PART B – PRACTICES

6.0 EROSION CONTROL PRACTICES

6.1 Principles of Erosion Control

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

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

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

6.2 Site Planning and Management

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

What sorts of considerations are being discussed here?

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

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

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

6.3 Water Management

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

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

Photo 6.1 Good water management strategies will reduce the potential for erosion on a site (Photo: Erosion Management Ltd)

6.3.1 Diversion Channels & Bunds

Photo 6.2 Diversion Bund installed on edge of landing site to direct water flows into a sediment control

Description/Purpose

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

Catchment Area

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

Construction

a) They need to be capable of conveying the 5% AEP storm event (plus freeboard) without eroding. Specific design may be necessary (e.g. for catchments greater than 5 hectares) and this design should accompany the application for resource consent. To calculate the 5% AEP storm refer to ARC Technical Publication TP108.

b) They should have a trapezoidal ("U" shaped) cross section as this minimises channel erosion. The channel should be a minimum base width of 0.75 m, have 1v:3h channel sides and be a minimum of 0.5 m deep. Bunds should be at least 0.5 m compacted height. *[Note: These dimensions are for catchments of less than 5 hectares in area].*

c) Identify the outfall first which should be stable and erosion proof. Work back from this point. Flumes will generally be necessary to convey runoff across unstable land such as fill etc.

d) The slope of the channel should be no more than 2% in grade otherwise the channel will need to be protected against erosion. Measures such as revegetation, rock armouring and geotextile fabrics can be used.

Construction Notes:

