

# MANAGING URBAN STORMWATER



## Soils and Construction

Volume 2C Unsealed roads

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Volume 2C    Unsealed roads

Department of **Environment & Climate Change** NSW



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# 1. Introduction

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## 1.1 Unsealed roads

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Unsealed roads are common in rural areas, forests, parks and other areas where traffic volumes are low. They can generate a significant amount of erosion during their construction and operation. This can have a negative environmental impact through accelerated erosion and the subsequent deposition of sediment in waterways and on adjacent land, with potential impacts on flora and fauna. Appropriate planning and design, good construction practice and active maintenance of unsealed roads can minimise erosion and off-site sedimentation significantly.

## 1.2 Purpose and scope

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The purpose of this document is to provide guidelines, principles and recommended design standards for good management practice in erosion and sediment control for unsealed roads. The target audience for this document includes those within local government, State government, utility providers, consulting firms, landholders and contractors who have a role in the planning, design, construction or maintenance of unsealed roads in New South Wales.

This document guides the user in applying the principles and practices of erosion and sediment control described in volume 1 of *Managing urban stormwater: soils and construction* (Landcom 2004a) to the planning, design, construction and maintenance of unsealed roads. It should therefore be read and used in conjunction with volume 1. While some of the key elements of volume 1 are outlined in this document, the reader will also need to access the background information and technical detail provided in volume 1. The reader is also referred to *The hip-pocket handbook* (Landcom 2004b), which is a small generic field guide for the use of contractors and others responsible for constructing and maintaining erosion and sediment controls in the field.

Throughout this report, cross-references to *Managing urban stormwater: soils and construction* vol. 1 (Landcom 2004a) are shown in bold, for example, see **1**: section 5.3. Similarly, references to *Managing urban stormwater: soils and construction* vol. 2 (DECC 2007) are shown as, for example, **2**: *A Installation of services*.

The principles of erosion and sediment control for urban development sites, as described in volume 1, apply equally to unsealed roads. Unsealed roads, however, have a number of key characteristics and differences relating to their planning, design, construction and maintenance:

- they are linear
- they cross multiple catchments and have numerous site discharge points
- the road corridor can be a limited width, with a designated easement for some types of unsealed roads and no easement boundary for others
- erosion and sediment control is an important issue during both the construction of the road and its ongoing operation
- specific works (e.g. bridges, culverts, causeways and borrow pits), road safety and constructability may all influence the selection and location of erosion and sediment control measures.

This publication updates the guidance provided by guidelines and manuals developed previously by various NSW government authorities regarding unsealed roads and tracks

– their planning, construction and management. It does not specifically apply to those activities undertaken by Forests NSW.

The different types of unsealed roads found across New South Wales may have different planning, design, construction and maintenance requirements in relation to erosion and sediment control. This document does not address the broader environmental issues associated with unsealed roads, however. Many potential environmental impacts, including impacts on flora and fauna, often relate to the selected route of the road, and should therefore be identified and assessed in the project planning and environmental assessment phase.

### 1.3 Structure of this document

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**Section 2** summarises NSW statutory requirements applicable to the erosion and sediment control aspects of the planning, construction and maintenance of unsealed roads

**Section 3** discusses how erosion and sediment control issues should be considered when selecting a route for an unsealed road

**Section 4** describes erosion and sediment control plans for unsealed road projects

**Section 5** presents detailed design considerations to address erosion and sediment control on unsealed roads

**Section 6** discusses erosion and sediment control when constructing an unsealed road

**Section 7** outlines operational phase considerations for unsealed roads

Appendices provide a sample erosion and sediment control plan (ESCP) for the construction of an unsealed road and a maintenance checklist for its operational phase.

### 1.4 Classification of unsealed roads

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An unsealed road is defined as a road with a surface that comprises either natural material or gravel, and is not surfaced by asphalt or concrete. There are a number of different types of unsealed roads, including:

- public roads
- Crown roads (reserved roads and boundary roads)
- rights of access (right of carriageway under the *Conveyancing Act 1919*)
- access/maintenance tracks (for service utilities)
- reserve roads
- tracks in use (undesignated tracks that provide legal and practical access)
- private access tracks
- fire trails.

For the purposes of this document, unsealed roads have been categorised into three broad groups:

Group 1 – designated easement roads, including public and Crown roads

Group 2 – access/maintenance tracks, including fire trails

Group 3 – private access tracks.



Different road types can have different planning, design, construction and maintenance considerations and requirements because of their specific use patterns, safety requirements and traffic volumes.

## **1.5 Management principles**

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There are seven general principles of effective soil and water management for land disturbance associated with urban development (see 1: section 1.6). These principles broadly apply to the planning, design, construction and maintenance of unsealed roads and can be paraphrased as:

- assess the implications of a project for soil loss and water quality at the planning stage
- plan to control erosion and sediment during the design phase and before any earthworks begin
- minimise the area of soil disturbed and exposed to erosion
- conserve topsoil for later site rehabilitation/regeneration
- control water flow from the top of and through the project area – divert up-slope ‘clean’ water away from disturbed areas and ensure concentrated flows are below erosive levels
- rehabilitate disturbed lands quickly
- maintain erosion and sediment control measures appropriately.

Some long-term erosion and sedimentation from unsealed roads is inevitable. These principles provide a basis for minimising these problems with unsealed roads. They also provide a framework for applying the specific practices described in this document and in volume 1, and account for the influence of factors such as climate, topography and soil types.



## 2. Statutory requirements

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## 2.1 Overview

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A number of state and local regulatory authorities may need to be consulted during the planning process to ensure that unsealed roads meet all necessary statutory requirements for erosion and sediment control. These agencies may also need to be consulted during the preparation of various plans such as ESCPs.

Legislation to be considered in the planning and design stages of an unsealed road project includes the development assessment framework and provisions of the *Environmental Planning and Assessment Act 1979*. These are likely to apply to many unsealed roads projects, particularly for roads within groups 1 and 2 (see table 1.1).

The main pieces of legislation that relate specifically to erosion and sediment control aspects of unsealed roads, but which may also have broader applicability to the project are:

- *Protection of the Environment Operations Act 1997*
- *Roads Act 1993*
- *Rivers and Foreshores Improvement Act 1948*
- *Fisheries Management Act 1984*.

Other Acts which may need to be considered in the project planning phase, and which may indirectly influence aspects of erosion and sediment control (e.g. through route selection), are listed below, but are not discussed in any detail in this document:

- *National Parks and Wildlife Act 1974*
- *Native Vegetation Act 2003*
- *Soil Conservation Act 1938*
- *Threatened Species Conservation Act 1995*
- *Water Management Act 2000*.

For a more detailed description of relevant legislation, see **1**: appendix K.

The information below was current at the time of publication. However, statutory requirements and the roles of government agencies can change over time – all parties should check that this information is current during the planning stage of their project.

## 2.2 Relevant legislation

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### Protection of the Environment Operations Act 1997

The NSW Department of Environment and Climate Change (DECC) is the regulatory authority for:

- activities listed in schedule 1 of the *Protection of the Environment Operations Act 1997* (POEO Act)
- activities carried on by a state or public authority
- other activities in relation to which a licence regulating water pollution is issued.

Local councils are the regulatory authority for other activities.

While unsealed roads are normally not the subject of an environment protection licence under the POEO Act, their construction and maintenance should comply with the provisions of the Act, including section 120 of the POEO Act, which prohibit the pollution of waters except in accordance with a licence.

## **Roads Act 1993**

The Roads Act, among other things, establishes the authorities responsible for roads, provides for the classification of roads and sets out the procedures for the opening and closing of roads. Authorities responsible for roads in NSW include:

- the Roads and Traffic Authority of NSW (RTA) – for all freeways, land held by the RTA and roads in the unincorporated area of western NSW
- local councils – for all public roads within their local government area, except for any Crown public road or any public road declared under the control of some other road authority
- Crown Lands NSW, Department of Lands, as the roads authority for all Crown public roads
- specified public authorities (e.g. the Lake Illawarra Authority) responsible for all public roads in a declared area.

## **Rivers and Foreshores Improvement Act 1948**

Activities associated with the construction of unsealed roads that require a permit under the Rivers and Foreshores Improvement Act include any that have the potential to result in the excavation or removal of material from the bank, shoreline or bed of any river, lake, coastal lake, lagoon or land within 40 metres from the top of the bank or shore of any water body, or that have the potential to obstruct the flow of water in a river, lake, coastal lake or lagoon.

This Act is administered by the Department of Water and Energy (DWE), except in relation to navigable waters which come within the jurisdiction of NSW Maritime. The appropriate agency should be consulted in relation to the design and construction of unsealed road crossings of streams or other waterways. Approval requirements under the Act are scheduled to be replaced in 2007 by new provisions under the *Water Management Act 2000*.

## **Fisheries Management Act 1994**

The NSW Department of Primary Industries (DPI) is responsible for the administration of the Fisheries Management Act. This Act provides a comprehensive framework for the sustainable management of fish resources. The former NSW Fisheries has been incorporated into the DPI.

Under the Act, a permit is required for any activity associated with unsealed roads that involves dredging or reclamation works or that has:

- the potential to block the passage of fish (e.g. road crossings)
- the potential to harm marine vegetation.

The following publications provide further guidance on the requirements of this Act:

- *Policy and guidelines – aquatic habitat management and fish conservation* (NSW Fisheries 1999)
- *Policy and guidelines for fish-friendly waterway crossings* (NSW Fisheries 2003)





## 3. Route selection

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### **3.1 Importance of route selection**

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Route selection heavily influences the long-term erosion and sedimentation from an unsealed road. Where the choice of route selection is limited, for example because of existing easements and adjacent land uses, the application of other principles of erosion and sediment control becomes increasingly important. Where few limitations exist, an appropriate route can minimise adverse environmental impacts as well as the costs of construction, temporary control measures and on-going maintenance by minimising the potential for erosion.

The impact of unsealed roads on the environment can be dramatically reduced by applying the principles and practices in this section when selecting a route for an unsealed road and assessing its physical constraints (see also 1: section 3.2, appendices A and C).

The purpose of the planned unsealed road will assist in determining the formation width requirements and shoulder width requirements, which will in turn determine its location, the limits of clearing, pavement standard and drainage requirements.

In addition, the type and volume of authorised and possibly unauthorised traffic will potentially influence the location and width of clearing and drainage requirements including, for example, for turnaround bays or lay-bys required for fire-fighting vehicles.

### **3.2 Road location**

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From an erosion and sediment control perspective, the following principles should be considered in selecting the location of new unsealed roads:

- reduce the catchment area above the road or track by locating the road along a ridge or as high as possible on side slopes
- minimise disturbance to soil and vegetation
- minimise the number of watercourse and drainage line crossings
- avoid steep cross-slopes (greater than 18 degrees)
- avoid high erosion hazard soils (e.g. dispersive soils, soil loss classes 5, 6 and 7)
- avoid areas of riparian vegetation and maintain buffer strips between the road and any watercourse
- avoid areas where there are perched water tables, swamps, or areas of poor drainage
- avoid areas prone to mass movement
- avoid soil types having poor construction quality.

Alternative routes for the proposed unsealed road or track should be considered if an assessment of the above issues finds that the proposed route has an unacceptably high erosion or environmental hazard, or high construction or maintenance costs.

Additional environmental considerations apply when selecting the location of unsealed roads, for example, by avoiding areas with high conservation value. However, detailed discussion of these issues is beyond the scope of this document.

### **3.3 Erosion hazard**

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Erosion hazards along a proposed route should be identified as part of the route selection assessment. Where practical, the route should avoid areas of high erosion hazard.

The erosion hazard should be assessed as recommended in **1**: section 4.4 and identified on design drawings. Due to the linear nature and length of unsealed roads and tracks, the erosion hazard is likely to vary along the road. Erosion hazard maps to assist in project planning are available from DECC.

The following physical attributes should be included in an erosion hazard assessment along the proposed route of an unsealed road or track:

- climate
- topography
- geology
- soil type
- drainage and surface hydrology.

These attributes are explained in more detail below.

## **Climate**

The assessment of local climatic conditions, particularly rainfall erosivity, assists in the assessment of erosion risk associated with a proposed unsealed road. For example, in areas of high-intensity, high-erosivity rainfall, it is particularly important to minimise the size of the catchment above a road to reduce the potential for erosion along the road. This can be achieved by constructing it along ridges, or as high up as possible on side slopes, and minimising the road's gradient.

Assessing climate requires rainfall patterns, such as seasonality, volumes, intensities and erosivity (R factors) to be considered (see **1**: appendix B for R factors across NSW).

## **Topography**

Topographic constraints that should be identified along a proposed route include steep slopes (e.g. greater than 20% or 10 degrees) and rock outcrops. The route should avoid areas with significant limitations. The route should take advantage of topographic opportunities, such as locating the road or track on high ground to minimise drainage requirements, and following the contour of the land to reduce requirements for cut and fill works.

## **Geology**

Road construction in areas with unstable geology or highly weathered rock may risk mass movement. The route should either avoid these areas or incorporate appropriate designs to minimise risk.

## **Soil type**

The identification of soil types along a proposed route will determine the location of potential 'problem' soils, such as:

- soils with a high erodibility
- shrink/swell, reactive or high plasticity soils
- highly saline soils
- potential or actual acid sulphate soils
- dispersible soils
- soils with abundant cobbles (greater than 60 millimetre diameter)
- soils prone to waterlogging (seasonal or permanent) and mass movement



- soils with low wet-bearing strength and high organic content
- Soils in the SM and CL class of the Unified Soil Classification System and in particular GP, SP, ML, OL, MH, CH, OH, and PT class soils.

Planning can then assess the severity of the issue, the potential impact on the selected route and whether appropriate design can effectively manage the issue. DECC can provide soil landscape maps and other guidance on the capability of soils for the construction of unsealed roads.

## **Drainage and surface hydrology**

During the route selection process, every attempt should be made to minimise the number of watercourses and drainage line crossings along an unsealed road or track. Crossing locations, where unavoidable, should be selected such that crossing approaches will be perpendicular, or nearly so, to the drainage line, unless an angled approach would further reduce disturbance.

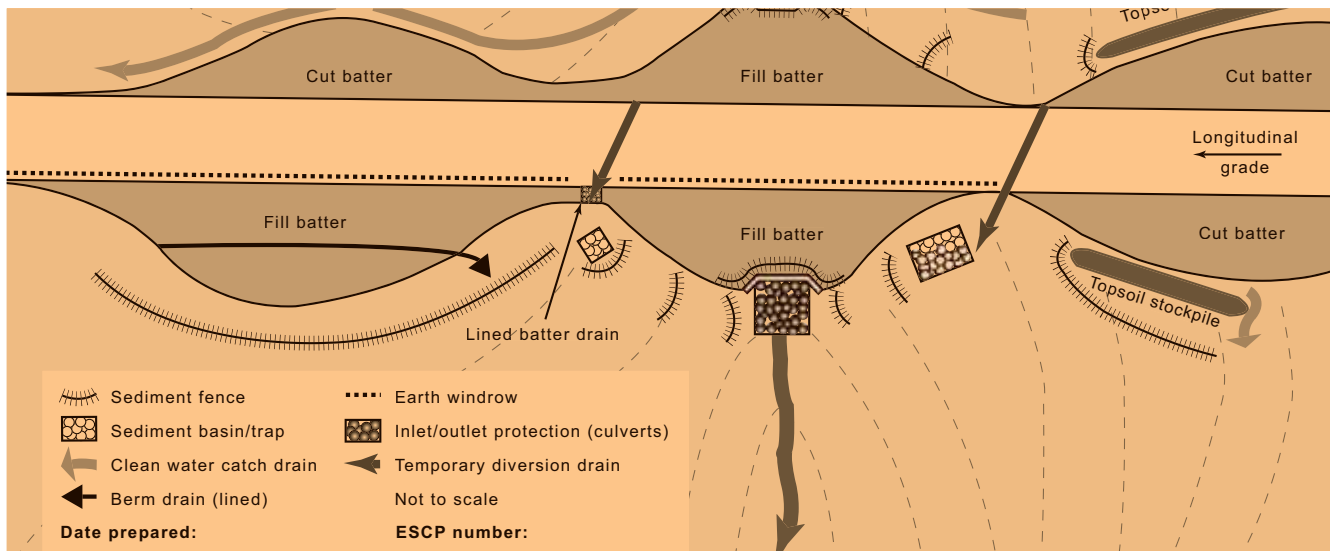
This approach will reduce the impact on the crossing by:

- minimising disturbance and the potential for erosion of adjacent banks or bed of a drainage line
- reducing bridge spans lengths and the number of piers required.

As noted in section 3.2, unsealed roads and tracks should be located along ridges or as high as possible on side slopes to reduce the catchment area above a road and reduce the number of drainage line crossings. Wetlands, swamps, areas prone to flooding (e.g. more frequently than the 20-year-average recurrence interval (ARI) and areas with wave erosion hazard) should be avoided (see 1: section 5).

Perched water tables should also be identified and avoided, because the frequent saturation of surface and subsurface soils can lead to mass movement. This is particularly relevant in alpine areas subject to snowmelt.

Floodplain areas in western NSW, where flow paths are often difficult to determine in the dry season due to their indeterminate channels and flat grade, require careful assessment to ensure that the route selected will not increase erosion of adjacent areas.



## 4. Plan preparation for unsealed roads

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## 4.1 Planning permanent and temporary measures

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Section 1.2 notes that effective erosion and sediment control is important during both the construction and operation of an unsealed road. This contrasts with sealed roads and many other forms of development where post-construction erosion and sediment control is a relatively minor issue.

The objectives for long-term erosion control for unsealed roads are similar to those applying during the construction phase noted in section 1.5. Appropriate geometric design of an unsealed road and the design of its drainage system are the keys to effective long-term erosion and sediment control.

The geometric design will determine the size of the catchment for drainage systems and the extent of the area to be disturbed. The permanent drainage system design should aim to control upstream flows across an unsealed road so as to minimise the risk of erosion while conveying runoff quickly away from the road itself using, for example, mitre drains. This will involve:

- controlling water flow from above and within the unsealed road corridor by diverting up-slope 'clean' water away from the unsealed road (e.g. through use of catch drains and berm drains to protect cut batters)
- ensuring any concentrated flows within the road corridor are below erosive levels, where erosion protection is not provided. Suitable drain and channel linings should be provided where flow velocities exceed erosive levels for the underlying soil material
- selecting batter grades and batter stabilisation treatments (see 1: section 4.4.2 for constructed slope length and gradient requirements on sites of high erosion hazard)
- protecting culvert inlets and outlets (e.g. with energy dissipators).

Road designers should be aware of the principles of erosion and sediment control as they relate to surface stormwater management. They should provide for all flows to be conducted along or through the corridors by stable and permanent measures (e.g. catch drains, lined channels and batter chutes) from the upper limits of the corridor catchments (e.g. top of cut batter or upstream boundary on flow line) down to the final points of discharge.

The detailed design should result in sets of drawings that illustrate and detail all the information required to construct the road, including the permanent road geometry and the drainage system. These design drawings are needed for the development of temporary erosion and sediment control during road construction.

The design drawings should include all measures for permanent stormwater management, and erosion and sediment control (e.g. lined catch drains, batter chutes, culverts, outlet dissipaters, sediment basins). Techniques for long-term erosion and sediment control are described in section 5, with maintenance considerations discussed in section 7.

However, it is usually the construction contractor who is responsible for the final selection and location of temporary control measures such as sediment fences, straw bale sediment traps and temporary diversion banks. Designers should not normally specify a location for these in design plans issued for tender as the final location may change regularly during construction, and the contractor would specifically address the location and management of different measures in their progressive ESCPs.

## 4.2 Planning framework for unsealed road construction

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Volume 1 of *Managing urban stormwater: soils and construction* defines a requirement for the preparation of an ESCP for small urban development projects where an area between 250 and 2500 m<sup>2</sup> will be disturbed, and a more broadly focused and detailed soil and water management plan (SWMP) for projects where more than 2500 m<sup>2</sup> is to be disturbed.

This precise application of this area-based approach is not considered suitable for the road construction industry. It is recommended that an ESCP be prepared to address erosion and sediment control for all unsealed road projects where more than 250 m<sup>2</sup> will be disturbed, with the level of detail presented in that plan reflecting the nature and scale of the project, the site and the surrounding environment, as described in the following sections.

