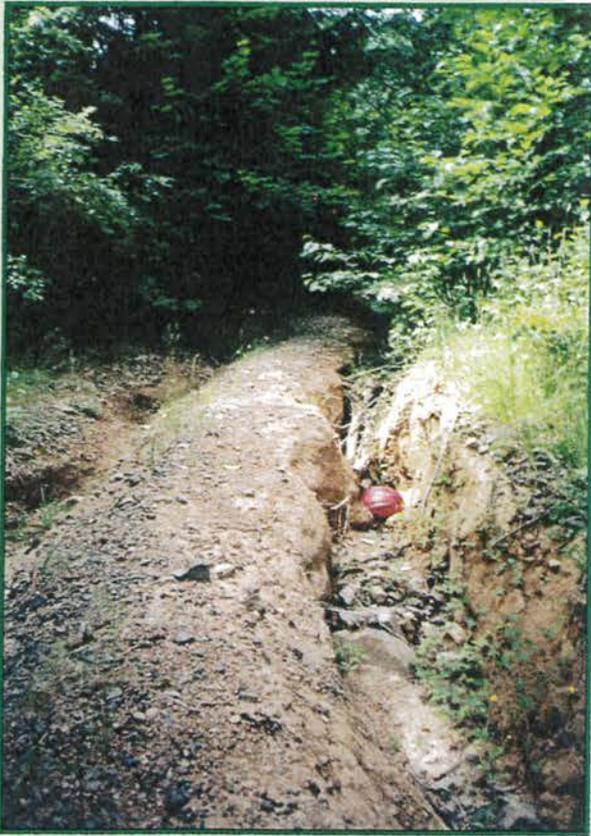
Maintaining drainage by shaping the road surface attention due to initial cutslope ravel. The quality of road surface materials also affect the need for maintenance activities.

The season of use of the road system will also affect the need for maintenance. Surfaced roads require more maintenance during wet weather, especially with heavy use. Unsurfaced roads should not be used during periods of wet weather and should be blocked prior to the onset of wet weather to limit access.



Well maintained and marked cross-drain

ROAD MAINTENANCE . . .



Effects of uncontrolled surface water creating gullies

Road Surface Drainage

Good management of road surface drainage protects the road surface from damage and mitigates impacts to other valuable resources such as water quality and aquatic habitat. Uncontrolled surface water can erode all parts of the road prism, and even light traffic can cause severe ruts on a wet surface. Once the surface is rutted, ruts often turn into gullies, sometimes moving much of the road surface into streams.

Disposal of Excess Soil, Rock and Woody Debris

Waste areas are locations for deposition of endhaul or “waste” — soil, rock and organic material, not petroleum products — material from road construction, reconstruction or road maintenance activities. Some general guidelines for good waste area location and management include:

- Locate away from streams and wetlands
- Shape with good drainage
- Utilize stable, relatively flat topography
- Broad, flat ridgetops are preferable
- Avoid being near steep slope breaks
- Use caution on midslope benches – they may be a result of an old slide feature
- Seed and mulch to reduce erosion



Good waste area location on a wide ridgetop

PRIORITIES FOR MAJOR REPAIRS

Road Surveys

A systematic road survey is necessary in order to make informed decisions about what road repairs are necessary and which locations should be repaired first. This survey should include all



Excessive outlet jump restricts juvenile fish passage

Priority Repairs Using Information from the Road Survey

Stream Crossings/Fish Passage

- Culvert outlet drops in fish bearing streams
- Non-embedded culvert with gradients above 0.5% slope
- Structures such as old log fills
- High washout potential due to an undersized structure and/or long steady grades below a stream crossing
- Scour, oversteepening or other erosion around culvert inlets or outlets
- Structural deterioration of pipe



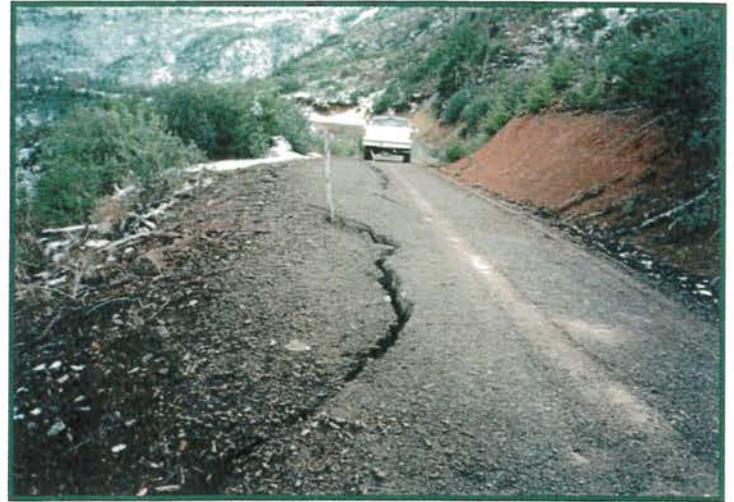
High priority for additional cross drainage to stop gullying

roads in an ownership and should collect information on: road surface drainage; road surfacing condition; stream crossing structures; and landslide risk. The **Forest Road Hazard Inventory Protocol** developed in Oregon includes all this information. Other survey protocols also collect necessary information. However, no survey will collect all information necessary for certain repairs, for example, design of replacement bridge structures or stabilization of large landslides. Therefore, additional field measurements are often necessary after priority repairs have been selected. The condition of roads near streams is an important consideration when prioritizing repairs. Roads near streams that are frequently muddy, or where a lot of historic erosion has occurred should be repair priorities.

PRIORITIES FOR MAJOR REPAIRS . . .

Sidecast Failures/Slope Stability

- Steep slopes
- Nearby slope failures
- High cutslopes — over 15 feet high
- Sidecast over two feet deep on steep slopes
- Fills supported by trees and/or organic debris
- Arc shaped cracks in the fill



Arc-shaped cracks in sidecast fill are evidence of a landslide starting to move



Exposed bridge fill next to stream will erode during high flows

Repair is often unnecessary:

- ✓ *Well drained stretches of road that are away from streams often need no repair*
- ✓ *Routine maintenance of drainage is often sufficient to protect streams and fish*
- ✓ *Target repairs only where they are really needed*

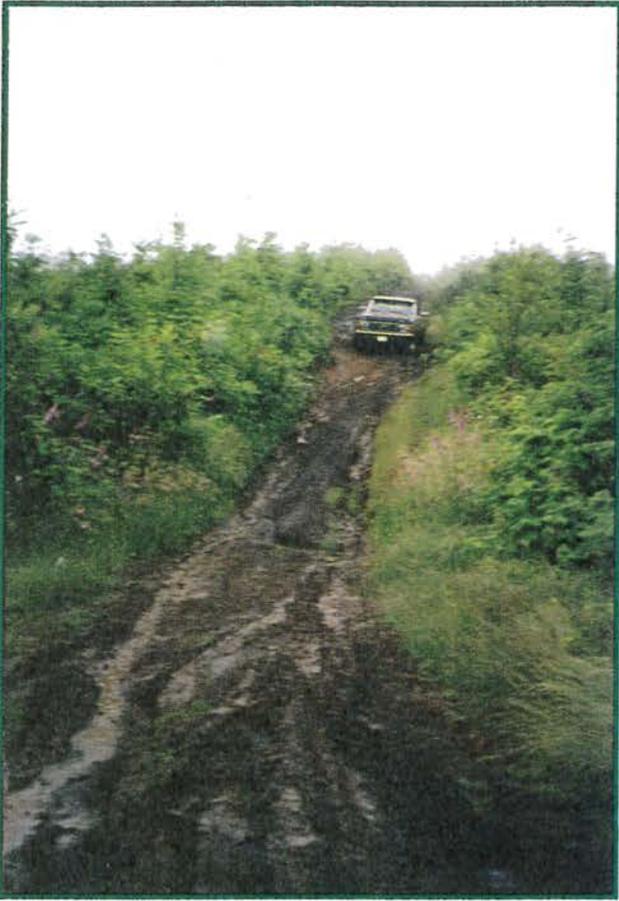


Damaged inlet greatly reduces flow capacity

Water Quality/Sediment Delivery

- Direct delivery of sediment in runoff water to streams
- Ditch downcutting
- Increase in heavy traffic
- Inadequate depth and/or poor quality road surfacing
- Damaged, collapsing, and/or inadequate drainage structures
- Eroding soil on cut and fill slopes
- Buried culverts
- Fill erosion at culvert outlet

PREVENTING DAMAGE FROM ROAD USE



Uncontrolled recreational use can cause severe erosion



Hauling on a wet, soft road surface can damage the road surfacing

Wet-season use of roads can result in increased stream turbidity and deposition of fine sediment in stream gravel. This occurs when the road surface is too soft to adequately support traffic, or when the surfacing material contains excess fine material. The proximity or direct connection of the road to the stream channel greatly affects the potential for fine sediment to enter streams and wetlands. The durability of the surfacing, traffic levels, and subgrade moisture all affect the potential for surface breakdown. Careful management of road use consistent with weather and durability of the surfacing can eliminate this potential problem.

The Problems

- Turbidity can be more detrimental to fish during low stream flow than turbidity during high stream flow because it is more likely to deposit in gravel at low flow
- Surfacing can sink into the subgrade — it is expensive to replace the gravel
- Hauling times are greatly increased
- Wet-season traffic on unsurfaced roads devastates surface drainage
- Even a few loaded trucks on a wet, soft road can do substantial damage

ROAD USE . . .

