WAMBO COAL
EROSION AND SEDIMENT CONTROL PLAN

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CONTENTS

1.0 INTRODUCTION....1
1.1 BACKGROUND....1
1.2 PURPOSE....3
1.3 SCOPE....3
1.4 STATUTORY REQUIREMENTS....6
1.5 STAKEHOLDER CONSULTATION....8
2.0 POTENTIAL SOURCES AND IMPACTS....9
3.0 OVERVIEW....10
3.1 SITE WATER MANAGEMENT....10
3.2 SOILS....10
3.3 SLOPE....11
3.4 HYDROLOGY....11
4.0 PLANNING....12
4.1 PRINCIPLES....12
4.2 EROSION & SEDIMENT CONTROL IMPLEMENTATION PLAN....13
5.0 EXISTING CONTROLS....19
5.1 DESIGN GUIDELINES....22
6.0 IMPLEMENTATION....25
6.1 CONSTRUCTION....25
6.2 SEDIMENT FENCES....25
6.3 CHECK DAMS....25
6.4 DIVERTED WATER MANAGEMENT....26
6.5 SURFACE WATER MANAGEMENT....26
6.6 WORKED WATER MANAGEMENT SYSTEM....28
6.7 TOPSOIL MANAGEMENT....29
6.8 SUBSIDENCE MANAGEMENT....29
6.9 PERFORMANCE INDICATORS....29
7.0 INSPECTIONS, MONITORING AND MAINTENANCE....31
7.1 ALL CONTROL STRUCTURES....31
7.2 SEDIMENT CONTROL DAMS....31
8.0 COMMUNITY COMPLAINT RESPONSE....32
9.0 REVIEW AND REPORTING....33

9.1 REVIEW 33
9.2 ANNUAL REVIEW 33
9.3 WEBSITE UPDATES 33
9.4 REPORTABLE ENVIRONMENTAL INCIDENTS 34

10.0 RESPONSIBILITIES 35

11.0 REFERENCES 36

Tables

Table 1: Summary of the Approved Wambo Coal Mine 1
Table 2: Development Consent Requirements for the Erosion and Sediment Control Plan 6
Table 3: Sources of Erosion and Sedimentation 9
Table 4: Sediment Dam Risk Analysis 17
Table 5: Water Management Control Structures 19
Table 6: Design Guidelines for Sediment Control 22
Table 7: Guidelines for Erosion Control 23
Table 8: Summary of Erosion Control Techniques 24
Table 9: Performance Indicators 30
Table 10: Erosion and Sediment Control Plan Responsibilities 35

Figures

Figure 1: Wambo Coal Regional Location 2
Figure 2: WCPL Site Water Management Plan 3
Figure 3: Approved Wambo Coal Mine Layout 5
Figure 4: Erosion and Sediment Control Matrix (Peabody, 2014) 18
Figure 5: Water Management Structures 21
Figure 6: Example of Sediment Fencing 25
Figure 7: Example of Check Dams 26
Figure 8: 5-Day Rainfall Depth 27
Figure 9: Settling and Storage Zones 28
Figure 10: Indicative Sediment Dam Capacity 28
Figure 11: Indicative Pump Out Time Frames 28

LIST OF APPENDICES

Appendix A Consultation with Regulatory Authorities
Appendix B Dispute Resolution Process
Appendix C Wambo Coal Surface Disturbance Permit
Appendix D Design Principles
Appendix E Sediment Control Structure Inspection Checklist
Appendix F Example of Certification of Sediment Dam Construction
Appendix G Risk Assessment Matrix
Appendix H Summary of Commitments

1.0 Introduction

1.1 Background

The Wambo Coal Mine (the Mine) is situated approximately 15 kilometres west of Singleton, near the village of Warkworth, New South Wales (Figure 1). The Mine is owned and operated by Wambo Coal Pty Limited (WCPL), a subsidiary of Peabody Energy Australia Pty Limited.

A range of open cut and underground mine operations have been conducted at WCPL since mining operations commenced in 1969. Mining under the current Development Consent (DA 305-7-2003) commenced in 2004 and permits both open cut, underground operations and associated activities to be conducted.

The approved run-of-mine (ROM) coal production rate is 14.7 million tonnes per annum and all product coal is transported from WCPL by rail. A summary of the approved Wambo Coal Mine is provided in **Table 1**.

Table 1: Summary of the Approved Wambo Coal Mine

Component	Approved Wambo Coal Mine[1,2]
Life of Mine	Wambo Coal may carry out mining operations at the Wambo Mining Complex until 31 December 2039, except for open cut coal extraction, which may only be undertaken until 31 December 2020.
Open Cut Mining	Open cut mining at a rate of up to 8 Mtpa of ROM coal from the Whybrow, Redbank Creek, Wambo and Whynot Seams
	An estimated total open cut ROM coal reserve of 98 Mt
	Open cut mining operations under current approved Mining Operations Plan
	Open cut mining operations up to 31 December 2020
Underground Mining	Underground mining of up to 9.75 Mtpa of ROM coal from the Whybrow, Wambo, Woodlands Hill and Arrowfield Seams. Underground ROM coal reserves are estimated at 161.3 Mt. Underground mining operations up to 31 December 2039
Subsidence commitments and management.	The subsidence performance measures listed in Conditions 22 and 22A of the Development Consent (DA305-7-2003).
ROM Coal Production Rate	Up to 14.7 Mtpa of ROM coal
Total ROM Coal Mined	259.3 Mt
Waste Rock Management	Waste rock deposited in open cut voids and in waste rock emplacements adjacent open cut operations
Total Waste Rock	640 million bank cubic metres (Mbcm)
Rail and Train Loading Infrastructure	Construction and operation of a rail spur, rail loop, coal reclaim area, product coal conveyor and train load out bin to enable the transport of coal (DA 177-8-2004)
Coal Washing	Coal handling and preparation plant (CHPP) capable of processing approximately 1,800 tonnes per hour (tph)
Product Coal	Production of up to 11.3 Mtpa of thermal coal predominantly for export
CHPP Reject Management	Coarse rejects and tailings would be incorporated, encapsulated and/or capped within open cut voids in accordance with existing Wambo management practices
Total CHPP Rejects	Approximately 40.3 Mt of coarse rejects and approximately 24.5 Mt of tailings
Water Supply	Make-up water demand to be met from runoff recovered from tailings storage areas, operational areas, dewatering, licensed extraction from Wollombi Brook and Hunter River
Mining Tenements	Coal Lease (CL) 365, CL374, CL397, Consolidated Coal Lease (CCL) 743, Mining Lease (ML) 1402, ML1572, ML1594, Authorisation (A) 444, Exploration Licence (EL) 7211.

Note: [1] Development Consent DA305-7-2003 (as modified December 2017) [2] Development Consent DA177-8-2004

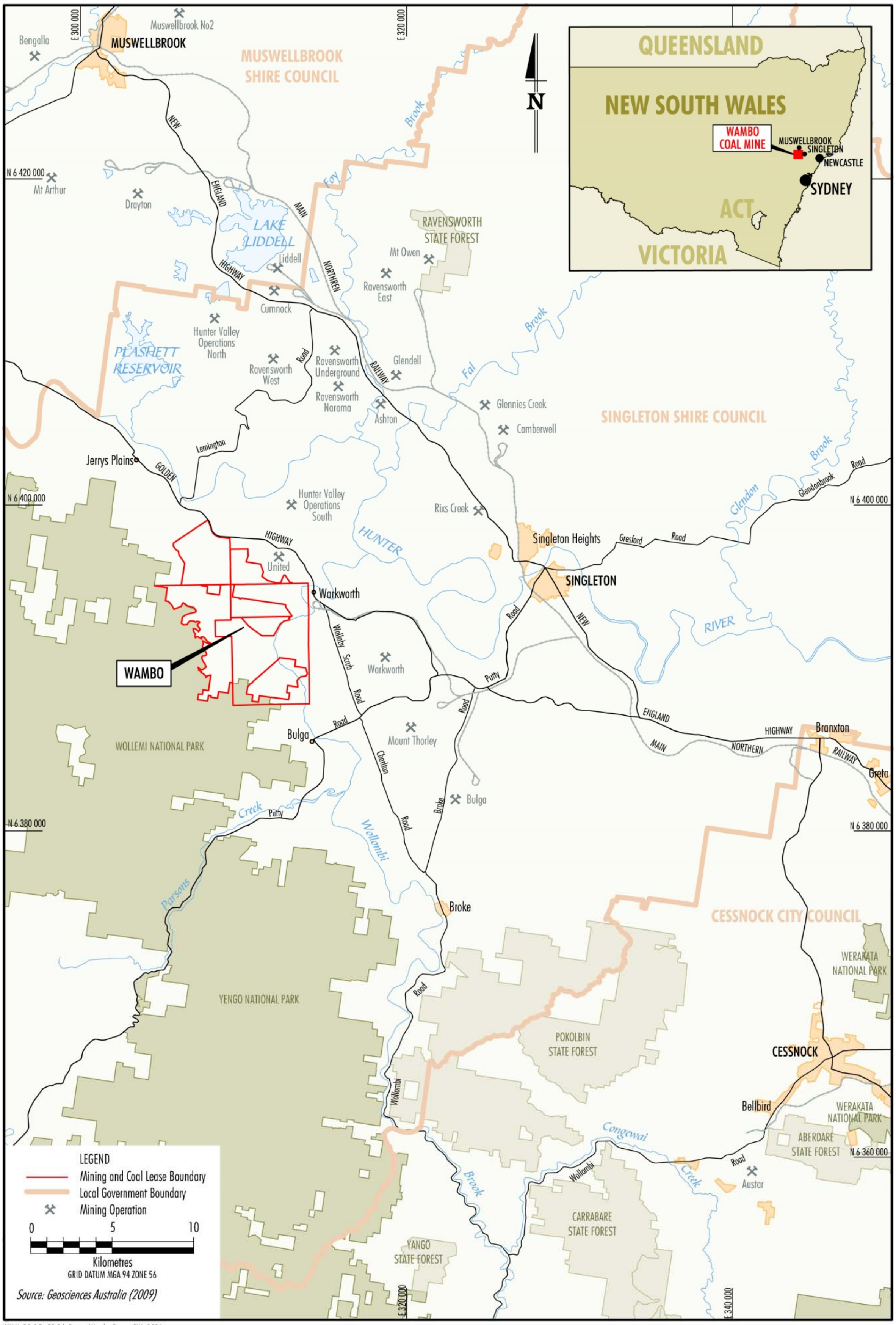


Figure 1: Wambo Coal Regional Location

In accordance with Schedule 4, Condition 30 of DA305-7-2003, WCPL is required to prepare a Site Water Management Plan (WMP). This Erosion and Sediment Control Plan (ESCP) is a component of the Site Water Management Plan (**Figure 2**). This ESCP shall be read in conjunction with the other components of the Site Water Management Plan, in particular the Surface Water Monitoring Program (SWMP) and the Surface and Ground Water Response Plan (SGWRP).

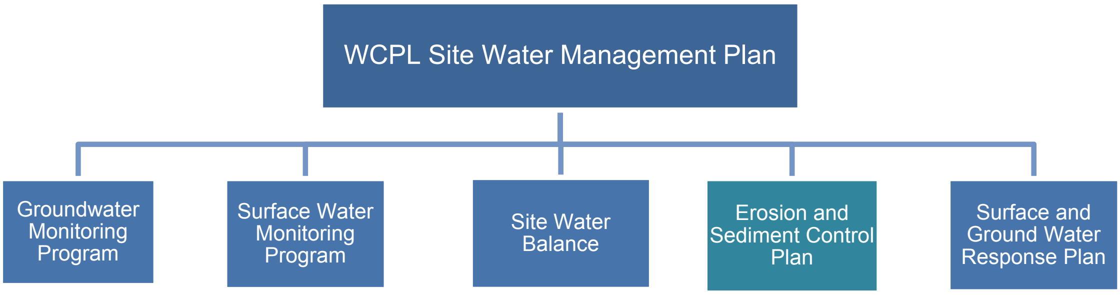


Figure 2: WCPL Site Water Management Plan

In accordance with WCPL's continuous improvement and review processes and Conditions 4 & 6, Schedule 6 of DA305-7-2003, reviews of the ESCP have been undertaken to ensure that erosion and sediment impacts from the Mine are managed and minimised where possible.

1.2 Purpose

This ESCP has been developed to address the requirements of relevant consent conditions and regulatory requirements. In accordance with Condition 32, Schedule 4 of DA305-7-2003, WCPL have prepared this ESCP to:

- Be consistent with the requirements of the Department of Housing's *Managing Urban Stormwater: Soils and Construction* manual;
- Be consistent with the Peabody Energy Australia *Erosion and Sediment Control Guideline (October 2014)*;
- Identify activities that could cause soil erosion and generate sediment;
- Describe the location, function, and capacity of erosion and sediment control structures; and
- Describe measures to minimise soil erosion and the potential for the migration of sediments to downstream waters.

1.3 Scope

This ESCP applies to all surface disturbance activities within surface and diverted water catchments undertaken within WCPL's mining authorisations and approved mining areas (**Figure 3**). This ESCP has been prepared to:

- Minimise erosion and sediment generation from disturbed areas;
- Maintain water quality in downstream water systems (primarily turbidity or sediment load, as indicated by Total Suspended Solids (TSS)); and
- Reduce the loss of valuable topsoil from land disturbed by mining activities.

This ESCP forms part of WCPL's Environmental Management System (EMS). The ESCP will be implemented at a catchment or sub catchment level. The specific controls and the subsequent monitoring and maintenance will be outlined in Erosion and Sediment Implementation Plans (ESCIP) (**Section 4.2**).

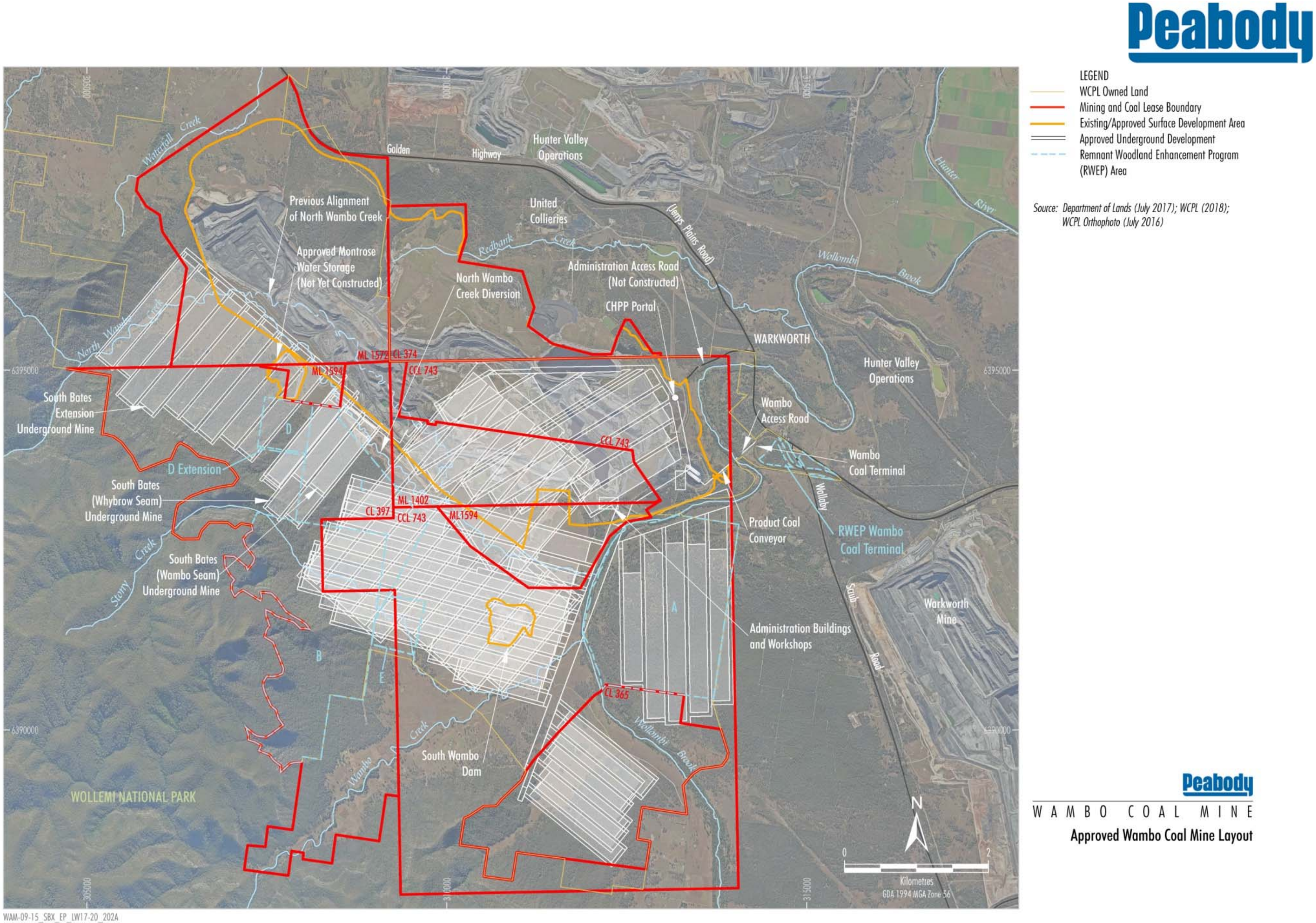


Figure 3: Approved Wambo Coal Mine Layout

1.4 Statutory Requirements

This ESCP has been prepared to address the relevant Development Approval (DA) consent conditions within DA305-7-2003 and DA177-8-2004 (**Table 2**).

