HAWKE'S BAY WATERWAY GUIDELINES

FORESTRY EROSION & SEDIMENT CONTROL

HAWKE'S BAY
REGIONAL COUNCIL

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SAFEGUARDING YOUR ENVIRONMENT + KAITIAKI TUKU IHO

Hawke's Bay Waterway Guidelines

DRAFT Forestry Erosion and Sediment Control

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Acknowledgement
This document for the Hawke's Bay Region is based on the Auckland Regional Council's Technical Publication No. 223 "Forestry Operations in the Auckland Region: Erosion and Sediment Control Guidelines". The ARC gave permission to use their document and that permission is greatly appreciated.

It should also be mentioned that the ARC document was based on the Forest Guideline produced by the Environment Bay of Plenty. Consistency of the three documents should facilitate effective implementation of erosion and sediment controls by operators who harvest on a widespread basis.

Modifications to the ARC document have been made so there will be some differences to the ARC approach to account for advances in practice design and to reflect local conditions.

Note
This document is a living document and may be reviewed from time to time as industry standards change and best practice evolves. Please contact Hawke's Bay Regional Council to ensure the latest version is used.

DRAFT April 2009
ISBN NO 1-877405-34-5
HBRC Plan Number 4108

Intent

These Guidelines build upon the concepts and practices from the Hawke's Bay Council Technical Guideline Erosion and Sediment Control Guidelines for the Hawke's Bay Region. This guideline however, is specifically designed for forestry operations in the Hawke's Bay Region.

The intent of these Guidelines is as follows:

- To provide a comprehensive guideline for erosion and sediment control in forestry situations.
- To minimise adverse environmental effects of sediment discharge through the appropriate use and design of specific measures.

The Guidelines are split into three parts. The first five sections provide introductory information and erosion and sediment control principles. Sections 6 and 7 provide technical specifications on a selection of erosion and sediment control practices. Finally, Section 8 discusses the principles associated with the application of the various control measures.

The practices detailed in these Guidelines are divided into erosion control and sediment control. A section on the application of these practices using a toolbox approach for each specific forestry activity is outlined. For each practice these Guidelines outline the following:

- Description/Purpose
- Catchment Area
- Design/construction specifications
- Maintenance

Contents

1 Background

1.1 Purpose of this Guideline

The Hawke's Bay Regional Council determined that a specific set of guidelines for earthworks and general land disturbing activities associated with forestry operations would be developed using the *Erosion and Sediment Control Guidelines for the Hawke's Bay Region,* as a base. It builds upon the concepts and practices from that Guideline which addresses erosion and sediment control across the region. This guideline also focuses on erosion and sediment control, but from a forestry perspective, and so there are control measures in this guideline that are not contained within the Erosion and Sediment Control Guidelines, and vice versa. Following the practices and methodologies in this guideline will minimise any erosion and sedimentation that may arise from forestry operations and help forest managers and contractors meet their statutory requirements.

1.2 Guideline Layout

The preferred concept for developing the guideline was to incorporate a series of "toolboxes" for specific operations. This concept uses a mix and match approach and enables a number of control options to be considered that can obtain a minimum standard of environmental outcome.

This guideline is split into three sections. The first is an introductory section that discusses whether a resource consent is needed, potential sediment related environmental impacts, erosion and sediment control principles, and earthworks and harvest management plans.

The second section provides technical specifications on a selection of commonly used erosion and sediment control practices.

The third section discusses the principles associated with the application of the various control measures in relation to different forestry operations (roading, tracking, landing sites, etc).

1.3 Extent of the Guideline

The objective of this guideline is to provide information on practices and methodologies that will minimise any erosion and consequent sedimentation that may arise from forestry practices. They do not replace or override in any manner other statutory requirements such as the Health and Safety in Employment Act or resource consents from the Hawke's Bay Regional Council and various Territorial Authorities.

In addition, it is suggested that you contact the the Hawke's Bay Regional Council to determine the status of the relevant regional plan rules and confirm that your operation, including any works proposed in streams, complies with the relevant regulations.

2 Do I need a Consent

2.1 General

There are two levels under the Regional Plan that address vegetation clearance: Rule 7 related to Permitted Activities and Rule 8 related to Restricted Discretionary Activities. Those two rules state the following:

Rule 7 **Permitted Activity**

Vegetation Clearance or Soil Disturbance Activities[25]

a. All cleared vegetation, disturbed soil or debris shall be deposited or contained to reasonably prevent the transportation or deposition of disturbed matter into any water body[26].

b. Vegetation clearance or soil disturbance shall not give rise to any significant change in the colour or clarity of any adjacent water body, after reasonable mixing.

c. No vegetation clearance shall occur within 5 metres of any permanently flowing river, or any other river with a bed width in excess of 2 metres, or any other lake or wetland, except that this condition shall not apply to:

   i. The clearance of plantation forestry established prior to the date of this Plan becoming operative, or

   ii. The areas identified in Schedule X to this Plan.

d. Deposition of soil or soil particles across a property boundary shall not be objectionable or offensive, cause property damage or exceed 10 kg/m^2.

e. Where the clearance of vegetation or the disturbance of soil increases the risk of soil loss the land shall be:

i. Re-vegetated as soon as practicable after completion of the activity, but in any event no later than 18 months with species providing equivalent or better land stabilisation; or

ii. Retained in a manner which inhibits soil loss.

[26] Explanation of Rule 7 (a): In considering whether condition/standard/term (a) in Rule 7 has been met, Council shall have regard to recognised Industry Codes of Practice, Best Practice Guidelines and Environmental Management Plans relevant to and adopted in carrying out the activity.

If a resource consent is needed, then this must be obtained before any work is undertaken, and the conditions of the resource consent <u>must</u> be followed.

Please also note that Rules 7 and 8 relate only to the Hawke's Bay Regional Council. The city and district councils may also have regulatory controls, such as for earthworks, which the forester should be aware of. A resource consent may be required from these councils as well, so the relevant council should also be contacted to determine their regulatory requirements.

Rule 8 **Restricted Discretionary Activity**

Vegetation clearance or soil disturbance activities, which do not meet the conditions in Rule 7[26].

a. The conditions, standards or terms which the activity cannot comply with, and the related environmental effects.
b. Monitoring and reporting requirements.
c. Duration of consent.
d. Review of consent conditions.

Applications may be considered without notification, without the need to obtain the written approval of affected persons.

Vegetation clearance and soil disturbance exclude:

The normal maintenance of legally established structures, roads, tracks, railway lines and river beds.
The clearance of grasses, forest thinning, and agricultural and horticultural crops.
The clearance of isolated or scattered regrowth on productive pasture.
The clearance of any indigenous vegetation understorey beneath plantation forests.
The clearance of noxious weeds covered by the Regional Plant Pest Management Strategy prepared under the Biosecurity Act, 1993.
Non-motorised soil disturbance activities.
Thrusting, boring, trenching or mole ploughing associated with cable or pipe laying or a network utility operation.
Soil disturbance undertaken by a mine or quarry operation which either had a valid mining licence at the date the Proposed Regional Resource Management Plan was publicly notified (15 April 2000) or is lawfully established.
Cultivation and grazing.
Foundations works for structures.
Construction and maintenance of fences and drains.

[26] Explanation of Rule 7 (a): In considering whether condition/standard/term (a) in Rule 7 has been met, Council shall have regard to recognised Industry Codes of Practice, Best Practice Guidelines and Environmental Management Plans relevant to and adopted in carrying out the activity.

Note: 10 kg/m^2 of dry soil is equivalent to 5 mm depth assuming a specific gravity of 2 kg/litre.

2.2 Resource Consent Requirements

An application to the Hawke's Bay Regional Council will require the appropriate application form to be filled in, relevant supporting information to be attached, and a deposit fee forwarded.

The fundamental aspect of the supporting information is the erosion and sediment control plan, which forms part of the Harvest Management Plan or Harvest Plan (see section 5 of this guideline). The erosion and sediment control plan, along with the supporting text and any necessary calculations, should address the potential effects of the proposed activity, and the various ways in which these may be avoided, remedied or mitigated.

An application for resource consent will involve a combination of technical and statutory matters associated with the Resource Management Act 1991. It is

considered good practice to lodge an application early and/or have a pre-application meeting with the Hawke's Bay Regional Council, as works will not usually be able to commence until the required approvals have been obtained.

3 Potential Impacts of Earthworks and Vegetation Removal Operations

All streams have a natural sediment load that varies primarily with rainfall, geology, topography and land use, both past and current. This natural level of sediment can be greatly increased by earthworks to a level that can result in significant adverse ecological effects. In addition, because of their physical and chemical characteristics, clay-rich soils in some portions of the Hawke's Bay Region are very difficult to remove once they have become suspended and are easily transported to lower receiving environments (*eg* estuaries).

Poorly managed earthworks and vegetation removal operations can have significant adverse effects on watercourses. There are a number of ways in which these effects may occur, such as:

- The failure to protect disturbed areas from erosion and/or treating runoff from earthworks; as well as effects resulting from mass-movement of soil (slumping) leading to an increased sediment load in watercourses. This is likely to affect water quality and the ability of aquatic life to survive and/or migrate;
- The damage or disturbance of the stream bed and banks during the construction of roads, tracks, culverts or the harvesting of trees. This may result in physical barriers to fish migration;
- The physical disturbance of stream bed and banks from the installation of stream crossings, as well as felling trees into watercourses and dragging trees across or along stream channels. This may result in physical barriers to fish migration.
- An increase in water temperature due to loss of shading from the removal of tree canopy;
- Depletion of oxygen in watercourses as any logging slash that has been deposited in watercourses decays. Barriers to water flows *eg* blocking of culverts from slash;
- Water flow may be affected by changes in vegetation cover impacting upon catchment hydrology. These may create areas of increased erosion potential.

Example of disturbance of the stream bed with debris and sediment from uncontrolled earthworking & harvesting operations

Stream headwaters, where production forestry often occurs, often have high ecological diversity and environmental value due to their relative intactness, compared to more modified lengths of streams and rivers lower down in the catchment.

This is not to undervalue the modified stream reaches but illustrate that these headwater areas have a higher level of susceptibility to environmental degradation due to their limited modification. Poorly designed and managed earthworks can directly impact on these values in the upper reaches. Earthworks

and harvesting operations therefore need to be well planned to ensure that the risks of erosion and the resultant sedimentation of watercourses is managed and the effects minimised.

4 Erosion and Sediment Control Principles

There are a number of erosion and sediment control principles that need to be adhered to. Fundamentally, they can be summed up as:

- Minimise the area of disturbed land (*i.e.* minimise erosion).
- Treat all runoff from earthwork operations before it is discharged so that sediment is retained on site (*i.e.* maximise sediment retention).
- Erosion and sediment control measures are sized for the total contributing catchment, not just the 'worked' area. When a work site is partially stabilised, such as stacked logs and slash on a landing, check that the unstabilised part such as the processing area remains fully controlled by sediment control measures unless it discharges to a different outlet.
- Optimise the location of any infrastructure to ensure the layout will: minimise and simplify any construction; avoid unnecessary stream crossings; and provide the simplest harvest solution which helps reduces the environmental risk.
- Time any operations to minimise any risk. Consider not only the construction of any infrastructure but also the harvesting to ensure the work is completed in an appropriate season or the work is phased to ensure risk areas are completed in the best weather window.

In giving effect to these principles, the forester needs to consider forward planning, erosion and sediment control measures and practices, and monitoring and maintenance. Each of these are briefly discussed in the following sections.

4.1 Forward Planning

Forward planning is essential to achieve good erosion and sediment control outcomes and should form part of the harvest plan (see Section 5). Consideration of how erosion and sediment controls will be achieved during each phase of the operation should form part of the planning for any harvesting operation, and be specifically defined in the harvest plan. Although the exact location of control measures may be difficult to detail in advance, it is essential that provision for erosion and sediment control measures be included for all earthwork/disturbed areas.

This guideline contains a range of erosion and sediment control measures that will help minimise sediment derived from forestry operations. These measures are covered in detail in Sections 6 and 7 with summaries outlined in the Operators Field Guide. It is important to emphasise that erosion and sediment controls need to be installed before the ground is disturbed, regularly maintained during their use, and only removed once that disturbed area is stabilised.

Forest operations are often split into several distinct operations:

1. Planning (salvage, construction, harvest, distribution). May require preparation of resource consent applications;
2. Salvage of road lines;
3. Construction of roads and landings;
4. Harvesting operations (including construction of haul tracks and temporary crossings);
5. Post harvest rehabilitation.

It is typical to have many operations occurring at the same time which can be spread out over lengthy time frames, and therefore it is important to ensure the integration between all four stages. The planning stage is where the erosion and sediment control measures for each subsequent phase are determined. As well as which measures will be installed where, the harvest plan should clearly identify who is responsible for the implementation of those measures as well as their maintenance. When and how any constructed measure is to be decommissioned should also be set out in the harvest plan. Clear lines of responsibility, a “sense of ownership” will ensure the measures are correctly implemented and the outcomes achieved.

4.2 Erosion Control

Erosion control acts by minimising erosion. This reduces and may eliminate the need to rely on sediment control measures to ensure that any operation causes minimal sediment generation. Erosion control should be the first consideration for any disturbed area as it enables the sediment control measures to operate more effectively. Moreover, good erosion control strategies will have the added advantage of reducing the installation costs of some forms of sediment control and will reduce or minimise the maintenance of structural controls.

The erosion control measures discussed in this guideline consist of planning, runoff control measures and stabilisation, and are expanded upon in Section 6 of this guideline.

4.3 Sediment Control

Sediment control focuses on providing impoundment and/or filtration of sediment-laden flows before discharging the treated flows to the receiving environment. The effectiveness of sediment control measures relies on suitable sizing and construction. Removal of sediment from sediment-laden flows via standing vegetation is generally limited due to the often fine-grained nature and consequent mobility of the soils, and by the lack of close ground cover (a dense grass cover is required). Sediment control measures will not retain all of the sediment generated unless there is no discharge from the measure.

Mulching of Landing Batters has been used to Protect the Surface from Erosion Although Slash or Hay Could have been Used

Sediment control measures are discussed in Section 7 of this guideline.

4.4 Monitoring and Maintenance

The monitoring and maintenance of erosion and sediment control measures, especially recently constructed devices, is essential for these controls to continually

be effective. The controls on new earthwork areas (e.g. landings and roads) should be checked prior to any forecast rain and following any heavy rainfall events to ensure they are open and working. Once it is confirmed that a structure is working as designed, the need for subsequent checks can be determined on a case-by-case basis. Any maintenance works identified, such as the removal of accumulated sediment, additional armouring of eroding water tables, or the reapplication of grass seed for example, should be undertaken as soon as possible.

Consideration also needs to be given to post harvesting monitoring and maintenance requirements. Control measures should be checked when operations are complete and replaced, reinstalled, disestablished or maintained to a standard that provides for an appropriate level of erosion and sediment control as the site becomes stabilised. Generally when operations are complete, permanent stabilisation lessens the need for on-going maintenance.

It is important to note that the responsibility for maintenance of these controls does not rest with the Hawke's Bay Regional Council. Accordingly, it is expected that the consent holder and/or operator or other authorised personnel will develop a maintenance schedule to ensure that the above factors are met.

5 Harvest Plans and Earthwork Activities

Harvest management plans, often simply called a harvest plan, are primarily designed to set out how an area is to be harvested. Often incorporated within the harvest plan are the earthwork plans defining the construction of the roads, landings and tracks necessary to support the harvesting operation. This part of the harvest plan should outline the strategies and treatment measures required to minimise the generation and discharge of sediment. In preparing the harvest plan, the Planner should identify all the activities that have the potential to generate sediment and create adverse effects, and combine best management practices for these activities with appropriate erosion and sediment control measures.

In the planning of earthworking and harvesting in forestry operations, the harvest plans should identify the following aspects:

- The boundaries/areas covered by the operation.
- Topographical features and/or contours.
- The existing and proposed roading network (and proposed final surface eg metal or clay).
- Watercourses, stream crossings and their locations.
- Earthworks activities, including landings, roads and tracks, and their extent and location.
- Streamside/riparian/wetland management areas and protection measures.
- Other features that need to be considered (archaeological sites, reserves, public roads, electricity pylons, etc).
- Harvesting methods (ground-based or cable, haul directions, processing areas, the type and tower height of haulers and therefore their ability to lift trees over streams etc). The focus of this is to minimise soil disturbance and any adverse effect on riparian areas.
- The types and locations of erosion and sediment control measures. This should address all the design issues including any required calculations.
- How the erosion and sediment control measures will be maintained (timing, access, sediment storage areas etc).
- Methodology for cleaning debris from perennial streams. The harvest plan should be designed to minimise trees being felled across streams because of the disturbance created by the activity. Manual stream cleaning is also a difficult and time consuming operation.
- Post harvesting management including stabilisation of bare earthworked areas, landings management and maintenance of control measures.
- Personnel responsible for the installation and maintenance of the erosion and sediment control measures.

Note: The information outlined above will need to accompany any earthworks or streamworks resource consent application submitted to the Hawke's Bay Regional Council.

6 Erosion Control Practices

6.1 Principles of Erosion Control

Erosion control is the minimisation and avoidance of accelerated erosion. Principles of erosion control include:

- Plan the operation carefully to minimise disturbance. Good planning will be essential to achieving this.
- Match the operation to the existing site conditions. Watch steep areas – keep earthworks away. Plan carefully around watercourses and note statutory requirements for working in watercourses.
- Retain riparian vegetation where possible.
- Minimise the area needing treatment by sediment control measures (by cleanwater diversion channels etc.).
- Minimise erosion by keeping disturbed areas as small as practicable.
- Stage earthworks and construction such as roading (progressively stabilise disturbed areas and so keep the time of exposure short).
- Keep on-site runoff velocities and volumes low (through low angle slopes, cut-off drains etc).
- Keep any excavated drains as flat or “U”-shaped (not “V” shaped)

Three different methods of erosion control are discussed in sections 6.2 to 6.4 of this guideline under the headings of Site Planning and Management, Water Management and Stabilisation of bare areas respectively.

6.2 Site Planning and Management

Works can often be undertaken without the extensive use of erosion and sediment control measures and techniques and still result in minimal sediment related problems. To do so on a consistent basis requires an awareness of the environmental problems that can be caused by land disturbing activities coupled with a sound knowledge of different erosion and sediment control measures, their effectiveness and their limitations. A works methodology can then be prepared to minimise the need for specific erosion and sediment control measures. If this can be done successfully, it will often result in an easier project to undertake, be more cost effective, and allow more flexibility on site while still achieving good environmental outcomes.

6.2.1 What sorts of considerations are being discussed here?

The works methodology should recognise and allow for the control of erosion and the retention of sediment on site. It covers erosion and sediment control planning and the administration of the project. Considerations such as the programming of works, works in specific “hot spot” situations, work methodology (e.g. keeping machines away from watercourses), identifying and allowing for erosion and sediment measures in contract documents, detailing stabilisation measures and timing, site inspection and maintenance considerations etc., all fall within site management. This is one of the most important aspects of erosion control and yet rarely done well.