Durable surfacing is:

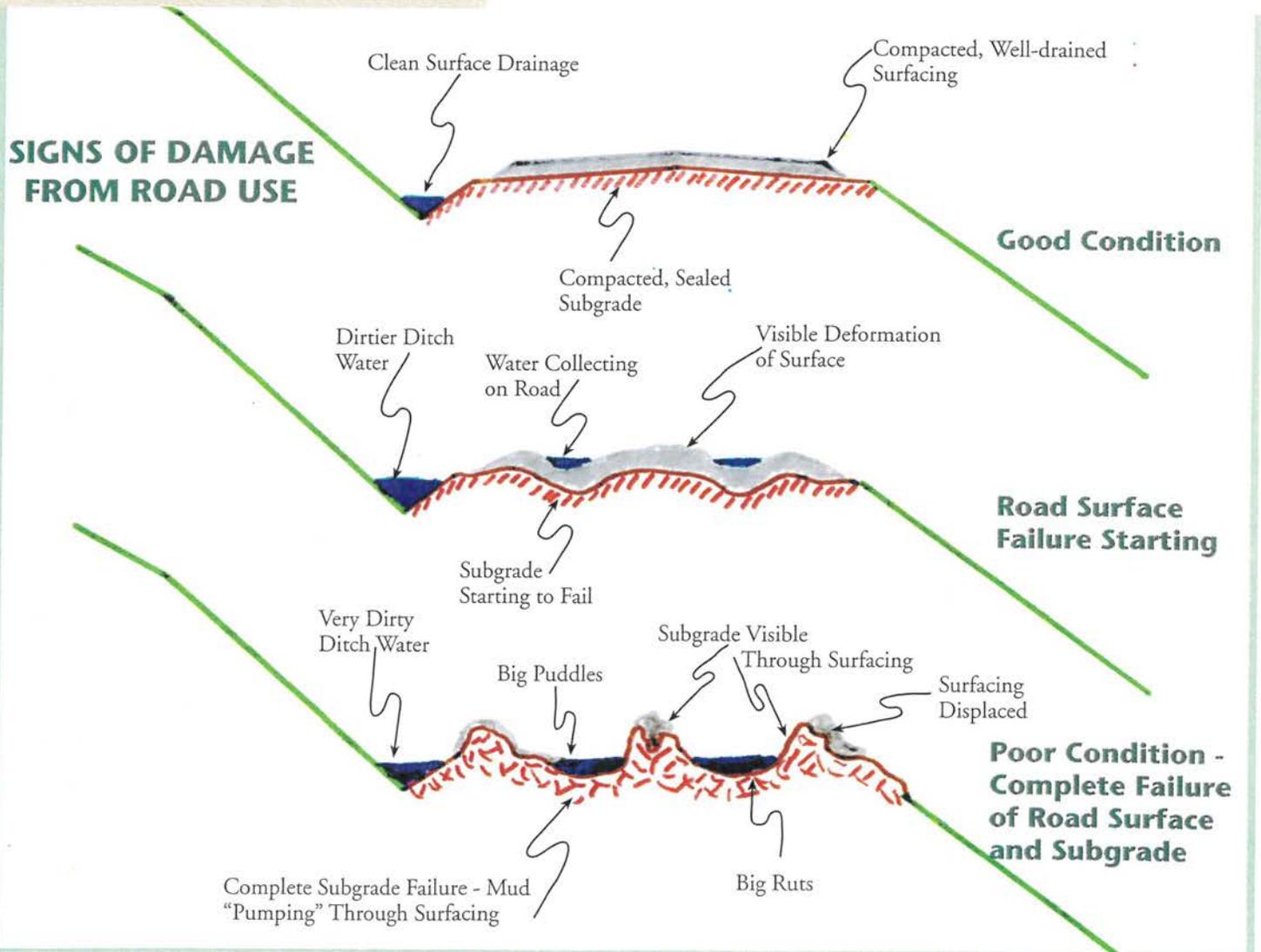
- ✓ *Hard rock, usually crushed, from basalt flow or igneous intrusive formations (sandstones and other sedimentary rocks found in Oregon are soft)*
- ✓ *Angular (round rocks do not pack well)*
- ✓ *Well graded (full range of fragments to pack tightly)*
- ✓ *Has a little clay to bind the particles together (however, too much clay and the rock loses most of its strength)*

Evidence of Inadequate Surfacing

- Badly rutted and uneven road surface
- Subgrade pumping through the gravel
- Muddy ditch water or road surface water entering relatively clean streams

How much surfacing is needed:

- If the subgrade can be well drained, a total depth of 10 to 12 inches will usually keep the surface stable if the road is not used during very wet periods, or during periods of thaw.
- A greater depth of surfacing, or the use of geotextiles under the surfacing are necessary where the subgrade is wet, soft, and cannot be effectively drained.



ROAD USE . . .

The Solutions

- Roads should be surfaced to handle the wettest road use condition
- Road users should be given criteria of when to cease or limit use
- Use gates and/or tank traps on inactive, unsurfaced roads, or consider vacating the road
- For road segments close to streams (at and near stream crossings, and roads in or near floodplains), add clean durable rock to the road surface before winter haul starts
- Provide drainage through snow berms prior to thaws
- Grade winter use roads frequently during use, since damage begins when water runs down ruts



Durable surfacing at stream crossing reduces sediment delivery potential



A gate can block uses that might damage the road



Road with durable surfacing can allow wet season use without sediment and turbidity problems

It's too wet to haul:

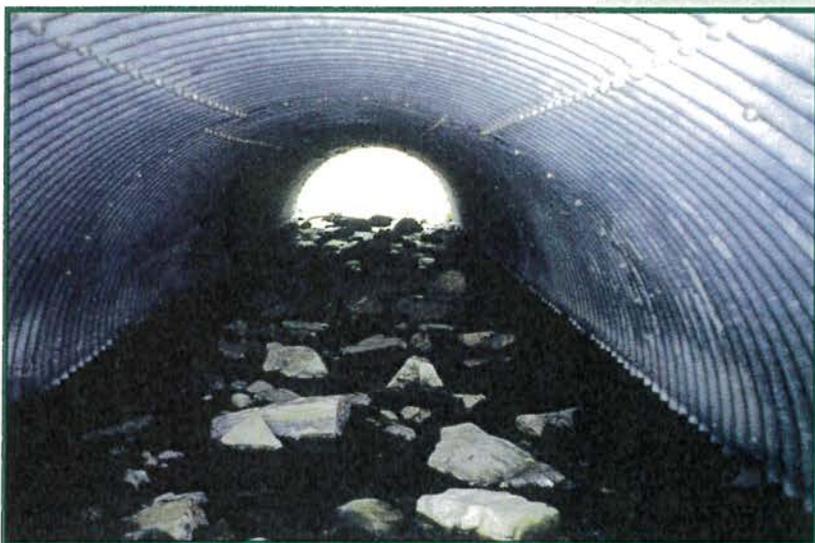
- *When ruts start to expose subgrade or*
- *When muddy runoff causes a visible increase in the color of stream channels*

REPAIRS TO IMPROVE FISH PASSAGE

Existing culverts often restrict the passage of juvenile fish, and sometimes even block adult fish migration. Culverts can increase water velocity, and can cause inlet or outlet drops. The smaller the fish, the more likely high velocity or drops will prevent these fish moving through the culvert. This section provides a brief summary of techniques used to provide for improved passage of these juvenile salmonids (trout and salmon). It does not



Juvenile salmonids that need to move upstream through stream crossings can be very small



Culverts that are seeded with cobbles or rocks can simulate natural streams

provide specific design information. For specific design information, refer to the **Oregon Road/Stream Crossing Restoration Guide**. Note that since there is little monitoring information on juvenile fish passage, the closer the installation resembles the natural stream, the more likely it is to pass juvenile fish.

Road repair options that can provide for juvenile fish passage include:

-  Retrofitted culverts with baffles or outlet weirs (newer culverts only)
-  New culverts at gradients less than 0.5 %
-  Countersunk round or arch culverts
-  New culverts with baffles
-  Open-bottom culverts
-  Bridges
-  Fords



Countersunk culverts can simulate the natural streambed

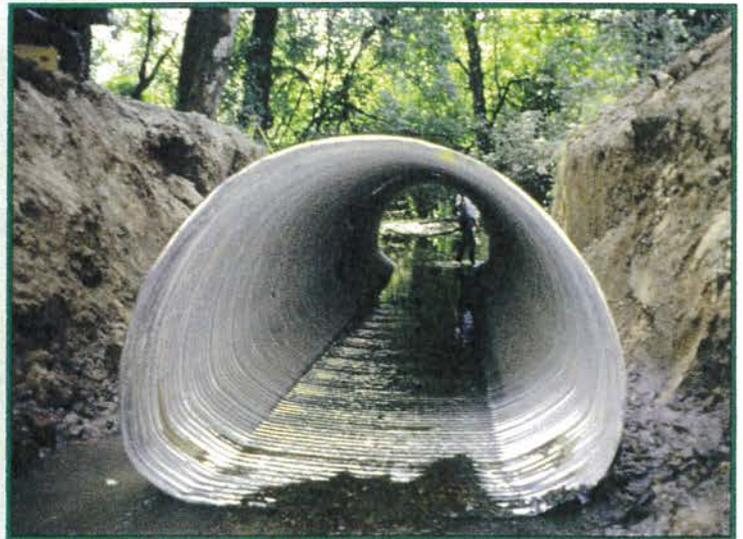
Culverts should be installed to avoid the following situations:

- Outlet drops
- Bare metal bottoms (gradient over 0.5%)
- Complete filling of the culvert by sediment
- Inlet drops caused by sediment deposition

Proper culvert design includes more than sizing for the 50-year peak flow. The design should also evaluate stream features such as:

- Stream gradient
- Elevation of the stream in relation to the road grade
- Stream width (active or un-vegetated width)
- Depth to bedrock
- Road alignment and grade
- Potential for sediment and debris movement during high flows
- Potential for sediment stored behind an old culvert to move downstream with the new installation

After repair, culverts must be able to pass flood flows. In Oregon, culverts must pass the 50-year flow without ponding above the top of inlet end of the pipe, a big safety factor.



Pipe-arch properly bedded at low gradient during installation

Retrofitting Existing Culverts

Retrofitting culverts is generally not recommended unless the culvert is over-sized for the 50-year peak flow because baffles, back-watering or outlet weirs will reduce the flow capacity of the structure.

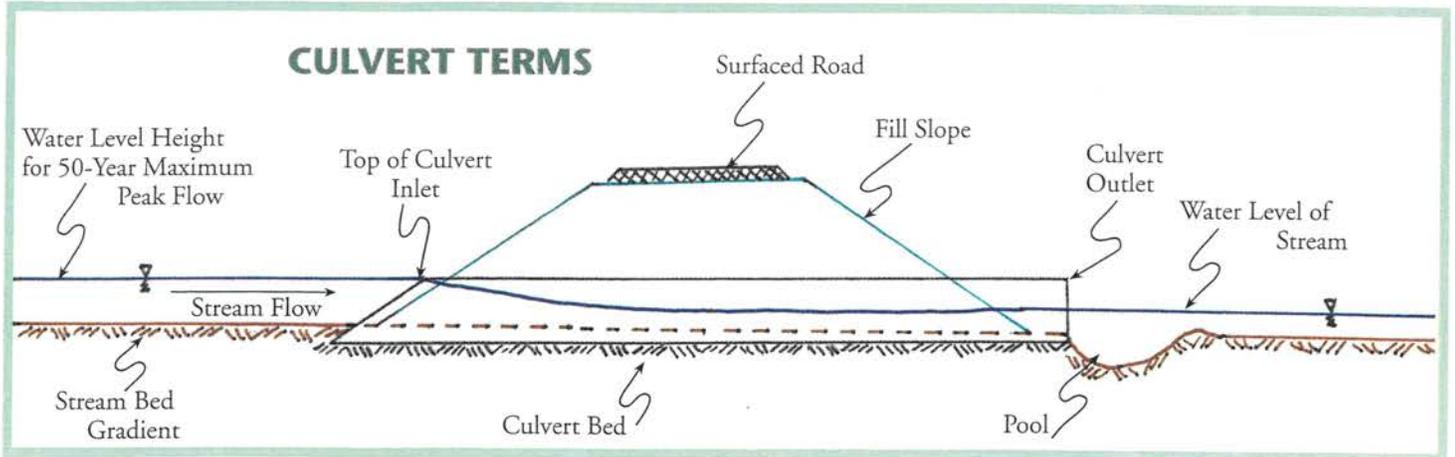
Weirs downstream of the outlet may improve fish passage, especially when used to repair a small outlet drop or to create a backwater in the pipe. Weirs should be constructed of riprap or other material large enough to remain stable during floods, and should not result in vertical drops that are barriers to juvenile fish.