1.4.1 Environmental Planning & Assessment Act 1979

WCPL received Development Consent (DA305-7-2003) in accordance with the *Environmental Planning & Assessment Act 1979* (EP&A Act) from the NSW Department of Planning and Environment (DP&E), formerly NSW Department of Planning, on 4 February 2004. Conditions within DA305-7-2003 relevant to erosion and sediment control at the Mine are summarised in **Table 2**.

WCPL received Development Consent (DA177-8-2004) in accordance with the EP&A Act from the NSW DP&E on 16 December 2004. Conditions within DA177-8-2004 relevant to erosion and sediment control at the Mine are summarised in **Table 2**.

Table 2: Development Consent Requirements for the Erosion and Sediment Control Plan

Schedule	Condition	Requirements	ESCP Section
DA305-7-2003			
4	30	Before carrying out any development, the Applicant shall prepare a Site Water Management Plan for the development in consultation with DRG and CLWD, and to the satisfaction of the Secretary. This plan must include: … (d) an Erosion and Sediment Control Plan; *By the end of October 2009, the Applicant shall revise the Site Water Management Plan in consultation with* DRG and CLWD *and to the satisfaction of the Secretary.**	**This ESCP**
4	32	The Erosion and Sediment Control Plan shall include: (a) Be consistent with the requirements of the Department of Housing's Managing Urban Stormwater: Soils and Construction manual;	**Section 4.1**
		(b) Identify activities that could cause soil erosion and generate sediment;	**Section 2.0**
		(c) Describe the location, function, and capacity of erosion and sediment control structures; and	**Section 4.2**
		(d) Describe measures to minimise soil erosion and the potential for the migration of sediments to downstream waters.	**Sections 6.0 and 7.0**
6	3	**Adaptive Management** The Applicant must assess and manage project-related risks to ensure that there are no exceedances of the criteria and/or performance measures in schedule 4. Any exceedance of these criteria and/or performance measures constitutes a breach of this consent and may be subject to penalty or offence provisions under the EP&A Act or EP&A Regulation. Where any exceedance of these criteria and/or performance measures has occurred, the Applicant must, at the earliest opportunity: (a) take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur; (b) consider all reasonable and feasible options for remediation (where relevant) and submit a report to the Department describing those options and any preferred remediation measures or other course of action; and	**Refer SGWRP**

Schedule	Condition	Requirements	ESCP Section
		(c) implement remediation measures as directed by the Secretary, to the satisfaction of the Secretary.	
6	4	**Management Plan Requirements** The Applicant shall ensure that the management plans required under this consent are prepared in accordance with any relevant guidelines, and include: (a) detailed baseline data;	**N/A to the ESCP**
		(b) a description of: - the relevant statutory requirements (including any relevant consent, licence or lease conditions);	**Section 1.4**
		- any relevant limits or performance measures/criteria;	**N/A to the ESCP**
		- the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures;	**Section 6.9**
		(c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/ criteria;	**Section 6.0**
		(d) a program to monitor and report on the: - impacts and environmental performance of the Wambo Mining Complex;	**Section 7.0**
		- effectiveness of any management measures (see c above);	**Section 9.0**
		(e) a contingency plan to manage any unpredicted impacts and their consequences;	**Refer SGWRP**
		(f) a program to investigate and implement ways to improve the environmental performance of the Wambo Mining Complex over time;	**Section 9.2**
		(g) a protocol for managing and reporting any: - incidents;	**Section 9.4**
		- complaints;	**Section 8.0**
		- non-compliances with statutory requirements; and	**Refer SGWRP**
		- exceedances of the impact assessment criteria and/or performance criteria; and	**Refer SGWRP**
		(h) a protocol for periodic review of the plan.	**Section 9.1**
DA177-8-2004			
4	17	Before carrying out any development, the Applicant shall prepare and implement a Soil and Water Management Plan for the development, to the satisfaction of the Director-General. This plan must include:	**This ESCP**
		(a) an Erosion and Sediment Control Plan that: - is consistent with the requirements of the Departments of Housing's Managing Urban Stormwater: Soils and Construction manual;	**Section 4.1**
		- identifies activities that could cause soil erosion and generate sediment;	**Section 2.0**
		- describes the location, function and capacity of erosion and sediment control structures; and	**Section 4.2**
		- describes measures to minimise soil erosion and the potential for the migration of sediments to downstream waters;	**Section 6.0**

Notes: * In September 2009, DP&E granted WCPL an extension to the submission date to 30/4/2010 to allow for DII and EPA review and comment.

1.5 Stakeholder Consultation

Following consultation with Department of Industry and Investment (formerly the Department of Primary Industries or DPI), Environment Protection Authority (formerly the Department of Environment, Climate Change and Water or DECCW) and NSW Office of Water (NOW), the ESCP (Version 7) was approved by DP&E in November 2015.

The ESCP was revised in April 2016 (Version 8) and submitted to DP&E for approval in May 2016. Despite several attempts by WCPL to follow up, this version was never approved.

The Version 8 revision included:

- Updating the format and layout of the ESCP, consistent with WCPL's current document management procedures and templates;
- Incorporating additional planning, risk analysis, design and surveillance monitoring of sediment control structures; and
- Including additional information to ensure the ESCP addresses Condition 4, Schedule 6 of DA305-7-2003.

Revision 9 changes were minor in nature, including formatting changes, updates to figures and tables to reflect the current water management structures, the approval of South Bates Underground Extension (Modification17) and the inclusion of a summary of commitments in Appendix H.

The DP&E provided comments on Revision 9 on 26 March 2018. This document (Revision 10) addresses those comments. A summary of the regulator comments and where each comment is addressed is presented in Appendix A.

Revision 10 was approved by DP&E on 27 June 2018.

2.0 Potential Sources and Impacts

Mining activities involve disturbance to the lands surface, which has the potential to result in erosion and sediment impacts to the surrounding natural environment. Erosion may result in increased sediment load in downstream drainage systems if appropriate control measures are not implemented. The potential sources and impacts of erosion and sedimentation are listed in **Table 3** below.

Table 3: Sources of Erosion and Sedimentation

Source	Potential Impact	Controls
Topsoil Stripping/Stockpiling	Loss of topsoil resource, Sediment mobilisation from stockpile entering drainage/waterways.	Battering, revegetation, and sediment fencing.
Corridor clearing (power lines, pipelines, etc)	Loss of topsoil resource, Sediment mobilisation entering drainage/waterways.	Revegetation of buffer zone with grasses, surface stabilisation of access track (road base or gravel), and rock check dams in drains and on batters of watercourse crossings.
Remote pad construction	Sediment mobilisation from cleared area and pad materials entering drainage/waterways.	Upslope catchment diversion, catch drains, rock check dams and sediment fences.
Access tracks and unsealed roads	Road instability, sediment generation entering waterways.	Cresting of roads, drainage channels, rock chutes, rock check dams and level spreading.
Building sites i.e. workshops, offices within a mine industrial area	Sediment generation blocking stormwater infrastructure.	Upslope catchment diversion, sediment fences and rock check dams in drainage lines.
Constructing accommodation camps	Loss of topsoil, sediment generation entering waterways.	Upslope catchment diversion, sediment fences and rock check dams in drainage lines.
Out of pit spoil dumping	Sediment generation, discolouration of waterways, chocking of drainage system and dump failure due to erosion.	Sediment dams, drainage channels, surface re-shaping, progressive rehabilitation.
Rehabilitation of dumps	Loss of topsoil resource, rehabilitation failure due to concentrating flows, sediment mobilisation and waterway discolouration.	Contour drains, rock chutes, rock lined drainage channels, energy dissipaters at drainage outlets, revegetation and sediment dams.
Subsidence areas	Potential areas of instability, destabilising creek bed and banks, sediment generation entering waterways.	Stabilisation of any areas of surface cracking using erosion protection measures including revegetation.

3.0 Overview

Erosion control and sediment control are two very different activities. Erosion control measures concentrate on preventing, or at least minimising, soil erosion. Sediment control measures concentrate on trapping sediment displaced by up-slope soil erosion. The three main controls are:

- **Drainage control** – prevention or reduction of soil erosion caused by concentrated flows and appropriate management and separation of the movement of diverted and surface water through the area of concern;
- **Erosion control** – prevention or minimisation of soil erosion (from dispersive, non-dispersive or competent material) caused by rain drop impact and exacerbated overland flow on disturbed surfaces; and
- **Sediment control** – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e. from up-slope erosion).

3.1 Site Water Management

The water within the Mine and outside the Mine has been divided into three classes depending upon the source of the runoff and water quality, they include:

- **'Worked Water'** (or mine water) is surface water that has generally come in contact with coal such as in the open cut mining area or from the ROM coal stockpile. This water may contain high total dissolved solids above values that represent fresh water as defined by ANZECC & ARMCANZ (2000);
- **'Surface Water'** (or dirty water) is surface runoff water from areas that are disturbed by mining operations (including land cleared ahead of mining and rehabilitated areas[1]). This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads, but does not contain contaminated material or high salt concentrations; and
- **'Diverted Water'** (or clean water) surface runoff from the surrounding catchment that is diverted around the mine site to ensure no direct impact on the water quality by the mining operations.

3.2 Soils

Soil classification and understanding their dispersive and erodibility properties is required during the planning phase (**Section 4.2**) of an activity.

Soil landscapes of the Mine and surrounds were classified and mapped in accordance with descriptions in the *Soil Landscapes of the Singleton 1:250,000 Sheet* (Kovac and Lawrie, 1991) and the *2003 Environmental Impact Assessment* (2003 EIS). Major soil types identified include alluvial soils along major drainage lines, siliceous sands to the east of Wollombi Brook, yellow podzolics and yellow solodic intergrades adjacent to the alluvials on lower slopes and undulating plains, soloths on moderately elevated slopes and lithosols along the eastern boundary of the Wollemi National Park.

[1] Reclassification of 'surface water' to 'diverted water' from rehabilitated areas, subject to meeting EPL water quality parameters.

Due to the known variability and distribution of the soils at WCPL, the concept of soil complex units is used to identify the soil types, and provide guidance on appropriate stripping depth. The different soil complex units found at Wambo, as identified in the 23003 EIS (WCPL, 2003), include:

- Red Podzolic – found on the ridges and middle to upper slope position of the site. The upper 0.10 m of the profile of each soil type is suitable for use as topsoil. Tunnel and gully erosion risk, high structural degradation risk.
- Yellow Podzolic / Solodic – found on the mid to lower slopes of the hills within the site. The upper 0.20 m of the profile of each soil type is suitable for topsoil. Tunnel and gully erosion risk, high structural degradation risk.
- Lithosols – Stony or gravely soils generally occurring on upper slope and hill top areas. No depth of the profile is suitable for topsoil.
- Alluvials – found around North Wambo Creek. Suitability for topsoil recovery highly variable from 0.30 m, to limited areas of 1.0 m. Erosion hazard, high structural degradation risk.

3.3 Slope

The steepness of the slope and slope length are important determinants in the erosion risk of site. The Australian Soils and Landscapes Handbook identifies that slopes can be categorised by their percentage or degree of slope. An assessment of the slope and the current and proposed landforms including drainage patterns is required during the planning phase (**Section 4.2**) of an activity.

3.4 Hydrology

The Mine is situated adjacent to Wollombi Brook, south-west of its confluence with the Hunter River (**Figures 3**). Wollombi Brook drains an area of approximately 1,950 square kilometres and joins the Hunter River some 5 km north-east of Wambo. The Wollombi Brook sub-catchment is bound by the Myall Range to the south-east, Doyles Range to the west, the Hunter Range to the south-west and Broken Back Range to the north-east.

The majority of lands within Wambo mining tenements drain via Wambo (also known as 'South Wambo'), Stony, North Wambo and Redbank Creeks to Wollombi Brook, while Waterfall Creek drains directly to the Hunter River (Figure 2).

A section of North Wambo Creek has been diverted to avoid the Wambo open cut (**Figure 3**). The North Wambo Creek Diversion was constructed in accordance with the approved North Wambo Creek Diversion Plan.

Approximately 980 m of the North Wambo Creek Diversion has been undermined by Longwalls 11 to 13 at South Bates Underground Mine. In December 2017, WCPL was granted consent to mine an additional nine longwall panels (LW17 to LW25), to the north-west of the South Bates Underground Mine. An additional 120 m will be undermined by Longwall 17 (**Figure 3**).

4.0 Planning

4.1 Principles

The following principles provide the foundation for this ESCP:

- Ensure erosion and sediment control measures are designed and constructed effectively;
- Minimise surface disturbance and restrict access to undisturbed areas;
- Progressively rehabilitate and stabilise disturbed areas;
- Maximise sediment retention onsite;
- Separate disturbed and undisturbed catchment runoff, where practicable;
- Minimise soil erosion where possible rather than applying down slope sediment controls;
- Utilise existing topography and adopt construction practices that minimise soil erosion and sediment discharge from the area;
- Integrate erosion and sediment control issues/measures into the planning phases of the mine operation;
- Choose the erosion and sediment control technique to account for site conditions such as soil, weather and construction conditions;
- Correct design of surface drains to facilitate the efficient transport of surface runoff (drains will generally be designed using trapezoidal or parabolic cross-sections);
- Construct sediment control structures, or utilize existing mine water storages, to contain runoff from disturbed areas;
- Maintain all erosion and sediment control measures in proper working order at all times; and
- Monitor the site and adjust erosion and sediment control practices to maintain the required performance standard.

The above principles take into account the general recommendations for site drainage works as specified in *“Managing Urban Stormwater – Soils and Construction Volume 1” (Section of housing, 2004)* and “*Managing Urban Stormwater – Soils and Construction Volume 2E: Mines and Quarries”* (DECCW, 2008) (Blue Book) as well as the International Erosion and Control Association (IECA) *“Best Practice Erosion and Sediment Control Guidelines* (IECA, 2008), as referenced in Peabody’s Erosion and Sediment Control Guideline (October 2014).

