3.0 Road Deactivation Assessments and Prescriptions

3.1 Introduction

Detailed field assessments and prescriptions for road deactivation may be carried out as part of hillslope restoration for roads or road segments. Often these will be identified in an overview assessment as having potential risk to downslope resources and values. Appropriately qualified field personnel usually carry out these assessments and prescriptions and the use of qualified registered professionals may be necessary.

For project areas with many kilometres of road requiring deactivation, it may be prudent to only assess and prescribe the amount of road that can be deactivated in one field season. This staged approach will also help to ensure that field markings are ‘fresh’ and that the most recent information is available. There may also be logistical benefits in coordinating efforts with operational deactivation crews, road construction crews, and salvage operators.

Treatment prescriptions are influenced by factors such as:

- site level restoration objective(s);
- current level of access;
- proposed deactivation level;
- desired final access strategy;
- stability at the site as well as the slopes below the site; and
- risk assessment.

The deactivation plan is based on the deactivation prescriptions. This plan may include a revised prioritization of road segments for treatment, a schedule of work and associated cost-estimate for the work, a summary of equipment and personnel requirements and considerations for agency review and approvals.

This section is concerned with the development of road deactivation prescriptions but also provides information and recommendations for implementation of the prescriptions. It includes:

- a suggested methodology for developing road deactivation field assessments and prescriptions;
- site level restoration objectives addressed by each of the techniques;
- descriptions of deactivation techniques supplemented by diagrams and site photographs;
- a list of field site indicators relevant to each deactivation technique;
- comments on how site conditions influence appropriate treatment prescriptions and implementation, as well as the limitations of the treatments;
- suggested tips for implementation of each treatment or technique; and
- main factors that influence treatment costs.
With the wide range of terrain, climatic conditions, access objectives and forest operations throughout the province, the methodologies that best suit the need of a specific project will also vary. Many individual operations have developed methods that work well for their particular needs with good results.

More information about implementation of restoration works is included in Section 8.

### 3.2 Deactivation Assessment Methodology (Field Techniques)

The objectives of field assessment for road deactivation are to:

- Assess the existing stability conditions and their potential for further deterioration;
- Evaluate the disruption to natural surface drainage paths along the road;
- Evaluate potential safety problems during project implementation;
- Mark prescriptions along the road at appropriate locations in an effective manner;
- Compile information for preparation of a report for field crews and site supervisors.

Developing road deactivation prescriptions involves previewing overview information, traversing the road and marking prescriptions in the field, and preparing a report for implementation. To develop effective road deactivation prescriptions, it is necessary to understand the terrain stability of the area (at the road and the hillslopes above and below the road), when and how the road was constructed, and applicable road deactivation techniques. This section discusses some techniques for assessing existing roads for deactivation; Section 7 contains specific information regarding the reporting of road deactivation prescriptions.

A first step is to preview material such as any overview report (see Section 2) before traversing the roads. If no report is available, review other similar overview information including air photos, detailed (1:5,000) topographic mapping, fish inventory data, and road construction information. Much of this information may be known as part of the FPC planning process. In some cases, discussing the site with the road supervisor and/or road crew may reveal some valuable first-hand information about conditions during construction.

Traverse the road carefully to assess the existing stability conditions and make prescriptions. Walking is preferred, especially in complex terrain. A hazard assessment must consider the site indicators along the road and the existing landslide, erosion, and sedimentation processes in the area for each section of the road. Typical indicators are listed in Section 3.5 for each prescription or treatment.

The traverse is usually conducted from the top end of the road, regardless of where the deactivation is planned so that no potential problems are missed or isolated. During the traverse of the road, the prescription(s) at each station must be marked to assist field crews during deactivation. For effective marking, paint can be used on suitable surfaces (such as rocks and logs) to provide highly visible prescription markings. Ribbon with markings can be used on both the road cut and outer edge of the road. For more permanent markings, metal tags can be used. These can be combined, and in some cases they are complementary. The actual marking techniques will depend on the conditions at the time of the assessment and the expected time between the traverse and implementation. For example, if the traverse is carried out during steady rain, marking stations with paint may not be feasible and ribbons and tags may be used. In cases
where bears or other wildlife are nearby, or an extended time is likely between the traverse and implementation, metal tags can preserve the field markings for longer periods. In areas with active operations, using distinctive colours and markings or standardized flagging with printing can avoid confusion with other types of layout.

Symbols for prescriptions should be specific, but not so numerous that field staff are confused. The most effective schemes use a limited number of symbols supplemented by site specific comments. The Advanced Road Deactivation Course (FCSN, 1997) provides one possible scheme. However, others exist that may be more applicable to a specific operation in specific terrain.

A person responsible for conducting the deactivation work under the WRP must meet the Forest Practices Code requirements for road deactivation. A review of the deactivation prescriptions by a qualified registered professional may be necessary. The extent of the review will depend on the existing stability conditions, the downslope/downstream resources at risk, the complexity of the prescribed deactivation, and the requirement of the Forest Practices Code. A qualified registered professional must prepare a prescription for deactivation work to reduce the likelihood of landslides in areas that have a moderate or high likelihood of landslides as determined by a terrain stability field assessment.

Other types of information may also be assessed and recorded during the field traverse. These include: the requirements for reactivation (see Section 3.4); the requirement for inspections and field reviews during the deactivation work; the expected hazard and risk to downslope/downstream resources; specific instructions to the operator at specific sites (such as sources of armour and armouring requirements); locations where benching and ramping are necessary to deal with large road fill volumes; and specific locations where safety of site personnel is a concern due to stability hazards along, or immediately above, the road.

3.3 Risk Management in Road Deactivation Prescriptions

**Overall Road System** Often the most critical part of a road deactivation assessment is deciding if continued access along a road is feasible, given its existing stability and potential deterioration. If the road is designated for permanent deactivation and no further access is required (and thus no further maintenance inspections are required) then the lowest practicable landslide hazard is desired after deactivation works are completed. If designated for semi-permanent deactivation, road access may allow maintenance inspections to identify and fix problems in a timely manner.

Water management and limited pullback are preferred to stabilize roads in cases where continued access is planned and practicable. Although this deactivation strategy may not be sufficient to stabilize the road in the long term, continued use of the road may be possible and preferred. Obviously, this strategy for deactivation is suitable only if it results in a tolerable landslide hazard and does not significantly increase the risk of damage to downslope and downstream resources. Where a significant or unacceptable risk exists, water management and full road fill pullback should be carried out.

When permanent deactivation with full pullback is being carried out, it is important to remember that although the cost of pulling back all road fill may be expensive, this is much less expensive than re-opening the road to fix inadequate pullback. Conceptually, different phases of road fill
pullback can be related to risk reduction as shown in Figure 3.01. For some projects carried out on western Vancouver Island, the combined cost of reactivating roads that had been previously deactivated using inadequate pullback standards, and deactivating them a second time to raise the standard of deactivation, was five to ten times the cost of the original deactivation.

The determination of tolerable residual risk following completion of road deactivation is an important component of the restoration planning and assessment process and may be the major factor influencing the eventual unit cost for any road deactivation project. Where only a low residual risk is deemed to be acceptable, the unit cost of road deactivation may be relatively high. This is especially so, for example, where a short section of high risk road occurs in a location isolated by previous deactivation and a significant portion of the project funds must be expended on reactivation. In other cases where access is reasonable and a higher level of residual risk can be tolerated, unit costs for deactivation may be significantly less. With a limited project budget, it may be more appropriate, for example, to deactivate to a less conservative level (e.g. partial rather than full pullback of fillslopes) in order to treat a greater number of sites. Any such risk management strategies, however, should be determined through consensus of all involved parties.

**Site Level** It is often necessary to evaluate the likely size and travel distance of a potential landslide to evaluate the landslide risk to downslope resources. In cases where the slopes below the potential initiation site are gentle or very steep, slope gradient may be the only consideration. However, for moderate to steep slopes, other factors that affect the mobility of a landslide need to be considered. These can include:

- Size and travel distance of existing landslides: Existing landslides in the area, or in nearby similar areas, can provide valuable information on the likely size and travel distance of potential landslides. Review of these existing landslides can provide valuable information on the type of landslide (material and mechanism of movement) and initiation factors in a watershed or along a road system.

- Degree of confinement: The slope morphology below the initiation site will determine if the landslide will be confined or unconfined. Confined landslides are more likely to develop into channelized debris flows and travel significantly further distances.

- Initiation Volume: Landslides that initiate with a larger volume are more likely to become larger and travel further due to their greater momentum. Conversely, smaller landslide events are much more likely to stop on relatively steep slopes. A review of the sizes of nearby landslides in similar terrain can help to elucidate this relationship.

- Stability of downslope areas and depth of material: Potential landslides above unstable slopes are more likely to be larger and travel further, since the landslide will entrain (scour) material as it passes through unstable (or marginally stable areas). For long landslides, the volume of the entrained material will often comprise most of the landslide volume. In
addition, the depth of soil downslope can provide some indication of the potential volume of material available for entrainment.

- Texture of material: Landslides containing a high proportion of fine material (sand, silt, clay) will travel further due to their lower internal friction relative to landslides containing coarse material (rock fragments, woody debris, coarse gravel, boulders).
- Water content: Landslides containing a significant amount of water and travelling as a flow are much more likely to travel further than landslides that are relatively dry. The source of the water may be from existing creeks on open slopes, within gully systems, or along existing landslide or snow avalanche tracks.

When or where appropriate, assessment of landslide hazard and consequence must be carried out by a qualified registered professional.

**Risk Assessment and Management** Risk is the likelihood of an event (hazard) occurring combined with the effect (consequence) that event will have on the resources in the watershed (i.e. Risk=Hazard X Consequence). The risk to resources is characterized by determining the expected adverse effects of a potential landslide to downslope downstream resources. A method for evaluating this risk is contained in a discussion on risk assessment and management in the Forest Road Engineering Guidebook.

In road deactivation and hillslope restoration, the risk remaining following treatment is termed “residual risk” (see Figure 3.01). It may neither be practical nor cost-effective to eliminate all risk at a site (i.e. leaving some residual risk may be an acceptable option). At other locations, where the stability of the hillslope is marginal and significant residual risk remains, additional work may be justified. It may be beneficial to have a qualified registered professional review sites of residual risk while the deactivation or restoration work is in progress, so that deficiencies can be corrected in a timely and cost-effective manner.

### 3.4 Road Reactivation Planning

**Objectives and Description:** Road reactivation involves the opening of abandoned or deactivated roads on a temporary basis to carry out deactivation work. Reactivation can be challenging where the roads have been abandoned for some time and the lack of maintenance has resulted in landslides or washed out stream crossings that require significant reconstruction work for machine access.

Reactivation commonly involves improving water management along the road corridor and re-establishing the road grade. Note that since the grade is not required for hauling activities, cross-ditches and waterbars can be used to manage water in conjunction with the existing culverts. At some locations, installation of additional culverts may be necessary where sedimentation concerns exist, or in fine soils where surface rutting from vehicle traffic will occur.