Culverts, pipe-arches and bridges need careful engineering to meet both fish passage needs and to assure structural stability. Use precise engineering equipment, such as levels and a level rod, to ensure the proper elevation and slope gradient of a culvert.



Checking elevations with a level rod to ensure culvert is not installed at too steep of a gradient

FISH PASSAGE . . .



Countersinking

Countersinking is the partial burial of a culvert into the streambed (either the inlet, outlet, or both) where the elevation of the culvert is lower than the **original stream channel**. The objectives of countersinking are to reduce the velocity of normal streamflow within the culvert, and to reduce the likelihood of plunge pool development at the culvert outlet. Countersinking is also usually intended to allow stream gravel to deposit in the bottom of the culvert. For countersinking to work, it is generally necessary to re-establish the natural stream channel (where sediment has backed up behind an old fill) to the maximum extent possible.



Culvert with backwatering through outlet

Important considerations

- A culvert that is “invisible” to the stream is likely to develop a “natural” bottom where fish can move as if they were in the natural channel
- Culverts that are as wide as the active stream channel are more likely to pass large wood and sediment
- Seeding of culverts with large rocks may be necessary on steeper culverts to keep gravel in the bottom of the culvert
- It is difficult to ensure that fine gravels and sands deposit and remain in culverts approaching an 8% gradient
- Removing fills and allowing the stream to self excavate over a winter in order to find its natural channel is often the best solution where stream sediment has built up behind the fill



Steep culvert gradient without countersinking

Potential countersinking problems

- Bedrock may be encountered, and can prevent proper bedding of the culvert
- A significant amount of excavation may be required when years of stream sediment have accumulated above the old fill

FISH PASSAGE . . .



Proper equipment to install a large culvert

Baffled Culverts

- Structures should be designed by persons with expertise in engineering hydraulics
- Can be used on steep gradient streams when properly designed
- Can be retrofitted to existing culverts if adequate flow capacity exists
- Generally cost less than open-bottom culverts



Short-span reinforced concrete bridge is less expensive than a pre-stressed concrete bridge



Railroad flatcar bridges are a low-cost alternative when available

Open-Bottom Culverts

- Require a stable foundation, usually bedrock
- Needs an investigation of foundation conditions
- May collapse if streamflow erodes the foundation
- Can be used over all stream gradients
- Maintain a nearly natural stream bottom
- Are similar to bridges in cost

Bridges

- Can be used over all stream gradients
- Provide the best fish passage
- Must be designed properly
- Need stable abutment foundations
- Can be temporary or permanent
- Are not practical where sharp curves are needed (steep slope areas)
- Pass debris more reliably than culverts

FISH PASSAGE . . .

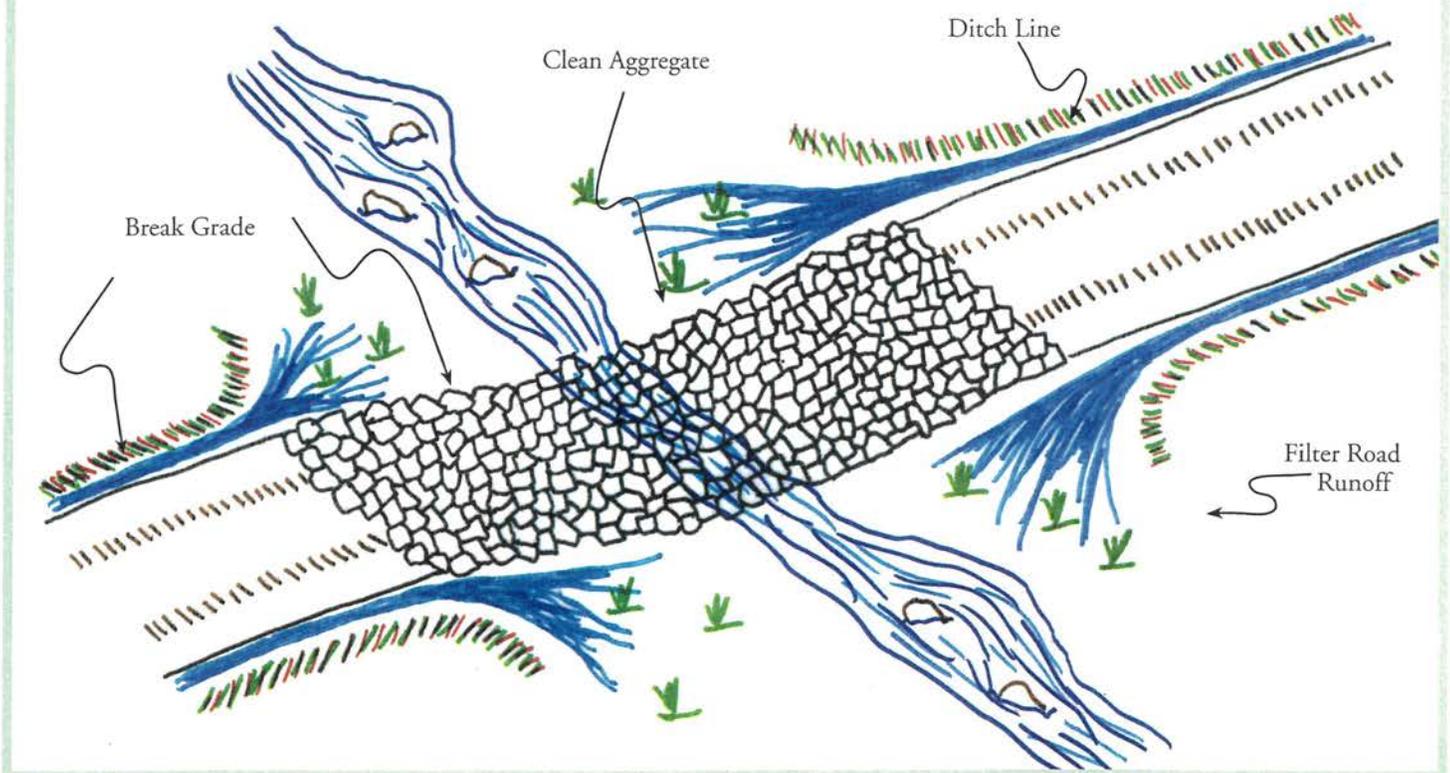
Fords

In some cases, fords can have the least impact on stream channels and fish passage. They pass large wood and have the lowest washout hazard. With fords, the major



Low impact ford with rocked approaches

STREAM FORD



concerns are delivery of fine sediment and loss of vehicle access during very wet periods. Fords can include structures that pass low flows, allowing for increased traffic. Structures that carry low water protect water quality, but can impede fish passage. Fords should be removed prior to likely high stream flows and periods of fish migration if they were not designed for these events.

Ford Installation

- Divert and filter road drainage runoff before it enters stream
- Armor approaches with clean, open graded aggregate for 100 to 200 feet on each side of stream
- Keep crossing perpendicular to stream
- Choose an area where the stream bottom is solid and stable, preferably in areas of solid bedrock
- Do not use during wet weather and/or high water flow
- Fords that cannot pass water under the roadway are not appropriate for heavy use

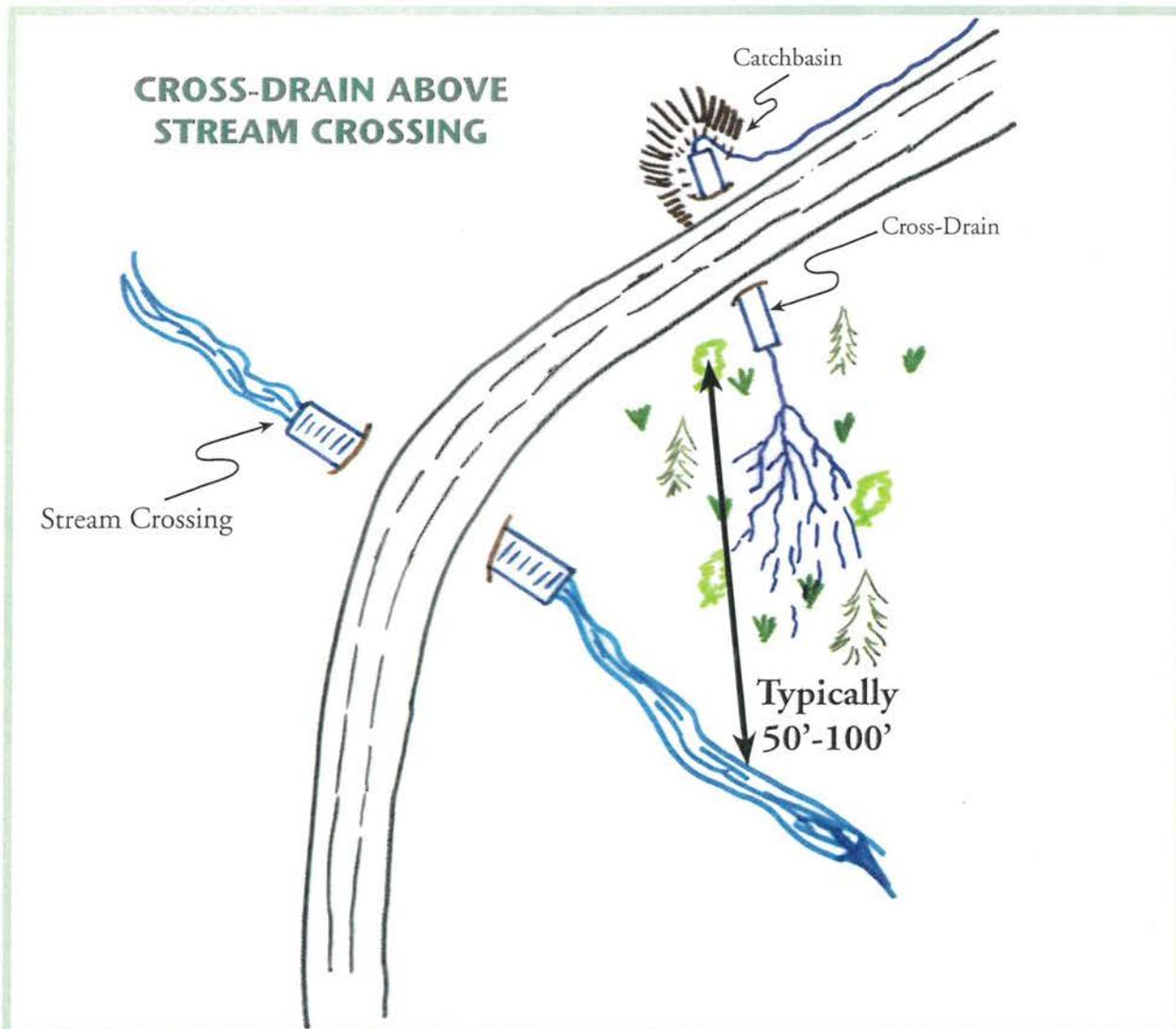
FISH PASSAGE . . .