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

Maintenance

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

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

Drawing

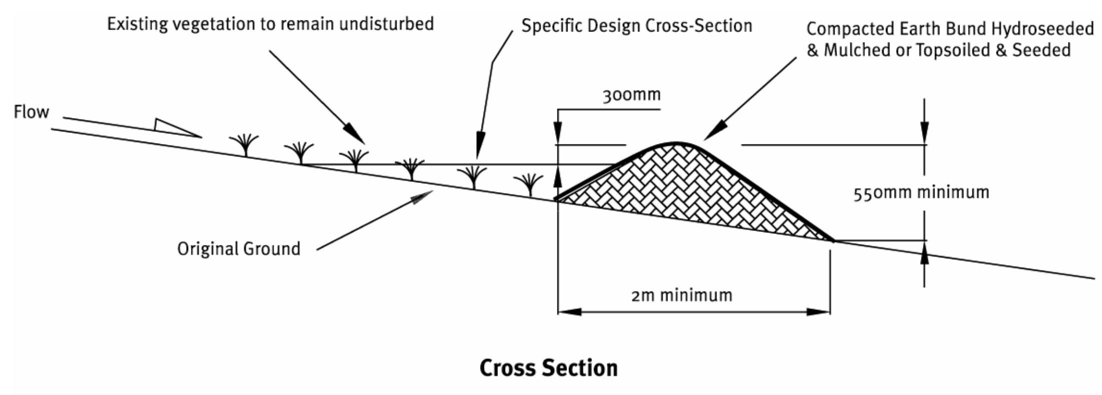

Figure 6.1 Runoff Diversion Bund

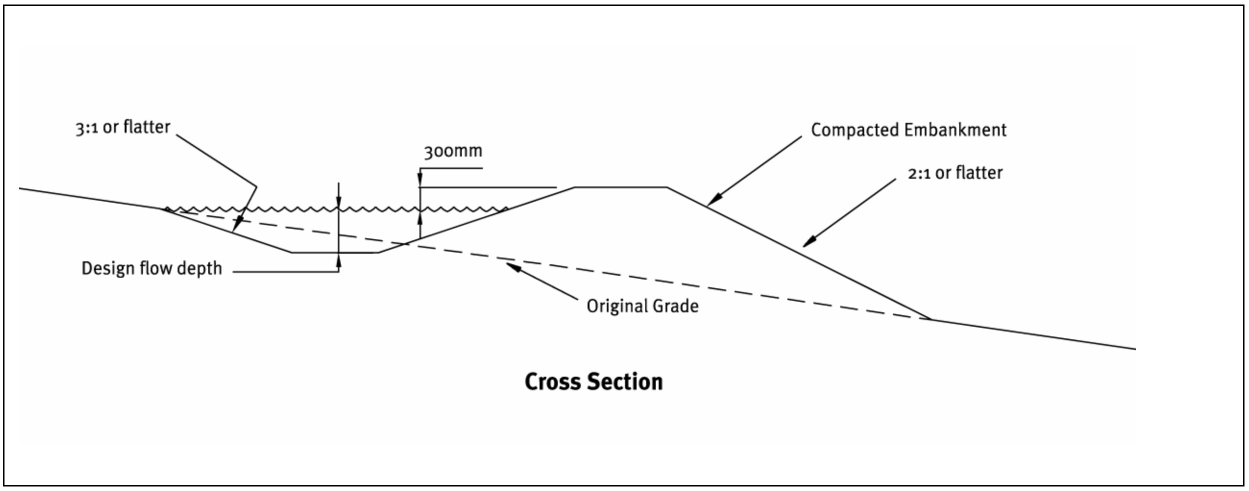

Figure 6.2 Runoff Diversion Channel

6.3.2 Contour Drains and Cutoffs

Photo 6.3 Contour Drain

Description/Purpose

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

Catchment Area

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

Construction

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

Table 1 Contour Drain Spacing

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

Construction Notes:

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

Maintenance

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

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

Drawing

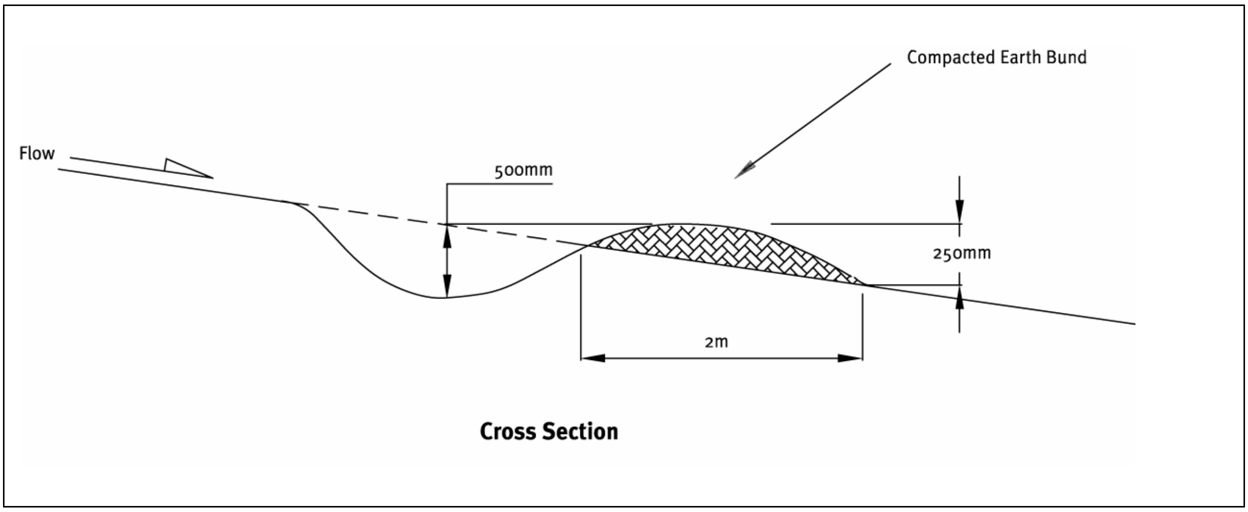

Figure 6.3 Contour Drain

Photo 6.4 Cutoffs in road and landing site (arrows indicate the position of the cutoffs)

6.3.3 Broad-based Dips

Photo 6.5 Broad-based Dip (Photo Source: Ohio State University Bulletin No 196)

Description/Purpose

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

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

Catchment Area

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

Construction

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

Table 2 Broad-based Dip Spacing

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

Construction Notes:

a) An inherent problem in the construction of a broad-based dip is recognising that the roadbed consists of two planes rather than one unbroken plane. One plane is the 6 metre reverse grade toward the uphill road portion and outlet. Another plane is the grade from the top of the hump or start of a downgrade to the outlet of the dip.
b) Ensure that the dip or the hump does not have a sharp angular break but is to be rounded to allow a smooth flow of traffic.