At locations where landslides have adversely affected the road grade, reactivation may involve endhauling to clear landslide debris from the roadway. At locations where road fill landslides have removed part of the running width of the road, reconstruction of the subgrade is often necessary (see Section 3.6.1).

Elements of a reactivation plan may include a map and tables showing:

- the sites that pose a safety hazard during reactivation;
- road stations with prescriptions for armoured swales, cross-ditches, and waterbars;
- site specific sketches for road reconstruction, prepared/reviewed as necessary by a qualified registered professional;
- location of streams and fisheries habitat in the watershed to assist in the planning of fish salvage and sediment control measures during reactivation and deactivation;
- a list of new culverts or portable bridges required for installation during reactivation, if any.

**Benefits:** Unstable and/or sensitive terrain often requires more careful reactivation to prevent an increase in landslide or sedimentation hazards. The preparation of a reactivation plan during the prescription process can provide important guidance for site staff organizing and carrying out reactivation activities. Reactivation plans can also identify sites for environmental monitoring and agency notification (and approval, where appropriate). Reactivation plans may also provide an increased level of due diligence where appropriate.

Often the assessment for reactivation can be completed concurrently with deactivation prescriptions. The methodology is the same, namely noting existing features and the needed techniques for reactivation by station along the road.

Developing reactivation plans can be beneficial where there are:

- numerous reactivation problem sites and/or safety concerns;
- narrow roads with likely machine access problems;
- roads with stability or erosion problems such that careful water management during reactivation is necessary;
- overgrown roads with stability and water management concerns (structurally unsound bridges or culverts);
- roads to be kept open for more than one season to complete deactivation work (for increased due diligence);
- previously deactivated roads with moderate to heavy pullback that require re-opening.

**Considerations:** Road reactivation planning can vary greatly, depending on the existing conditions of the road. Where the costs of reactivation of a road (or a portion of road) may outweigh the potential benefits of deactivation, an assessment of risk to downslope and downstream resources by a qualified registered professional may be warranted. For example, road reactivation costs along road segments of previous
pullback can be extremely costly, and pose site specific safety hazards. Assessment of such a situation must consider the potential safety of the operator and crew using the road, water management along the reactivated road, the cost of the reactivation, and the expected decrease in landslide hazard as a result of improved deactivation.

3.5 Deactivation Technique Descriptions

The following are typical measures carried out during deactivation. They are often combined at specific locations. For example, at a single culvert location the deactivation prescription may be “Pull Metal Culvert” and “Cross-ditch”, or sections with a prescription for “Scarification” may be in conjunction with a prescription for “Insloping” for water control.

The descriptions are divided into two parts: water management (Sections 3.5.1 to 3.5.11) and road fill pullback (Sections 3.5.12 to 3.5.14). Commonly, road fill pullback will be carried out along sections of road, while water management techniques may be carried out at specific locations within or adjacent to the pullback.

Some previous discussions of road deactivation techniques have sub-divided some of the techniques listed below into more than one operation. For example, the Advanced Road Deactivation Course contains separate prescriptions for heavy pullback and gully restoration. However, in terms of the principles involved and the work carried out, these are both variations of full road fill pullback. While separating them may be beneficial for cost estimates, at times it unnecessarily complicates prescriptions.

All road deactivation practitioners are encouraged to develop clear, effective symbols and prescriptions that best address stability, sedimentation, and site productivity objectives in a particular operating area. A review by operations staff may result in valuable feedback that can make the prescriptions less ambiguous. Alternatively, some operations may have an established set of symbols and prescription formats that are appropriate for their use. The symbols and system in the Advanced Road Deactivation Course (BCFCSN, 1997) may also be used.

Coastal and Interior factors are also discussed in the prescriptions, especially with respect to the prescription indicators and cost factors for each technique. For areas where coarse rock is not available for armouring, emphasis should be placed on alternatives such as revegetation, erosion control blankets, or perhaps soil bioengineering installations.

For the following descriptions, Figure 3.04 shows some of the common terms used to denote road components and relative directions. Deactivation is most commonly carried out from the woods side to the camp side.
Fig. 3.04  Road orientations and naming conventions relative to a stream culvert location.

The following comments are applicable to Sections 3.5.1 to 3.5.14 on the discussion of deactivation techniques:

- **Objectives** - goals for the given techniques incorporating the broad goals (site level objectives) for the hillslope restoration
- **Descriptions** - a list of the typical features of the technique or structure
- **Prescription Indicators** - a list of site observations that may lead to the prescription of the technique at a given location along a road corridor
- **Sketches** - illustrations of the important points or features of the techniques
- **Suggested Construction/Deactivation Tips** - items or issues to consider during implementation of the techniques
- **Cost Factors** - a list of site factors that can potentially increase the cost of the technique
- **Additional Comments** - considerations regarding the techniques that may be important in specific circumstances
3.5.1 Cross-ditch (Road Intact)

**Objective:** To capture road surface and ditch line water, and route it across the road to stable, non-erodible slopes below the road. If constructed properly, cross-ditches are maintenance free.

**Description:** A cross-ditch is a ditch across a road excavated to a depth equal to, or greater than, the depth of the ditch at the road cut. Cross-ditches generally have a berm on the lower side, and a compacted ditch block (Figure 3.05). For areas with fine soils where vehicle access is intended, it may be better to use a broad deep swale without a berm to contain water flow (since berms will become rutted and ineffective due to ongoing traffic).

**Prescription Indicators for Cross-ditches (Road Intact):**

- Natural hillslope drainage path location (surface flow over road cut)
- Unstable hillslopes below road (frequent cross-ditches aid in dispersal of road drainage)
- Water flow across road (road scour)
- Excessive seepage on road cut
- Relatively steep road grades
- Backup of cross-drain culverts
- Upgrade end of road sections with relatively steep grades or unretrievable unstable fills.

![Diagram of a cross-ditch with road intact (no pullback)](image)

*Fig. 3.05 Cross-ditch with road intact (no pullback).*
Notes:

1. Frequent cross-ditches can be used to disperse hillslope drainage above and/or upgrade of unstable hillslopes. Consider consulting a qualified registered professional regarding the landslide hazard and risk at the site.

**Suggested Construction Tips for Cross-ditches (Road Intact):**

- As the outlet location is more important than the inlet to establish the gradient of the cross-ditch, start at the outlet by pulling back all woody debris and potentially unstable/erodible road fill.

- Make sure the cross-ditch inlet is deeper than the base of the existing road ditch, and the entire cross-ditch excavation is adequately sloped to resist sediment deposition. The size, depth, and shape of the cross-ditch will depend on the access requirements and the expected flows. If vehicle access is to be retained, gently slope the cross-ditch approaches. Note that on steep grades, the large berm needed to contain flow in the cross-ditch may preclude access. For steep grades an increase in skew may be necessary to reduce deposition in the cross-ditch.

- The ditch block must be relatively impermeable and non-erodible and large enough to divert expected flows into the cross-ditch. For permanent or semi-permanent deactivation, the ditch block is normally higher than the road surface. It preferably contains a mix of rock and soil, keyed into the road cut where necessary.

- Berms must be compacted and large enough to contain the expected flows, and located on the downgrade side of the cross-ditch for both favourable and adverse grades. For areas of fine soils, consider using a broad, deep swale to contain flow instead of a berm.

- Armour base of cross-ditch if erosion is expected to cause a problem for future road access. Use angular or sub-angular rock large enough for armouring against expected flows but small enough to allow for safe vehicle passage.

- Armour the outlet of the cross-ditch, unless noted in the prescriptions. Size and placement of the armour will depend on the anticipated flows and downstream consequences. Use angular rock large enough to protect exposed soil, but small enough not to divert or obstruct flows. For areas without coarse rock, suitable alternatives may include careful grading to form gentle sidewall slopes, revegetation, erosion control mats, sand bags, soil bioengineering structures, or appropriately sized and placed woody debris.

**Increased Cost Factors for Cross-ditches (Road Intact):**

- Gully locations (gully restoration)
- Depth of road fill at outlet
- Rocky road fill or lots of large woody debris in road grade
- Road width or landing width
- Lack of suitable armour; importing required
- Heavy woody debris at outlet
- Sediment control and monitoring
- Strict timing constraints
- Excessive road fills (large volume at outlet)
- Endhauling of excavated material necessary to maintain access

Notes:

1. Cross-ditch locations at gully crossings can involve more armouring and/or endhauling of material if excavated material cannot be placed against the road cut.
2. Importing of rock can be very expensive depending on haul distance and quarrying costs.
3. The connectivity of the stream to fish habitat or water supply areas increases the need for sediment control during cross-ditch excavation.

**Additional Comments for Cross-ditches (Road Intact):**

- All road fill material must be removed from the outlet area; this is particularly important for preventing landslides. Outlets of cross-ditches should not divert water onto erodible or unstable slopes.
- Larger expected flows and steeper road grades will usually require more frequent cross-ditches of greater size. Where ditches are deeply eroded, regrading of the ditch line may be needed.
- Backup cross-ditches at culvert locations (also known as “failsafes”) are installed directly downgrade of the culvert location. At some locations, it may be appropriate to install these directly above or alongside the culvert; however, care must be taken to leave an adequate thickness of fill over the existing culvert. For backup cross-ditches of cross-drain culverts in erodible soils, locating the cross-ditch about 5m downgrade of the culvert may prevent a culvert washout and reduce maintenance costs. The backup cross-ditches must be large enough to handle the expected flow, and similar in design and construction to a regular cross-ditch. Backup cross-ditches must also maintain the pre-construction stream location for stream culverts.
- Cross-ditches that are located at low points in the road grade (receive water from both directions along road) need neither a ditch block nor a berm. In this case, the cross-ditch can be constructed as a broad, gentle swale.
- Careful assessment is necessary for outlet locations where significant flows are expected in the cross-ditch, and the outlet is located outside a natural channel. In these cases, the flow may cause erosion or stability problems downslope.
- Cross-ditches should be constructed to allow vehicle access commensurate with the Access Management Plan.
3.5.2 Cross-ditch In Full Pullback

Objective: To restore the natural hillslope drainage paths to historic (pre-construction) locations along the hillslope, through road fill pullback.

Description: A cross-ditch in pullback is a ditch across the old roadbed connecting a natural hillslope drainage path (streams, gully channels, and swales with flow). Cross-ditches in pullback usually must be excavated down to natural (undisturbed), non-erodible material. The size, depth, and shape of the cross-ditch should mimic the
nearby natural ground profiles and contours (Figure 3.09). Since no water flow along the road surface is possible in areas of road fill pullback, fewer cross-ditches are needed in pullback than for roads where no pullback is carried out.