Concurrent Repairs

When upgrading stream crossings, make sure surface drainage waters are filtered above the crossing. Add new cross drains if good filtering locations are available, especially when the ditch is scoured or more than a few hundred feet of road drains directly to the stream. Also, when replacing culverts for fish passage, make sure the new pipe can pass at least the 50-year peak flow.



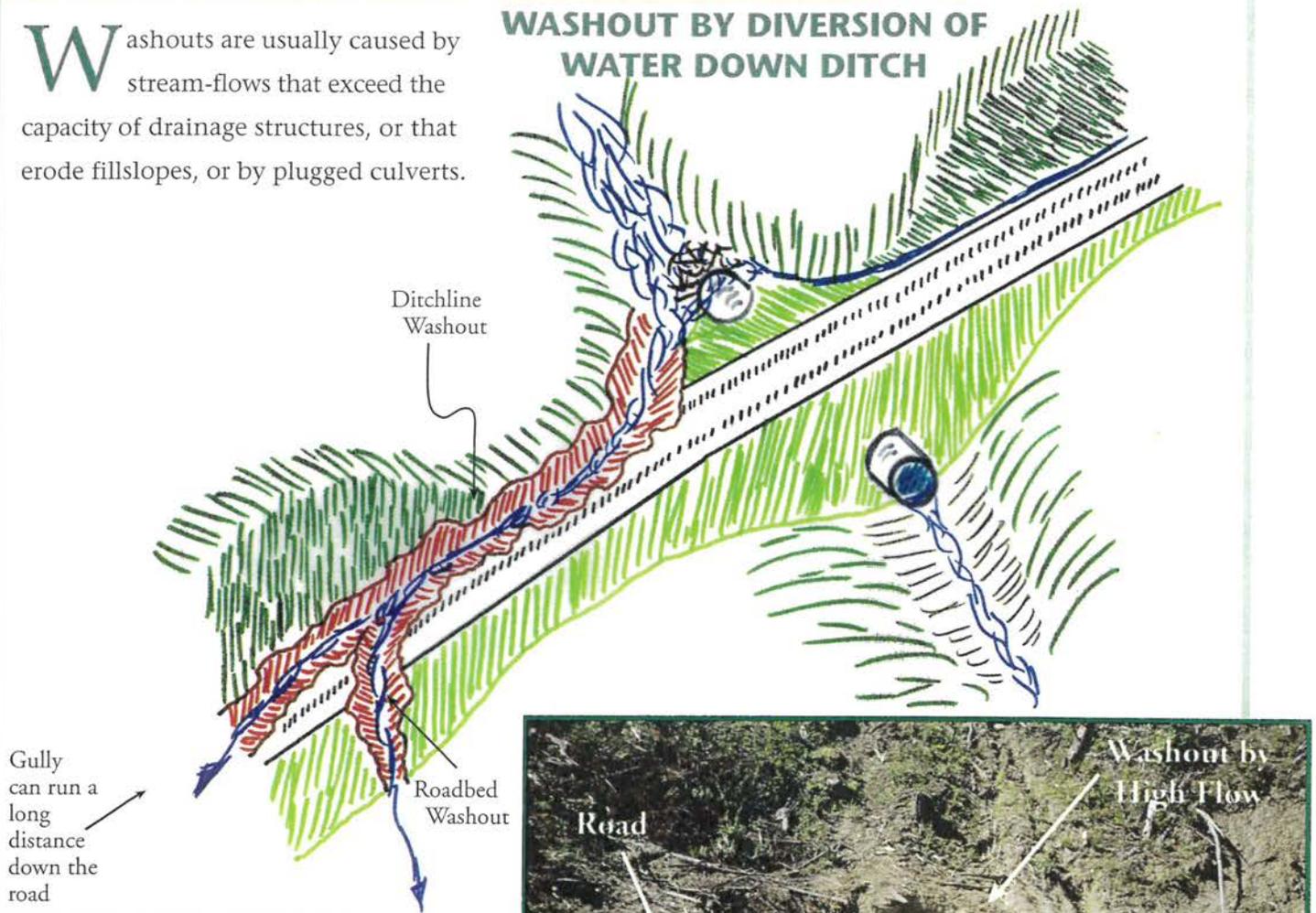
Newly constructed ditch relief designed to filter sediment



REPAIRS TO PREVENT WASHOUTS

Washouts are usually caused by stream-flows that exceed the capacity of drainage structures, or that erode fillslopes, or by plugged culverts.

WASHOUT BY DIVERSION OF WATER DOWN DITCH



Washout Problems

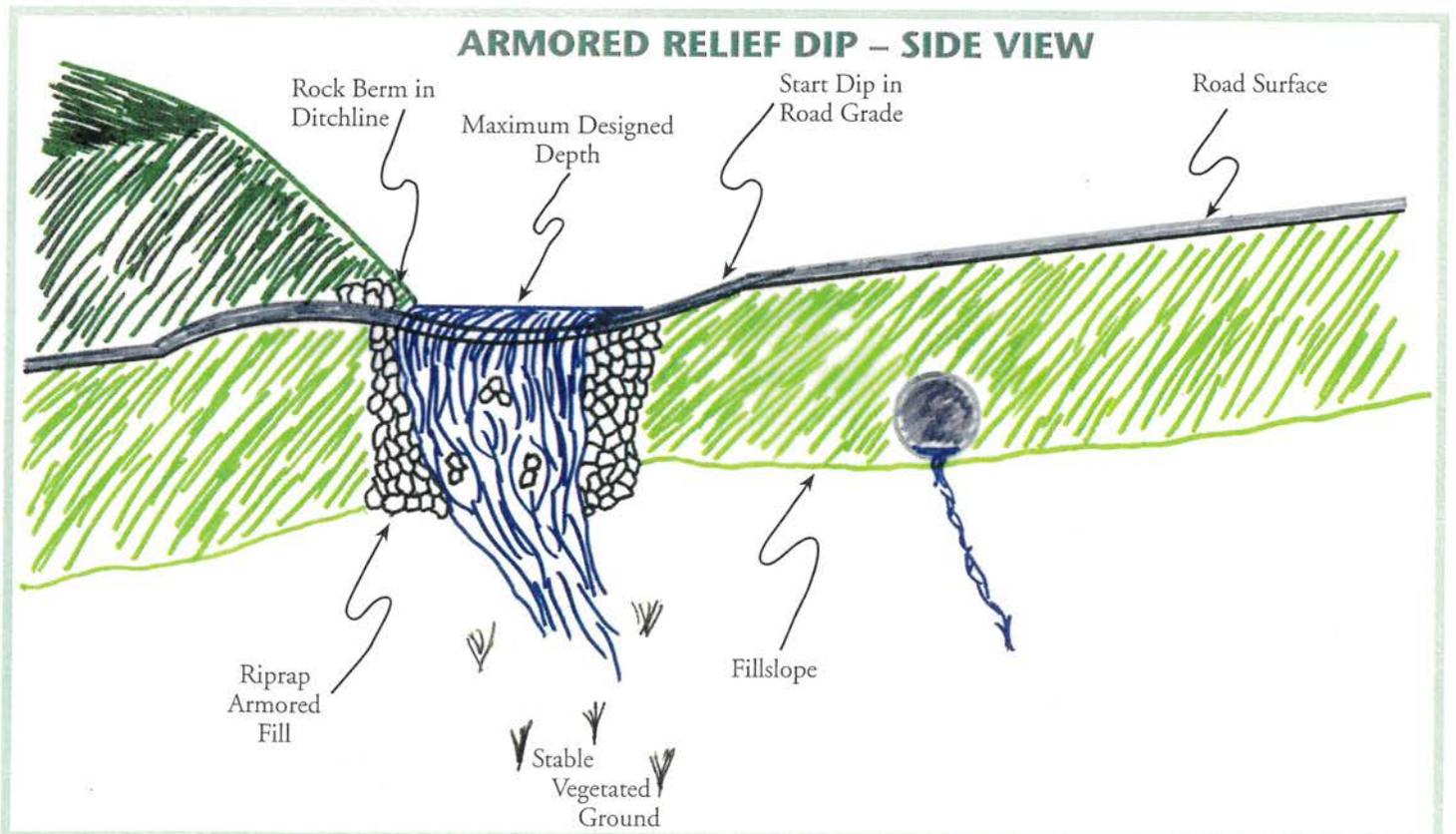
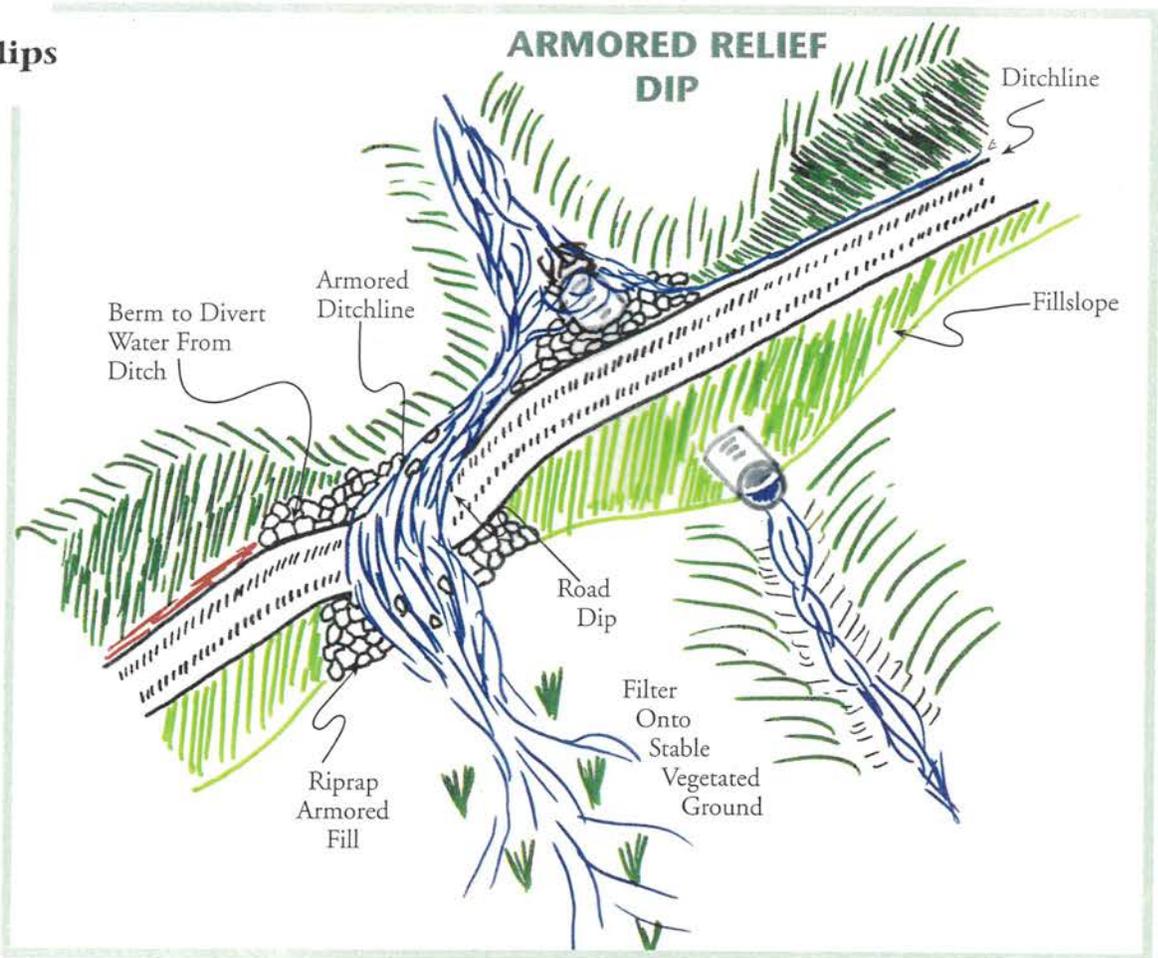
- Culverts that plug where there is no overflow structure
- Undersized culverts
- Debris upstream that can plug culverts
- Long, steady road grade below stream crossings
- No relief dip
- Flood waters run down the road
- "Domino effect" downgrade of the crossing
- Ditch and road can turn into giant gully
- Overwhelms downgrade cross-drain(s)
- Potential to affect substantial length of road segment