ESCPs for unsealed roads should focus on the construction phase, as discussed in section 6, rather than on road design, discussed in section 5.

Other construction-phase water management issues associated with large-scale road construction projects will typically be addressed in a more broadly focused project or construction environmental management plan (PEMP or CEMP) or in a SWMP that forms one component of a PEMP or CEMP. Such issues include:

- potential groundwater changes and contamination
- water extraction from rivers and creeks
- the management of concrete materials
- storage, usage and management of fuel and chemicals on a site
- the management of curing compounds
- wastewater management and treatment
- emergency response to environmental incidents
- water quality monitoring
- documentation procedures
- work method statements
- subcontractor requirements.

The development consent conditions or contract requirements placed on an unsealed road project may specify the requirement for an ESCP, SWMP, PEMP or CEMP to address environmental issues and their management. All soil and water management issues associated with unsealed road projects should, however, be adequately addressed within a PEMP/CEMP and an ESCP, with the latter sitting directly under the PEMP or CEMP and focusing solely on erosion and sediment control. That is, SWMPs should generally not be required, except in the absence of a PEMP or CEMP. As discussed in section 4.3, the size and complexity of a project will determine the necessity and complexity of these plans.

## 4.3 Erosion and sediment control plans

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### Primary and progressive ESCPs

Volume 1 provides general guidance on the preparation of ESCPs. Due to the unique nature of road construction projects (and many of the particular issues noted in section 1.2), contractors have generally found that use of a multi-part ESCP (comprising primary and progressive ESCPs) allows operational flexibility for planning appropriate control measures.

The primary ESCP is a broad-based framework that outlines the intentions and fundamental principles that will be followed in planning and implementing control measures for an entire project. The primary ESCP is prepared as a document and usually includes standard drawings of control measures to be used in the project. It is often supplemented with a series of subordinate 'progressive' ESCPs.

Progressive ESCPs detail the specific location and type of individual erosion and sediment control measures along the project. These should be consistent with the approach outlined in the primary ESCP, referencing standard drawings in the primary ESCP as appropriate.

Progressive ESCPs are prepared with construction personnel to formulate practical documents for field reference. They are prepared on relevant copies of the drawings, particularly for:

- stockpiling with revision for bulk earthworks (figure A2.1)
- areas of high erosion hazard (e.g. culvert construction, bridge abutments and areas with significant limitations, such as steep slopes (figures A2.2, A2.3))
- specific areas that may occur outside the road alignment (e.g. compound, stockpile sites and access roads).

Progressive plans should be reviewed and updated as construction activities change, for example, from the clearing and grubbing stage to bulk earthworks and drainage works.

Accordingly, it is important to maintain a register of these progressive ESCPs on site, to ensure that:

- there is no confusion regarding which ESCP is current
- appropriate processes are followed in the planning, implementation and decommissioning of erosion and sediment controls during the life of the project.

### Content, complexity and detail

For the basic requirements of an ESCP, see 1: section 2.2. Table 4.1 outlines the typical contents of primary and progressive ESCPs. For the construction of unsealed roads, it is important to adopt a practical and realistic approach for ESCPs. The requirements and level of detail for a project should be a function of:

- its scale, in terms of both the duration and the degree of earthworks required
- its location, in terms of soil erodibility, the erosivity of local rainfall patterns and overall erosion hazard
- its proximity to sensitive receiving environments, such as those with high conservation value.

In general terms, an ESCP should be prepared for all unsealed roads categories (see table 1.1), except where erosion hazard and the risk of environmental degradation is

likely to be low, including in areas of Western NSW. Appropriate erosion and sediment control measures should nonetheless be implemented in these areas, particularly in the vicinity of creek crossings. For smaller projects, a single ESCP could be prepared that covers all aspects of the primary and progressive plans required for larger projects.

Appendix A presents a sample primary ESCP and progressive ESCPs.

<b>Table 4.1 Typical contents of primary and progressive ESCPs</b>	
<b>Primary ESCP</b>	<b>Progressive ESCP</b>
Introduction	Date ESCP prepared and who prepared it
Project description	Contours and drainage paths
Scope	Chainages
Description of soil types including their potential for erosion, topography, sensitive areas, rainfall characteristics and erosivity (see 1: section 4)	Extent of earthworks
Risk assessment	Limits of clearing/disturbance
Supporting publications	Specific control measures and their location
Key strategies to minimise erosion and off-site sedimentation. These may include:	Specific construction details/notes
<ul style="list-style-type: none"> <li>• training and induction</li> <li>• minimising disturbance and clearing, and delineating limits of clearing</li> <li>• topsoil management</li> <li>• implementation schedule of erosion and sediment control measures</li> <li>• early installation of drainage</li> <li>• control of runoff onto, through and off site</li> <li>• development of work method statements for works around watercourses and/or sensitive areas</li> <li>• establishment of an inspection and maintenance program</li> <li>• progressive revegetation</li> <li>• water quality monitoring program.</li> </ul>	Note linking plan back to primary ESCP
Documentation – erosion and sediment control implementation, inspections and maintenance	Note whether a more detailed progressive ESCP or work method statement has been prepared for a section shown on the plan (e.g. a culvert or bridgeworks)
Design criteria	
Attachments	
<ul style="list-style-type: none"> <li>• standard ESC forms, etc.</li> <li>• standard drawings</li> </ul>	
Calculations	





## 5. Road design considerations

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## 5.1 Longitudinal grades

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The longitudinal grade of an unsealed road or track should ideally be less than 10 degrees (18%). However, short lengths of steeper grade (up to 15 degrees or 27%) may be needed to:

- negotiate rock outcrops, unstable soils or poorly drained soils
- take advantage of a suitable bench or saddle
- take advantage of soils which are more suitable for the construction and drainage of the road
- reduce the catchment area above the road.

In designing sections with grades exceeding 10 degrees, it should be noted that effective, easily trafficable cross-banks can be built only on tracks with grades generally less than 12 degrees (21%). Graveling and more sophisticated road drainage may be required where grades are required to exceed:

- 15 degrees on soils of low erodibility
- 12 degrees on soils of moderate erodibility.

Unsealed roads and tracks on grades exceeding 10 degrees on high erodibility soils should be avoided. It is recommended that unsealed roads or tracks should not be constructed on grades exceeding 18 degrees (33%). Steep slopes should be avoided wherever possible.

If any section of a proposed route is determined to have an erosion hazard greater than the A-line in 1: figure 4.6, then that section should be deemed as having a high erosion risk and designers should apply the principles in 1: section 4.4.2.

Unsealed roads and tracks should have at least a slight cross-sectional grade to allow free surface drainage and to avoid excessive ponding in wheel tracks. Sections of ineffectively drained unsealed roads and tracks can quickly become untrafficable, especially in areas of moderate to high erodibility.

## 5.2 Maximum clearing width

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The clearing width should be limited to a maximum of between 2 and 5 metres from the edge of any construction activity (see 1: table 4.1), unless otherwise specified or required. The clearing width can be increased to accommodate, where required:

- road drying
- an increased line of sight at corners
- curves
- turning bays.

### 5.3 Batters

A batter is the face of an embankment or cutting produced as a result of earthmoving operations involving cutting or filling. A cut batter is the face that is exposed as a result of the excavation while a fill batter is the face created by the placement of soil material.

The large, sometimes steep, areas exposed during cut and fill operations can present a significant erosion problem. Rainfall impact on a batter slope, run-on water onto a cut batter, erosion of the batter toe and runoff over unconsolidated fill material can all contribute to erosion and compromise the integrity of a batter.

Cut and fill batters should be designed to be no steeper than the in-situ soil stability permits (see table 5.1 for guidance, or undertake geotechnical assessment). For an indication of maximum batter slopes to minimise batter erosion, see 1: figures 4.7 and 4.8.

For stability, the following factors should be considered during the design of batters:

- the batter should not exceed the maximum permissible slope
- the dip angle of the rock should be taken into account as rock dipping towards a cutting is prone to mass movement. Where this is unfavourable and unavoidable, batters should be laid back or benched to reduce the exposed vertical height
- fills higher than 1.5 metres constructed from soils with a moderate or high erodibility (as defined in 1: table 5.2) will require special stabilisation works, such as batter drains and mulching
- fill material should not contain large rocks or vegetative debris as these prevent effective compaction
- catch drains above a cut batter may be required to prevent run-on water flowing onto the cut batter (figure 5.1)
- batter drains may be required to transfer water down the slope over a fill batter if alternative discharge sites are not available (e.g. at the cut/fill line) (see figure 5.1 and 1: section 5.4.4 for further information)

**Table 5.1 Recommended maximum batter slopes according to soil type or rock stability**

<b>Soil or rock type</b>	<b>Slope (horizontal:vertical)</b>
Rock – slip plane horizontal or dipping away from cutting	0.5:1
Rock – slip plane dipping toward cutting	1.5:1
Well-graded gravels	1:1
Poorly graded gravels	1.5:1
Clayey or silty gravels	2:1
Silts and fine sands	3:1
Clayey sands	2.5:1
Sandy clays	2.5:1
Clays	2:1

Source: adapted from Wallis (1996)

- berm drains are installed on batters that have been breached due to the height of the batter. They are constructed at the toe of the bench on a 2–3% grade and directed to the end of the batter. The drain's outlet discharges onto a stable surface adjacent to the batter or into a lined catch drain
- permanent drainage should be provided at the toe of cut batters and at the top of fill batters
- energy dissipaters are required at the end of chutes and culverts (see 1: section 5.4.5 for specific information on energy dissipaters).

In some circumstances, near-vertical batters may be necessary, particularly when cutting through rock or compacted subsoils. A wider horizontal area is required between the toe of the batter and the road in these instances. Occasionally, barriers may have to be erected to restrict slumped material from entering drainage structures and to act as retaining walls on smaller batters (see figure 5.2).

## 5.4 Surface drainage

Effective surface drainage is required on unsealed roads and tracks to minimise erosion by controlling runoff. All unsealed roads and tracks should be constructed with adequate permanent drainage. The design peak flow discharge should be calculated on a site-by-site basis and will depend on the type of unsealed road, the sensitivity of receiving waters and the environment, and other consequences of drainage structure failure. These structures are commonly designed to convey a 5-to-10-year ARI design flow. For more information on managing concentrated flows, see 1: section 5.4.3.

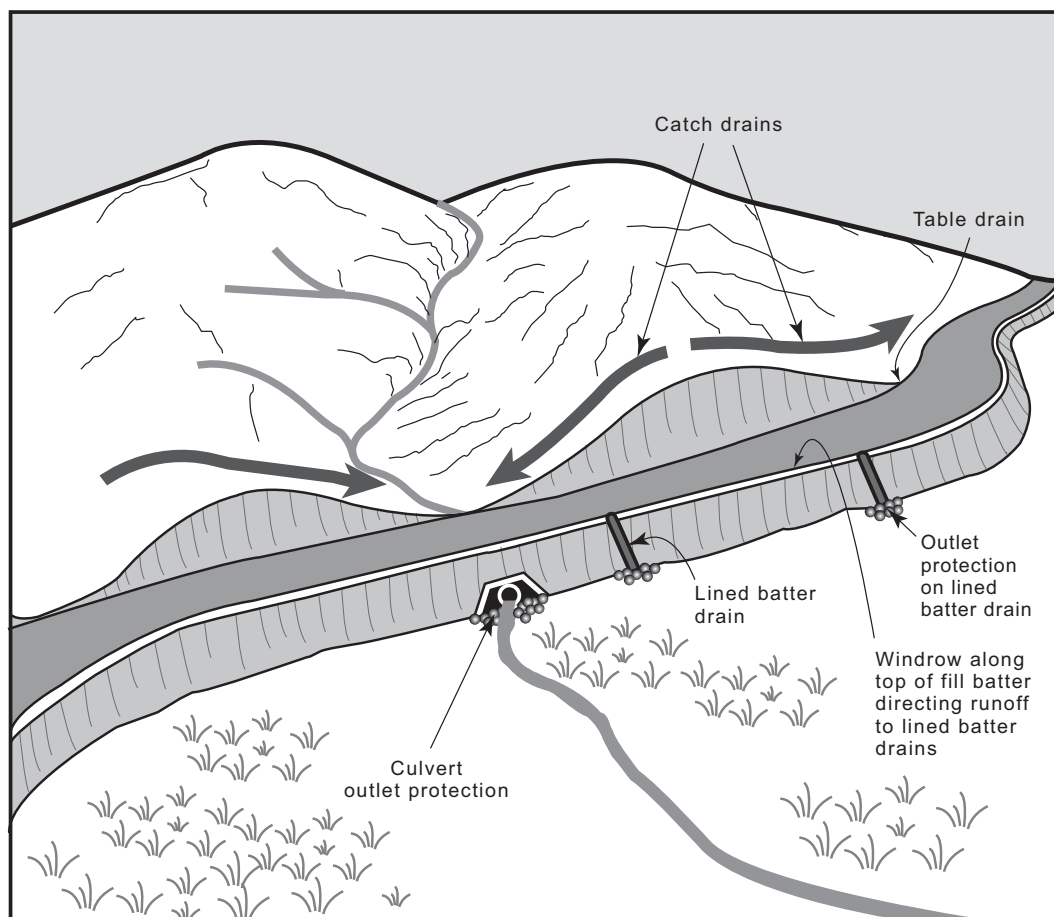


Figure 5.1 Batter protection techniques

A number of types of drainage structures can be used to provide surface drainage. The following text details a range of the more commonly used drainage structures on unsealed roads and tracks.

## Cross-drainage

To minimise erosion, two techniques can be used to remove water from a road surface – crowning and cross-fall drainage (figure 5.3).

### Crowning

This technique involves ‘crowning’ the centre of the road 150–300 millimetres above the surface of the table drain or natural surface, directing water to either side of road. This technique is often used on roads along ridges or where the terrain has a relatively low grade.

### Cross-fall drainage

The second technique may take the form of either outfall or infall drainage. These techniques are used on roads where there is sufficient cross-slope to cause water to flow across the road surface rather than along it.

### Outfall drainage

Outfall drainage refers to the situation where the road surface slopes away from a cut batter or hillside with water flowing evenly to the lower side of the road. The cross-slope required to achieve such drainage is commonly 1:15 or less and should normally not exceed 1:10 for safety reasons. Outfall drainage is achieved by grading a road surface so that there is a downward slope across the road, away from the toe of the cut batter, to the shoulder of the fill.

In situations where the fill batter is not stable, table drains, compacted earth windrows (a bund along the top edge of a fill batter) and batter drop-down drains are generally required to ensure that runoff from the road surface flows down the fill batter in a controlled manner (without causing erosion). In most situations, it is not possible to achieve uniform sheet flow over a fill batter due to the uneven nature of vegetated batters and the usual presence of wheel ruts or depressions at the top of the batter which tend to concentrate runoff.

Outfall drainage is often preferred because it reduces the need for drainage structures and therefore reduces costs.

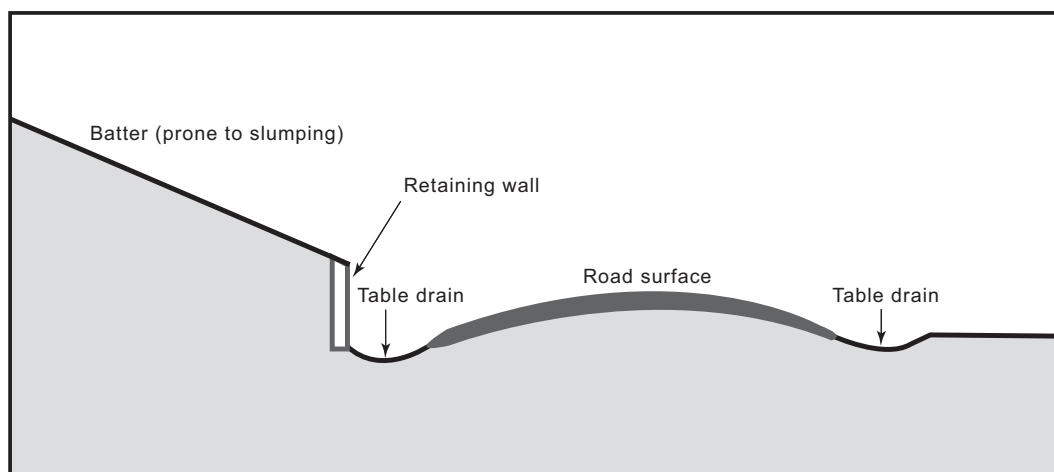


Figure 5.2 Retaining wall

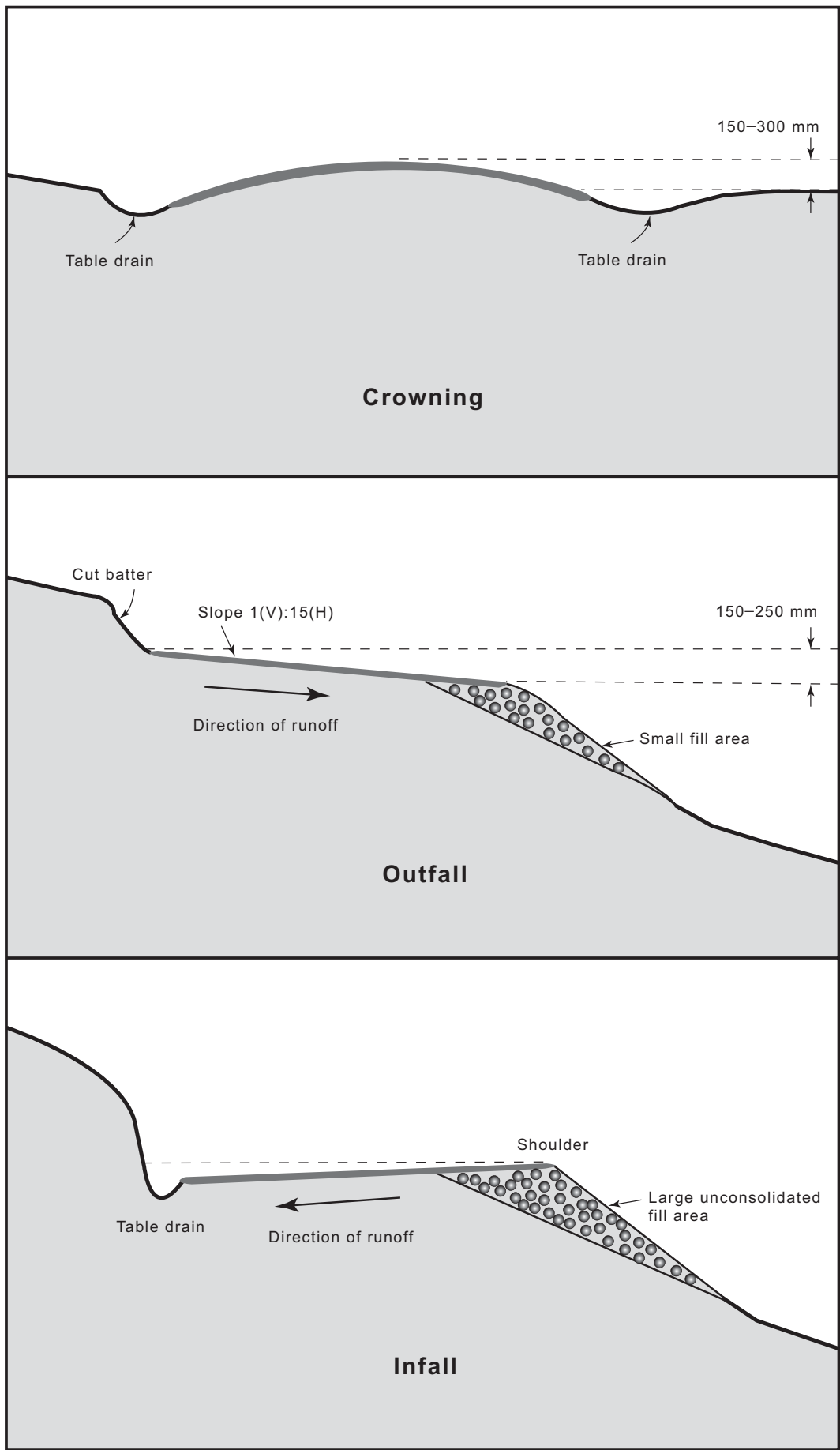


Figure 5.3 Types of cross-drainage

### ***Infall drainage***

Infall drainage occurs when surface flows are directed across a road surface, towards a cut batter or hillside, into a table drain. Stable table drains and adequate culverts or stabilised causeways are required at predetermined intervals to direct water in a controlled manner to the down-slope side of the compacted road. Infall drainage should be used where:

- fill batters are insufficiently compacted and likely to erode
- establishing adequate vegetative cover to prevent erosion is difficult
- fill batters exceed 1.5 metres in height.