In addition to these principles, activities will occur in the following order:

- Employees and contractors working on-site **must** complete a general site induction which will include details on erosion and sediment control and environmental management;
- Prior to ground disturbance, the person seeking to undertake ground disturbance activities **must** complete a Surface Disturbance Permit (SDP) (**Appendix C**), in consultation with the Environment and Community Manager (or delegate);
- As part of the SDP process, the person seeking to undertake surface disturbance activities will identify and document the potential erosion and sediment issues (**Section 4.0**) and controls in consultation with the Environment and Community Manager (or delegate);

- As part of the SDP process, the person seeking to undertake surface disturbance activities **must** provide a specific ESCIP (**Section 4.2.1**) to the satisfaction of the Environment and Community Manager (or delegate);
- Construction of diversion drains, sediment dams and other erosion and sediment control structures, will be undertaken in accordance with (but not limited to) the ESCP, design guidelines and planning phases in **Section 4.2** and **Section5.1**;
- Construction of berms, levees and catch drains to collect runoff from disturbed areas and divert water to sediment dams or other mine water storages, will be undertaken in accordance with the ESCP, as described **Section 5.1 and Section 6.0**; and
- Construction or mining activities will not commence until all relevant erosion and sediment controls are in place as required by the SDP and its accompanying ESCP. The preparation of the ESCIP is the responsibility of the person seeking to undertake the surface disturbance activities.

4.2 Erosion & Sediment Control Implementation Plan

In preparing an Erosion & Sediment Control Implementation Plan (ESCIP), the proposed activity shall generally be split into four phases:

- **Planning**
  - During the planning phase (e.g. **Section 4.2.1**), the opportunity to incorporate ESCP principles (**Section 4.1**) into the design and construction schedule for the activity; and
  - Completion of an appropriate risk assessment (e.g. **Table 4**) of the likely impacts. Understand the catchment and surrounding area must also be considered.
- **Mobilisation/Pre-construction**
  - This phase is generally when access is established, hard stands, offices and site set out are prepared.
- **Construction**
  - This is where the bulk of the disturbance is to take place and the risk of erosion and sediment movement is at its greatest and also where great care is to be taken as to the selection and siting of erosion and sediment control devices so as not to impede on construction or require repeat installation.
- **Post-construction**
  - Post-construction is effectively once the activity is complete, how is the impact going to be managed going forward or until the area is considered stable.

Each of these ESCIP phases will require control strategies tailored to address the impacts (and level of risk) of the activities undertaken at the time.

The final ESCIP for the proposed activity shall detail the type, location, specification and installation timing and removal of all control devices identified in the planning phase.

4.2.1 Content of an ESCIP

The structure of the ESCIP will be as follows:

- **Proposed activity:**
    - A detailed description of the proposed activity and work site i.e. what is to be built, where, location of offices, accesses, stockpiles, existing drainage and location of services.
- **Site description:**
    - An overview of the local area drainage, catchments, identification of protected areas, protected vegetation and sensitive receptors.
- **Soils description:**
    - An summary of the topsoil and subsoil measured or anticipated conditions, such as their dispersive and erosive nature, K-factor, classification of soils, fines grading, permeability and any relevant information regarding the presence of groundwater interaction i.e. groundwater springs.
- **Identified Erosion, Drainage & Sediment Controls:**
    - As many drawings as required to clearly indicate the type and location of erosion and sediment controls for the duration of the activity such that they can be interpreted and executed appropriately, examples of ESC Plan Drawings are provided in Appendix 1, design details and calculations for sediment dams, drainage chutes, sediment fences, etc. must also be included, some of which can be displayed on the drawings,
    - A schedule detailing when each control measure is to be installed including emergency controls to be implemented in the event of an impending storm.

Technical specifications for measures requiring inspection and test plans (such as spillways) will also be provided, this is to assist construction and maintenance personnel to build to design intent.

The plan itself is not intended to be an exhaustive document, ideally it will be structured and presented in such a way that it is easily implemented and clearly demonstrates an understanding of how the risk is to be controlled.

Small projects where all of the runoff reports to an existing mine water management system capable of accommodating those volumes generally do not need the same level of investigation and control as large greenfield projects that could impact a local waterway.

4.2.2 Erosion and Sediment Control Matrix

The decision as to which combination of erosion and sediment control measures will be on a case by case basis. The decision is based on several factors including:

- Site topography;
- Material/soil/surface/strata type;
- Current disturbance category e.g. spoil, topsoil or peripheral lands (such as haul roads, exploration tracks etc);
- Site specific constraints e.g., proximity of a local water course;
- Length of time that the area will remain at this disturbance category;

- Overall purpose of implementing erosion and sediment control at a [particular location; and
- Applicability of the erosion and sediment control measure as per **Figure 4**.

Figure 4 shows a matrix of land uses and erosion and sediment control measures developed to assist in determining which erosion and sediment control measure is applicable (Peabody, 2014). This tool for selecting appropriate erosion and sediment control measures is based on:

- The phase of the mine site (operational, non-operational or construction);
- Land use type (specific to the mining application), adjacent land usage/classification and proximity to watercourses;
- Level of priority in providing erosion and sediment control measures.

The selection of the appropriate erosion and sediment control measures must be in consultation with the Environment and Community Manager (or delegate) and person seeking to undertake surface disturbance.

4.2.3 Sediment Dam Planning

Table 4 has been developed to assist in the decision making process in regards to potential risks associated with the construction of sediment dams.

When the need for a sediment dam and type of sediment dam i.e. Type C, F of D has been determined by a competent person; a risk assessment **must** be completed using the Peabody Risk Analysis Matrix (**Appendix G**), prior to the activity commencing.

If the risk assessment determines an activity with a **score ≥ 51**, then the activity must not proceed.

If the risk assessment determines an activity **≤ 50**, then the actions and controls (as a minimum) in **Table 4** must be applied.

During the sediment dam planning phase and risk assessment, the following ***key considerations*** must be investigated, but not limited to:

- Detailed review of the regulatory requirements, for example, any site specific or general conditions in Development Approvals/Consents (i.e. is the activity approved), EPL conditions, or other commitments made in management plans (e.g. MOP);
- Can the design allow for deeper excavation as opposed to constructing a higher dam wall;
- Survey and understand the surface and sub-soils, their erodibility, dispersive nature, silt-sand-clay content and risk of mobilisation;
- Review the proposed work site drainage system to understand existing conditions and incorporate any existing drainage, catchments, watercourses or sensitive receiving environments into the plan and identify areas that can be diverted around the work area to minimise the volume of water to be managed;
- Subject to the potential risk, superimpose the proposed activity layout over the area to identify any interactions with the existing drainage network, and identify the locations for site access, site facilities, stockpile areas, hardstand etc. and identify potential areas of non-disturbance and prepare a detailed construction drainage plan showing the water shed and drainage concentration across the work area;
- Develop the proposed schedule of disturbance works and identify and design control techniques for all stages of the proposed activity;

- Subject to the potential risk, undertake an assessment on the local receiving environment based on the risk of the activity and identify suitable controls for all stages of the activity;
- Subject to the potential risk, undertake monitoring of all identified controls through all stages of the activity (e.g. geotechnical surveillance); and
- Subject to the potential risk prepare ESC drawings for the Mobilisation, Construction and Post-construction phases of the activity, these drawings form part of the ESC Plan.

Table 4: Sediment Dam Risk Analysis

<table>
<tr><th>Low</th><th>Minor</th><th>Moderate</th><th>Significant</th></tr>
<tr>
<td>Negligible or reversible environmental impact, no clean up required, no breach of regulations and no need to report incident (The likelihood of sediment laden water leaving the existing mine water system, if sediment dam fails, is Rare)</td>
<td>Minor reversible environmental impact, <5 days to clean up, may result in fine and requirement to report incident (e.g. The likelihood of sediment laden water leaving the existing mine water system, if sediment dam fails, is Unlikely)</td>
<td>Moderate revisable environmental impact (short term effect), < 1 month to clean up, may result in a fine or prosecution and requirement to report incident (e.g. The likelihood of sediment laden water leaving the existing mine water system, if sediment dam fails, is Possible)</td>
<td>Significant environmental impact causing medium term harm, >12 months or more to clean up, significant legal issues resulting in fine and prosecution and requirement to report incident (e.g. The likelihood of sediment laden water leaving the existing mine water system, if sediment dam fails, is Likely)</td>
</tr>
<tr><th colspan="2">Further Actions/Controls</th><th colspan="2">Further Actions/Controls</th></tr>
<tr>
<td colspan="2">
• Risk Activity Scores <11:
- Implement the ESC Plan;
- As a minimum, sediment dam design requires Blue Book concept design by competent person;
- Built by competent operator;
- Supervised by WCPL Projects Engineer;
- Built to design;
- Confirm controls are in place prior to commissioning dam;
- Inspection of sediment for performance as required by Section 7.0;
- Maintain sediment dam as required by Section 7.0.
</td>
<td colspan="2">
• Risk Activity Scores 11 to 30:
- Implement ESC Plan;
- Review controls to ensure risks are as low as reasonable possible (ALARP);
- Detailed sediment dam design by certified engineer;
- Survey control;
- Built by competent operator;
- Supervised by WCPL Projects Engineer;
- Built to design with As Built drawings at completion;
- Confirm controls are in place prior to commissioning dam;
- Monitor controls for effectiveness through all task stages of dam construction.
- Inspection of sediment for performance as required by Section 7.0;
- Maintain sediment dam as required by Section 7.0.
• Risk scores 31 to 50;
- Conduct a formal risk review controls to ensure risks are as low as reasonable possible (ALARP);
- Reconsider undertaking activity if additional controls cannot reduce risk level;
- Built by competent operator;
- Supervised by WCPL Projects Engineer;
- Sediment dam requires detailed construction design by certified engineer, material testing, material moisture content, compaction and core wall test (i.e. geotechnical surveillance testing), staged inspected and certified by independent engineer, survey control with As Built drawings at completion;
- Completion of Certificate of Sediment Dam Construction (example provided in Appendix F) by independent certified engineer;
- Inspection of sediment for performance as required by Section 7.0;
- Inspection of sediment dam wall in accordance with Section 7.0.
</td>
</tr>
</table>

ID	Phase (O = Operational; N = Non-operational; C=Construction)	Land use type	ESC Priority (L= low, M = Medium, H = High, HH = top priority	Drainage Control								Erosion Control						Sediment Control			
				Contour Banks	Check Dams	Grass	Cellular Confinement System	Rock Mattress	Rock Lining	Level Spreader	Rock Chutes	Cellular Confinement System	Compost Blanket	Mulching	Revegetation	Rock Mulch	Soil Binders	Check Dam Sediment Trap	Sediment Basin (QLD & NSW)	Buffer Zone	Sediment Fence
1	O	Spoil - Draining Externally	HH	✓							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	O	Spoil - Draining Internally	M	✓	✓						✓			✓				✓	✓		✓
3	O	Spoil Topsoiled (to be revegetated)	H	✓	✓									✓	✓		✓	✓	✓	✓	✓
4	O	Spoil Topsoiled, ripped and seeded	L	✓	✓	✓												✓	✓	✓	✓
5	O	Topsoil stripping area	M	✓	✓									✓				✓	✓	✓	✓
6	O	Topsoil Stockpiles	M	✓	✓	✓							✓	✓	✓			✓	✓	✓	✓
7	O	Exploratory and access tracks	M	✓	✓	✓	✓			✓		✓		✓	✓	✓	✓	✓		✓	✓
8	O	Haul Roads	H	✓	✓	✓	✓	✓	✓	✓								✓	✓	✓	✓
9	O	Industrial Areas	L	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
10	N	Exploration Activity	M	✓	✓	✓	✓			✓			✓	✓	✓		✓		✓	✓	✓
11	C	Land clearing (woody vegetation)	M	✓	✓					✓				✓					✓	✓	✓
12	O	Drainage channels	HH	✓	✓	✓	✓	✓	✓	✓	✓										
13	N	Licenced stream diversions / Levees	H			✓	✓	✓	✓						✓	✓					
14	C	Construction / excavation work	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓

Figure 4: Erosion and Sediment Control Matrix (Peabody, 2014)

5.0 Existing Controls

Figure 5 provides the locations of existing water management structures and dams at the Mine. The purpose and storage capacity of the main sediment control structures on-site are provided in **Table 5**.

Table 5: Water Management Control Structures

Site	Function	Purpose	Storage Capacity (ML)
Admin Box Cut	Clean Water Storage/Sediment Control	Dirty / Mine Water	305
North Wambo Creek Diversion Levee Bank	Flood mitigation structure	Diverted Water	NA
Eagles Nest Dam	Process Water	Dirty / Mine Water	245
Gordon Below Franklin Dam	Sediment Control/Mine Water Management	Dirty / Mine Water	82
Gordon Below Franklin Sediment Control Structures (ROM Pad Catchment)	Sediment Control	Dirty / Mine Water	0.5
C11 Area Dam	Sediment Control/ Mine Water Management	Dirty / Mine Water	410
South Wambo Dam ^	Mine Water Management	Dirty / Mine Water	486^
West Cut Dam (Wollemi pump out)	Mine water	Dirty / Mine Water	0.05
Wollombi Brook Sediment control structures (Hales Crossing)	Sediment Control	Dirty / Mine Water	0.06 (4x 0.015)
Wambo Rail Line Catchment Dams	Sediment Control	Dirty Water	Various
Montrose East 1	Sediment Control	Dirty Water	6.7
Montrose East 2	Sediment Control	Dirty Water	2.9
Wombat Dam	Sediment Control	Dirty Water	29.4
Rug Dump Dam	Sediment Control	Dirty Water	16.05
Milk Can Dam	Sediment Control	Dirty Water	104
Pluver Sump	Sediment Control	Dirty Water	6.05

Notes:. ^ South Dam currently not in use.

With regards to the design principles applied to each of the structures listed in **Table 5**, Montrose East 1 and Montrose East 2 were designed to Blue Book standards. The Admin Box Cut and West Cut water storage areas are within mining voids. It is unknown what design standards were applied to the other structures at the time of construction, as records are no longer available."