Maintenance

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

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

Drawing

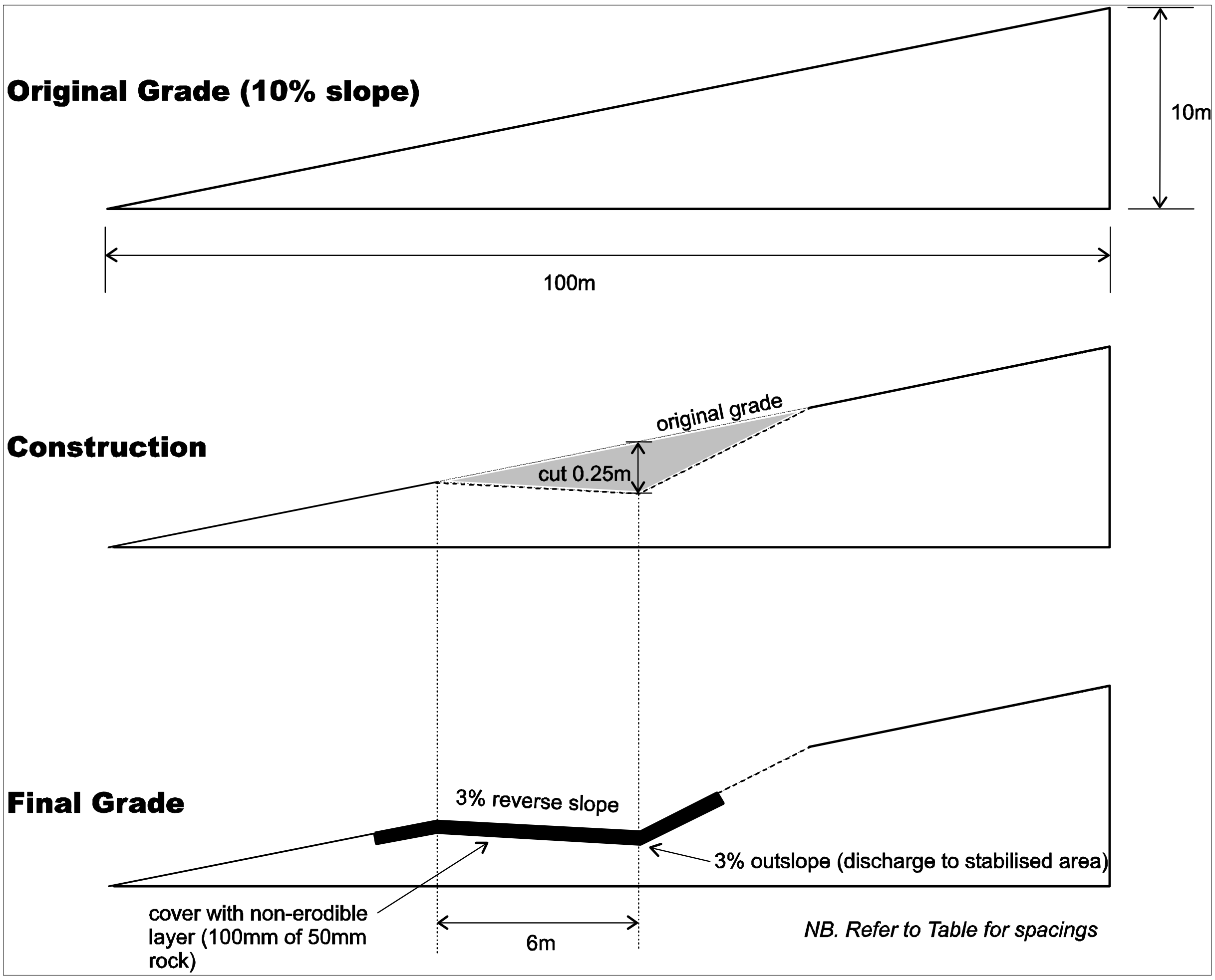

Figure 6.4 Broad-based Dip

6.3.4 Rolling Dip

Description/Purpose

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

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

Catchment Area

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

Construction

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

Table 3 Rolling Dip Spacing

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

Construction Notes:

