

# Erosion and sediment control for forestry operations

## GUIDELINES



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NEW ZEALAND



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# CONTENTS

<b>Introduction</b>	<b>5</b>
Why we need guidelines	5
How these guidelines work	5
How these guidelines relate to forest industry guidelines	5
Erosion and sediment control in the Bay of Plenty	6
Do I need a resource consent?	7
When do I need to control erosion and sediment?	7
<b>Controlling erosion and sedimentation</b>	<b>8</b>
Different forms of erosion	8
<b>Guidelines for forestry operations</b>	<b>11</b>
Planning	11
Operations	12
Forestry earthworks	13
Land preparation	17
Planting and tending	18
Planning	19
Maintenance after the operation	21
<b>Best Management Practices</b>	<b>23</b>
<b>Water table controls</b>	<b>25</b>
BMP 1.1 Check dams	26
BMP 1.2 Rock lining	29
<b>Runoff controls</b>	<b>30</b>
BMP 2.1 Runoff diversion channel/bund	31
BMP 2.2 Contour drain	33
BMP 2.3 Water bars/cut-offs	35
BMP 2.4 Bale barrier	37
BMP 2.5 Flume/pipe drop structure	38
BMP 2.6 Outlet controls/energy dissipaters	40

<b>Surface stabilisation</b>	<b>41</b>
BMP 3.1 Mulching/bark/logging residue	42
BMP 3.2 Surface vegetation – hydroseeding	43
BMP 3.3 Surface vegetation – grassing	44
<b>Sediment control</b>	<b>46</b>
BMP 4.1 Soak hole/sediment trap	47
BMP 4.2 Sediment retention fencing – silt fence	48
BMP 4.3 Soak hole plus silt fence	50
BMP 4.4 Sediment retention fencing – super silt fence	51
BMP 4.5 Sediment retention pond – silt pond	54
<b>Other measures</b>	<b>56</b>
BMP 5.1 Permeable slash bunds	57
BMP 5.2 Corduroying	58
BMP 5.3 Geosynthetic erosion control systems (GECS)	59
<b>Bibliography</b>	<b>61</b>
<b>Glossary</b>	<b>62</b>
<b>Appendices</b>	<b>64</b>
Consent requirements	64
Other consents or permits	64
Harvest Plan example	65

# INTRODUCTION

## Why we need guidelines

These guidelines provide advice for land users undertaking plantation forestry operations. They outline the **principles** of erosion and sediment control, give **guidelines** to minimise erosion and sedimentation for plantation forestry and provide **specifications and standards** for erosion and sediment control practices. They replace the July 2000 Erosion and Sediment Control Guidelines for Forestry Operations.

We need guidelines because:

1. All land preparation and forest establishment should be planned and carried out in a way that matches how you intend to harvest.
2. All plantation forestry operations should be carried out using management practices that protect soil and water.

## How these guidelines work

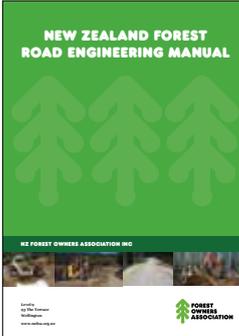
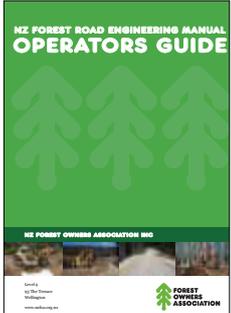
**SECTION 1** – covers erosion and sedimentation, and the principles for controlling them. Here you’ll find information on general principles to consider when you’re planning or carrying out forestry operations.

**SECTION 2** – covers guidelines for planning and implementing forestry operations, It includes a guide for preparing consent applications, and guidance for forestry operations where consents aren’t needed.

**SECTION 3** – includes specifications for particular erosion and sediment control practices and design requirements for these. These can be used in consent applications, and cited as minimum design standards in consent conditions.

In the appendices you’ll find an example of a Harvest Plan that could be used for a resource consent application, and a guide to help you work out if your proposed activity needs consent.

## How these guidelines relate to forest industry guidelines

Forest industry technical	Council guidelines	Forest industry operator guidelines
<p><b>NZ Forest Road Engineering Manual</b></p> 	<p><b>BOPRC Forestry Guidelines</b></p> <p>Expands on sections 4.10 and 6.3 of NZ Forest Road Engineering Manual.</p>	<p><b>Forestry Earthworks Construction Guide for Operators</b></p> 
For engineers.	For planners, supervisors and compliance staff.	For operators.

## Erosion and sediment control in the Bay of Plenty

Land in the Bay of Plenty is used for many things. Many uses – earthworks, roading, and clearing vegetation – can cause erosion and sedimentation problems. The erosion and sediment control measures in this guide apply to a range of different plantation forestry work.

Our Bay of Plenty soils are very susceptible to surface erosion and erosion caused by flowing water (fluvial erosion), particularly from poorly controlled stormwater runoff. We need good erosion and sediment control.

Our water resources are valued for their high quality, and wide range of potential uses. Sediment does occur naturally, but large amounts can damage our natural environment. Sediment-laden runoff from poorly managed land activities can affect:

- stream values – modified or destroyed
- estuarine or coastal habitats
- fauna and flora – buried, choked or abraded
- food sources (changes) and life cycles
- pumps and water supplies.

Effects can be long-term – stream life can take years rather than months to recover – or it can set off other effects. A pulse of sediment in a stream system can start an erosion cycle which can be difficult to control. Suspended sediment can also be a carrier for other contaminants, such as phosphorus.

If you follow the principles and practices outlined in this Guideline you can reduce the adverse effects of land disturbance.

Most of the soils in the Bay of Plenty are formed from volcanic eruptions. Some are young and have had limited time to develop, and these ash and pumice soils are extremely prone to surface and fluvial erosion.

Soil texture is dominated by sand and silt, rather than clay. This means they are easily worked. Using simple runoff controls and surface stabilisation techniques can prevent on-site erosion problems. Unless deeper clay layers are excavated, or earthworks continue into winter, you may not need more stringent treatment techniques. Erosion and sediment control techniques for sand and silt are generally much simpler than those required for clay.



*Poorly planned earthworks and/or harvest operations can result in erosion and potential downstream effects.*

In the Bay of Plenty we have very deep deposits of volcanic ash and volcanic flow. There are unconsolidated pumice and ash, more cemented silts, ashes and sands and buried soils. Some deeper and more consolidated layers may be saturated. When these layers are excavated, they form springs. In some areas, there are also old lake beds with very fine-grained deposits prone to liquefaction. Any land disturbance involving deeper cuts and fills may disturb materials that do have a higher clay and/or water content. You will need more stringent erosion and sediment control systems to reduce adverse off-site effects.

## Do I need a resource consent?

The Bay of Plenty Regional Water and Land Plan<sup>1</sup> (RWLP) has several rules on land management activities that require a resource consent. The RMA<sup>2</sup> requires resource consents for activities to do with river beds, using natural water and any discharges.

If you don't know whether you need a resource consent, contact Bay of Plenty Regional Council on 0800 884 880.

<sup>1</sup> December 2008

<sup>2</sup> Resource Management Act 1991.



*Typical Bay of Plenty soils; deep ash and pumice layers.*

## When do I need to control erosion and sediment?

For any land disturbance activity or vegetation removal, you have to consider what erosion and sediment control is needed.

If you need a consent, erosion and sediment controls will be an integral part of the consent conditions. In most cases the consent should be in place before earthworks start. In some forestry situations where there is adequate vegetation or surface protection, erosion and sediment controls can be installed as works progress – particularly in first rotation plantation forests.

Control measures are also required when sites are closed down. Controls need to be maintained until the area is fully stabilised.

If consent is not required, the guidelines and practices in section 3 provide guidance about what needs to be considered to ensure that any proposed works don't create adverse environmental effects.

# CONTROLLING EROSION AND SEDIMENTATION

Erosion is a natural process – earth is slowly loosened and removed (usually by wind and rain). Erosion can be sped up by what we do on the land. Erosion rates are affected by the type of soil, surface cover, topography (steepness) and climate. Human activities on soil, surface cover and changing the slope of the land can all increase erosion. There are two kinds:

1. surface erosion (splash and sheet),
2. fluvial erosion (from water flow). This leads to rill and gully erosion on-site and stream and channel erosion off-site.

## Different forms of erosion

Sedimentation occurs when earth particles transported by wind and water settle somewhere. How quickly depends mostly on the particle size and speed of runoff. Heavy particles, like gravel and sand, settle out sooner than the finer particles like silt and clay. Clay particles can stay suspended in water for long periods, causing discolouration.

To control erosion and sedimentation you need to control water speed so it doesn't ever gain the energy to pick up and carry soil.

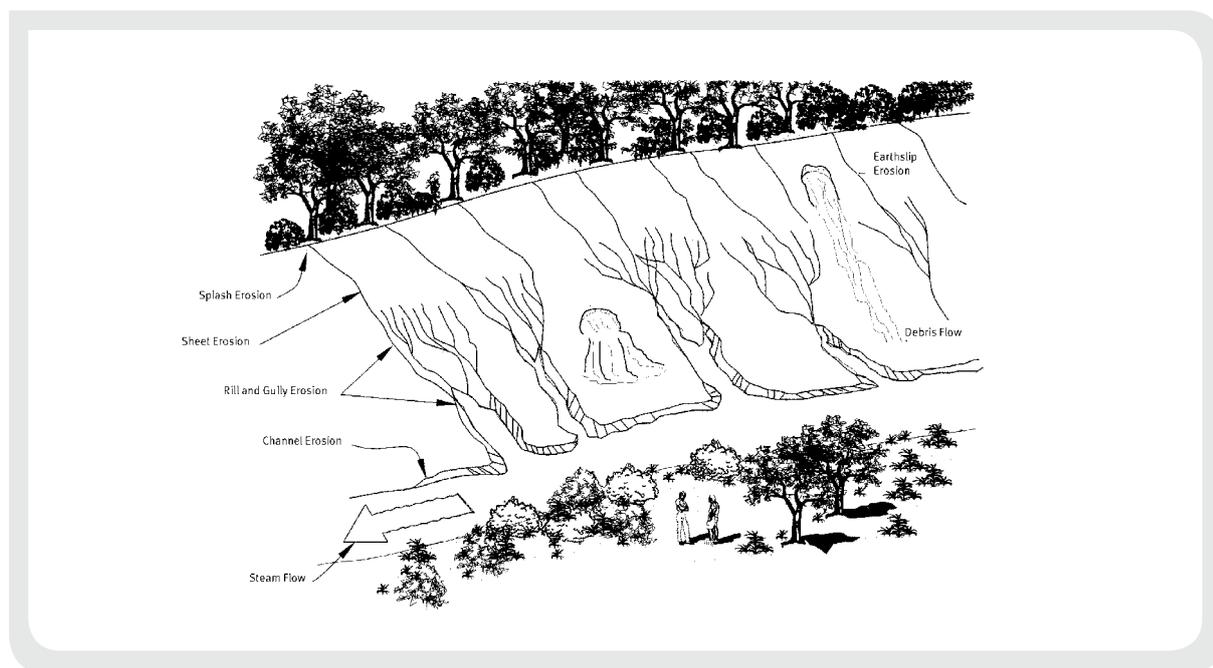
Control of stormwater runoff is especially important, as this is usually on bare ground where it is easier for water to erode and pick up soil particles.

Pumice is a problem in the Bay of Plenty. It is light and can travel a long way downstream before settling. It can also cause blockages in smaller diameter culverts.

Because finer particles can be difficult to capture once they are on the move, the best way to control sediment is to prevent erosion.

### Control involves:

1. Protecting the soil surface from rainfall and stormwater runoff (erosion control).
2. Capturing eroded particles on-site (sediment control).



### 1. Keep disturbed areas small and exposure time short

- Plan construction activities to minimise the area and time that bare soils are exposed.
- Take the season into account and avoid winter earthworks. For short-term, sensitive operations, check the weather forecast.
- Plan operations to stage construction works. Limit the construction area of each stage.
- Stabilise disturbed areas quickly. Regardless of the season, look at revegetation as each stage is completed. You can repeat this in autumn or spring.

### 2. Control erosion at source

- Don't rely on controlling sediment later.
- Prevent erosion and sediment removal by keeping on-site water speed low.
- Control stormwater runoff so that it doesn't move fast enough to scour. Disperse water at stable discharge points. Use diversion drains and bunds on gentle grades. And use the water backed up behind check dams or in soak holes - so it can act as a plunge pool).

### 3. Install perimeter controls

- Isolate the disturbed area to contain and control on-site problems.
- Keep the works site divided into separate catchment areas so that clean runoff water from undisturbed areas is kept separate from sediment-laden runoff draining the disturbed areas.
- Clearly mark the boundary of the working area using fences, flags, signs, high visibility tape etc to stop machinery going into undisturbed areas.

### 4. Try to keep sediment on site

- Make every effort to minimise sediment discharge.
- Before starting, figure out where sediment control measures should go. Install controls before any large scale operations commence.
- Where possible, incorporate some stormwater detention capacity into the sediment control devices.
- Large-scale earthworks will need sediment control systems to be designed to ensure that they can cope with critical storm flows.

### 5. Protect critical areas

- Fit the development to existing site conditions.
- Consider how to protect steep slopes and watercourses.
- Retain as much existing vegetation as possible to help erosion and sediment control, particularly to filter runoff.

NOTE: Clearing native vegetation may require a specific consent.

### 6. Inspect and maintain control measures

- Set up a maintenance schedule for regular inspections, and inspect the works during wet weather to check that stormwater runoff controls are working properly.
- Be flexible, and continually assess your operations.
- Long-term monitoring of controls will show where you can improve design and fine tune construction practices, for instance small changes to design and construction may significantly reduce erosion or sediment production.

- To ensure you have a feedback loop, either have someone on-site responsible for construction and monitoring erosion and sediment controls, or have very good communication and hand-over between people responsible.
- Use suitably experienced people to install and monitor erosion and sediment control measures.
- Maintain sediment controls to ensure they retain their storage capacity.

- ✓ Minimise earthworks.
- ✓ Control erosion at source.
- ✓ Endeavour to keep sediment on site.

**Erosion control** involves both stabilising the surface and controlling runoff.

- **Stabilise the surface** using vegetation, mulch, aggregate – anything that protects the soil surface from erosion.
- **Runoff control** includes slowing down the speed of stormwater runoff, as well as dissipating the runoff at numerous discharge points. Keep water speed low by having gradients as flat as possible. This will also reduce turbulence, which can start erosion.

**Sediment control means** keeping sediment on site.

- **Trap water that is carrying sediment** in sediment traps, soak holes or vegetation where it can be managed.
- **Once the speed of the water is slowed, sediment falls out and settles.** Empty sediment traps regularly, so they always have storage volume free.



*Road side gullying.*

# GUIDELINES FOR FORESTRY OPERATIONS

## Planning

Forward planning is essential for all forestry operations. Poor planning can be costly long-term.