In March 2018, SLR Consulting Australia (SLR) finalised a high level assessment of the existing dam capacities at the Wambo Coal Mine against the requirements of the Blue Book and current best practices relating to mine water containment. The SLR report concludes '*where the existing dam storage capacity is known, all of the sediment dams comply with the Blue Book requirements and all of the mine water dams are sufficiently sized to contain runoff from the 100 year ARI, 24 hour duration and 72 hour duration design storm events.'*

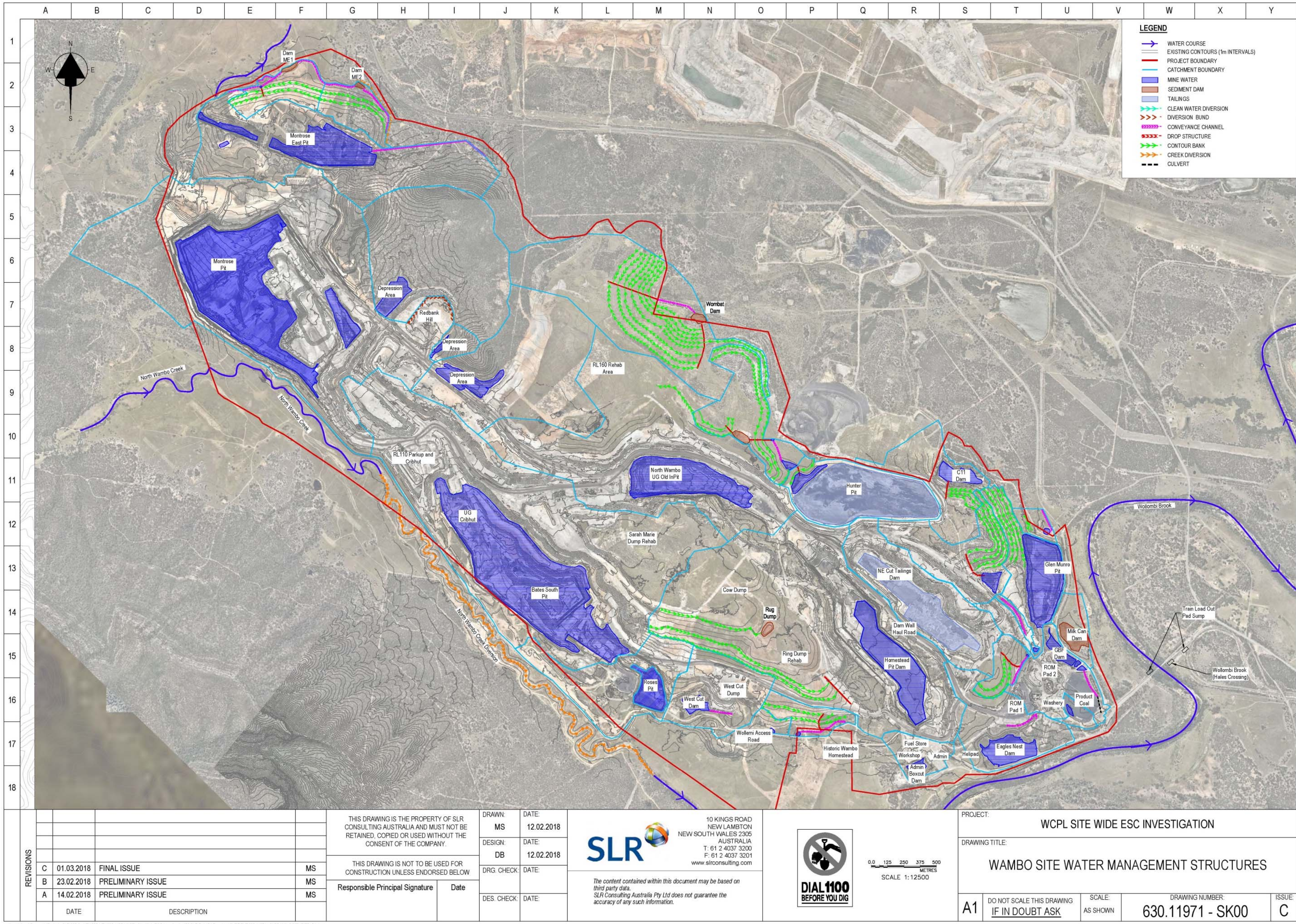


Figure 5: Water Management Structures

5.1 Design Guidelines

As a minimum, sediment control structures at Wambo shall be generally constructed in accordance with the guidelines presented in the Blue Book and design guidelines summarised in **Table 6**. However, subject to the potential risk identified in **Table 4**, sediment dams will require construction design by certified engineer if the risk is determined Significant.

Table 6: Design Guidelines for Sediment Control

Control Structure	Function	Design Guidelines
Permanent Drainage Control Structures	Permanent drainage refers to diversion channels that will be in place at the end of mine life.	• For Life of Mine structures, requires construction design by certified engineer.
Temporary Drainage Control Structures **'low gradient areas'**	Temporary drainage in low gradient areas such as catch drains, diversion channels or flow diversion banks (or contour banks) that either collect concentrated flow or overland flow on rehabilitated areas of the Mine.	• Temporary drainage controls that are anticipated to last longer than 24 months would be designed to cater for a 100 year Average Recurrence Interval (ARI) design storm to provide effective separation of diverted and surface water. • Temporary drainage controls that have an anticipated design life of 2 to 24 months would be designed to cater for a 5 Year ARI. • Temporary drainage controls that have an anticipated design life of <12 months would be designed to cater for a 2 Year ARI. • Maintain channel velocities to <1.5m/s where possible.
Temporary Drainage Control Structures **'steeper slopes'**	Rock chutes (or drop structures) are drainage channels designed specifically for steep slopes. They are typically outlet structures for contour banks and primarily convey water from relatively flat longitudinal drains, down a steep slope to a sediment basin or outlet device on rehabilitated areas of the Mine.	• Design requires for ARI events as described for 'low gradient areas'. • Maximum slope of 1V:2H for rock lining stability. • Suitable for flow velocities up to 8m/s.

Control Structure	Function	Design Guidelines
Sediment Dams **'surface water'**	A sediment basin is a temporary "dam-like" structure used to capture and retain sediment-laden runoff. It is often the last line of defence in a drainage network to prevent sediment laden runoff from discharging off-site. A sediment basin is designed to reduce the inflow velocities. Once below a threshold velocity, bed load materials are settled out.	• Detailed design and sizing of a sediment basin will be undertaken by a competent person to ensure the basin has sufficient capacity and the water being discharged is of acceptable quality to meet regulatory requirements. For more information refer to Section 6.5. • **Settling Zone:** Capacity to store the runoff produced from the 85th percentile, 5- day rainfall event. For Wambo, the 5 day rainfall depth is an average of 26mm. • **Sediment Storage Zone:** Assumes two months calculated soil loss estimated using RUSLE[2]
Sediment Fencing	Sediment fences are temporary devices constructed to reduce sediment transportation by intercepting sheet flows.	• Sediment fences will be installed prior to and maintained during all construction earthworks. • Support post spacing maximum 2m apart, sediment fence material keyed into ground to 200mm or secured with 300mm of aggregate on the surface to the upstream. • Installation of sediment fences will be in line with contours and have returns every 20 metres that extend at least 1 metre upslope.
Buffer Zones	A buffer zone is a vegetated area, generally a grassed area, provided around the perimeter of an earthworks footprint. Its primary purpose is to reduce sediment transportation by acting as a 'sediment trap'.	• A buffer zone shall generally be located at least 50 metres from the earthworks clearance footprint. A visible structure, such as a fence, will generally be constructed around the buffer zone to clearly identify the area and prevent traffic from driving over it. • Vegetation shall be a minimum of 50mm high and must cover at least 80% of the surface to be effective in controlling bed load sediment runoff.
Check Dams	Check dams are formed by created small weir structures in an open channel at regular intervals. They are effective in reducing the flow velocity by creating small ponds of water upstream of these structures. The three main materials used to construct check dams are sandbags, rock and fibre rolls.	• Construction shall commence at the downstream check dam first then progress upstream. Ensure that the toe of the upstream check dam is at the same elevation as the crest of the downstream check dam. • Construction shall extend up the batters of the channel but will be limited to 500 millimetres from the base of the channel to ensure water does not spill at the edges of the check dam. • A weir will be created in the centre of the check dam by allowing at least a 150 millimetre depression. The base of the check dam shall be trenched at least 200 millimetres below the invert of the drain to minimise the risk of undermining or side cutting the structures.

Table 7: Guidelines for Erosion Control

[2] Sediment loading is to be undertaken using the Revised Universal Soil Loss Equation (RUSLE) method as detailed in IECA (2008), the design storm event runoff volume is to be estimated using either the methods in Landcom (2004) .

Erosion Control Technique	Typical Use
Cellular Confinement Systems	Containment of topsoil or rock mulch on medium to steep slopes Control erosion on non-vegetated medium to steep slopes such as bridge abutments
Compost Blanket	Used during the revegetation of steep slopes either incorporating grasses or other plants Particularly useful when the slope is too steep for the placement of topsoil, or when sufficient topsoil is absent from the slope
Gravelling	Protection of non-vegetated soils from raindrop impact erosion. Stabilisation of site office area, car parks and access roads
Heavy Mulching	Stabilisation of soil surfaces that are expected to remain non-vegetated for medium to long periods. Suppression of weed growth on non-grassed areas.
Light Mulching	Control of raindrop impact erosion on flat and mild slopes. May be placed on steeper slopes with appropriate anchoring. Control water loss and assist seed germination on newly seeded soil.
Revegetation	Temporary and permanent stabilisation of soil Stabilisation of long term stockpiles
Rock Mulching	Stabilisation of long term, non-vegetated banks and minor drainage channels.
Soil Binders	Dust control. Stabilisation of unsealed roads.

A list of appropriate erosion control measures on steep slopes is given in **Table 8.**

Table 8: Summary of Erosion Control Techniques

Flat Land (flatter than 1 in 10)	Mild Slopes (1 in 10 - 1 in 4)	Steep Slopes (steeper than 1 in 4)
Gravelling	Mulching	Cellular Confinement Systems
Mulching	Revegetation	Revegetation
Revegetation	Rock Mulching	Rock Armouring

The selection of the appropriate erosion and sediment control measures (**Table 6, Table 7 and Table 8**) must be in consultation with the Environment and Community Manager (or delegate) and person seeking to the undertake surface disturbance activity.

6.0 Implementation

6.1 Construction

For activities or projects not currently approved as part of existing operations, the requirement for a specific ESC Plan will be identified during the activity or project's planning phase (**Section 4.2**).

As outlined in **Section 4.2**, a project specific ESC Plan must be prepared in consultation with Environmental and Community Manager (or delegate). An SDP will also be required (**Appendix C**).

All proposed sediment control structures will be designed (but not limited to) in consideration of design guidelines provided in **Table 6, Table 7** and **Table 8** and implemented as described in **Section 6.0**, in consultation with the Environment and Community Manager (or delegate).

6.2 Sediment Fences

Sediment fences are temporary devices constructed to reduce sediment transportation by intercepting sheet flows. Settlement of entrained sediment particles is achieved by reducing the velocity of the overland flow and creating small ponds of water on the upstream side of the fence. Sediment fences will be installed around all construction footprints, as a last line of defence system to contain sediment. Sediment fences are created using special purpose synthetic material laid vertically by securing to stakes and anchored the toe of the fence in to a trench. Design principles for sediment fencing are provided in **Table 6** and **Appendix D.**

Figure 6: Example of Sediment Fencing

6.3 Check Dams

Check dams are formed by created small weir structures in an open channel at regular intervals. They are effective in reducing the flow velocity by creating small ponds of water upstream of these structures. The effectiveness of these check dams depend on the selected materials, spacing, channel properties and flow characteristics. Design principles for check dams are provided in **Table 6** and **Appendix D.**

Figure 7: Example of Check Dams

6.4 Diverted Water Management

Consistent with the principles provided in **Section 4.1**, runoff water from undisturbed catchments will be diverted around disturbed areas, where practical. Diversion drains will be suitably designed, grassed and (if required) protected with rock armouring, geotextile fabric, or similar. Water will be discharged downstream of the disturbed area into a suitable receiving environment. Drainage outlets, along with clean water diversion drains, will be appropriately designed in consultation with the Environment and Community Manager (or delegate). Design principles for diversion drains are provided in **Table 6** and **Appendix D.**

6.5 Surface Water Management

Runoff from disturbed areas as a result of mining related activities operations, including land cleared ahead of mining and rehabilitated areas, may contain high sediment loads.

Where potentially sediment-laden runoff is, sediment control structures must be installed to intercept and capture sediment prior to leaving site.

6.5.1 Land Disturbance

In accordance with the erosion and sediment control principles outlined in **Section 4.1**, land disturbance at the Mine will be minimised, and limited to those areas outlined in the Mining Operations Plan (MOP).

Prior to any surface disturbance activity, the person seeking to undertake ground disturbance **must** complete a Surface Disturbance Permit (SDP) (**Appendix C**), in consultation with the Environment and Community Manager (or delegate).

The SDP process identifies potential erosion and sediment risks associated with proposed disturbance projects, and requires appropriate erosion and sediment control measures to be implemented prior to disturbance commencing.

6.5.2 Land Rehabilitation

Progressive rehabilitation is an essential part of the Mine's erosion and sediment control strategy. Mining disturbed land (with altered topography, surface conditions and catchment sizes) represents a high potential for erosion and sediment impacts. The potential for erosion and sedimentation impacts decreases substantially as disturbed land is reshaped and revegetated as part of the land rehabilitation process. In order to minimise erosion and sedimentation impacts until the rehabilitated area is suitably stable, sediment control structures (such as contour drains, drop structures and sediment control dams) will be designed and constructed in accordance with the design principles provided in **Table 6**, **Appendix D**, and Peabody's *Erosion and Sediment Control Guideline (October 2014)*.

6.5.3 Sediment Dams

Sediment dams will be constructed to capture sediment from runoff flowing through site drains and diversions prior to its onsite re-use, or discharge from site. Design principles for these sediment dams are summarised in **Table 6 (and Appendix D)** and provided below.

Detailed design and sizing of a sediment basin will be undertaken by a competent person to ensure the basin has sufficient capacity and the water being discharged is of acceptable quality to meet regulatory requirements.

A sediment basin fundamentally consists of an inlet, a sediment storage zone, a settling zone and an outlet. Bypass systems are also constructed when a piped outlet is provided. The sizing of a sediment basin is based on the 85th percentile of the 5-day rainfall depth for the site. For the Wambo mine, the 5-day rainfall depth is an average of 26 millimetres (**Figure 8**Figure 8: 5-Day Rainfall Depth).

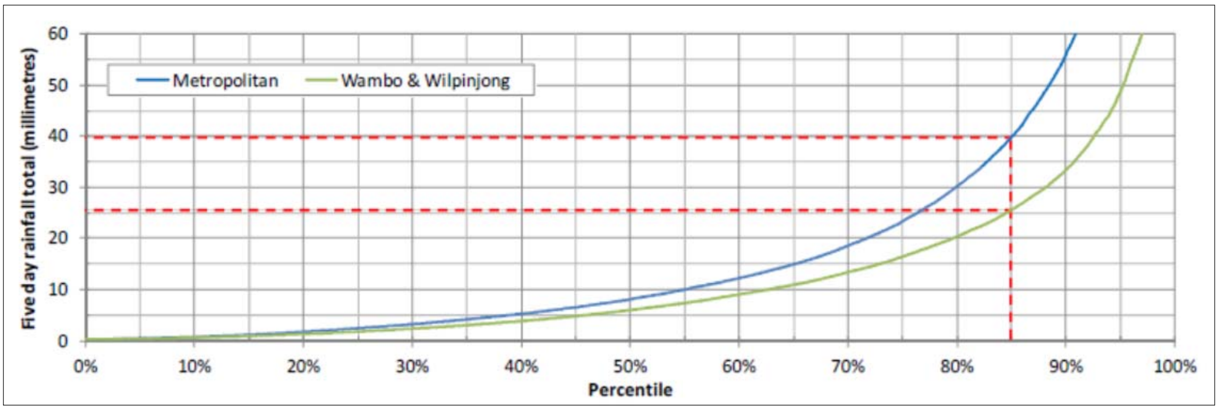


Figure 8: 5-Day Rainfall Depth

The upper zone within the sediment basin is the settling zone and slows the velocity of inflow water and allows suspended particles to settle. The lower zone within the sediment basin is the sediment storage zone and is used as a dead storage area to contain the settled particles. The volume of the sediment storage zone shall be approximately half the volume of the settling zone (**Figure 9**).

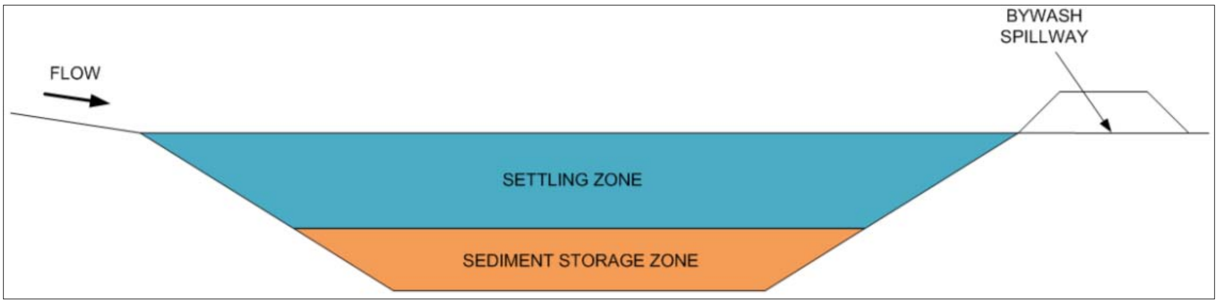


Figure 9: Settling and Storage Zones

Figure 10 provides an indicative overview of the required footprint area needed to construct a sediment basin, however advice from a competent person shall be sought to accurately determine the sizing prior to construction commencing.