**Prescription Indicators for Cross-ditches (Road Fill Pullback):**

- Road crosses natural hillslope drainage path (surface flow over road cut)
- Excessive and defined seepage areas (“piping flow” or bedrock swales)
- Upgrade or downgrade side of placed pullback material
- Road is unstable or has erodible slope below and it is important to maintain dispersed drainage across the hillslope

**Note:**

1. Constructing a cross-ditch upgrade of pullback sections will prevent erosion along the toe of the pullback material. Constructing a cross-ditch on the downgrade side will prevent accumulation of water if the roadbed remains intact (i.e. has not been decompacted and outsloped prior to placement of pullback material) under the road fill pullback material.

**Suggested Construction Tips for Cross-ditches (Road Fill Pullback):**

- If armouring is needed, stockpile available rock during road fill pullback approaching the cross-ditch.
- Decompact and outslope the road surface as part of road fill pullback adjacent to the cross-ditch (see Section 3.5.14).
- Remove ballast from cross-ditch location and excavate a bench to position machine for further reach downslope. Place material on the woods side bench.

*Fig. 3.08 Failed ditch block has resulted in water running down road grade.*
Clear outlet of debris and road fill. Place material on the woods side bench. **Do not leave excavated material on the outside of the road if potentially unstable.**

- Excavate cross-ditch from outlet to inlet, exposing native ground for the full length of the cross-ditch. Place as much material on the woods side, and fill the bench to the top of the slope. Place armour as required; excavate as “steps” if insufficient armour is available to cover all flow areas. Do not leave oversteepened sideslopes on the cross-ditch, particularly in fine soils.

- Finish the sidewall on camp side prior to finishing cross-ditch pullback.

- At gully locations, blend slopes of pullback into existing slopes above and below the road, in and out of the gully.

**Increased Cost Factors for Cross-ditches (Road Fill Pullback):**

- Gully locations (gully restoration)\(^1\)
- Depth of road fill at outlet
- Rocky road fill, or lots of large woody debris in road grade
- Road width or landing width
- Armour required; lack of available armour
- Endhauling of excavated material (cannot place material in road cut)
- Sediment control and monitoring\(^2\)

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**Fig. 3.09** Cross-ditch in area of road fill pullback.
- Strict timing constraints
- Heavy woody debris at outlet
- Excessive road fills (large volume at outlet)

Notes:

1. Cross-ditch locations at gully crossings typically involve the removal of more road fill and less space on the bench for pullback (consider endhauling).

2. The connectivity of the cross-ditch to fish habitat or water supply areas increases the need for sediment control and adherence to timing windows and measures during cross-ditch excavation.

**Additional Comments for Cross-ditches (Road Fill Pullback):**

- All road fill material must be removed from the outlet area; this is particularly important for preventing landslides. Outlets of cross-ditches should not divert water onto erodible or unstable slopes.

- Armour placement (volume and size) is dependent on anticipated flows and downstream consequences. Armouring may not be needed in cases of very low flow or where the flow is not hydraulically connected to larger streams in the watershed (fish habitat or water supply areas).

- Outlets and the cross-ditch base should be armoured if the cross-ditch is located in erodible material (as compared to the natural stream channel materials). The armour must be small enough so that it does not divert flows. Armouring may not be needed if the cross-ditch is excavated into natural (undisturbed) ground, or if no sedimentation is expected.

- In pullback, skew is only necessary to line up natural hillslope drainage paths.

- For frozen roads in fine soils, cross-ditches can be difficult to maintain due to rutting from ongoing traffic. Consider armouring ditches (provided that diverted water does not cause stability problems) or using steel cattleguard-type structures as alternatives.

- Other possible prescriptions at locations where the room on the bench is needed for pullback material and coarse rock is available are trench drains (see Section 3.5.6) and blanket drains (see Section 3.5.7).

- Stream restorations at stream crossings are similar to cross-ditches but require restoring the width of the stream as well as armouring the channel. Reconstruction of streambanks should mimic upstream and downstream channel geometry and bank materials. Consider also excavating a stepped channel in non-erodible materials to reduce the flow energy if erodible materials are present downslope. These sites may warrant specific comments as part of the prescriptions. At critical sites it may be necessary to consult a specialist with expertise in stream hydrology. At sites that are expected to impact fish habitat, review by a fisheries habitat specialist is prudent.
3.5.3 Waterbars

**Objective:** To divert water off the road onto the fillslope to prevent erosion of road surface. Reverse waterbars direct flow off the road into the ditch.

**Description:** A waterbar is a shallow ditch across a road, skid trail, or backspar trail to prevent excessive flow down the road surface (or trail). Waterbars are not intended to intercept ditch lines; thus, the base of the waterbar is above the base of the ditch and no ditch block is required. Waterbars are used where a road is kept open for vehicle traffic, or where cross-ditches cannot be used (such as throughcuts). Waterbars may not include a berm if traffic along the road is expected to cause rutting and render the berms ineffective.

**Prescription Indicators for Waterbars:**
- Surface flow on road grade (road scour)
- Relatively steep road grades where ditch remains intact
- Throughcut with steep grades, surface erosion expected
- Upgrade of switchback to keep water off steep road grade at switchback
- Reverse waterbar where water needs to be kept off unstable road fill and can be carried in stable ditch

**Suggested Construction Tips for Waterbars:**
- In coarse soil and rock, place excavated material from the waterbar immediately downgrade to form a berm (as for cross-ditches); use excavator bucket to compact if road traffic is expected. In fine soil, consider using a broad swale with no berm.
- Waterbars do not have to cross the entire road surface to be effective; they must only intercept flow on the road and divert it off the road
- Waterbars must be shallow enough to allow for unimpeded vehicle access
- Consider using a herringbone pattern in throughcuts to divide the flow between the two sides. Ditching may also be necessary if the road is not sloped, or the surface is erodible.
Waterbars can be constructed with bulldozers or graders, depending on material type and amount of intended use of the road; however, these machines are not suited for placement of armour.

Waterbars constructed of parallel lengths of lumber (e.g. 2x4’s) embedded in the road grade may be appropriate on active roads (Figure 3.13).

**Increased Cost Factors for Waterbars:**

- Dense road surface materials
- Depth of road fill at outlet
- Heavy woody debris at outlet
- Road width or landing width
- Armour required; lack of available armour
- Strict timing constraints¹
- Sediment control and monitoring¹

Notes:

1. The connectivity of the waterbar to fish habitat or water supply areas increases the need for sediment control and adherence to timing windows and measures during waterbar excavation.

**Additional Comments for Waterbars:**

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**Fig. 3.12** Waterbar and reverse waterbar (on right corner with favourable grade).
- Typically waterbars are skewed to better divert water off the road surface. Skew will depend on road gradient, anticipated flows, and potential erodibility of the outfall area.
- Frequency of waterbars along a road section will depend on anticipated flow on road surface.
- In erodible materials, armouring of the outlet area is needed.
- In cases where the ditch is likely to plug, consider using a cross-ditch instead of a waterbar to provide greater flow capacity and more controlled water management.
- Depending on the volume of vehicle traffic and the road grade, periodic maintenance may be necessary to ensure long term effectiveness.
- For frozen roads in fine soils, waterbars can be difficult to maintain due to rutting from ongoing traffic. Consider armouring ditches (provided that diverted water does not cause stability problems) or using steel cattleguard-type structures as alternatives.

Fig. 3.13 Waterbar constructed with parallel lengths of lumber on an active road.
3.5.4 Metal Pipe Culvert Removal (Sediment Control)

Objective: To remove the existing stream culvert with the least amount of sedimentation possible and leave a cross-ditch. This technique is recommended where running water is present and the stream is hydraulically connected to fish habitat or community water supplies. If no water is present, no sedimentation concerns exist and cross-ditch technique can be used (Section 3.5.1 cross-ditch for road intact, 3.5.2 for cross-ditch in full pullback).

Description: Often, pipe culverts must be pulled and cross-ditches constructed where culvert maintenance is impractical or impossible (Figure 3.14). This technique can allow for culvert removal while water is present in the channel. In cases where the traffic use is expected to continue, an armoured swale or ford can be constructed following the removal of the pipe culvert (see Section 3.5.9).

Prescription Indicators for Metal Pipe Culvert Removal (Sediment Control):
- Culvert has inadequate capacity
- Damaged pipe (reduced flow capacity)
- Sediment accumulation at inlet locations (reduced flow capacity)
- Impeding fish passage; fish concerns
- Improper location of culvert (disrupting hillslope drainage paths)
- Culvert in gully or creek crossing as part of permanent deactivation

Fig. 3.14 Staged removal of a metal pipe culvert where water is flowing.
Note:

1. If fish are present or downstream, designate the site for work during a timing window or have an environmental monitor on site. **Fish exclusion and salvage may be necessary prior to culvert removal.**

**Suggested Construction Tips for Metal Culvert Removal (Sediment Control):**

- Assess the potential adverse environmental effects at the site. Divert flows if practical. If water cannot be diverted, install sediment control downstream prior to work at the site.
- Remove road fill to expose the woods side of the culvert; then remove the road fill over the culvert. While flow is in the culvert, excavate the road fill from the downstream side to the upstream side, exposing the side of the culvert. Leave some material on the upslope side of the road to continue to divert flow into the culvert. Armour the new channel beside the culvert with rock if necessary. See Figures 3.15a to 3.15c.
- Breach the remaining road fill to route the flow into the new channel. Remove the culvert and the remaining road fill on the camp side. Armour exposed soil as required.

**Increased Cost Factors for Metal Pipe Culvert Removal (Sediment Control):**

- Size of culvert
- Width of road surface and length of culvert
- Amount of road fill over culvert
- Attempts to salvage the pipe
- Sediment control and monitoring
- Strict timing constraints
- Possible fish removal
- Excessive road fills (large volume at outlet)
- Heavy woody debris at outlet
- Amount of rock available for armouring

Notes:

1. Salvaging metal culverts during removal can increase the time for culvert removal.
2. The connectivity of the cross-ditch to fish habitat or water supply areas increases the need for sediment and adherence to timing windows and measures control during excavation.
3. Coarse rock for armouring is much more important for pipe locations at stream crossings. Culverts that only drain ditch water may not need armouring.

**Additional Comments for Metal Pipe Culvert Removal (Sediment Control):**

- Each location is different and site specific approaches must be used. For complex sites, discuss options for work at the site with experienced staff and/or fisheries agencies to reduce the potential sedimentation to acceptable levels.
Making and keeping the site as dry as possible is often the most effective means to prevent sedimentation. Methods may include: diverting water down the ditch line until the cross-ditch is constructed and armoured provided the ditch line is not compromised; diverting streamflow using polyurethane pipe (or similar) with gravity flow; constructing a secondary cross-ditch in non-erodible materials until the main cross-ditch is complete; pumping flows around working area (if reliable pump equipment is available).

The size, depth, and shape of the cross-ditch depends on the expected flows. Blend sidewalls of the structure to match adjacent slopes.

If no water is present, removal of culverts in deep road fills often requires four steps: 1) remove surfacing and road fill on woods side, to expose top of culvert; 2) slope approach to a suitable grade on woods side if vehicle access is to be maintained; 3) expose and remove culvert; 4) move to camp side and complete cross-ditch excavation (slope approach to a suitable grade if vehicle access is to be maintained).