You need harvest planning experience to do this. Ideally, the contractor who will do the operation should also be involved in this planning phase. If not, the planner needs to be aware of all of the constraints that the contractor will encounter.

You need a physical plan showing:

- boundaries/areas covered by the operation,
- topographical features and/or contours,
- water bodies,
- proposed earthworks (roads, tracks, landings), stream crossings,
- proposed stream side management measures,
- proposed haul direction (harvesting operations),
- proposed erosion and sediment control measures,
- environmental features (pā sites, protected reserves etc.),
- other features that need to be considered (public roads, electricity pylons etc.).
- the scale of the plan needs to be have enough detail to identify features easily when you are on site.

Appendix 2 has an example of a Harvest Plan, setting out earthworks and logging methods.

Tailoring planting boundaries to match the proposed harvesting method is very important, to minimise impacts on soil and water. This doesn't mean detailed harvest planning before a forest is established, but it does mean you need to consider:

- Future access options for harvesting,
- Types of harvesting systems likely to be used,
- Environmental constraints that you need to take into account at harvesting.

It's extremely important to choose the correct harvest system. If it is not appropriate for the site conditions, adverse effects are more likely, no matter how well an operation is carried out.

Poor planning can result in excessive earthworks and poorly-sited skids.

- Ensure planting boundaries are matched to an appropriate harvesting method.
- Choose a logging system appropriate to site conditions – you need harvest planning experience to do this.
- If you choose the wrong logging system for harvesting, best logging practices won't help.

## Operations

Many forestry activities require skilled operators.

A well-planned operation still needs to be implemented well so that soil and water values are not adversely affected.

You need attention to detail at construction and when carrying maintenance for sound erosion and sediment control.

The contractor is the key, as they construct erosion and sediment control measures.

- Successful erosion and sediment control relies on attention to detail.
- Minimise earthworks.
- Control erosion at source.
- Endeavour to keep sediment on site.

### Monitoring and maintenance

You must monitor and maintain erosion and sediment control measures.

During the operational phase, all erosion and sediment control structures must be checked on a regular schedule, as well as before and after heavy rainstorm events.

When operations are completed erosion and sediment controls. Leave them in a condition that provides for follow-up maintenance. For example, if you won't be using a track for a number of years, install deep water bars or soak holes that don't need much maintenance, and spread slash/logging mulch over the track.

Set up an inspection programme once operations are complete, based on the use level and risks posed by the erosion control works. For example you'll need regular monitoring and maintenance of erosion and sediment control structures near sensitive features.

- Successful erosion and sediment control relies on regular monitoring and maintenance.
- Always check erosion and sediment controls before and after heavy rain.
- When operations are completed, ensure the control systems are sized to cope with the likely level of follow-up maintenance.

### Streamside management

Many operations can damage streams and other water bodies. You can reduce this by forward planning and careful work practices, but the risks increase the closer the operation is to the water.

If you're working beside a stream the main problem is sediment discharge. The best way to deal with this is to use a specific management system.

Earthworks have the highest risk of discharging sediment into streams, so controlling operations and stormwater is the key to avoiding problems. The simplest and most successful method is to keep all earthmoving machinery well clear of streams by marking a "no-go" area at an appropriate distance from the stream.

Use natural benches and terraces to help set no-go areas close to streams. Avoid earthworks on slopes that fall directly into streams.

- Earthworks operations near streams have a high risk of creating sediment problems.
- Keep well clear of watercourses when undertaking earthworks, except at stream crossings.

## Forestry earthworks

Many earthworks operations are done to form permanent assets. Planning and attention to construction detail will influence their working life.

Earthworks can be a major source of sediment, and have the greatest impact on soil and water values. All earthworks should be carefully planned for location, construction, runoff control and maintenance.

You should move as little soil as possible to complete the job. Disturbed ground should be stabilised as soon as possible when you've finished the works. Earthworks should be kept well clear of water bodies, and out of lowest points of dry gully floors.

Always key earthworks into natural ground, compact fill slopes in layers, and avoid burying organic or woody material into structural fill.

- Always key your earthworks into natural ground.
- Compact fill material in layers.
- Do not bury organic or woody material in structural fill.

## Roading

When constructing and maintaining a road, always use machinery that is suitable for the job.

Roads should be constructed with as little soil disturbance as possible by following ridge tops, and using natural benches and flatter slopes. Avoid steep slopes. If you need to make substantial cut and fill, avoid sensitive areas such as old erosion features. When planning alignment of new roads, try to avoid crossing streams and dry gullies.

Roads should always be keyed into natural ground. When roads are constructed in

conjunction with salvage logging, construct them onto benches and leave at least an extra metre of bench visible to place stumps and other heavy woody debris.

Plan runoff control so that the discharge will be controlled and directed to a safe outlet, such as a stable ridge, or through vegetation. Never discharge runoff directly onto fill slopes. Any discharge over a fill slope must be safely flumed or piped to a stable low point where the discharge can be dissipated.

On roads with long continuous grades, discharge runoff in a controlled manner at regular intervals so that water speeds don't increase and cause surface erosion. For outlets from road carriageways, choose the outlet point before installation and then work your levels from the outlet point back to your inlet point. This way the levels will be correct, and the discharge will be to the chosen safe outlet point.

Where you can't safely discharge runoff, you may need to line water tables with compacted graded rock to avoid scour. You can also use small check dams made of rock or sandbags to slow the rate of runoff.

On free draining volcanic soils, use soak holes to receive stormwater runoff. Always construct these in natural ground, never in fill material. Soak holes can also be constructed in series so they can dissipate stormwater into the ground. Soak holes require regular maintenance and cleaning out to ensure they are kept open and functional.

Stage new road construction so you can maintain erosion and sediment controls in effective working order. Stabilise disturbed areas prone to surface erosion (such as fill slopes) by seeding, compacting, benching, mulching or planting. Install cut-offs and flumes to prevent scouring.

When constructing roads on steep slopes, minimise side-casting operations. Consider using other methods, such as end-hauling.

Unsealed roads on highly erodible volcanic soils will be susceptible to erosion of the road surface

when the grade is over 7° (12% slope). Keep the lengths of steeper sections as short as possible, and consider metalling the road surface and lining the water tables with rock to prevent erosion.

To avoid being pressured into taking shortcuts in construction technique, construct logging roads well before logging operations. This allows time for the roads to settle in. Sediment controls will have trapped sediment in 'first flush' runoff from

- Minimise side-cast operations.
- Construct logging roads well in advance of logging operations to allow for adequate stabilisation of disturbed areas, and clearing 'first flush' sediment from sediment traps.

newly disturbed areas, and will have been cleaned out. Early construction also gives time for any surface stabilisation of exposed earthworks to be completed and effective. Ideally, aim to complete earthworks by the end of March to allow for revegetation of disturbed ground before winter.

## Tracks and firebreaks

Tracks and firebreaks should be located to minimise the chance of debris and/or soil entering watercourses. For steep slopes which run directly into watercourses do not create firebreaks by using earthworks construction. Form the firebreak without soil disturbance such as hand-cut vegetation, then chemical spray/fire retardant.

Avoid forming tracks along the lowest point of dry gully floors. Many tracks are temporary and must be carefully checked for potential erosion problems once operations are complete. They must be decommissioned using water bars or other methods to ensure they do not concentrate stormwater flow.

Control runoff and stabilise the track surface.

Firebreaks and tracks need to be maintained to a reasonable standard to control runoff, rilling and

gully erosion. Construct cut-offs and/or soak holes at concentration points. Avoid ponding of water above steep drop offs. If ponding occurs, ensure that water is safely discharged without causing gully erosion.

- Avoid forming tracks along the lowest points of gully floors.
- When decommissioning temporary tracks, pay particular attention to runoff control and surface stabilisation.

## Landings

Landings, also known as skids or processing sites, may be permanent assets or temporary formations. Often future harvesting operations will use the same landing sites. For long-term use they need to be well founded into natural ground, well compacted, and carefully drained to discharge stormwater to well-chosen outlets on stable ground.

When choosing landing sites, make sure there's enough room for stockpiling logs, manoeuvring logging trucks, parking vehicles etc. Places to dispose of logging slash are also critical for long-term stability of the landing. Managing logging slash is dealt with in later in this Guide.

Landings should generally be kept well clear of streams. When there is no alternative, ensure that the waterway is not obstructed. Form the landings so that water flow is directed away from the water body.. Use well-compacted earth bunds as a barrier between the stream and the landing. Where practicable, harvest trees between the landing and the water body before constructing the landing. This means the earth bund along the edge of the landing won't be damaged. For the next rotation make sure production trees are not planted between the landing and the stream.

As with other earthworks, landings need to be keyed into natural ground. Form benches in natural ground for the foundations of the landing. Compact the fill material in layers as the level is

built up. Progressively compact the batter slopes of the landing by pulling loose fill back up to the top as the batter is being built. Slope the surface of the landing so that stormwater is drained towards well-chosen stable outlets on undisturbed ground. Any discharge directed over fill slopes must be flumed, but will always be at risk of causing scour problems if the flume system fails. Divert surface runoff from the access road leading to the landing to safe outlets on stable ground, rather than letting it flow onto the landing itself.

When benching the foundations, leave at least a metre of bench visible so that heavy woody material such as stumps can be placed on the exposed bench and not buried under structural fill. Incorporate other measures wherever possible to help control stormwater runoff; for instance soak holes in stable areas, existing vegetation etc. Ensure that no surface flow or runoff is directed onto fill or batter slopes by using compacted earth bunds on the perimeter of the landing. Stabilise exposed areas of fill or batter slopes by compacting them. When completed, follow up with surface stabilisation using ground cover vegetation, slash or mulch.

- Careful location of landings is the key.
- Landings are a long-term asset to the forest. Plan and construct them accordingly.
- Slope the surface of the landing so that stormwater runoff is drained towards well-chosen stable outlets.

## Hauler pads

Hauler pads are normally located on ridge tops or high points, and involve far less earthworks than landings, but construction principles are the same.

Minimise side cast. Ensure that the hauler pad is keyed into solid natural ground using benching and compaction in layers. Control surface runoff, and direct drainage to stable outlet points.

Once logging is complete, hauler pads should be decommissioned following the same principles as for temporary tracks, using runoff controls and surface stabilisation.

## Stream crossings

Most stream crossings need a resource consent. Check the Regional Water and Land Plan rules or ask a Regional Council consent officer.

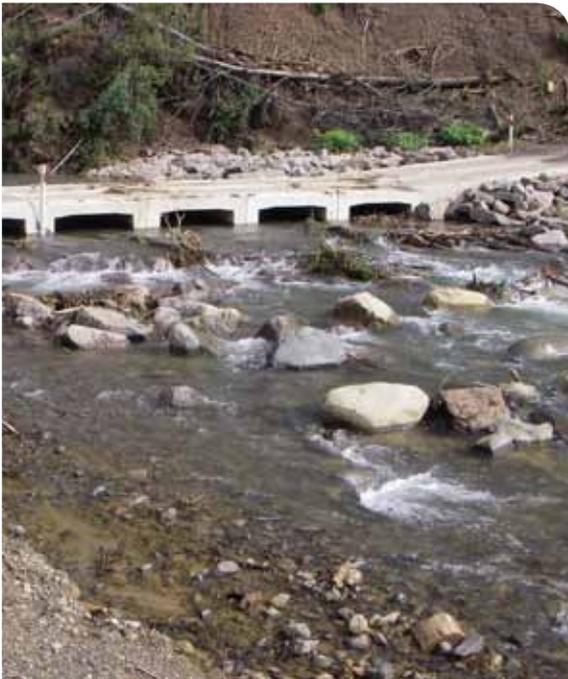
All stream crossings should use construction methods that cause minimal disturbance to water bodies and their adjacent protective vegetation. Cross watercourses at right angles, on a straight section of the stream. Crossing approaches should use a gradient which is less than 10° (18 percent slope) where possible. Stabilise the approaches as soon as construction is complete. Use runoff controls and fluming so that stormwater is not discharged onto any loose fill near the approaches or abutments. Stabilise the abutments using rock protection, compacting, benching or revegetation). Design batter slopes so that they are stable and not likely to collapse. Design the culvert length to achieve a stable batter slope, as well as ensuring fish passage is not impeded.

Avoid constructing stream crossings during winter, prolonged wet weather or during fish spawning or migration periods.

To prevent erosion of the culvert outlet you may need rock riprap or similar flexible material. Minimise the use of temporary crossings. When they are needed, use lightweight temporary culverts which fit the channel size as closely as possible. Log crossings are generally discouraged, but may be appropriate where streams are small, suitable logs are available and soil is not dragged across the crossing when logs are pulled.

Construct major bridges and culverts during normal low flow periods. Before starting any stream crossing construction, ensure you have all materials, machinery and people on hand. Ensure that machine refuelling or fuel storage is done where a fuel spill cannot enter a water body.

- Always use appropriate machinery for construction of a stream crossing.
- A suitably experienced person should supervise stream crossings construction.
- Steepness and length of slope, fill placement and runoff management are critical factors in assessing erosion potential.
- Ensure exposed ground is stabilised as soon as practicable once earthworks are completed using hydro seeding or mulching if necessary.



*Drift deck.*

## Quarry Operations

Quarry operations are often done at the same time as forestry operations. In many cases, the road access may be through an area of rock that is suitable for roading. A small quarry operation may become part of the roading construction as 'road widening' occurs near the rock source. Standard erosion and sediment controls as part of the road works are normally enough. Sometimes the quarry operation may be a stand-alone used intermittently, so it may need a resource consent.

Controlling potential adverse effects should be covered in an Erosion and Sediment Control Plan (ESCP). This Plan should be a blueprint for locating, installing and maintaining everything to:

- control all anticipated erosion, and
- prevent sediment leaving the site.
- Design matters covered in the ESCP are:
  - Stormwater control; separation of clean stormwater and contaminated stormwater; and changes over time as the quarry is worked out.
  - Overburden management; stripping/disposal/management of disposal sites.
  - Stockpile areas.
  - Rehabilitation of worked out areas.
  - Maintenance of erosion and sediment control structures.

Bay of Plenty Regional Council Guideline 2010/01 – Erosion and Sediment Control Guidelines for Land Disturbing Activities (June 2010) Section 9 covers these in more detail.

The only time sediment retention ponds are recommended for a plantation forestry operation is to control quarry sediment. Whenever possible, use sediment controls taking advantage of natural ground contours, existing vegetation and discharge to ground soakage to treat sediment-contaminated stormwater runoff. In many cases, this is preferable to constructing an artificial sediment retention system requiring periodic, ongoing maintenance.

## Land preparation

You usually need some form of land preparation before establishing a plantation forest. This provides suitable conditions to establish the forest crop and may include disturbing the ground surface and/or desiccating or removing existing vegetation. Some land preparation activities increase the risk of soil erosion for a short period.

### Mechanical land preparation

To minimise runoff being concentrated down the cultivated lines mechanical land preparation should be carried out on, use the contour as much as possible. Where you can't avoid downhill runs, try to limit them to 50 metres. Don't attempt these runs on slopes that are too steep for the tractor to reverse up. Blade or rake at least one line on the contour along the lower boundary of downhill operations to help prevent runoff concentration at low points or gullies. Finish downhill runs well before any fill batter slopes such as landings or access roads. Always leave an undisturbed strip beside water bodies.