Preventing Washouts

- ✓ Design stream crossings to pass 50-year flow with no ponding above the top of the inlet
- ✓ Armor relief dips
- ✓ Eliminate road edge berms that keep water on the road
- ✓ Construct berm or plug in ditchline below stream crossings
- ✓ Where possible, reduce the height of fills over culverts
- ✓ Remove old log fill culverts

Armored relief dips

- Riprap reinforced fill on upstream (inlet) side of culvert
- Riprap-reinforced fill on downslope side of dip
- Berm in ditchline below dip to divert any overflow from ditchline through the armored dip
- Overflow water is dissipated and filtered onto stable slope and vegetation
- Use a complete road grade reversal within length of dip

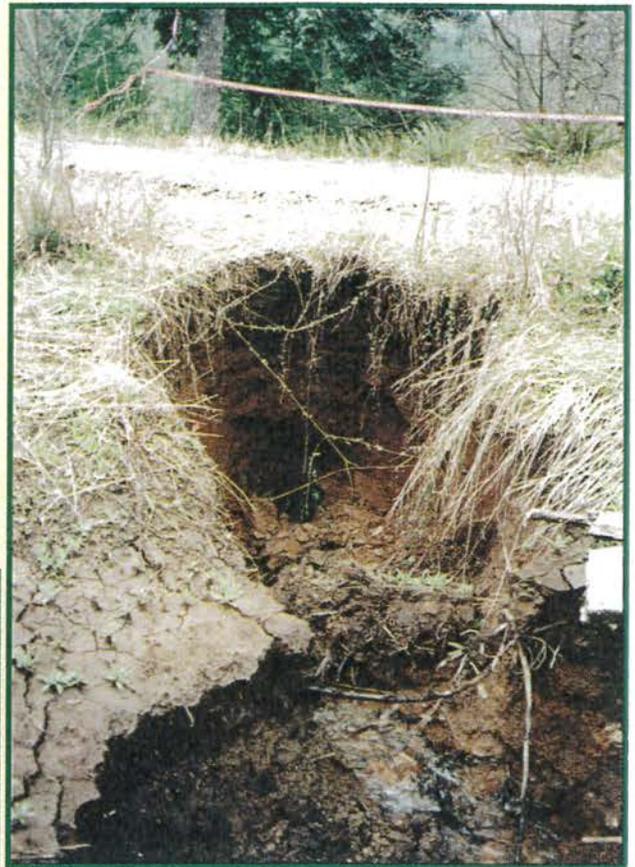


WASHOUTS . . .

Log culverts buried in fills pose one of the highest risks for fill failure. They are difficult to detect and there is no way to predict when they will fail. They may fail catastrophically, creating a dam-break flood, or may fail slowly, resulting in chronic stream turbidity.



Old log fill failure seriously damaged the road and water quality



This hole in the fill is evidence of log fill starting to fail

Replacing log culverts

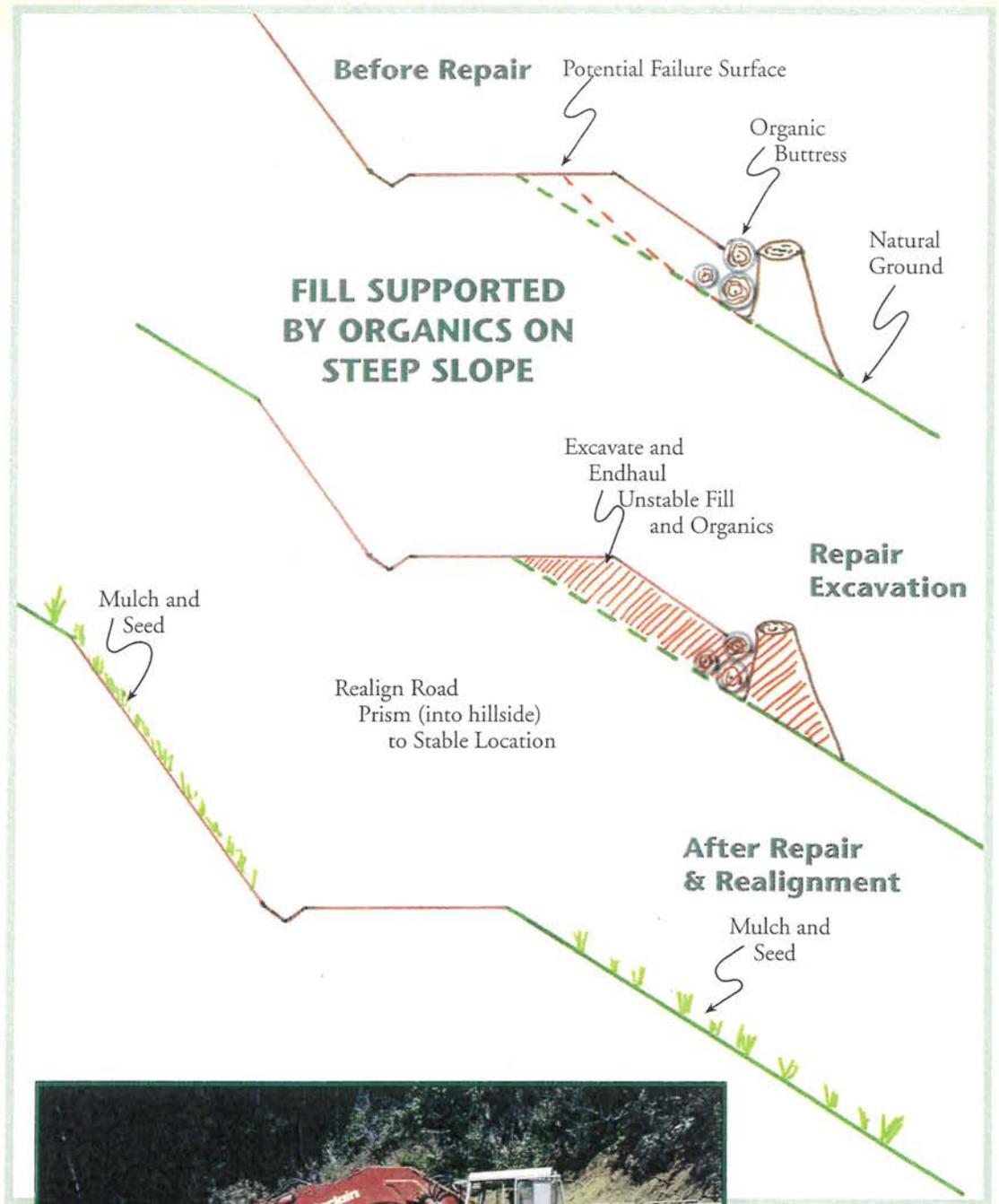
- Remove all old logs and muck
- Replace drainage structure
- Where feasible, re-establish old channel grade
- Reestablish stable, compacted fill
- Revegetate, stabilize fill slopes to minimize erosion



Good example of repair with a stabilized free-draining fill, and revegetated soil

REPAIRS TO PREVENT SIDECAST FAILURES AND STABILIZE LANDSLIDES

Road-related landslides are categorized into sidecast failures, fill failures, base or loading failures, cutslope failures, and deep-seated landslides. Sidecast failures are sometimes common on older roads on steep slopes. Most road repairs deal with reducing the sidecast landslide hazard. This guidebook deals only with sidecast failures and cutslope failures. Large landslides should be investigated by a geotechnical specialist prior to repair. In many cases, these landslides cannot be economically stabilized. The road can be relocated, or it can be kept open with the grade conforming to the landslide movement. Fill should not be placed on large, actively moving landslides. Road water should be routed away from large, actively moving landslides.



Endhaul excavation of unstable sidecast

LANDSLIDES . . .