Where coarse rock is scarce, use rock preferentially at stream crossings. Consider prompt revegetation, erosion control matting, or keeping excavated slopes as flat as possible.

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Fig. 3.15  *Metal culvert removal with sediment control.*

a) *Step 1 - maintain flow in pipe while excavating cross-ditch.*
b) *Step 2 - divert flow to newly-constructed channel.*
c) *Step 3 - when excavation complete, remove diversion structure.*
### 3.5.5 Wood Box Culvert Removal (Sediment Control)

**Objective:** To remove the existing stream culvert with the least amount of sedimentation possible, and leave a cross-ditch or restored stream channel. This technique is recommended where running water is present and the stream is hydraulically connected to fish habitat or community water supplies. If no water is present, no sedimentation concerns exist and cross-ditch technique can be used (Section 3.5.1 cross ditch for road intact, 3.5.2 for cross ditch in full pullback).

**Description:** Often, cross-ditches are used to replace existing culverts where maintenance is impractical (or the road is designated for semi-permanent deactivation). This technique allows for culvert removal while water is present in the channel, but is not necessary if the stream is not hydraulically connected to fish habitat or water supply areas (Figure 3.16).

**Prescription Indicators for Wood Box Culvert Removal (Sediment Control):**

- Existing culvert with inadequate capacity to handle expected flows
- Degraded wood sills or deck; undermined wood sills; holes in ballast on deck
- Sediment accumulation at inlet locations
- Impeding fish passage; fish concerns
- Improper location of culvert (disrupting hillslope drainage paths)
- Culvert in gully or creek crossing as part of permanent deactivation

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**Fig. 3.16** Staged removal of a wood box culvert where water is running. It is important to follow the indicated sequence of work to minimize sedimentation.
Note:

1. If fish are present, designate the site for work during a timing window or have an environmental monitor on site. **Fish exclusion and salvage may be necessary prior to culvert removal.**

**Suggested Construction Tips for Wood Box Culvert Removal (Water Present):**

- Assess the potential adverse environmental effects at the site. Divert flows if practical. If water cannot be diverted, start by installing sediment control downstream of the culvert site. Consider attaching filter cloth ‘diaper’ below superstructure to catch sediment during de-construction.
- Excavate the road fill to expose the ends of the culvert and remove the material from the deck. Excavate road fill on the woods side to within 0.3m (1ft) of the sill log, and leave enough material to keep flow in the existing channel.
- Move to camp side of culvert. Remove the woods side sill log, pushing retained material up and out of the channel.
- Excavate camp side road fill and pull back camp side sill log, pulling soil back and away from the creek.

**Increased Cost Factors for Wood Box Culvert Removal (Sediment Control):**

- Size of culvert
- Width of road surface and length of culvert
- Amount of road fill over culvert
- Heavy woody debris at outlet
- Sediment control and monitoring\(^1\)
- Strict timing constraints\(^1\)
- Possible fish removal\(^1\)
- Excessive road fills (large volume at outlet)
- Cable reinforcement

Notes:

1. Consider potential sediment destabilization before removing embedded large woody debris from channel.

2. The connectivity of the site to fish habitat or water supply areas increases the need for sediment control and adherence to timing windows and measures during cross-ditch excavation.

**Additional Comments for Wood Box Culvert Removal (Sediment Control):**

- Each location is different and site specific approaches must be used. For complex sites, discuss options for work at the site with experienced staff and/or fisheries agencies to reduce the potential sedimentation to acceptable levels.
Methods to make the site as dry as possible may include: diverting water down the
ditch line until the cross-ditch is constructed and armoured; diverting flow using
polyurethane pipe (or similar) using gravity flow; constructing a secondary
cross-ditch in non-erodible materials until the main cross-ditch is complete;
pumping flows around working area (if reliable pump equipment is available).

The size, depth, and shape of the final cross-ditch depends on the expected flows.
Blend sidewalls of the structure to match adjacent slopes.

3.5.6 Trench Drain

**Objective:** To pass both surface and seepage flow across road fill pullback. Trench drains
are particularly useful where all the space on the bench must be used for placement of
road fill pullback.

**Description:** Trench drains consist of a cross-ditch that is infilled with coarse rock, to
carry water from seepage areas on the road cut and/or small surface flows (Figure 3.18).
Rocks used in the trench drain are usually sorted from the surrounding road fill during
pullback. Trench drains differ from blanket drains in that the coarse rock extends upward
to near the top of the pullback material and it is not covered with pullback material.

**Prescription Indicators for Trench Drains:**

Note that trench drains are only prescribed in areas of full (heavy) pullback.

- Excessive seepage zones (“piping flow” or bedrock swales)
- Road crosses relatively natural hillslope drainage path (surface flow over road cut)
- Surface flow upslope is not in an entrenched creek
- Buttressing of road cut needed at seepage area; some overland flow expected

**Suggested Construction Tips for Trench Drains:**

- The outlet area of the trench drain must have no erodible or unstable material.
- Excavate ditch from outlet to inlet, exposing native ground for full length. Infill
  with rock as ditch is excavated.

![Fig. 3.18 Trench drain shown in cross-section through pullback.](image-url)
- Trench drains must be wider than a cross-ditch to carry the same amount of flow.
- The sorting of the angular rock for the trench drain can be done while pulling back road fill. A limited amount of soil with the rock is acceptable.
- Place as much material on the woods side of the trench drain before moving to the camp side.
- Trench drains are infilled with coarse rock and built up as the road fill is pulled back.
- Double or triple handling coarse rock can help to separate fine soil from coarse rock.

**Increased Cost Factors for Trench Drains:**
- Amount of road fill to pull back
- Road cut height (height of seepage zone)
- Lack of availability of suitable rock
- Distance to road cut (width of road)
- Endhauling of road fill pullback material
- Volume of flow (determines size of armour)
- Larger size of trench drain (great width and/or depth)

**Notes:**
1. At locations where the rock for the trench drain is not available, importing rock can substantially increase the cost.
2. Endhauling of road fill may be necessary where limited space on the bench is available for placement of road fill pullback.
3. Larger flows will require larger rock for erosion resistance; this larger rock may not be available in the road fill and may have to be imported.

**Additional Comments for Trench Drains:**
- If no surface flow is expected, consider using a blanket drain instead of a trench drain.
- Trench drains must not divert flow onto unstable or erodible slopes.
- Wider trench drains can help disperse the water over a larger hillslope area.
- Consider importing rock for trench drains rather than using an open cross-ditch in pullback at locations where support is needed to prevent large slumps from the road cut.

### 3.5.7 Blanket Drain

**Objective:** To disperse point seepage or subsurface flow under the road fill pullback. Blanket drains disperse flow rather than concentrate the flow at one hillslope location. Blanket drains are not intended to convey surface flow or replace open cross-ditches in areas of substantial flow.

**Description:** A blanket drain consists of a layer of cobbles or shot rock placed against the seepage zone in the road cut. The blanket extends down the cutslope and across the
decompacted road surface to the ground surface (Figure 3.19). Road fill is placed on top of the cobbles or shot rock, from the top of the road cut to the bottom of blanket. The blanket of shot rock does not extend to the top of the road cut, but only to the top of the seepage zone.

**Prescription Indicators for Blanket Drains:**

Note blanket drains are only prescribed in areas of full (heavy) pullback.

- Seepage as “piping flow”
- Very little surface flow
- Expected flows are not expected to be high, but may cause slump in pullback material
- Need to use the space on the bench for road fill pullback
- Road cut with seepage needs buttressing
- Bedrock “swales” (local depressions in bedrock) that have evidence of water flow

**Suggested Construction Tips for Blanket Drains:**

- The road surface must be decompacted and outsloped prior to placement of sorted angular coarse rock, otherwise the flow may be carried in the ditch line along the road.
- Retrieve all road fill material from outlet area.
- The sorting of the angular rock for the blanket can be done while pulling back road fill. A very limited amount of soil with the rock is acceptable.

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*Fig. 3.19  Blanket drain shown in cross-section through pullback.*
Leaving the rock blanket exposed both above and below the pullback should be
done to allow for inspection following the deactivation work.

“Sprinkling” the rocks on the cutslope and allowing the larger rocks to roll down
the longest distance will create a rock blanket at the road cut and along the
decompacked road surface. Road fill pullback can then be placed on top of the
blanket drain.

Increased Cost Factors for Blanket Drains:

- Larger size of blanket drain (great width and/or depth)
- Road cut height (height of seepage zone)
- Lack of availability of suitable rock\(^1\)
- Distance to road cut (width of road)
- Endhauling of road fill material\(^2\)

Notes:

1. At locations where the rock for the blanket drain is not available, importing rock can
   substantially increase the cost of blanket drains.

2. Endhauling of road fill may be necessary where limited space on the bench is
   available for placement of road fill pullback.

Additional Comments for Blanket Drains:

- If surface flows are expected, consider prescribing a trench drain rather than a
  blanket drain.
- Blanket drains will not disperse water along roads with steep road grades; check
  outfall location at lower end of blanket drain for stability.
- Less rock can be used if the blanket is covered with geotextile prior to placement of
  pullback road fill. If road fill pullback material is fine, erodible soil (silt or fine
  sand), use of geotextile will keep the blanket from plugging for a much longer
  period of time.
- If the road cut is in fine or erodible soil, the rock blanket may need to be wrapped
  entirely in geotextile.

3.5.8 French Drain

Objective: To divert flow along the base of the cutslope to discharge at a stable location,
such as a creek or gully. French drains can be used where road fill pullback or bank
sloughing may block the ditch and cause water management problems. French drains can
also provide some means of water management if the road cannot be decompacted to
below the ditch line depth.

Description: French drains can be used where cross-ditches are impractical, specifically:
where the seepage zone is extensive in length; the retrieved road fill will be impermeable
when placed against the road cut; the stability of the road fill material may be
compromised if it becomes saturated. Rock for the French drain is sorted during road fill
pullback of adjacent areas.
Prescription Indicators for French Drains:

Note that French drains are normally used in conjunction with road fill pullback, but sometimes they can be used for active roads with road cut instability.

- Heavy seepage or groundwater piping in road cut (could also use insloping)
- Need to keep water off unstable road fills
- Raveling or sloughing road cuts (allows for buttressing and drainage)
- Where ditch line needs to be maintained under road fill pullback material

Suggested Construction Tips for French Drains:

- The rock must be free draining; geotextile should be used between the drain rock and soil if the soil is expected to clog the spaces between the rocks.
- The size of the French drain will depend on the width and height of the seepage zone.
- French drains must not direct flow onto unstable or erodible slopes. Coarse rock should be placed at the outlet of the French drain to prevent erosion where necessary.

Increased Cost Factors for French Drains:

- Size of French drain (height, width, depth; determined by size of seepage area)
- Lack of suitable rock nearby
- No availability of geotextile or slotted pipe (if needed)
- Length of French drain along road cut
- Height of road cut (if French drain is used for buttressing)
- Endhauling of road fill material

Fig. 3.20 French drain shown in cross-section (left) and in oblique view (right).
Notes:

1. At locations where the rock for the French drain is not available, importing can substantially increase the cost.

2. Endhauling of road fill may be necessary where rock is imported and limited space on the bench is available for placement of road fill pullback.