Cultivation on landings should be done by cultivating or ripping 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 water bodies. Align windrows of slash along the contour of sloping land to help form a barrier and filter for any sediment wash.

Use roller methods for crushing wherever possible, provided ridge tracking only is used for access.

Operations near water bodies, gullies or drop-offs must run parallel to them. Always inspect the site once operations are complete for areas of potential erosion problems. Check to make sure water is not concentrating or ponding near drop-offs.

### Weed control (herbicide)

All herbicide operations should comply with the current *Agrichemical Users' Code of Practice* which sets out how to store chemicals during operations, clean containers and remove material and containers off-site.

All herbicide operations, particularly aerial, must avoid spray drift on to water bodies, and their adjacent protective vegetation zones.

You need a resource consent before spraying herbicide over water. If spray drift is a problem, this will also have conditions about spray drift. Rule 21 of the RWLP provides for application of agrichemicals to land as a permitted activity. There are restrictions on aerial application of agrichemicals in riparian areas (see rule 37).

Environmentally sensitive areas can be spot sprayed instead of blanket sprayed. You might be able to schedule aerial operations so you can oversow with grass or legumes before winter.

Arrange to have water available for mixing the chemical well away from any natural water. Minimise the risks of chemical being spilt on the ground or entering natural water.



*Frost mounds.*

## Burning

Burning can have significant adverse environmental effects, both on-site and off-site. You need to carefully control burning to ensure it doesn't spread beyond the target area. You may also need consents from the Regional Council and local Fire Authority (which may be the District Council, Department of Conservation or Forestry Company). Check what consents are required.

Burning is not encouraged. If alternative methods are not suitable, and you have to burn, then clearly identify and safeguard protected areas. Have a Burn Plan and Fire Control Plan and liaise with the local fire authority to ensure all requirements are followed. Use burning techniques that leave designated areas of protected vegetation intact. In critical sites, such as on steep slopes or near water, burnt areas should be immediately oversown in a suitable grass/legume mix to reduce the risk of surface erosion. Firebreaks and tracks associated with burning operations should follow the guidelines above. You could use mechanical land preparation (on flat to easy slopes), manual line cutting, light-well cutting, herbicide application/roller crushing or intensive cattle grazing instead.

## Planting and tending

**Planting** doesn't usually cause environmental problems, but harvesting those trees can be a problem in certain sites.

For new forest establishment, set planting boundaries to minimise the impacts of future harvesting operations on water bodies, gullies and erosion-prone land. Planting boundaries on clearfell sites should also take account of past logging difficulties. Boundaries should be set taking into account topography and soil stability, and set case-by-case. Tailor boundary planting to match an appropriate method of harvesting (see page 11, Planning).

The unplanted zone between the production crop, and the water body/at-risk area should be left to regenerate naturally to protect water and soil values. In some cases, it may be appropriate to actively plant protective species to control erosion or hasten revegetation. Any regeneration from a previous crop or adjacent production stands should either be removed (before growing too large), or left and treated as protection only, not production.

Where burning or herbicide application destroys protective vegetation outside the designated planting boundaries, keep production planting inside the boundaries. You can plant protective species in areas accidentally burnt.

In environmentally sensitive sites, it may be appropriate to have designated protection areas that are not be planted in production species. This creates a clear boundary of production areas and protection areas. Or rather than lose all production from a marginal site in sensitive areas use species that require specialised management, such as longer rotation species like Douglas fir. Grazing livestock (particularly cattle) in the unplanted/protection zones is discouraged.

- Setting planting boundaries can have a big impact on future logging operations. Poor planting plans can cause significant environmental problems and incur major costs when the forest is harvested.
- Tailor your planting to a proposed Logging Plan.

**Tending** operations usually have minor effects on water and soil values.

No slash from pruning or thinning operations should get into streams or watercourses, and natural water should not be contaminated by chemicals and fertilisers. Any earthworks associated with tending operations should follow the Guidelines on Production thinning and thinning to waste should follow the Guidelines on harvesting.

Manage the impacts of planting and tending operations on stream values.

## Harvesting operations

### Planning

Harvest planning is vital. Well planned harvesting will mean that the road lines, stream crossings and landings are placed so the area can be harvested in a similar way when the next rotation is ready for harvesting.

Ideally, include your proposed contractor in harvest planning, and the preliminary work should include a thorough site inspection. Aerial photos, contour maps and clear indications of property boundaries will help in the harvest planning process.

When **felling** trees within reach of a water body, ensure that an experienced logger controls the operation. Where practicable and safe, fell or back-pull trees away from watercourses, particularly on steep or unstable slopes or edges. Safety is paramount. Consider machine-assisted felling if it makes felling operations safer.

Where trees cannot be felled or back pulled away from a water body, fell them directly across the watercourse and extract the trees before trimming them. Avoid putting debris, such as logging slash, into a water body.

Ensure that stream flow is not dammed by logging debris. Remove any likely to cause a blockage or obstruction of the watercourse.

In general, when harvesting near water bodies, and environmentally sensitive areas, **extraction** should be towards the landings which are located away from the water body/sensitive area.

### Ground-based systems

Keep tracking and stumping to a practical minimum. Use a few carefully chosen tracks and stay on these, rather than taking shortcuts that may cause extra ground disturbance.

Carry 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. If you need to extract logs across a stream, use a permanent or temporary crossing or use shovel logging (See page 15). Avoid pushing standing dead trees into streams.

### Cable systems

When using cable systems in environmentally-sensitive areas, keep the settings small, the haul distance short and the hauling direction uphill wherever practicable. Avoid cross-slope haul-

lines that damage areas of protective vegetation or sweep slash and soil into waterways. Where possible, lift logs clear of these areas. Always use the appropriate machine, tower height and carriage to suit the site. Use shovel logging in conjunction with hauler logging when trees are blind to the hauler or where deflection is minimal.

Avoid forming log channels or furrows that direct and concentrate runoff towards a stream.

### Slash and residue management

Before harvesting, assess whether you'll have large volumes of slash and residue from on-site processing. Your silvicultural regime generally determines the amount of waste. If felling in steep country, and for large amounts of slash and residue, you will need a Slash Management Plan. This should include:

1. The approximate volume of slash you will have to deal with,
2. Designated sites for slash disposal near landings,
3. "No-Go" zones where slash is not to be deposited around landings,
4. Managing operations to avoid accumulation of 'birds' nests' on the edge of landings,
5. If the designated sites for slash disposal are remote from landings, the SMP should detail how slash will be progressively removed as the operation is undertaken,
6. Possible burning options for slash,
7. Potential for storing slash on landings following completion of harvesting.

Slash and residue from processing operations can cause problem 'birds' nests' if not managed properly. All slash and residue will settle and possibly collapse over time as the woody debris rots down. Disposal sites for slash and debris

must be carefully located in designated areas, and clearly marked on site. They should be on stable land, well away from steep slopes, fill material, slips, gully heads and riparian areas to reduce the likelihood of adverse off-site effects.

Using two staging operations, with the main processing site on easy stable ground, may allow you to manage slash and residue material more easily. Other options for slash disposal include processing, burning or removal off-site.

- Plan your harvest, then harvest according to your plan.
- Use trained, skilled and experienced operators with the correct machinery.
- Place slash and residue so they will not move off site.



*Good slash management.*

## Maintenance after the operation

When you've finished harvesting operations:

1. Remove any 'at risk' logging debris from water bodies by hand, or with appropriate machinery. Avoid disturbing the bank or deepening the stream channel.
2. Remove all temporary crossings and rehabilitate disturbed banks, ensuring runoff is not directed towards the stream.
3. Construct cut-offs and/or water bars and/or soakholes on extraction tracks, haul paths and firebreaks. Spread logging slash over exposed areas.
4. Ensure there is adequate drainage on landings, and ensure that debris from landings cannot enter any streams.
5. Dispose of any slash and residue material that could collapse and affect streams.
6. Vegetate and/or stabilise any exposed sidecast material, or fill batters on earthworks sites.
7. Ensure that runoff is channelled safely over or away from batter slopes and onto stable areas.
8. Remove all non-biodegradable waste from the site (wire rope, paint cans, fuel/oil containers, old chains, plastic containers etc.).
9. Remove all chemical containers from the site.
10. Bury all biodegradable waste.



Waterbar.

### Maintenance

Post operational maintenance of earthworks is very important. Have a regular maintenance programme to ensure that erosion and sediment controls continue to function properly between inspections. For systems less often, it may be better to over-design them with larger soakholes, deeper water bars.

Ensure the grader doesn't block soak holes, flumes and drainage channels. Inspect after grading to ensure that all drainage systems are working.

Check that culverts and bridges are not blocked or scoured out.

Landings, haul paths, tracks and fire breaks are often problem areas, because they are seldom used again after an operation is completed. In some instances, you may need to do on-going maintenance of earthworks until the cutover/establishment area is fully vegetated and stabilised. Inspect vulnerable areas before and after heavy rain.



# BEST MANAGEMENT PRACTICES

Erosion and sediment control  
for forestry operations



# EROSION AND SEDIMENT CONTROL PRACTICES

Erosion and sediment control practices are covered in these groups of activities as best management practices (BMPs):

## **Water table controls** (Bay of Plenty volcanic soils cause real problems)

- BMP 1.1 Check dams
- BMP 1.2 Rock lining

## **Runoff controls**

- BMP 2.1 Runoff diversion bund/channel
- BMP 2.2 Contour drain
- BMP 2.3 Water bars/cut-offs
- BMP 2.4 Hay bale barrier
- BMP 2.5 Flume/Pipe drop structure
- BMP 2.6 Outlet controls/energy dissipaters

## **Surface stabilisation**

- BMP 3.1 Mulching/bark/logging residue
- BMP 3.2 Surface vegetation – hydroseeding
- BMP 3.3 Surface vegetation – Grassing

## **Sediment control**

- BMP 4.1 Soak hole/sediment trap
- BMP 4.2 Sediment retention fencing – silt fence
- BMP 4.3 Soak hole plus silt fence
- BMP 4.4 Sediment retention fencing – super silt fence
- BMP 4.5 Sediment retention pond – silt pond (for use only in quarries)

## **Other measures**

- BMP 5.1 Permeable slash bund
- BMP 5.2 Corduroying
- BMP 5.3 Geosynthetic erosion control systems (GECS)

# WATER TABLE CONTROLS

Volcanic eruptions are responsible for the geology and soil formation for much of the Bay of Plenty. These soils are unconsolidated or weakly cemented and scour very easily when there is concentrated water flow.

## Control erosion of water tables by:

- reducing runoff speed, and
- stabilising the channel of the water table where it is prone to scour erosion.



*This forestry road has a range of controls in the water tables, including metalling, grassing and using hay bales to slow down the speed of the water flow.*

- **Keep water speed down. Keep grades low and use check dams in series.**
- **Keep volumes down. Discharge water frequently at safe outlets, particularly on steep sections of road.**
- **Use flat-bottomed channels rather than V-shaped channels.**
- **Use graded rock and/or compacted sub-grade aggregate to armour water tables in critical sites where the ground is unconsolidated and prone to scour erosion.**

# BMP 1.1 Check dams

**Check dams are used to reduce the speed of concentrated stormwater flows, thus reducing erosion of the stormwater channel.**

## Description

Check dams are very small temporary or semi-permanent dams constructed across a stormwater channel or roadside water table. They are lower in the centre to direct water in a controlled manner over the dam wall, and are used in series. Although they may trap some sediment, they are not designed to retain sediment.

They are used in stormwater drainage channels and in roadside water tables to prevent erosion, by slowing water speed, and are normally made out of graded rock. In these situations they are often called rock check dams. You can use other materials such as sandbags as temporary measures until rock check dams are installed.

## Where to use

Check dams can be used in:

- Roadside water tables on unconsolidated soils such as volcanic ash.
- Temporary channels which need some protection to reduce erosion, but because of their short length of service, are not suitable for non-erodible lining.
- Permanent stormwater runoff channels that don't yet have a permanent, non-erodible lining.
- Temporary or permanent stormwater runoff channels which need protection while vegetative cover is being established.
- Short lengths of stormwater runoff channels or roadside water tables, where the grade is steeper to reduce speed and control potential erosion of the stormwater channel.

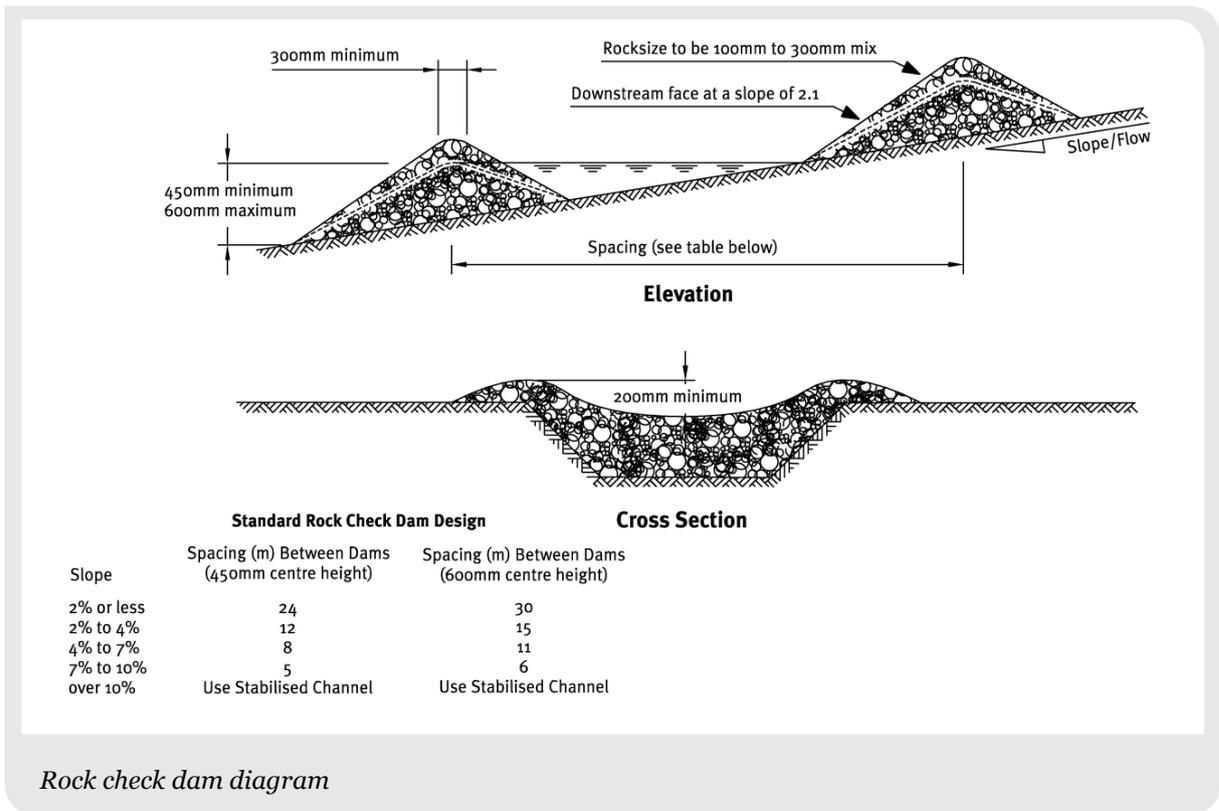
**DO NOT** use check dams in permanent watercourses.