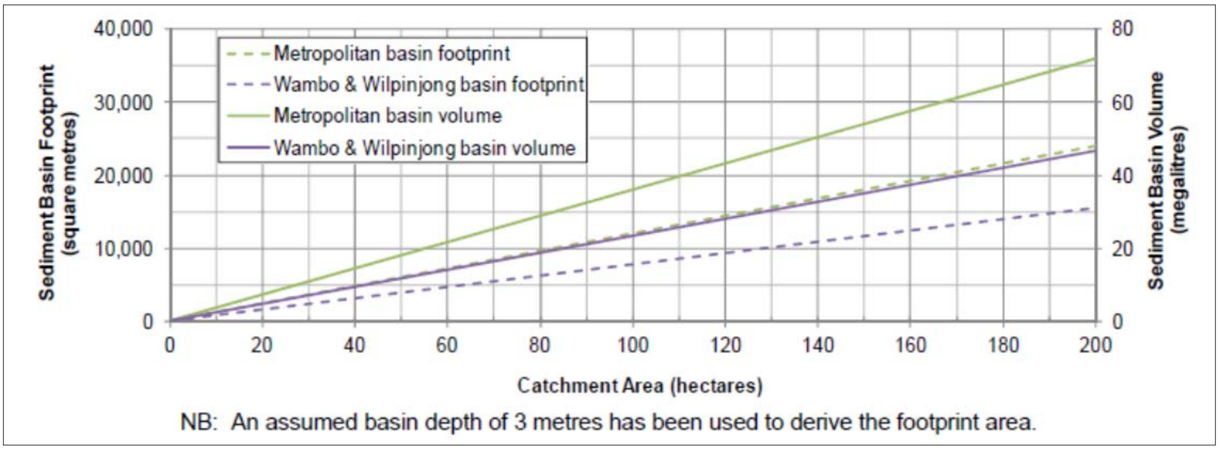


Figure 10: Indicative Sediment Dam Capacity

Sediment basins are typically designed to be filled, treated and discharged during a maximum 5 day cycle period. **Figure 11** below will be compared against the pump-out time-frames. Dewatering will be undertaken to prevent salinity build-up within the basin.

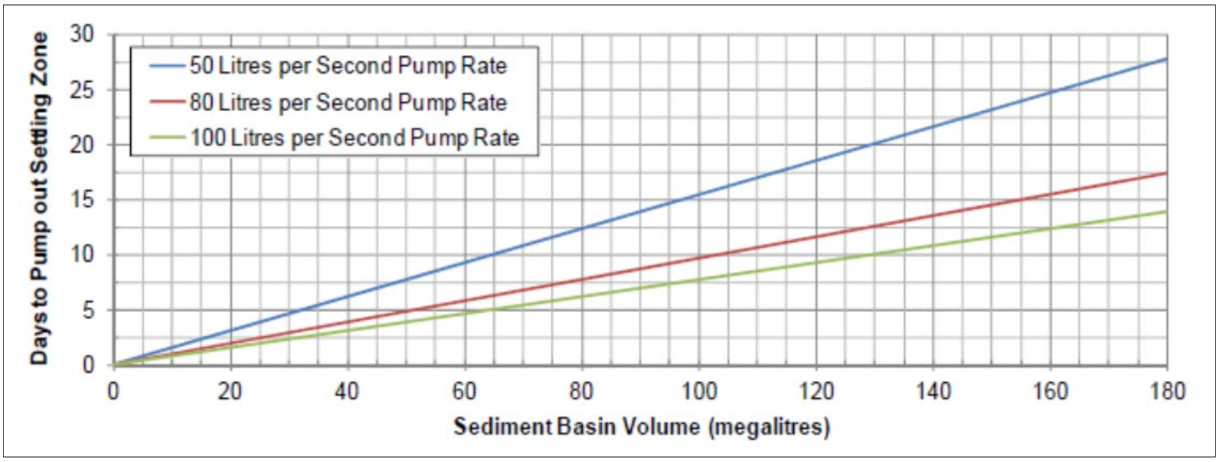


Figure 11: Indicative Pump Out Time Frames

Clean water catchments shall be diverted away from a sediment basin where possible. This will aid in reducing the total storage volume required in the sediment basin.

Sediment basins shall be located in an area clear of construction activities and above any existing 1 in 5 year flood level. Planning prior to construction is required to ensure adequate access is provided to and adjacent the sediment basin to allow maintenance and desilting. As previously outlined, detailed design, sizing, safe access for maintaining and cleaning, energy dissipaters etc of a sediment basin must be undertaken by a competent person.

6.6 Worked Water Management System

Mine water dams and mine water sediment dams are used around the Mine to contain mine water (i.e. Worked Water). This water has the potential to contain elevated EC and/or potential hydrocarbon contamination as a result of runoff from haul roads, workshop areas, infrastructure areas and areas exposed to carbonaceous material (**Table 4** and **Figure 5**).

Within this system, several dams function as sediment dams for sediment control but do not discharge into adjacent watercourses. They form part of the Mine's surface water management system and their design storage capacities are typically beyond the requirements of the Blue Book.

The Mine can only discharge mine water through its only licensed discharge point (LDP) in accordance with Environmental Protection Licence 529 (EPL 529), under strict conditions. The Environment and Community Manager (or delegate) can provide more information about the Mine's water management system and capacity to discharge.

6.7 Topsoil Management

Topsoil will be stripped in accordance with the SDP and procedures outlined in the MOP. Erosion and sediment control measures, as identified in the completed SDP, will be implemented prior to topsoil removal.

Once topsoil is stripped, it will either be placed directly onto shaped overburden and seeded or will be stockpiled for later use. If stockpiling is required, stockpiles will be managed in accordance with the MOP.

6.8 Subsidence Management

Erosion control measures may be required to address destabilised areas and surface cracking as a result of subsidence. This may involve infilling cracks with suitable material, ripping cracks and re seeding with appropriate MOP pasture species of in highly disturbed areas to ensure erosion is not exacerbated by these cracks.

Where cracking occurs on sloped areas, sediment control measures will also be used down slope, such as check dams and sediment filter fences, in accordance with the Blue Book. Other sediment control measures may be required to minimise impacts until the area is suitably stabilised.

Regular monitoring of ground subsidence and associated surface cracking is undertaken in accordance with the requirements of the relevant Extraction Plan. Should surface cracking be identified as presenting a safety or environmental hazard (including erosion hazard), the area will be repaired and rehabilitated in accordance with Extraction Plan commitments.

6.9 Performance Indicators

The performance indicators in **Figure 9** will be used to assess the performance of the Mine against the predicted impacts.

Table 9: Performance Indicators

Performance Indicator	Number
Number of complaints received relating to erosion and sediment control	Nil
Number of reportable environmental incidents relating to erosion and sediment control	Nil

WCPL will report on progress against these performance indicators in the Annual Review (**Section 9.2**). In the event that a complaint is received relating to erosion and sediment control, it will be handled in accordance with the complaints management protocol (**Section 8.0**). Contingency plans for unpredicted erosion and sediment control impacts are discussed in the SGWRP.

7.0 Inspections, Monitoring and Maintenance

7.1 All Control Structures

All erosion and sediment control measures are maintained in a functioning condition until individual areas have been deemed “successfully” rehabilitated. Where controls are observed to be not functioning correctly, the controls are restored to meet the required standard.

Sediment control structures will be inspected on a monthly basis and/or following rainfall events ≥ 20 mm/day (midnight to midnight), as recorded by the Mine’s meteorological station. If no rain is received for at least a 24 hour period, any subsequent rain event ≥ 20 mm/day will trigger a new inspection. The sediment control structures will be inspected for capacity, structural integrity and effectiveness by Mine’s E & C Manager (or delegate).

Water from sediment control structures may be tested for pH, EC and total suspended solids (TSS), and compared to water quality criteria provided in the Wambo Surface Water Monitoring Program (SWMP), to assess the effectiveness of the sediment control structures.

In accordance with Schedule 4, Condition 33(g) of DA305-7-2003, sediment dams with discharge potential (as identified in Table 13 of the Surface Water Monitoring Program) will be sampled when observed to be holding water during regular monthly sampling. In addition, following rainfall events greater than 20mm in 24 hours (≥20mm day), these locations will be inspected and sampled if discharging. Sediment dams with discharge potential have been identified as:

- Montrose East 1;
- Montrose East 2; and
- Milk Can Dam.

These dams are actively managed and operated in accordance with the requirements of the Blue Book, as outlined in **Section 7.2**.

Minor onsite sediment dams, identified as Rug Dump Dam and Wombat Dam may discharge offsite in the future. As such, they will be included in the monitoring program.

Details of inspections and monitoring results will be recorded on the erosion and sediment structure inspection sheet. Any required maintenance work will be scheduled following the inspection. An example of Wambo’s Sediment Control Structure Inspection Checklist is included in **Appendix E**.

7.2 Sediment Control Dams

During construction, the frequency of inspections will be proportional to the level of risk posed by the sediment dam, for example:

- Sediment dams that have been assessed as low to moderate risk, daily inspections and/or key construction milestones by the Mine’s Project Engineer will be undertaken to ensure the dam is being constructed to design; and
- Sediment dams that have been assessed as significant risk, daily inspections by the Mine’s Project Engineer, in concurrence with staged inspections by an independent certified engineer will be undertaken to ensure the dam is being constructed to design.

Post construction, sediment dams will be inspected weekly by the Mine's E & C Manager (or delegate) to verify dam walls, drainage channels etc have been successfully stabilised by revegetation methods.

All established sediment dams will require regular maintenance to ensure they are operated in line with the requirements of the Blue Book. The requirement of Mine's E & C Manager (or delegate) to inspect and maintain sediment dams include, but not limited to:

- Monthly inspections;
- Following rainfall events ≥ 20 mm/day;
- Water quality testing as described in Section 7.1;
- Ensure dams have been pumped out within 5 days after the rainfall event;
- De-silting of dams (subject to the amount of sediment being delivered); and
- No excessive erosion is evident and existing erosion and sediment controls remain effective.

8.0 Community Complaint Response

All erosion and sediment control related community complaints received by WCPL will be recorded within the Community Complaints Register. The Environment and Community Manager (or delegate) will investigate the complaint, which will include, where possible, contacting the complainant within 24 hours to discuss the complaint. A review of the effectiveness of the corrective or preventative actions will be conducted within a month of the complaint and the relevant work procedures updated if required.

Preliminary investigations will commence as soon as practicable upon receipt of a complaint to establish if WCPL is responsible. All efforts will be made to determine the likely causes contributing to the complainants concerns.

WCPL will attempt to address the complainants concerns such that a mutually acceptable outcome is achieved. However, if required, the Independent Dispute Resolution Process would be referred to (**Appendix B**).

Details of all community complaints will be included in the Monthly Environment Monitoring Report. WCPL will retain a copy of the Community Complaints Register for at least four years. The Environment and Community Manager (or delegate) Manager will ensure the latest Community Complaints Register is posted on the WCPL website.

9.0 Review and Reporting

9.1 Review

A complete review of the ESCP will occur:

- Every two years;
- When there are changes to consent or licence conditions related to any aspect of this ESCP;
- Where there are significant changes to erosion and sediment control structures;
- Following significant erosion and sediment control related incidents at WCPL;
- Following an independent environmental audit which requires ESCP review; or
- If there is a relevant change in technology, practice or legislation.

The revised ESCP will be re-submitted to the Secretary for approval as required by Condition 30, Schedule 4 of DA305-7-2003.

9.2 Annual Review

Prior to the end of March each year, WCPL will review the environmental performance of the Mine and submit an Annual Review report to the DP&E. This report will:

- Describe the development (including any rehabilitation) that was carried out in the past year, and the development that is proposed to be carried out over the next year;
- Include a comprehensive review of the monitoring results and complaints records of the Project over the past year, which includes a comparison of these results against the:
    - Relevant statutory requirements, limits or performance measures/criteria
    - Monitoring results of previous years; and
    - Relevant predictions in the EA;
- Identify any non-compliance over the last year, and describe what actions were (or are being) taken to ensure compliance;
- Identify any trends in the monitoring data over the life of the Project;
- Identify any discrepancies between the predicted and actual impacts of the Project, and analyse the potential cause of any significant discrepancies; and
- Describe what measures will be implemented over the next year to improve the environmental performance of the Project.

9.3 Website Updates

A comprehensive summary of surface water monitoring results, as required by the SWMP, will be made publicly available at WCPL website:
https://www.peabodyenergy.com/Operations/Australia-Mining/New-South-Wales-Mining/Wambo-Approvals,-Plans-Reports

Information on the website will be updated regularly as required by DA305-7-2003.

WCPL will also ensure that any information relevant to the management of erosion and sediment control is uploaded to the website (and kept up to date). This includes:

- Current statutory approvals;
- Approved strategies, plans or programs required under the DA305-7-2003;
- A community complaints register;
- Minutes of Community Consultative Committee (CCC) meetings;
- Annual Reviews;
- A copy of any Independent Audits and WCPL's response to any recommendations in any audit; and
- Any other matter required by the Secretary.

9.4 Reportable Environmental Incidents

All reportable incidents will be reported via the EPA's Environmental Line on **131 555** by the E&C Manager in accordance with WCPL's Pollution Incident Response Management Plan (PIRMP).

In accordance with the PIRMP, WCPL must notify all relevant authorities of incidents causing or threatening material harm to the environment immediately after the person becomes aware of the incident in accordance with the requirements of *Part 5.7* of the *POEO Act.*

For all other incidents that do not cause threatening material harm to the environment associated with the Project, WCPL will notify the Secretary and any other relevant agencies as soon as practicable after WCPL becomes aware of the incident.

Within 7 days of the date of the incident, WCPL will provide the Secretary and any relevant agencies with a detailed report on the incident to include:

- The cause, time and duration of the event
- Where possible the type, volume and concentration of every pollutant discharged as a result of the event
- The name, address and business hours telephone number of employees or agents of the licensee who witnessed the event
- The name, address and business hours telephone number of every other person (of whom the licensee is aware) who witnessed the event, unless the licensee has been unable to obtain that information after making reasonable effort
- Action taken by the licensee in relation to the event, including any follow-up contact with any complainants
- Implement remediation measures as directed by the Secretary, to the satisfaction of the Secretary
- Details of any measure taken or proposed to be taken to prevent or mitigate against a recurrence of such an event; and
- Any other relevant matters.

10.0 RESPONSIBILITIES

Table 10 below summarises responsibilities documented in the ESCP. Responsibilities may be delegated as required.