Outfall drainage would normally be used in all other situations.

### **Cross-banks**

Cross-banks (or rollover banks), are earth banks with upstream channels used to minimise erosion by directing runoff across a road surface, minimising the concentration of runoff along the road and reducing runoff velocities. They are designed to collect road runoff at key locations (e.g. directly above an increase in track grade) and divert the cumulative flow across the surface of the road to a stable discharge point.

Public roads and some Crown roads have higher design speeds and greater usage which normally preclude cross-banks as a drainage solution. However, they are an important erosion control measure on lower class roads such as group 2 (access/maintenance tracks) and group 3 (private tracks). Correctly located and built, these banks provide effective, cheap, easily trafficable, and low-maintenance unsealed road drainage.

The following design issues should be considered when determining the location of cross-banks for an unsealed road:

- spacing of cross-banks
- location of stable and clear outlet points – the discharge site should be stable and clear of obstructions that may force the water back on the road
- location of short sections of flatter track grade, allowing cross-bank construction on a generally steep track.

### ***Cross-bank spacing***

The spacing of cross-banks will be dictated by soil type, slope, local rainfall characteristics and the existing track condition if cross-banks are being retrofitted to an existing road. The location of cross-banks should ideally be determined in the field as the design plan scale is often too large to provide the fine detail required for the selection of cross-bank locations. Table 5.2 provides guidelines for cross-bank spacing depending on soil erodibility (see also 1: table 5.2). This spacing is suitable for sites with moderate rainfall erosivity. Sites with low rainfall erosivity (see 1: appendix B) should have increased spacing, and high-rainfall-erosivity sites should have decreased spacing.

When assessing an existing road, note should be taken of where the road surface has begun to degrade, as evidenced by surface rilling or erosion in the table drain (figure 5.4). These points indicate where the runoff has developed enough energy to cause erosion and are key locations for cross-banks.

The stability of the road in operation will eventually dictate the need for variations in the location and spacing of cross-banks.

### ***Cross-bank capacity***

Cross-banks should normally be designed to have a minimum consolidated effective height of 300 millimetres. Road or track gradient and soil type will dictate the height for specific unsealed roads and tracks. The bank can be up to 0.6 metres from the base of the excavation to the top of the crest with a crest width of up to 2–3 metres, which will allow easy traversing by vehicles (figure 5.5).

### ***Cross-bank outlets***

A suitable outlet point for a cross-bank should be stable, level and not blocked by a stump or rock. Outlets should be located so that runoff will spill into undisturbed vegetation (where this does not have high conservation value) and not flow back onto the track (figure 5.6). Cross-bank outlets should not discharge onto areas directly adjacent or near to watercourses (see also 1: section 5.4.5).

### **Cross-drains**

Cross-drains are an alternative to cross-banks, used for lower road grades. They are effective, low-cost structures that help reduce runoff velocity and trap sediment. Cross-drains are excavated, dished drains in the road surface (figure 5.7). They are usually used only on minor unsealed roads and tracks (groups 2 and 3) and are not installed on public or Crown roads due to their design speeds and usage.

Road grade	Soil erodibility		
	Low	Moderate	High
Up to 8°	70 to 90 m	60 to 70 m	20 to 30 m
8° to 12°	60 to 70 m	60 to 50 m	*
12° to 16°	40 to 60 m	*	*
16° to 18°	40 to 30 m	*	*

\* indicates that tracks of the grade specified should not normally be constructed on these soil types. Cross-banks, combined with limiting or discouraging traffic access, may however be the best available means of erosion control on existing roads of these grades. Where tracks are constructed on slopes exceeding 12°, only light and infrequent traffic should normally be permitted. Source: modified from Department of Conservation and Land Management (1994)



**Figure 5.4** The result of a lack of drainage on a quarry access track

Cross-drains have a smaller capacity than cross-banks, with a greater likelihood of overtopping occurring on steep slopes. They should normally only be used on grades less than 18 degrees (10%). The spacing of cross-drains will depend upon soil type, slope, local rainfall characteristics and access to stable outlet points, and should be determined in the field for the same reasons as those for determining cross-bank spacing. Table 5.2 can be used as a guide for cross-drain spacing, adjusted for rainfall erosivity.

## Rolled grades

On many group 2 or 3 unsealed roads or tracks, the road surface is generally level with no crowning. Water can effectively be transferred off the road by 'rolling the grade'; that is, by installing a series of gently undulating dips along the road grade (figure 5.8).

This technique is used mainly on minor unsealed roads and tracks and is suitable for reasonably steep grades. Often the natural undulations of the terrain can assist in installing rolled grades, and will determine the frequency of the depressions.

The technique is usually incorporated into new road construction, although it can be used during road upgrades or maintenance works. The technique requires depressions to be excavated along the length of the road resulting in an undulating surface. It is important that within each of the depressions water can flow freely to a stable discharge site by installing the depression on an adverse grade and having the floor of the dip angled at 30 degrees to a line perpendicular to the direction of the road (figure 5.8).

Lined batter drains are recommended where rolled drains outlet onto unstable fill batters.

## Table drains

A table drain is a longitudinal drain that runs parallel to the road along the edge of the formation and is constructed as part of the road formation. The dimensions of a table drain depend upon the catchment size, soil types, slope and length of run between disposal points. To prevent erosion of the table drain floor, sufficient water disposal points, such as mitre or spoon drains, are required. Disposal points should be determined through appropriate design calculations to minimise erosion. Without adequate disposal points, table drains quickly erode, often reducing road trafficability.

The potential for erosion in the table drain can also be minimised by lining the table drain with rock, jute mesh or other erosion control products. For a guide to permissible flow velocities for a range of surface covers, see 1: table 5.2.

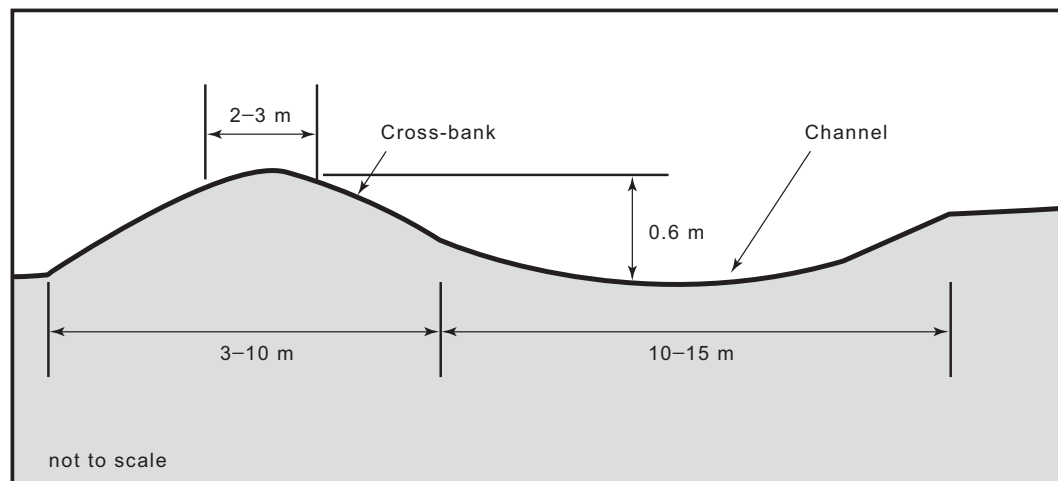


Figure 5.5 Cross-bank dimensions (modified from Beatty 1995)



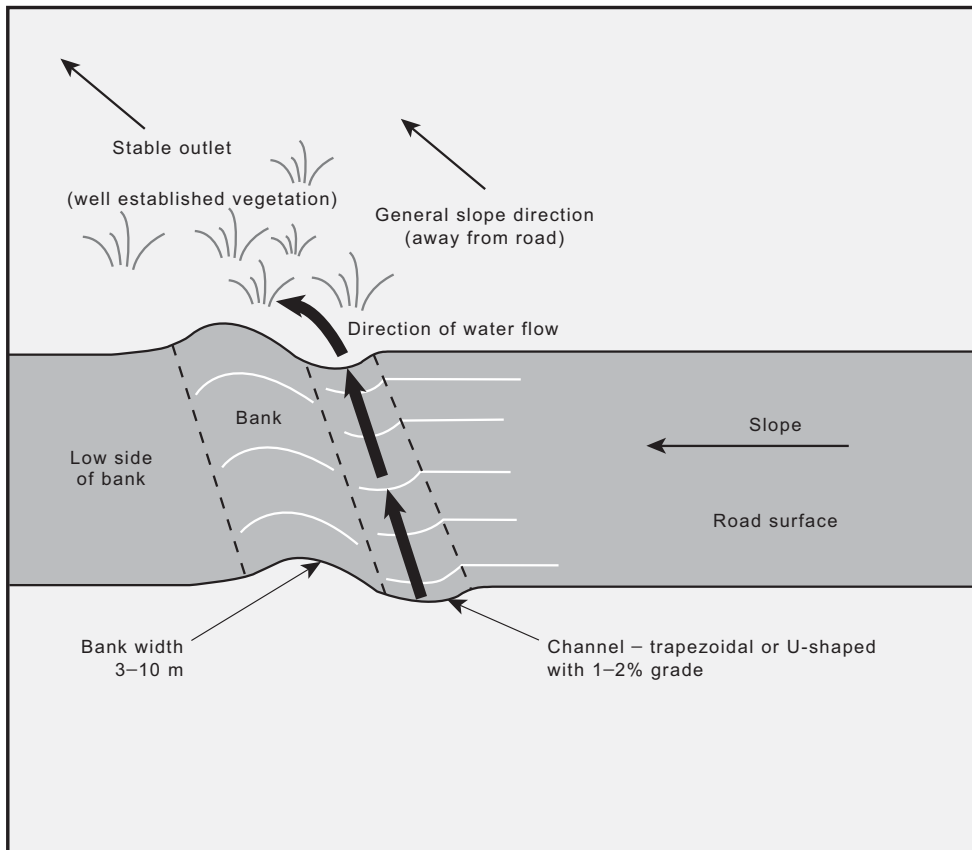


Figure 5.6 Cross-bank profile

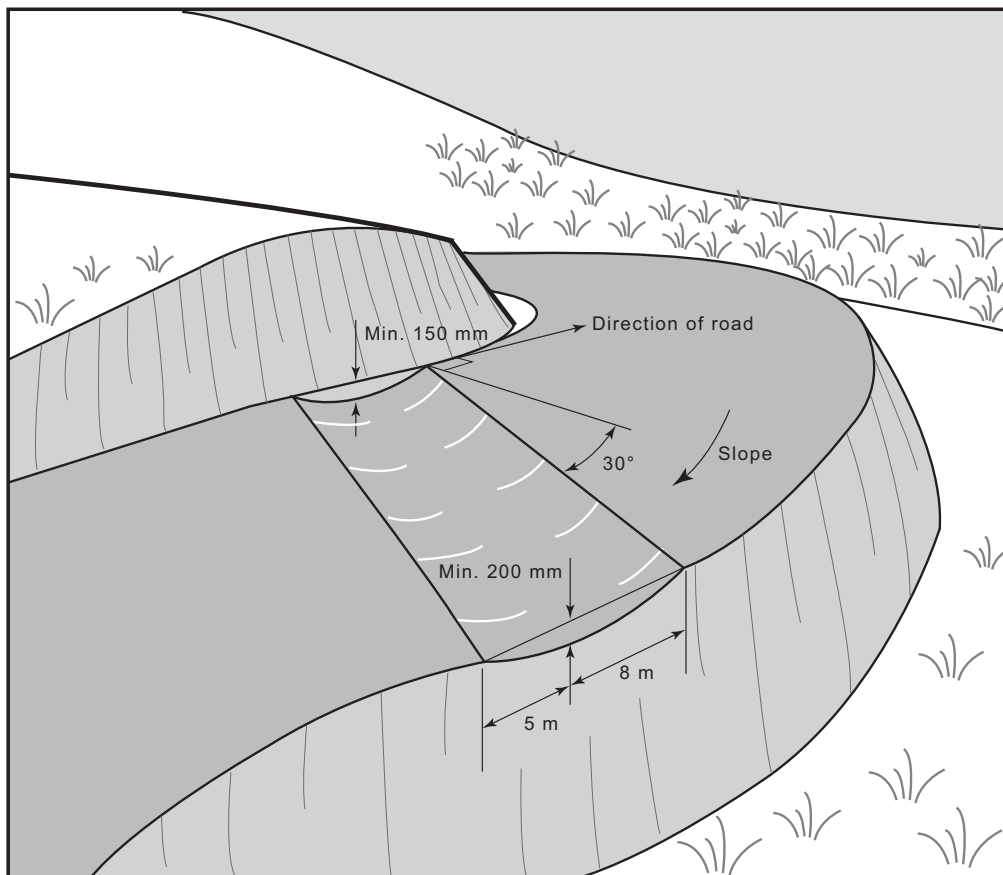


Figure 5.7 Cross-drain detail (modified from Garden 1988)

## Mitre drains/spoon drains

A mitre drain conveys runoff from the shoulders of an unsealed road or track to a disposal area away from the road alignment, but still within the road/track easement. They keep the flow of runoff to a non-erosive velocity in table drains by reducing the length of run and potential flow velocities, and diverting runoff onto a stable surface.

Mitre drains are a simple, low-cost drainage option that do not cause any impediment to vehicles or road speed, and are therefore suitable for all three groups of unsealed roads. Mitre drains are usually restricted to ridge-top roads or roads that have a low slope (less than 8 degrees or 14%). A combination of road crowning and mitre drains provides adequate drainage on ridge roads (figure 5.9). However they can be used intermittently with other 'in-road' structures to ensure road stability on steeper slopes. The frequency of use will be determined by soil type, catchment, rainfall characteristics and slope. However, a maximum distance of 50 metres between mitre drains should not normally be exceeded on soils with a low erodibility.

Mitre drains are often 'V' shaped in cross-section. However, where a drain is required to carry larger flows, a 'U' or trapezoidal shaped design will be more stable and have a greater capacity. They should have a grade of no more than 5 degrees or 1:20 (5%), sufficient to ensure the effective removal of runoff from the table drain (figure 5.10).

Mitre drains should not discharge to areas adjacent to or near watercourses or into high-conservation-value areas.

Spoon drains are drains that direct runoff away from the road or table drain in a similar manner to mitre drains. The main difference is that a spoon drain has an excavated sump or 'spoon' at its outlet. This acts as a sediment trap and reduces flow velocities before the runoff flows onto adjacent vegetation.

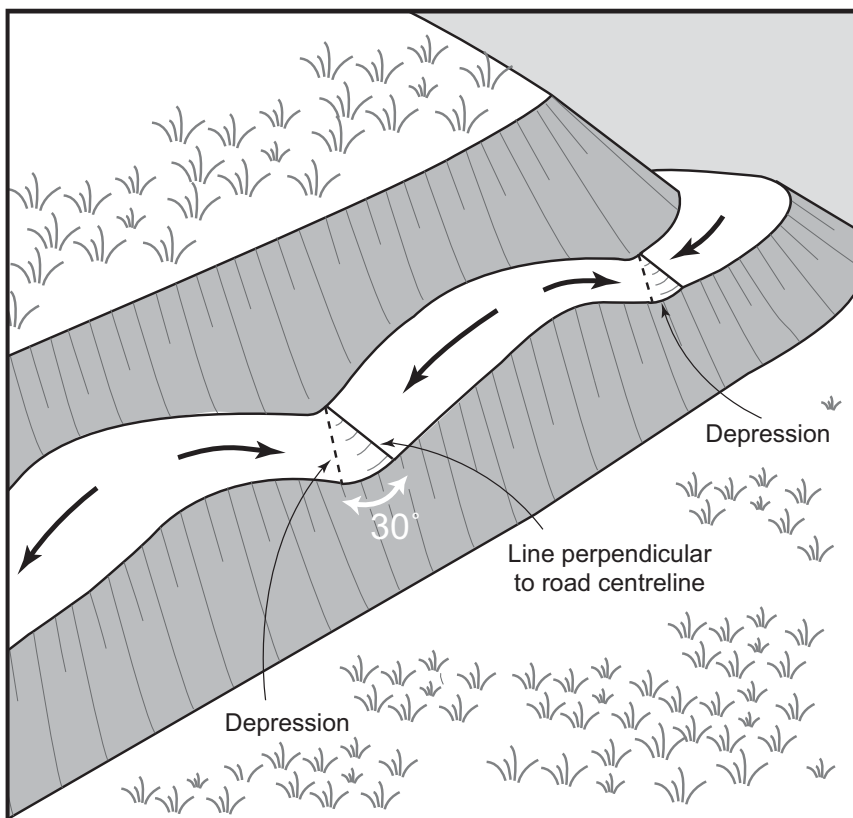


Figure 5.8 Rolled grade drainage (redrawn from Garden 1988)

## Catch drains

Catch drains are lined or unlined drains located along the top of cut batters that minimise erosion by directing runoff from the up-slope catchment away from the cut batter face to a stable outlet point. This could be a culvert, drainage line or vegetated slope. The size and lining of catch drains depends on:

- the size of the catchment above the cut batter (figure 5.11) and the rainfall characteristics
- slope steepness (both of the above catchment and steepness of the catch drain down a slope)
- length of the catch drain.

For a list of materials that can be used to line catch drains, see 1: table D1. Maximum design flow velocities for a variety of lining materials are given in 1: table 5.2.

## Flumes/batter drains

Flumes are structures that can convey water from a higher level down to another without causing erosion. In many instances it is necessary to install flumes to protect batters or to assist the transfer of road runoff away from erodible areas. All flumes consist of an inlet, a chute and an outlet. Flumes on batters are often referred to as batter drains. For examples of batter drains, see 1: figures 5.6 and 5.7.

Chutes carry the water down a slope and can be constructed from a variety of materials, depending on variables such as catchment size, rainfall characteristics, soils and vertical fall. Common materials include round or half-round pipes of galvanised steel and concrete, or they can be formed using rock, cement, geotextiles, jute mesh and bitumen or with the use of vegetation.

The inlet should be designed to ensure that all intended flows are directed into the chute. Diversion banks, box inlets or headwalls (or a combination of these) can achieve this. It is important that water does not escape around the inlet structure as this could cause the structure to fail and will affect the stability of the batter and increase the potential for erosion.

A batter may require more than one flume to successfully transfer the water down-slope, depending on the batter size, length of the fill, catchment size and the size of the structure. Flumes can also be used to carry water over unconsolidated fill batters. At the outlet of any flume it is important to install an energy dissipator (examples include rock or timber) to reduce water velocity and prevent scouring at the disposal point.