*Check dam – formed from plastic fluming and graded rock*

## How to design and construct a check dam

- The contributing catchment must be less than 1 hectare. Rock check dams used on catchments greater than 1 hectare require specific design and calculations.
- Direct all flows over the centre of the rock check dam. Ensure no flow goes around the edges.
- Maximum centre height of dam is 600 mm. Build the sides 200 mm higher than the centre to direct flows to the centre.
- Graded rock (50 mm to 100 mm) may be used in the core, but the outside batters should be a mix of 100 mm to 300 mm diameter washed rock, and should completely cover the width of the channel.
- Ensure rock batter slopes are no steeper than 2:1.
- Space rock check dams so that the toe of the upstream dam is level with the crest of the downstream dam (top to toe placement). Ensure the toe of the upstream dam is never higher than the crest of the downstream dam.



Rock check dam diagram

Slope	Spacing (m) between dams	
	450 mm centre height	600 mm centre height
2% or less	24	30
2% to 4%	12	15
4% to 7%	8	11
7% to 10%	5	6
Over 10%	Utilise stabilised channel	

**DO NOT** use rock check dams as a primary sediment trapping facility. Ensure that any sediment laden runoff passes through a sediment trapping device before being discharged off the site.

Temporary check dams can be made from sandbags filled with spoil from the site. The spacing between structures and the construction design to ensure water flows over the centre of the dam is similar to the rock check dams. Sandbag check dams centre height should not exceed 450 mm maximum.

## Maintenance

Rock check dams may trap some sediment, but they are not designed to be used for sediment retention.

1. Remove any trapped sediment when it has accumulated to half the original height of the dam.
2. Check that all flow is still directed over the centre of the dam and not around the edges, as this will scour the dam out.
3. Check that the rock is not being removed from the dams when high speed water hits it. Check that the rocks are big enough that they won't be washed away. Top up the rock if required.
4. Check that dams are not damaged by road maintenance operations.
5. Check for channel scouring between the check dams. If this is happening, put more dams in the scoured section to reduce the speed. Ensure dam series is 'top to toe' placement.
6. When temporary channels are no longer needed, remove the rock check dams and fill in the channel.
7. In permanent channels, rock check dams may be removed if you install a permanent lining. For grass-lined ditches, rock check dams may be removed when the grass has established enough to protect the channel. The area beneath the rock check dam needs to be seeded and mulched or stabilised with appropriate geotextile immediately after removing the dams.

# BMP 1.2 ROCK LINING

**Rock lining is used to protect the water table surface lining, thus reducing the risk of erosion.**

## Description

Rock lining is the use of well-graded rock or coarse subgrade roading aggregate which is compacted into the water table. It reduces scouring potential by armouring water tables with compacted rock or coarse aggregate.

Rock lining may be done at the same time the subgrade aggregate is applied to the road surface. Aggregate is applied to the full width of the road, not just the driving surface. Compact the water table aggregate as soon as possible, after grading the road surface.

Take particular care around culvert inlets to avoid aggregate being washed into culverts and/or blocking culverts.

## Where to use

Use rock lining on erosion-prone water tables where:

- the water table is formed in unconsolidated soils, such as volcanic ash.
- there are steep grades, higher velocities and a higher risk of scour.
- there is a greater volume of stormwater in the water table due to longer than normal distance between outlet culverts.
- on newly formed roads, where water tables have not had time to be stabilised by other means.

## How to use and construct rock lining

- The water table needs to be well formed, stable and deep enough to apply the rock lining.



*Rock lining*

- Ensure there is no threat of the batter collapsing onto the water table.
- Use hard, well-graded rock or coarse sub grade aggregate with numerous broken faces, rather than smooth river run rock.
- Apply at least twice the thickness of the maximum rock size.
- Rock should ideally be well compacted in place using a large rubber-tyred machine if possible, and taking particular care around culvert inlets.

## Maintenance

When road grading is done, make sure that finer aggregate from the road surface is not being graded into the road side water table as it may block the culvert inlets.

Check that rock lining remains compacted and in place. Replace any scoured areas or augment with other measures such as rock check dams.

# RUNOFF CONTROLS

Erosion control requires both runoff control and surface stabilisation. Runoff controls direct stormwater runoff to a particular place. Runoff is carried at a low enough grade that the water speed is low enough to prevent scour.

You can use perimeter runoff controls to keep clean stormwater from above a site separate by diverting it around the disturbed area. Runoff controls on site can safely carry sediment-contaminated stormwater to treatment areas before discharging them off site. This approach can be used to isolate skid sites where they are located in valley floors, and to divert runoff from skid sites to stable discharge points.

Using the right runoff control grades on site will result in water speed

- low enough to prevent scour, and
- high enough to prevent waterborne sediment from settling out.

Keep runoff controls within disturbed areas short if the slopes are steep enough to result in scouring or the soils are erodible, otherwise ensure the runoff controls are stabilised.

Using runoff controls correctly can minimise erosion caused by water flow (fluvial erosion). Stormwater discharge then has very little sediment contamination. Ideally, runoff controls are designed to carry a specific amount of stormwater flow (the critical design flow). Well-designed runoff controls will carry stormwater efficiently without causing any further erosion in the process.

Critical design criteria include:

1. Cross section of runoff bund or channel.
2. Grade of runoff control.
3. Stable erosion proof discharge point.

- **Use runoff controls to carry stormwater runoff to a chosen outlet point.**
- **Use perimeter runoff controls to separate clean water off site from dirty water on site.**
- **Use correct sizing and grade of runoff controls so they do not scour out.**
- **Every runoff control must have a stable erosion-proof outlet point.**
- **Before installing your runoff control start surveying from your chosen outlet point to survey the grade.**
- **Consider where excess runoff will go if the design storm is exceeded.**

## BMP 2.1 RUNOFF DIVERSION CHANNEL/BUND

Runoff diversion channels are used to intercept clean runoff above an activity site and divert around the works area to safe outlet(s), or

To divert sediment-laden water to an appropriate safe (erosion proof) outlet on stable ground or sediment retention structure.

### Description

A runoff diversion channel is a non-erodible channel and bund to convey runoff. It is constructed to a site-specific cross section and grade design.

Bunds to divert clean water runoff should minimise disturbance to existing ground cover where the clean runoff water will flow. Construct using material from within the disturbed site, such as topsoil.

All runoff diversion channels/bunds rely on a stable erosion proof outlet. Always start the survey from the chosen outlet point. The survey line can then be made on the correct grade to safely pick up runoff water.

Consider where excess runoff will drain to. If the design storm is exceeded and the bund is overtopped, allow for safety overflow in the most appropriate location.

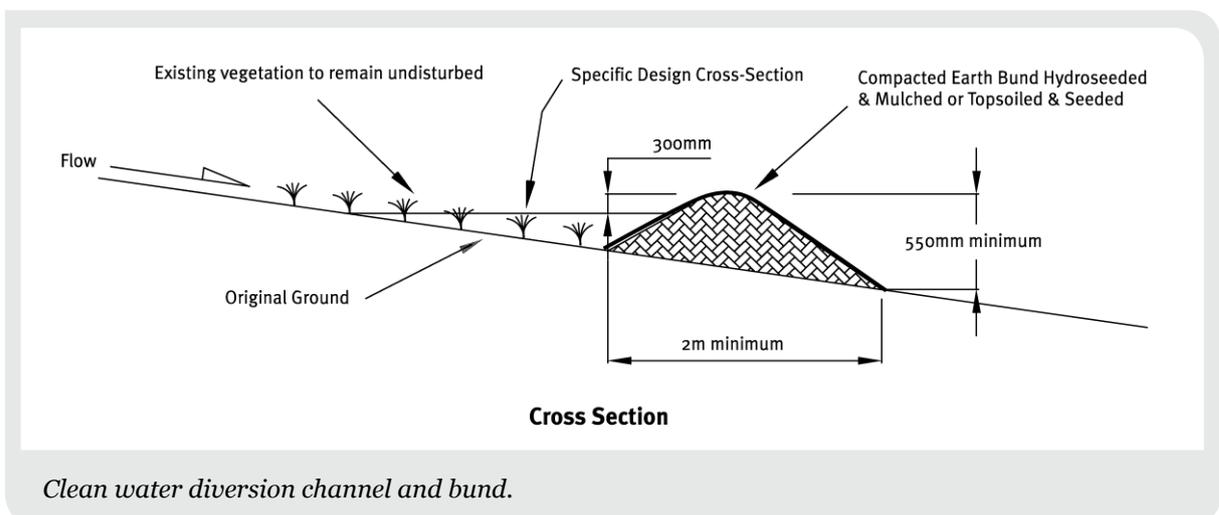
Protect bunds from damage as far as possible from adjacent activities, such as harvesting, or else reinstate following harvesting.

### Where to use

- Around the perimeter of a landing or road, to prevent sediment and logging debris from leaving the area.
- Along the lower perimeter of a landing to divert sediment-laden water to a controlled outlet or sediment treatment area (such as a soak hole or vegetation/slash area).
- Can be temporary or permanent.

### How to design and construct

- Design the runoff diversion channel to carry the flow for at least a five year return period storm, allowing for freeboard.
- Ideally, grades should be less than 2 percent unless the channel is armoured with aggregate, or protected with geotextile. However, short channels (up to 20 metres) on slopes up to 5 percent may be possible if the channel is well compacted).

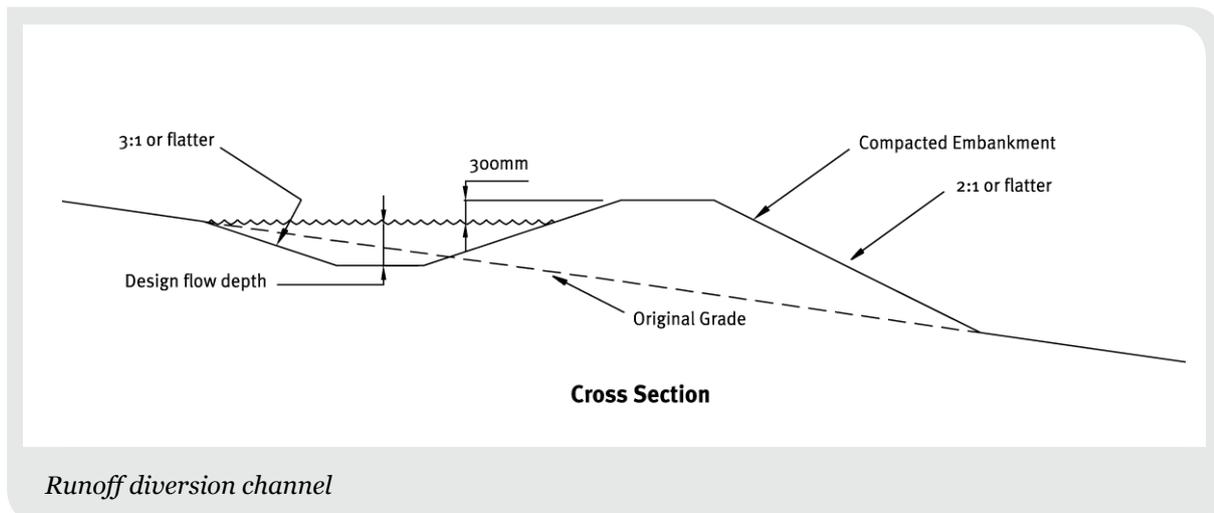


- Ensure that the channel empties into a stable erosion proof outfall on stable ground.
- Construct the bunds so that they are between 0.5 metre and 1 metre high, and keyed into natural ground.
- Ensure the bunds are well compacted and vegetated or hydroseeded.
- Use a trapezoidal cross-section for the channel (flat bottom, even slope sides).
- Internal sides of the bund must be no steeper than 3:1, external sides no steeper than 2:1.

## Maintenance

Runoff diversion channels/bunds need regular maintenance:

1. Check for scour, sediment build up or weakening of the bund wall after rain and during periods of prolonged rain.
2. Check outlets for scour and erosion problems.
3. Repair any storm damage immediately.
4. Remove any sediment deposited in the diversion channel, and from the outlet area if necessary.



## BMP 2.2 CONTOUR DRAIN

Contour drains are used to intercept overland flow on exposed sloping ground and divert sediment-laden water to stable outlet areas.

### Description

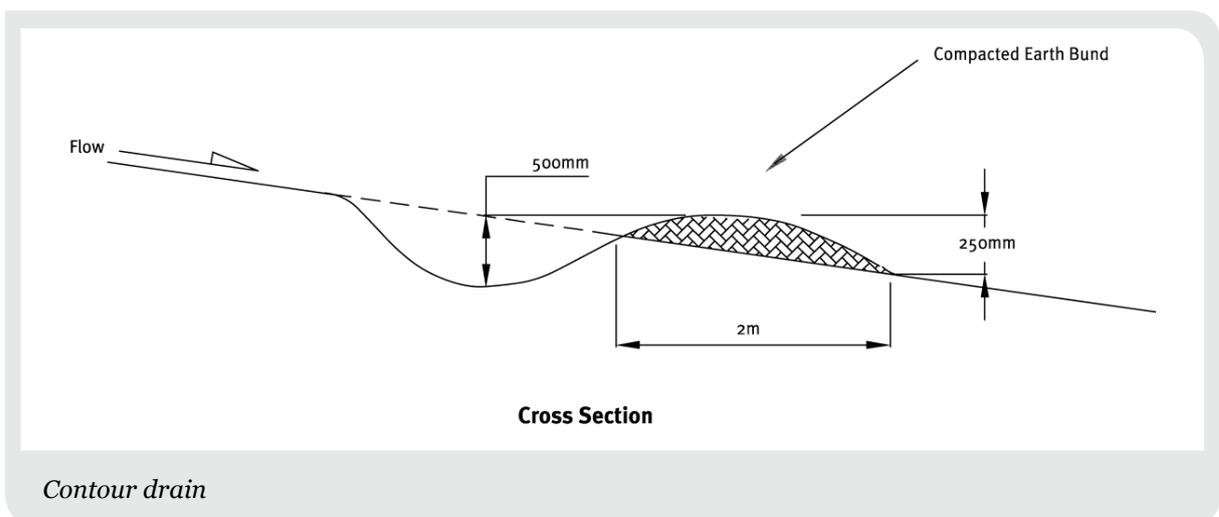
They are a temporary ridge or excavated channel (or combination of ridge and channel) that conveys stormwater runoff across sloping land on a minimal gradient.