**Additional Comments for French Drains:**

- In cases where steady flow must be maintained through the French drain, install a slotted pipe in the centre of the drain. This system is much more resistant to clogging than regular coarse rock.
- For active roads, lateral French drains can be installed in place of culverts to carry seepage under the road surface (use where culverts are prone to plugging).

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**Fig. 3.21** Above, sequence of construction for French drain:

- **a)** Excavate trench along ditch line
- **b)** Infill with coarse rock
- **c)** Cover with filter fabric, then cover with fill.

**Fig. 3.22** French drain installed at toe of high road cut in fine-grained soil.
3.5.9 **Ford and Armoured Swale**

**Objective:** The main purpose of a ford and armoured swale is to provide an erosion resistant and storm-proof wet crossing for motor vehicle access. A ford structure is used to cross a stream, whereas an armoured swale is constructed where a cross-ditch would normally be used. The reduction of sediment generation and sediment transport during the intended period of road use is a paramount consideration in the design of both structures. Fords are generally restricted to crossings of non-fish-bearing streams unless otherwise approved by the fisheries agencies. Armoured swales are intended to route road surface runoff, ditch water or cut bank seepage across a road where short-term vehicle access is required. Both may be constructed on access roads where culverts are not functioning (e.g. washed out or collapsed) and replacement structures not available, or where seasonal/ephemeral flows may exceed the capacity of the existing culverts during the time of road use.

**Description:** A ford is a dip in the road grade installed to facilitate crossing a stream (perennial or ephemeral stream flows) and is typically designed and built as a permanent feature at the time of original road construction, or during semi-permanent or permanent road deactivation (Figure 3.23). Fords are a suitable road deactivation option where existing bridges or culverts must be removed but where vehicle access must be maintained. Installation during deactivation requires excavation of all road fill to expose the original streambed. This is followed by careful placement of coarse angular rock armour. The rock armour may be graded upward to provide a more driveable surface but all material must be coarse enough to withstand mobilization during peak flows. The finished width of the ford and the approaches should mimic the adjacent natural stream channel to avoid constraining stream flow and to provide for passage of the Q100 flow. A properly designed and constructed ford should allow low flows to infiltrate through the coarse rock base and peak flows to pass over the structure with no alteration of the structure. Metal pipes may also be incorporated to aid in conveying low flows (Figure 3.25). Standard templates with site specific parameters are usually suitable for the design of most fords along existing roads. Design by a qualified registered professional may be required for large streams or for non-standard crossing situations (e.g. in close proximity to a fish-bearing reach). For further information, refer to the following updated Forest Practices Code guidebooks (in preparation at the time of publication of this handbook): *Fish Stream Crossing Guidebook* and *Forest Road Engineering Guidebook*.

An armoured swale is a dip in the road grade installed to convey seasonal/ephemeral flows across the road while continuing to provide access where it is critical to minimize sedimentation during short-term works such as road deactivation. The fill below the road grade is only partially removed and the excavated dip or swale is armoured with rock carefully placed and graded to ease vehicle access (Figures 3.24 and 3.26). An armoured swale is, therefore, intended as a temporary structure that is usually replaced with a normal cross-ditch once access is no longer required. Where flows are expected continuously during the time the road is in use, construction of a modified armoured swale using metal pipes may be preferable to further limit sedimentation. Design of an armoured swale by a qualified registered professional is not necessary given the low flow conditions and the temporary nature of this type of structure.
**Prescription Indicators for Ford and Armoured Swale:**

**Ford**

- Vehicle access required across natural drainage path (non-fish bearing stream)
- Stream flow expected during period of use
- Sufficient coarse rock available for armouring
- Existing crossing structure is required to be removed, not fully functional or unsafe
- If connected to fish habitat or water supply and stream flow is expected during the period of road use, installation of culvert pipe for modified ford\(^1\) may be appropriate

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**Fig. 3.23** Example of ford installed on a non-fish-bearing stream.
Armoured Swale

- Connectivity to fish habitat or water supply
- Temporary vehicle access required where flowing water from road surface, cut slope or ditchline is expected during period of use (Note: generally replaced with a non-driveable cross-ditch when access is no longer required)
- May be appropriate on snow avalanche tracks where conventional culverts are prone to blockage
- Sufficient coarse rock available for armouring
- Existing culvert is undersized, not fully functional or unsafe
- Modified armoured swale may be appropriate where flow is expected and there is connectivity to fish habitat or water supply

Note:

1. Pipes should be sized to carry most of the flow, but extreme flows will still pass over the road.

Fig. 3.24 Example of armoured swale to convey road surface, cut slope seepage and ditch water across road while maintaining vehicle access with minimal sediment generation.
Suggested Construction Tips for Ford and Armoured Swale.

- Stockpile coarse, angular rock and install sediment control prior to starting work.
- Work from the downstream side of the road to the upstream side. Place rock armour concurrently with excavation. Where practicable, divert or block flow to reduce sediment transport during excavation.
- Where appropriate, make site specific recommendations (or provide a sketch) of the ford or armoured swale in the deactivation prescriptions. These recommendations can also be provided in a reactivation plan.
- Where practicable, use angular gravel on the approaches to prevent rutting and improve trafficability in wet weather.

Increased Cost Factors for Ford and Armoured Swale:

- Larger swales (width and depth)
- Excessive road fills (large volume at outlet)
- Lack of suitable armour (appropriate size and/or amount)
- Lots of woody debris in road fill
- Endhauling of excavated material (cannot place material in road cut)
- Connectivity to fish habitat or water supply may require environmental monitoring (sediment control) during excavation
- Strict timing constraints if connectivity to fish habitat or water supply
- Fish exclusion and salvage will be required for approved fords on fish-bearing streams

Additional Comments for Ford and Armoured Swale:

- Installation of a culvert pipe (or several pipes) can decrease the need for maintenance, although these may need to be inspected and cleaned in conjunction with other culverts in the area. Inspect after large rainstorms and maintain as needed.
- Heavy-walled steel pipe (used pipeline pipe) can be easily maintained and retrieved for use at another location once the structure is no longer needed.
- To construct an armoured swale where a cross-ditch is present, infill with coarse rock and maintain a swale for possible overflow.
- Large armoured swales may be suitable as longer term structures where roads cross active snow avalanche tracks and culverts will be prone to blockage.
3.5.10 Insloping/Outsloping

**Objective:** To control water without the use of ditches or cross-ditches. Insloping directs the water into the road cut while outsloping directs the water across the road to the fillslope (or road shoulder).

**Description:** Insloping is the sloping (reshaping) of the road surface to direct road surface water toward the road cut and away from unstable or erodible road fill materials. Outsloping is the sloping (reshaping) of the road surface to direct water across the road and onto the road fill in a dispersed fashion (Figure 3.28). Insloping may not be effective on significant grades (6% or greater) as the water runs down the wheel ruts. Outsloping is best applied where the road grade is gentle to flat.

**Prescription Indicators for Insloping/Outsloping:**

- Maintain access during reactivation
- Narrow road - no room for ditch
- Insloping: non-erodible material in road cut
- Outsloping: ditch line cannot be maintained due to ravelling road cut
- Outsloping: flat to gentle grades; concern about local instability with cross-ditch outlets and waterbar outlets; continuous cutslope seepage

**Suggested Construction Tips for Insloping/Outsloping:**

- The slope of the road surface laterally must be greater than the grade of the road to effectively direct water.
- Insloping/outsloping may not be suitable for areas with fine grained soil where rutting due to vehicle traffic is expected. Traffic rutting can reduce or eliminate the effectiveness of insloping and outsloping. In these cases, consider importing road surfacing material and compacting adequately to resist rutting.

*Fig. 3.27 Fords are generally restricted to non-fish-bearing streams unless otherwise approved by the fisheries agencies. Fords may be acceptable to fisheries agencies where infrequent vehicle traffic is anticipated provided certain criteria are met. In this example, the ford has been constructed on a low gradient fish stream using large rock slabs to form a ‘pavement’ across the wetted perimeter of the stream (left photo). At low flows, fry access is possible between the rock slabs, while at high flows juvenile and adult fish can pass over the structure (right). At such installations, gates or other approved methods of restricting motor vehicle access may be necessary to protect fish and fish habitat.*
Increased Cost Factors for Insloping/Outsloping:

- Wide roads or landings
- Improper equipment
- Need to maintain a driveable surface
- Endhauling of excavated material
- Dense road surface materials
- Importing suitable road surfacing material

Notes:

1. Insloping and outsloping over longer distances can be completed effectively using a grader or a bulldozer; using an excavator can substantially increase costs.

Additional Comments for Insloping/Outsloping:

- A ditch is optional for insloping/outsloping; however, a ditch can prevent some of the water from reaching the outsloped road surface and may improve trafficability. Where no maintenance will be carried out, the ditch line should be removed or filled in during outsloping.
- Outsloping may present a safety hazard on snow-covered roads where traffic use continues through the winter.
- Insloping and outsloping may require constant, careful re-grading in areas of heavy truck traffic.

Fig. 3.28 Cross-sections showing insloping and outsloping to control road drainage. Preservation of the ditch is dependent on factors such as the frequency of maintenance and the stability of the road cut.

Fig. 3.29 Example of outsloped road.
3.5.11 Berm Pullback

**Objective:** To restore natural hillslope drainage paths where road maintenance activities have left a berm or windrow on the outer edge (or inner edge) of the road. Larger berms may also be pulled back to reduce the weight on the outside edge of the road and/or for silvicultural reasons.

**Description:** Berms or windrows are often the result of road grading and road reconstruction activities. On older roads (constructed with a grade shovel), berms may be present on the outer edge of the road (see Figure 3.30). Pullback of berms allows water to pass over the shoulder of the road. Pullback of berms may also be carried out in conjunction with outsloping and/or cross-ditching to restore hillslope drainage paths.

**Prescription Indicators for Berm Pullback:**
- Water diversion along road by berm on outer edge (or inner edge) of road
- Water entrenched into road surface
- Large continuous berm with no vegetation
- Weight of large berms may initiate landslide in road fill, and larger landslide downslope

**Suggested Construction Tips for Berm Pullback:**
- Determine spoil site requirements and location(s) for berm material.

**Cost Factors: The following factors will tend to increase the costs of berm pullback**
- Berm size (volume of material)
- Machine requirements
- Removal of large second growth on berm
- Double handling of material on wide roads
- Endhauling of material (cannot be placed on road grade or on fillslopes below road)
- Sediment control

Note:
1. Size of berm will dictate the most efficient machine type and size for pullback.

*Fig. 3.30 Cross-section showing road fill and berm prior to pullback.*
Additional Comments for Berm Pullback:

- Consider natural drainage paths along with pulling of berm. May want to prescribe cross-ditches, outsloping, insloping, (or ditching for active roads) to best control drainage.
- If the berm is to be breached locally to discharge road drainage, rather than pulled back, assess the stability and erosion potential at the outlet areas.