On urban earthwork sites, a contractor would usually aim to construct some sort of sediment control measure (e.g. a sediment retention pond) at the bottom of a small

catchment and rely upon this as the sediment control 'catch all'. The contractor can then turn to organising labour, machinery etc and get on with the project. Forestry operations however, generally take a different approach in that any sediment retention works considered necessary are implemented at source e.g. around each landing. There are often good reasons for this such as the type of terrain, the type of activity being undertaken etc. This system has the potential to have better outcomes and is generally cheaper to install and maintain if done correctly; however it does require a constant and ongoing regard to make sure that the measures are appropriate, and that they are well constructed and maintained. The measures are also generally less robust and more prone to failure than the urban catchall silt pond. There is therefore more onus on forestry personnel to "get it and keep it right", and it can be a higher risk option than the usual urban approach. Failure of any one of the control measures usually results in poor outcomes.

On all projects, large and small, it is the awareness factor that is so important. This is an understanding of the need for both erosion and sediment control, the knowledge of what will work and what will not, and the ability to translate this through into the works methodology.

6.3 Water Management

Control of site runoff is one of the most important erosion control measures that can be done, and is an area that the forest industry has traditionally recognised and worked at. Good runoff control not only makes a drier site that works better, it also sets the platform for better environmental outcomes.

Good Water Management will Reduce the Potential for Site Erosion

Further detail is provided below on the common measures to control water and runoff on land disturbing sites around the Hawke's Bay region. Diversion channels and diversion bunds, contour drains and cutoffs, flumes and outfalls, surface roughening, check dams and corduroying are discussed.

6.4 Diversion Channels & Bunds

6.4.1 Description/Purpose

Diversion Bund installed on Edge of Landing Site to Direct Water Flows into Sediment Control Practices

These are permanent runoff control measures that both intercept and convey runoff. They can be used to convey cleanwater runoff around working areas to non-erodible outlets, or convey site runoff (sediment-laden) to a sediment treatment device.

6.4.2 Catchment Area

Less than five hectares. If the catchment exceeds this, then specific channel design showing channel size, dimensions, slope and erosion protection is necessary.

6.4.3 Construction

a) They need to be capable of conveying the 5% AEP storm event (plus freeboard) without eroding. Specific design may be necessary (e.g. for catchments greater than 5 hectares) and this design should accompany the application for resource consent.
b) They should have a trapezoidal ("U" shaped) cross section as this minimises channel erosion. The channel should be a minimum base width of 0.75 m, have 1v:3h channel sides and be a minimum of 0.5 m deep. Bunds should be at least 0.5 m compacted height. *[Note: These dimensions are for catchments of less than 5 hectares in area].*
c) Identify the outfall first which should be stable and erosion proof. Work back from this point. Flumes will generally be necessary to convey runoff across unstable land such as fill etc.
d) The slope of the channel should be no more than 2% in grade otherwise the channel will need to be protected against erosion. Measures such as revegetation, rock armouring and geotextile fabrics can be used.

Construction Notes:

a) Don't eyeball diversion channels/bunds in – survey them with a clinometer, laser or similar.
b) Bunds are better than channels because they usually have more capacity than excavated drains.
c) The channel can become a depositional area because of its low slope (2%) and so access for cleaning may be necessary.

6.4.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) Check for deposition (which reduces the capacity of the channel/bund or can result in it spilling and failing) and remove sediment.
b) Check for erosion of the channel and stabilise if necessary.
c) Check for breaches or structural integrity and repair accordingly.

6.4.5 Drawing

Figure 6-1
Runoff Diversion Bund

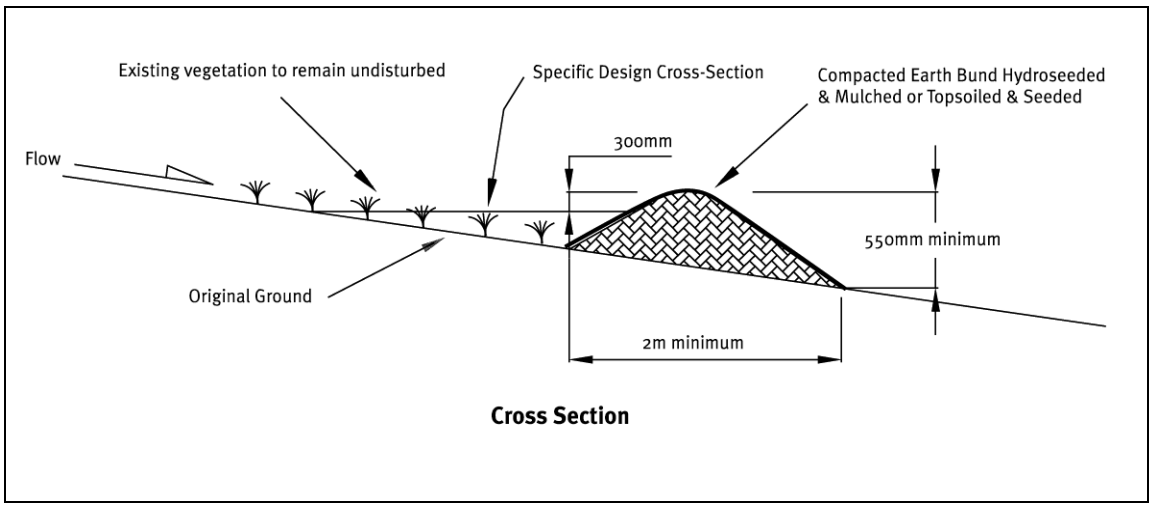
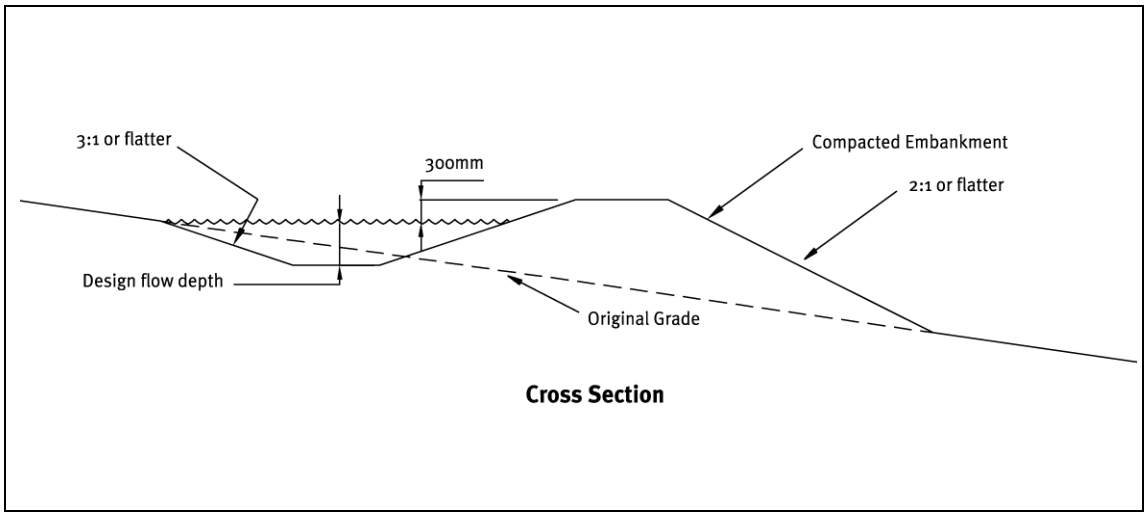


Figure 6-2
Runoff Diversion Channel



6.5 Contour Drains and Cutoffs

6.5.1 Description/Purpose

These are channels, often temporary, which are constructed to reduce slope length and intercept and divert potentially erodible flows of runoff to erosion proof outlets. Once the area that they are draining has been stabilised, then they may not be required.

6.5.2 Catchment Area

These are for small flows. [See Diversion Channels for larger flows]

6.5.3 Construction

a) As a “rule of thumb” they should be 0.5 m deep and constructed with a general “U” shape.
b) Identify a stable outfall and work back from there. Other than this, the following general spacing as outlined in Table 1 applies.
c) The gradient of the channel should be no steeper than 2% otherwise the channel will start to erode (if not stabilised).

Table 6-1
Contour Drain Spacing

Slope of site (%)	Spacing of contour drains/cutoffs (m)
5	50
10	40
15	30
30	20

Construction Notes:

a) Survey cutoffs, particularly those installed at the end of operations.
b) Contour drains and cutoffs do not require any specific design other than that given above (unlike diversion channels).
c) They are often installed at the end of the days work or in the event of rain.
d) If there is rilling or erosion between cutoffs, then more cutoffs are required. It is better to have too many than too few.
e) Always direct cut-offs so they drain to the outside of the track, not to the inside (note the need to work back from stable outfalls).

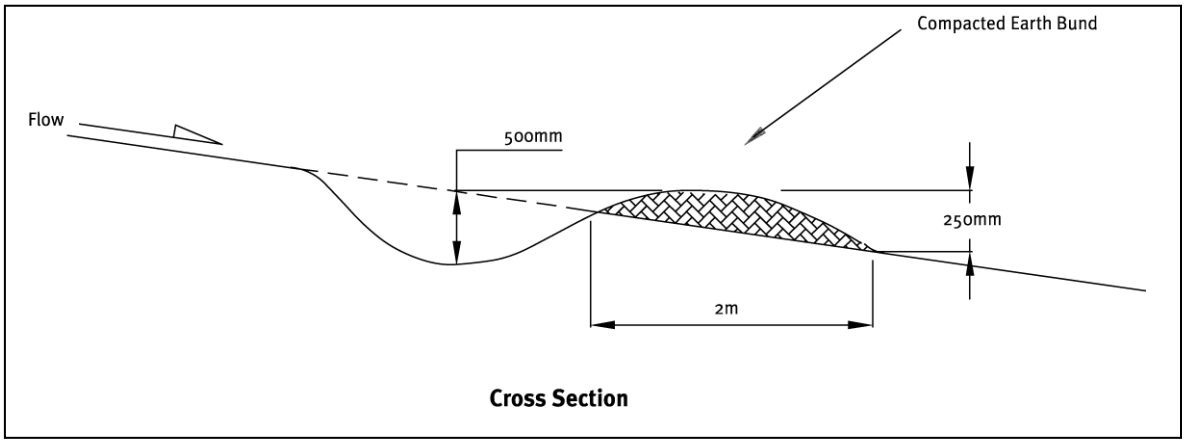
6.5.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

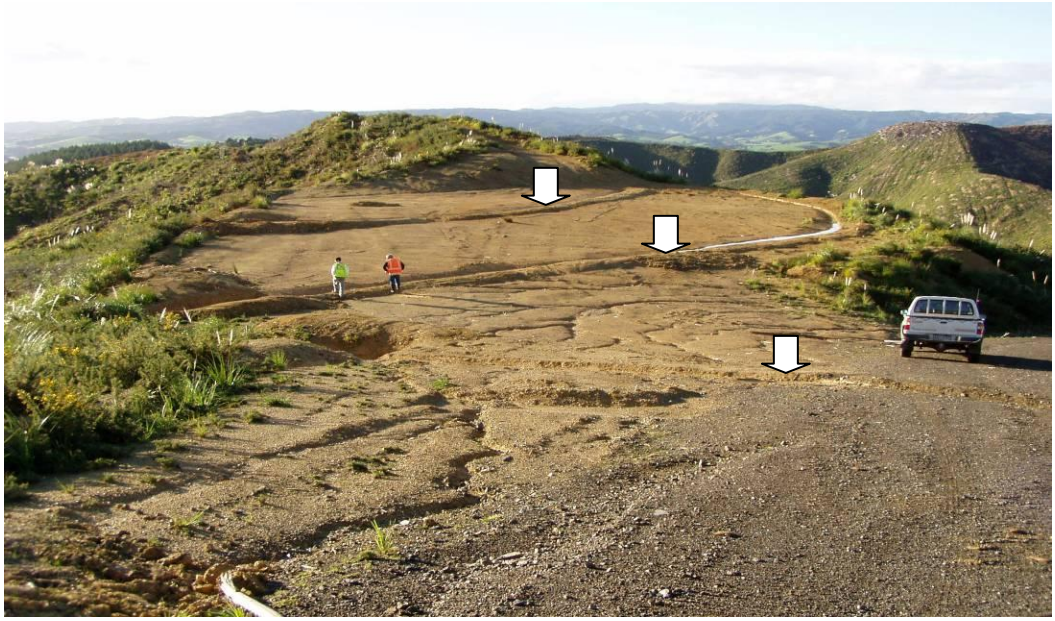
a) Repair or reinstate them if destroyed by machinery movement or logging operations.
b) Inspect them after rainfall or storms and repair as necessary.
c) Check the outfall for erosion and repair if required. It may be necessary to install a flume.
d) Use sandbags during rainfall events if extra height is needed on the ridges of contour drains.

6.5.5 Drawing

Figure 6-3
Contour Drain



Contour Drains in Road and Landing Site
(Arrows indicate position of contour drains)



6.6 Broad-based Dips

Broad-Based Dip

6.6.1 Description/Purpose

This structure is a dip and reverse slope in a road surface with an out-slope in the dip for natural cross drainage. This practice provides cross drainage on inslope roads and prevents build-up of excessive surface runoff velocities and subsequent erosion.

Broad-based dips are very effective in gathering surface water and directing it safely off the road. The dips are placed across the road in the direction of water flow and this type of structure allows normal truck speeds without adding stress to the vehicle.

6.6.2 Catchment Area

Not applicable. This practice applies where truck haul roads and heavily used skid tracks have a gradient of 10% or less. Use rolling dips with gradients > 10%.

6.6.3 Construction

a) The installation of a broad-based dip takes place after basic clearing and grading for the road/track construction.
b) Begin construction by locating the discharge point; usually a low point in the road.
c) Compact the area and cover the dip with a non-erodible layer (100mm of 50-75mm aggregate or like) for conveyance of stormwater runoff and roadbed protection.
d) Ensure that the flows from the broad-based dip discharge onto a stabilised surface (slash, rock etc).
e) A six metre long, 3% reverse grade is constructed into the existing roadbed by cutting from upgrade of the dip location.
f) The cross drain outslope should be a maximum of 3%.
g) The distance between the dips is determined by Table 6-2.

Table 6-2 Broad-based Dip Spacing	
Road Grade (%)	**Spacing Between Dips (m)**
1	150
2	90
3	70
4	60
5	50
6	48
7	46
8	44
9	42
10	40

Construction Notes:

a) An inherent problem in the construction of a broad-based dip is recognising that the roadbed consists of two planes rather than one unbroken plane. One plane is the 6 metre reverse grade toward the uphill road portion and outlet. Another plane is the grade from the top of the hump or start of a downgrade to the outlet of the dip.

b) Ensure that the dip or the hump does not have a sharp angular break but is to be rounded to allow a smooth flow of traffic.

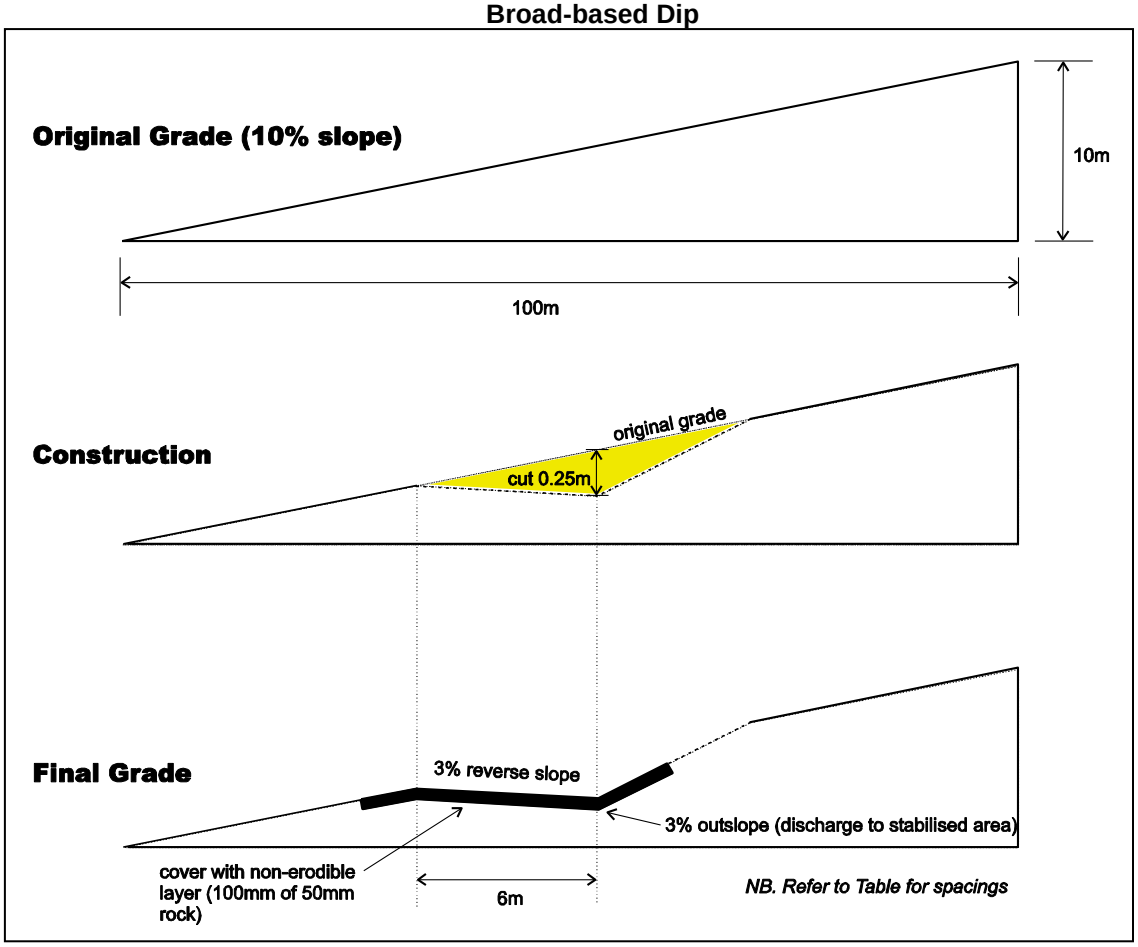
6.6.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) Repair or reinstate them if destroyed by machinery movement or logging operations.
b) Inspect them after rainfall or storms and repair as necessary.
c) Check that there is no erosion at the outfall.

6.6.5 Drawing

Figure 6-4
Broad-based Dip



6.7 Rolling Dip

6.7.1 Description/Purpose

This structure is a dip and reverse slope in a road surface with an out-slope in the dip for natural cross drainage. This practice provides cross drainage on inslope roads and prevents buildup of excessive surface runoff and subsequent erosion. A rolling dip is used on roads that are too steep for broad-based dips.