Evidence of Sidecast Landslide Potential

- ✓ Steep slopes
- ✓ Nearby landslide scars
- ✓ Arc-shaped cracks along the outside edge of the road
- ✓ Fill perched on vegetation or debris
- ✓ Cutslopes over 15 feet high
- ✓ Road location around hard rock outcrop

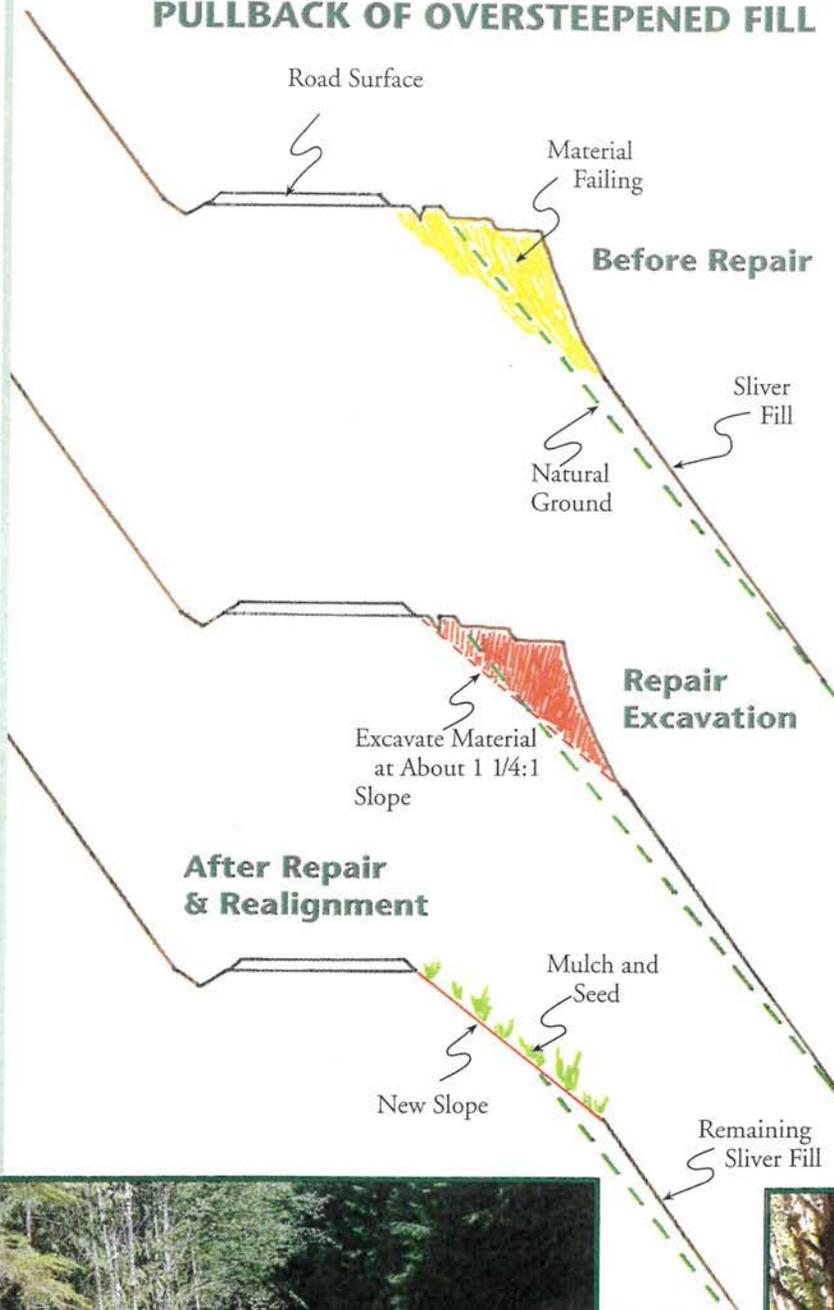
Steep Slopes Include:

- Any slope over 70%
- Headwalls over 60%
- Stream banks where road fill is adjacent to or above streams
- Debris flow scars below the road are evidence of problems

Indicators of Higher Risk to Resources

- Upper end of watershed location
- No benches between road and stream
- No sharp channel junctions (over 70 degrees) between road and stream

FILL FAILURE ON STEEP SLOPE: PULLBACK OF OVERSTEEPENED FILL



Example of good sidecast pullback –
Note old fill marks on stumps



LANDSLIDES . . .

Repair of Sidecast Roads

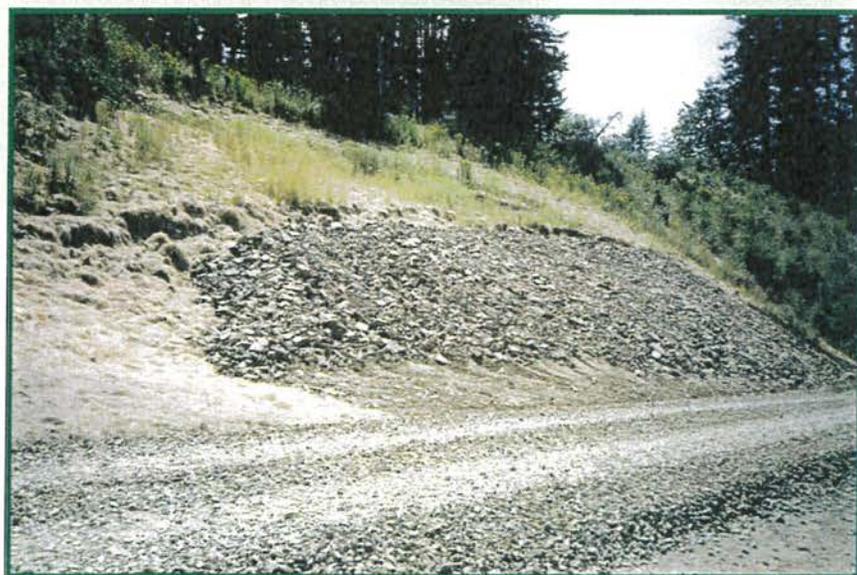
- Usually requires pullback by an excavator
- Remove all fill perched above debris
- Flatten upper slopes on sliver fills
- Haul soil to a stable location
- Woody debris can be scattered downslope if not mixed with soil
- Just scraping the surface can make problems worse
- May need to widen road into cut bank to maintain a safe width
- Construct uniform slope that will drain (no bench or notch cut) at the base of the pullback

Concurrent Repairs

If adding new culverts, make sure the outlets do not direct water onto steep sidecast fills. In limited cases it may necessary to direct water to stream channels without providing filtering, since directing water onto steep slopes can create a far greater water quality problem.



Cutslope and fillslope failure caused by road located through steep slopes in weak rock



Free-draining rock fill buttress stabilizing the slope

Cutslope Instability

Scale of Problem

- ✓ The failure is over 50 cubic yards (approximately 5 dump truck loads)
- ✓ Cracks seen above (walk up there if question)
- ✓ There is a history of failures at this location
- ✓ May be evidence of a large scale problem, and a geotechnical specialist should be consulted

Typical Repair

- Remove material and haul to stable location

Repair of Larger Cutslope Slide

- Free draining rock fill buttress

Repeated Failures

- Consider insloping road (so that drain is less likely to be diverted to the fill)
- Where feasible, add an additional cross-drain upslope to divert ditchline water before it reaches the problem area
- It may be necessary to vacate these problem road segments

REPAIRS TO REDUCE CHRONIC TURBIDITY

Surface erosion, if uncontrolled, can result in chronic erosion during the wet season. If the eroded material enters streams, this results in turbidity (muddy water). Turbidity lowers water quality (for drinking water and other beneficial uses). Fine sediments can also deposit in stream gravels and impact fish, their eggs and other aquatic life. Chronic sediments are especially damaging during low and moderate flow periods, when they can settle into gravels. At high flows, much of the fine sediment is washed through the stream system. When possible, keep stream water and road water separate.

Outlet erosion at cross drains

Cross drainage water that flows on to steep slopes of fill material causes erosion, and

may lead to landslides. Where there is evidence of continuing erosion, consider:

- ✓ Flumes installed on culvert outlets to direct water over the fill
- ✓ Large riprap to armor the fill or steep slope
- ✓ Additional culvert(s) up the road from the problem location

Filtering

To cause problems, the eroded materials must enter streams. One solution to a sediment problem is to provide additional cross drainage above stream crossings. In the Pacific Northwest, undisturbed soils are typically permeable, meaning water flows easily into them and overland flow is uncommon. This fact can aid the road manager, since it is often less expensive to improve drainage than it is to stop all erosion on-site. To be effective, cross drains should be placed at least 50 to 100 feet from streams, and directed onto uncompacted slopes which are less than a 60 percent sideslope. **Water must not be directed onto very steep fills or old landslides.**

Other repairs

When filtering is not possible, it is usually necessary to either control erosion on-site, or to cause the sediment to settle out of the water.

On-site controls include:

- Slope revegetation
- Armoring slopes with rock
- Use of geotextiles

It is often more effective to trap sediment using:

- Hay bales
- Settling ponds

These should be installed before water enters the streams, and above high water level. These need to be cleaned periodically.



Road surface sediment captured by temporary filter of hay bales in ditchline

Ditch downcutting

When roadside ditches cut deeper and deeper, there is too much water flowing in the ditch. Additional cross drain culverts are needed when ditch downcutting is observed, or when there are no cross drain culverts within a few hundred feet of stream crossings. The recommended diameter for a cross drain culvert is 18 inches. If it is not possible to add culverts, rocking the ditch may be the only solution. Coarse (up to a six inch diameter or so), fairly clean rock will usually prevent additional erosion, and often causes a lot of the sediment to settle out. Rock can also be placed to create sediment ponds. Ditches should be nearly filled in the locations where there is downcutting to achieve maximum sediment retention.

Do not carry stream flow down the ditchline. This greatly increases the potential for increased turbidity in streams and ditch downcutting.

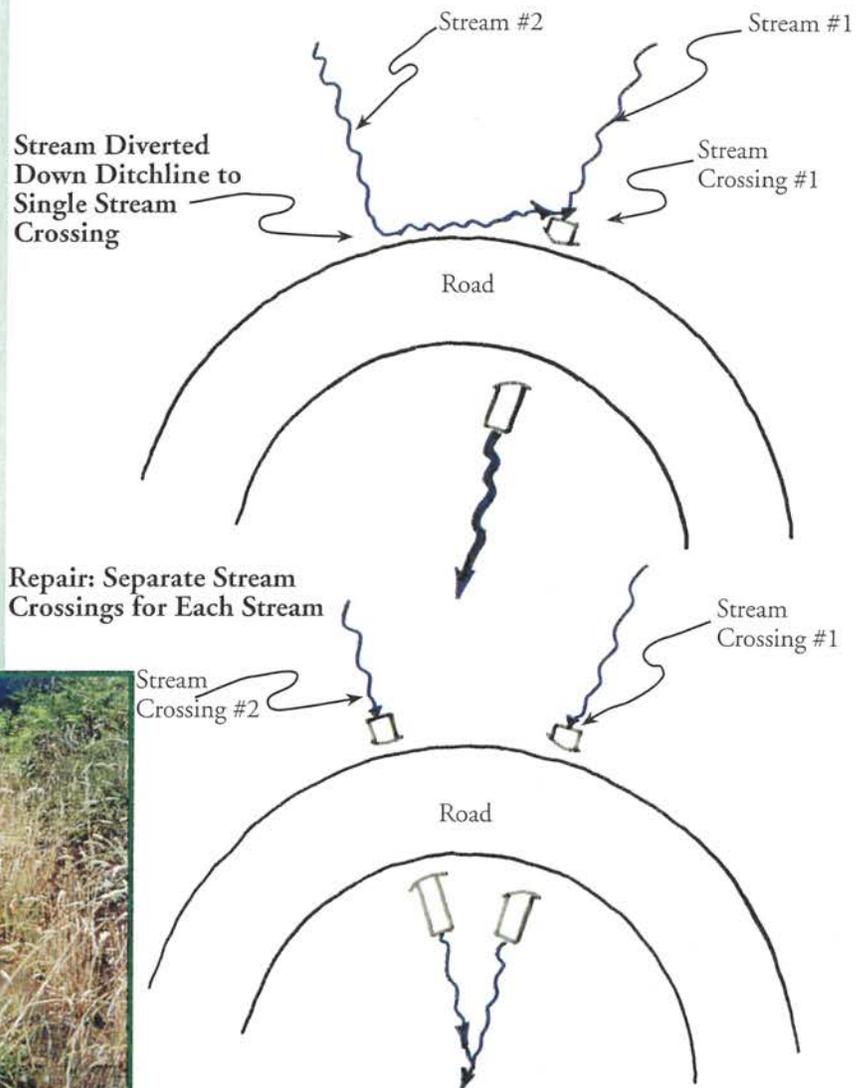


Natural vegetation in ditches helps filter the sediment

Cleaning Ditches

Clean ditches only when they cannot carry road runoff. A well vegetated ditch can keep sediment from entering streams. When water starts running down the road, that part of the ditch needs cleaning. Do not clean more ditches than necessary. It is also important to divert and filter water to stable locations away from streams.