## 5.5 Drainage line crossings

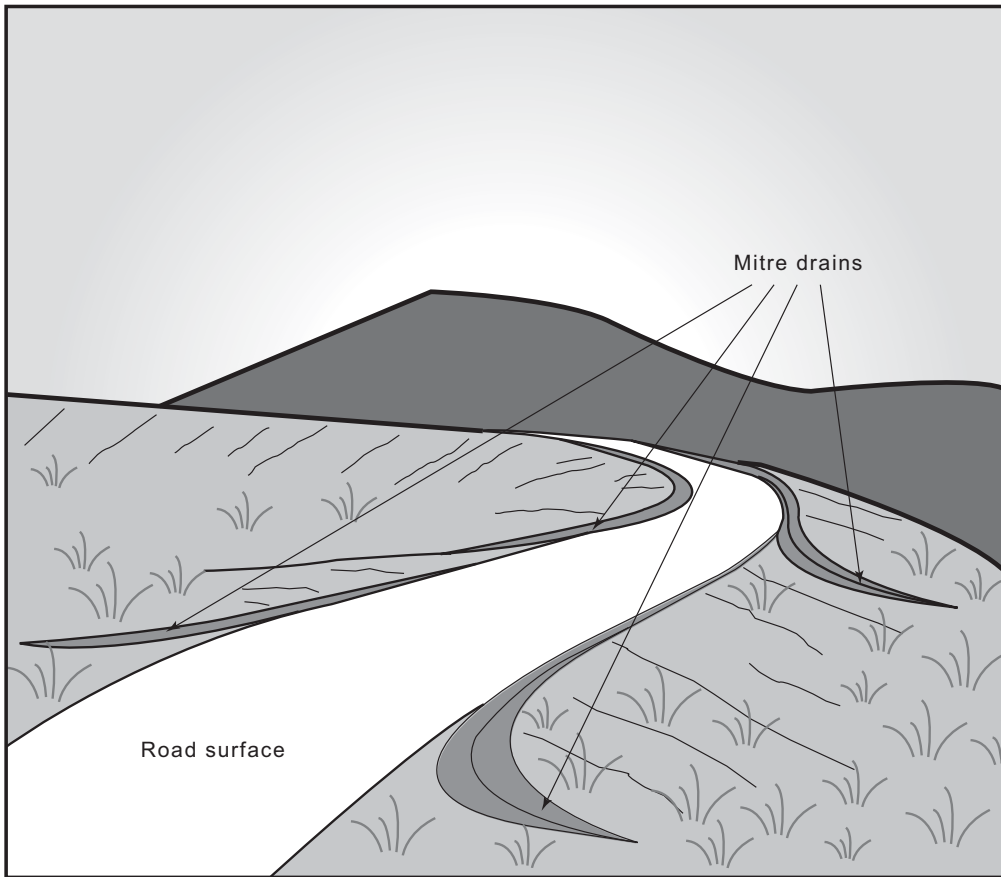
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Drainage lines should be crossed with fords, culverts or bridges. Log dam crossings should not be used as they obstruct flood flows and can create turbulent flow and erosion.

Hydrological and engineering criteria should be used to determine the most appropriate watercourse crossing structure and its design. This will ensure that:

- the structure is inherently stable
- there is minimal disturbance to stream flow for a designated peak-flow discharge
- the long-term stability of the bank and bed of a drainage line and the integrity of a structure are not compromised.

Drainage line crossings should be designed to minimise disturbance to the bed and bank.



**Figure 5.9** Runoff dispersal using mitre drains (redrawn from Garden 1988)



**Figure 5.10** Mitre drains

## Culverts

Culverts carry water away from a table drain or in a drainage line under a road without affecting the trafficability of the road surface or restricting the type of vehicle that can use the road. They are often used on roads that require use in all weather conditions and by all types of vehicles. However, they can block up with sediment and vegetative debris in forest areas or where watercourses have a high sediment bedload. This can lead to local flooding, erosion of the road surface and the failure of drainage structures and batters downstream.

Culverts should be designed with a headwall or box inlet (where water is being directed under the road or track from a table drain). Box inlets and headwalls direct water into the pipe, while allowing water to pond, forcing the culvert to run at its greatest capacity. When the culvert is flowing at its full capacity, it normally becomes self-scouring, clearing itself of sediment and debris. Headwalls and box inlets also reduce the potential for erosion around the inlet of the culvert.

The culvert size for road drainage should be based on the catchment area of the drain and rainfall characteristics. Size and spacing should also be determined by soil erodibility and stable outlet points for culverts used for roadside drainage purposes. As a general rule, in forest areas culverts should have a minimum diameter of 450 millimetres to reduce the likelihood of blockage by forest litter. Culverts should not be used where frequent debris blockages are likely unless the culvert is designed to accommodate debris input.



**Figure 5.11** The lining of a catch drain should be selected to suit the size of the catchment above and slope steepness

Where any new culvert construction is considered necessary, suitably qualified engineers should be consulted to develop culvert specifications. Factors to be considered in the design of new culverts include:

- catchment size
- rainfall intensities and runoff characteristics, particularly peak flow rates
- road class and intended use.

Where soil or gravel is used as the pavement surface for a culvert crossing of a drainage line, structures should be installed to prevent the pavement material eroding into the drainage line.

Culverts to be installed in drainage lines should be designed to be installed as close as possible to the natural alignment of the drainage line to avoid diverting the flow into the stream banks or creating scour of the drainage line.

In some circumstances, culverts can be designed to be offset from the existing flow line where the cross-section of the flow line is broad. This aids effective erosion and sediment control during construction, as the existing flow line can be left undisturbed while the culvert is being constructed, allowing water to pass through the site uncontaminated by sediment-laden site runoff.

Inverted box culverts are preferred as they effectively straddle the streambed to allow water to flow over the natural surface of the drainage line and do not restrict the movement of aquatic animals.

Ideally, culvert outlets should be located at the toe of a fill batter, not halfway up a batter, unless a lined batter drain is incorporated into the design to ensure that water can flow in a controlled, non-erosive manner down the batter face. An energy dissipator should be included in the design of the outlet to prevent potential erosion undermining the culvert and batter (see 1: section 5.4.5).

## **Bridges**

Bridges are the most appropriate option for crossing rivers and streams when:

- all-weather, all-vehicle access is required
- river flows are high
- flow lines are deeply incised
- the flow line has a wide cross-section.

They are the preferred option where topography and normal stream volumes make causeways/fords and culverts impractical. Bridges do not normally restrict stream flows nor impede the movement of aquatic animals. Bridge design and construction is, however, expensive and the benefits and costs of bridge construction should be carefully assessed.

Where any new bridge construction is considered necessary, suitably qualified engineers should be consulted to develop the bridge specifications and supervise the project. Refer to the previous discussion regarding culverts for factors that should be considered in the design of new bridges.

The following erosion and sediment control issues should be considered in the design phase of a bridge:

- locate the bridge in the area of least environmental value and impact (e.g. minimise disturbance to riparian vegetation)

- minimise the number of piers required to be placed in the watercourse by considering span length
- locate instream piers away from watercourse banks to minimise turbulence and potential scour of the banks
- provide adequate scour protection around piers and along abutments and creek banks
- locate abutments and spill-throughs away from creek or river banks in order to minimise bank disturbance
- provide appropriate bridge drainage – avoid the use of scuppers as water discharging from these can cause erosion.

It is not recommended that soil or gravel be used for the pavement for a bridge surface, as traffic can dislodge this material into waterways.

## Log and earth-fill crossings

In the past, log and earth-fill crossings have often been used to cross ephemeral streams and drainage lines. The technique involved placing logs into the channel until the desired height had been obtained. Although relatively simple to construct, these structures have a number of environmental impacts. Depending on the circumstances, they can impede high flows, cause erosion of the downstream channel and banks, are potentially unstable and create a physical barrier impeding the movement of aquatic and terrestrial animals. The use of log and earth crossings is generally discouraged. When existing crossings of this type fail, they should be removed and replaced by alternative, lower-impact options.

## Fords/causeways

Fords are most appropriate where stable natural crossings exist with no defined bank or bed and minimal earthworks are required (figure 5.12). Fords should not normally be used where a watercourse has a deep cross-section requiring considerable excavation to provide approaches to the crossing.

Fords or causeways should be aligned as close as possible to perpendicular to the direction of the drainage line, unless an angled approach would reduce ground and soil disturbance and not impede or disturb the flow between the banks of the drainage line.

To provide a stable surface, imported rock may be required or the ford concreted. The upstream side of the ford should merge with the natural surface of the watercourse bed, unless culverts are also used. However the ford may be higher than the bed level on the downstream side. Energy dissipators are sometimes required on the downstream side to prevent erosion of the streambed because of this height difference. A ford would not normally affect streamflows; however, the upstream progression by aquatic animals can be impeded if the height difference from the streambed to the ford is too great (NSW Fisheries 2003).

Not all ford sites require extensive in-stream structures. Often, natural rock outcrops provide sufficient traction for safe crossings. In other instances, it may be necessary to stabilise the streambed using rock, with a 'retaining wall' where required to prevent any imported material from being washed away. The height of such a wall will depend on the site conditions, but should be the minimum necessary to contain the placed material. The surfacing material is then placed behind the wall and levelled.

Fords and causeways should be designed so that the entrances to the crossing are as level as possible. This will assist vehicle access into and out of the flow line while minimising erosion of the approaches. If the soils are unstable or the track is steep, drainage controls should be included at the top of the cutting and, if it is a long approach to the watercourse, then at strategic points along the grade.

The track immediately either side of a watercourse should be stabilised with coarse aggregate material to prevent erosion. Gabion mattresses can be effectively used for this purpose. Excavation works are required when installing a gabion basket/mattress design to ensure that the top of the mattress is at the same level as the streambed or bank.

Causeways can be used in conjunction with culverts by laying concrete over the pipes. The pipes provide an avenue for normal trickle flows with the causeway providing non-erosive passage for higher flows. It is important that the causeway is keyed into the natural surface to ensure that water does not undermine the structure.

## 5.6 Temporary side tracks – public roads

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During the construction of new roads or the upgrading of existing unsealed and/or sealed roads, it may be necessary to manage traffic by constructing temporary unsealed side tracks. If so, the side tracks should be properly designed with appropriate drainage structures and capacities to minimise erosion during storm events.

Temporary drainage measures for sidetracks can be undersized relative to those required for permanent roads, as the short duration of side track operation means that the likelihood of failure is relatively low. Drainage for side tracks is commonly designed to convey a 2-year ARI peak flow, although this may be modified taking into account the likelihood and consequences of failure, road class and duration of side track operation. Temporary watercourse crossings have a high potential for erosion and should be designed to minimise the risk of failure (figure 5.13).

Side tracks should be rehabilitated immediately they are no longer required.



Figure 5.12 A simple causeway across a drainage line



## 5.7 Fire trails

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Special consideration should be given to the design of an unsealed road or track that may be used as a fire trail, including route selection, the area of disturbance and drainage considerations. The Bush Fire Coordinating Committee (BFCC) identifies two categories of active fire trails:

- primary fire trail – primary feeder route to a network of secondary trails
- secondary fire trail – used for fire control, suppression and mitigation purposes.

BFCC (2003a,b) contains recommendations regarding the design of these categories of fire trails.

## 5.8 Site stabilisation and revegetation

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A permanent program for site stabilisation, revegetation or landscaping should be prepared during the design of new unsealed roads. The details will be determined by considerations such as the aim of the program, climate, and surface stabilisation and safety requirements. The risk of erosion will depend on the site location as rainfall patterns and plant growth rates vary greatly across the state, as can topography and soil type. When preparing a site stabilisation or revegetation program, see 1: section 7 and 1: appendix G. Gray et al. (2006) provides further information on site assessment if native vegetation is to be re-established.

The site stabilisation or revegetation program should aim for a minimum 70% ground cover to minimise the risk of erosion, particularly in areas of regular and/or high rainfall.

## 5.9 Road surface

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Unsealed roads and tracks can have various surfaces. Many are regularly graded while others are rough. Many minor tracks are covered in groundcover vegetation and leaf litter.

Some unsealed roads act as strategic firebreaks. In these instances, the road surface should be kept free of vegetation and have slashed firebreaks on either side. However, other roads and particularly minor tracks should be left to accumulate a vegetative groundcover and leaf litter deposit. Vegetative cover with cross-banks and drains provide the most stable natural road surface available for minor tracks (e.g. group 3). By reducing the effects of raindrop impact and reducing the velocity of surface flows, erosion is minimised.

The source and type of pavement material should be appropriate for the site. For example, if the pavement has a low erodibility but contains dispersive fines, it should be capped with a suitable material.



Figure 5.13 The failure of a side track watercourse crossing following a storm event

Some unsealed roads or sections of them (e.g. bridge or ford approaches) may require gravelling to reduce erosion. Gravel should be tested and should not be used if it contains significant levels (greater than 10%) of dispersible fines. The use of gravel that breaks down easily, particularly under traffic, should also be avoided where possible.

## 5.10 Borrow areas for fill material

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If the cut-to-fill ratio cannot be balanced when constructing a new unsealed road or track, additional suitable fill will need to be sourced. When this is necessary, the size of the borrow area should be limited, and the pit worked so as to reduce the risk of erosion and subsequent sedimentation.

Borrow areas should be revegetated progressively. They should not be located near drainage lines because this would increase the risk of sediment being deposited into waterways. Where practical, topsoil and litter (free of timber debris) should be stockpiled in an area of low erosion hazard that allows easy access for later respreading over disturbed areas. This material contains valuable seed and other organic material to assist in revegetation.

In areas of western NSW, where gradients are very flat, borrow areas or pits within the road reserve (or easement) are quite common. They are often left to act as water storages for stock with table drains along roads being directed into the borrow pit via mitre drains. Where a borrow area is located on dispersible soils and is used as a water storage structure, it may be necessary to construct grade-stabilising structures in the drains leading to the borrow pit/water storage area in order to minimise erosion of the drains.

A grade-stabilising structure (using sand/cement-filled sandbags) should be installed at the outlet of the table drain into the mitre drain, where the grade in the drain changes or where the mitre drain is eroding. A series of weirs, using sand/cement-filled sandbags, should then be installed in the mitre drain, if it has eroded, to prevent further erosion along the table drain.

## 5.11 Sediment basins

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Where group 1 or 2 roads or tracks cross areas having a high conservation value, temporary sediment basins may need to be incorporated into the road's design.

This will ensure sufficient space is allocated within the easement for the basin. Alternative erosion and sediment controls will be required if there is insufficient space for a basin within the easement.

For the design of sediment basins see 1: sections 6.3.3 to 6.3.5. In New South Wales, the majority of soils are either type D or F. Sediment basins for these soil types should include a low-flow pipe similar to that shown in 1: SD 6-3 for a dry basin (type C soils), but without a trash rack or geotextile wrapped around the riser pipe. Instead, the outlet of the low-flow pipe should have a valve installed that can be shut off until water within a basin is treated and ready for discharge.

In rare cases, permanent sediment basins may be required. Examples include unsealed roads in areas of high erosion hazard located upslope of particularly sensitive environments. An exception to this is in western NSW, where the risk of frequent erosive rainfall events is very low. Guidance on the design of permanent sediment basins is provided in *Managing urban stormwater: treatment techniques* (EPA 1997).





## 6. Road construction considerations

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## 6.1 Contract management issues

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### Specifications and payment for erosion and sediment control items

Many unsealed roads and tracks are constructed, upgraded and maintained under a contract between the client and contractor. Erosion and sediment control should be specifically addressed in the contract specifications for such work.

To promote the implementation of erosion and sediment control measures, it is recommended that separate pay items be given to relevant erosion and sediment control measures (and their implementation) instead of a general lump-sum payment item. Individual pay items promote transparency in the tendering process and show a client how much a contractor has allowed for the implementation of erosion and sediment controls. It also promotes an even playing field for contractors in the tendering process and makes the implementation of erosion and sediment control measures both more accepted and more likely.

### Erosion and sediment control plans

The development consent conditions for an unsealed road project can require a CEMP, PEMP and ESCP to be prepared to address environmental issues and their management. The size and complexity of a project will determine the necessity and complexity of these documents (see section 4).

Where an ESCP is not required as a development consent condition, it is recommended that the project principal (the organisation on whose behalf the project is being constructed) requires the contractor to prepare an ESCP anyway. This will ensure that the contractor plans their construction activities to minimise the risk of erosion and off-site sedimentation. In some instances, an ESCP could also be required if an unsealed road is to be upgraded and/or maintained, depending upon the type of activity, its location relative to areas of high conservation value and/or the degree of disturbance to be undertaken (e.g. replacing a bridge, or upgrading or maintaining works around drainage lines).

ESCPs, as part of the CEMP and quality system, should be supplemented with:

- erosion and sediment control checklists
- work method statements for works in sensitive areas (e.g. in or adjacent to creeks and rivers)
- an inspection and audit schedule.

These should all be integrated within a contractor's quality system. The inspection and test plan (see 1: figure 2.1a) can be modified to suit a specific unsealed road project (regardless of whether it involves construction, upgrading or maintenance activities) and the contractor's quality system.

Once an ESCP has been prepared, it is important for the contractor to let construction personnel and subcontractors know that it exists, inform them of their responsibilities in relation to the ESCP, and emphasise the importance of documenting erosion and sediment control management during the construction, upgrade and/or maintenance of an unsealed road or track.

## 6.2 Site management procedures

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A number of simple measures can help ensure effective erosion and sediment control during work on unsealed roads. These measures include:

- timing construction to avoid wet weather
- programming construction stages to minimise erosion
- minimising the extent and duration of disturbance
- conveying clean water through the site
- practising good site housekeeping.

### Timing of construction

The construction and upgrading of unsealed roads and tracks should ideally be scheduled for drier months of the year when the erosion hazard is lowest and, in alpine areas, that avoid snow and snow melt. Otherwise, extra temporary erosion and sediment control measures will be required. For information on determining erosion hazard, see 1: sections 4.4.1 and 4.4.2.

### Sequence of construction – construction programming

Programming the works (that is, considering the order in which stages are completed) can contribute to effective erosion and sediment control. An example is the early installation of permanent drainage works, such as culverts and catch drains, to ensure that clean water flowing onto and through a site can be kept separate from any sediment-laden runoff from the site itself.

Many erosion and sediment control practices also make good construction practices. For instance, in the above example, conveyance of clean water through or around the site will allow the erosion and sediment control measures to be sized to treat a smaller volume of runoff.

Construction programming considerations that promote good erosion and sediment control include:

- early installation of culverts and other permanent drainage works (where practical)
- installation of culvert outlet and inlet protection works directly after culvert installation
- early installation of permanent catch drains (where relevant) and their lining
- progressive revegetation programmed throughout project
- progressive stabilisation of batters.

### Minimising the extent and duration of disturbance

The following techniques should be employed to minimise the extent and duration of disturbance, where practicable:

- clearly mark the limits of clearing (see 1: table 4.1)
- stage construction (see above)
- for lower grade tracks, where possible, construct the track simply by slashing or blading the surface vegetation. Avoid blading soil except where it is necessary to build a track bench on side slopes, to form drainage line approaches or to make rough surfaces trafficable
- limit borrow areas by balancing cut to fill earthworks along an alignment as much as possible
- minimise cut volumes for earthworks

- progressively revegetate disturbed areas
- stabilise drainage structures as quickly as possible following their construction or installation.

## Conveying clean water through the site

As noted previously, it may be necessary to convey water from above the site, through and away from the disturbed area in a controlled manner. This could involve the early construction of catch drains above cut batters for directing water to a proposed culvert site and/or managing through-flow in a drainage line. In both instances, this run-on water will need to be conveyed through and from the site as clean water – it should not flow over any erodible surface. To do this, a temporary diversion drain or channel should be constructed (see section 6.3). In some areas in western NSW, permanent structures may be installed without a temporary diversion drain, due to the low likelihood of rain during construction in some months.

## Practising good site housekeeping

Good site housekeeping means keeping a site tidy. This includes limiting the number of sediment sources by minimising the number of stockpiles on site and removing unwanted spoil stockpiles progressively and quickly (where practical). The progressive removal of unwanted spoil stockpiles will assist with general site management by reducing double handling and freeing up space, especially where space is restricted on site easements.

Placing material as it is being excavated will reduce the number of stockpiles (and potential sediment sources) on a site. Managing cut to fill activities in this manner reduces the erosion potential and provides a direct cost saving by reducing double handling.

All stockpiles should be located away from heavily trafficked areas, areas prone to inundation and drainage lines (see figure 6.1 and 1: section 4.3).



Figure 6.1 Construction of unsealed road showing topsoil stockpiles ready for respreading

## 6.3 Temporary control measures

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### Overview

The following section provides guidance for selecting and applying temporary erosion and sediment control measures during the construction of unsealed roads. It includes some specific issues not covered in volume 1. It covers:

- risk assessment
- key locations
- temporary creek diversions
- in-stream works and control measures
- temporary erosion control measures
- sediment barriers, traps and basins
- maintenance.

Appendix B provides a flowchart and table for use in selecting appropriate measures.

### Risk assessment

To determine the erosion hazard along the proposed route of an unsealed road or track, see **1**: section 4.4.1. Due to the linear nature of unsealed roads and tracks, erosion hazard is likely to vary along the route, particularly as slopes change. Unless the topography of an unsealed road is uniform, it is recommended that the road be divided into sections of similar slope gradient with the soil type and soil loss class assessed for each section. Determining the erosion hazard will assist in the selection of temporary erosion and sediment control measures during the construction stage.