Ash/pumice soils are very susceptible to rill and gully erosion because of their lack of cohesion. Although some overland flow will be lost to ground soakage, spacing between contour drains on these soils needs to be much closer than in cohesive soils.

Contour drains are generally temporary and control runoff until the ground surface is stabilised, such as on landings. Contour drains are not designed to carry a specific flow, so maintenance is critical. Dimensions in the diagram below are an indication only and contour drains could be smaller, depending on circumstances.



*Contour drain*



*Contour drain*

## Where to use

- At intervals across disturbed areas to shorten overland flow distances.
- As temporary or daily controls.
- To split and direct flow from disturbed areas to runoff diversion channels/bunds.
- To direct flow to safe disposal areas such as vegetation.

## How to design and construct

- Gradients are less than 2 percent.
- Channels and ridges of the contour drains must be well compacted.
- Contour drains should be kept as short as possible - maximum length 20 to 40 metres.
- The outfall of the contour drain must be stable.
- Spacing between contour drains varies according to ground slope, but the overriding requirement is for a stable outfall, and that often dictates where they are placed.

Site slope (%)	Indicative Contour Drain Spacing	
	Cohesive soils	Ash and pumice soils
5	50 m	30 m
10	40 m	20 m
15	30 m	10 m

Install contour drains to control overland flow while the area becomes vegetated or otherwise stabilised:

- at the end of each day,
- prior to a storm warning, or
- at the end of a stage of work.

## Maintenance

- Ensure that the outlet remains stable.
- Inspect contour drains after every rainfall and during periods of prolonged rainfall.
- If extra height is required on the ridges of the contour drain use sandbags during rain. Sandbags are ideal for controlling water flow during storms. Revisit the site after rain to tidy up any maintenance carried out during the rainfall event.
- Carry out maintenance work immediately.

## BMP 2.3 WATER BARS/CUT-OFFS

**Water bars or cut-offs are used to control rill or gully erosion on a road or track surface by catching stormwater runoff and diverting to a controlled outlet or to ground soakage. Known as water bars or cut-offs, but will be referred to as cut-offs here.**

### Description

They are an excavated channel/ridge combination across a road or track to control and divert stormwater runoff to a safe outlet and/or to ground soakage.

In the Bay of Plenty region, cut-offs are used in porous soils.

When setting out cut-offs, make sure that the outlet is stable. As with diversion drains/earth bunds, survey the grade from an identified stable outlet point whenever possible. Flumes may be required to carry runoff water safely over fill slopes.

Always run cut-offs so they drain towards the outside of the track. If the track is sloped inward towards the inside bank, don't use cut-offs. The water table may need compacting or armouring.

Ridges will generally provide more stable outlets than gullies. Discharging onto ridges will spread the water flow rather than concentrate it. Discharging onto fill could undermine the access track.

As with contour drains, set the spacing between cut-offs based on the soil cohesiveness. If the track is not compacted and the soils are erodible coarse ash or pumice, the cut-offs will need to be closely spaced.

In unconsolidated soils, some overland flow will be lost to ground soakage. In very porous pumice soil, cut-offs can be used so all of the runoff is discharged to ground soakage. If the soils are very porous, reduce the gradient of the channel along the cut-off to encourage more soakage to ground.



*Water bars installed in decommissioned haul track on pumice soils.*



*Cut off installed on haul track diverting water onto stable outfall area.*

## Where to use

- To shorten overland flow distances, and to disperse flow.
- As temporary or daily controls on haul tracks in critical situations.
- To direct flow from road and track surfaces to safe disposal areas, such as vegetation.
- Install on temporary tracks when they are decommissioned.

## How to design and construct

- The gradient of the cut-off across the access track must have sufficient fall to divert and convey stormwater runoff to the safe outlet. The gradient and capacity are critical, as the velocity of the runoff flowing down the track may be such that it overtops the cut-off, and continues flowing down the main track.
- Channels and ridges of the cut-offs must be well compacted, unless the cut-off is designed to discharge to ground soakage in very porous pumice soils.
- The outfall of the cut-off must be stable (undisturbed ground).
- Cut-offs for decommissioning temporary tracks need to be over-designed (spacing and sizing of the cut-offs) so that maintenance is not needed, and machinery should not cross over the cut-offs once they are completed.
- For decommissioned tracks where maintenance is unlikely, sow grass seed.
- The spacing between cut-offs will vary according to slope of the ground as shown on the following table.

## Indicative positioning for water bars/cut-offs

Site slope (%)	Cut-offs Spacing	
	Cohesive soils	Ash and pumice soils
Up to 12%	40 m	30 m
From 12% to 30%	30 to 20 m	20 to 10 m
Over 30% slope	Less than 10 m	5 m

## Maintenance

Maintenance is critical for cutoffs to keep working. If one cutoff fails, the flow speed will cause erosion problems, and may affect other cut-offs further down.

- Check outlet stability and keep clear of sediment.
- Inspect cutoffs after every rainfall and during periods of prolonged rainfall.
- Carry out maintenance work immediately.
- If there is rill or gully erosion on the track, put in more cutoffs.

## BMP 2.4 BALE BARRIER

**Bale barriers are used to intercept or direct sediment-laden runoff from small areas to a sediment retention area, where transported sediment can drop out. Hay bale barriers have limited uses.**

### Description

Temporary barriers of hay bales to intercept and direct surface runoff from small areas.

Hay bale barriers are used far more often than they should be, because they are incorrectly seen as being a sediment treatment device. They should only be used to divert and detain stormwater runoff. Hay bale barriers are used most successfully where they are constructed to divert runoff from small catchment areas to treatment devices or stable areas.

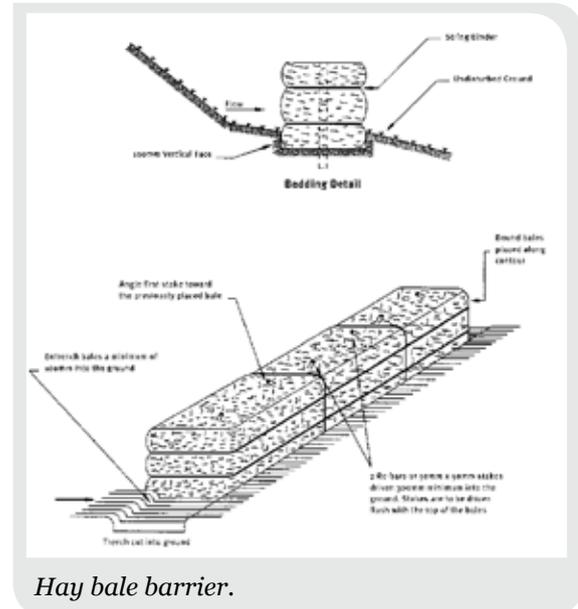
**DO NOT** use hay bale barriers as a primary sediment filter.

### How to use

- Use short-term (generally less than one month).
- Only use to intercept sheet flow and not channelled flow.
- Only use in catchment areas less than 0.2 ha per 100 m length of bales

**DO NOT** use as speed checks in channels, or where they will intercept any concentrated runoff flow. Hay bales do not work as filters; they can be easily overtopped, or scoured out.

**DO NOT** use on slopes over 20 percent. The risk of concentrated flow is too great.



*Hay bale barrier.*

### How to design and construct

- Place along the contour with bales in a row with the ends tightly abutting adjacent bales.
- Dig each bale into the ground 100 mm and place so the bale bindings are horizontal.
- Only use one bale high. Do not stack bales on top of each other.
- Secure bales in place by two stakes driven through the bale 300 to 400 mm into the ground. Drive the first stake towards the previously laid bale at an angle to force the bales together. Drive stakes flush to the top of the bale.

### Maintenance

Inspect hay bale barriers frequently, and after each rain event.

Spread the hay bale mulch when the site has been fully stabilised. Do not spread in areas subject to channelled flow. Stabilise the trench where the bales were located and grade so the ground level is flush.

## BMP 2.5 FLUME/PIPE DROP STRUCTURE

**Flume or pipe drop o convey stormwater runoff down the face of a batter slope, or to safely convey runoff from the top of the slope to the bottom. They also prevent erosion from concentrated discharges onto the exposed slope face.**

### Description

They are a constructed flume or pipe structure, placed from the top of a slope to the bottom. Unless specifically referred to otherwise, both are called flumes in this document.

### Where to use

Flumes are used in conjunction with runoff diversion channels or roadside water tables. The stormwater runoff is discharged into the flume, which conveys this flow down the face of the slope.

Each flume should have a maximum of 1 ha catchment area. Over 1 ha requires specific design to ensure adequate flume capacity.

### How to design and construct

- Construct all flumes of watertight materials.
- Extend the flume beyond the toe of the fill and adequately protect the outlet from erosion using rock riprap over a geotextile apron, or other suitable energy dissipater (see the next section).

This table can be used as a guide to pipe sizing for catchments up to 1 ha, in the absence of specific design information.

Design criteria for pipe drop structures	
Pipe diameter (mm)	Maximum catchment area (ha)
300	0.2
450	0.6
500	1.0
600	1.0



*Flume drop structure.*

- The runoff diversion channel at the flume inlet must be at least twice the height of the flume or pipe diameter as measured from the invert.
- Inlets to flumes are a common failure point – the inlet needs to be well keyed in.
- Ensure the entrance is well compacted.
- In a disturbed catchment, ensure the flume discharges into a disposal site where the sediment can be trapped.
- In a stabilised catchment, ensure the flume discharges on to a stabilised area at a non-erosive velocity. The point of discharge may be protected by rock riprap.
- Ensure that the flume has a minimum slope of 3 percent. If flexible pipes (culvert socks) are used, the minimum recommended grade is 5 percent.
- Where flexible flumes are used (culvert socks) check the manufacturer's specifications and use experienced personnel for installation.
- Consider the weight of water that will be conveyed through the flume or pipe drop structure, and whether this will affect the stability of the structure.

## Specific design for flumes

- Prevent outflanking of the flume entrance, or scouring of the invert to the flume by waterproofing the flume entrance. Do this by trenching using impervious geotextile or plastic liner so that all flows are channelled into the flume. Or install a piped entrance.
- Flumes can be constructed in site from corrugated steel, construction plywood, sawn timber or halved plastic piping. Make sure it doesn't leak. If leakage may be likely, put an impervious liner down the entire length of the flume (wooden or plywood flumes).
- For slopes greater than 30 percent, construct a flume from a standard 1.2 m x 2.4 m x 22 mm plywood sheet. This is adequate for a catchment of up to 1 ha. You need specific design for larger catchments.
- Fasten the flume to the slope using waratahs or wooden stakes placed in pairs down the slope at 1 to 4 m spacings, depending on the flume material to be used. Fasten the flume to the waratahs or stakes using wire or steel strapping.
- Place flumes on undisturbed soil or well-compacted fill.



*Flume drop structure.*

## Specific design for pipe drop structures

- Backfill and compact around and under the pipe with suitable material to get firm contact between the pipe and the soil at all points. This is to prevent failure of the structure when water saturates the soil at the inlet, and seeping along the pipes
- Make pipe drop structures from rigid or flexible pipe. Flexible pipe must be pinned to the slope to prevent twisting and potential blockages/blowouts.
- Place pipe drop structures on undisturbed soil or well-compacted fill. Choose locations that will minimise adverse effects if they fail.
- Immediately stabilise all disturbed areas after construction.
- Secure the pipe drop structure to the slope at least every 4 m. Use no less than two anchors equally spaced along the length of the pipe.
- Ensure all pipe connections are watertight.
- Always ensure that the outlet is well secured.

## Maintenance

- Inspect the flume/pipe drop structure regularly, and after each rainfall event that is likely to impair the function or performance of the structure.
- Ensure that the inlet is kept open at all times.

## BMP 2.6 OUTLET CONTROLS/ENERGY DISSIPATERS

**Outlet controls and energy dissipaters are used to dissipate energy from the discharge of stormwater at an outlet point before it discharges off site or into ground soakage.**

### Description

Outlet controls ensure that energy from the stormwater discharge is safely dissipated. Outlet controls can be very simple, making use of on-site factors, such as spreading discharge onto a stable ridge, or a level spreader to disperse the discharge. Or they can be designed structures such as rock rip rap or concrete apron and gabion mattress.

### Where to use

Outlet controls are generally used in conjunction with flumes, culverts or pipe drop structures.

Always use some type of outlet control whenever there is a concentrated point source discharge that could result in scouring. It must control the discharge to reduce water energy and thus avoid scouring.

You can bury outlet controls so that they act as a natural scour hole. The discharge fills up the scour hole (outlet control) and then discharges at ground level on a level outlet with the energy dissipated. For discharging above ground onto structures such as rock over geotextile, you'll need some engineering design so that the discharge doesn't scour.

### How to design and construct

- Ensure above-ground outlet controls are well anchored.
- Encourage discharge to ground soakage via the outlet control system.
- Disperse the discharge from the outlet control or put it over a level spreader system.



*Flume drop structure with energy dissipater as an outlet control*

- Use heavy rocks angular rocks for rock riprap as an energy dissipater. They must also be sufficiently graded to prevent fines washing out from under the structure. This will require some engineering design. Or geotextile material can be used underneath the rock to prevent fine material being lost.
- Geotextile material can be used to assist with safe dispersal of discharge after exiting the outlet control.

### Maintenance

- Inspect the outlet control regularly, when water controls are inspected, and after each rainfall event that could affect its performance.
- Ensure that the outlet control remains well anchored, with little or no scouring below the final discharge point.

# SURFACE STABILISATION

Surface stabilisation means protecting ground that has been disturbed by earthworks to control surface erosion, splash, sheet, wind and minor rill erosion.

Surface stabilisation can be temporary or permanent. Aggregate is most commonly used. This section covers surface stabilisation techniques using vegetation. These are generally not suitable for controlling concentrated water flow.

When vegetation is used for surface stabilisation, you need to get a dense ground cover to protect the exposed soil. The most suitable vegetation includes surface cover plants such as grasses and legumes. Dense grass cover can withstand heavy rainfall, as well as overland flow velocities of up to 2 m per second without eroding (Humes Design Manual – Humes Industries Ltd).



*Dense grass cover can withstand heavy rainfall as well as overland flow of up to 2 m/sec. Surface protection such as logging slash, mulch or hydroseeding can be used in forestry situations.*

- **Surface stabilisation is used to control surface erosion of earthworks at source.**
- **Surface stabilisation techniques are generally not suitable for controlling concentrated stormwater flow.**
- **Dense surface vegetation can provide excellent surface stabilisation.**

## BMP 3.1 MULCHING/BARK/LOGGING RESIDUE

**Mulching, bark or logging residue is used to prevent scouring from raindrop impact and minor overland flow by providing a protection layer (mulch) over the ground surface.**

### Description

The use of mulch from bark, wood residue or wood pulp, spread over the surface of disturbed ground, in an even layer.

### Where to use

Use mulching where you want instant protection for the soil surface. Use with seeding to establish vegetation, or by itself to provide temporary protection of the soil surface.

Mulching is particularly useful when vegetation establishment would be difficult because it's too dry, hot, or cold.