Table 10: Erosion and Sediment Control Plan Responsibilities

No	Task	Responsibility	Timing
1	Conduct environmental training for all contractors and site employees (as part of the site induction)	Site Training Coordinator (or delegate)	Pre start/then every two years.
2	Persons seeking to undertake activity must complete Surface Disturbance Permit prior to disturbance in consultation with Environment & Community Manager (or delegate)	Projects Engineer, E&C Manager	Prior to general construction/mining activities
3	Persons seeking to undertake activity must identify project specific potential erosion and sediment impacts	Projects Engineer, E&C Manager	Prior to general construction/mining activities and ESCIP.
4	Facilitate the design and implementation of control measures described in this ESCP	Projects Engineer, E&C Manager	Prior to general construction/mining activities and ESCIP.
5	Inspect sediment and erosion control structures	Projects Engineer, E&C Manager	Monthly, and following rainfall events /≥20mm day
6	Maintain erosion and sediment control structures	Projects Engineer, E&C Manager	As required
7	Review ESCP in accordance with **Section 9.0**.	E&C Manager	As required under **Section 9.0**.
8	Notify government departments if an incident occurs in accordance with **Section 9.4**	E&C Manager	As required
9	Submit updated ESCP to DP&E.	E&C Manager	As required
10	Erosion and sediment control related complaints to be responded to in accordance with **Section 8.0**	E&C Manager	As required
11	Annual Review to include relevant monitoring results, complaints, mitigation measures undertaken and a review of the monitoring undertaken	E&C Manager	Annually
12	Regulator review to be undertaken of the ESCP	E&C Manager	As required
13	Prepare investigation reports and implementation of corrective actions in accordance with **Section 9.4**	E&C Manager	As required

11.0 References

- Development Consent (DA305-7-2003) (as modified)
- Development Consent (DA177-8-2004) (as modified)
- Wambo Development Project Environmental Impact Statement (EIS), July 2003
- Resource Strategies Pty Ltd (2003) Wambo Coal Mine Project Environmental Impact Statement. Report prepared for Wambo Coal Pty Ltd
- Wambo Environment Protection Licence (529)
- *Environmental Planning and Assessment Act 1979*
- *Environment Protection and Biodiversity Conservation Act 1999*
- Barclay Mowlem Construction Limited (2005) Soil and Water Quality Management Plan Wambo Coal Rail Construction Project.
- DECCW NSW (2008) Managing Urban Stormwater – Soils and Construction Volume 2E. Mines and Quarries. NSW Government, Parramatta, March.
- Landcom (2004) Managing Urban Stormwater – Soils and Construction Volume 1. 4th ed., NSW Government, Parramatta, March.
- Peabody Energy Australia (2014), Erosion and Sediment Control Guideline. October 2014, Version 1.
- Resource Strategies (2003) Wambo Development Project – Environmental Impact Statement, prepared for Wambo Coal Pty Limited.
- Resource Strategies (2006a) Modification Statement of Environmental Effects, prepared for Wambo Coal Pty Limited.
- Resource Strategies (2006b) North Wambo Underground Subsidence Management Plan, prepared for Wambo Coal Pty Limited
- SLR Consulting (2018) Dam Capacity Assessment Report Number 630.11971-R01, prepared for Wambo Coal Pty Ltd

APPENDIX A
CORRESPONDENCE WITH REGULATORY AUTHORITIES

NSW GOVERNMENT | Planning & Environment

Planning Services
Resource Assessments
Contact: Philip Nevill
Phone: 8275 1036
Email: philip.nevill@planning.nsw.gov.au

Mr Peter Jaeger
Environment and Community Manager
Wambo Coal Pty Ltd
PMB 1
Singleton NSW 2330

Dear Mr Jaeger

Wambo Coal Mine (DA 305-7-2003 & DA 177-8-2004)
Erosion and Sediment Control Management Plan

The Department has reviewed the revised Erosion and Sediment Control Management Plan for the Wambo Mine Complex, prepared in accordance with the Wambo Mine development consent (condition 32 of Schedule 4 of DA 305-7-2003) and Wambo Rail development consent (condition 17(a) of Schedule 4 of DA 177-8-2004).

The Department is satisfied that the Erosion and Sediment Control Management Plan (Revision 10) dated April 2018 adequately addresses the relevant requirements of DA 305-07-2003 and DA 177-8-2004. As such, the Secretary approves this management plan.

Please note the requirements under condition 12 of Schedule 6 of DA 305-07-2003 and condition 8 of Schedule 6 of DA 177-8-2004 to make copies of all approved plans, programs and strategies publicly available. Should you have any enquiries in relation to this matter, please contact Philip Nevill at the details listed above.

Yours sincerely

Howard Reed 27.6.18

Howard Reed
Director Resource Assessments
as the Secretary's nominee

Department of Planning and Environment
320 Pitt Street Sydney NSW 2000 | GPO Box 39 Sydney NSW 2001 | T 1300 305 695 | **www.planning.nsw.gov.au**

Planning Services
Resource Assessments
Contact: Philip Nevill
Phone: (02) 82751036
Email: Philip.nevill@planning.nsw.gov.au

Mr Peter Jaeger
Environment and Community Manager
Wambo Coal Pty Ltd
PMB 1
Singleton NSW 2330

Dear Mr Jaeger

Wambo Coal Mine (DA 305-7-2003 & DA 177-8-2004)
Erosion and Sediment Control Plan and Environmental Management Strategy

The Department has reviewed the revised Environmental Management Strategy and Erosion and Sediment Control Plan for the Wambo Mining Complex which have been prepared in accordance with the Wambo Mine Development Consent (DA 305-07-2003) and Wambo Rail Development Consent (DA 177-8-2004).

The Department is satisfied that the Environmental Management Strategy (Revision 5) meets the requirements of condition 1 of Schedule 6 of DA 305-7-2003 and condition 2 of Schedule 6 of DA 177-8-2004. Consequently, the Secretary approves this strategy.

The Department considers that the Erosion and Sediment Control Plan (Revision 9) dated March 2018 does not adequately address the requirements of condition 32 of Schedule 4 of DA 305-7-2003 and condition 17(a) of Schedule 4 of DA 177-8-2004. The Department's comments are enclosed in **Attachment A**.

The Department requests that the Erosion and Sediment Control Plan is re-submitted once the comments have been addressed, by no later than **27 April 2018**.

If you wish to discuss this matter further, please contact Philip Nevill at the details listed above.

Yours sincerely

Howard Reed

Howard Reed 26.3.18
Director Resource Assessments
as the Secretary's nominee

Attachment A

Wambo Coal Mine (DA 305-7-2003) Erosion and Sediment Control Plan – DP&E Comments 23 March 2018 and WCPL Responses

Erosion and Sediment Control Plan Rev 9 Condition32, Schedule 4	**Satisfactory**	**Comments**	**Action Required**	**WCPL response to comments**
The Erosion and Sediment Control Plan must: (a) Be consistent with the Department of Housing's Managing Urban Stormwater: Soils and Construction Manual	No	THE ESCP does not address the requirements of *Managing Urban Stormwater: Soils and Construction – Volume 2E mines and quarries (DECC 2008), Appendix C: Erosion and sediment control planning*.	Revise the ESCP to ensure consistency with *Managing Urban Stormwater: Soils and Construction – Volume 2E mines and quarries (DECC 2008), Appendix C*	The following sections make reference to *Managing Urban Stormwater: Soils and Construction – Volume 2E mines and quarries (DECC 2008), Appendix C* (also known as the Blue Book): • Section 1.2 – Purpose; • Section 4.1 – Principles; • Table 4 – Sediment Dam Risk Analysis; • Section 5.1 - Design Guidelines ; • Section 6.6 – Worked Water; • Section 6.8 – Subsidence Management; and • Section 7.1 – All Control Structures.
(b) Identify activities that could cause soil erosion and generate sediment;	Yes	Section 2, Table 3 outlines sources of erosion and sedimentation. Figure 4 (erosion and Sediment Control Matrix)	Nil	Nil required
(c) describe the location , function and capacity of erosion and sediment control structures; and	Partial	Section 5. discusses the 'Design Guidelines' and Appendix D 'Design Principles'. However it is unclear if the current sediment and erosion controls have been constructed in accordance with the referenced guidelines and principles.	Integrate the descriptions of erosion and sediment control structures, location, function and capacity. For example, update Table 5 to include the type of erosion and sediment control structure at each location. Include a reference to the relevant design principles applied to each structure.	Refer to Section 5.0. In March 2018, SLR finalised an assessment of existing dam capacities at Wambo against the requirements of the Blue Book and current best practice. The SLR report concludes '*where the existing dam storage capacity is known, all of the sediment dams comply with the Blue Book requirements and all of the mine water dams are sufficiently sized to contain runoff from the 100 year ARI, 24 hour duration and 72 hour duration design storm*

				events.'
(d) Describe measures that minimise soil erosion and the potential for the migration of sediments to downstream waters	Yes	Sections 6 and 7 outline the current and proposed measures. Details outlining the specific design, function and use are included in Tables 6, 7 and 8	Nil	Nil required
General Comments				
• The use of the word 'should' throughout the ESCP is to be replaced with 'shall' or 'will' or similar. Please check the document for non-committal wording and replace				Complete, refer to changes throughout in blue font
• The ESCP does not reference the additional mining lease required by the approval of the South Bates Underground Extension (MOD17). All mining lease areas need to be included with the lease boundaries shown on the mine layout plan				A Mining Lease Application has not yet been lodged for the portion of South Bates Underground Extension not currently subject to a Mining Lease. The Approved Wambo Coal Mine Layout (**Figure 3**) will be revised to include the new Mining Lease, once approved.
• Section 3.4 (hydrology) should include comment on the area subject to MOD 17 that comprises a section of North Wambo Creek above the diversion				See text added to **Section 3.4**.
• Condition 4, Schedule 6 outlines the requirements of all management plans. Please ensue the ESCP addresses these requirements.				The requirements of Condition 4, Schedule 6 are listed in Table 2 which also provides section links to where each requirement is addressed in the ESCP.

NSW GOVERNMENT | Planning & Environment

Contact: Scott Brooks
Phone: 6575 3401
Fax: 6575 3415
Email: scott.brooks@planning.nsw.gv.au
Our ref: 305-7-2003

The General Manager
Wambo Mine
PMB 1
SINGLETON NSW 2330

Attention: Steve Peart

Dear Steve

Wambo Coal – Approval of Water Management Plan

Thank you for forwarding the Wambo Water Management Plan and all its parts as required under project approval DA 305-7-2003 for the Department's consideration.

The Water Management Plan is required by Condition 30 Schedule 4 and the following 5 components of the Plan were reviewed:

Site Water Balance (30)
Erosion and Sediment Control Plan (32)
Surface Water Monitoring Program (33)
Ground Water Monitoring Program (34)
Surface and Ground Water Response Plan (35).

The Department has reviewed these plans, and is satisfied that they generally address the requirements set out in the relevant conditions of the project approval. Consequently, I would like to advise you that the Secretary has approved the plans.

These plans come into force on the 30th November 2015 and remains in force until replaced by any future updated approved Plans.

I am aware that DPI Water are expected to comment on the Extraction Plan for the South Bates U/G (Wybrow seam) LW 11-13. Should this comment require significant changes to any component of the Water Management Plan, I ask if these changes could be made and the plans resubmitted for review and approval.

Could you please forward finalised copies of the above plan (preferably in PDF format with a copy of this approval letter appended) for the Department's records by the end of November 2015.

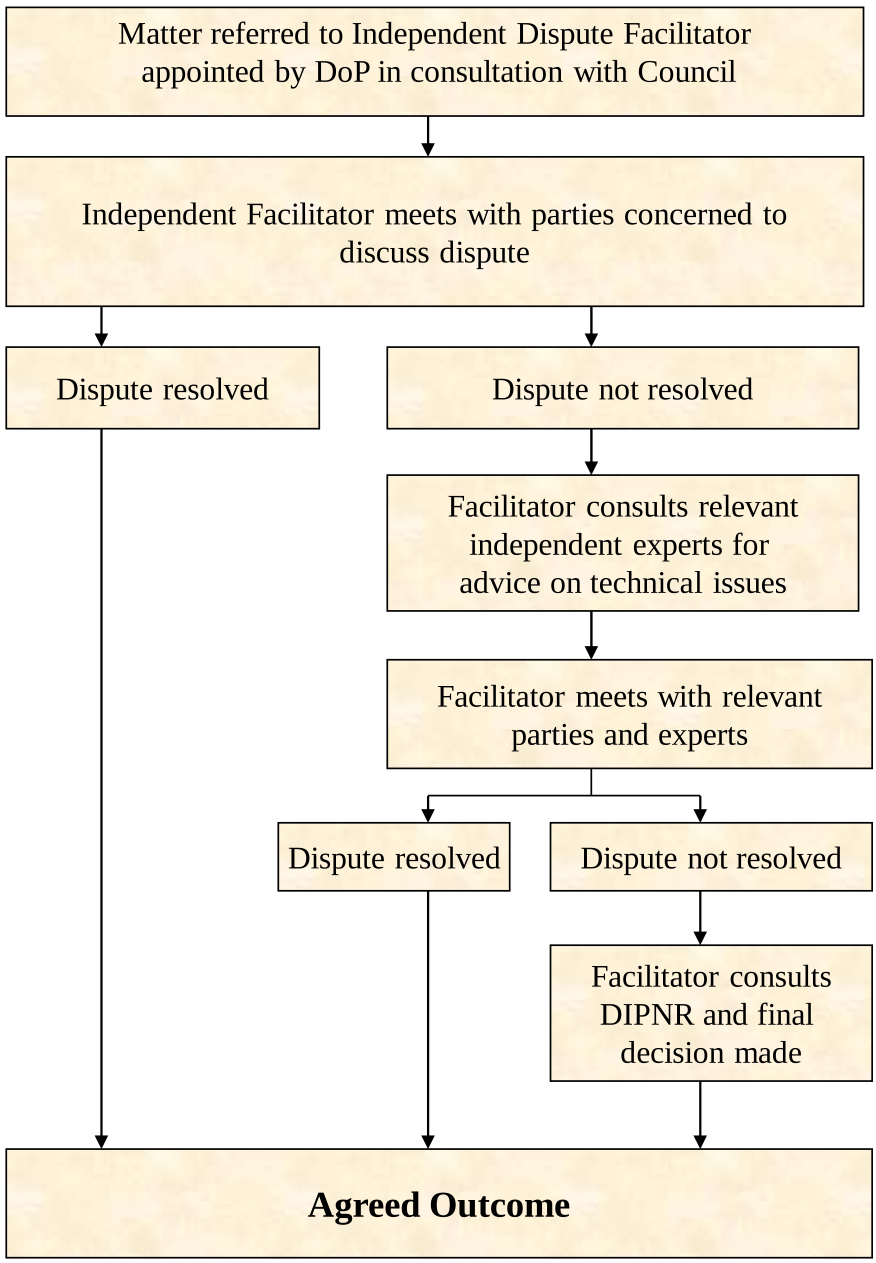
If you require further information or clarification in this matter please contact Scott Brooks on 6575 3401 or by email to scott.brooks@planning.nsw.gov.au.