3.5.12 Scarification

**Objective:** Scarification (also known as Silvicultural Fluffing) is carried out to increase the site productivity of compacted road surfaces.

**Description:** Scarification is the breaking up of the road surface to a minimum depth of approximately 400 mm or 16-20 inches. Where practical, scatter organics and woody debris on scarified road surface.

**Prescription Indicators:** Any of the following site indicators may require scarification.

- Compacted road surface
- Road fill stable, no pullback needed
- Site productivity for conifers may be improved
- Road is stable and no further access is needed

**Suggested Construction Tips for Scarification:**

- Scarification is more important for road surfaces where the materials are well graded, and/or high traffic volumes have compacted the road surface.
- Consider consulting with a silviculture forester to determine the benefit of scarification relative to planned tree species and site index parameters along the road.
- Evaluate the effective compaction in both the traveled and untraveled parts of the road running width.
- Mixing soil with rock during scarification may also increase site productivity

**Increased Cost Factors for Scarification:**

- Road or landing width
- Water management (insloping, etc)
- Road ballast depth (depth of compaction)
- Significant amount of large woody debris
- Road age (extent of compaction)
- Numerous large non-commercial trees growing on road

**Additional Comments for Scarification:**

- Consider the existing site productivity along the road prior to prescribing scarification; existing conditions may be in an acceptable state of recovery.
- Consult with silviculture forester to determine expected improvement in site productivity relative to existing conditions (road grade and adjacent stand).
3.5.13 Partial Road Fill Pullback (Access Maintained)

**Objective:** To reduce stability problems along the road yet maintain vehicle access. Partial road fill pullback is carried out when full restoration is not needed for immediate stability, or road access is needed at some future date.

**Description:** Partial road fill pullback retrieves the currently or imminently unstable portions of the road fill and leaves those portions with no evidence of immediate instability intact. Retrieved road fill is placed tight to the road cut with organic soil and woody debris on top to promote revegetation (see Figure 3.31). Endhauling of material is necessary when the unstable volumes of road fill exceed the available room in the ditch line. Carrying out partial road fill pullback may not reduce the landslide hazard to the fullest extent possible.

**Prescription Indicators for Partial Road Fill Pullback:** Any of these site indicators often justifies partial pullback on a road where access is to be maintained.

- Road fills with a large proportion of shot rock
- Small road fills over high landslide hazard areas
- Full road fill pullback not needed for immediate stability
- Newer roads where some root strength is retained, and short term access is needed

**Notes:**

1. For road fills with a large proportion of rock, some material can be left on slopes below the grade and full road fill pullback may not be needed.
2. Inspection should be carried out, and full road fill pullback may be needed at a later date.

**Suggested Construction Tips for Partial Road Fill Pullback:**

- Decompaction is not needed for partial road fill pullback where access will be maintained.
- Pullback currently unstable road fill. Endhauling may be necessary if placement of unstable road fill will result in loss of road running width.
- Place retrieved road fill material in the following order:
  1. Road surface materials and shot rock (non-organic soils)
  2. Organic soils and fine grained soil
  3. Woody debris and other vegetation (organics)

**Increased Cost Factors for Partial Road Fill Pullback:**

- Location (gully versus open slope)
- Size of existing vegetation
- Road fill comprised of difficult materials (large woody debris, or large rocks in road fill)
- Improper machine size (match size of machine to volumes of pullback)
- Road fill volume and/or long fillslope length (P distance)
- Excavation of saturated material
- Maintenance inspections to confirm water management controls are functioning well and there are no slope stability concerns
- Wide road or landing
- May need to re-mobilize equipment at some future time to carry out full road fill pullback to address long-term stability concerns

Notes:
1. Often pullback in gully areas requires more endhaul or movement of material out of the gully.
2. Sizeable trees on the road fill may not be large enough to stabilize the road fill, but may still increase the time and/or machine size requirements for pullback.
3. Saturated material is more difficult to keep on the bench and maintain the required angle on road fill pullback (angle of repose). Some endhaul may be necessary.

Additional Comments for Partial Road Fill Pullback:
- Cross-ditches must be constructed immediately upgrade of the start of road fill pullback to prevent erosion of the retrieved road fill.
- Consider constructing cross-ditches immediately downgrade of the retrieved road fill also, especially if the ditch line is intact under the road fill pullback.
- All natural watercourses must remain free of pullback material. Accommodate water flow in these areas using cross-ditches, trench drains, or in some cases, French drains.

**Fig. 3.31** Cross-section showing partial road fill pullback (left) and view showing cross-ditch for diversion of flow away from placed pullback material (right).
Endhauling may not be necessary when continued access is not planned; most material can be placed directly on the bench. If access is required, endhaul requirements can be lessened by placing removed brush and woody debris back onto the pulled back fillslope. This material will aid in short-term erosion control as well as enhance soil nutrients. It may be cost-effective to complete all required pullback for a road section, then replace the brush and woody debris in conjunction with installation of water management structures.

Do not inslope or outslope the road unless specified. Consider decompaction if no access will be needed following deactivation.

In some cases, wood box culverts can be left in place if the openings are adequately sized and they are backed up by adequate cross-ditches.

If access will not be maintained, consider how stability of the road will deteriorate over time before concluding that full road fill pullback is not necessary.

At some sites, partial pullback combined with appropriate water management may be the most cost-effective means of reducing landslide risk to tolerable levels for the intended period of continued vehicle access, but future full roadfill pullback may be needed on steeper slopes to reduce the landslide hazard to tolerable levels.

3.5.14 Full Road Fill Pullback

Objective: To retrieve all potentially unstable sidecast road fill and place it tight against the road cut. Full road fill pullback reduces the road fill landslide hazard to the fullest extent possible. Typically, no access or only limited access for foot or ATV traffic is possible after full road fill pullback has been carried out.

Description: Full road fill pullback, also known as “re-contouring” or “de-building”, is the de-construction of the road subgrade to restore the original hillslope profile and contours (Figure 3.34). Full road fill pullback typically involves decompaction and removal of the road surface to establish safe working areas and increase the downslope reach of the excavator. Where very long and deep road fills are present, benching and/or ramping may be needed to adequately retrieve and place all the road fill present (Figure 3.36). In cases where all of the retrieved material cannot be placed on a stable bench, endhauling may be needed. Woody debris is randomly scattered on the surface of the pullback material, promoting revegetation and inhibiting deer movement to reduce browse on seedlings.

Decompaction may be necessary for full road fill pullback (Figure 3.34) especially in areas of heavy seapage. Decompaction is the breaking up of road fill materials (ballast and subgrade) to a depth equal to, or greater than, the depth of the ditch and removing the material. The decompacted surface is outsloped, to provide better downslope reach and promote water flow across the road under the pullback material. Decompaction of the road fill can also define the width of the natural bench so that a safe working limit for the excavator can be established.

Prescription Indicators for Full Road Fill Pullback: Any of these site observations is often an indicator that full road fill pullback is needed. Consider both the landslide hazard and the risk to downslope/downstream resources when deciding whether full road fill pullback is needed.
Landslides from road fill in adjacent areas
- Large retrogressive landslides in road cut
- Tension cracks in road (not settlement cracks)\(^1\)
- Sidecast construction with high road cut
- Pistol-butted trees or jackstrawed (tilted) trees on road fill
- Narrow roads and high cut slopes on steep slopes
- Road fill supported by stumps and other woody debris; abundant large woody debris in road fill
- Road fill settlement above steep, unstable areas; repeated filling and grading of road fill areas

Notes:
1. Settlement from decomposing wood may not be a stability problem on gentle to flat hillslopes, but may be a safety problem for vehicle traffic or hauling activities.

**Suggested Construction Tips for Full Road Fill Pullback:**

- Walk site to evaluate safety concerns prior to starting road fill pullback. **If a safe approach is not apparent, ask for help.**
- Prior to starting pullback at the station, visualize the ground profile and contours above and below the road.
- As appropriate, decompact and remove the road surface to a depth below the ditch line. Sitting the excavator on the lowered (decompacted) surface will extend the effective reach of the excavator during pullback. Note that decompaction may not be possible in areas where a portion of the road bench is blasted into solid bedrock. In this case, complete fill retrieval may not be possible. Consider using a log to push any residual unstable fill downslope. It may be preferable to unload this material in a controlled manner during dry conditions, rather than have it fail during wet conditions.
- Retrieve all fill to expose native material.
- Place road fill material tight to the road cut. During road fill pullback in rocky materials, releasing material above the slope and letting the rocks roll down to the bench can often create a blanket drain.
- Place retrieved road fill material in the following order; see sketch below.
  - Road surface materials and shot rock (non-organic soils)
  - Organic soils and fine-grained soil
  - Woody debris and other vegetation (organics)
- Benching-Ramping may be necessary in areas where unstable road fill is present beyond the reach of the excavator. An example of the steps for benching and ramping is shown in Figure 3.36.
- Step 1 establishes a bench that is wider and lower than the existing road grade, increasing machine reach. Additional benching may be necessary to retrieve all unstable fill. **Benching must only be done by experienced operators, only into native ground with an escape route available at all times.**
Fig. 3.32 Site indicators for full road fill pullback include fill supported by woody debris.

Fig. 3.33 Presence of tension fractures and/or slumping of road shoulder may also justify full road fill pullback.

Fig. 3.34 Cross-sections showing road prior to pullback (left) and completed pullback with full retrieval of fill (right).
Fig. 3.35 Full sidecast pullback before (left) and after (right).

Notes:
1. Numbers refer to recommended sequence for machine positioning and road fill pullback.
2. Never position the tracks of the machine parallel or at right angles to the centerline of the road. Always work 20° to 45° off the road centerline.
3. For areas with less road fill and/or wide roads, ramping may not be necessary if the material can be sorted during pullback and placed appropriately.

Fig. 3.36 View showing process of benching and ramping to complete full road fill pullback and sort the retrieved material as it is placed against the road cut.
- Step 2 retrieves material from the road fill and places it in an intermediate position. After moving the excavator up the ramp, material can then be sorted and placed at specific positions on the bench (Steps 3 to 5).
- To create a blanket drain with road fill containing large rock, sort the material by sprinkling it onto the slope to segregate the larger rocks from the fine soil (see Section 3.5.7).
- The bench and ramp sections should generally be kept short to ensure the completion of each section. The bench and ramp should form a “Y” in plan view. The length of the bench will depend on bench width, road fill volumes to be retrieved, and fillslope length.
- Additional benching is not necessary for road fills that can be retrieved from the decompacted bench.
- Woody debris should be scattered with random orientations (Step 6) to reduce deer browse on seedlings and increase the number of productive microsites.