Rolling dips are very effective in gathering surface water and directing it safely off the road. The dips are placed across the road in the direction of water flow and this type of structure allows normal truck speeds without adding stress to the vehicle.

6.7.2 Catchment Area

Not applicable. This practice applies where truck haul roads and heavily used skid tracks have a gradient of 15% or less.

6.7.3 Construction

a) The installation of a broad-based dip takes place after basic clearing and grading for the road/track construction.
b) Begin construction by locating the discharge point; usually a low point in the road.
c) Ensure that the flows from the broad-based dip discharge onto a stabilised surface (slash, rock etc).
d) A 4.5 metre long, 3% to 8% reverse grade is constructed into the existing roadbed by cutting from upgrade to the dip location. Use the cut material to build the mound for the reverse grade. Blend the mound to as gentle a slope as possible, to make travelling over it easier.
e) The cross drain outslope should be a maximum of 3%.
f) Table 6-3 determines the distance between the dips.

Table 6-3
Rolling Dip Spacing

Road Grade (%)	Spacing Between Dips (m)
2 - 5	50
5 - 10	45
10 - 15	40
>15	35

Construction Notes:

a) Ensure that the dip or the hump does not have a sharp angular break but is to be rounded to allow a smooth flow of traffic.

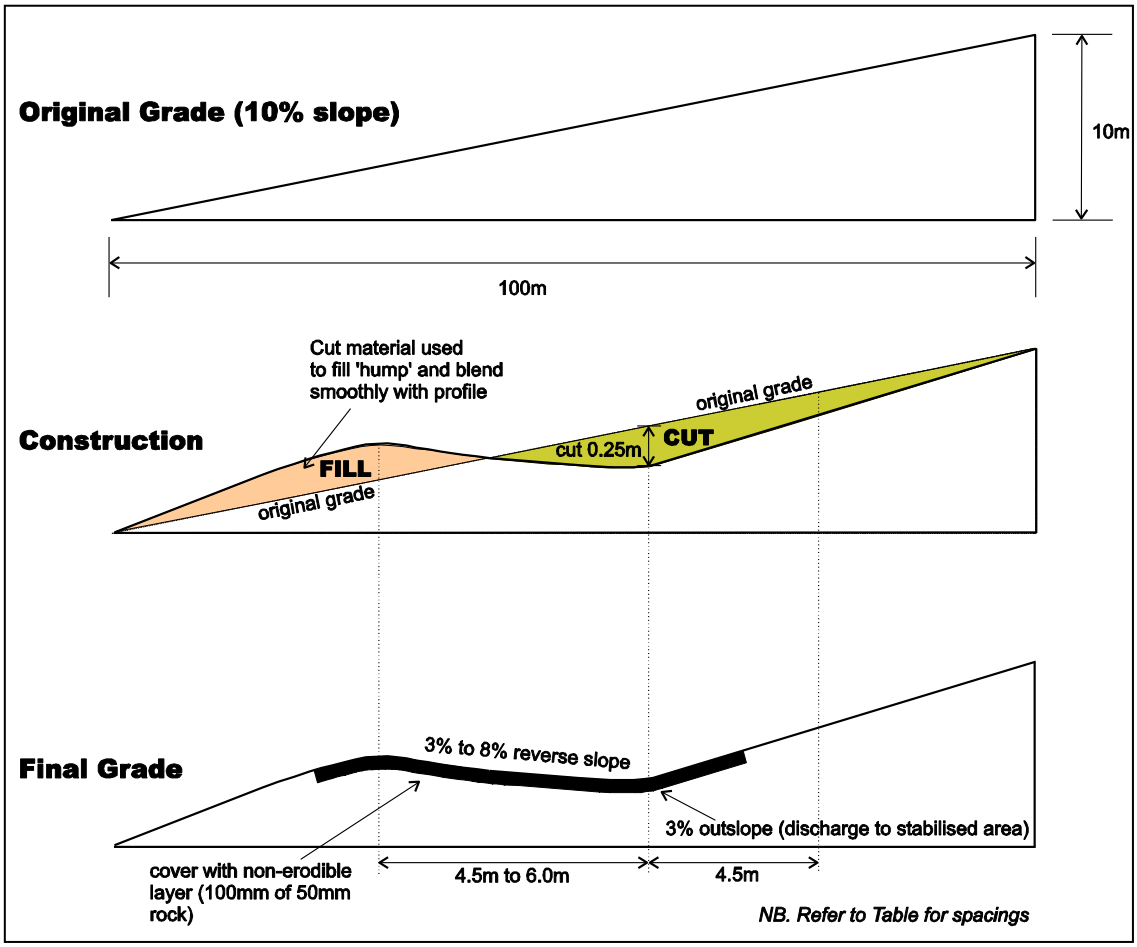
6.7.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a. Repair or reinstate them if destroyed by machinery movement or logging operations.
b. Inspect them after rainfall or storms and repair as necessary.
c. Check that there is no erosion at the outfall.

6.7.5 Drawing

Figure 6-5
Rolling Dip



6.8 Flumes and Outfalls

Flume conveying Sediment-Laden Water into an Earth Bund

6.8.1 Description/Purpose

A flume is a mechanical conveyance system that transports water from one area to another without causing erosion. An outfall is an erosion proof discharge point.

6.8.2 Catchment Area

Less than 2 hectares

6.8.3 Construction

a) Flumes are generally half round open pipes, wooden chutes constructed on a wooden frame or fabric flumes ("lay flats"). In some circumstances they can be constructed from geo-textile cloth laid over a swale shaped earth base.
b) Work out how the flume will work for the site. It is important that the capacity of the flume is not exceeded by the volume of water generated from the upper catchment. Establish the inlet point (where the in-flows collect) and the outlet point (which should be a stable area). The flume is then constructed to fit between these two points.
c) When sizing the flume or pipe drop structure use the criteria outlined in Table 2.
d) The inlet is generally at the end of an earth diversion channel/bund. It is vital that the inlet does not leak and this is usually achieved by way of a pipe or combinations of geo-textile cloth and rock or concrete.
e) The outlet is generally constructed with combinations of geo-textile cloth and rock or concrete, and needs to be sufficiently robust and extensive to withstand the force of water when the flume is full. Outfalls are generally positioned on stable areas (e.g. spurs), or constructed with large rock (e.g. 300 mm diameter rock laid over geo-textile cloth).
f) Ensure that there is at least 300mm freeboard so that overtopping does not occur. Note that the freeboard is measured from the crest of the bund to the top of the flume.

Table 6-4
Design Criteria for Pipe Drop Structure/Flume[1]

Pipe Diameter (mm)	Maximum Catchment Area (ha)
300	0.5
375	0.9
450	1.5
525	2.2

[1] Derived from NZ Forest Service - Civil Engineering Bulletin 4: August 1980

Construction Notes:

a) Take care with the supports of the flume (flumes are often laid over unstable ground and this land can move).
b) Inlets often fail from poor installation practices such as using clay to block gaps or laid directly on fill material. The inlet must not leak – a pipe is often a good way of directing runoff to flumes. Ensure that the pipe has a grade of at least 3% onto the flume and that the surrounding earth is well compacted.

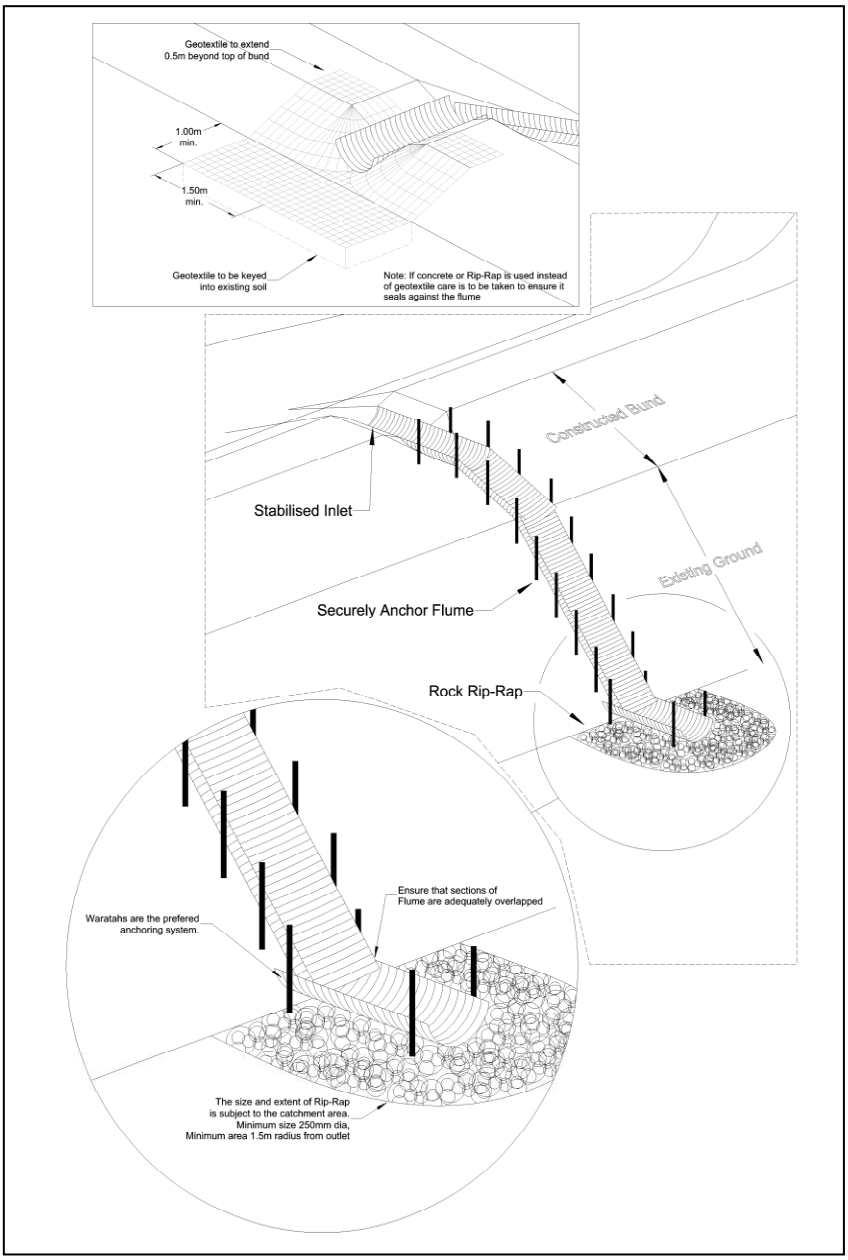
6.8.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) Ensure all flow is directed to flume, that the flume is securely attached to the inlet and that the outfall is not eroding.
b) Make sure that runoff has not spilled over the structure causing erosion and undermining the supporting structure of the flume.
c) Retain the flume until the area has been permanently stabilised or the flow has been redirected.

6.8.5 Drawing

Figure 6-6
Pipe Drop and Flume Structure



6.9 Check Dams

Check Dam

6.9.1 Description/Purpose

Check dams are barriers placed across channels primarily to reduce runoff velocity. They can also retain sediment but this is not their primary function.

6.9.2 Catchment Area

Less than five hectares. Specific engineering design is required for larger catchments.

6.9.3 Construction

a) Locate the lowest check dam first. Clear any vegetation and topsoil from the footprint of the check dams and place in a location where it cannot be mobilised.
b) The sides of the check dam must be higher than the centre so that water is always directed over the centre of the dam (this avoids the dam being outflanked by the flow). Energy dissipation at the outfall is required (this is usually rock or fabric).
c) The maximum height of the check dam at its centre should be 1.0 metre and the outer edges should be least 0.2 m higher so that a spillway is formed over the centre.
d) The distance between dams is based on the toe of the upstream dam being at the same elevation as the crest of the downstream dam. The spacing between dams therefore varies with slope.
e) Make sure that the downstream channel is protected against scour and erosion by extending the rock 1 metre downstream of the lower dam, or by using fabric etc.

Construction Notes:

a) They can be constructed from a variety of material such as concrete, rock, fabric, sand/cement bags etc. Rock is the most common material used. Despite the variety of material that can be used, the following construction principles apply.
b) If using rock, angular rock is more suitable than rounded rock. Use 300 mm diameter graded rock and install a 300 mm thickness of finer grade rock on the upstream face. Make sure that rock batters are no steeper than 1 vertical: 2 horizontal.
c) If using a sand/gravel/cement mix in plastic bags, make sure that the bags are UV resistant.

d) Do not construct check dams in watercourses or permanently flowing streams without specific design (because of possible restrictions to fish passage).
e) The drain may need to be increased in size to ensure that it's capacity is not reduced (if check dams are installed).

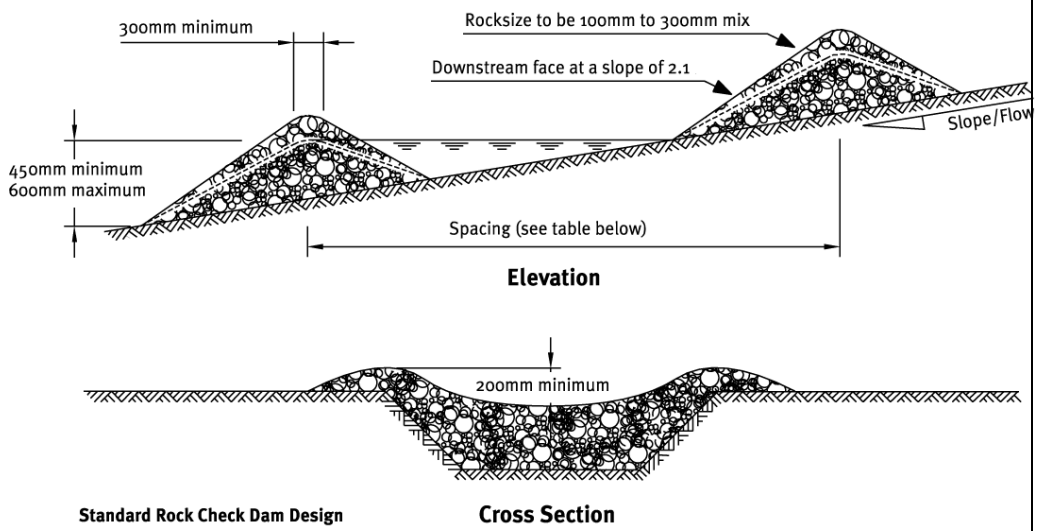
6.9.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) It is recommended that they are inspected regularly and after significant rainfall (when 15mm of rainfall has fallen in the preceding 24 hours).
b) Check to ensure that the flow is over the centre of the dam and not either under or around the dam.
c) Check that there is no erosion at the outfall.
d) Implement repairs to ensure the dams remain in good working order.
e) Construct additional check dams if there is scour along the channel.

6.9.5 Drawing

Figure 6-7
Check Dams



Standard Rock Check Dam Design

Slope	Spacing (m) Between Dams (450mm centre height)	Spacing (m) Between Dams (600mm centre height)
2% or less	24	30
2% to 4%	12	15
4% to 7%	8	11
7% to 10%	5	6
over 10%	Use Stabilised Channel	Use Stabilised Channel

6.10 Surface Roughening

Surface Roughening with Bulldozer Cleats

6.10.1 Description/Purpose

This is the roughening of a bare surface to create horizontal grooves that will reduce the concentration of runoff, aid infiltration, trap sediment and aid vegetation establishment.

6.10.2 Catchment Area

In general small areas (less than 0.25ha) only as the practice will also require other forms of erosion and sediment control.

6.10.3 Construction

Run a tracked machine up and down the slope to roughen the surface

Construction Notes:

a) This technique helps stop the concentration of runoff. Once runoff has formed rills down a slope however, any advantages of the technique are lost.

6.10.4 Maintenance

Check the area for rills and washes. Rework and re-seed the area as necessary.

6.11 Log Corduroying

6.11.1 Description/Purpose

Log Corduroying of a Landing Site

Corduroys are primarily used to provide a solid working platform where ground conditions are generally wet and or soft. Often this is within the processing area of landings and sometimes when tracking / roading across soft wet areas (not streams). This technique helps to keep soft areas from becoming 'bog holes' and minimises the generation of sediment. In most cases, sediment controls will be required to treat any runoff from these areas.

6.11.2 Catchment Area

Not Applicable

6.11.3 Construction

Place trimmed pulp logs neatly together over the ground being strengthened, to effectively 'bridge' the wet soft areas. The pulp logs should fit neatly together and not protrude into a water table.

Construction Notes:

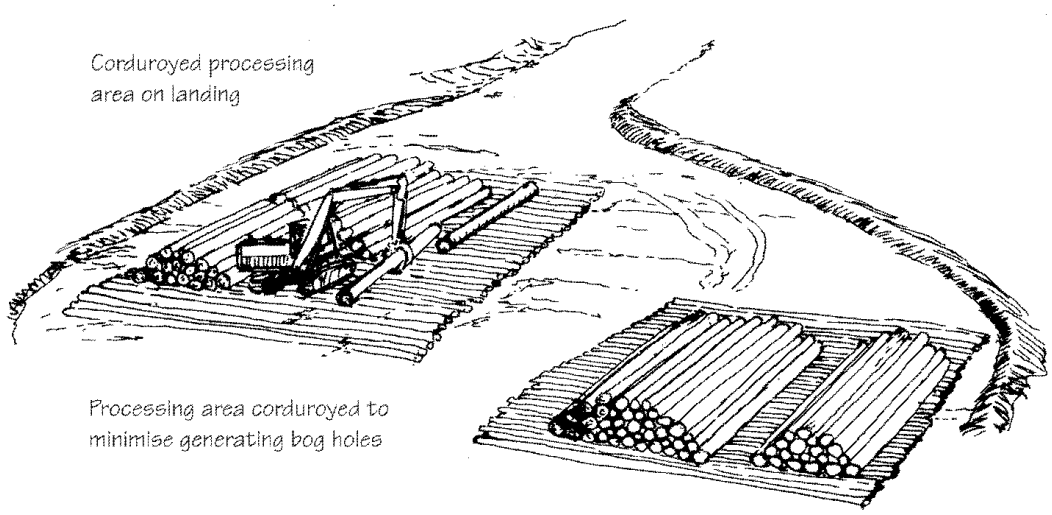
a) Plan ahead, this technique is more effective if put in place to avoid or minimise areas becoming a "bog" rather than to continue working a "boggy area".
b) The less valuable pulp/malformed sections of the tree is generally used down to a size that will support heavy machinery without breaking up. If they breakup and or bend severely they will not achieve the desired outcome *i.e.* still generate fine sediment and will be high maintenance. The pulp logs should be pushed hard into the ground, essentially to refusal as they must be capable of holding up heavy machinery. Sometimes larger trees and or cross bearers may be necessary in extremely soft conditions.