### How to design and construct

Before applying mulch, ensure that the site has adequate erosion and sediment control so that overland flow is not concentrated.

Make sure mulch material doesn't contain any plant pest material (see *Regional Pest Management Strategy July 2011- 2016* for details). Spread mulch uniformly, and secure to the soil surface, if the weight of the mulch is not suitably heavy.

For smaller areas, hand spreading of mulch is satisfactory. For larger areas apply mulch mechanically. Mulch can be anchored by using a tackifier (such as hydroseeding), or crimping the material with discs.



*Shovel logging to stack logs ready for the hauler leaves slash and logging residue relatively undisturbed, and protects the soil surface before replanting*

In forestry situations wood products suitable for mulching, such as bark or wood chips, are likely to be available. The high cost of hydro seeding or applying straw mulch will normally mean that it is only used on critical sites. Straw mulch should be applied using unrotted straw at a minimum rate of 6000 kg/ha.

## BMP 3.2 SURFACE VEGETATION – HYDROSEEDING

**Hydroseeding is used to establish vegetation quickly, and also provides a degree of instant protection from rain drop impact.**

### Description

Seed, fertiliser and paper/wood pulp slurry is sprayed over the area to be revegetated. The seed generally sticks to the pulp, which improves the micro-climate for germinating and establishing. This method allows vegetation to establish on difficult sites and can extend into cooler winter months, especially if it is used with mulching.

Use local knowledge and experienced contractors to ensure that the seed mix is appropriate for the site.

Heavy rainfall can wash hydroseeding away, particularly from smoother hard surfaces and overland flow paths. For unsatisfactory vegetation establishment, re-hydroseed.

### When to use

- Critical areas in an earthwork site, such as steep slopes or fill batters.
- Critical areas where conventional sowing methods don't work.
- Protection of bare areas where seasonal timing is poor for conventional sowing methods.
- Around watercourses, or on runoff diversion channels/bunds, water tables, where rapid establishment of a protective vegetation cover is required before introducing flows.



*Surface stabilisation of this batter slope has been achieved by hydroseeding*

### How to do hydroseeding

- Before hydroseeding, install any necessary erosion and sediment control to control stormwater runoff.
- Hydroseeding requires moisture for germination and growth. Because hydroseeding is important. Check that steep pumice slopes are not so dry that they will crumble as the hydroseeding is applied.

### Maintenance

Protect all revegetated areas from traffic flows and other activities that may disturb the hydroseeded surface. Hydroseeding on non-cohesive soils can give mixed success because the hydroseed grass can peel off after establishment. Use appropriate seed mix (deeper rooting legumes) to reduce this risk.

## BMP 3.3 SURFACE VEGETATION – GRASSING

**Grassing is used to protect from rain drop impact, sheet erosion and minor rill erosion medium to long-term, by using surface vegetation.**

### Description

Applying grass and legume seed (with fertiliser if necessary), to disturbed and/or exposed ground to establish a dense surface vegetative cover.

Use local knowledge and experienced contractors to get a seed mix appropriate for the site. The better the seed bed, the more chance vegetation will establish well. Improve establishment by making use of whatever topsoil is available to help with forming a good seed bed or use pelleted seed.

Be wary of sowing grass seed on overland flow paths, as the seed may be washed off the site.

### When to use

For medium to long-term protection of earthworks areas or exposed ground in critical sites.

- Riparian areas.
- Large areas of disturbed ground following earthworks, where the cost of other surface protection methods (such as hydroseeding) is prohibitively expensive.
- Protection of disturbed ground where seasonal timing suits the establishment of grass and/or legumes.



*Combination of hydroseeding, grassing and slash to stabilise ground surface and help filter any sediment before reaching stream channel*

### How to do

Apply grass seed by hand, hand-held seed spreader or by aerial application. Autumn sowing is best, although spring sowing can be successful. Avoid high fertility grass seed mixes, as most disturbed ground associated with forestry sites will not be fertile sites. You can add fertiliser to the mix.

Sowing rates are from 30 kg/ha to 160 kg /ha depending on fertility and other site factors.

Fertiliser should also be used in conjunction with sowing:

- Sulphate of ammonia – two applications of 125 kg/ha
- Super phosphate – 450 kg/ha.
- NPK 12.10.10 – 500kg/ha.

If the pH is low (less than 5), lime may also be required.

Two seed mixes suitable for disturbed sites are:

	Seed Mix A	Seed Mix B
Lotus Major 'Maku'	10%	5%
Annual ryegrass 'Moata'	25%	20%
Yorkshire fog 'Massey Basyn'	25%	15%
Cocksfoot	5%	15%
White cover	10%	15%
Subterranean clover	10%	20%
Suckling clover	10%	5%
Browntop	5%	5%

These two suggested seed mixes include an annual ryegrass to give a quick cover. 'Moata' is specified, although other cultivars are available and you can use them as long as they do not require high fertility sites.

**NOTE:** Lotus Major can increase susceptibility of plantation forests to pests such as leaf-roller caterpillar if it is broadcast sown over large areas. It can be used on bunds, roadside berms and around skid sites successfully.

Buying a mixed seed line can reduce the costs of seed (Yorkshire fog and Cocksfoot; white clover and suckling clover etc.) as seed viability and purity of seed mix are what adds cost. Large volumes of seed mix should be ordered well in advance.

Make sure legumes are inoculated with the correct Rhizobium bacteria. Seed can be purchased pelleted (with fertiliser) and inoculated.

For a quick cover, cereals (oats, barley etc.) can be sown as 150 kg/ha. To establish grass in coarse ash or pumice soils, use higher percentages of Yorkshire fog.

## Maintenance

Follow up application of fertiliser can ensure that an established vegetative cover will persist.



*Re-grassing, and good water control from upslope.*

# SEDIMENT CONTROL

Sediment control is used to trap sediment on site before it is discharged as sediment-contaminated stormwater, or 'silt control'.

The aim is to slow stormwater down enough that the sediment drops out, and is retained on site.

For most volcanic ash soils, sediment control successfully reduces the offsite effects of erosion, because the soil particles are composed of the larger sand sized material that drops out easily (unlike silt or clay). Low-tech systems of slowing and trapping sediment work very well.

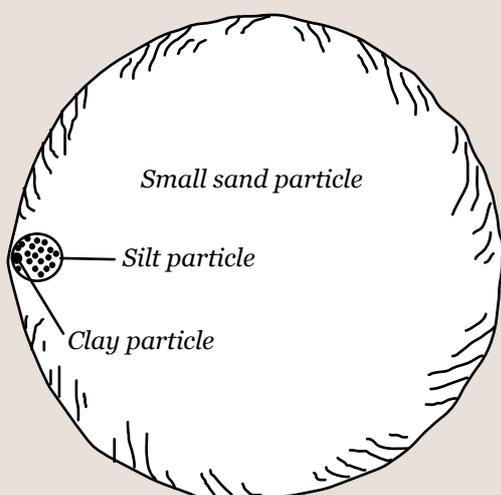
In very porous soils such as pumice, sediment controls can detain stormwater long enough to enable discharge to ground

soakage. To work long-term these systems need to be regularly cleaned out. Cleaning prevents fine material building up, which otherwise reduces the soakage speed into the ground.

Sediment control measures require regular maintenance to work. Remove sediment regularly as the control measures fill up. Put the removed fill material in a place where it cannot move again.

Sediment control measures are often the last line of control before stormwater is discharged off site, or to ground soakage. You still need good on-site erosion control to reduce the amount of sediment that needs to be trapped.

- **Sediment control slows down stormwater runoff enough that sediment drops out into (low tech) sediment trapping devices.**
- **Successful sediment control still needs good on-site erosion control to reduce the amount of eroded soil.**
- **Sediment control measures need to be regularly cleaned out.**



*Sand particles are larger and heavier than silt or clay particles, so they settle out more easily in sediment traps<sup>3</sup>.*

<sup>3</sup> from Soils in the NZ Landscape A Living Mantle  
by L Molloy

# BMP 4.1 SOAK HOLE/SEDIMENT TRAP

**Soak holes and sediment traps are used to control stormwater runoff from roads/tracks and trap sediment on-site.**

## Description

A constructed hole which acts as a sediment trap and can also act as a soakage bay in porous soils. Referred to as 'soak holes' in this document. Stormwater runoff is collected and left to discharge to a controlled outlet or soak into the natural ground.

Soak holes require regular maintenance to maintain storage volume, and to stop the floor of the soak hole from sealing with fine material. If you can't regularly maintain them, make a large soak hole, and ensure there is a safe outlet if the hole becomes full.

## Where to use

- On the lower boundary of landings.
- Water from water tables on the edge of roads and tracks.
- On free draining soils such as pumice or non-cohesive ash.
- In natural ground, as long as slopes are not too steep.
- As permanent or temporary drainage controls.
- In conjunction with water bars/cut-offs.

## How to design and construct

- Excavate 1 to 1.5 m deep.
- The width of the excavator bucket used for the operation.
- Always install soak holes in natural ground. Never in disturbed soil.
- Keep the slope of the inlet into the soak hole reasonably flat, to avoid erosion.
- Soak holes are located to suit the terrain, with this spacing guide:



*Sediment trap has been installed in stable ground. Discharge is through a flume over the batter slope*

Site slope	Soak hole spacing
Less than 12%	40 m
More than 12%	30 m down to 10 m

**DO NOT** dig soak holes on blind areas of road, where they may be a safety hazard for vehicles.

**DO NOT** install soak holes where the slope above them could collapse into the soak hole.

## Maintenance

- Check soak holes during prolonged rainfall, and after heavy rainstorm events.
- During heavy rainfall, check that spacing of soak holes is sufficient to control the stormwater runoff.
- Check that fine material is not sealing the floor of the soak hole.
- Check that the inlet is not being scoured out with stormwater runoff.
- When cleaning out soak holes, put the removed fill material where it cannot wash back into the soak hole.

## BMP 4.2 SEDIMENT RETENTION FENCING – SILT FENCE

Silt fences are used to detain runoff so that transported sediment can settle out.

### Description

A temporary barrier of woven geotextile fabric used to intercept runoff, reduce its speed and retain sediment-laden runoff from small areas of disturbed soil. Commonly called silt fences.

Silt fences are strongly preferred over hay bales.

Only use silt fences to intercept sheet flow, or in conjunction with soak holes (see BMP 4.4). Do not use them as velocity checks in channels or place them where they will intercept concentrated flow.

The silt fence is only as strong as its weakest point.



*Silt fence used to intercept diffuse runoff from road, and trap sediment on site*



*Silt fencing with more open weave where discharge occurs.*

**DO NOT** install silt fences across watercourses or in concentrated flows. Consider using revegetation/slash or mulch as a cheaper alternative where appropriate.

### How to design and construct

- Silt fence height to be between 300 mm – 400 mm above ground level.
  - Supporting posts/waratahs must be embedded a minimum of 400 mm into the ground.
  - Use supporting posts/waratahs at no more than 2 m apart, or
  - If a strong woven fabric is used in conjunction with a wire support (tensioned wire (2.5 mm HT) along the top of the silt fence) the distance between posts can be up to 4 m.
  - Double the silt fence fabric over, and fasten to the wire and posts with wire ties or cloth fastening clips at 150 mm spacing.
  - Always install silt fences along the contour. If this is not possible, or where there are long sections of silt fence, install short silt fence returns projecting upslope from the silt fence to minimise concentration of flows. Silt fence
- On low gradient sites or for confined areas where the contributing catchment is small such as short steep batter fills and around water courses.
  - To mark the limit of disturbance on an earthworks site, such as riparian areas or bush reserves.

### Where to use

returns are a minimum of 2 m in length, can incorporate a tie-back, and are generally constructed by continuing the silt fence around the return and doubling back, eliminating joins.

- Join lengths of silt fence by doubling over fabric ends around a wooden post or batten or by stapling the fabric ends to a batten and butting the battens together.
- Maximum slope lengths, spacing of returns and angles for silt fences are:

Silt fence design criteria			
Slope steepness %	Max slope length (m)	Spacing of returns (m)	Max silt fence length (m)
Flatter than 2%	Unlimited	N/A	Unlimited
2-10%	40	60	300
10-20%	30	50	230
20-33%	20	40	150
33-50%	15	30	75
Over 50%	6	20	40

- Install silt fence wings at either end of the silt fence, projecting upslope to a sufficient height to prevent outflanking.
- Provide for a riprap splash pad or other outlet protection device where impounded flow:
  - may overtop the silt fence,
  - crossing natural depressions, or
  - at low points.
- In catchments greater than 0.5 ha silt fences are not recommended. Use other control measures such as the super silt fence.
- Where water may pond behind the silt fence, provide extra support with tie-backs from the silt fence to a central stable point on the upward side. Provide extra support by stringing wire between support stakes and connecting the filter fabric to this wire.

- Fabric cloth recommended for forestry silt fences is UV resistant windbreak material of 50 percent to 65 percent porosity. **NOTE:** This is different from what is recommended in the Land Disturbance Guidelines (BOPRC Guideline 2010/01). Commonly called windbreak or shade cloth; this material is more porous than the geotextile recommended for earthworks and is therefore less prone to blockage.

## Construction

- Use silt fence material appropriate to the site conditions and in accordance with the manufacturer's specifications.
- Excavate a trench at least 100 mm wide and 200 mm deep along the proposed line of the silt fence. Install the support posts on the downslope edge of the trench and silt fence fabric on the upslope side of the support posts to the full depth of the trench, then backfill the trench with compacted fill.
- Use supporting posts of tanalised timber a minimum of 50 mm square, or steel waratahs at least 1.5 m in length.
- Reinforce the top of the silt fence fabric with a wire support made of galvanised wire of a minimum diameter of 2.5 mm. Tension the wire using permanent wire strainers attached to angled waratahs at the end of the silt fence.
- Where ends of silt fence fabric come together, ensure they are overlapped, folded and stapled to prevent sediment bypass.

## BMP 4.3 SOAK HOLE PLUS SILT FENCE

A soak hole silt fence combination is used to control stormwater runoff from areas where there's a risk of sediment-laden runoff discharged from the disturbed area (such as landings), or where there is a sensitive receiving environment (such as a stream in close proximity to the discharge point).

### Description

A combination of soak hole and silt fence, with the silt fence at the outlet of the soak hole.

### Where to use

- On the lower boundary of landings.
- Draining from water tables on the edge of roads and tracks in riparian areas.
- In situations where further treatment is needed after discharge from the soak hole.

### How to design and construct

Use the design criteria for both soak holes and silt fences.

- Check soak holes and silt fence during prolonged rainfall, and after heavy rainstorm events.
- Ensure that runoff does not outflank the silt fence.
- Check that fine material is not sealing the floor of the soak hole.
- Check that the inlet is not being scoured out with stormwater runoff.
- When cleaning out soak holes and/or silt fences, place the excavated sediment where it cannot be remobilised.



*Soak hole plus silt fence where the discharge point is close to a stream*

### Maintenance

Regularly maintain to remove any sediment build-up in the soak hole and/or behind the silt fence.