**Increased Cost Factors for Full Road Fill Pullback:**

- Location (gully versus open slope)\(^1\)
- Size of adjacent vegetation\(^2\)
- Large road fill volume and/or long fillslope length (P distance)

**Fig. 3.37** Two hoes working in tandem to complete full road fill pullback. Hoe on right is benching down to retrieve fill, while hoe on left is ramping up to place fill tight against cutslope. Note placement of woody debris on top of recontoured slope.

- Excavation of saturated material\(^3\)
- Wide road or landing (unless material does not have to be placed tight to road cut)
- Undersized machine (larger machines can be more efficient)
- Landslide material on road grade\(^4\)

**Notes:**

1. Often pullback in gully areas requires more endhaul or multiple handling of material.
2. Sizeable trees on the road fill may not be large enough to stabilize the road fill, but may still increase the time and/or machine size requirements for pullback.
3. Saturated material is more difficult to keep on the bench and maintain the required angle on the placed road fill pullback (angle of repose). Some endhaul may be necessary.

4. Endhauling of material is often necessary where space for placement of road fill pullback material is limited.

**Additional Comments for Full Road Fill Pullback:**

- All road fill must be retrieved from gully channels, gully headwalls, and creek channels. Consider removing all road fill from open slope depressions and wet hillslope areas.

- Cross-ditches, trench drains, blanket drains, and in some cases French drains must be used to restore the natural hillslope drainage paths concurrent with full road fill pullback.

- The ditch line must be eliminated using decompaction for roads with moderate to steep grades, otherwise the ditch will continue to divert water.

- In areas with road cut instability, full road fill pullback can also partially support the road cut and reduce the landslide hazard.

- Placing road fill during wet conditions may result in small slumps in the retrieved road fill, or problems retaining retrieved material on the bench. Consider suspending operations during extremely wet conditions for safety and/or environmental reasons.

- Assess the stability of the site continually during pullback in terms of machine stability and safety of the operator. Change the positioning of the machine or suspend operations in wet weather as required. In extreme cases, consider modifying the work plan as appropriate to ensure safety.

- If foot access is required following deactivation, a walking path can be left by leaving a gap at the top of the brush and woody debris placed on the retrieved pullback.

### 3.6 Prescription Considerations

In addition to the deactivation techniques described in Section 3.5, some important considerations merit discussion. These include special sites along the road that must be assessed during deactivation (or in some cases, reactivation). Often these sites will require assessment by very experienced site personnel in conjunction with a qualified registered professional.
3.6.1 Special Sites

Road Reconstruction

Objective: To achieve temporary access for deactivation activities by reconstructing the road subgrade and/or drainage system as necessary. For example, reconstruction of the road subgrade is necessary at locations where a landslide has reduced the running width of the road, making access unsafe and/or impossible.

Description: Road reconstruction involves altering the road grade and/or alignment to achieve the necessary running width. There are three general options for reconstruction:

1) Excavating into the road cut to increase the running width. This method is suitable when the road cut materials can be excavated, (i.e. don’t require blasting), and the slopes immediately above the road are not steep (otherwise large volumes of material will be created).

2) Excavating to lower the road grade to achieve the necessary running width. This method is suitable when the material below the road is stable.

3) Constructing retaining structures on the outside of the road to increase the strength of the road fill. This method can be used where excavating into the road cut is not possible due to cost or stability concerns, and excavation to lower the road grade is not possible due to cost concerns or because non-rippable bedrock comprises the road bench.

The three methods of road reconstruction can be used together. For example, it is possible to combine 1) and 2) to move the road centreline both into the slope and lower the grade to reduce the amount of excavation in some cases.

Benefits: The benefits of road reconstruction are access for machinery and increased safety during access. At some locations, such as gully crossings, excavation into the road cut and/or lowering the road grade (followed by subsequent endhauling) are often needed during road fill pullback regardless.

Considerations: Road reconstruction is practical often when part of the road fill is stable. If the entire running surface of the road is unstable, simply moving the road centreline into the road cut may not provide for a stable running width.

Costs for reconstruction can be considerable, particularly if blasting, hauling coarse rock, constructing engineering structures such as a retaining wall, or using geosynthetic-reinforced road fill is required.

Endhauling

Objective: Endhauling is required at specific locations during reactivation and deactivation to ensure that enough room is available on the road bench to avoid placing landslide debris or road fill pullback on unstable slopes.

Description: Endhauling involves moving material along the road corridor to a stable location. Endhauling is commonly required in four cases where unstable slopes are located below the road and road fill cannot be placed in the immediate area:
1) Landslide material (or material from the road cut) is present on the road grade and blocks access, or occurs along a section requiring road fill pullback (assuming that all of the space on the bench is needed for placement of pullback material);

2) Road cuts with inadequate space to accommodate the expected volumes to be retrieved (where material was moved laterally along the road during construction). This is common for bulldozer construction in steep terrain and/or gully areas.

3) Road reconstruction requires excavation and the material cannot be placed safely on the road grade nor on steep/unstable slopes immediately below the road;

4) Road fill material that is saturated and will not maintain a slope steep enough to remain on the bench following pullback.

Wise and Horel (1998) discuss endhauling during reactivation and deactivation, as well as some of the criteria for selecting spoil sites.

**Benefits:** Endhauling during reactivation can ensure that the maximum amount of room on the bench is available in areas of full road fill pullback. For deactivation, some endhauling during full road fill pullback may help to restore the hillslope contour and profile, reducing the likelihood that road fill will remain on unstable hillslope areas and cause landslides in the future.

**Considerations:** Endhauling increases the costs of reactivation and/or deactivation. The extent of the increase is dependent on the working room at the site, the distance to spoil sites, and the size and quantity of the spoil sites available. This increased cost must be

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**Fig. 3.39** Fillslope pullback and endhauling required to remove excess fill volumes in and adjacent to a gully.
considered and evaluated against the increased hazard associated with not endhauling material. In some cases, endhauling material can improve the efficiency of pullback operations. In steep, mountainous terrain identifying suitable endhaul spoil sites can be challenging. Where necessary, deactivation prescriptions should identify all possible endhaul spoil locations in steep terrain. It may be possible at some locations where the road is to be kept open to reduce endhaul costs by using some of the spoil to build up the road grade in the immediate area.

**Gully Restoration**

**Objective:** To restore the gully channel to its historic (pre-construction) conditions and decrease the landslide hazard along the road approaches on the sidewall of the gully.

**Description:** Gully restoration typically involves pulling all of the material out of the gully channel during deactivation activities, and is carried out during full road fill pullback. The size, depth, and shape of the pullback must mimic the natural ground profiles and contours of the gully system above and below the road. Armouring of the gully channel at the road location, and endhauling of excess road fill material is often required. Similar techniques can also be used for entrenched creeks. Refer to the Gully Assessment Procedure Guidebook for detailed information on the deactivation of roads at gully crossings.

**Benefits:** Gully restoration is the most viable means of stabilizing gully systems and reducing the landslide hazard to historic (pre-construction) levels. Since even small debris slides into gully systems can develop into larger debris flows, gully restoration decreases the risk to downslope and downstream resources.

**Considerations:** Some sidecast material on gully sidewalls can be difficult to retrieve. This occurs frequently in gully areas where bulldozers were used for construction and bedrock prevents benching down to retrieve the material. Also, large woody debris in gully channels can be difficult to excavate due to its interlocking nature. In these cases, the decision to remove it during deactivation should consider the gully processes and the consequence of leaving the woody debris in place (see Section 5.3.1).

![Fig. 3.40 Restored gully at road crossing in Merritt Forest District. Some large woody debris is left to provide obstacles to cattle, act as sediment traps and to provide nutrients and shade for seedlings.](image)
**Blasting of Road Fills for Deactivation**

**Objective:** To stabilize road fills at isolated locations where access for excavators is neither possible nor cost effective.

**Description:** Blasting is intended to remove the weight of the road fill and disperse the fill onto the slopes below the road. Generally, blasting is applicable at locations where intermittent or isolated stability concerns exist along a road. Muir et al. (1999) discuss a case study where blasting was used to stabilize a road fill for deactivation.

**Benefits:** Blasting can be used to deactivate isolated, high risk sections of road where no other means is viable.

**Considerations:** Blasting may not be applicable at locations where the road requires a large, continuous length of pullback, or where the blasting may pose a risk to houses, highways or other infrastructure. In addition, blasting may not be possible at locations where the road fill contains a large proportion of woody debris that would prevent adequate confinement of the blast and reduce its effectiveness. Blasting should only be carried out in dry weather and potential fire hazard should be considered. A series of blasts may be needed to stabilize large road fills at locations where the explosives cannot be placed deep into the road fill.

**Continued Future Access**

**Objective:** To incorporate continued future access requirements into road deactivation prescriptions to provide for continued road use and/or minimize the cost associated with reactivating the road at a later date.

**Description:** Future access is often required for forest operations or for other users once deactivation is completed. In these cases, some minor modifications can be made to the deactivation prescriptions to decrease the future access costs. For water management, these modifications include:

- Prescribing armoured swales (or modified armoured swales) as part of deactivation;
- Leaving the road bed intact under road fill pullback to enable future access once the fill is removed to a suitable location;
- Leaving culverts in place, backed up with cross-ditches;
- Stockpiling coarse rock for later use as riprap at portable bridge sites;
- Partial road fill pullback combined with outsloping, insloping, leaving a running width suitable for access.

**Benefits:** Modifying deactivation prescriptions to permit future access is a low cost approach to allow for re-opening roads following deactivation. Where access is maintained, the road can be easily inspected and repaired as necessary.

**Considerations:** Modifying the deactivation techniques to decrease costs for future access should only be carried out where such modifications will not significantly decrease the effectiveness of the road deactivation techniques. At some locations, it may be appropriate to require inspection/monitoring of a road over a specific period of time.
Planning for deactivation during road design and construction

**Purpose:** Planning for deactivation during the design and construction of forest roads can decrease the costs and improve the effectiveness of deactivation. For winter roads, using deactivation measures during road construction can significantly decrease maintenance costs.

**Description:** The design and construction of newer roads represents an opportunity to decrease the costs associated with deactivation, and improve its effectiveness (Horel, 1998). Examples include stockpiling coarse rock for use at armoured swale and cross-ditch locations, limiting the length of road fills so that benching is not needed during road fill pullback, and stockpiling organic soils for later use on road fill pullback or subgrade.

**Benefits:** For winter roads, planning for deactivation during the construction of the road can decrease the amount of maintenance and deactivation needed during the summer months, when the roads are generally impassable. On other roads, planning for deactivation during construction can allow for the road to be deactivated at less cost using smaller excavators.

**Considerations:** During the road design process, it is often possible to make a decision on the need for road fill pullback along a branch road. Where the design calls for minimal road fill, marginally stable locations may only require water management rather than road fill pullback following harvesting activities.

For winter roads, carrying out deactivation immediately following hauling is important to reduce the potential for erosion from vehicle traffic.

Range Management Issues

**Objective:** Road deactivation in range areas requires due consideration of the access requirements and the potential consequences of disrupted road access to ranchers including removal of traditional watering sites for livestock.