6.11.4 Maintenance

a) Where possible check for broken pulp logs and replace, and or add on to as necessary. Any sediment generated from these areas must be placed in an area where this material can be contained, *ie* a pit in the ground and in extreme cases where side slopes make it difficult to contain, consider using a 'debris dam' and/or slash bund to help contain the sloppy material.

6.11.5 Drawing

Figure 6-8
Drawing of a Corduroyed Processing



6.12 Stabilisation

- A stabilised site is one that is resistant to erosion. Stabilisation is defined as applying measures, such as vegetative or structural, that will protect exposed soil and prevent erosion.
- Common stabilisation measures include aggregate, grassing areas with either grass seed or hydroseed, applying slash or mulch, rock lining and the use of geotextiles.
- Where aggregate is used, a 50 mm thickness (on non-trafficked areas only) is usually sufficient. It is preferable to use angular (broken faces) fragments as this provides better binding with the interlocking of the pieces.
- In relation to geotextiles, there are many and varied different types and products. They range from those that physically shed water (e.g. plastic and polythene) through to those that incorporate seed and mulch and so encourage vegetative growth while protecting the bare soil against erosion.
- Where vegetation is used, during the earthworking portion of forestry activities (eg construction of tracks, landing sites) the surface is considered stabilised once an 80% vegetation cover (density) has been established over the entire exposed area of earthworked areas. For areas associated with harvesting, a 75% vegetative density is required for all disturbed areas: adjacent to Category 1 (perennial) streams; all areas with an average slope greater than 15° and all areas associated with ground based operations where the harvesting does not include limbing at the 'stump'.
- Further detail is provided below on the common stabilisation measures used in the forest industry around the Hawke's Bay region. These are slash, mulch, grassing, hydroseeding, rock lining, and geotextiles.

Examples of stabilisation methods used on forestry roads, especially hydroseeding of road batters, rock armouring of watertables and aggregate layer on road

6.13 Slash and Mulch

Slash used to Stabilise an Access Track (dashed line indicates track allignment)

6.13.1 Description/Purpose

Both slash[1] and mulch[2] can be applied as protective layers to reduce rain drop impact and sheet erosion on bare areas.

6.13.2 Catchment Area

Not applicable. However neither surface cover is effective once runoff has concentrated into channelised flow.

6.13.3 Application

<u>Hay or straw mulch</u>

a) Place mulch around or over disturbed areas and to a depth so that the soil cannot be seen through the mulch.
b) Place mulch only on stable areas of land (mulch does not usually help with earth flows).
c) Place mulch to a density of 6,000 kg/ha.

<u>Slash</u>

a) Place slash around or over disturbed areas to a depth such that little, or no soil, or disturbed ground is visible.
b) Slash can be used on almost any surface.
c) Place slash to at least 100 mm thickness as a cover of exposed areas. For protection for tracking from an erosion and ground compaction perspective, up to 300mm slash cover may be required.

Construction Notes:

a) Install other erosion and sediment control measures before spreading slash or mulch.
b) Slash can be used for erosion protection of minor spillways and outfalls. It can also be useful for stabilising haul tracks.
c) Bark or woodchip may be more readily available and apply this instead.
d) Straw lasts longer than hay and doesn't contain undesirable weed species.
e) Straw or hay mulch can be spread by hand on small sites. A rule of thumb is to have 30 mm of mulch cover when freshly applied.
f) Add grass seed to all applications if long term stabilisation is required.
g) Mulch will generally not 'stick' on slopes greater than 30-40%.
h) These measures are usually immediately effective for stabilisation once applied.

---

[1] **Slash is the off cuts such as branches, tree heads and bark removed from production logs.**
[2] **Mulch is a surface cover of bark, straw or hay.**

6.13.4 Maintenance

a) Hay/Mulch has a relatively short life (about 3 months maximum) so reapplications may be necessary, particularly if grass seed is not used. Slash has a longer life but may also need to be supplemented.
b) Mulch can blow away if it is not sufficiently well “tacked” down (water/rain, tackifier etc).
c) Remove concentrations of slash from riparian areas and from the edges of landings.

Example of a Stabilised Landing Site Using Slash

6.14 Grassing and Hydroseeding

Hydroseeding of a Road Cut and Fill Embankments

6.14.1 Description/Purpose

This is the sowing of seed to establish a protective vegetative cover over exposed soil. Hydroseed is the application of seed and fertiliser in a slurry and allows revegetation of steep or critical areas that cannot be stabilised by conventional sowing methods.

6.14.2 Catchment Area

No limit

6.14.3 Application

a) Apply in either autumn or spring and allow sufficient time for the seed to germinate and establish. Applications in summer and winter may not be as successful (summer sowing is dependant on rainfall while that in winter will be slow because of cooler temperatures).
b) Rip or scarify smooth compacted clay surfaces and spread topsoil before sowing grass seed.

Construction Notes:

a) Install other erosion and sediment control measures before hydroseeding or sowing seed.
b) After the 30th April it may be necessary that the sowing of grass seed be supplemented with mulch or similar material (because grass growth becomes increasingly suppressed after this time by cooler temperatures).
c) Hydroseed is typically the only way a robust grass cover can be achieved on hard clay surfaces such as cut faces and landing surfaces.
d) Apply seed and fertiliser at rate according to Table 3. Annual rye grasses are more vigorous and cold tolerant than perennial rye grass. Fertiliser is essential. Sow preferably in March rather than later to take advantage of warm temperatures and rainfall.
e) When applying hydroseed or grass in earthworked areas, the HAWKE'S BAY REGIONAL COUNCIL considers a site to be stabilised once 100% of the disturbed area has a robust grass cover (*ie* 80% coverage density). When using this technique for stabilising of harvested areas, refer to the appropriate rule(s) in the Regional Plan for coverage densities (generally 75% density).
f) The protective function of grass will usually need supplementing in steep channels (e.g. with fabrics etc).

Table 6-5 Grass Seed and Fertiliser Application Rates			
	Mix	**Rate (kg/ha)**	**Comments**
Seeding	*Temporary* Annual Rye Grass (ie Tama) and Clover Seed mix *Permanent* Perennial Ryegrass and Brown Top with a Red/White Clover mix	300 Perennial – 120 Brown Top-45 Clover-45	Annual Rye Grass mix is more suitable for colder times of the year when ground temperatures are low
Fertiliser Application	D.A.P. (Di-Ammonium Phosphate) N P K S 18:20:0:2	240	D.A.P. is an ideal fertiliser for the rapid development of grass cover whilst neither damaging seed or inhibiting seed germination
Maintenance Fertiliser Application	Straight Nitrogen eg Urea (46% N)	120	Urea provides an efficient means of encouraging further development of grass cover

6.14.4 Maintenance

The site may need to be re-sown if germination is unsatisfactory (which can be caused by heavy rain washing seed away, bird predation etc).

6.15 Rock Lining of Channels

6.15.1 Description/Purpose

To protect bare drains and roadside water tables in erosion prone soils against erosion when the gradient exceeds 2%.

Rock Lining of Watertable

6.15.2 Catchment Area

Less than 5 hectares. For areas greater than 5ha, specific engineering design will be required.

6.15.3 Construction

a) Construct a trapezoidal or "U" shaped channel to the required size. A finished channel size of 0.5 m channel base, 0.5 m high and with 1:1 sides will convey almost all flows from a 5 hectare catchment. Note that it will be necessary to over cut the channel slightly to maintain the capacity once the rock has been placed.
b) Use material comprising of at least 50% of 65mm to 150mm graded rock and place along the bottom and on channel sides[3]. Note that this sized rock will start to be washed out on grades that exceed 10 %. Larger rock, concrete etc will then be necessary).
c) Discharge to a stabilised outfall (e.g. not over fill).

Construction Notes:

a) Identify (or construct) an erosion proof outfall first. Outfall protection may be necessary (rock, fluming etc). Work back from this point.
b) Place the protective rock carefully and make sure that the capacity of the channel is retained.

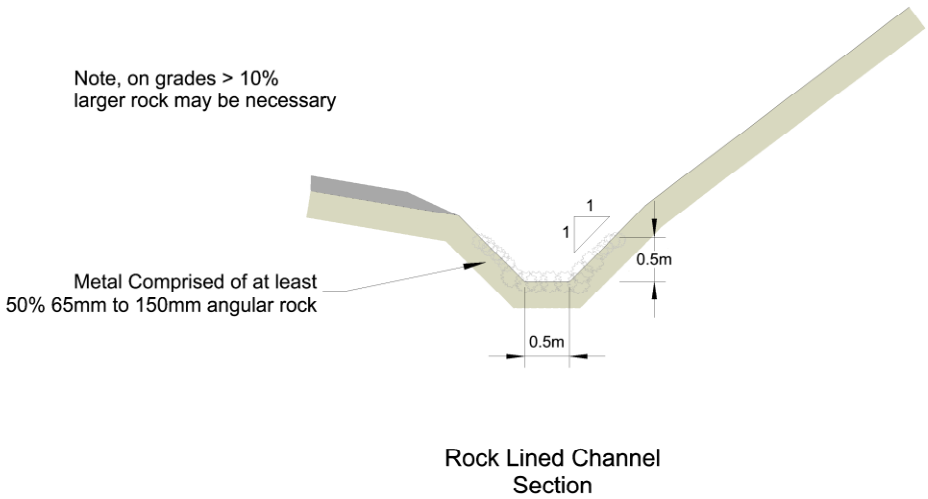
6.15.4 Maintenance

a) Inspect after storm events. Remove debris and repair/replace stone. Check for scour at outlets and on outside bends.
b) Check the discharge point for erosion and repair as necessary.

[3] **See Table 5 in section 9.1 for an assessment of stormwater velocities between clay and rock on different slopes.**

6.15.5 Drawing

Figure 6-9
Rock Lined Channel



6.16 Geotextiles

6.16.1 Description/Purpose

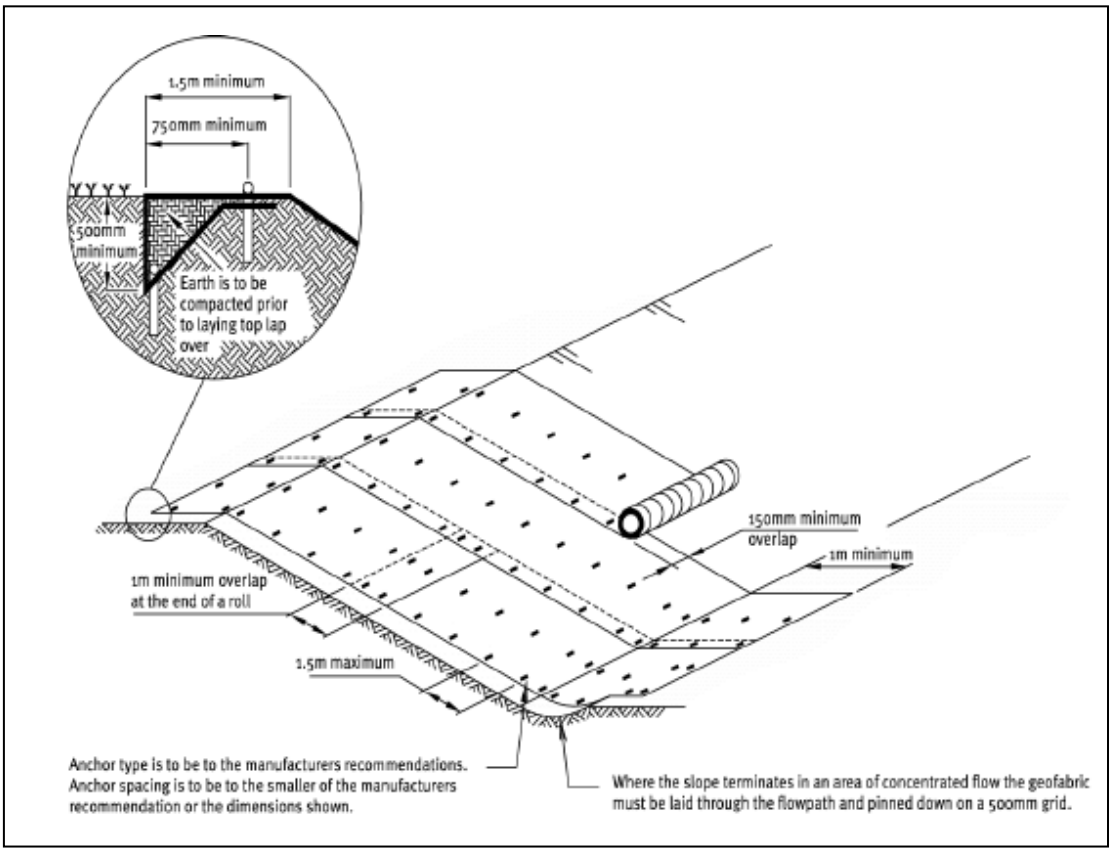
Geotextiles are fabrics that are used to protect surfaces against erosion. Common uses are to line spillways and diversion channels.

6.16.2 Catchment Area

Different fabrics have different strengths and abilities to withstand erosive forces and so vary in the volumes and velocity of water that they can withstand. The manufacturer's instructions should be referred to determine the design limits of the fabric.

6.16.3 Drawing

Figure 6-10
Geotextile Laid on Slope



6.16.4 Construction

a) Shape the area to its final shape and smoothen the surface as much as possible to minimise hollows under the fabric.
b) Lay the fabric and pin it in line with the manufacturer's instructions, or at about 0.5 m spacing in a grid pattern.
c) Dig the sides and top of the fabric into the earth and pin securely.

Construction Notes:

a) There are many different types of fabrics and care is needed in selection. Soft needle punched fabrics hug the ground but are permeable. Low permeable fabrics are more waterproof but are also generally less pliant and do not have such good ground contact. In some situations *eg* pond spillways both would be required.
b) Some fabrics are biodegradable and therefore have a limited life.
c) A smooth ground surface, a well anchored fabric at both top and sides, and good pinning are the keys to successful fabric installation and performance.
d) When used for channel lining, the strength of the pinning to the channel is critical.
e) Large "T"-shaped pins (10mm x 300mm) cut from sections of reinforcing steel are ideal.

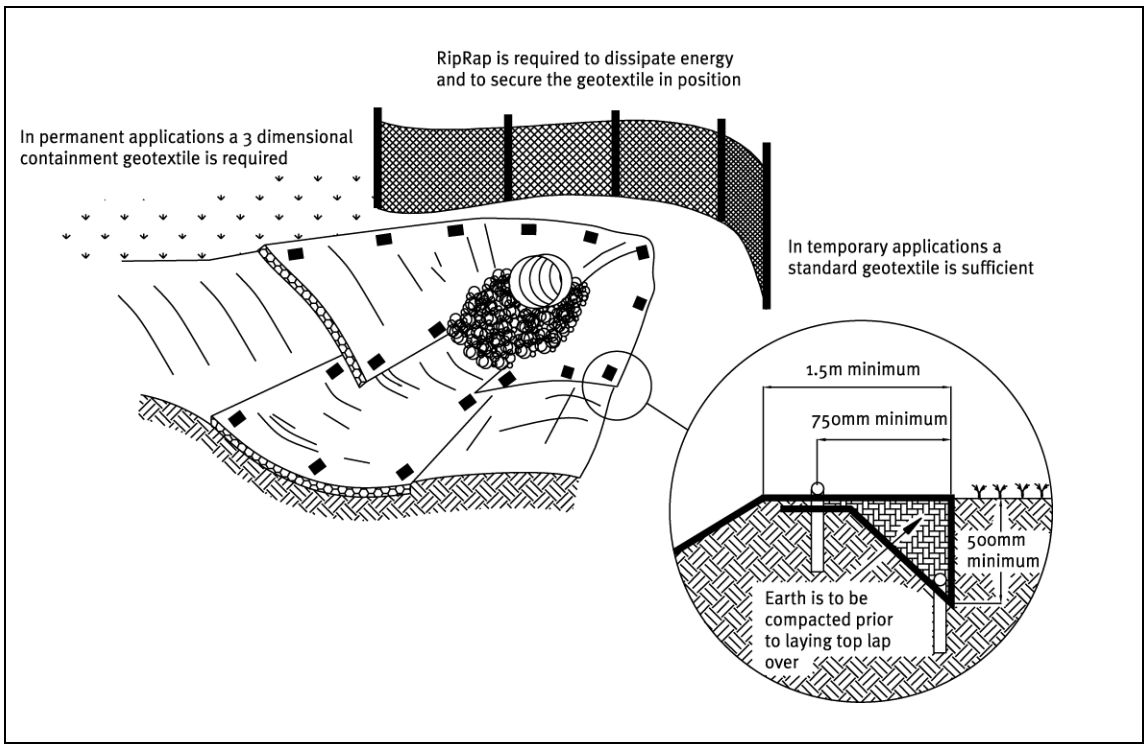
6.16.5 Maintenance

The usual faults with fabric installation are that it is not fastened particularly well on the sides or that the entry point (to channels) is poorly secured.

a) Check the entry point for secure fastening and remedy as required.
b) Check the pinning and repair as necessary.
c) Check that the ground under the fabric is not being eroded by water seeping through the fabric. The fabric may need to be lifted, the land re-shaped, and the fabric re-laid.

6.16.6 Drawing

Figure 6-11
Geotextile Mat at Culvert Outlet



7 Sediment Control Practices

There are numerous types of sediment control measures that can be used. Those common to the forest industry include silt traps, decanting earth bunds, silt fences, debris dams, haybale barriers and sediment retention ponds. Details associated with these control options follow in this section.

Two fundamental matters to note with sediment control measures are:

1. The maximum area of catchment for most control measures is small (*e.g.* the maximum catchment for a silt trap is 0.5ha and for a decanting earth bund is 0.3 hectares); and,
2. All of the catchment draining to a sediment retention measure needs to be included in the assessment (not just the bare area alone). Runoff diversion measures (see section 6.3.1) that divert clean water away from sediment control measures, reduce the catchment required for the treatment systems. This therefore reduces the volume required for the sediment controls.

The sediment control practices in this section include the practices listed in Table 7-1.

Table 7-1
Sediment Control Practices Contained in this Standard

Practice	Maximum Operating Catchment Area
Strabale Barrier	1,000 m^2
Earth Bund	1,000 m^2
Slash Bund	1,000 m^2
Decanting Earth Bund	3,000 m^2
Silt Fence	5,000 m^2
Super Silt Fence (“Debris Dams”)	5,000 m^2
Silt Trap	5,000 m^2
Sediment Retention Pond	5.0 ha

7.1 Strawbale Barriers

Straw Bale Barrier

7.1.1 Description/ Purpose

These are used as temporary sediment retention devices for very small catchments. They can be useful as impermeable barriers and to intercept and divert site runoff. However, they do not filter sediment effectively and are often prone to flow short-circuiting around the strawbales.

7.1.2 Catchment Area

Less than 0.1 hectare. Generally there should be no more than 20 m of upslope behind this measure.