The soil loss class for sites (or road sections) of high erosion hazard can be calculated using the revised universal soil loss equation (RUSLE) (see **1**: appendix A and table 4.2). The LS factor can be reduced from the default slope length of 80 metres (see **1**: section 4.4.2b), through the use of temporary diversion drains across the cleared easement.

Consult **1**: table 4.3 to determine whether special measures are required for minimising the erosion hazard for different months of the year in different rainfall zones.

### Key locations

The key locations for temporary erosion and sediment control measures along an unsealed road or track (figure 6.2) include:

- cut/fill lines for temporary diversion drains directing runoff to sediment traps or filters below the cut/fill line
- directly below cut/fill lines for temporary sediment traps and sediment filters
- along the toe of fill batters for sediment filters, such as sediment fences or timber windows
- bridge abutments and associated approach embankments for sediment traps and sediment filters
- either side of drainage lines and watercourses, where the road is not significantly elevated on an embankment
- along the top edge of fill batters for temporary earth windrows to direct runoff to temporary lined batter drains.



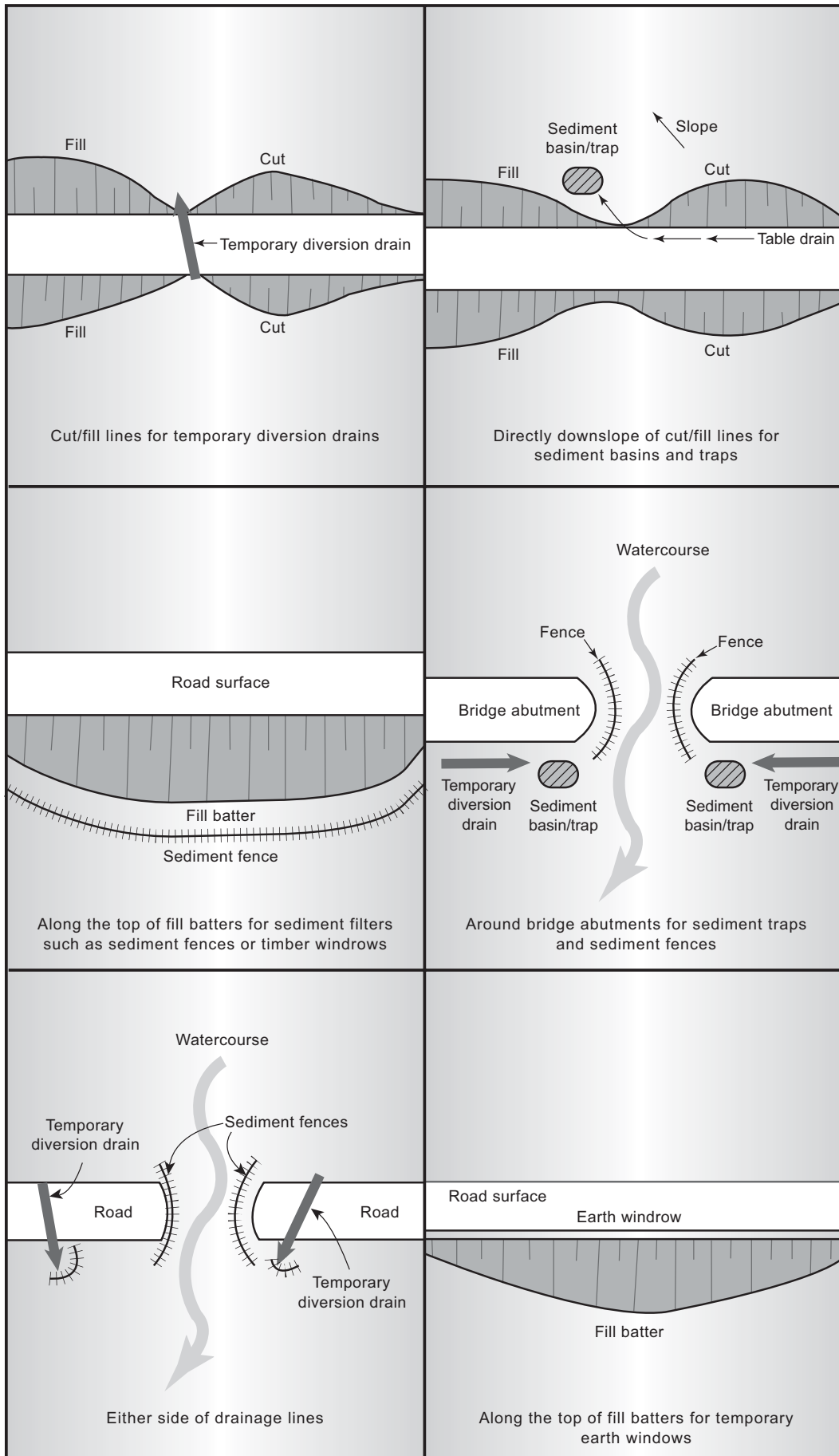


Figure 6.2 Key locations for temporary erosion and sediment control measures

## Temporary creek diversions

Temporary creek diversions may be required during the installation of culverts in both perennial and ephemeral drainage lines and the construction of bridges. They are installed to convey runoff from the catchment above.

Temporary creek diversions should normally be designed to convey a minimum 2-year ARI peak flow (see 1: section 5.3.5). They should be lined with either a non-woven, needle-punched geotextile (not minimum grade thickness) or plastic. The geotextile or plastic should extend up the sides of the temporary diversion, be staked and trenched in on the upstream side of the diversion and be removed at the end of the works.

A temporary crossing may need to be constructed across the temporary creek diversion. In order to maximise stability, these may be constructed using aggregate (with the size dependent on anticipated flow velocities) and have a low-flow pipe installed to convey, for example, a 2-year ARI peak discharge flow (see 1: SD 5-1). Alternatively, if soil is used to construct the crossing, it should be wrapped in geotextile so that the upstream and downstream batters of the crossing are covered with geotextile (see 1: section 5.3 for an example of a temporary watercourse crossing and 1: section 5.4 for temporary creek diversions, and 2: *A Installation of services*).

## In-stream works and control measures

During the construction of bridges, certain works often have to be undertaken in-stream. These can include: piling platforms, piling works, pouring of concrete piers, formwork for headstocks and pouring of headstocks. A number of measures can be installed to minimise the impact of these activities, including:

- coffer dams – to temporarily dam a watercourse upstream of the proposed works and allow the dammed water to be pumped around the worksite to the downstream channel so that the construction site can remain dry. Cofferdams can be constructed using sandbags or specifically designed products. At times, it may be necessary to dam the downstream side of the works area to prevent water backing up into it
- sediment curtains – consisting of a needle-punched geotextile curtain suspended in and across a watercourse downstream of the works area which should be securely anchored at either side of the watercourse and weighed down so it traps suspended sediment and does not float up
- use of appropriate and 'clean' materials (for example, clean aggregate and geotextiles) if a piling platform is required within a watercourse or a stream bank requires temporary stabilisation.

## Temporary erosion control measures

To determine the most appropriate temporary erosion control measures, see 1: sections 4.3 and 5.4. Other temporary erosion control measures that can be used during construction, upgrading and maintenance activities on unsealed roads and tracks include:

- using non-woven, needle punched geotextile or plastic to provide temporary surface protection in temporary creek diversions, temporary creek crossings, on batter drains and along creek banks or beds that have been disturbed
- maintaining the existing vegetation in flow lines for as long as possible and only clearing directly prior to the installation of culverts
- constructing temporary compacted earth windrows, with a minimum depth of 400 millimetres along the top of fill batters, to direct runoff to temporary lined batter drains or sediment traps at cut/fill lines
- revegetating topsoil stockpiles and temporary drainage structures with a cover crop if

the stockpile is to remain in place longer than 28 days, except where the risk of rainfall is extremely low (e.g. in western NSW). The surface of topsoil stockpiles should be left rough to assist with seed germination

- temporary geotextile or plastic-lined batter drains on fill batters. The geotextile or plastic should be keyed in at least 300 millimetres deep at the top of the batter drain and staked to the batter at regular intervals either side of the drain. The drain should be slightly dish-shaped so runoff stays on the geotextile or plastic. A sediment filter, such as a sediment fence, sediment trap or drain taking the runoff from the batter drain to a sediment trap, should be installed at the toe of the fill.

Design criteria recommended for adoption in the design of temporary erosion control measures are listed in table 6.1. Designers, during the design phase, may translate these hydrological criteria into project-specific guidelines, for use by contractors responsible for the installation of such temporary measures. Such project-specific guidance might provide, for example, a standard temporary catch drain design, for a site, along with the maximum catchment area that should drain to that standard design, together with a requirement that catch drains for larger catchments be designed on a case-by-case basis.

## Sediment barriers, traps and basins

To determine the most appropriate sediment control measures for a site, see 1: sections 6.1 to 6.3. Other measures not mentioned in volume 1 that can be used for unsealed roads and tracks include:

- timber windrows, which should:
  - be constructed from cleared vegetation
  - be placed at the toe of fill batters
  - be to a maximum height of 1.5 metres
  - have little or no soil mixed in with the vegetation, to assist in fire management
  - be spread back onto adjacent batters with other cleared vegetation to provide surface protection and a native seed source once topsoil has been respread
- excavated sediment traps or sumps (figure 6.3) which should:
  - be used where narrow easements prevent the installation of sediment basins
  - be appropriately sized (table 6.1)
  - be located at low points or below cut/ fill lines
  - have temporary drains directing runoff into them
  - have geotextile-lined spillways
  - be maintained regularly after rain



Figure 6.3 Temporary sediment trap



Figure 6.4 A sandbag sediment trap with a spillway in the outlet of a table drain

- sandbag sediment traps (figure 6.4) which should be:
  - constructed from sandbags or bags filled with aggregate or other permeable material
  - placed either side of culvert wing walls and headwalls, in low points, in catch drains and in table drains
  - from one to three sandbags high.

Temporary sediment basins (figure 6.5) should be installed early during construction with outside batters and the crest of the basin wall topsoiled and stabilised with a temporary cover crop. Basin inlets and outlets can be lined with a non-woven, needle-punched geotextile, making sure that the lining is keyed in on the upstream side and staked for the length of the lining.

**Table 6.1 Design storm events – minimum average recurrence interval (ARI) for temporary erosion and sediment control measures**

Control measure descriptions	Duration of disturbance < 6 months		Duration of disturbance 6–12 months	
	Standard design	Sensitive environment <sup>1</sup>	Standard design	Sensitive environment <sup>1</sup>
<b>Temporary drainage (erosion) control</b>				
(e.g. diversion banks, perimeter banks, catch drains, level spreaders, check dams, batter drains and chutes) should be designed to have a non-erosive hydraulic capacity (excluding freeboard) sufficient to convey the nominated design storm event	2-year ARI	5-year ARI	5-year ARI	10-year ARI
<b>Temporary sediment control</b>				
(e.g. sediment fences, stacked rock sediment traps etc.) in small catchments where used as a 'last line of defence' (i.e. without a sediment basin down-slope) should be constructed to remain structurally sound in the nominated design storm event	2-year ARI	5-year ARI	5-year ARI	10-year ARI
<b>Type C Sediment retention basins</b>				
Designed to achieve required water quality for flows up to:	0.5 x 1-year ARI	1-year ARI	1-year ARI	1-year ARI
Embankment and spillway	10-year ARI	20-year ARI	20-year ARI	50-year ARI
<b>Type D Sediment retention basins</b>				
Basic volume based on nominated percentile rainfall depth for 5-day duration <sup>2</sup> storm:	75 <sup>th</sup> percentile	80 <sup>th</sup> percentile	80 <sup>th</sup> percentile	85 <sup>th</sup> percentile
Embankment and spillway	10-year ARI	20-year ARI	20-year ARI	50-year ARI

1 A 'sensitive environment' is one with a high conservation value, or that supports human uses of water that are particularly sensitive to degraded water quality.

2 Storm duration can be modified for different management regimes – see 1: section 6.3.4

Table 6.1 lists criteria recommended for the design of temporary sediment control measures. Designers may translate these hydrological criteria into project-specific guidelines for contractors to use during installation. For example, a design for a standard temporary sediment trap could be provided with a specification of the maximum catchment area that should drain to a trap, with larger catchments requiring site-specific designs. Where site constraints limit the size of a temporary sediment basin to less than the design capacity for a given catchment area, other controls will be required within the catchment.

It is not recommended that vegetative filter strips normally be used as a sediment control measure down-slope of a disturbed area during the construction of unsealed roads and tracks, as there is typically an insufficient width for the filter to function effectively due to the narrow easements. Adjacent off-site vegetation should not be used as a filter strip.

## Maintenance

During construction, the inspection of temporary erosion and sediment control measures should be undertaken regularly and following rain events (figure 6.6), with any necessary maintenance to controls being undertaken promptly (1–5 days after rain ceases). For further information on the maintenance of temporary erosion and sediment control measures, see 1: section 8.

## 6.4 Construction of permanent control measures

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### Cross-fall drainage

To ensure outfall drainage is effective, and where the fill batter is stable, any earth windrows formed on the down-slope side of the road during construction or maintenance activities should be removed.

### Catch drains and outlets

Permanent catch drains, above cut batters, should be installed early and permanently lined before the batter face is excavated.

### Cross-banks

Cross-banks are normally constructed from the natural road-base material. However, clean imported material can be used where the quantity or quality required is not available on-site.

During cross-bank construction:

- the track or road should be ripped to a depth of 200–300 millimetres across the width of the road or track, back from the chosen outlet point. The loose earth should then be pushed into a bank, commencing at the uphill side of the track and working across the outlet side
- the material used for bank construction should be free of sticks and logs which can contribute to bank failure as they decay
- a long, shallow excavation for the bank is preferable to a short, deep excavation. This will allow runoff to collect and be diverted while allowing vehicles to cross
- sufficient loose earth should be used to give the required dimensions (see figure 5.5) after shaping and compaction
- the crest width dimensions should be long enough for comfortable vehicle access. The channel depth dimensions are important to prevent runoff from overtopping the bank

- cross-banks are most effective if constructed with only a slight angle to the track obtaining a grade of approximately 1:20 to allow the water to be diverted freely off the road and prevent ponding behind the bank (which can cause the bank to breach)
- the entire length of the bank should be track- or wheel-rolled to obtain maximum compaction and a smooth, even surface
- any loose earth or other material that may restrict the water flow off the road should be removed from the excavation. The small bank of earth resulting at the outlet can often be left as a sediment trap and water spreader. Push this earth only just far enough so that draining water can clear the track effectively



**Figure 6.5** Temporary sediment basin adjacent to an unsealed road



**Figure 6.6** Erosion and sediment controls are only as effective as their maintenance

- if an eroded table drain has to be filled to build a bank, compact the bank at that point with extra earth to allow for slumping and to cope with the concentrated runoff in the table drain
- where cross-banks are installed adjacent to a cut batter, the cross-bank should be tied into the cut batter to prevent runoff from bypassing it.

In addition, the following practices are strongly recommended during the construction of cross-banks (figure 6.7). Cross-banks should:

- extend right across an unsealed road or track – too short and they increase erosion
- discharge onto a stable surface – to prevent erosion at the outlet
- be constructed with a moderate gradient – a steep gradient may cause erosion and too flat a gradient will cause ponding
- have adequate capacity – otherwise they will breach
- be constructed so that their slope is relative to the fall of the road, not the road alignment – otherwise the grade of the cross-bank will be incorrect and create erosion or ponding, breaching the bank
- be adequately compacted – to minimise the risk of banks breaching and to maintain their capacity as vehicles travel over them.

## **Cross-drains**

Cross-drains are inexpensive and quick to construct. Section 5.4 notes the dimensions and layout of these drains. Excavated material can be distributed to a depth of 75 millimetres or more on the road surface below the cross-drain to increase its capacity.

## **Table drains**

When possible the table drain should be trapezoidal rather than U-shaped, preferably 1–2 metres wide at the base, to assist in reducing flow velocities and erosion. Often the table drain can be stabilised by lining it with rock, grasses or native vegetation (depending on soil erodibility and flow velocities) as soon as practical after its construction.

## **Mitre drains/spoon drains**

A mitre drain is cut from the table drain into the roadside vegetation on a slight angle to the road. During construction:

- determine the length of the drain on-site as this will depend on the location of an appropriate outlet point
- position the discharge site so that water does not re-enter the road from another drainage line
- excavate to a depth of no more than 300 millimetres. A deep excavated channel is not necessary as the runoff should flow freely into the drain and be directed into roadside vegetation
- ensure that the runoff will enter and not bypass the mitre drain from the table drain. It may be necessary to ‘dish’ the mitre drain entrance to encourage water to flow, or construct an earthen headwall to direct flows
- use a grader, bulldozer, front-end loader or backhoe. The equipment used will depend on its availability and its capacity to minimise disturbance to the surrounding environment
- construct the sump (sediment trap) at the spoon drain outlet.

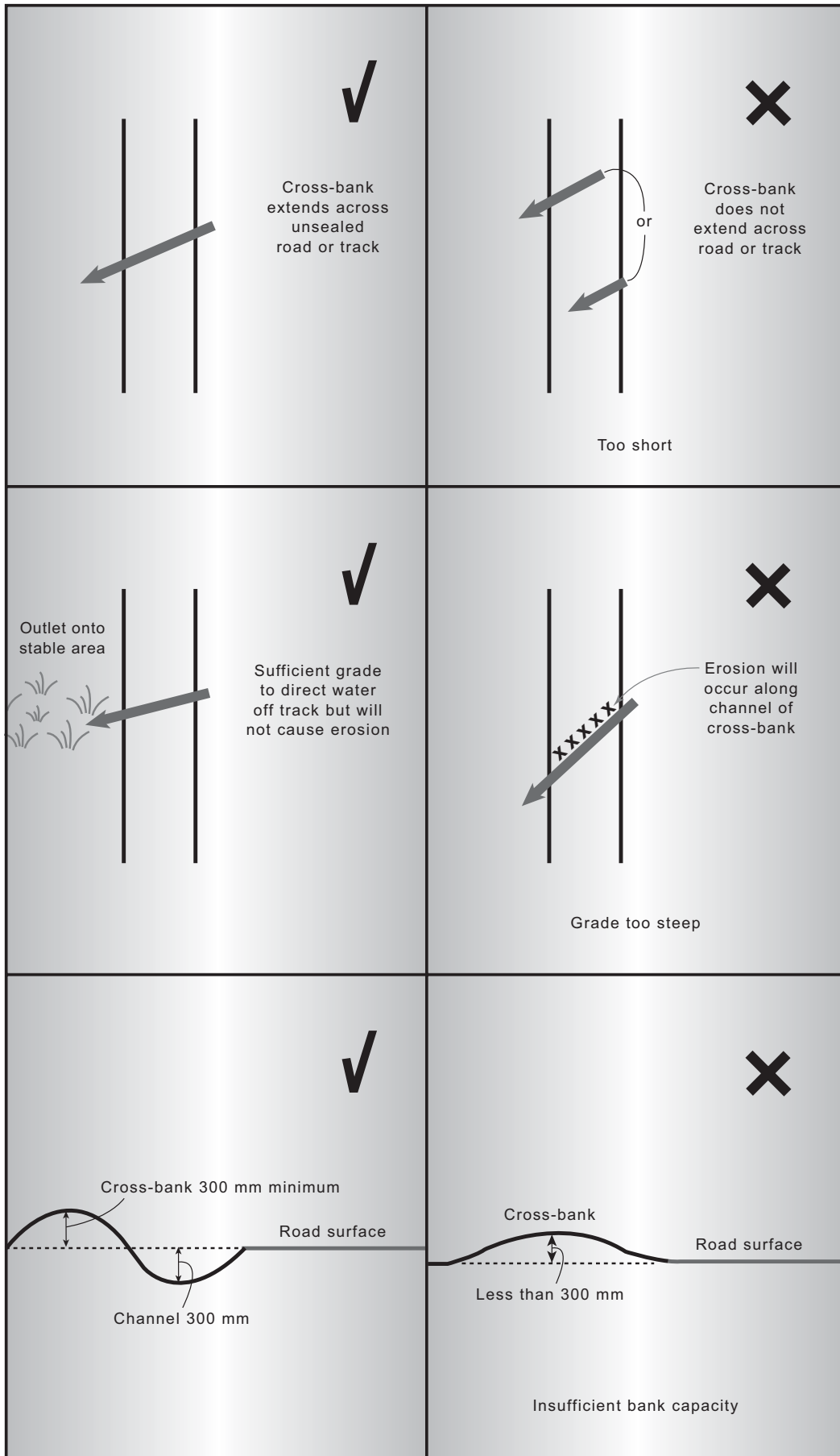


Figure 6.7 Cross-bank construction guide



## **Berm drains and outlets**

A berm drain should be shaped to prevent erosion along the toe of the batter above the berm drain. The outlet should have:

- a minimal grade
- sufficient width to keep flow velocities low
- a level spreader to prevent erosion occurring.