DIVERTED STREAM: Undesirable Situation



VACATING AND RELOCATING ROADS

Vacating

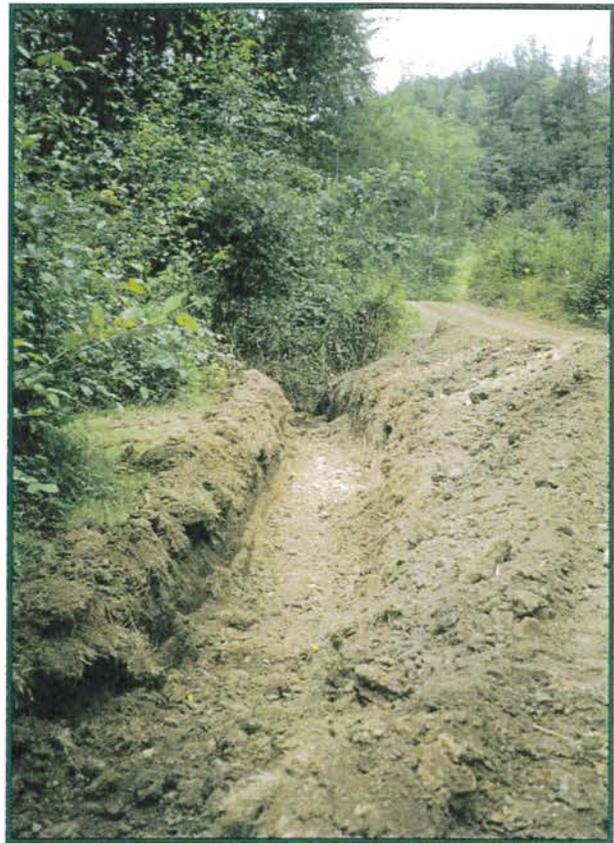
A vacated road has been left in a condition where traffic cannot use the road, and where erosion is unlikely.

Target Roads Where:

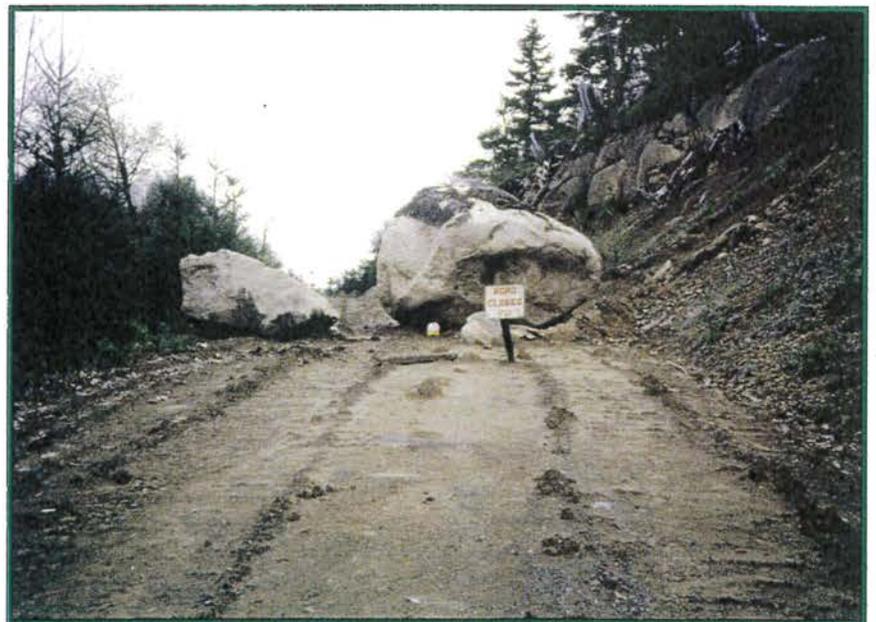
- Access is not needed for management activities
- Serious erosion is occurring, or is very likely
- Costs of adequate maintenance (over the long term) exceed vacating costs
- A stream is adjacent to the road

Road Vacating Goal: To leave the road in a self-maintaining condition

- Excavate stream crossings to remove entire fill and culvert
- Fill material should be excavated to recreate the original channel grade and orientation
- If there is room, place fill material in the bench portion of the adjacent road prism, otherwise it must be hauled to a stable location
- Remove steep sidecast (if it could fail and enter a stream)
- Remove fills on large landslides and reestablish ground profile as close as possible to the natural terrain
- Block access to all motor vehicles using tank traps or other physical barriers



Tank trap used to keep all traffic from using the road



Boulders are good physical barriers that will keep traffic off of vacated roads

VACATING . . .

Road surface runoff and other drainage structures:

- Ensure adequate, self-maintaining surface drainage
- Keep drainage water away from steep slopes
- Prevent erosion and delivery of sediment to a stream



Complete removal of road prism in a steep slope area

Cross-road ditches

- Intercept flow from inside ditchlines
- Deeper than standard waterbars
- Drain out onto stable, vegetated ground
- Space 100 to 300 feet apart



Cross-road ditch captures all surface drainage water

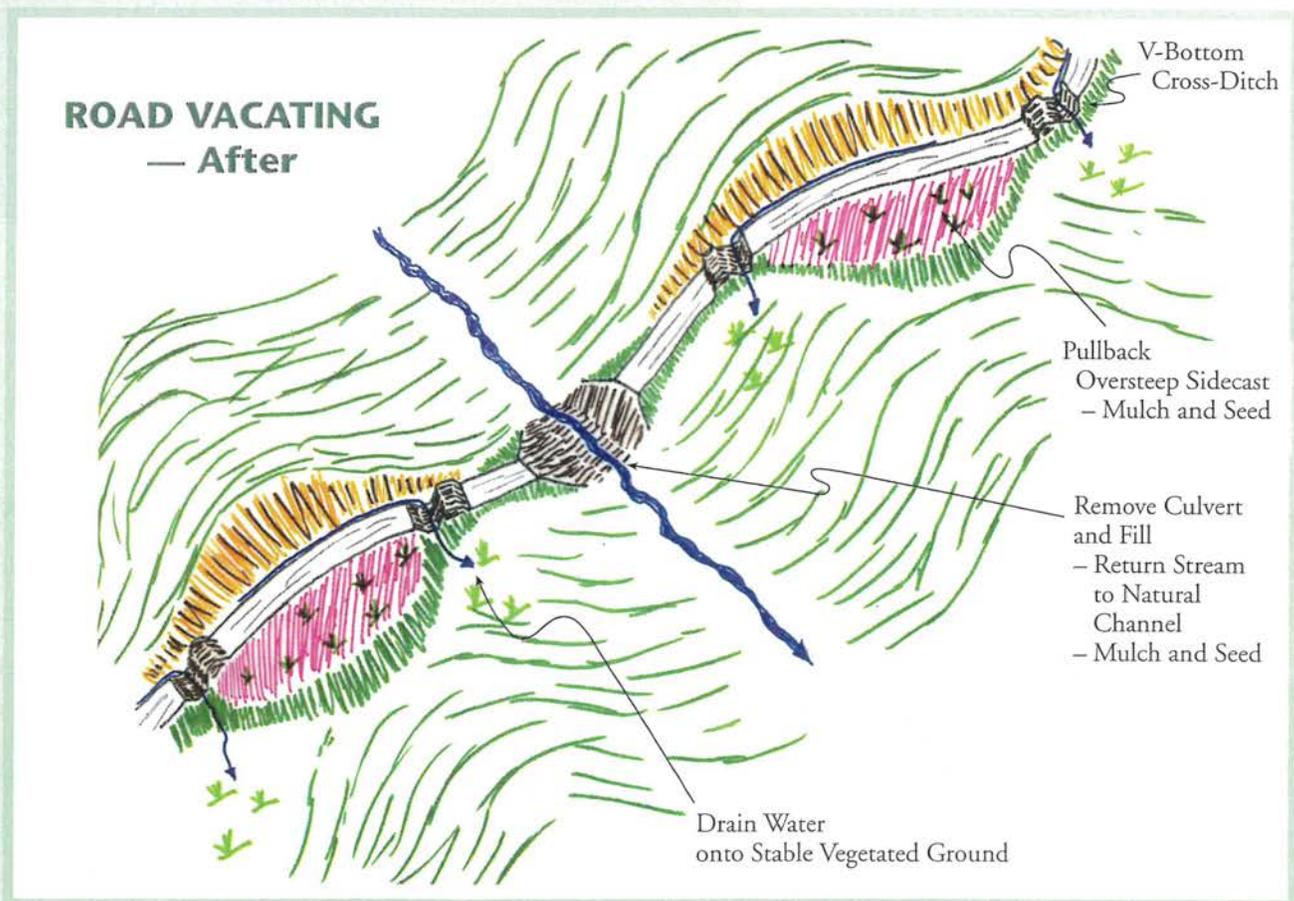
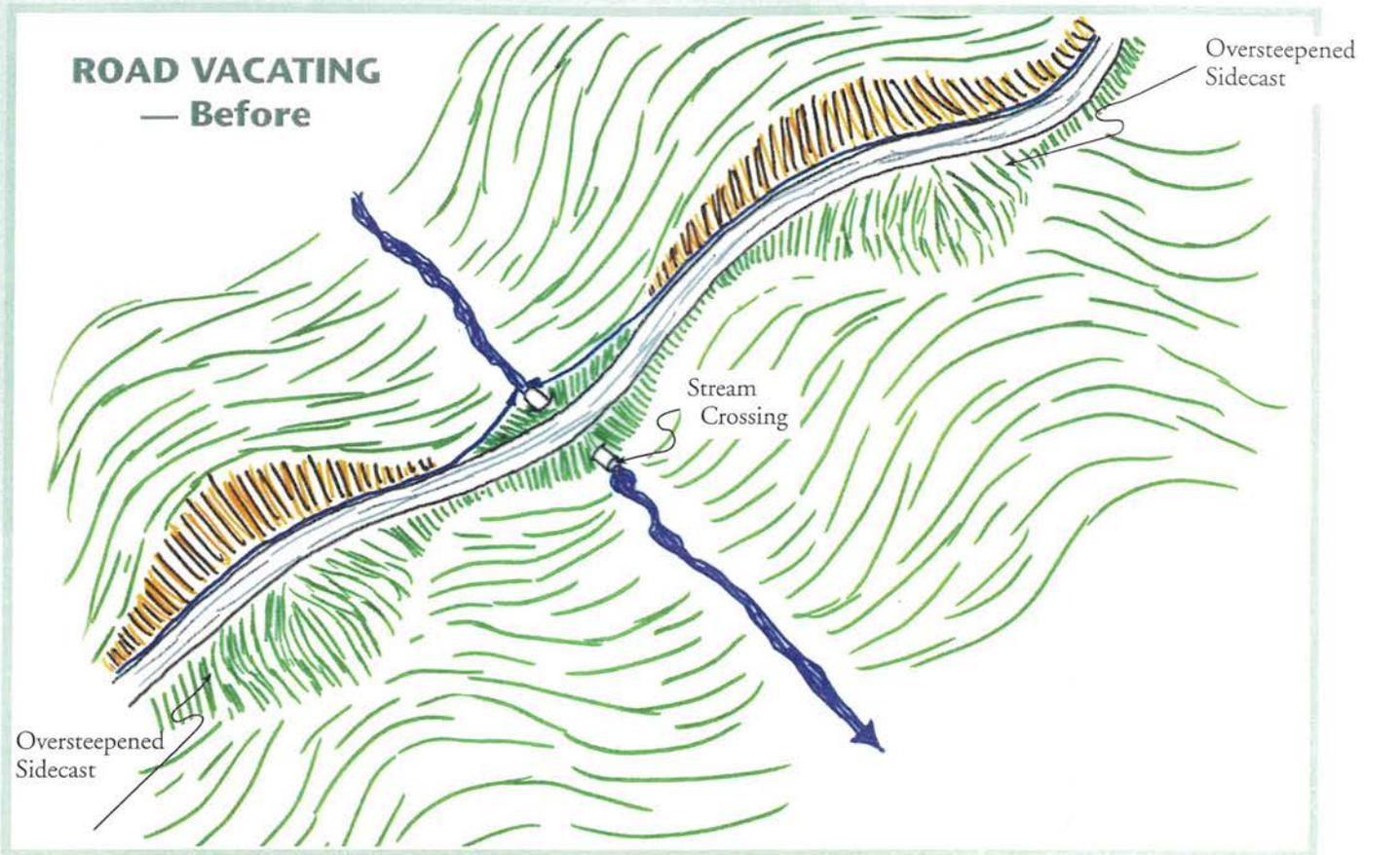