7.1.3 Construction

a) Place in a row along the contour and butt them tightly together. Turn the ends up to capture runoff if they are being used for sediment retention.
b) Butt each bale up to the previous bale and stake each bale with 2 stakes driven 300 mm into the ground. The first stake in each bale should be driven towards the previously laid bale to force the bales together. Holes under or between the bales need to be securely plugged with clay.

Construction Notes:
a) They do not filter runoff and are therefore mini dams.
b) They can get very heavy when wet and difficult to shift.
c) They are commonly used in situations beyond their capability.

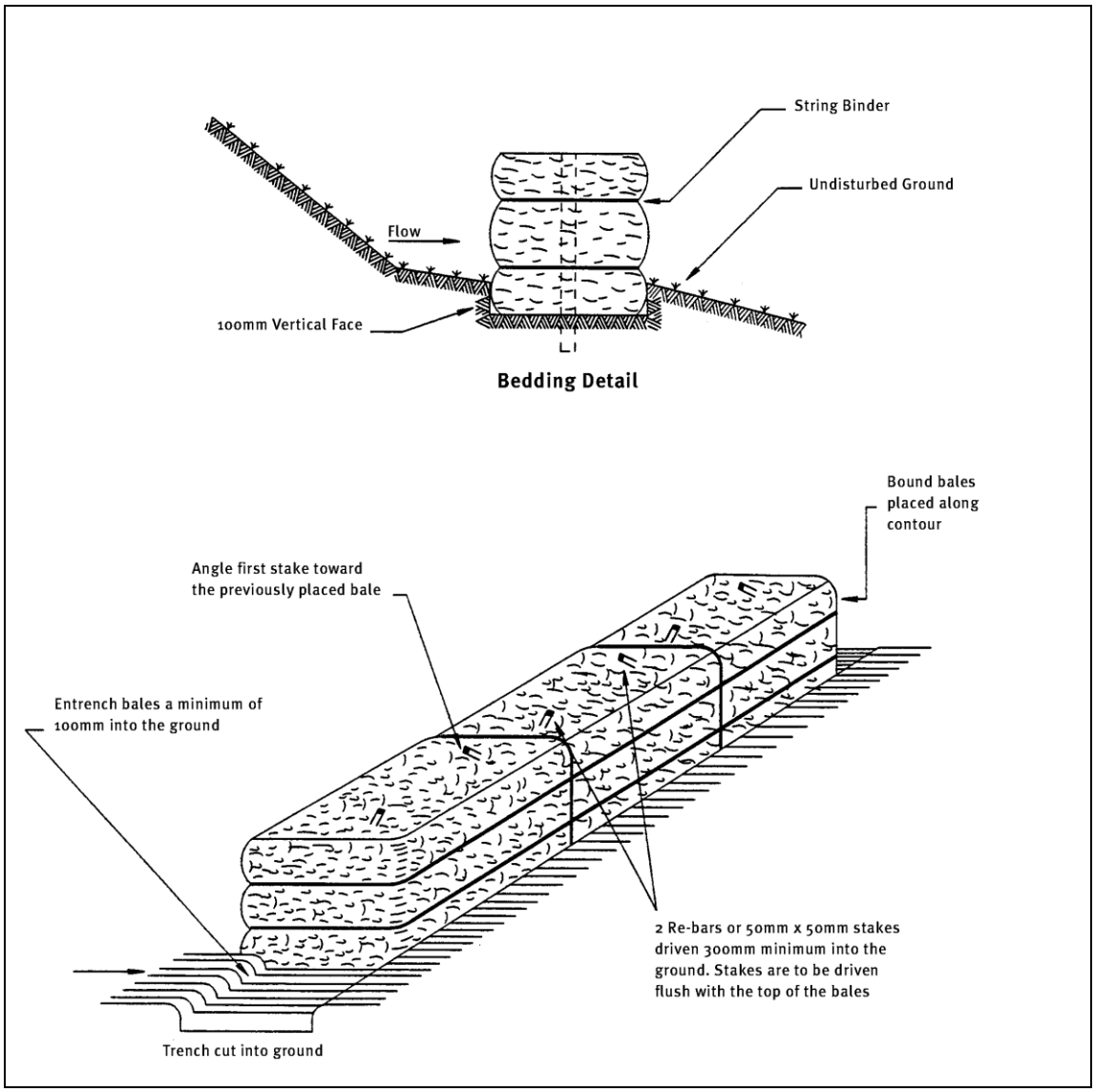
7.1.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) They can be removed after rainfall. Otherwise, inspect and repair after each rainfall event.
b) Remove sediment when half way up the bale if they are being used as a sediment retention device.

7.1.5 Drawing

Figure 7-1
Strawbale Barrier



7.2 *Silt Fences*

Silt Fence

7.2.1 Description/Purpose

A silt fence is a geotextile barrier attached to posts and used to retain sediment from small areas of sheet flow only.

7.2.2 Catchment Area

Less than 0.5 hectares.

7.2.3 Silt Fence Design Criteria

Design criteria are provided in Table 7-2.

Table 7-2
Silt Fence Design Criteria

Slope Steepness %	Maximum Slope Length above fence (m)	Spacing of Returns (m)
0 – 10%	40	60
10 – 20%	30	50
20 – 33%	20	40
33 – 50%	15	30
> 50%	6	20

7.2.4 Construction

a) The silt fence should be positioned on the contour where possible. Install "returns" at the spacings shown in Table 6 above. A return is a minimum 2m of silt fence constructed at right angles to the main silt fence, and used for retention areas.
b) Dig a 200 mm deep trench along the silt fence.
c) Install posts/waratahs on the lower side of the trench at maximum 2 metre centres and to at least 400 mm height.
d) Install a tensioned wire (2.5 HT) along the top of the fence. Tie this back at either end for strength.
e) Install the silt fence fabric along the fence and secure to the posts and wire.
f) Backfill the trench to anchor the fabric 200 mm into the ground. Compact firmly to ensure that the fence is not undercut.
g) Install tie backs at low points for additional strength.

Construction Notes:

a) Use proprietary silt fence fabrics only (from fabric manufacturers/suppliers). Refer Table 7-3 below for minimum specifications.
b) Join lengths of silt fence by overlapping, folding and fastening e.g. by stapling to a wooden batten or similar.
c) A silt fence can be reinforced with sheep netting, chain mesh netting or similar behind it. Note that this strengthening netting must also be dug into the ground.
d) Do not use them across flowing watercourses or similar areas of concentrated flow as they do not have the strength to stand the energy of concentrated flows.
e) They can be useful for delineating features such as wetlands and similar from work areas.

Table 7-3
Minimum Performance Requirements

Properties	**Rating**
Tension Strength	>440N, *(ASTM D4632)*
Tensile Modulus	0.140pa (minimum)
Apparent Opening Size	0.1-0.5mm, *(ASTM D4751)*

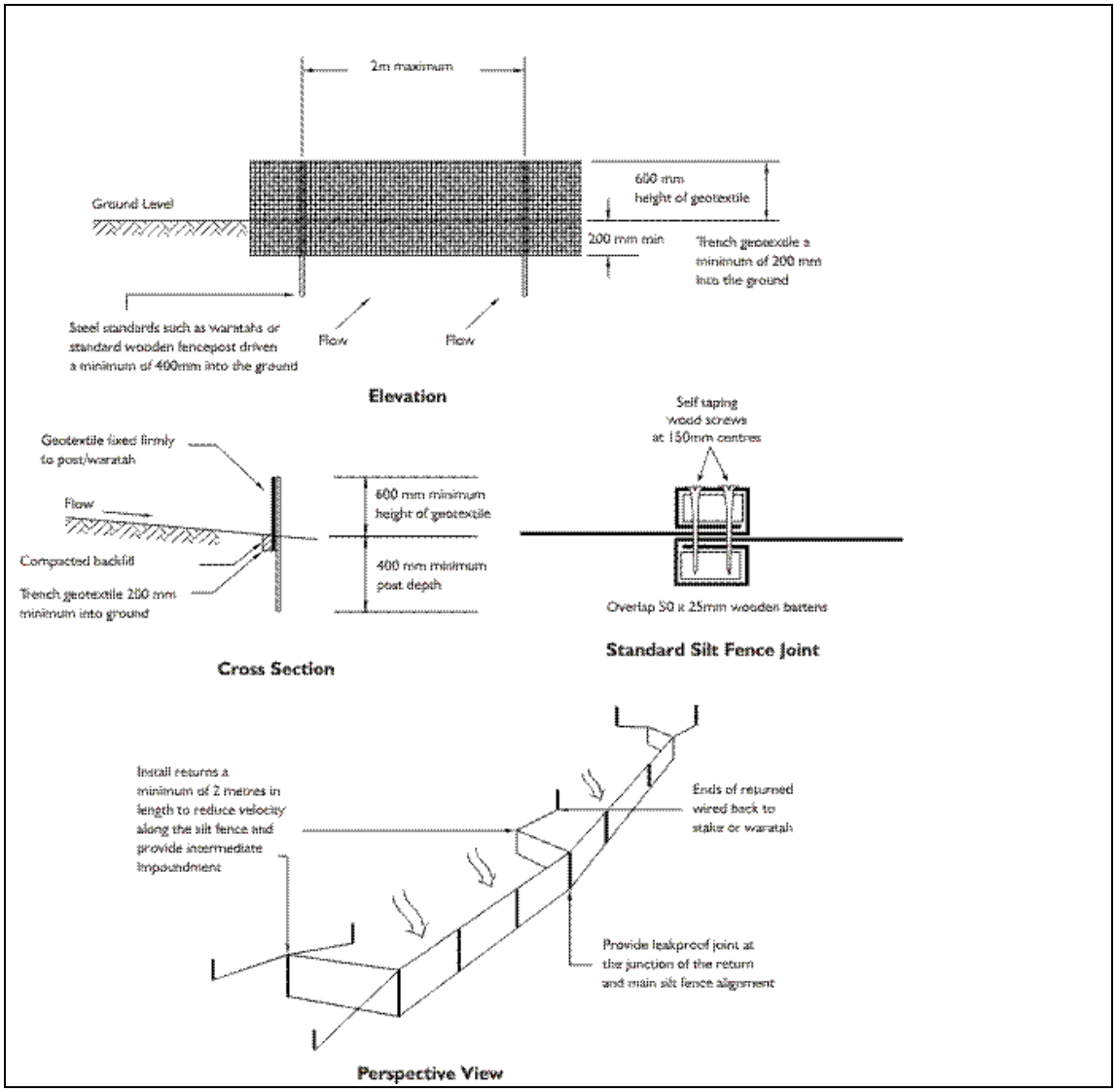
7.2.5 Maintenance

Silt fences are only as good as their maintenance. Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) Inspect the fence on a weekly basis and after heavy rain (15mm in the preceding 24 hours) and repair as necessary. They often fail by being undercut.
b) Remove accumulated sediment when it causes bulges in the fence.
c) If there is an outfall, then ensure that it remains stable (use slash, fabric etc).

7.2.6 Drawing

Figure 7-3
Silt Fence Detail



7.3 Super Silt Fences ("Debris Dams")

Super Silt Fence Used as a Debris Dam to Contain Mobilised Sediment

7.3.1 Description/Purpose

These are small but strong sediment retention barriers made of filter fabric, timber, rock etc. They are often constructed in areas of actively moving surface soil or slip material. Typical forestry use includes forming a tightly compressed bund of slash (refer Section 7.4-Slash Bunds) just below the slip material in such a way that there is sufficient bulk (or constructed support using a super silt fence as described below) in the bund to hold the slip material in place. Generally, additional treatment measures would be installed below the debris dam to treat the runoff of finer sediment.

7.3.2 Catchment Area

Less than 0.5 hectares.

7.3.3 Construction

a) The debris dam should be no more than 500 mm in height at the centre to prevent it from being destroyed by "waves" of sediment.
b) The sides of the debris dam must be higher than the centre so that the flow is always directed to the centre of the dam (this avoids the debris dam being outflanked). Energy dissipation at the outfall is required.
c) The crest of the downstream dam should be at about the same elevation as the toe of the upstream dam. The spacing between dams therefore varies with slope angle.
d) Supports (e.g. waratahs) should be no more than 1 metre apart in the centre and driven a minimum of 500 mm into ground. Spacing can be increased to 1.5 metres on banks.
e) In the case of a fabric dam (refer Figure 7.3), the geotextile needs to be strengthened with chain mesh or boundary fence netting.
f) Dig the material into the ground to avoid the dam being undercut. If fabric is used (refer required properties in Table 7, Section 7.2), this, plus the strengthening wire netting, needs to be dug at least 300 mm into the ground.
g) The middle of debris dams should be tied back with No. 8 wire to deadmen at least 2 metres upstream of the dam. Deadmen can be steel posts or similar angled back to dam and driven at least 500 mm into the ground. Tie back either end of the dam in a similar fashion as well.

Construction Notes:

a) Debris dams should be positioned as close to the sediment source as possible and extended down from that point.
b) They should be built in a semi-circular shape for strength.
c) Once filled with sediment, more dams may be constructed by positioning the new ones half way between the existing dams.

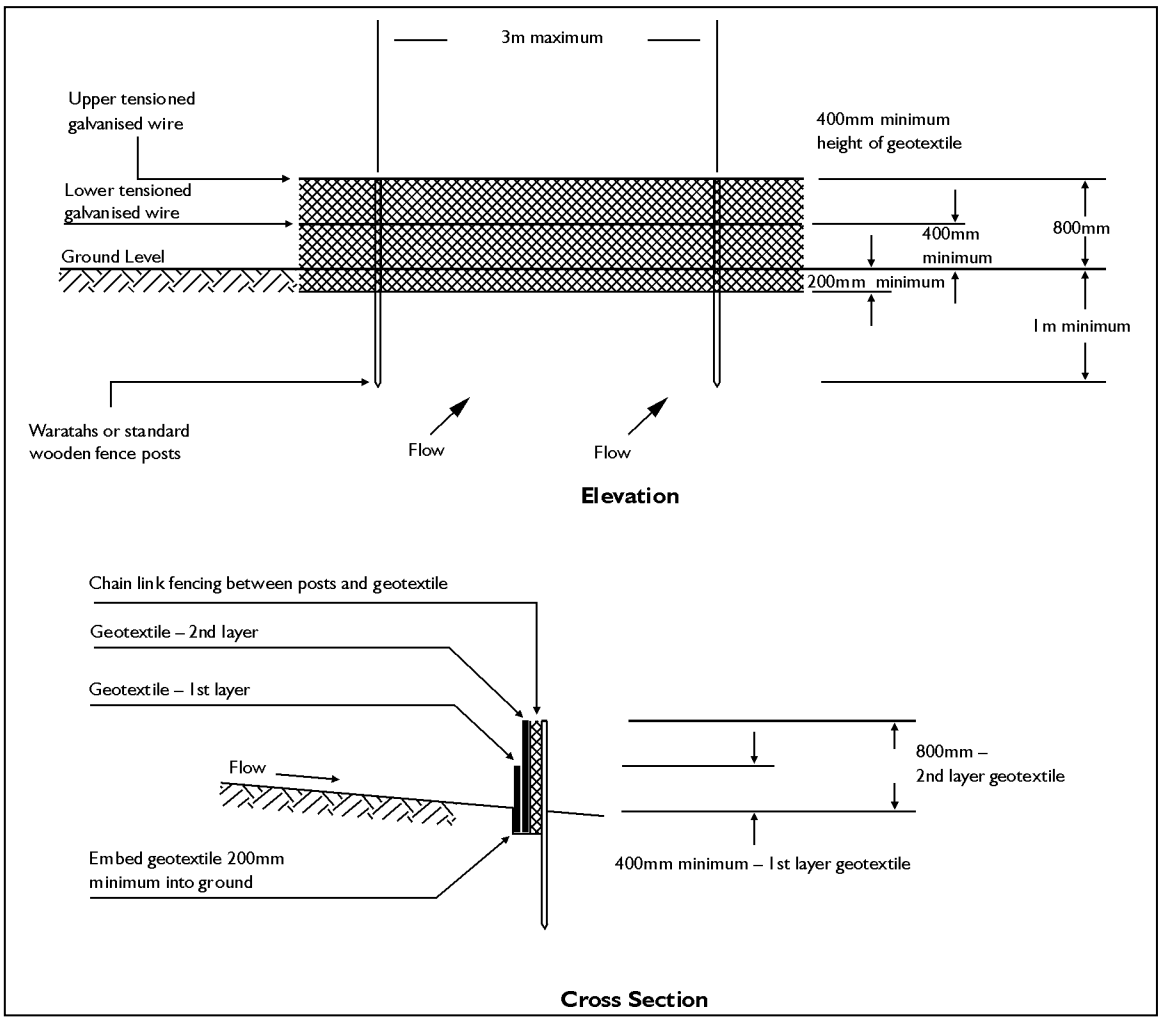
7.3.4 Maintenance

Debris dams can hold large volumes of relatively mobile sediment and any weakness in the structure will quickly become apparent. The most common causes of failure are the undercutting or outflanking of the measure. Therefore:

a) Ensure that flow is not flowing either under or around the debris dam.
b) Inspect regularly and after every storm event (15mm in the preceding 24 hours).
c) Implement repairs to ensure the dams remain in good working order.
d) Check to ensure that no erosion is occurring at the outfall.

7.3.5 Drawing

Figure 7-3
Super Silt Fence



7.4 Slash Bunds

7.4.1 Description/Purpose

Example of a Slash Bund Used to Impede the Flow of a Sediment Slug

These are used as temporary sediment retention devices for very small catchments to catch the initial 'pulse' of earth material. Often fills and/or embankment failure and earth material generated on landings fits this description. They can be useful as temporary barriers to intercept and divert site runoff. However, sediment controls will still be required down slope of a Slash Bund to treat any runoff as these earth movements are often made up of wet and fine material that will ultimately pass through the slash.

7.4.2 Catchment Area

Less than 0.1 hectares. Generally there should be no more than 20 m of slope behind this measure.

7.4.3 Construction

a) Place as much slash as possible in a 'windrow' shape, with as much height and width as necessary to contain / control the mass movement of earth material.
b) The weight of the slash needs to be equal to the weight of the material pushing against it and in extreme cases may need large logs in critical areas to provide the necessary support.
c) These bunds do not provide filtration of finer sediments and some form of sediment control maybe necessary below these slash bunds to control the finer sediment material that passes through the bunds.

Construction Notes:

a) They are not effective sediment filters and are recommended just to stop the viscous earth material migrating to sensitive areas.
b) Controlling the viscous material at the source will usually mean it is easier to construct sediment controls below the material being contained.
c) Divert any upper catchment flows around the site as any flows will compound the problems with such loose / fine material.
d) They are often mistakenly used as the only form of sediment control.

7.4.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) Check for breaches or failures of the slash bund, particularly where the most weight is being exerted from the sloppy earth movement.
b) Where pressure is beginning to exceed the ability of the slash bund to hold back the sloppy earth material, add further slash and logs to strengthen.
c) Check that the sediment controls below the bunds are functioning and clean out as required.