Berm drains and outlets should be stabilised, for example, by lining with erosion matting or jute matting and by revegetating immediately following construction.

## **Batter drains and outlets**

For effective operation, a batter drain should be correctly installed such that:

- the edge is flush with the surrounding surface to prevent water channelling down either side of the material used to line the batter drain
- road surface runoff does not bypass the inlet and erode the fill batter elsewhere
- the batter drain extends to the bottom of the fill
- some form of outlet protection prevents water flowing down the batter drain eroding the toe of the fill or the area adjacent to it. Outlet protection can comprise rock, vegetation or a combination of the two depending on:
  - the catchment of the batter drain and rainfall characteristics
  - the material the batter drain is constructed from (some linings are more dissipative than others)
  - the height of the batter and its slope.

For additional information on batter drains and outlets, see **1**: sections 5.4.4 and 5.4.5.

## **Batter faces**

Benched cut-and-fill batters should be progressively dressed with topsoil and revegetated to minimise erosion (see **1**: section 4.3.2). Fill batters should be free of vegetation debris to avoid poor compaction and slumping as the vegetation decays.

## **Culvert inlets and outlets**

During culvert construction, soil and vegetation disturbance should be kept to a minimum. Drainage lines should be kept free of timber, scrub, soil or debris – these should be placed well above flood levels.

Roadside culverts should be orientated down-slope on a slight angle or excavated and laid on a down-slope grade to ensure that water flows freely through the culvert. The outlet of the culvert should be at the natural ground surface when possible. If necessary, drop structures and energy dissipaters may be required to prevent erosion occurring at the outlet point.

As noted in section 5, culverts in drainage lines and watercourses should be installed directly in the line of the flow. The water should enter and discharge at the natural surface level to prevent erosion occurring.

## Bridges

Bridgeworks should be carefully planned before construction begins. A construction method statement should detail how works will be undertaken, including:

- construction of a piling platform (if required)
- piling operations (including type of piling – e.g. driven or drilled, concrete pouring of piles)
- management of groundwater outflows
- management of creek/river flows
- containment of potential pollutants (e.g. concrete wash-out areas, excess concrete from pours)
- management of runoff from bridge approaches
- management of tidal flows (if relevant)
- management of acid sulfate soils (if relevant)
- installation of formwork for head stocks (which can cause further disturbance to creek banks and bed depending on where the piers are located)
- temporary erosion and sediment control measures (figures 6.8 and 6.9)
- management of runoff from curing concrete bridge deck (if relevant).

Scour protection works (where relevant) around piers, along creek banks and on bridge abutments should be installed as early as possible.

Typical temporary erosion control measures around bridgeworks include:

- geotextile installed and secured on disturbed creek banks and beneath piling platforms
- sediment fences
- sediment curtains or other turbidity barriers
- barriers to contain groundwater outflows and concrete slurry.

Regular maintenance of temporary control measures associated with bridgeworks is critical.

## Permanent site stabilisation/revegetation

Revegetation of disturbed areas is important for minimising erosion. The site stabilisation/revegetation program prepared as part of the design stage (section 5.8) should be implemented progressively.

Before revegetating, all excess bare areas and stockpile sites should be tyned to:

- loosen compacted soil
- increase infiltration of runoff
- allow topsoil to 'key' into the subsoil
- provide a decent seed bed.

Ripping/tyning should be on the contour to minimise erosion, ideally to a depth of 200 millimetres or more. If reshaping of an area is necessary, it should be done with no disturbance to the surrounding vegetation. It should take into account adjacent drainage forms and be sympathetic to the surrounding area to blend in as much as practical. After the soil has been tyned or loosened up, the area should be seeded.

Respreading cleared native vegetation over disturbed areas requiring revegetation can be a cheap and effective means of protecting the disturbed area from rain impact and promoting the establishment of native vegetation. For further guidance on alternative stabilisation techniques see 1: section 7.

Areas that have been revegetated should be monitored at regular intervals to ensure that revegetation has been successful and to determine whether additional seeding or hydromulching is required. Temporary sediment control measures such as sediment fences should remain in place until 70% of ground cover has been reached.



**Figure 6.8** Temporary erosion and sediment control measures along a creek



**Figure 6.9** Typical erosion and sediment control measures around bridge abutments



## 7. Operational phase maintenance

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## 7.1 Maintenance program

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It is standard practice to have some form of maintenance inspection program regardless of whether the road is an unsealed public road, a fire trail or a private access track. Unsealed roads and tracks should be regularly inspected and properly maintained to provide for continuing structural integrity and safety, and to minimise the erosion and sedimentation potential. The frequency of maintenance inspections will vary depending upon the grade and purpose of the unsealed road or track, vehicle usage, climate, rainfall intensity patterns, soil types and drainage structures in place.

A maintenance program should include the following:

- location and class of road or track
- frequency of inspections, including scheduling after significant storms
- operational standards required for road to function effectively with minimum impact on surrounding environment – these can include council guidelines and NSW RTA specifications
- maintenance issues to be inspected
- condition of existing drainage structures, road features and drainage lines (e.g. culverts, bridges, batters, drains, vegetation cover, road surface, creeks)
- maintenance checklists
- maintenance required
- a record of maintenance work undertaken.

Appendix C provides a sample checklist of items that should be inspected as part of a maintenance program. Maintenance activities may include:

- grading
- gravelling
- patching
- resurfacing
- removing sediment from surface drainage structures and repairing them
- repairing erosion on batters, etc.
- installing additional surface drainage structures (for example, cross-banks) where erosion is occurring
- repairing bridges, fords, causeways and culverts.

Maintenance of the road drainage and surface should ensure that:

- structures are working effectively
- the road surface is stable
- vegetation is established (that is, there is at least 70% groundcover) on batters and in drainage structures (e.g. catch drains), as appropriate
- erosion is not occurring.

As discussed earlier, an ESCP may be required for significant maintenance activities (e.g. bridge replacement or work adjacent to watercourses), depending on the degree of likely ground disturbance.

## 7.2 Maintenance of drainage structures

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It is important to provide appropriate and regular maintenance to all road/track drainage structures, to ensure they continue to function effectively and the unsealed road or track maintains its structural integrity.

### Cross-banks

When cross-banks fail, because of poor or irregular maintenance, there is a cumulative effect down-slope, often causing other banks to fail, leading to erosion of track surfaces and table drains. It is better to provide regular, effective maintenance to existing road drainage structures than to reform an entire section of road because of failures. Points to inspect include:

- reduced bank capacity because of sediment build-up – remove sediment if capacity is reduced by 30%
- adequacy of bank capacity – increase bank height if necessary
- degree of erosion at the outlet or in the channel
- any failures such as overtopping or breaches of the bank.

Common problems with cross-banks include the development of depressions in the crest caused by vehicles continually crossing at the same point or by gouging a channel through the bank crest with a towbar. These depressions reduce the capacity of the bank and create weak points where water can overtop the drain, leading to bank failure, as can motorbikes or trail bikes, insufficient compaction, use of the bank during wet weather and ponding. Where the cross-bank is adjacent to a cut batter, it should be keyed in to prevent water from bypassing it. Similarly, the outlet should be clear of debris to prevent water from ponding or overtopping the bank.

### Cross-drains

Cross-drains are usually low maintenance, requiring only periodic removal of sediment from the channel. However, if the cross-drain is constructed at least 30 degrees to the track, sediment build-up is minimised. The outlet should be inspected for erosion and the cross-drain for an accumulation of sediment and evidence of overtopping.

### Rolled grades

The depression floor and outlet should be inspected for erosion, any sediment build-up and overtopping. Additional drainage structures may be required if there is significant erosion or overtopping.

### Table drains

Table drains should be inspected for erosion. If erosion is occurring, the road or track may require additional water disposal points, the table drain may need to be lined, or the existing disposal points may need to be repaired. It is important to ensure that the drainage structures are kept open during maintenance activities and are not adversely affected by road maintenance works.

## Mitre drains

Mitre drains should be inspected to ensure they have adequate capacity and are not eroding or causing erosion (figure 7.1). Sediment build-up should be removed to ensure that a mitre drain has adequate capacity to prevent runoff overtopping the drain or bypassing it causing erosion elsewhere. Drains that have been constructed correctly will tend to flush sediment clear of the channel in a high rainfall event. Water bypassing mitre drains has the potential to cause table drain erosion and increases the likelihood of failure in the next drainage structure.

Where mitre drains are eroding, it may be necessary to install further mitre drains, reduce their grade or where this is not possible, to reinforce existing drains using rock or geotextiles.

On unsealed roads and tracks that receive regular maintenance, the road is often lower than the inlet of mitre drains. This is caused by the regular removal of road material during maintenance grading. It is important after any road surface maintenance that all mitre drains are reopened (deepened if necessary) and cleared of any windrowed soil. It may be necessary to resurface a road when the mitre drains no longer function because they cannot drain. Windrowed material can be reused on the road surface by regrading it towards the centre of the road.

## Culverts

Culverts should be inspected for pipe blockages and leaks, signs of overflows, erosion at the inlet or outlet of the culvert and undermining of the pipe structure. Maintenance activities to rectify these problems should be given a high priority.

## Bridges

Bridges should be inspected for:

- structural deterioration, such as excessive corrosion
- deterioration of the decking
- deterioration or erosion of the bridge approaches



Figure 7.1 Sediment build-up in a mitre drain

- erosion from inadequate road drainage either side of the bridge
- erosion around the abutments and spill-throughs
- build up of flood debris around piers or abutments that could redirect creek flows and cause erosion
- erosion of the banks or bed of the adjacent watercourse
- erosion beneath scuppers, if present
- the condition of any fish passages.

Bank and streambed erosion can contribute to bridge failure and sedimentation of waterways and should also be regularly monitored. Inspections for obvious structural damage should occur following high rainfall or flooding events to ensure the structural integrity of the bridge.

## **Fords and causeways**

Fords and causeways should be inspected for undermining, surface stability and trafficability, the stability of the approaches and erosion of the adjacent creek banks, with repairs undertaken as required.

## **Batters**

Maintenance activities around batters should avoid compromising the integrity of existing drainage structures such as diversion banks, table drains and batter drains. If existing drainage has failed or is damaged as a result of maintenance activities, immediate remedial works are needed.

Occasionally batters will slump and deposit a quantity of soil to the base of the batter. Where this does not interfere with road drainage, the material should be left in situ. Removing the material may cause further slumping and increase the batter instability. Maintenance of the road surface and drains should not affect the toe of the batter. Often the toe is removed and/or undercut by regular grading which causes batter instability and slumping. Continued slumping of batters and erosion of the batter surface should be investigated to determine its cause. Additional drainage, revegetation or revetment works may be required to fix the problem.

## **Fire trails**

Fire trails should be maintained to provide safe four-wheel-drive access by fire-fighting vehicles. Unsealed roads and tracks used for fire-fighting purposes should be inspected regularly for erosion and trafficability, (e.g. annually, at the beginning of the fire season and after significant rainfall events).

## **Road surface**

Although it is important to provide maintenance to an existing road surface, care should be taken not to 'over maintain' in the process. Varying levels of disturbance occur to the road surface and the drainage structures every time a road is graded. The level of disturbance can vary, for example, from removing stabilising vegetation and leaf litter to undercutting batters, bypassing drains or road deepening. Each of these activities can affect road stability and increase erosion and sedimentation during rainfall events.

Grading of a road should be restricted to times when recrowning is necessary to ensure that proper drainage occurs or where the road surface is obviously degrading because of active erosion.



A simple slashing program can maintain lower class unsealed roads and tracks while new road construction of minor tracks (group 2 roads from table 1.1) should consider the removal only of larger restrictive vegetation where possible. In the event of the track being required for fire access or to act as a firebreak, the remaining low vegetation and leaf litter could be removed quickly with a small bulldozer or grader.

## Grading

When grading for maintenance purposes, ideally:

- avoid working beyond the original road width – this is a common problem with dry grading, where a grader is used on its own without a water cart and roller. This increases the area requiring maintenance and increases the potential for erosion
- ensure that the cross-fall of the road is not graded to less than 4% (ARRB 2000). This can be achieved by making two passes with a grader up each side of the road, windrowing the material into the middle and then making two passes on each side from the centre to the side of the road (Shaw 2001). This ensures that the grader does not have to make a pass down the centre of the track removing the crown, and it minimises track width by depositing excess material on the centre while creating a better cross-fall
- maximise compaction and optimise moisture content as much as possible to reduce excessive loose material
- use wet maintenance techniques (grading with a water cart and roller) to ensure better compaction and moisture content, reducing the frequency in which resheeting and routine grading is required, leading to a reduction in the whole-of-life cost
- avoid undercutting batters and damaging culverts and other drainage structures
- avoid constructing mitre drains with excessive grade or length, and reconstruct them where necessary
- remove earth windrows from the sides of roads to allow free drainage, unless in place to protect fill batters and direct runoff to a batter drain. Windrowed material can be graded back towards the crown, minimising the risk of lowering the road in relation to adjacent drainage structures
- avoid V-shaped table drains
- do not grade stable table drains or mitre drains if they are functional
- do not grade roads and tracks when the surface is dry and powdery or saturated – grade when it is moist
- do not deposit spoil or loose material in drainage lines, drainage structures or where there is concentrated flow. If loose material inadvertently ends up in these areas, it should be removed
- take care when undertaking grading activities that the road level does not become lower than the surrounding surfaces so that runoff from the road cannot get away.

Select grader attachments to achieve specific aims. A free-roll attachment can provide a smoother, tighter crust which holds moisture longer and performs better under traffic. Serrated cutting edges scarify the surface allowing the backspread material to key in with the existing surface, while breaking up larger stones in the pavement and uniformly mixing the material. These options increase grader versatility and provide a better result than a conventional flat blade.

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## Further reading

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## Appendices

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<b>Appendix B: Selection of control measures</b>	<b>85</b>
<b>Appendix C: Sample maintenance checklists</b>	<b>90</b>

## **Appendix A: Sample erosion and sediment control plans**

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### **A.1 Introduction**

Land that has been disturbed or cleared of vegetation is potentially subject to erosion by stormwater runoff. Soil particles that are eroded in such a way are transported down-slope, usually settling in watercourses, wetlands and lakes.

Erosion and sedimentation may result in many adverse environmental impacts including:

- reduction in water quality, increased turbidity and nutrient enrichment of water bodies
- damage to vegetation communities
- disturbance to aquatic flora and fauna
- increased potential for flooding
- restrictions to navigation
- reduction in recreational and aesthetic values of waterbodies
- increased maintenance costs
- promotion of weed growth
- reduced agricultural, forestry and biomass production.

This plan will form the initial 'link in the chain' to minimise on-site erosion and off-site sedimentation and therefore reduce adverse environmental impacts.

### **A.2 Project description**

[Insert the project description here if there is no environmental management plan (EMP) for the project, or refer to the relevant section of the EMP.]

### **A.3 Scope of this plan**

This document is a broad-based erosion and sediment control plan (ESCP) that outlines the intentions and fundamental principles that will be followed in the planning and implementation of erosion and sediment control measures for the entire project.

This primary/generic plan will be supplemented by numerous progressive plans [where relevant – small, simple or low-hazard sites and projects may not require a series of plans] detailing individual control measures. These progressive ESCPs will be:

- prepared by the project's soil conservationist in association with the environmental manager and construction personnel to formulate practical documents for field reference. This process will give a 'sense of ownership' of the proposals to all parties
- prepared on relevant copies of the drawings for:
  - different stages of construction (e.g. initial clearing, grubbing, topsoil stripping and stockpiling with revision for bulk earthworks)
  - an area not exceeding one sheet or 500 metres for road construction projects per plan
  - areas of high erosion hazard (e.g. culvert and bridge construction [if relevant]). These plans will be revised as required
  - specific areas that may occur outside the road alignment (e.g. compound, stockpile sites, etc.). These plans will be revised as required by changing circumstances
- integrated with work method statements and scheduling especially for culvert construction
- site-specific and will not generally repeat the information contained in this primary/generic plan

- given a sequential number and recorded in the register for progressive ESCPs (see attachment A1)
- controlled and distributed in accordance with the [contractor's name] quality system procedure for document control.

For samples of progressive plans, see attachment A2.

## **A.4 Existing environment**

### **Topography**

[Complete this section or provide cross-references to the relevant section in project EMP. Information can be found in the project EIS or REF.]

### **Sensitive areas**

[Complete this section if relevant. Identify the location of any sensitive areas along the route indicating why they are considered sensitive.]

### **Soil types**

[Complete this section or provide cross-references to the relevant section in the project EMP. Information can be found in the project EIS or REF. Further information on soils and their limitations can be found in the relevant soil landscape maps and booklets available from DECC offices.]

### **Rainfall**

[Complete this section or provide cross-references to the relevant section in the project EMP. Information can be found in the project EIS or REF. Rainfall data can be found on the Bureau of Meteorology website.

To identify the rainfall zone and which months have the greatest rainfall erosivity and erosion hazard rate, see *Managing urban stormwater: soils and construction*, vol. 1 (Landcom 2004a) section 4.

## **A.5 Supporting documentation**

This ESCP meets the requirements and guidelines of:

- Landcom (2004a). *Managing urban stormwater: soils and construction*, vol. 1 (Blue Book)
- [Insert any other relevant documentation such as RTA road construction specifications, council specifications, etc.]

## **A.6 Key strategies**

The following list outlines principles and control measures that will be employed on this project for minimising erosion and sedimentation. Sections marked with an asterisk\* may be ignored if not relevant. The project methodology will include:

### **Site planning and design**

- liaise with the relevant government authorities in relation to control measures in watercourses and creeks (e.g. Department of Primary Industries)
- engage a professional soil conservation company with extensive experience in road construction. The company will coordinate and oversee all erosion and sediment

control aspects. The curricula vitae of the company's relevant personnel are included in attachment A3

- ensure input into detailed design including:
  - design and location of sediment basins\*
  - siting sediment basins to maximise capture of runoff from construction areas\*
  - siting sediment basins to also contain road spillages during road operation\*
  - location and stabilisation of open drains (e.g. catch and berm drains)
  - batter treatments\*
  - culvert design with consideration for a stable flow path during construction\*
  - bridge design in sympathy with maintaining the integrity of drainage lines
  - dissipation of high velocity flows\*

### **Training and induction**

- form a specialist labour team to construct temporary controls including sediment fences, batter drains on fill batters and sediment basins, etc.
- hold site inductions highlighting the importance of soil conservation issues
- schedule half-day awareness seminars early in the project for all personnel involved in construction. The program will include the following components:\*

  - environmental impacts
  - relevant legislation
  - principles of erosion and sediment control
  - techniques of erosion and sediment control

More detail on the program appears in attachment A4

- convene regular toolbox meetings during the course of the project to address relevant matters

### **Minimising disturbance/delineating limits of clearing**

- minimise disturbance of vegetation along the road corridor with special emphasis on construction activity adjacent to watercourses\*
- leave watercourses undisturbed until culvert and bridge construction has begun. Where vegetation clearance is necessary and approved, the cut stump method will be preferred to stump removal to maintain stream bank stability
- leave the soil surface in a reasonably rough condition with some vegetative cover following initial clearing and grubbing
- use cleared vegetation for timber windrow sediment traps and filters\*

### **Topsoil management**

- ensure good topsoil management to improve post-project revegetation
- place stockpiles of soil material in low-hazard areas clear of watercourses, and provide additional protection with vegetation, diversion banks and sediment fences if required

### **Implementation schedule**

- construct permanent drainage structures early in the project including:
  - sediment basins and traps
  - catch drains
  - culverts and associated inlet and outlet protection (e.g. dissipators)
- progressively implement temporary erosion and sediment controls (e.g. sediment fences, diversion banks, diversion drains, sediment traps, etc.)