Berms must be cut-through to provide drainage

Remove outside edge berms on roads:

- Keep water draining off road surface rather than channeling it down the road
- Revegetate exposed soil where necessary

VACATING AND RELOCATING ROADS . . .



SOURCES OF ADDITIONAL INFORMATION

Useful References

- Fish Passage Design at Road Culverts** – A design manual for fish passage at road crossings. Washington Department of Fish and Wildlife. March 1999.
- * **Forest Practices Field Guide.** Oregon Department of Forestry. 1999.
 - Forest Practices Illustrated.** Washington Department of Natural Resources. 1997.
 - Forest Road Engineering Guidebook.** British Columbia Ministries of Forestry and Environment. 1995.
 - * **Forest Road Hazard Inventory Protocol.** Oregon Department of Forestry, Forest Practices Program. 1997.
 - Forestry for Idaho BMP's.** Idaho Department of Lands. 1996.
 - Handbook for Forest and Ranch Roads.** Weaver, W.E. and D.K. Hagans. Mendocino County Resource Conservation District. 1994.
 - Montana Forestry Best Management Practices.** Montana Division of State Lands. 1991.
 - * **Oregon Road/Stream Crossing Restoration Guide:** Advanced Fish Passage Training Version. Oregon Department of Forestry. Spring 1999 (or later version if available).
 - * **Road Sediment Monitoring Project Report: Survey of Road Drainage in Western Oregon.** Oregon Department of Forestry, Forest Practices Monitoring Program. 1995, 1996 and 1997.
 - * **Storm Impacts and Landslides of 1996: Final Report.** Robison, G., K. Mills, J. Paul, L. Dent , and A. Skaugset. Forest Practices Technical Report #4. Oregon Department of Forestry. 1999.
 - * **Water Bar Systems Manual.** Goeller, S. 1999.
 - ** **Watershed Restoration Reporting Form.** Oregon Watershed Enhancement Board. 1999 (or later version)
- * Available from Oregon Department of forestry field offices or by calling (503) 945-7470 and generally available at www.odf.state.or.us.
** Available from the Oregon Watershed Enhancement Board and at www.oregon-plan.org under [Status/Monitoring](#)

Sources of Technical Assistance

Forest Practices Foresters – for information on forest practices rules, rule compliance, notification and planning requirements

Fishery Biologists – for information on the types, needs, time of use and other information about fish in streams near roads

Forest Engineers – for most road location and design issues

Civil Engineers – for structural bridge design and hydraulic analysis of complex culvert installations (baffles, weirs, etc.)

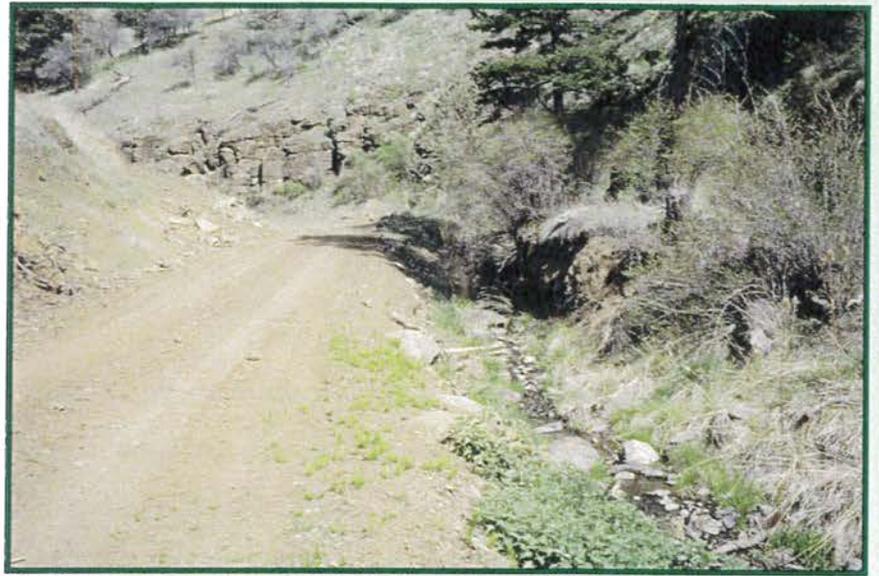
Geotechnical Engineers and Engineering Geologists – for landslide and sidecast fill slope stability analysis, waste disposal areas, and bridge and culvert foundations

VACATING AND RELOCATING ROADS . . .

Relocating

Purpose is to actively target and treat those segments of road which:

- ✓ Are needed for continued access
- ✓ Have the potential to significantly impact water quality and/or slope stability
- ✓ Have location and design options that will reduce impacts at a reasonable cost



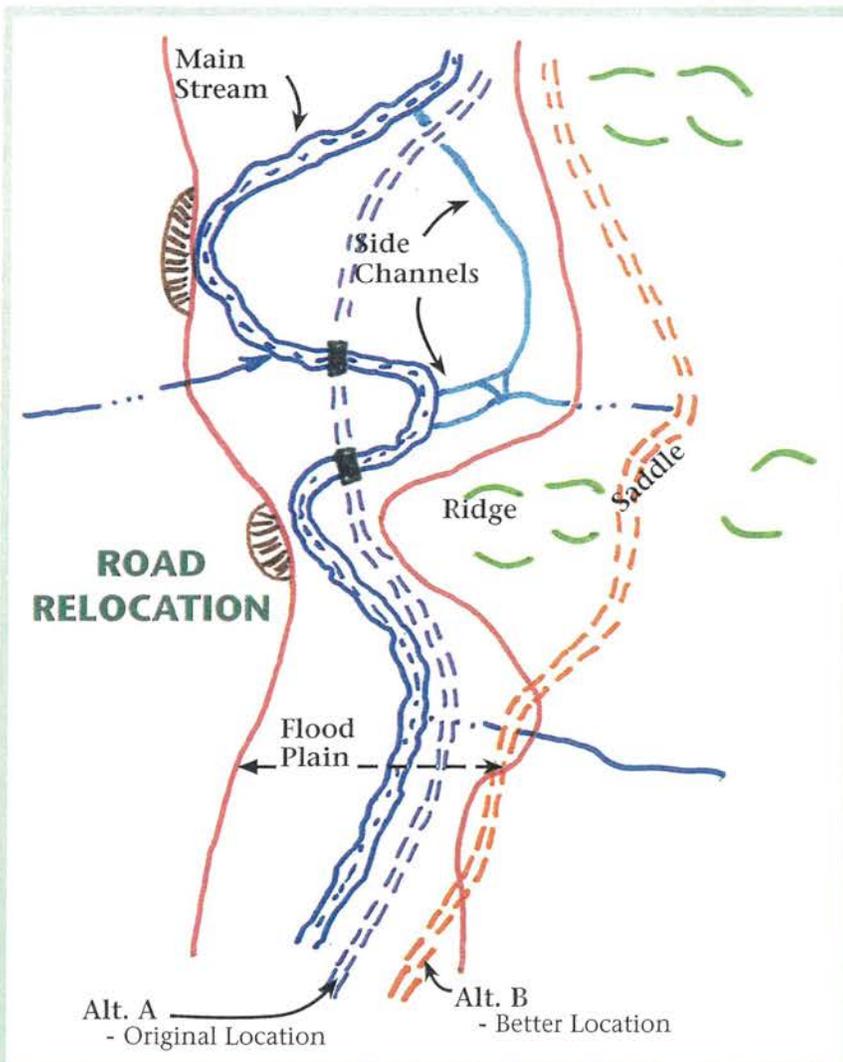
Road next to streams often result in sediment delivery

Areas of high potential impacts include:

- Roads located parallel to streams and within the flood plain
- Roads that cross streams and side channels excessively
- Roads across unstable areas that have experienced frequent landslides

Basic principles of relocation include:

- Move the road above the flood plain
- Move the road near ridgelines where possible; use the topography to follow naturally stable, drier areas
- Avoid valley bottoms, crossing side channels low in the drainage, wetlands, flat areas without distinct drainage patterns



This guidebook has been developed by the Oregon Department of Forestry, Forest Practices Program, in cooperation with the: Oregon Forest Industries Council, Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality and the Department of Forest Engineering at Oregon State University.

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