7.5 Earth Bunds (No Decant Outlet)

7.5.1 Description/Purpose

Earth Bund Installed Downslope of Road Works

An earth bund (EB) is formed from a bunded or ponding area which detains runoff long enough to allow sediment to drop out of suspension prior to discharge. It differs from a silt trap in that an excavation is not necessarily created, and typically is a continuous bund constructed on the contour (e.g. around the toe of a landing). Other commonly used configurations may include a 'horseshoe' shape sometimes incorporating a natural depression off to one side of the area requiring treatment.

Earth Bunds can be constructed from topsoil or clay, but as the bund must be 'waterproof', slash is not recommended. The earth bund does not require a decanting device as the maximum contributing catchment is 0.1ha. For areas greater than 0.1ha, other treatment practices will be required.

7.5.2 Catchment Area

Less than 0.1 hectare.

7.5.3 Construction

a) Work out how the Earth Bund will fit in/work for the site. Identify the catchment area (more than one Earth Bund may be necessary). Discuss with the harvesting contractor where ground based haul tracks will access and exit the landing and avoid placing controls where damage from these activities is likely to occur. The same considerations are necessary for haulers as often a single setting can result in trees being hauled over most of the landing edges.

b) Construct a 1.5 m high earth bund (maximum height) at the selected point. The embankment must be compacted. The bund must provide a minimum storage volume behind the bund equivalent to $2m^3$ for each $100m^2$ of catchment. Extend the bund so that the runoff from the required catchment can be intercepted and directed to the Earth Bund for treatment. If an excavation is created the sides should be no steeper than 1:1.

c) Inlet points must be located as far as possible away from the outlet to optimise sediment deposition. Ideally the Earth Bund should be 3 times longer than it is wide with inflow at one end and the outlet at the other.

d) Any discharge from the Earth Bund must be to an erosion proof outlet e.g. to slash, a natural depression/watercourse etc. Do <u>not</u> discharge over bare land, fill or unstable ground. If necessary, the outflow may need to be flumed to an erosion proof discharge point.

e) Remove Earth Bunds when the catchment has been stabilised and stabilise the remaining bare area (such as with grass seed, slash etc).

Construction Notes:

d) Do not install them above unstable slopes as infiltration and the loading surcharge may exacerbate instability. Remove all vegetation prior to construction. They may need to be keyed in on steep slopes.

e) Subsoil is the preferred material to construct embankments and this material must be compacted. If topsoil is used, the embankment is to be a minimum of 4 m wide, with 1:1 batters and compacted.

f) The minimum height for the diversion bunds can be 0.75 m (bunds that direct runoff to treatment areas but have no impounding function) but ensure that they are always higher than the spillway. The spillway must always be at the lowest point of the bund.

g) Slash or unsuitable organic material can be placed immediately below the bunds as it can provide some structural support as well as a stabilisation function.

7.5.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) Make sure that runoff is not outflanking the system.
b) Make sure that the spillway is the lowest point over the bund wall, that it is functional and protected against erosion. Repair any damage.
c) Check for erosion at the outfall and remedy as required (e.g. redirect to a new outlet, install a flume etc).
d) Repair any damage to the drainage systems.
e) Inspect for seepage through the embankment and repair as necessary.
f) Remove accumulated sediment when the Earth Bund is no longer working to volume criteria (generally when 20 % full of sediment). Place the soil away so it can't wash back into the Earth Bund or into natural water etc.
g) Repair immediately if logging operations has damaged the Earth Bund.

7.6 Decanting Earth Bunds – (Decanted Outlet)

7.6.1 Description/Purpose

Decanting Earth Bund Treating a Maximum Catchment Area of 3,000 m^2

A Decanting Earth Bund (DEB) is formed from a bunded or ponding area which detains runoff long enough to allow sediment to drop out of suspension prior to discharge. It differs from a silt trap in that an excavation is not necessarily created, and for all purposes is similar to an Earth Bund, except that the water column in the impounded area is decanted. Other commonly used configurations may include a 'horseshoe' shape sometimes incorporating a natural depression off to one side of the area requiring treatment.

Decanting Earth Bunds can be constructed from topsoil or clay, but as the bund must be 'waterproof', slash is not recommended. The Decanting Earth Bund is required to have a decant outlet device, and due to this higher level of treatment (sediment removal) has a maximum contributing catchment is 0.3ha. For areas greater than 0.3ha, other treatment practices (silt traps, sediment retention ponds) will be required.

7.6.2 Catchment Area

Less than 0.3 hectares.

7.6.3 Construction

a) Work out how the Decanting Earth Bund will fit in (work) for the site. Identify the catchment area (more than one Decanting Earth Bund may be necessary). Discuss with the harvesting contractor where ground based haul tracks will access and exit the landing and avoid placing controls where damage from these activities is likely to occur. The same considerations are necessary for haulers as often a single setting can result in trees being hauled over most of the landing edges.

b) Construct a 1.5 m high earth bund (maximum height) at the selected point. The embankment must be compacted. The bund must provide a minimum storage volume behind the bund equivalent to 2m^3 for each 100m^2 of catchment. Extend the bund so that the runoff from the required catchment can be intercepted and directed to the Decanting Earth Bund for treatment. If an excavation is created the sides should be no steeper than 1:1.

c) Inlet points must be located as far as possible away from the outlet to optimise sediment deposition. Ideally the Decanting Earth Bund should be 3 times

longer than it is wide with inflow at one end and the outlet at the other – a baffle may be necessary to achieve this.

d) Lay a 150 mm diameter non perforated drainage pipe through the bund at the low point and compact soil firmly around the pipe. The pipe needs to discharge to an erosion proof outlet e.g. to slash, a natural depression/watercourse etc. Do not discharge over bare land, fill or unstable ground. If necessary, the outflow may need to be flumed to an erosion proof discharge point.

e) Install a decanting upstand. Place a 90-degree bend on the inside end of the outlet pipe near the bund wall and install a vertical pipe so that the top is no more than 1 m from the ground. Securely glue/fasten all connections. Drill 6 rows of 5 mm diameter holes at 50 mm spacing for drainage from the top of the upstand down to 0.3 m from the silt trap floor. This will result in a permanent pool at the bottom of the Silt Trap, which aids sediment treatment. [Note: 1/3 of the volume of the trap should be "dead storage" i.e. a pool of water and the other 2/3 is operating volume *i.e.* is the volume decanted off through the perforated upstand during and after rainfall events].

f) Drive a waratah into the ground next together and wire together for support.

g) Install a 2.0 metre wide trapezoidal spillway over the Decanting Earth Bund (preferably to spill to natural land). This must be level across its width and 150 mm above the invert of the upstand. Stabilise the surface of the spillway against erosion if the down slope is more than 2% (e.g. with geotextile fabric, rock [150-300 mm diameter], slash, or concrete).

h) Remove Decanting Earth Bund's when the catchment has been stabilised and stabilise the remaining bare area (such as with grass seed, slash etc).

Construction Notes:

a) Do not install them above unstable slopes as infiltration and the loading surcharge may exacerbate instability. Remove all vegetation that will compromise the geotechnical integrity of the structure prior to construction. They may need to be keyed in on steep slopes.

b) Subsoil is the preferred material to construct embankments and this material must be compacted. If topsoil is used, the embankment is to be a minimum of 4 m wide, 1:1 batters and compacted.

c) The minimum height for the diversion bunds can be 0.75 m (bunds that direct runoff to treatment areas but have no impounding function) but ensure that they are always higher than the spillway. The spillway must always be at the lowest point of the bund.

d) Compact carefully around the drainage pipe through the embankment to avoid seepage and potential trap failure.

e) Surround the perforated upstand with chicken mesh to keep bark, slash etc from blocking the drainage holes in the upstand.

f) Slash or unsuitable organic material can be placed immediately below the bunds as it can provide some structural support as well as a stabilisation function.

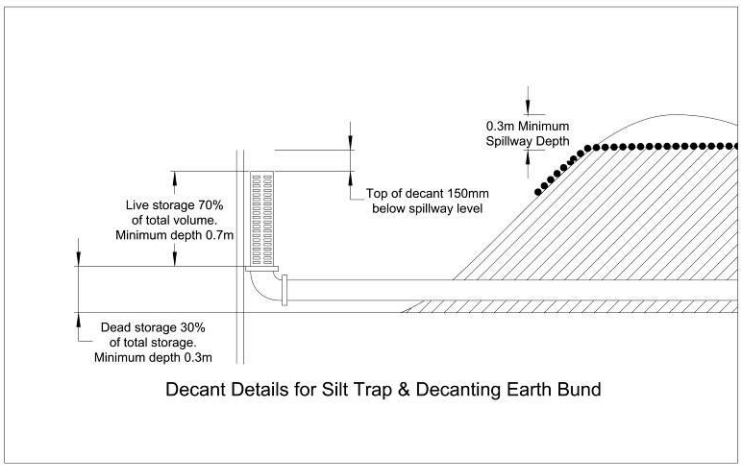
7.6.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

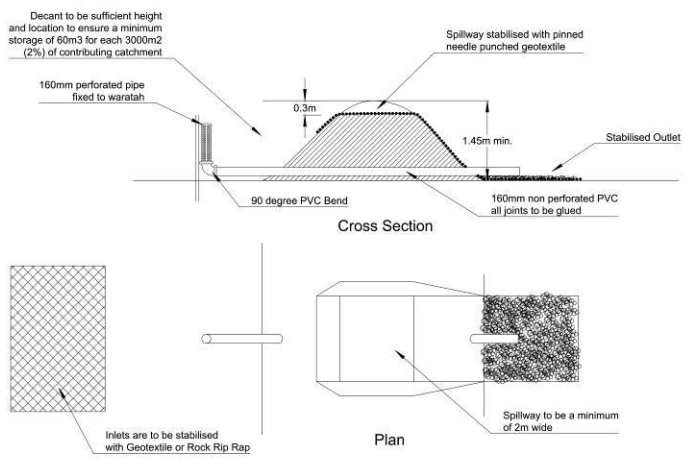
a) Make sure that runoff is not outflanking the system.
b) Make sure that the spillway is the lowest point over the bund wall, that it is functional and protected against erosion. Repair any damage.
c) Check for erosion at the outfall and remedy as required (e.g. redirect to a new outlet, install a flume etc).
d) Repair any damage to the pipe drainage systems.
d) Inspect for seepage through the embankment, or along the outlet pipe and repair as necessary.
e) Repair any blockages such as to the holes in the upstand etc.
f) Remove accumulated sediment when the Earth Bund is no longer working to volume criteria (generally when 20 % full of sediment). Place the soil away so it can't wash back into the Earth Bund or into natural water etc.
g) Repair immediately if the Decanting Earth Bund has been damaged by logging operations.

7.6.5 Drawing

Figure 7-4
Decanting Earth Bund Details



Decant Details for Silt Trap & Decanting Earth Bund



Decanting Earth Bund Inlet and Outlet Details

7.7 Silt Traps

Silt Trap

7.7.1 Description/Purpose

A Silt Trap is a small sediment retention pond system rather like a mini sediment retention pond. They can be formed by excavation and/or embankment. They also have 'stricter' design criteria than Decanting Earth Bunds and can therefore treat larger areas.

7.7.2 Catchment Area

Less than 0.5 hectares.

7.7.3 Construction

a) Work out how the silt trap will fit in/work for the site. Identify the catchment area as more than one Silt Trap may be necessary. Discuss with the harvesting contractor where ground based haul tracks will access and exit the landing and avoid placing controls where damage is likely to occur. The same considerations are necessary for haulers as often a single setting can result in trees being hauled over most of the landing edges, causing damage to controls.
b) Diversion channels/bunds will usually be necessary to intercept and direct site runoff to the Silt Trap for treatment.
c) Construct the Silt Trap at the selected point ensuring that the bund or excavation is no more than 1.5 m high. The created storage area must provide a minimum storage volume equivalent to $2m^3$ for each $100m^2$ of contributing catchment (2% criteria). The bottom of the trap should be level and flat and the sides no steeper than 1:1.
d) Silt Trap embankments may need to be keyed in on steep slopes.
e) The inlet to the Silt Trap should be 3 horizontal: 1 vertical and be as wide as the floor of the Silt Trap. This inlet will usually need to be stabilised e.g. with geotextiles. It must be located as far as possible away from the outlet to optimise sediment deposition.
f) The Silt Trap should be <u>3 times longer</u> than it is wide with inflow entering at one end and the discharging through the outlet at the other. Baffles may be necessary to achieve this. A baffle is a barrier constructed across the pond to direct flows and so maximise the efficiency of the Silt Trap. Its height should be the same as that of the top of the perforated upstand. It can be constructed from fabric such as silt fence fabric or shaped when being excavated leaving a clay barrier. When using clay barriers, the top must be covered with fabric or similar to guard against erosion. If erosion over the barrier cannot be prevented, the secondary part of the pond will then form the silt trap (*i.e.* it must have $2m^3$ for every 100 m^2 of catchment) and the first stage becomes a fore bay that will retain larger soil particles (and aid cleaning).
g) Lay a 150 mm diameter non-perforated drainage pipe through the bund at the low point and compact soil firmly around the pipe. The pipe needs to discharge to an erosion resistant outlet e.g. to slash, a natural depression/watercourse

etc. Do not discharge over bare land, fill or unstable land. If necessary, the outflow may need to be flumed to an erosion resistant discharge point.

h) Install the upstand. Place a 90-degree bend on the inside end of the outlet pipe near the bund wall and install a vertical pipe so that the top is no more than 1 m from the ground. Securely glue/fasten all connections. Drill 6 rows of 5 mm diameter holes at 50 mm spacing for drainage from the top of the upstand down to 0.3 m from the silt trap floor. This will result in a permanent pool at the bottom of the Silt Trap which aids sediment treatment. [Note: 1/3 of the volume of the trap should be "dead storage" i.e. a pool of water and the other 2/3 is operating volume i.e. is the volume decanted off through the perforated upstand during and after rainfall events].

i) Drive a waratah into the ground next to the upstand and wire together for support.

j) Install a 2.0 metre wide trapezoidal spillway over the Silt Trap embankment (preferably to spill to natural land). This must be level across its width and 100 mm above the invert of the upstand i.e. no higher than 1.1 m above the floor of the trap. Stabilise the surface of the spillway against erosion if the down slope is more than 2% (e.g. with geotextile fabric, rock [150-300 mm diameter], slash, or concrete).

k) Remove Silt Trap when the catchment has been stabilised and stabilise the remaining bare area (with grass seed, slash etc).

Construction Notes:

a) Do not install them above unstable slopes as seepage may cause slumping.

b) Remove all vegetation prior to construction.

c) Subsoil is the preferred material to construct embankments and this material must be compacted. If topsoil is used, the embankment is to be a minimum of 4 m wide, have 1:1 batters and be compacted.

d) The minimum height of the diversion bunds can be 0.75 m (bunds that direct runoff to treatment areas but have no impounding function) but ensure that they are always higher than the spillway. The spillway must always be the lowest point of the embankment.

e) Compact carefully around the drainage pipe through the embankment to avoid seepage and potential trap failure.

f) Surround the perforated upstand with chicken mesh to keep bark, slash etc from blocking the drainage holes in the upstand.

g) Slash or unsuitable organic material can be placed immediately below the bunds.

7.7.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) Make sure that runoff is not outflanking the system.

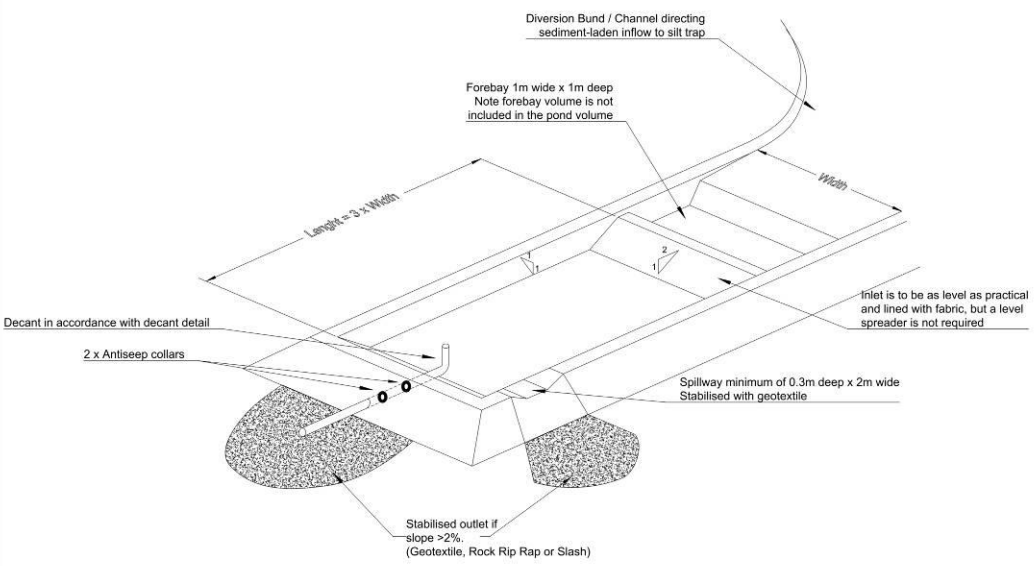
b) Make sure that the spillway is the lowest point of the embankment, that it is functional and protected against erosion. Repair any damage.

c) Check for erosion at the outfall and remedy as required (e.g. redirect to a new outlet, install a flume etc).

d) Repair any damage to the pipe drainage systems.
h) Inspect for seepage through the embankment or along the outlet pipe and repair as necessary.
i) Repair any blockages such as holes in the upstand etc.
j) Remove accumulated sediment when the Silt Trap is no longer working to volume criteria (generally when 20 % full of sediment). Place the soil away so it can't wash back into the Earth Bund or into natural water etc.
k) Repair immediately if the Silt Trap has been damaged by logging operations.

7.7.5 Drawing

Figure 7-5
Silt Trap Design Details



Typical Silt Trap details

7.8 Sediment Retention Ponds

Sediment Retention Pond

7.8.1 Description/Purpose

These are specifically designed ponds used to treat site runoff and retain sediment. This facility is the usual treatment measure for urban earthwork sites treating catchments larger than 0.5 hectares in the Hawke's Bay region. It should be noted that sediment retention ponds are complex and expensive to construct and consequently are not often used in forestry in the Hawke's Bay region.

7.8.2 Catchment Area

Less than 5 hectares.