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

Maintenance

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

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

Drawing

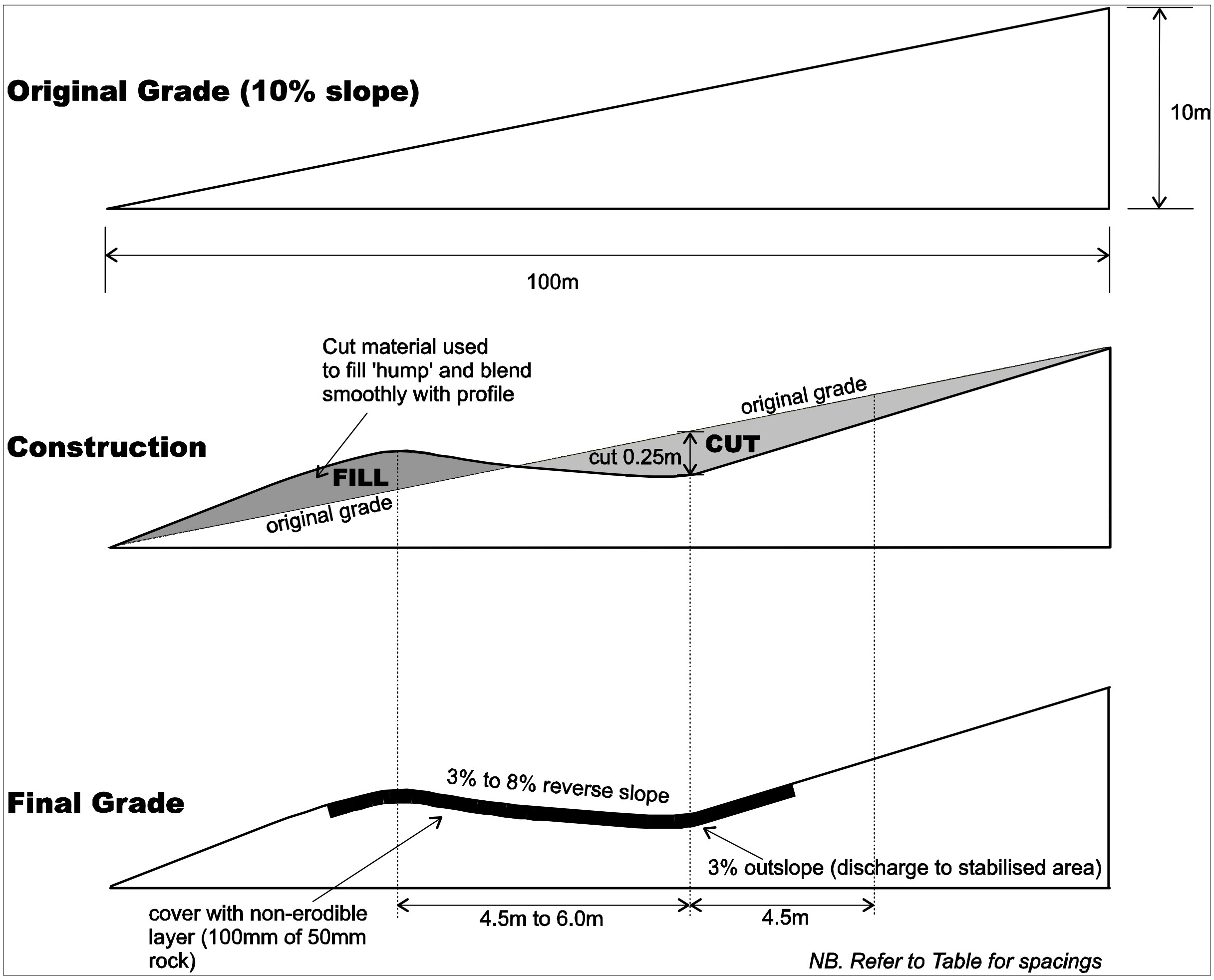

Figure 6.5 Rolling Dip

6.3.5 Flumes and Outfalls

Photo 6.6 Flume conveying sediment-laden water into an earthbund.

Description/Purpose

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

Catchment Area

Less than 2 hectares

Construction

a) Flumes are generally half round open pipes, wooden chutes constructed on a wooden frame or fabric flumes ("lay flats"). In some circumstances they can be constructed from geo-textile cloth laid over a swale shaped earth base.

b) Work out how the flume will work for the site. It is important that the capacity of the flume is not exceeded by the volume of water generated from the upper catchment. Establish the inlet point (where the in-flows collect) and the outlet point (which should be a stable area). The flume is then constructed to fit between these two points.

c) When sizing the flume or pipe drop structure use the criteria outlined in Table 2.

d) The inlet is generally at the end of an earth diversion channel/bund. It is vital that the inlet does not leak and this is usually achieved by way of a pipe or combinations of geo-textile cloth and rock or concrete.

e) The outlet is generally constructed with combinations of geo-textile cloth and rock or concrete, and needs to be sufficiently robust and extensive to withstand the force of water when the flume is full. Outfalls are generally positioned on stable areas (e.g. spurs), or constructed with large rock (e.g. 300 mm diameter rock laid over geo-textile cloth).

f) Ensure that there is at least 300mm freeboard so that overtopping does not occur. Note that the freeboard is measured from the crest of the bund to the top of the flume.