*Silt net and rock work twin culverts.*

# BMP 4.4 SEDIMENT RETENTION FENCING – SUPER SILT FENCE

Sediment retention fencing and silt super fences are used to detain flows from runoff so that transported sediment can settle out. A super silt fence is a much more robust sediment control measure than a standard silt fence and a larger catchment area can be treated.

## Description

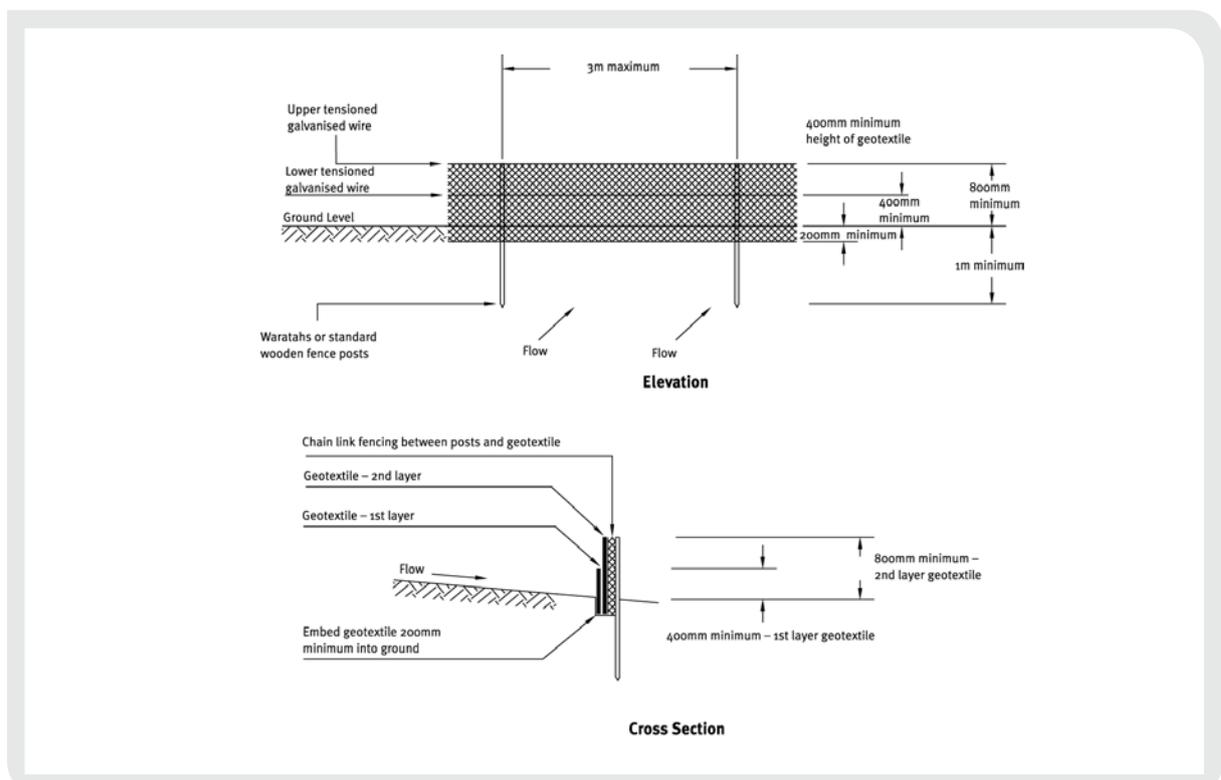
A temporary barrier of woven geotextile fabric backed with chain link fence or other Bay of Plenty Regional Council-approved product. Used to intercept runoff, reduce its speed and retain sediment laden runoff from areas of disturbed soil.

## Where to use

Only use super silt fences to intercept sheet flow, or in conjunction with soak holes. Do not use them as speed checks in channels or put them where they will intercept concentrated flow.

- Use super silt fences in catchments of more than 0.5 ha, rather than standard silt fences.
- Use where you need a controlled treatment barrier to treat sheet flow runoff from disturbed areas, where the discharge is to sensitive receiving environments, such as a wetland or water course.
- Use to mark the limit of disturbance on an earthworks site, such as riparian areas or bush reserves.
- Use to store runoff behind the super silt fence without damaging the fence or the submerged area behind the fence.

**DO NOT** install super silt fences across watercourses or in concentrated flows.



## How to design and construct

### Design

- Super silt fence height must be between 400 mm and 800 mm above ground level.
- The geotextile fabric must be in two layers, with two layers for the lower half of the fence, and one layer for the top half of the fence.
- Use supporting posts/waratahs at:
  - no more than 3 m apart.
  - If you use a strong woven fabric in conjunction with a wire support, (tensioned wires (2.5 mmHT) half way up the fence, and along the top of the fence) the distance between posts can be up to 4 m apart.
- Double the silt fence fabric over, and fasten to the wire and posts with wire ties or cloth fastening clips at 150 mm spacings.
- Ensure supporting posts/waratahs are embedded a minimum of 800 mm into the ground.
- Join lengths of super silt fence by doubling over fabric ends around a wooden post or batten or by stapling the fabric ends to a batten and butting the battens together.
- Install silt fence wings at either end of the super silt fence projecting upslope to a sufficient height to prevent outflanking.
- Install super silt fences along the contour. If this is not possible, or where there are long sections of super silt fence, install short silt fence returns projecting upslope from the super silt fence to minimise concentration of flows. Super silt fence returns are a minimum of 2 m in length. They can incorporate a tie-back, and are generally constructed by continuing the silt fence around the return and doubling back, eliminating joins.

- Maximum slope lengths for super silt fences are:

Super silt fence design criteria	
Slope steepness %	Maximum slope length (m)
0-10%	Unlimited
10-20%	60
20-33%	30
Over 33%	20

- Where impounded flow may overtop the super silt fence, crossing natural depressions or at low points, provide for a graded rock splash pad or other outlet protection device.
- Where water may pond behind the super silt fence, provide extra support with tie-backs from the super silt fence to a central stable point on the upward side. Give extra support by stringing wire between support stakes and connecting the filter fabric to this wire.
- Fabric cloth recommended for forestry silt fences is UV resistant windbreak material of 50 percent to 65 percent porosity. NOTE: This is different from that recommended in the Land Disturbance Guidelines (BOPRC Guideline 2010/01). Windbreak material is more porous than the geotextile recommended for earthworks and is therefore less prone to blockage.

## Construction

- Use super silt fence material appropriate to the site conditions and in accordance with the manufacturer's specifications.
- Excavate a trench a minimum of 100 mm wide and 300 mm deep along the proposed line of the silt fence. Install the support posts on the downslope edge of the trench and super silt fence fabric on the upslope side of the support posts to the full depth of the trench, then a further 200 mm buried up slope. Backfill the trench with compacted fill.
- Use supporting posts of tanalised timber a minimum of 50 mm square, or steel waratahs at least 1.6 m in length.
- Reinforce the centre and top of the super silt fence fabric with wire supports made of galvanised wire of a minimum diameter of 2.5 mm. Tension the wire using permanent wire strainers attached to angled waratahs at the end of the super silt fence.
- Where ends of super silt fence fabric come together, ensure they are overlapped, folded and stapled to prevent sediment bypass.
- Inspect super silt fences at least once a week and after each rainfall.
- Make repairs when:
  - bulges occur,
  - sediment accumulation reaches 50 percent of the fabric height, or
  - any discharge is in danger of outflanking the super silt fence.
- Replace any areas of collapse, decomposition or ineffectiveness immediately. Do not remove the old fence unless this is unavoidable. Build a replacement fence immediately upslope instead.
- Remove sediment deposits to allow for adequate sediment storage and reduce pressure on the super silt fence.
- Ensure that the sediment is removed to a secure area, where it cannot be remobilised.
- Do not remove super silt fence materials and sediment deposition until the catchment area has been appropriately stabilised. Stabilise the area where the super silt fence has been removed.



*Silt fence as final perimeter control below forestry operations.*

# BMP 4.5 SEDIMENT RETENTION POND – SILT POND

**Sediment retention ponds are used to treat sediment-laden runoff from quarries and reduce the volume of sediment discharged from the site.**

## Description

Sediment retention ponds are not normally used in plantation forests. Within plantation forests in the Bay of Plenty they are only used to treat sediment laden runoff from quarries where other measures won't work.

They are made by forming an excavated pond and forebay natural ground. It includes a decant system to dewater the clearer water near the surface of the pond at a controlled rate.

Sediment retention ponds have:

1. a permanent pool of water (dead storage) which reduces re-suspension of retained sediments by inflow.
2. an operational volume (live storage) through which stormwater volumes can be temporarily detained while the decant system skims surface water off at a controlled rate.
3. an emergency spillway for more extreme rainfall events.

The design allows suspended sediment to settle out in the forebay and pond basin.

## Where to use

Sediment retention ponds take up a significant area. This space is needed for machine movement. This is why they are only used in forestry situations when quarry discharge treatment is required.



*Typical sediment retention ponds used in forestry*

## How to design and construct

Bay of Plenty Regional Council Erosion and Sediment Control Guidelines for Land Disturbing Activities Guideline 2010/01, section 7.1 has full design specifications. In summary:

- Choose the inlet and outlet to maximise the detention time for any stormwater runoff that is directed into the structure.
- Ensure the length to width ratio is between 3:1 and 5:1 to avoid creating short circuiting or increased flow speeds. The length of the sediment retention pond is the distance between the inlet and the outlet decant.
- The primary and/or emergency outlet must be sited with the discharge directed to stable undisturbed ground and with appropriate erosion protection.
- Always use a forebay with a level spreader inlet to the main pond basin.
- Ensure there is good wet weather access to clean out the pond and forebay.
- To calculate pond volume, use the live storage volume and ignore the forebay volume.

- Maximum depth of the ponds is 2 m. Ideal depth is 1.5 m.
- Install a marker peg in the forebay and main pond basin to show when the sediment will reach 20 percent of storage volume.
- You'll need engineering design to size the emergency spillway. The emergency spillway must be able to discharge the 1 percent AEP (Annual Exceedence Probability) storm, where the storm duration is equal to the time of concentration.
- You can use sediment retention ponds for catchments of up to 3 ha using these design specifications:

Sediment retention ponds design specifications for sizing		
Slope angle or length of slope	Minimum % of contributing catchment	Storage volume per hectare of contributing catchment
≤ 10 % and/or ≤ 200 m	2%	200 m <sup>3</sup> / ha
> 10% and/or > 200 m	3%	300 m <sup>3</sup> /ha

- 2 percent ponds have 200 cubic metres of storage for each hectare of contributing catchment. 3 percent ponds have 300 cubic metres of storage for each hectare of contributing catchment.

**ALWAYS** locate sediment ponds in stable ground, not fill material.

**DO NOT** locate sediment retention ponds in permanent watercourses.

## Maintenance

Ponds require regular maintenance to remove any build-up of sediment.

- Clear out the forebay when it is 20 percent full of sediment to help avoid excessive sediment transfer into the main pond basin.
- Clear out the main pond basin when it is 20 percent full.
- Place excavated sediment in a disposal site where it cannot be re-mobilised.
- Check the sediment retention pond regularly to ensure it is operating correctly. Repair any damage caused by erosion, machinery, ground settlement etc as soon as possible. Most problems occur with the outlet pipe work or with the decant system blocking.



*Sediment pond.*

## **OTHER MEASURES**

This section covers practices that do not naturally fit into water table controls, runoff controls, surface stabilisation and sediment controls. These practices include permeable slash bunds, corduroying and geosynthetic erosion control systems.

## BMP 5.1 PERMEABLE SLASH BUNDS

**Permeable slash bunds are used to slow down overland flow or stormwater runoff to encourage sediment to settle out, and stormwater to infiltrate the soil.**

### Description

A permeable bund of logging slash material placed on the contour across a slope. They are used in series on a dry valley floor, and placed in a herringbone fashion to allow excessive flows around a controlled bypass. The bund acts as a temporary sediment retention device before ground cover is established and canopy closes after replanting. The logging material in slash bunds will break down over time.

### Where to use

- Across slopes with shallow grades.
- Across dry valley floors in series or in a herringbone fashion.
- Above areas being rehabilitated such as decommissioned skid sites.
- Deactivation of temporary tracks.

### How to design and construct

- Always construct permeable slash bunds on the contour.
- Make sure the permeable slash bund is logging material only, with no soil in the structure.
- Slash bund height should be between 0.5 and 1.5 metres high.
- For catchments up to 1 ha and slope of up to 10 degrees (18 percent) slash bunds can be constructed in series right across a valley floor.



*Slash bunds used to intercept and slow down overland flow during high rainfall.*

- For catchments greater than one hectare or slope is greater than 10° (18 percent), construct the permeable slash bunds in a herringbone fashion across no more than two-thirds of the valley floor to allow for excessive flows to flow safely around the end of the bund.
- When constructed right across a valley floor, ensure that water flows through the slash bund are not excessive. Convert to herringbone design if flows are excessive.
- Ensure that flows around the end of bunds do not result in scouring.
- Slash bunds can be used in conjunction with other water control measures including bunds and/or silt traps.

### Maintenance

- When cleaning out sediment from behind slash bunds, place the excavated sediment in a safe location where it cannot be remobilised.

## BMP 5.2 CORDUROYING

**Corduroying is used as a low-cost alternative to geotextiles so machinery can gain access over very weak soils or wet areas (not wetlands or streams).**

### Description

The placement of (generally) low value logs neatly together over the soggy ground to 'bridge' over the soft area. When used in road construction, corduroying can involve laying a mat of slash or low value logs on top of the subgrade, and then placing aggregate over the top of the corduroying. Corduroying spreads the load and redistributes it over the whole width of the corduroy, increasing its load bearing area. Reinforcement is greater with log than with slash corduroy since the logs act as a rigid platform.

### Where to use

Corduroying over very weak, soft or wet areas allows for:

- Lower cost construction compared with alternatives (reduced need for aggregate).
- You can use roads and/or skid sites immediately.
- Minimise the amount of exposed earth that could erode or cause offsite sedimentation.
- When used in conjunction with aggregate, it can provide a separation layer and improve drainage.

### How to design and construct

- Use trimmed straight logs.
- Place logs neatly together to effectively bridge the wet soft area, and avoid protruding log ends into the water table.



*Corduroying*

- Avoid using the corduroying technique after the area becomes a bog – plan ahead and install corduroying as soon as the problem is identified.
- When placing the logs, push them hard into the ground, so they can support the weight of the machinery without bending or breaking.
- Sometimes, larger trees and/or cross bearers may be required in extremely soft conditions.