## **Control of runoff**

- keep clean water and turbid runoff separate
- maximise the diversion of turbid construction runoff into sediment basins
- construct erosion control measures as close as possible to the potential source of sediment
- control runoff during the construction of embankments (e.g. using fill shaping, temporary dykes and batter drains)
- construct erosion controls within the various sub-catchments to complement and increase the effectiveness and efficiency of sediment controls in the lower areas (e.g. sediment basins\* and traps)
- use geotextile linings to temporarily protect the land surface protection in areas of concentrated flows (e.g. batter drains and when constructing culverts)
- divert formation runoff into pits and the stormwater drainage system as soon as practical to reduce surface flow lengths
- progressively revegetate disturbed areas with appropriate plant species
- implement erosion and sediment control at associated construction sites, which may include:
  - access roads and tracks
  - office and compound sites

## **Site management**

- control dust using progressive revegetation techniques, water tankers etc.
- regulate water quality during dewatering activities (e.g. by using filtering techniques and flocculating with gypsum)
- place sediment cleaned from structures, including sediment basins, in a secure location to prevent further pollution
- control the deposition of mud and soil material onto sealed public roads adjacent to the site

## **Inspection and maintenance**

- implement a program to ensure regular maintenance of all erosion and sediment control measures
- have the project soil conservationist regularly inspect, review and update control measures. Conduct additional inspections during or immediately following significant rainfall events to monitor the functioning of controls
- manage sediment basins immediately after rain as required by:\*
  - flocculating with gypsum
  - pumping out water after settling for construction purposes or dust control
  - retain water in sediment basins until water quality criteria are achieved (see attachment A5)\*
- implement a water quality monitoring program in the adjacent watercourses and analyse results to determine the efficiency and effectiveness of implemented controls
- document and record erosion and sediment control activities with:
  - progressive ESCPs (see section A.3)
  - inspection reports from the project soil conservationist (see attachment A6 for a sample format, including sections for location, control, recommendations, comment, action and 'close-out')



- ESCP plan maintenance checklists completed by nominated construction personnel each fortnight (see attachment A7 for sample format)
- site notes forwarded internally between Environmental and Construction personnel
- meeting minutes
- formal correspondence (e.g. with RTA, Department of Environment and Climate Change, Department of Primary Industries, local councils etc.)
- water quality monitoring results (e.g. sediment basins, upstream and downstream)\*.

Attachment A8 provides a sample guide to scheduling erosion and sediment controls during construction for a 13-month period.

The above points address the key issues and techniques for controlling erosion and sedimentation on many road construction projects. The points collectively fulfil the principles of sound soil conservation practice as detailed in the documentation described in section 5. This will ensure a preventative rather than a cosmetic or remedial approach to erosion and sediment control.

## **A.7 Conclusion**

The relatively high rainfall together with the erodibility of the soils will create a high erosion hazard, especially in areas of concentrated flows when the protective vegetation cover is removed.

The strategies presented in this plan will address all erosion and sediment control issues appropriately and will minimise the potential impact of the project.

Planning, adhering to a documented system and training will be key elements in ensuring good performance in the field.

## **A.8 Attachments**

Attachment A1 Sample register of progressive erosion and sediment control plans

Attachment A2 Sample progressive erosion and sediment control plans

Attachment A3 Curricula vitae

Attachment A4 Program for erosion and sediment control awareness seminars

Attachment A5 Procedure for water-quality management in sediment basins

Attachment A6 Maintenance checklist report for project soil conservationist

Attachment A7 Maintenance checklist for nominated construction personnel

Attachment A8 Erosion and sediment control checklist and schedule.



## **Attachment A2    Sample progressive erosion and sediment control plans**

### **Introduction**

Notes such as the following are usually included on an ESCP, not separately, to simplify use of the plan in the field and because some management techniques need to be represented diagrammatically.

### **Bulk earthworks**

- 1 This ESCP (see figure A2.1) should be read in conjunction with the primary ESCP for this project.
- 2 Erosion and sediment control measures will be implemented and maintained in accordance with *Managing urban stormwater: soils and construction* vol. 1 (Landcom 2004a).
- 3 Disturbance will be kept to a minimum (within the limits of clearing).
- 4 Additional control measures will be installed as required.
- 5 A more specific ESCP will be prepared for the culvert works shown on this plan.
- 6 Control measures will be inspected regularly (e.g. weekly, before a long weekend and after rain) with maintenance undertaken as necessary.
- 7 Disturbed areas beyond the road shoulder will be progressively revegetated.

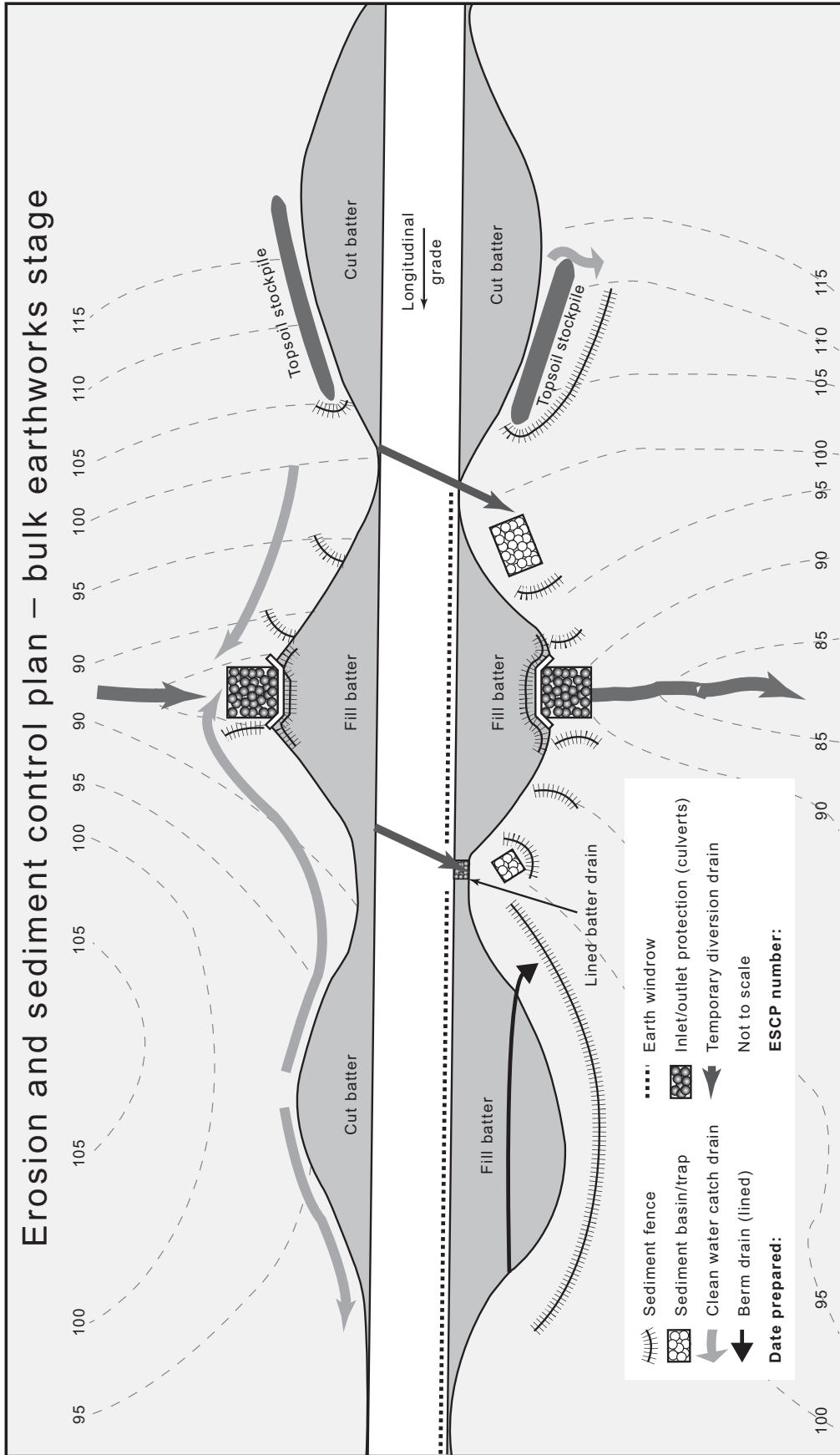


Figure A2.1 ESCP – bulk earthworks stage

## Culvert installation

All creek diversions and temporary crossings should be designed for a design storm that reflects the length of time that the diversion/crossing will be present.

- 1 This ESCP (see figure A2.2) should be read in conjunction with the primary ESCP for this project.
- 2 DWE and DPI (NSW Fisheries) will be consulted regarding the creek diversion.
- 3 Erosion and sediment control measures will be implemented and maintained as per *Managing urban stormwater: soils and construction* vol. 1 (Landcom 2004a).
- 4 The temporary diversion will be designed to cater for a 1 in 2-year storm event.
- 5 The temporary diversion will be installed before beginning any works associated with culvert installation.
- 6 A sandbag coffer dam will be installed on the upstream and downstream sides of the diversion and water pumped around the site during the installation of the temporary diversion. The coffer dam will be removed once the diversion is lined.
- 7 The temporary diversion will be lined with geotextile. The geotextile will be trenched in on the upstream end of the diversion and staked in.
- 8 Clean aggregate will be used to construct a temporary crossing.
- 9 Disturbance will be kept to a minimum during the installation of the temporary diversion.
- 10 Control measures will be inspected regularly (e.g. weekly, before a long weekend and after rain) with maintenance undertaken as necessary.
- 11 The temporary diversion will be removed once the culvert and upstream and downstream protection works are installed.
- 12 A sandbag coffer dam will be installed above the temporary diversion, before undertaking bank restoration works associated with rediverting the creek back through the completed culvert.
- 13 Disturbed areas will be revegetated.

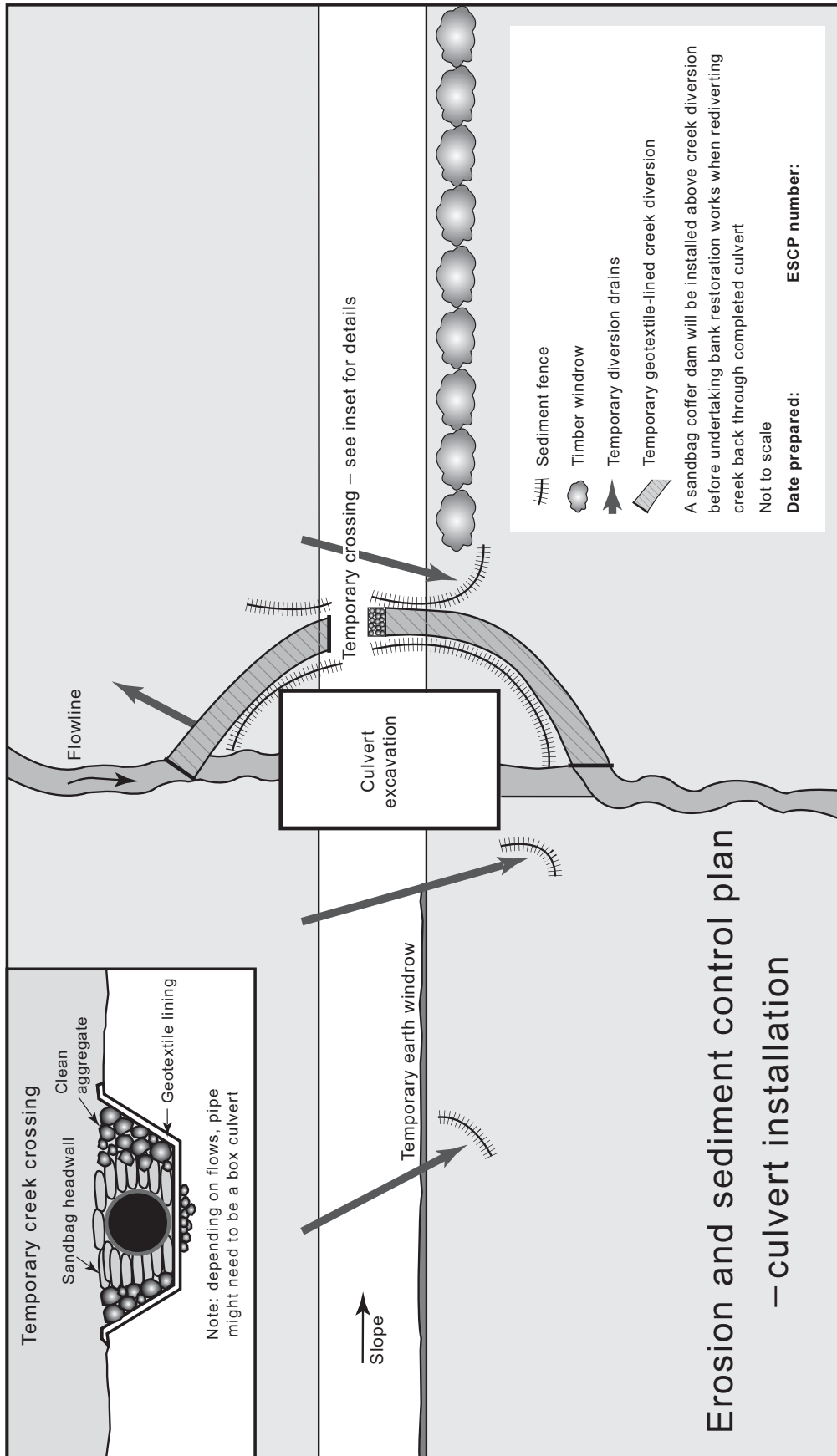


Figure A2.2 ESCP – culvert installation

### **Ridge-top unsealed roads**

- 1 This ESCP (see figure A2.3) should be read in conjunction with the primary ESCP for this project.
- 2 Erosion and sediment control measures will be implemented and maintained as per *Managing urban stormwater: soils and construction* vol. 1 (Landcom 2004a)
- 3 Disturbance will be kept to minimum within the limits of clearing.
- 4 Cross-banks will have a minimum capacity of 300 millimetres, be track-rolled, have a 2% slope, and will discharge onto a stable area.
- 5 Mitre drains will be installed early with sediment controls installed at their outlets. The road will be graded to ensure runoff from the road can enter the mitre drains. The distance between mitre drains will be determined by soil erodibility and road gradient.
- 6 Control measures will be inspected regularly (e.g. weekly, before a long weekend and after rain) with maintenance undertaken as necessary.
- 7 Disturbed areas beyond the road shoulder will be progressively revegetated.

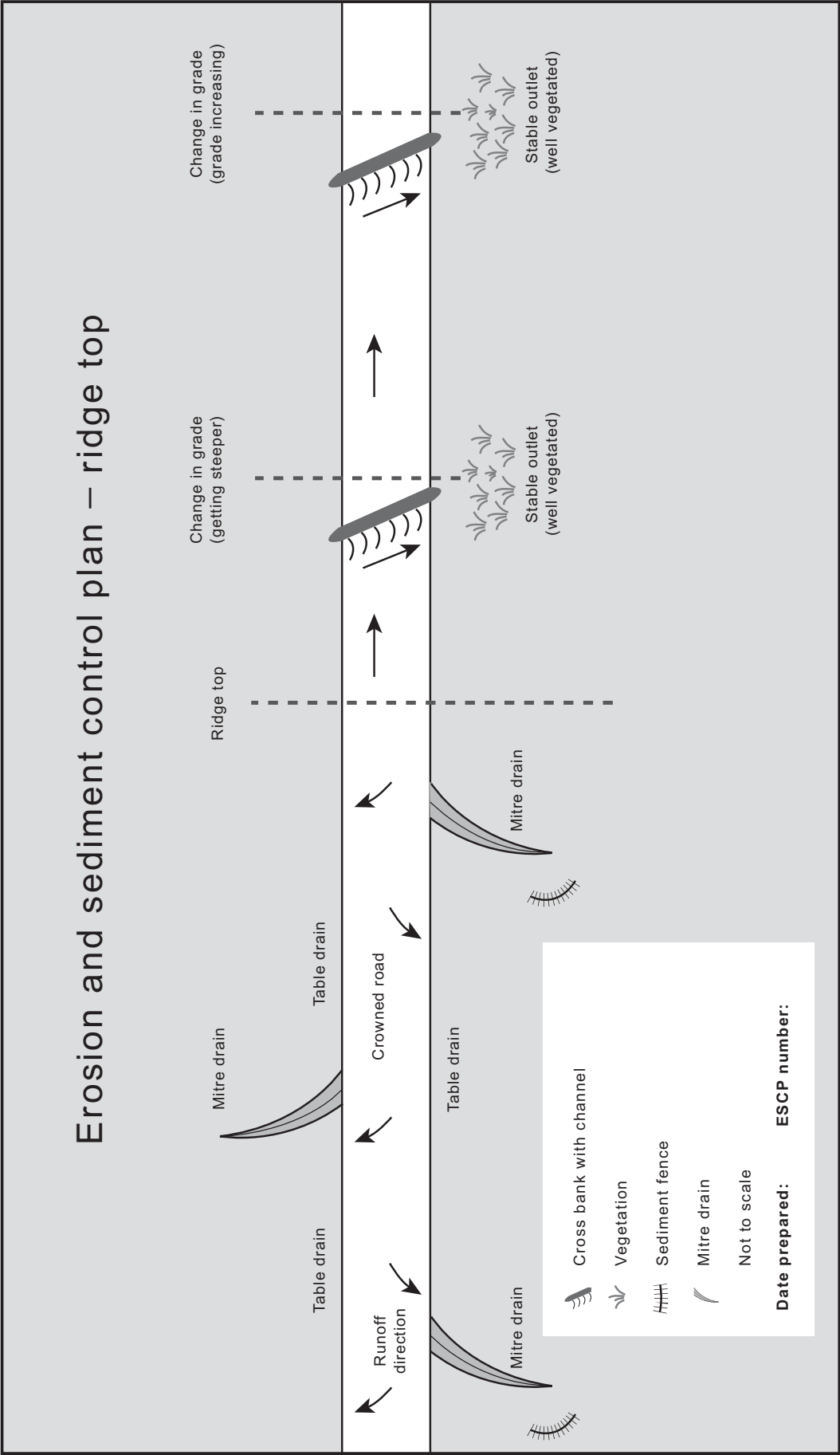


Figure A2.3 ESCP – ridge top



## **Attachment A3 Curricula vitae**

[Proponent to insert curricula vitae of key personnel involved in preparing and implementing this ESCP.]

## **Attachment A4 Sample program for erosion and sediment control awareness seminars**

### **1 Introduction**

This program outlines a half-day seminar designed to raise awareness about the importance of erosion and sediment control during the construction of unsealed roads.

### **2 Environmental impacts**

This session focuses on the on-site and off-site environmental impacts of erosion and sedimentation (e.g. water quality, fauna, flora etc.). It concludes with an exercise listing all impacts.

### **3 Environmental legislation**

This session examines relevant legislation (such as the POEO Act) and its practical application in the field.

### **4 Principles of erosion and sediment control**

This session covers nine principles of erosion and sediment control:

- investigation of site features
- planning
- minimum disturbance
- topsoil management
- control of runoff
- minimisation of erosion
- trapping sediment
- progressive rehabilitation
- maintenance.

### **5 Techniques of erosion and sediment control**

This session includes the most common techniques of erosion and sediment control.

Aspects covered include:

- clearing
- topsoil management
- drainage and installation of permanent structures (e.g. culverts, catch drains etc.)
- diversions banks
- drains and channels
- batter protection
- revegetation
- sediment basins and management
- sediment traps
- sandbags and their application
- maintenance
- miscellaneous issues (e.g. mud on local roads, dewatering and dust control).

### **6 Field inspection**

This session examines erosion and sediment control measures constructed in the field together with associated discussions on impacts, legislation and principles.

## Attachment A5 Procedure for water-quality management in sediment basins

### Why sediment basin management is required

Under the *Protection of the Environment Operations Act 1997*, there is a legal responsibility to ensure that runoff leaving a construction site (including water discharged from sediment basins after storm events) meets acceptable water-quality criteria.

The parameters to be monitored in the management of sediment basins and their assessment criteria include:

- total suspended solids (TSS) < 50 mg/L
- pH 6.5 to 8.5
- oil and grease visual assessment.