**Description:** Where road access is important for range management, deactivation should be carried out to provide required access and maintain the existing drainage patterns that may be linked to range watering systems where practicable.

**Benefits:** Identifying where range management may be affected by deactivation may preclude conflicts over road access and provide for better management of water resources in an area.

**Considerations:** Roadside ditches can sometimes act as water sources for cattle. Restoring natural drainage paths in these situations may result in removal of these sources, forcing the livestock to use existing creeks for a water source. This may result in environmental damage to these creeks. Construction of small watering ponds at appropriate road sites in conjunction with deactivation may alleviate this concern. Fencing may also decrease the potential environmental damage from livestock where sensitive slopes are at risk.

Knapweed and other noxious weeds need to be considered during road deactivation assessment. Such plants are common along many old logging roads and deactivation may
spread these through machine travel or seed disturbance. Consultation with a Range Agrologist may be warranted to minimize the likelihood of spreading these problem weeds. Scheduling of deactivation work outside seed maturity time should also be considered.

3.7 **Surface Erosion and Sediment Control**

Control of surface erosion and subsequent sediment transport during road deactivation is paramount where there is direct or indirect connectivity to aquatic habitat and/or aquatic resources. As erosion control has a generally higher level of effectiveness than sediment control, the primary goals should be to first minimize potentially damaging erosion of the disturbed sites; and second, limit the transport of sediment from these sites. While some amount of soil disturbance is inevitable from most road deactivation activities, the ultimate aim should be to re-establish natural rates of erosion and sedimentation as soon as possible following works.

Reduction of erosion during deactivation is possible through careful planning of operations and through awareness during operations. Confining sensitive operations to periods of dry weather, minimizing traffic through these areas, and selecting equipment that will create less disturbance (e.g. rubber tired or rubber tracked machinery) are options that should be considered where practical. Compliance with local rainfall shutdown guidelines is mandatory and care should be exercised in this regard (i.e. accurate precipitation measurements should be taken at appropriate intervals, antecedent moisture and soil saturation should be monitored, rain-on-snow events considered). For deactivation of water crossings (e.g. culvert removals, stream restorations), temporary diversion and/or impoundment of stream flow can reduce the exposure of disturbed soil to flowing water, however, prior agency approval may be required.

Once soil disturbance has occurred, erosion protection should be implemented as soon as possible. Revegetation by seeding with a grass and legume mix, as described in Section 3.8, is generally the most appropriate treatment for reducing erosion. Grading of disturbed slopes to a stable angle will help to facilitate establishment of the vegetation cover. For newly created slopes (e.g. pulled back fillslopes, slopes comprised of retrieved road fill), erosion may be reduced and revegetation aided by striating the soil with the excavator to form a series of small terraces. On gently sloping sites, placing a layer of straw or similar material in conjunction with the seeding can be a cost-effective means of providing short-term benefit in reducing rain splash erosion until the vegetation establishes. A similar effect may be gained by replacing the brush on pulled back fillslopes. Placement of properly sized rock riprap is effective in reducing runoff velocities and associated erosion in stream channels and ditches. In certain situations the use of alternative, more costly, revegetation treatments may be warranted (e.g. erosion control revegetation mats, bonded fibre matrix products).

Once sediment has been mobilized by erosion, a number of sediment control measures can be used to minimize sediment transport. Each has its own advantages and limitations. Regardless of the measures taken, it is critical that all of the necessary materials, tools and personnel be on hand as the work proceeds. A certain amount of routine maintenance is also necessary to ensure optimal performance. The main sediment control techniques that are applicable in road deactivation include:
Silt Fencing is appropriate for installation immediately below the toe of the slope to prevent mobilized sediment from becoming entrained in flowing water. The bottom of the woven geotextile material should be keyed into the soil or buried with drain rock for maximum effect (Figure 3.42). Suitable locations for installation of silt fence include the base of pulled back fill slopes, along stream banks or ditch sidewalls (above the high water mark) and around recently spoiled material. Silt fencing should be carefully removed and disposed of following adequate establishment of vegetation cover. Silt fencing is not effective when installed in flowing water and may lead to an increase in bank erosion. Use of certain types of erosion control revegetation mats (ECRM’s) may be an alternative to conventional silt fencing. When laid down and anchored as narrow strips (i.e. 0.5 to 1.0 m wide) in place of silt fence they can act as effective sediment traps. They can also be seeded through and left in place. Sod strips may be used to provide a similar benefit.

**Fig. 3.41** Silt fence installed at toe of pulled back fillslope.

**Fig. 3.42** Proper silt fence installation (modified after Fifield, 1997).
Check Dams are intended to both reduce erosion of a channel by reducing flow velocity and to provide for retention of sediment in the channel. They are generally appropriate for channels or ditches where relatively low flows are anticipated in the short-term following deactivation works. For Coastal sites, sediment retention is usually intended to be short-term with subsequent sediment release over an extended period. For some Interior sites, check dams may provide a long-term benefit in reducing erosion. Installation of rock check dams may be useful across cross-ditches constructed within fillslope pullback zones where full armouring of the channel is not practicable due to lack of rock. Check dams may be constructed solely of rock or in combination with materials such as straw bales and filter cloth (N.B. construction with straw bales alone is not recommended). For sediment retention by check dams built with rock only, rock diameter will depend largely on expected flow volumes. Where adequate size rock is not available, sandbags may be a cost-effective alternative for construction of temporary check dams. Proper construction requires that the sides of the structure be 15 cm to 45 cm higher than the centre to allow water to flow over the structure rather than around it (Figure 3.44). Soil bioengineering structures such as live silt fences and live gully breaks also act as check dams and may be appropriate for low flow sites.

Fig. 3.43 Check dam constructed of hay bales wrapped in filter fabric for temporary sediment retention.

Fig. 3.44 Proper check dam construction (modified after Fifield, 1997).
Riprap involves the placement of rock riprap (armouring) to reduce the velocity and erosive effect of flowing water and, like check dams, can provide temporary sediment retention. Riprap is commonly placed along ditch lines and at the inlets and outlets of cross-drain structures. Rock size is dependent on anticipated flow volumes. Angular rock is generally best suited for use as riprap.

Sediment Catchment Basins are intended to provide for longer-term retention of fine sediment that settles slowly. They should be constructed in or lined with non-erodible material and must be large enough to provide sufficient time for the fine sediment to settle. Basins generally require periodic cleaning and appropriate disposal of material. For this reason they may not be suitable for situations where regular maintenance is not carried out.

Stream Crossing Techniques are used to limit sedimentation caused during crossing of streams. These may include conducting activities during periods of low flows, diverting any flows around the work site (via pumps and impoundments), and minimizing both the removal of existing vegetation and the duration of the activities. For control of sediment mobilized during the work, check dams constructed with a filter fabric can be effective for sediment removal. Depending on conditions, a series of these structures may be necessary to provide sufficient benefit. Installation of silt fencing may be appropriate along disturbed streambanks until revegetation or placement of riprap has occurred. The temporary use of open bottom, arched culverts may be acceptable to fisheries agencies where repeated crossing of a fish stream is necessary during the period of deactivation. Such structures are intended to allow for continued fish passage and may be reusable (Figure 3.45).

3.8 Revegetation

Revegetation of deactivated roads is essential to reduce erosion and aid in restoring productivity to the road area. This section presents information on the revegetation of deactivated roads, landings and associated soil disturbances to reduce the risk of erosion and associated impacts to downstream resources. General information on revegetation presented in this section is also applicable to revegetation of gullies and landslides. Effective revegetation can reduce erosion rates by as much as 100 times (Wischmeier and Smith, 1965), however, improper revegetation can result in the establishment of a dense cover of seeded species on the disturbed sites leading to successional stagnation (Kimmins, 1987) and the loss of site productivity.

3.8.1 Grass and Legume Seeding

Seeding is the most common and usually the most cost-effective means of treating deactivated roads to prevent erosion and should be considered even where some level of vehicle access will be possible following deactivation. In most cases, a seed mix
composed of agronomic species is used and is applied dry either with or without fertilizer. For some areas, it may be desirable to select a seed mix that will not encourage grazing by livestock. A discussion of the principles used for selection of appropriate seed species is contained in Section 4.3.3.

Dry broadcast seeding immediately following the deactivation works is the most common means of applying seed, whether by hand using a hand-held “cyclone” type seeder or by machine such as a vehicle-mounted spreader or a helicopter-slung bucket. A major problem with most seeding projects has been the tendency to over-apply the seed. Mixed grass and legume seed should not be applied at rates that exceed 50 kg/ha. Higher rates will generally result in severe seedling competition to the eventual detriment of the established stand and planted or invading woody species.

Fertilizer may or may not be applied with the seed at the time of seeding. In most cases, where deactivated roads are seeded using agronomic species, a light application of fertilizer will assist in initial establishment and growth. Unless there are indications to the contrary, a high analysis, balanced fertilizer containing all of the essential macro-nutrients, Nitrogen, Phosphorus and Potassium (N, P & K) applied at a rate of from 100 to 300 kg/ha will be suitable for most sites throughout the Province. At these rates of application, detrimental effects to water quality or fish habitat are unlikely. It is important to remember that the objective of most forest land revegetation programs is not to establish a permanent stand of grasses and legumes but to encourage the eventual invasion of the site by native woody species.

If handseeding is carried out, the product (seed and fertilizer) should be transported to the site as work is progressing to avoid having to pack material to the work area if vehicle access has been removed. The amount of product required per lineal metre of road will depend on the width of the road prism requiring revegetation.

Hydroseeding, where seed, fertilizer, mulch and tackifier are applied in a slurry with water, can be used for revegetation of deactivated roads, although it is more costly and, for freshly deactivated roads, often not as effective as dryseeding. As with broadcast seeding, seed application rates should not exceed 50 kg/ha. Hydroseeding is discussed in greater detail in Section 4.3.3.
3.8.2 Woody Species Establishment

Establishment of woody species on disturbed forest sites, whether through natural invasion or planting, is essential for restoration of the site. Pioneering species such as alder, willow and, in some cases, lodgepole pine and Douglas fir are important early colonizers of disturbed sites. These species prepare the site for later successional forest species such as spruce, cedar and hemlock. The establishment of native woody species is discussed in greater detail in Section 4.3.5.

Conifers can be established on deactivated roads and other disturbed forest sites, although unless the soils of the site are similar to those of the surrounding block, the growth will generally be slower than in the adjacent stand. In general, disturbed forest sites tend to be drougthy and have reduced available nutrients compared to the adjacent stands. Tree species selected for planting should be suited to conditions that are one step drier and one step more oligotrophic (nutrient poor) than would be predicted for the prevailing soil moisture and nutrient regime classes for the corresponding adjacent stand. A qualified forester or biologist should review the selection of tree species for planting on any disturbed forest sites.

3.8.3 Special Revegetation Considerations

Soil bioengineering (see Section 6) as well as a variety of specialized revegetation techniques can be helpful in the treatment of difficult sites. In most cases, discussions with a revegetation specialist are useful when dealing with difficult sites.