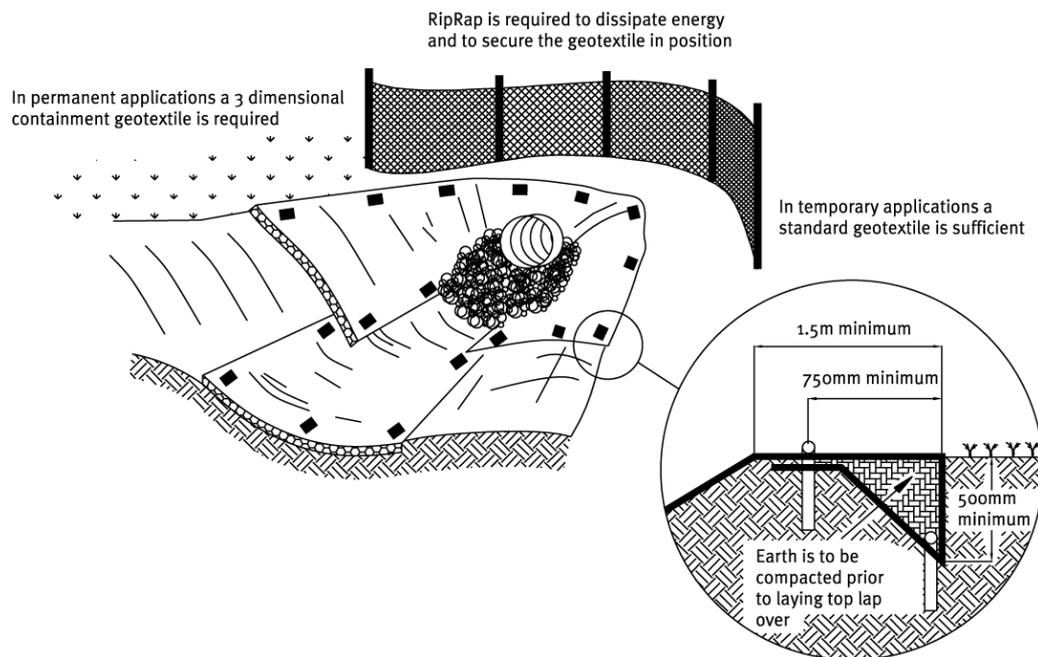
### Maintenance

The logging material in corduroying will break down in time so consider it a temporary measure while you require access.

- When possible check for broken logs and replace if necessary.
- In most cases, sediment control will be required to effectively treat stormwater and or sediment discharged from corduroyed areas.
- Consider removing logs within the corduroyed areas following completion of operations.

## BMP 5.3 GEOSYNTHETIC EROSION CONTROL SYSTEMS (GECS)

Geosynthetic erosion control systems are used to reduce the erosion potential of disturbed areas and/or eliminate erosion on critical sites with immediate effect, during the period required to establish protective vegetation. Some forms of artificial protection may also help establish vegetation.



### Description

Using artificial erosion control material such as geosynthetic matting, geotextiles or erosion matting to protect channels and erodible slopes.

**NOTE:** It's difficult to compare different products, and there are no industry standards to validate comparable products or compare prices of like products. Sometimes a particular product is specified, without the associated design parameters.. Check that the geotextile is suitable for the job you have in mind.

### Where to use

- On short steep slopes.
- On areas that have highly erodible soils.
- For high runoff speeds, where tensile and shear strength of conventional mulches aren't enough.
- In channels (both perennial and ephemeral) where the design flow produces shear forces beyond what the soils can withstand.
- Where there's not enough room to install other (cheaper) sediment controls.
- In critical erosion-prone areas, such as sediment retention pond outlets and inlet points.

- Where adequate permanent vegetative cover may be slow to establish.
- Where you need rapid stabilisation for high-value downstream environment.

## How to use and construct

### **Temporary degradable GECS**

These are where vegetation alone will give enough site protection once established. They prevent loss of seedbed and promote vegetation to establish. Common temporary GECS are erosion control blankets, open weave meshes/matting and organic erosion control netting (fibre mats factory-bonded to synthetic netting).

### **Permanent non-degradable GECS**

These are used to extend the erosion control limits of vegetation, soil, rock or other materials. They include three-dimensional erosion control and revegetation mats, geocellular confinement systems, reno mattresses and gabions.

Selecting the right GECS means balancing the relative importance of:

- **Durability** - degree of resistance to deformation over time, ultra violet radiation, and chemicals (natural chemicals and contaminants).
- **Physical dimensions** - thickness, weight, specific gravity and degree of light penetration. Generally, a thicker, heavier material will provide better protection.
- **Hydraulic** - ability of the system to resist ripping forces and protect against channel erosion, erosion of underlying soils or slope erosion from rainfall impact.
- **Mechanical** - deformation and strength behaviour. Tensile strength and elongation, stiffness (how well it will conform to the subgrade), and how well it will resist ripping forces.

For temporary channel or spillway protection, consider combining a high strength low permeability cloth over a soft pliable needle punch cloth, pinned to ensure the cloth is in contact with the entire soil surface. Trench and pin all flow entry points so the upslope geotextile edge overlaps the downslope geotextile mat. Toe in the upslope end of the downslope mat.

In high risk areas such as spillways and diversions, pin geotextiles down on a 0.5 m grid or in accordance with the manufacturers specifications, whichever provides the greatest number of contact points. If in doubt, do more pinning. If it is not satisfactorily anchored the speed of the water running over the surface creates a pressure difference, sucking fines through the geotextile. The greater the velocity, the greater the pressure difference.

Products are available for all situations. Many products combine a revegetation technique and an artificial erosion control measure. Choose the product designed for the intended use. Follow design specifications closely. Install and maintain according to specifications. Choose based on:

- Sediment yield (generally ranked highest).
- Stability under flow.
- Vegetation enhancement.
- Durability.
- Cost.

When installing GECS within a channel, ensure the product's design velocity and the product is appropriate for your intended use.

## Maintenance

Inspect after every rainfall, and undertake maintenance immediately.

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Bay of Plenty Regional Council Guideline 2010/01, 2010: *Erosion and Sediment Control Guidelines for Land Disturbing Activities*.

New Zealand Forest Owners Association, 2007: *New Zealand Environmental Code of Practice for Plantation Forestry*.

New Zealand Forest Owners Association, 2012: *New Zealand Forest Road Engineering Manual*.

Spiers JJK, 1986: Logging Operations Guidelines published for New Zealand Logging Industry Research Association (Inc.) and the National Water and Soil Conservation Authority by the Water and Soil Directorate of Ministry of Works and Development.

# GLOSSARY

*Note: Any definition set out in the Resource Management Act 1991 (RMA) shall apply to these guidelines.*

<b>Aggregate</b>	Crushed rock or gravel screened to sizes for use in road surfaces, concrete or bituminous mixes.
<b>BMP</b>	Best management practice (for erosion and sediment control).
<b>Catchment</b>	A geographical unit within which surface runoff is carried under gravity by a single drainage system to a common outlet or outlets. Also called a watershed or drainage basin.
<b>Compaction</b>	Compaction is any process by which the soil grains are rearranged to decrease the void space and bring them into closer contact with one another, thereby reducing permeability, increasing the weight of solid material per unit of volume, and increasing their shear and bearing strength.
<b>Composite soils</b>	When one soil is formed on top of another, and the resultant soil exhibits characteristics of both the soils.
<b>Deposition</b>	The accumulation of material that has settled because of reduced velocity of the transporting agent (wind or water).
<b>End hauling</b>	Removal of all excavated material off-site while road construction is being carried out. The material is normally carted back down the newly formed carriageway as the road is being constructed for disposal or stockpiling off site.
<b>Ephemeral flow path</b>	(see Regional Water and Land Plan)
<b>Erosion</b>	The processes of wearing away of the land surface, by natural or accelerated means, and the transport of the resultant material.
<b>Erosion and Sediment Control Plan</b>	A detailed plan which sets out the control measures to be used to minimise erosion and off-site sedimentation.
<b>Flume</b>	A high velocity open channel for conveying stormwater to a lower level without causing erosion. Also called a chute.
<b>Fluvial</b>	The action of running water in ephemeral flow paths, rivers or streams.
<b>Fluvial erosion</b>	Erosion caused by flowing water.
<b>Geotextile fabric</b>	A woven or non-woven, permeable or semi-permeable material generally made of synthetic products such as polypropylene and used in a variety of engineering, stormwater management and erosion control applications.
<b>Ground soakage</b>	The soakage of stormwater discharge into the ground as a form of treatment.
<b>Gully erosion</b>	Gully erosion is removal of soil, regolith or rock by fluvial incision, greater than 60 cm deep and greater than 30 cm wide. Gullies initially form through channelised flow of water, and both headward and lateral erosion of the channel. Gullies may be linear or amphitheatre in shape, depending on rock type, and usually only carry water during rainstorms.

<b>Hauler logging</b>	Logging using a hauler which suspends logs on an aerial cable system and brings them to a hauler pad or directly to a log processing site.
<b>Hydroseeding</b>	The spraying of a slurry of seed, fertiliser and paper or wood pulp over a ground surface to be revegetated.
<b>Landing</b>	A prepared area to which logs are extracted and where they may be sorted, loaded, processed, or stockpiled. Also called processing site, skid, and dump.
<b>Mulch</b>	Absorbent covering (such as straw, small woody debris) spread on the surface of exposed soil to protect it from raindrop impact and surface erosion, and to improve germination.
<b>NZ Forest Accord</b>	An agreement reached between the Forest Industry and conservation agencies on the protection of indigenous forestry resources.
<b>Plantation forestry</b>	The system of growing selected species of trees, usually in even aged compartments, which are specifically planted, managed and harvested for the production of timber or other wood based products.
<b>Rill erosion</b>	Erosion of small channels resulting from the removal of surface soil by running water that is concentrated into streamlets of sufficient discharge and velocity to create cutting power.
<b>Riparian management</b>	The management of land adjacent to streams, lakes, and other natural water.
<b>Rip rap</b>	Rock placed on stream banks or stream channels to control fluvial erosion.
<b>RMA</b>	Resource Management Act 1991 and amendments.
<b>Runoff</b>	The amount of rain that runs off a catchment and is not lost through ground soakage or evapotranspiration.
<b>Sedimentation</b>	The settling out of earth particles that have been transported by wind and/or water.
<b>Sediments</b>	Particles that have settled out in the sedimentation process.
<b>Sheet erosion</b>	Erosion of the ground surface in a thin sheet as a result of runoff over the surface. Usually a precursor to rill erosion.
<b>Skid</b>	See landing.
<b>Suspended sediment</b>	Sediment held in suspension in water. Suspended sediment may take a long time to settle, or may require flocculation for particles to settle out.
<b>Water quality</b>	The capacity of water to support life and retain a wide range of uses.
<b>Windrow</b>	Logging slash, stumps, logs or other debris stockpiled in a row by machine.

# APPENDICES

## Consent requirements

*When do I need a resource consent?*

A **resource consent** is required for controlled, restricted discretionary and discretionary activities in the Bay of Plenty Regional Water and Land Plan – December 2008 (RWLP).

Consents are required on activities such as vegetation clearance, tracking, roading, earthworks or burning once threshold levels are reached. Refer to the RWLP itself for specific details consents requirements or ask consent staff at Bay of Plenty Regional Council.

Earthworks, reclamation and dumping within the bed of a lake, river or stream, stream crossings, (bridges, culverts etc) may also require a land use consent.

Any earthworks which may modify or destroy an archaeological site will require separate approval from the Historic Places Trust.

Burning operations may also require separate consents from the Regional Council, District Council and Department of Conservation, depending on the area and location of the proposed burning operations.

## Other consents or permits

Discharge of particulate matter to air (dust emissions) may also require a discharge permit if they cause a nuisance off site.

Any activity which results in discharges of stormwater containing sediment to water or onto land (such as quarries, construction of subdivisions etc.) also requires a discharge permit. Ongoing stormwater discharges of clean stormwater may also require a discharge permit.

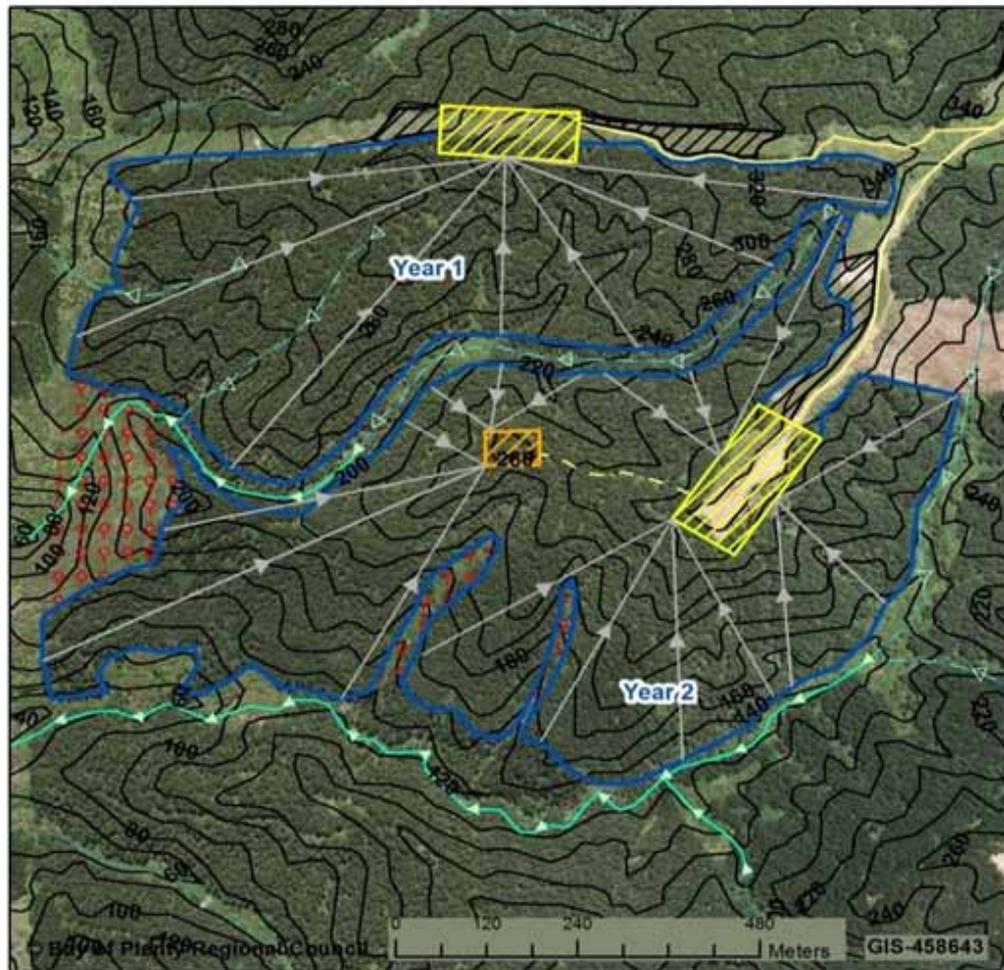
Consents staff from the Regional Council can explain specific requirements for other applications.

# HARVEST PLAN EXAMPLE

## Example Harvest Plan

Year: 2014, 2015 Plan

NZMS260 6320 4324



### Legend

- Permanent Stream
- Ephemeral Stream
- Haul Direction
- Main Logging Road
- Stage 2 Haul Road
- Processing Area
- Harvest Boundary
- Haul Pad
- Indigenous Bush
- Slash Management Area
- Stream
- 20m Contour



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