7.8.3 Construction

Sediment retention ponds are now complex devices and require specific design and construction. The following information introduces this measure but the Erosion and Sediment Control Guidelines for the Hawke's Bay Region should be referred to for more definitive detail.

a) The pond usually has a volume of 300 m^3 to every hectare of contributing catchment. The pond has a piped outlet and the volume is calculated from the floor of the pond to the top of the piped outlet.
b) It is usually between 1 and 2 m in depth, 3-5 times longer than its width (otherwise baffles are required), and the inlet is located at the opposite end of the pond to the outlet.
c) The pond has 30 % of its volume retained as a permanent pool of water, while the upper 70 % (the operational volume) is decanted off with floating decants.
d) Specifically designed floating decants are required and are fastened to the piped outlets.
e) An emergency spillway is required capable of conveying the 1% AEP storm event. Usually both the inlet and emergency spillway are the width of the pond floor.
f) Both the inlet and spillway need to be stabilised to protect them against erosion.

Construction Notes:

a) Do not place them in streams.
b) Install at least two antiseep collars on the outlet pipe and compact thoroughly around the pipe.
c) Ensure good compaction of the embankments.
d) Ensure that the pond floor is level.
e) Consider maintenance and access when locating the pond.

7.8.4 Maintenance

Develop a maintenance and monitoring schedule to ensure that these controls are operating effectively and, to look for any changes in the structure. Important details to check on are:

a) The pond needs to be cleaned out when 20 % full of sediment.
b) Check for piping through the embankment (particularly where the piped outlet is installed) and remedy if required.
c) Ensure all runoff enters only at the inlet end of the pond.
d) Check the floating decants as they can quickly block with floating detritus. Clean as required.

7.8.5 Drawing

Figure 7-6
Sediment Retention Pond
(refer to Erosion and Sediment Control Guidelines for specific design details)

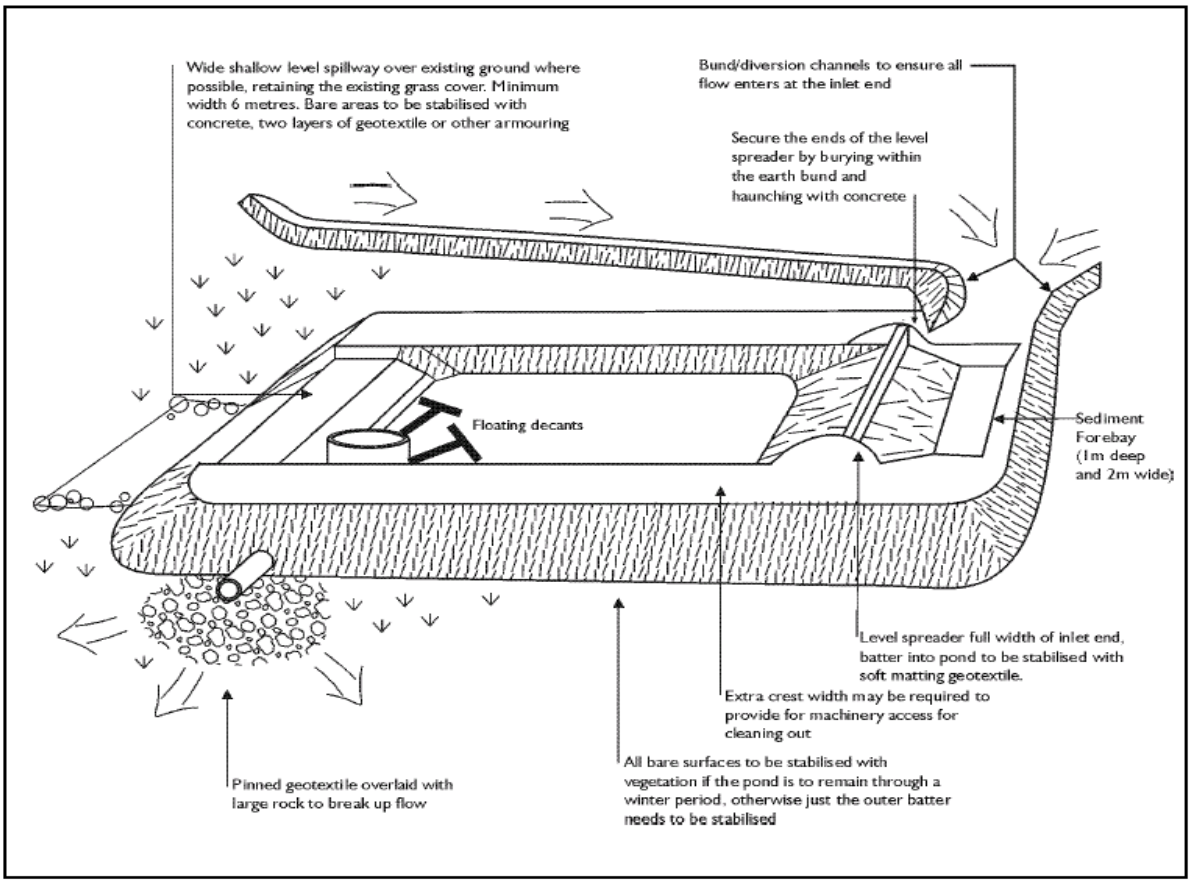
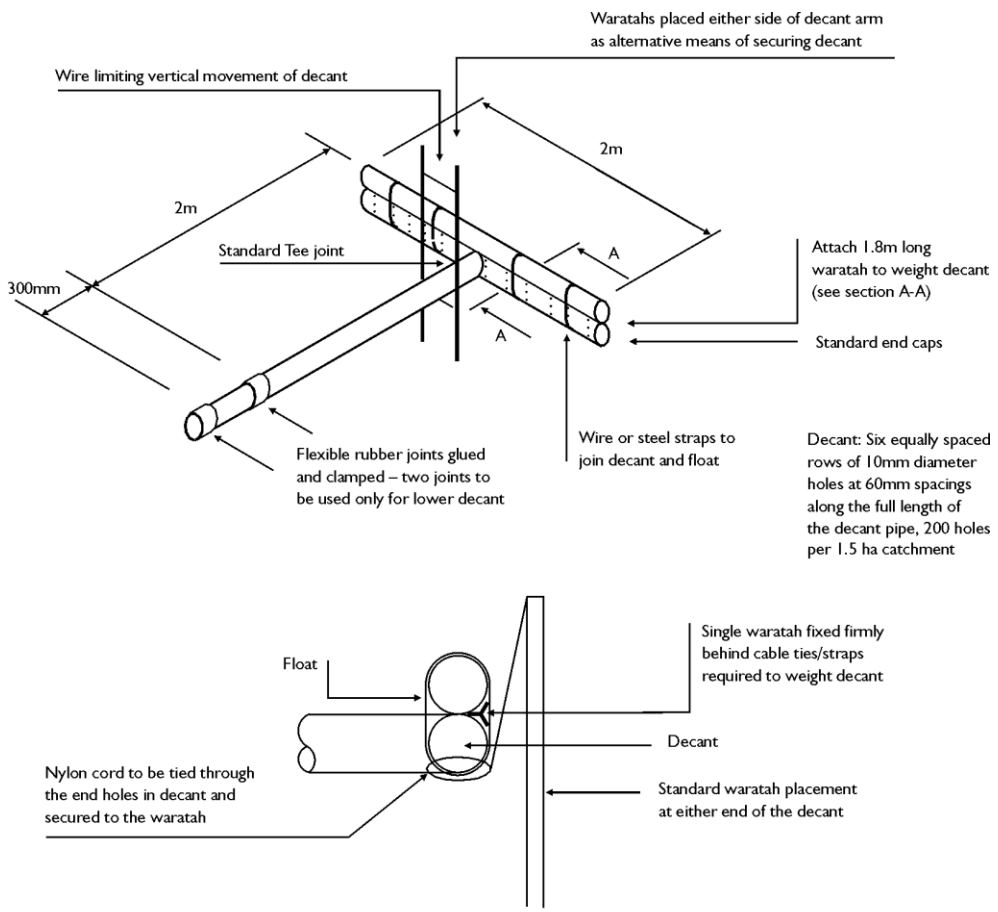


Figure 7-7
Sediment Retention Pond - Decant Details



Section A-A

8 Specific Forestry Activities - Erosion and Sediment Control

This section outlines commonly undertaken forestry activities, how they might be undertaken from an erosion and sediment control perspective and the types of control measures that can be used to minimise potential effects on the receiving environment. Each activity is described, relevant considerations discussed, and an erosion and sediment control toolbox portrayed.

The activities discussed in this section include:

- Roading
- Landing Sites
- Haul Tracks and Firebreaks
- Land Preparation
- Harvesting
- Post Harvesting Management

The development of roads, landings and haul tracks are essentially earthwork activities and Sections 6 & 7 have outlined a number of commonly implemented erosion and sediment control methodologies for these activities.

A table outlined in Figure 8.4 provides a summary of the operating thresholds based on a catchment size of all of the erosion and sediment controls mentioned in the previous section.

8.1 Access Roading

Construction of roads can be a major contributor of sediment. Forward planning can reduce this risk by locating roads away from vulnerable areas, carrying out the work during fine weather in summer etc. Progressive stabilisation e.g. by progressively laying aggregate on completed sections of road, will further reduce the risk of erosion and sediment generation.

During construction, erosion and sediment control measures will generally be required, particularly where an overland flow path or a watercourse crosses the earthwork area, and at discharge points. These erosion and sediment control systems are generally temporary as, when completed, the road carriageway should be stabilised and not require further sediment control.

At the completion of construction, all bare areas should be stabilised. In roading terms this usually means that the road surface will have a cover of aggregate, that watertables are stabilised such as by lining with suitably sized aggregate, and that cut and fill batters have been hydroseeded or sown with grass seed.

Where the road is to be constructed on ridge tops with minimal cut and fills, aggregate can be progressively placed on completed portions of the road and often no or only minimal sediment controls are required. Controls become necessary when a disturbed area cannot be stabilised within one working day. Effectively this means that work may proceed without sediment controls while the weather window is clear, however when work stops for a weekend and/or rain is forecast, then treatment and control measures, such as those detailed in this guideline, should be installed[4].

8.1.1 Roading Considerations

- Construct roads on, or as near as possible, to ridge tops, natural benches and flatter slopes. Where possible, steep slopes should be avoided, particularly where watercourses are close by.
- Minimise clearing and keep the road width to the minimum necessary to operate safely and effectively.
- Where possible, do not construct roads in the floor of gullies, and minimise gully crossings as much as possible.
- Do not discharge runoff directly to a watercourse. Where possible, discharge runoff from unstabilised areas through a sediment control measure (*e.g.* decanting earth bunds) and then to stable outfalls.
- Where steep side cuts cannot be avoided, ensure adequate cross-formation drainage is installed and that these channels flow onto stable or erosion proof areas such as spurs. Ensure they do not discharge onto areas of fill. End hauling of soil may be necessary on steeper slopes to prevent side cast material slipping into watercourses.
- Sediment control measures are required to treat runoff from all bare areas during construction where the road cannot be progressively stabilised before forecast rain. Areas can be stabilised with, for example, grass, aggregate, slash or mulch.

[4] Note that there is considerable risk in relying on favourable weather to complete earthworks or to harvest an area via haul tracks without erosion and sediment control measures in place. While there are some small-scale operations that can be carried out without specific controls installed because immediate stabilisation can be achieved, most require some control measures to be installed and maintained during the works.

- Complete cut faces by leaving a rough surface with small benches to help grass seed and or hydro-seed to establish. Operate the machine parallel to the cut or at right angles to water flow direction, leaving small ledges as often as is practicable. This can also be achieved by dragging the teeth of an excavator bucket horizontally across the cut.
- Compact road fills to appropriate engineering standards. Failed fills can cause significant environmental damage and be expensive to repair.

8.1.2 Roading - Erosion & Sediment Control Toolbox

Erosion Control

Recommended erosion control methods for roading include (specific details are contained in Section 6)

- Stabilise bare road surfaces (e.g. with aggregate) and batters (e.g. hydroseed) as soon as practical.
- Culvert pipe sizes should be a minimum of 300 mm diameter to minimise blocking.
- Stabilised inlets and outlets for culverts should be installed. Discharged flows must not be discharged directly onto or over fill, or erosion-prone areas. In those situations, runoff should be piped or flumed to an erosion proof area, and suitable energy dissipation provided in the form of rock rip rap or stable areas of slash.
- Stabilise watertables with aggregate or other approved methods as soon as practicable once the gradient exceeds 2%. This is because watertable velocities can become high and erosive on bare slopes and particularly as slope grades increase.
- Install rock lining and/or check dams in the watertable drains when the slope and distance increases the erosion risk.
- Hydroseed or apply grass seed and mulch to bare areas as soon as possible.

Sediment Control

Common sediment control methods used for roading include (specific details are contained in Section 7):

- Silt traps and decanting earth bunds to be installed during the construction phase and retained until the area has been stabilised against erosion. These are appropriate for areas of less than 3,000 m^2 - 5,000 m^2 (note that the catchment area refers to all of the catchment, not just the bare area alone).
- Silt fences can also be used for disturbed areas of less than 3,000 m^2 in area (although they are less robust).
- Sediment retention ponds for areas exceeding 5,000 m^2.

Table 8-1
Watertable Velocities on Different Grades and Surfaces[1]

Slope of Site (%)	Velocity – bare clay surface (m/s)	Velocity – rock lined (100 to 150mm) (m/s)
2	3.2	1.6
5	5.1	2.6
10	7.2	3.7

A drain 0.5 m deep, 1:1 sides and 0.5 m wide channel base has been assumed.

8.2 Landing Sites

Landings may be permanent or temporary formations. They are generally constructed 12 to 18 months prior to harvesting and must be well drained and stable with appropriate erosion and sediment controls in place.

The construction of landings can require significant earthworking with the potential to generate large volumes of sediment from rainfall events. Therefore, all sediment-laden flows should be directed to sediment treatment measures prior to discharge from the landing. The site may require shaping or a diversion channel/bund installed to direct the flows to one or more control systems. Furthermore, the cumulative impacts of many landing sites within a single forest, if constructed without appropriate erosion and sediment control, can potentially create a significant adverse effect on watercourses.

Hard, compacted surfaces such as landings can be left unstabilised for varying timeframes provided the appropriate erosion and sediment controls are installed and any necessary approval (resource consent and/or winter works extension) from the Hawke's Bay Regional Council has been obtained. Any loose soil should be stabilised with grass seed, mulch, slash etc. An example of a landing site that was constructed during the earthworks season and not used for harvesting immediately after construction is outlined in the following picture.

Landing site with Bunded Edges to Direct Water Flow into Decanting Earth Bund Prior to Discharge. Slash and Offcuts used as Stabilisation of Embankments. Decanting Earth Bund Located at Upper Point of Landing. Landing Area < 3,000 m^2

In practice, the disturbed areas over the landing tend to become progressively become smaller during harvesting operations due to the coverage of slash and mulch, generally leaving only that area where logs are being processed requiring sediment control. In these circumstances it is still essential that the exposed areas and any contributing catchment are identified and that treatment measures are installed and fully maintained. If the entire landing including 'stabilised' areas of log

stockpiles all discharge to one discharge point, then the treatment measures must be sized accordingly.

8.2.1 Landing Site Considerations

- Where possible locate landings outside riparian corridors and away from perennial (Category 1) watercourses and overland flow paths to minimise upper catchment flows onto the landing and associated tracks.
- Construct landings with a slight slope or crown to promote efficient drainage in the required direction.
- Ensure landings are constructed providing sufficient space for sediment control measures such as silt traps and decanting earth bunds to be formed for the treatment of flows off the landing. Control measures should be located away from the main harvesting action to avoid damage or sited such that they remain intact until the landing has been stabilised.
- Take care in constructing erosion and sediment control measures as the concentrated water flows can create their own problems if discharged to unstable areas (e.g. see Silt Traps and Decanting Earth Bund details in section 7.6 and 7.7).
- Compact any fills associated with landings to appropriate engineering standards.
- Ensure exposed ground is stabilised as soon as practicable following completion of the earthworks, using sowing of grass seed, hydroseeding or mulching as necessary.
- Ensure slash is disposed to a stable part of the landing, or plans are put in place to either pull it back at the end of harvesting, or to burn it.
- Many problems at landings occur after the completion of logging and are due to failure of runoff control measures. Maintenance may be necessary for a number of years after logging has been completed.

Landing Site that has been Hydroseeded on the Batters and Margins as Erosion Control.

8.2.2 Landing Sites - Erosion & Sediment Control Toolbox

Erosion Control

Recommended erosion control methods for landings include (specific details are contained in Section 6).

- Divert any upper catchment clean water flows from the landing surface.
- Install Diversion Channels, Diversion Bunds and Cut-off Drains to break up overland flow paths.
- Undertake interim stabilisation with grassing, hydroseeding, mulching, placement of aggregate, slash, etc. following construction of the landing and prior to use (particularly on fill embankments).
- Following the use of the landing, stabilise remaining areas that pose an erosion and sedimentation risk. This may include runoff diversion measures such as Piping and Fluming to remove surface water down any unstable landing batters. Hydroseed or apply grass seed and mulch bare areas.
- Monitor the site and remedy as required.

Sediment Control

Common sediment control methods used for landings include Silt Traps, Decanting Earth Bunds, and Silt Fences. Specific details are contained in Section 7.

Outlined in Figures 8.1 to 8.3 is a spectrum of different erosion and sediment control devices suitable for use on landing sites. These scenarios are not considered exhaustive but provide some examples of the different toolbox of controls available. The configuration and type of control used along with the location of these devices may have some influence on the operating radius of any hauling and therefore some careful planning is required to ensure these controls operate at peak efficiencies whilst hauling operations are occurring.

Figure 8-1

Scenario: 90° Operating Radius

Toolbox of erosion and sediment control used on a landing site and accessway. The prime treatment devices are continuous decanting earth bunds with flumes conveying the flows from the processing area. Note that the cut batter and watertable have been stabilised and therefore require no treatment.