Yours sincerely

Scott Brooks
Investigations (Lead), Compliance
27-11-2015
As Nominee for the Secretary, Planning & Environment

APPENDIX B
INDEPENDENT DISPUTE RESOLUTION PROCESS

Independent Dispute Resolution Process



APPENDIX C
WAMBO COAL SURFACE DISTURBANCE PERMIT

WA-SAH-PER-305.23 SURFACE DISTURBANCE PERMIT

Peabody ENERGY

The Surface Disturbance Permit is to be used when assessing and approving mine related activities requiring ground disturbance within exploration and mining leases

SDP Number:	

Activity:					
Responsible Person:			**Statutory Area Manager:**		
Project Start:			**Project Finish:**		
Disturbance Area (ha):		**Easting:**		**Northing:**	

ALL PERMITS REQUIRE A FIGURE SHOWING RELEVANT: ABORIGINAL ARCHAEOLOGY, THREATENED ECOLOGICAL COMMUNITIES, MONITORING LOCATIONS, DEVELOPMENT CONSENT, MOP, MINING/EXPLORATION LEASE, LAND OWNERSHIP AND EPL BOUNDARIES

Approvals and Constraints	**Y**	**N**	**N/A**	**Boundaries and Conditions**	**Y**	**N**	**N/A**
Regulatory approvals/notifications required?	☐	☐	☐	Is the proposed activity ***inconsistent*** with any of the following boundaries or conditions:			
Landholder notification/access agreement required?	☐	☐	☐	Wambo's land ownership	☐	☐	☐
Flora/fauna or archaeological constraints?	☐	☐	☐	AHIP	☐	☐	☐
Erosion and Sediment Control Implementation Plan (ESCIP) required?	☐	☐	☐	EPL 529	☐	☐	☐
Will any infrastructure be impacted? (e.g. access tracks, pipelines, monitoring)	☐	☐	☐	MOP	☐	☐	☐
Dust, noise, or lighting impacts?	☐	☐	☐	Mining and Exploration Leases	☐	☐	☐
Does the SDP boundary require fencing?	☐	☐	☐	Development Consents	☐	☐	☐
Topsoil resource identification and an appropriate stockpile location required?	☐	☐	☐	Environmental Management Plans	☐	☐	☐
Activity within 40m of a riparian zone?	☐	☐	☐	Relevant regulation and planning policies	☐	☐	☐

IF YES WAS ANSWERED TO ANY OF THE ABOVE; FURTHER APPROVALS, CONTROLS OR DUE DILIGENCE ASSESSMENTS MAY BE REQUIRED. ATTACH COPIES OF ALL ADDITIONAL WORKS

Comments and Conditions

SDP Approval			
Role	**Name**	**Signature**	**Date**
Responsible Person			
Environment and Community Manager			

PRIOR TO SDP COMPLETION SIGN OFF THE DISTURBANCE AREA IS TO BE REHABILITATED WITH TOPSOIL REPLACED AND SEEDED. ALL UNECESSARY INFRASTRUCTURE, EQUIPMENT AND MATERIALS ARE TO BE REMOVED WITH THE SITE LEFT IN A CLEAN AND TIDY MANNER.

SDP Completion Sign Off			
Role	**Name**	**Signature**	**Date**
Responsible Person			
Environment and Community Manager			

APPENDIX D

DESIGN PRINCIPLES

Description

Contour banks are small, open channels constructed at regular intervals along a slope bank or upstream of a disturbed area. They are also commonly known as diversion banks or contour banks.

Contour banks are typically used to direct flows across a slope, upstream of disturbed areas, and to divert water around a construction area or stockpile.

Contour banks intercept sheet flows and divide slope banks up in to smaller drainage areas, reducing the flow paths and hence velocities down an embankment. Contour banks typically discharge in to a rock chute which then outlet in to a sediment basin.

Advantages	Limitations
• Effective form of drainage control • Can be removed as designs progress • Low maintenance requirements • Can be shaped to allow vehicle crossings	• Lack of grade control in dispersive soils promotes ponding which may lead to tunnel erosion • Suitable for use on embankments with slopes up to 1V:1H • Drain longitudinal slope should ideally be 1V:100H or 1V:67H for dispersive soils

Design Principles

Contour banks are generally required on a slope when the upstream catchment area is greater than 1500 square metres. Below are some typical guidelines for sizing contour banks, although it is recommended that advice should be sought from a competent person prior to commencing construction of contour banks.

It is recommended that for the Peabody operations, a longitudinal drain slope of 1V:100H is used; however longitudinal slopes of up to 1V:67H may be required in dispersive soils. Increasing the slope in dispersive soils is aimed to counteract ponding which may lead to tunnel erosion. Tunnel erosion can have a more detrimental outcome than erosion occurring along the base of the drain. Contour banks do not need to be lined when the longitudinal slope is less than 1V:100H, but should be lined when longitudinal slopes exceed 1V:100H (grass lining for velocities up to 1.5 metres per second or rock lining if velocities exceed 1.5 metres per second). Note that grass lined drains are only effective once sufficient vegetation is established to stabilise the drain.

Contour banks are typically formed with a trapezoidal or parabolic cross-section for ease of construction and long-term stability. The nominal drain depth of 1 metre is preferred for ease of construction. The side slopes on the drain and downstream flow diversion bank should be a maximum of 1V:2H, however 1V:4H side slopes are preferable to provide trafficability of the drains. A contour bank shall be sized to convey a 1 in 10 annual exceedance probabilty rainfall event with 30 centimetres freeboard. Drains spaced too far apart are not effective in containing the sheet flows and can have adverse effects on the downstream surface. A maximum spacing indication is provided in Figure 1, although spacing should be reduced on sites containing highly erodible soils. This spacing is based on the maximum distance it takes for sheet flow to transform into channelized flow on various slopes.

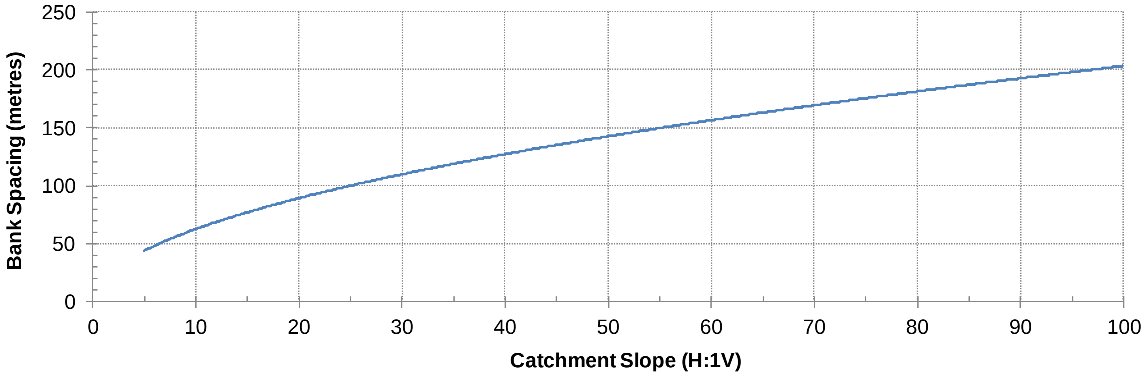


Figure 1

Typical contour bank design depths, flow rates and flow velocities are presented in the figures below. These assume a trapezoidal drain profile, 3.5 metre base width, 40 metre drain spacing, 1V:100H longitudinal slope and 1V:4H side slopes. Firstly, use Figure 2 is used to determine the maximum flow rate in the drain. Figure 3 is used to identify the design drain depth and flow velocity in the drain.

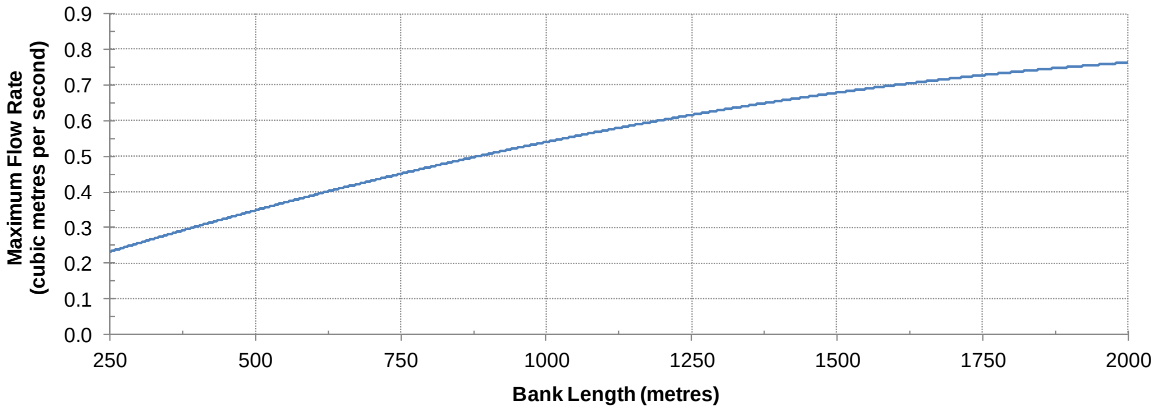


Figure 2

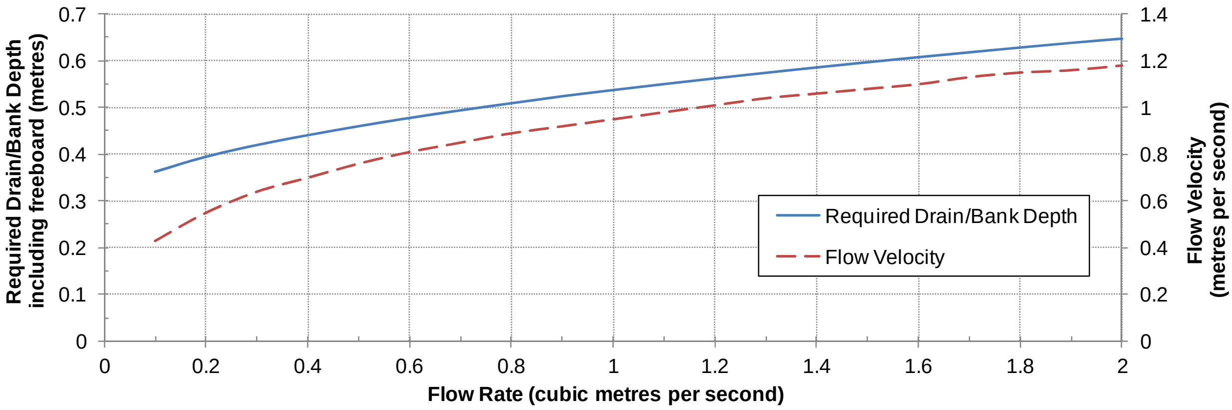


Figure 3

Construction Guidelines

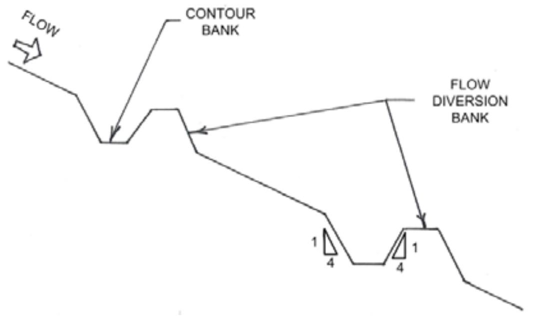


Figure 4

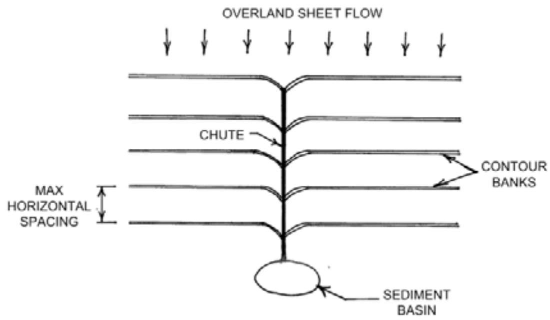


Figure 5

Formation of contour banks is typically achieved using a grader blade or excavator to shape trapezoidal or parabolic profiles. This will result in a nominal drain base width of 3.5 metres to 7.5 metres given the commonly available mining equipment used for drain construction. The excavated material removed from the drain is used to construct a diversion bank on the downhill face of the drain as shown in Figure 4, which requires shaping and compaction.

If contour banks are to be constructed on dispersive soils, the drain shall be lined with a minimum 100 millimetre thickness of non-dispersive soil. This is applicable even if the drains will be lined with rock or geotextile.

Construction shall commence with the uphill contour bank first. The spacing of subsequent downstream contour banks shall be as per specified intervals Figure 1 and as shown in Figure 5.

Monitoring

Monitoring and subsequent maintenance of contour banks shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Inspection shall identify:

- Erosion occurring downhill of a contour bank
- Erosion along a contour bank
- Failure of a contour bank
- Ponding within the contour bank

Maintenance

Evidence of erosion downslope of a contour bank signifies that the upslope contour bank capacity has been exceeded. The drain shall be deepened to increase the hydraulic capacity of the drain. Alternatively, intermediate contour bank can be constructed to reduce the catchment area reporting to each contour bank.

Erosion occurring within a contour bank suggests the drain is too steep or the lining mechanism is not adequate for the flow velocities. The longitudinal grade of the contour bank can be reduced to flatten out the drain and reduce the flow velocity. Alternatively, if the contour bank is unlined, consider lining with rock, grass or a geotextile material. The effectiveness of a grass lined contour bank is only available once sufficient vegetation is established. Rock mulch may be used to line long-term contour banks until vegetation is established if erosion is occurring. Tunnel erosion occurring within the channel suggests ponding may be occurring as a result of settlement. This shall be treated by regrading the drain. In dispersive soils, the longitudinal slope of the drain shall be increased to reduce the likelihood of ponding occurring. This may actually increase the erosion in the base of the contour bank but will combat tunnel erosion which can be detrimental to the structure.

If a cascading failure of the contour bank is observed (e.g. an upstream drain has failed causing the drains down slope to fail due to the increased flow), re-establishment of the drains is required and the spacing of the drains shall be reduced. Contour banks are only required to be removed when they are used as temporary flow diversion drains around a disturbed area.

Description

Check dams are formed by created small weir structures in an open channel at regular intervals. They are effective in reducing the flow velocity by creating small ponds of water upstream of these structures. The effectiveness of these check dams depend on the selected materials, spacing, channel properties and flow characteristics.

Advantages	Limitations
• Reduce flow velocity without changing channel design • Easy to construct • Secondary benefit of acting as a sediment fence to entrap sediment • Effective velocity control in newly formed channels	• Used in low velocity channels only • Channel banks must not exceed 1V:2H • Suitable for channels with a slope greater than 1V:100H but less than 1V:10H

Design Principles

There are three main material types used in the construction of check dams. These are:

1) Sandbags filled with sand, gravel, straw or compost
   - Suitable for shallow drains <500 millimetres deep
2) Rock
   - Suitable for deep drains >500 millimetres deep
   - Typically 200 millimetre mean rock diameter (D_{50}) is used, although larger rock may be warranted on steep slopes

Slope	D_{50} Rock Size (millimetres)
1V:100H – 1V:50H	200
1V:50H – 1V:20H	300
1V:20H – 1V:12.5H	400
1V:12.5H – 1V:10H	500

3) Fibre rolls
   - Biodegradable logs (e.g. Maccaferri Cocologs) made from a fibre blanket filled with organic material
   - Suitable for wide, shallow drains or in vegetated channels
   - Typically last between 4 and 10 years before biodegrading
   - Standard size of 300 millimetre diameter

Check dams should only be used in drains with a slope of less than 1V:10H, they shall not be used in batter chutes.

Construction Guidelines

Construction shall commence at the downstream check dam first then progress upstream. Ensure that the toe of the upstream check dam is at the same elevation as the crest of the downstream check dam. See Figure 1.

Although rarely required, a geotextile underlay or rock apron can be installed to reduce erosion in dispersive soils. If required, a rock apron should be installed downstream of the check dam to a length equivalent to twice the height of the structure.

Construction shall extend up the batters of the channel but should be limited to 500 millimetres from the base of the channel to ensure water does not spill at the edges of the check dam, see Figure 2. A weir should be created in the centre of the check dam by allowing at least a 150 millimetre depression. The base of the check dam shall be trenched at least 200 millimetres below the invert of the drain to minimise the risk of undermining or side cutting the structures.

Fibre rolls shall be anchored in a trench to a depth of at least one third of the diameter of the roll and fixed with wooden stakes at a maximum spacing of 1 metre. Logs can be stacked to achieve a higher crest level but remain limited to the 500 millimetre total height restriction, see Figure 3.