### Pipe outlets

Sediment basins should be designed and constructed with a low-flow pipe through the wall, and have a perforated riser at the inlet within the water storage area and a valve at the outlet below the structure.

### Emergency outlets

Every sediment basin should have an emergency outlet that overflows when a rainfall event exceeds the design capacity of the basin.

### Procedure

To effectively manage the sediment basins the following procedure should be undertaken:

- 1 Inspect all sediment basins for capacity and water quality immediately after rain ceases
- 2 Treat water unless it is to be used for construction purposes (e.g. compaction or dust control). Release stored water within 5–7 days to restore basin storage capacity.
- 3 If the design capacity has been reduced by 30% or more by sediment, then desilt the basin immediately after treating the water, as outlined below.
- 4 If the design capacity has been reduced by 30% or more by water, then test the water for pH, TSS and oil and grease and take action as follows:

#### pH

- test basin water with pH meter
- if pH between 6.5 and 8.5, take no action
- if pH below 6.5, add lime
- if pH above 8.5, as hydrochloric acid (32% muriatic acid)
- determine volume of water in basin
- determine amount of lime or acid required by adding a known amount of lime or acid (initially 0.004%) to a 10-litre sample of basin water until the pH reaches acceptable limits
- once the required percentage has been determined, calculate the actual amount of lime or acid to be added by multiplying the volume of water in the basin by the determined percentage
- add the required amount of lime or acid to the basin
- mix the water in the sediment basin well
- test and treat water for pH before testing for TSS.

## **TSS**

- test basin water using a turbidity tube that has been calibrated for the site through laboratory testing. This will enable a relatively accurate comparison, which will be verified by laboratory testing approximately every six rainfall events
- if TSS < 50 mg/L, take no action
- if TSS > 50 mg/L, add bulk gypsum evenly as a flocculant immediately across the top of the water at an acceptable rate (determined by trial and error for each basin). Methods of application include broadcast by shovels (on small basins < 200 m<sup>3</sup>) or mixing in a drum with water and pumping through a hose (on large basins > 200 m<sup>3</sup>).

## **Oil and grease**

- examine surface of water for evidence (e.g. sheen or discolouration)
  - if no visual contamination evident, take no action
  - if contamination evident, spread oil absorbent material such as Cell-u-sorb.
- 5 Leave basins to compensate for 24 to 48 hours.
  - 6 After retesting, and once the field tests indicate that water quality is acceptable, release water slowly through the stop valve, opening it no more than two or three notches (approximately 10%). Emptying should take 24–36 hours to prevent sediment from being stirred up.
  - 7 Repeat steps 4 and 5 if acceptable water quality is not achieved initially.
  - 8 Close the stop valve once water in the basins has been released.
  - 9 Keep records of the rainfall events, inspections, field tests, dosage rates and water releases (see checklist, table A5.1).
  - 10 Complete the whole process of water-quality management in sediment basins within 7 days of rain ceasing.

Table A5.1 Checklist for water-quality management in sediment basins

CONTRACT NO:

CONTRACT TITLE:

Rainfall event mm: \_\_\_\_\_ days: \_\_\_\_\_  
 Water quality criteria TSS <50 mg/L  
 pH 6.5 to 8.5  
 Oil and grease 10 mg/L max.  
 (by observation)  
 Desilting >30% reduction in design capacity

Basin no.	Design capacity m <sup>3</sup>	Is water to be used for construction?	Water quality before treatment			Rate of acid added	Rate of gypsum added	Oil absorbent added	Water quality after treatment			Date valve opened	Date valve closed	Desilting required?	Date desilted
			pH	TSS	Oil & grease				pH	TSS	Oil & grease				

Basin no./comments \_\_\_\_\_

Inspected by (name and position) \_\_\_\_\_ Signed (Environmental manager) \_\_\_\_\_  
 Date \_\_\_\_\_ Date \_\_\_\_\_

**Attachment A6 Sample maintenance checklist for project soil conservationist**

LOCATION	CONTROL	RECOMMENDATIONS / COMMENTS	ACTION * WHO & WHEN	CLOSE-OUT DATE

Date of inspection \_\_\_\_\_  
 Soil conservationist \_\_\_\_\_ Signed (Environmental manager) \_\_\_\_\_  
 Date \_\_\_\_\_ Date \_\_\_\_\_

\* This column must include person responsible and proposed completion date of action.

## Attachment A7 Sample maintenance checklist for construction personnel nominated in ESCP

CONTRACT NO:

CONTRACT TITLE:

ESCP number:

	Chainage :		
			To
LOCATION	DATE INSPECTED	COMMENTS	DATE RECTIFIED
INITIALS WHEN RECTIFIED			

Inspected by (name and position) \_\_\_\_\_ Signed (Environmental manager) \_\_\_\_\_

Date \_\_\_\_\_ Date \_\_\_\_\_

\* Refer to following page as memory jogger.

## Attachment A8 Erosion and sediment control checklist and schedule

Table A8.1 Erosion and sediment control checklist

Check	Item to be inspected
	<p><b>Topsoil and stockpile sites</b></p> <ul style="list-style-type: none"> <li>• Have sediment traps been constructed (e.g. sediment fence, timber windrows)?</li> <li>• Have the areas been seeded and fertilised?</li> </ul>
	<p><b>Drainage lines</b></p> <ul style="list-style-type: none"> <li>• Has the minimum area only been disturbed?</li> <li>• Do exposed areas require temporary lining (e.g. with geotextile)?</li> <li>• Are any sediment traps required?</li> </ul>
	<p><b>Sediment basins</b></p> <ul style="list-style-type: none"> <li>• Have sediment basins been constructed?</li> <li>• Do basins require maintenance (e.g. flocculating, emptying, desilting etc.)?</li> <li>• If yes refer to procedure for sediment basin water-quality management</li> </ul>
	<p><b>Cut section protection</b></p> <ul style="list-style-type: none"> <li>• Are catch drains installed?</li> <li>• Is runoff diverted to pits or sediment control devices?</li> </ul>
	<p><b>Fill batter protection</b></p> <ul style="list-style-type: none"> <li>• Are earth windrows installed along the top edges?</li> <li>• Do they have adequate capacity?</li> <li>• Are temporary diversion drains installed?</li> <li>• Do they have adequate capacity?</li> <li>• Do they outlet at batter drains?</li> <li>• If not, are they required?</li> <li>• Are batter drains lined with plastic or geotextile?</li> <li>• If not, is this required?</li> <li>• Are there sandbags at the top of batter drains?</li> <li>• Do windrows, diversion drains or batter drains require maintenance?</li> <li>• Is runoff diverted to pits or sediment control devices?</li> </ul>
	<p><b>Sediment fences</b></p> <ul style="list-style-type: none"> <li>• Are sediment fences installed correctly?</li> <li>• Do they require maintenance (e.g. trenching, retying, desilting etc.)?</li> <li>• Are additional fences required?</li> </ul>
	<p><b>Sediment traps (e.g. sandbags, timber windrow, straw bales etc.)</b></p> <ul style="list-style-type: none"> <li>• Are traps installed correctly?</li> <li>• Do they require maintenance (replacement, desilting etc.)?</li> <li>• Are additional traps required?</li> </ul>
	<p><b>Diversion banks and drains</b></p> <ul style="list-style-type: none"> <li>• Are diversion banks and drains installed correctly (e.g. bank on down-slope side, grade OK, outlet stable)?</li> <li>• Do they have adequate capacity?</li> <li>• Is plastic/geofabric lining in place where required?</li> <li>• Do they require maintenance (e.g. desilting, reshaping)?</li> <li>• Are additional banks or drains required?</li> </ul>
	<p><b>Revegetation</b></p> <ul style="list-style-type: none"> <li>• Are there any areas to be seeded, fertilised or mulched with straw?</li> <li>• Do any areas require retreatment?</li> </ul>



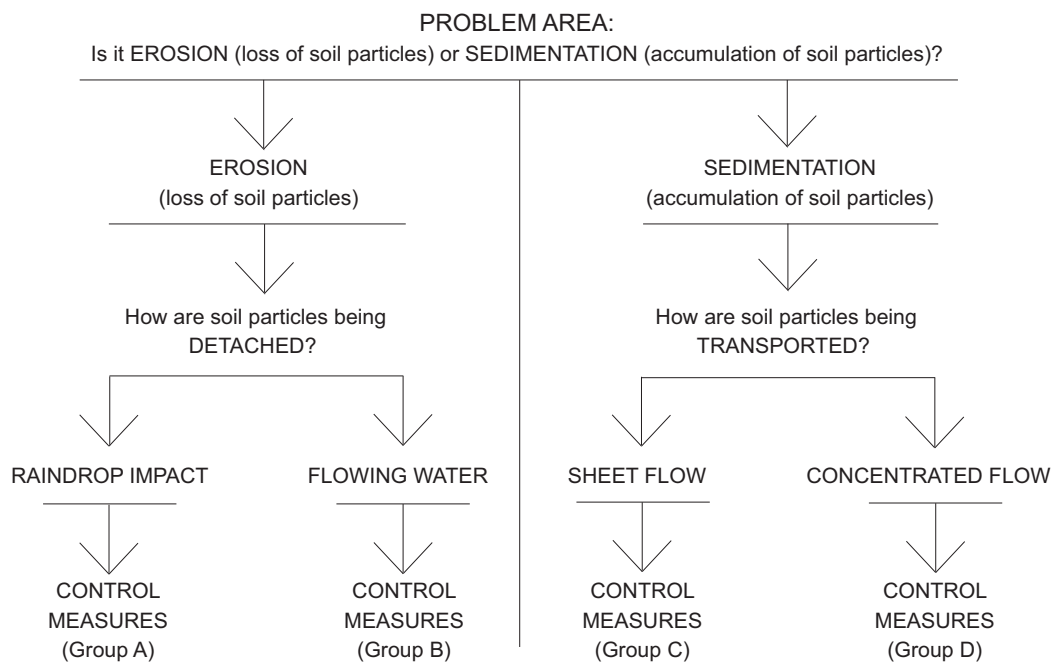


## Appendix B: Selection of control measures

This appendix describes a step-by-step approach for selecting erosion and sediment control measures, based on an approach developed by Soilcon Pty Ltd for the Queensland Department of Main Roads. Figure B.1 presents a simple flowchart that asks whether the problem is:

- erosion or sedimentation
- raindrop impact or flowing water
- sheet flow or concentrated flow.

The flowchart then guides the user to table B.1 outlining groups of treatment options which are described in detail in volume 1.



**Figure B.1** Decision-support flowchart for selection of erosion and sediment control measures (modified from Soilcon Pty Ltd. Used with permission)

**Table B.1 Erosion and sediment control measures**

**Group A: Erosion control – raindrop impact**

**Vegetation**

- temporary vegetation – cover crop only
- permanent vegetation – introduced (exotic) pasture species or native (endemic) species
- see 1: sections 4.3.2, 7.1, 7.2, appendix A6 and appendix G



**Batter blankets**

- vegetation promotion blankets
- vegetation suppression blankets
- needle-punched geotextile membrane
- builder's plastic membrane
- see 1: section 5.4.2, SD 5-2, appendix A6 and appendix D



**Soil surface mulching**

- hydromulch or hydraulic bonded fibre matrix
- blown straw, hay, crop residue, with bitumen tack
- tub-ground or chipped organic mulch
- brush-matting
- rock or gravel mulch
- see 1: section 7.4, figure 7.3, appendix A6 and appendix D



**Geocellular containment systems**

- non-woven geotextile type material
- polypropylene material (perforated and non-perforated)
- see 1: section 5.4.2, SD 5-3 and appendix D



**Surface roughening**

- roughening parallel to contour
- contour ripping or scarifying
- trackwalking
- see 1: section 4.3.2, figures 4.3(a) and (b)



**Geobinders**

- organic tackifiers
- co-polymer emulsions
- bitumen emulsion
- cementitious products
- see 1: section 7.1.2, appendices A6 and D



**Table B.1** Erosion and sediment control measures

**Group B: Erosion control – flowing water**

**Up-slope diversions**

- excavated channel-type bank
- backpush-type bank or windrow
- catch drains
- shoulder dyke
- see 1: section 5.4.4, SD 5-5 and SD 5-6



**Mid-slope diversions**

- berms and benches
- temporary diversions (at cut/fill line)
- cross banks
- see 1: section 4.3.1, figure 4.2 and appendix A4



**Soft armour channels**

- trapezoidal or parabolic shape
- consider channel grade and maximum permissible velocity
- establish vegetative ground cover
- standard (non-reinforced) or reinforced turf
- biodegradable erosion control mat (temporary) or synthetic erosion control mat (permanent)
- see 1: sections 5.4.3, 7.3, SD 5-7 and appendix D



**Hard armour channels**

- loose rock
- rock-filled wire mattresses
- articulating concrete block systems
- grouted rock
- cast in-situ concrete
- builder's plastic lining or geotextile lining
- see 1: section 5.4.4, table 5.2, figure 5.4 and appendix D



**In-stream diversions**

- temporary coffer dams
- water-filled structures
- temporary lined channel (stream diversion)
- see 1: section 5.3.5 and appendix I



**Table B.1 Erosion and sediment control measures**

**Group B: Erosion control – flowing water (continued)**

**Check dams**

- stacked rock
- sandbags and geotextile sausages
- straw bales
- logs
- proprietary products
- see 1: section 5.4.3, SD 5-4, and figures 5.3(a) and (b)



**Batter drains**

- concrete (pre-cast or in-situ)
- half 'armco' pipe
- sandbags
- rock-filled wire mattresses
- loose rock rip-rap
- builder's plastic or geotextile lined chutes
- see 1: section 5.4.4 and appendix D



**Grade control structures and flumes**

- gully pits and field inlets
- sandbag drop structures
- rock-filled wire gabions and mattress structures
- driven sheet piling
- concrete chutes
- inclined pipe spillways
- builder's plastic-lined chutes



**Outlet dissipation structures**

- loose rock riprap aprons
- rock-filled wire mattresses
- roughness elements
- hydraulic jump-type structures
- impact type structures
- see 1: sections 5.4.5, figures 5.8, 5.9, 5.10, 5.11 and SC 5-8



**Revetments and retaining walls**

- riprap
- rock-filled wire gabions and mattresses



**Table B.1 Erosion and sediment control measures**

**Group C: Sediment control – sheet flows**

**Vegetative buffers**

- well established sward with good groundcover
- see 1: section 6.3.8, table 6.4, SD 6-13 and appendix G



**Sediment barriers/filters**

- sediment fences
- vegetation, brush, rock or gravel windrows
- earthen down-slope diversion directing sheet flows to sediment traps or sumps
- straw bale barriers
- see 1: section 6.3.7, SD 6-7, SD 6-8, figure 6.10 and appendix D



**Site exit points**

- shaker ramps
- rock aprons
- wheel wash systems
- see 1: section 6.3.9 and SD 6-14



**Group D: Sediment control – concentrated flows**

**Sediment curtains/turbidity barriers**

- floating geotextile
- proprietary polypropylene products
- temporary coffer dams
- water-filled structures
- see 1: section 6.3.7, SD 6-10 and appendix D



**Sediment traps**

- stacked rock/timber with geotextile
- excavated sumps
- straw bale or sand bag structures
- gully pit, field inlet and kerb inlets
- see 1: section 6.3.6, figure 6.11, SD 6-11, SD 6-12



**Sediment retention basins**

- type C (riser type) basin
- type F (extended settling) basins
- type D (flocculation) basins
- see 1: sections 6.3.3, 6.3.4 and 6.3.5, SD 6-3, SD 6-4, appendices E and J





**Table C.2 Checklist for operational phase maintenance: erosion and sediment control**

<b>CONTRACT NO:</b>		<b>CONTRACT TITLE:</b>
<b>Check</b>	<b>Item to be inspected</b>	
	<p><b>Road surface</b></p> <p>Does the road require resurfacing?</p> <p>Does the road require patching?</p> <p>Does the road require resheeting?</p> <p>Is there any large build-up of loose material on the road?</p>	
	<p><b>Cross-fall</b></p> <p>Is there sufficient cross-fall (minimum 4%) on the road or track to allow drainage?</p> <p>Is there a windrow along the edge of the road or track to prevent runoff entering the table drain?</p>	
	<p><b>Table drains</b></p> <p>Can road runoff enter the table drain?</p> <p>Are the table drains eroding?</p> <p>Do table drains require lining or does their lining need repair?</p> <p>Do the table drains require cleaning out so that they function more effectively?</p> <p>Are table drains discharging into other drainage structures properly (e.g. mitre drains, culverts)?</p>	
	<p><b>Mitre drains</b></p> <p>Can road runoff enter the mitre drains?</p> <p>Do the mitre drains require cleaning out?</p> <p>Are the mitre drains eroding?</p> <p>Is erosion occurring on the road between mitre drains?</p> <p>Are additional mitre drains required?</p>	
	<p><b>Cross-banks</b></p> <p>Is erosion occurring on the road between cross-banks?</p> <p>Are additional banks required?</p> <p>Do the cross-banks have adequate capacity?</p> <p>Have cross-banks been breached?</p> <p>Do cross-banks extend right across the road or track?</p> <p>Are cross-banks discharging onto stable ground (with no erosion occurring at the outlet)?</p> <p>Is the channel of the cross-bank eroding (is the grade too steep)?</p>	
	<p><b>Rolled grades and spoon drains</b></p> <p>Do they have sufficient capacity?</p> <p>Do they require cleaning out to increase their capacity?</p> <p>Are they discharging onto a stable surface (with no erosion occurring)?</p> <p>Is erosion occurring in the spoon drain or rolled grade (is the grade too steep)?</p> <p>Is erosion occurring between the spoon drain or rolled grade?</p> <p>Are additional drainage structures required?</p>	
	<p><b>Culverts</b></p> <p>Can runoff enter culverts?</p> <p>Do culverts have at least 90% capacity?</p> <p>Do they require cleaning out?</p> <p>Is erosion occurring at the outlet of the culvert?</p> <p>Is erosion occurring around the headwall or sidewalls of the culvert?</p> <p>Is erosion occurring on the banks or bed of watercourse because of the culvert?</p>	



**Table C.2 Checklist for operational phase maintenance: erosion and sediment control (cont.)**

<b>CONTRACT NO:</b>	<b>CONTRACT TITLE:</b>
<b>Check</b>	<b>Item to be inspected</b>
	<p><b>Watercourses and bridges</b></p> <p>Are the approaches to the watercourse stable (not eroding)?</p> <p>Are additional drainage structures required on the approaches to the bridge?</p> <p>Is additional non-erodible material required on the approaches to the watercourse?</p> <p>Are bridge abutments stable?</p> <p>Does road runoff discharge off the road before it reaches a watercourse or wetland?</p> <p>Is erosion occurring beneath the bridge scuppers?</p> <p>Is erosion occurring on the banks of the watercourse because of the bridge or its piers?</p> <p>Are bridge piers causing the bed of the watercourse to erode?</p>
	<p><b>Fords and causeways</b></p> <p>Are they functioning effectively?</p> <p>Is erosion occurring on the bed or banks of the watercourse adjacent to or downstream of the ford?</p> <p>Is the ford being undermined?</p> <p>Are the approaches to the ford eroding?</p> <p>Are additional drainage structures required on the approaches to the ford?</p>
	<p><b>Batters</b></p> <p>Is there any slumping occurring on batters?</p> <p>Is erosion occurring on batter faces?</p> <p>Are batter drains functioning properly (water from the road can get into them, erosion is not occurring either side of the batter drain, erosion is not occurring at the outlet of the batter drain)?</p> <p>Are additional batter drains required?</p> <p>Is there sufficient vegetation on batters (at least 75% cover)?</p> <p>Are catch drains above cut batters functioning effectively (e.g. can water get into them from the catchment above)?</p> <p>Do catch drains require cleaning out?</p> <p>Is erosion occurring at the outlet of catch drains?</p> <p>Is erosion occurring in the catch drain?</p> <p>Do catch drains require lining or does their lining need repair?</p>
	<p><b>Fire trails</b></p> <p>Is there sufficient roadside clearance?</p> <p>Is the road surface capacity sufficient to carry fully loaded fire-fighting vehicles (28 tonnes or 9 tonnes per axle)?</p> <p>Are passing points wide enough (20 m long and 3 m wide with a minimum trafficable width of 7 m at the passing bay)?</p>



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