(note to scale)

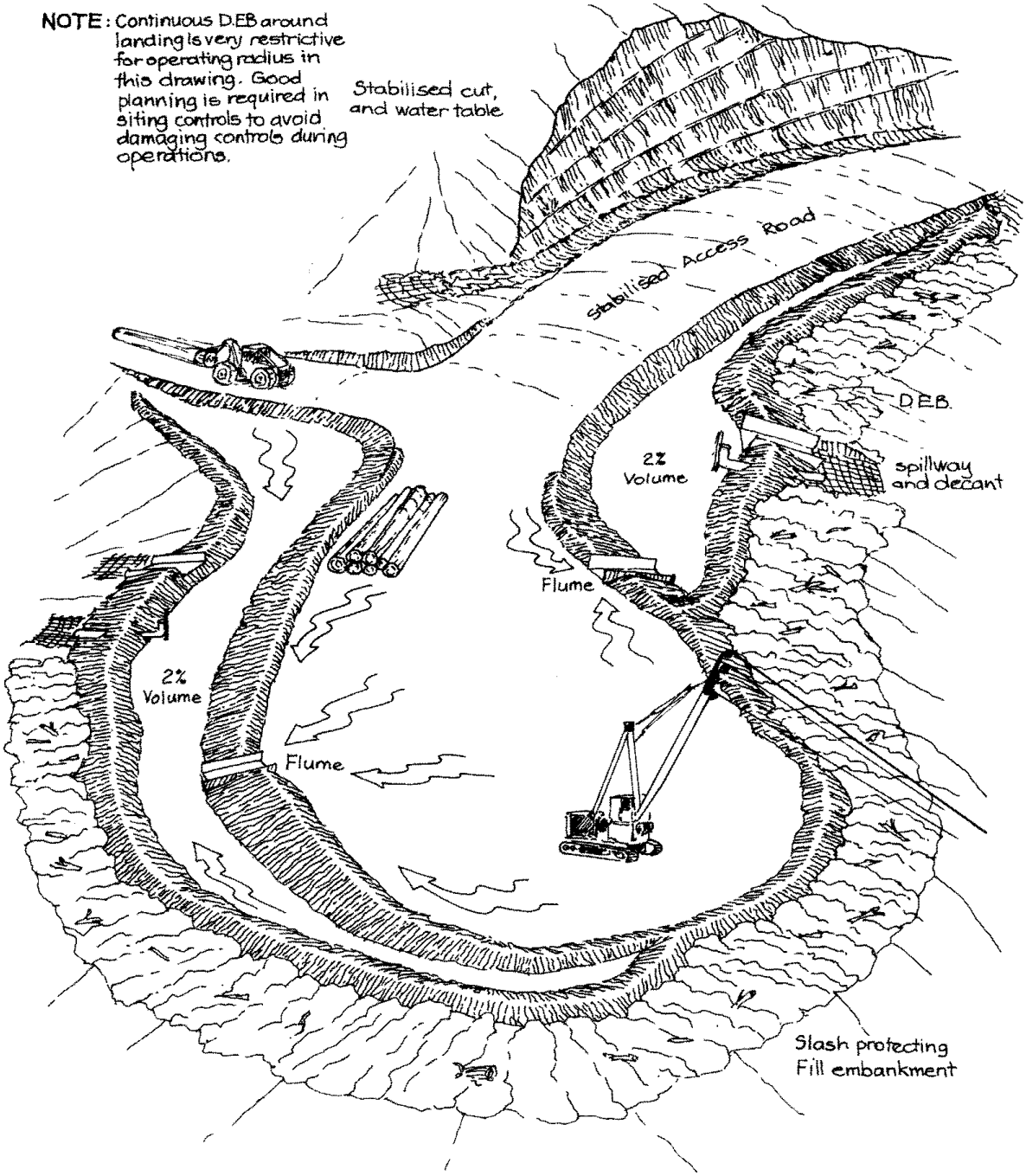


Figure 8-2

Scenario 2: 180° operating radius

Toolbox of erosion and sediment controls used on a landing site and accessway. The prime treatment devices used in this example are a continuous decanting earth bund and silt trap with flumes conveying the flows from the processing area. Note that the cut batter and watertable, which have not been stabilised, have a catchment of less than 1,000 m^2 and therefore runoff is treated via an earth bund (horseshoe shaped with no decant installed.

(not to scale)

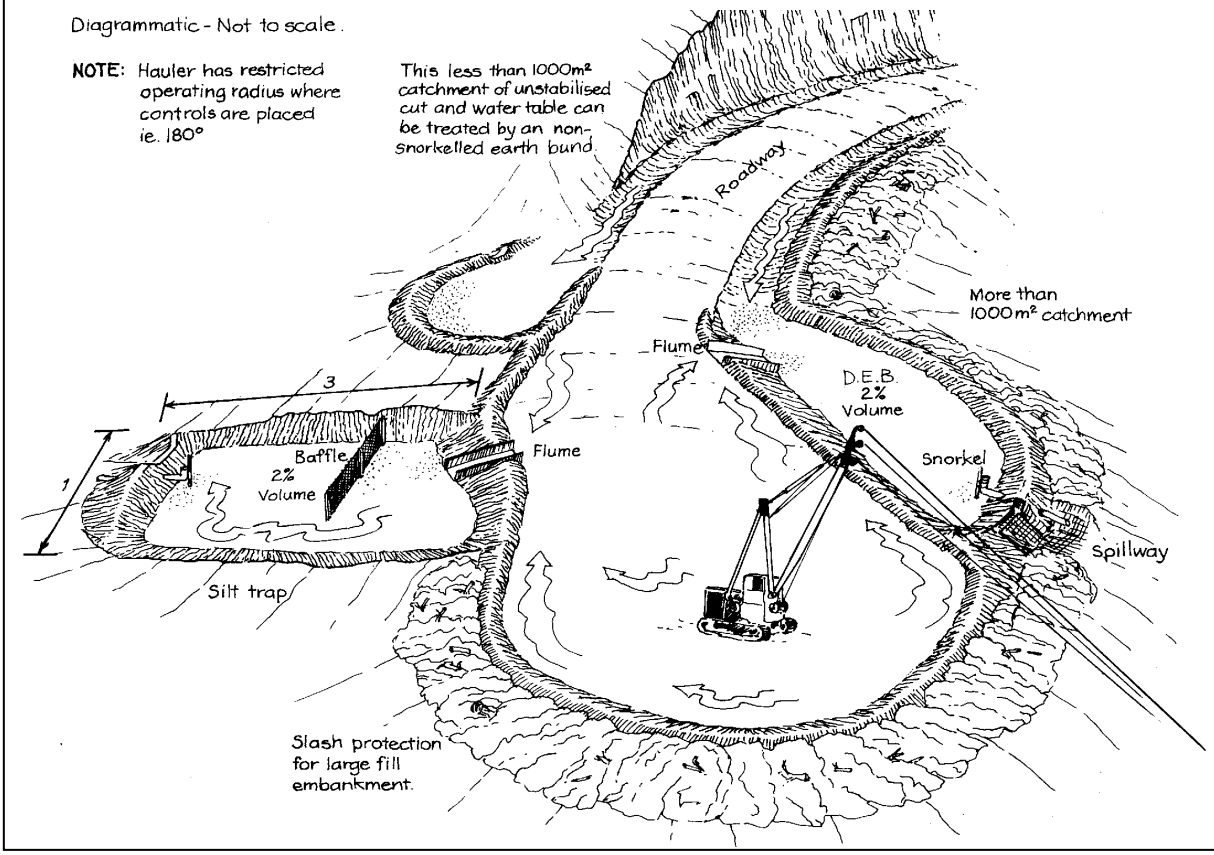
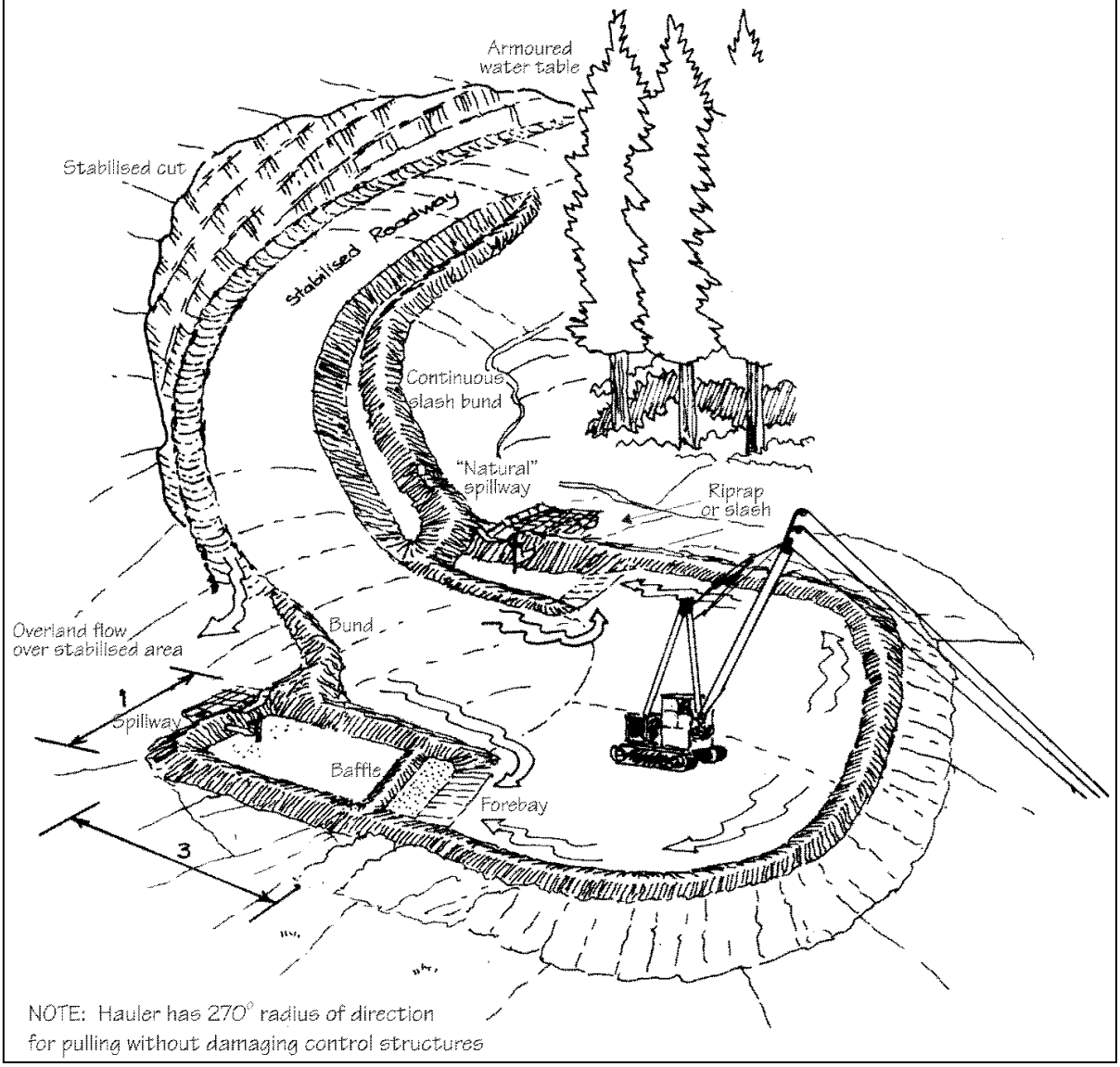


Figure 8-3

Scenario 3: 270° Operating Radius

Toolbox of erosion and sediment controls used on a landing site and accessway. The prime treatment devices (two silt traps) have been located away from the hauler enabling a clearer operating radius.

(not to scale)



8.3 Haul Tracks and Firebreaks

Haul tracks and firebreaks often cut through or across overland flow paths and ephemeral watercourses, and their construction has the potential to generate large volumes of sediment. Maintaining sediment control measures on these tracks and firebreaks is problematic, particularly for tracks that are in constant use, as the logs being hauled often block control measures such as cut-off drains installed to intercept and deflect flows. Sediment laden flows should be directed to a control system in places where the water naturally flows, to be less reliant on physically maintaining cut-offs with machinery. These treatment systems should be operational until the tracks are stabilised by oversowing or placing of slash when no longer required.

8.3.1 Haul Track Considerations

- Tracks and firebreaks should be located to minimise the likelihood of debris and/or soil entering watercourses.
- Tracking results in the concentration of runoff and consequently an increase in erosion. Minimise erosion by tracking across contours and where possible locate tracks on ridges rather than gullies.
- Make sure extraction tracks do not lead directly to watercourses.

An Example of a Poorly Designed and Constructed Haul Track with no Erosion or Sediment Controls Allowing Sediment to Discharge Directly into Adjacent Waterways

8.3.2 Firebreak Considerations

- Do not undertake firebreak formation (by earthworks construction) on steep slopes that fall directly to watercourses. If fire breaking is necessary in these

locations, the firebreak should be formed without soil disturbance (e.g. hand cut vegetation, then apply herbicide/fire retardant).

8.3.3 Track and Firebreaks - Erosion & Sediment Control Toolbox

Erosion Control

- Recommended erosion control methods for haul track and firebreaks include diversion channels/bunds, cut-offs/contour drains to shorten overland flow distances and to direct flow to stable disposal areas. Specific details are contained in Section 6.
- Stabilisation of these areas is best achieved by the progressive application of a layer compressed slash to a thickness of 300mm before machinery is tracked over. If this method is applied, then sediment controls may not be required.

Sediment Control

- Common sediment control methods used for haul tracks and firebreaks include Silt Traps, Decanting Earth Bunds and Silt Fences. Specific details are contained in Section 7. Note for maintenance purposes, it is recommended that these areas be stabilised with the methods outlined in Section 6 (*eg* slash) as continual repair of these sediment controls after harvesting may be difficult.

8.4 Land Preparation

Land preparation may include disturbance of the ground surface, desiccation or removal of existing vegetation or a combination of both. In doing so, these activities expose bare land and therefore increase the risk of soil erosion. They may be subject to the rules contained in the Hawke's Bay Regional Plan.

Mechanical land preparation should be carried out on the contour as much as possible to minimise runoff being concentrated down the cultivated lines. Where downhill runs are unavoidable, limit them to 50 metres (approximate) maximum length. Do not attempt these runs on slopes that are too steep for the tractor to reverse back up. Blade or rake at least one line on the contour along the lower boundary of downhill operations. This will help prevent runoff concentration at low points or gullies. Finish downhill runs well before any fill batter slopes e.g. landings or access roads. Always leave an undisturbed strip beside watercourses.

If carrying out cultivation on landings, cultivate or rip the landings across their general slope. Repair or reinstate drainage channels and cutoffs after any mechanical preparation. Be particularly careful near roadside edges.

Do not push slash from windrows or firebreaks into watercourses. Align windrows of compacted slash along the contour of sloping land. This will help form a barrier and filter for trapping sediment (although note that slash bunds are not a recognised sediment control measure in the Hawke's Bay region).

When working near watercourses, gullies or steep areas, work along the contour. Always inspect the site at the completion of operations for areas that will potentially erode and implement remedial action.

8.5 Harvesting Operations

8.5.1 Planning

The need to carry out planning prior to harvesting is vital. If harvesting is well planned, any potential adverse effects to the receiving environment will be minimised. A harvest plan (see section 5) should include the location of proposed roading and stream crossings (including standards and pipe sizes), landing locations, recommended haul tracks, hauler settings and any special precautions required for sensitive areas. All watercourses, historic sites and other features that will need to be considered (such as wetlands, electric powerlines, gas lines, waahi tapu sites etc) should be identified. Earthworks & harvest planning should involve the proposed contractors if possible, and the preliminary work should include a thorough site inspection. Aerial photos, contour maps and clear indications of property boundaries, will assist in the harvest planning process.

A Practice to be Avoided. Blind Hauling "sweeping" Sediment into Watercourses as Well as Unnecessarily Exposing Earth

8.5.2 Extraction

In general, hauler settings and landings should be located so that extraction is away from watercourses and sensitive areas.

(a) Ground-based systems

Keep tracking and stumping to a practical minimum. Where soil conditions and the terrain allow, use a few carefully chosen tracks and stay on these, rather than taking shortcuts that may cause unnecessary ground disturbance.

Carry the butts of logs off the ground, or on the machine wherever possible. Keep the machine blade up, and do not bulldoze soil and stumps needlessly.

Do not haul through or along streams. However, if the operation necessitates the extraction of logs across a stream, and there is no alternative route, then use a permanent or temporary crossing (See section 8.2).

(b) Cable systems

If cable systems are used in environmentally sensitive areas, wherever practical, keep the settings small, the haul distance short, and the hauling direction uphill.

Where possible, minimise cross-slope haul-lines that damage areas of protective vegetation or sweep slash and soil into watercourses. Where possible, lift logs clear of these areas, and always use the appropriate machine with the required tower height and carriage system to suit the site. Don't form log channels or furrows that direct and concentrate runoff towards a watercourse.

8.5.3 Slash and Residue Management

Prior to harvesting operations commencing, there should be some assessment of whether large volumes of slash and residue will be produced, following on-site processing. Where possible, dispose of the slash to a stable area, bearing in mind that the slash is an excellent resource for stabilisation material. If large amounts of slash and residue will be produced, then contingency measures to deal with the volume of material will need to be put in place.

Slash and residue from processing operations can cause problem "bird nests", if not managed in a proper manner. With all slash and residue disposal, the overburden material will collapse over time, as the woody debris rots down. Disposal sites for slash and debris should be carefully located in designated areas, and marked on site for clear identification. These areas should be on stable land, well away from steep slopes, fill material, slips, gully heads, and riparian areas. This will reduce the likelihood of adverse off-site effects. In this instance post operation water control is critical to ensure the slash and slope on which it sits does not become waterlogged and aid slope instability.

A Practice to be Avoided. An Example of Offcuts and Slash Providing a Physical Barrier to Flows within Perennial Stream

8.6 Post Operational Management/Maintenance

8.6.1 Management

On completion of harvesting operations, ensure that the following matters (where appropriate) are addressed:

- Remove any logging debris from within the 1:100 year (1%AEP) flowpath of Category 1 watercourses that may provide significant barriers to waterflow and/or of fish passage; either by hand, or with appropriate machinery, whilst avoiding bank disturbance and/or deepening of the stream channel.
- Remove and rehabilitate all temporary crossings in a manner that minimises sediment being discharged into the watercourse.
- Construct cut-off drains on extraction tracks, haul paths[5] and firebreaks (refer Table 1 of Section 6.3.2) until adequate stabilisation has been achieved.
- Ensure there is adequate drainage provided on landings and that slash and logging residue is in a stable position to minimise the potential to collapse.
- Slash and logging residue should be placed in a stable position to minimise the potential to collapse and adversely affect watercourses.
- Vegetate and/or stabilise any exposed sidecast material, or fill batters on earthworks sites except where approved at the time of site monitoring by the Hawke's Bay Regional Council.
- Ensure that runoff is channelled safely over batter slopes and onto stable areas.

8.6.2 Maintenance

Post operational maintenance of earthworks is very important. A regular maintenance program should be put in place, to ensure that erosion and sediment controls continue to function properly. This maintenance program should be established at the onset of earthworking and continue until the earthworks have been stabilised and/or the erosion and sediment controls no longer required. The development of a formalised schedule may assist in this regard.

Ensure that stormwater runoff is managed appropriately, and that the systems are capable of working well between inspections. In some instances it may be preferable to over design the systems that have been constructed in areas of difficult access and therefore may be checked less often. To achieve this may require for example, larger control measures, deeper cut-offs, *etc*.

When undertaking grading of roads, ensure that the grader does not block control measures, flumes and drainage channels. Inspect after grading to ensure that all systems are working. Check that culverts and bridges are not blocked or scoured out. Landings, haul paths, tracks and firebreaks can become problem areas, because they are seldom used again after an operation is completed. In some instances, ongoing maintenance of earthworks may be required until the earthworks areas are stabilised. In general, areas at greater risk should be inspected more frequently.

[5] Haulpaths in this context are defined as linear tracks or pathways where repeated use of machinery has disturbed the ground and exposed bare earth. Typically used for log hauling.