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

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

Construction Notes:

a) Take care with the supports of the flume (flumes are often laid over unstable ground and this land can move).

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

Maintenance

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

a) Ensure all flow is directed to flume, that the flume is securely attached to the inlet and that the outfall is not eroding.

b) Make sure that runoff has not spilled over the structure causing erosion and undermining the supporting structure of the flume.

c) Retain the flume until the area has been permanently stabilised or the flow has been redirected.

[1] Derived from New Zealand Forest Service – Civil Engineering Bulletin 4; August 1980

Drawing

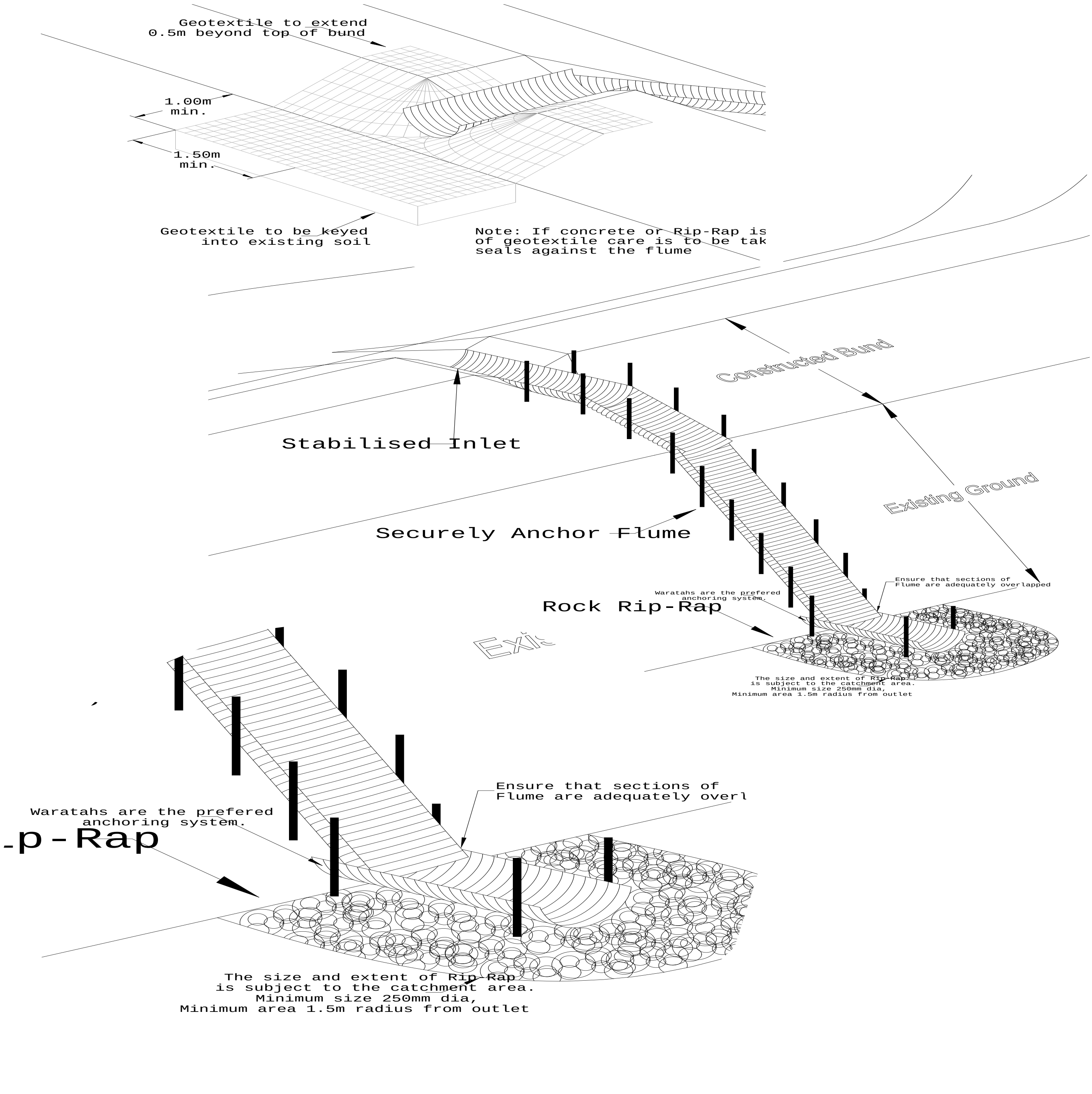

Figure 6.6 Pipe drop & flume structure