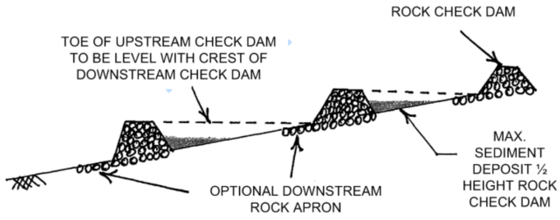


Figure 1

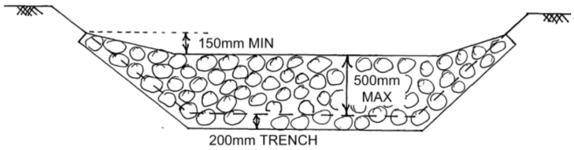


Figure 2

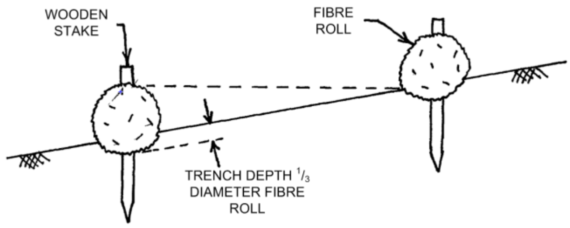


Figure 3

Monitoring

Monitoring and subsequent maintenance of check dams shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Monitoring shall identify:

- Excess sediment deposit build-up upstream of a check dam
- Failure of a check dam
- Erosion within the drainage channel or adjacent to a check dam

Maintenance

Occasional removal and disposal of sediment deposit behind the check dam is required if the sediment is approaching the top of the check dam or causing flows to divert around the ends of the structures.

If failure of a check dam occurs or erosion is evident, the size of the rock needs to be increased, intermediate check dams could be constructed to reduce the upstream velocity, or a channel liner (as discussed in the *Drainage Control Guidelines*) could be used between the check dams of concern. Observation to ensure flow is concentrated over the weirs and not around the structures necessary. Inspection to ensure the rocks remain sufficiently anchored after extended storm events is required.

Rock and sandbag type check dams are to be removed once vegetation has established sufficiently to stabilise the channel. Seedlings can be planted directly into the fibre log as they are 100% biodegradable. The protective netting should be removed once any planting has become established.

Description

Grass is the most common material used to line channels and embankments to reduce the velocity of sheet flows and minimise the potential for erosion. Grass provides a permanent ground cover on rehabilitated surfaces.

The establishment of grass typically involves ripping and seeding the surface with native grass and broadleaf species.

Advantages	Limitations
• Can be applied at majority of site locations	• Suitable for channels with flow velocities less than 1.5 metres per second • Sites should plan to establish ground cover during wet seasons (typically February to May and September to November for Queensland and New South Wales sites) • Not suitable for channels steeper than 1V:10H

Design Principles

The selection of vegetation species is dependent on the site location and the season that the grass is sown.

The minimum recommended height of ground cover shall be 5 centimetres in channels with a velocity up to 1.5 metres per second. The maximum design velocities for dispersive and non-dispersive soil types are as follows:

Slope	Non-dispersive soil maximum velocity (metres per second)	Dispersive soil maximum velocity (metres per second)
0 – 1V:20H	1.5	1.2
1V:20H – 1V:10H	1.0	0.8

Construction Guidelines

Seeding of the final earthworks surface shall occur as soon as plausible after construction completion. Temporary rock mulching may need to be utilised in the short-term to control sediment displacement until grass is sufficiently established. A minimum topsoil depth of 75 millimetres shall be spread across the entire rehabilitation footprint and the surface ripped to promote root establishment.

Seed shall be applied at a rate of 10 kilograms of seed per hectare. Where practical, watering of the seed is advantageous in promoting germination of the seed and establishing grass vegetation. Depending on the location, the grass seed may benefit from a light mulch cover. Germination of seed may take several months, especially at Central Queensland sites, due to defined wet and dry seasons.

Monitoring

Monitoring and subsequent maintenance of grass shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Monitoring shall ensure:

- A minimum of 80% ground cover
- The grass seed has not been dislodged in a rain event

Maintenance

If a minimum of 80% ground cover is not achieved, the surface is required to be re-seeded.

Removal of excess sediment (greater than 50 millimetres deep) will maintain the hydraulic capacity in the channel. Reducing the sediment thickness above the seed will alsoaid the germination process.

Re-seed if washed away by a large storm event. If consistent dislodgement is occurring, consider using turf reinforcement matting, rock mulch or cellular confinement systems to contain the topsoil and add stability to the surface. Rock mulching may be used on dispersive soils where topsoil and seed is dislodged prior to the establishment of grass roots.

Assessment of areas where grass has been established but has experienced die-back due to events such as bushfires or drought is required to determine the long-term viability of the grass. Revegetation of grass shall take place in areas where losses greater than 20% have occurred. This is only applicable when complete root structure of the grass is lost or re-establishment will not occur naturally.

CELLULAR CONFINEMENT SYSTEMS

Description

Cellular confinement systems for drainage control are formed by constructing a series of cells using a high density polyethylene (HDPE) material. Installation of these systems in channels is an effective drainage control technique. The cells essentially create numerous small check dams within the slope, hence reducing the velocities within the channel.

The use of this system as an erosion control device is discussed in more detail in Guideline H347052-0000-10-215-0010 Cellular Confinement Systems (Erosion Control).

Advantages	Limitations
• Can be used on slopes up to 1V:1H • Can be used in shady areas where vegetated erosion control techniques are not suited • Smaller rock required than typical rock lined channels • Easy to transport and handle lightweight and collapsible panels • Promotes vegetation • Flexible, durable and easy to install	• Not suited to high velocity channels • Quite expensive and relatively time consuming to construct

Design Principles

Cellular confinement systems are most applicable in the mining sector to stabilise steep embankments and drainage channels. Cell walls can be smooth, textured or perforated. Perforated walls are most commonly used as they allow free-drainage of excess moisture through the structure and add structural integrity by allowing interlocking of particles with the cell walls.

Cellular confinement systems come in standard sizes with depths between 75 millimetres and 200 millimetres depending on the expected flow and the infill material.

Cell Size	Cell Length (millimetres)	Cell Width (millimetres)
Standard Cell	203	244
Large Cell	406	488

The three main materials used to fill the cells are:

1) Gravel
    - Best suited to areas where vegetation does not have enough sunlight to establish
    - Suitable for use in higher velocity channels up to 3 metres per second
    - Recommended nominal rock diameters (in millimetres) are as specified:

Cell Depth (millimetres)	Standard Cell	Large Cell
75	38	75
100	50	100
150	75	150
200	75	150

2) Vegetated soil
    - Environmentally sensitive solution
    - Best suited to areas of low velocity (up to 1.5 metres per second), intermittent (durations less than 24 hours) flows occur (extended periods of flow creates rills and gullies under the system)
    - Fill cells with topsoil, then seed and water until vegetation is established

DRAINAGE CONTROL

- A cell depth of 100 millimetres shall be used unless specified in arid regions where larger cell depths may be required.

3) Concrete
   - Durable and erosion resistant
   - Used on embankments when high flow velocities (up to 6 metres per second) and turbulence are expected down a slope
   - Should only be used on slopes less than 1V:3H due to concrete slump

Construction Guidelines

The construction area shall be cleared of vegetation and rocks and a geotextile underlay can be installed if the in-situ soils are dispersive. The geotextile fabric is provided for separation, filtration and stability and should be pinned in a minimum 200 millimetre deep trench at the top of the channel, as illustrated in Figure 1. The system shall be aligned so cells can be expanded down the slope. Construction of the cellular confinement system is to commence at the top of the slope, ensuring anchor stakes are installed in every cell along the top row in the trench.

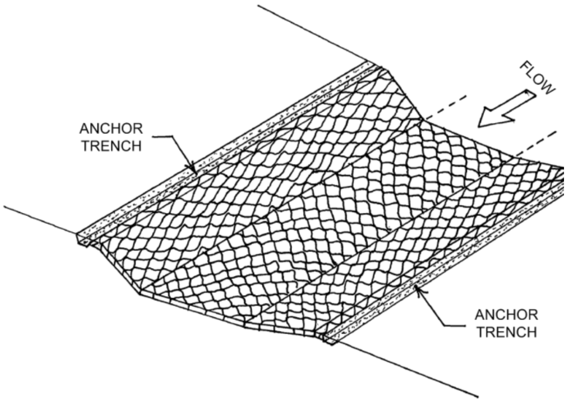


Figure 1

Prior to expanding the cells, as an optional supplied addition, tendons shall be threaded through the tendon slots in the system and knotted at the ends. The tendon strength must be specified by the engineer and must meet design requirements for the application. Stretch the HDPE material to create cells between 23 to 48 centimetres long and 26 to 51 centimetres wide, as shown in Figure 2, depending on the selected system. Anchors shall be inserted every 2 metres down the embankment on slopes greater than 1V:10H. To ensure the cells are kept open during filling, either anchor the material at the toe of the embankment or fill the bottom row of cells with selected material.

Connection of systems can be achieved by stapling or through the use of a specialised device (eg. ATRA® key connection device).

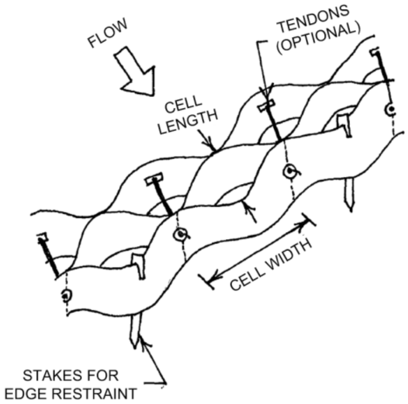


Figure 2

Monitoring

Monitoring and subsequent maintenance of cellular confinement systems shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Monitoring shall ensure:

- The system remains anchored at the top of the slope and scour is not evident around or under the system
- Infill material still fills the cells and dislodgement or settlement has not occurred

Maintenance

Scour may occur as a result of poor construction or unfavourable soil conditions. Adequate anchorage at the top of the slope is crucial to ensure runoff does not flow beneath the cells and cause undermining of the structure. If localised failure has occurred, the affected panels must be replaced after the subsoil conditions have been improved (or a geotextile has been installed) and the structure needs to be re-anchored in the trench. Additional infill material will need to be added to the cells if settlement results in an infill depth of less than half of the cell depth. The system should be extended to cover any adjacent areas where scour is evident around the structure.

Cellular confinement systems promote revegetation so can be used as permanent erosion control devices and do not need to be removed.

Description

A rock mattress is a shallow wire basket with inner cells and filled with rock. Rock mattresses are similar to gabions but their geometry is thin and rectangular rather than cubic. Rock mattresses are commonly used in high velocity channels, chutes, culvert inlet and outlets and sediment basin spillways where long term scour is prominent.

Mattresses are constructed on the ground and can be linked together to cover large surface areas. The rock fill provides the weight to resist shear flow and the wire cells aid in withstanding movement of the rock.

Advantages	Limitations
• Can be used in high velocity flow locations • Mattresses can fold flat for ease of transport • Simple to install • Instant drainage control when installed • Smaller (and hence cheaper) rock sizes can be used	• Not ideal for use on dispersive soils • Typically quite expensive • Recommended for maximum slope of 1V:1.5H • Construction is labour intensive

Design Principles

Rock mattresses are made from a flexible woven wire mesh 60 millimetres by 80 millimetres and are typically zinc coated (a plastic coating is available if used in corrosive conditions). The wire baskets come in standard sizes of 6 metres by 2 metres with thicknesses typically between 170 millimetres and 300 millimetres. The selection of the mattress thickness depends on the erodibility of the bank slope, maximum expected velocity and the bank slope. Internal walls every 1 metre create cells within each mattress to minimise rock movement. Wire mattresses can be cut to size and linked to adjacent mattresses to suit any arrangement.

Flow Velocity (metres per second)	Recommended Mattress Thickness (millimetres)	Rock Infill Size (millimetres)
Less than 4.2	170	75 – 100
4.2 - 6.1	230	75 – 150
6.1 - 6.4	300	75 – 200
6.4 – 8.0	500	100 - 250

By containing rock within the wire baskets, rock mattresses are approximately 4 times more effective than rock lining with the same thickness. Selection of a rock size depends on the slope and velocity in the channel. The rock infill shall be between 75 millimetres and two-thirds the thickness of the mattress, or 250 millimetres, whichever is the lesser. The selected rock material must be hard, durable, well graded and weather resistant with a density no less than 1,700 kilograms per cubic metre.

Construction Guidelines

Geotextile material must be laid under the link mattresses (as shown in Figure 1) to reduce erosion through the rock infill. If the soil is highly dispersive, an allowance shall be made to remove and replace the top 200 millimetres with non-dispersive soil. Ensure the geotextile is not torn or punctured during the installation of the rock mattresses.

The wire baskets shall be shaped, wired-up and inspected for deformities before rock is added to the baskets. Filling shall occur from the downstream cells first and can be done by hand or mechanically. Each cell shall be slightly overfilled to allow for settlement of the rock.

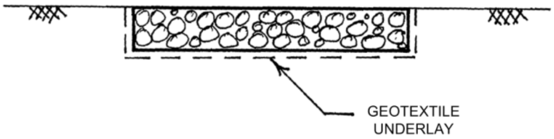


Figure 1

Where rock mattresses are to be installed in a channel bed, the wire baskets shall be installed so that the internal walls (diaphragms) are perpendicular to the direction of flow. Conversely, if mattresses are to be installed on slopes or channel banks, they should be aligned so the diaphragms are parallel to the banks (as shown in Figure 2).

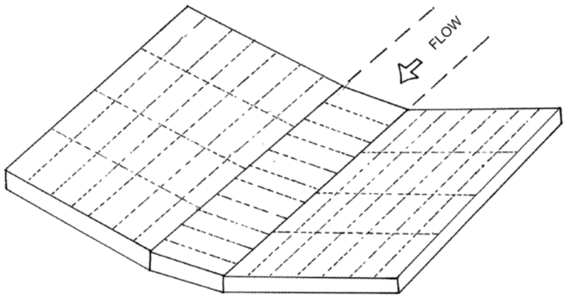


Figure 2

Anchoring of the mattresses is required on slopes greater than 1V:1.5H. Hardwood stakes or star pickets should be temporarily installed every 2 metres inside the upper end panel. The stakes are required to be removed upon completion of filling to maintain flexibility of the structure.

On dispersive soils it may be necessary to fill voids in the mattresses with soil or vegetation to help reduce erosion under the structure. Where rock mattresses are used for spillway construction, an additional layer of concrete shall fill the voids to reduce seepage through the mattress.

Monitoring

Monitoring and subsequent maintenance of rock mattresses shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

During the inspection process, particular focus should be on:

- Checking for erosion around and under the mattress
- Ensuring integrity of the wire baskets, ie no breaks in the wire
- Monitoring movement of the rock within the baskets

Maintenance

Rock mattresses are designed to be flexible and have the ability to withstand slight ground deformation. Failure often occurs due to inadequate protection against scour at the downstream edge of the rock mattress and can result in tunnel erosion under the structure. Consider extending the structure or adding downstream rock protection if erosion is evident.

If large breaks are visible in the wire mesh, then a patch should be immediately installed directly over the affected area. Minor deformation and breaks in the wire should not affect the integrity of the structure as the construction technique inhibits unravelling of the mesh.

If the mattresses deform due to settlement of the rock, the lid shall be removed and additional rock placed in the baskets. Exposed surface around the rock mattresses should be rehabilitated upon completion of construction.

Description

Rock lining involves spreading thick layers of rock in a drainage channel or chute to control the flow velocity. The rough surface of the rock lining dissipates flow energy in high velocity and/or steep channels.

Rock lined channels are a highly effective and cost efficient solution for controlling flows.

Advantages	Limitations
• Can be used in channels with velocities greater than 2 metres per second • Considered the most effective form of drainage control • Not labour intensive • Environmentally friendly • Cost effective	• Limited availability of rock from mining operations may mean it needs to be sourced off-site • Must be designed to ensure the flow capacity of the drain is not compromised

Design Principles

The rock selected must be well graded, durable, weathered and preferably angular for stability.

The minimum recommended thickness of the rock lining shall be 1.5 times the mean rock diameter (D_{50}). Example D_{50} rock sizes are presented in Figure 1.

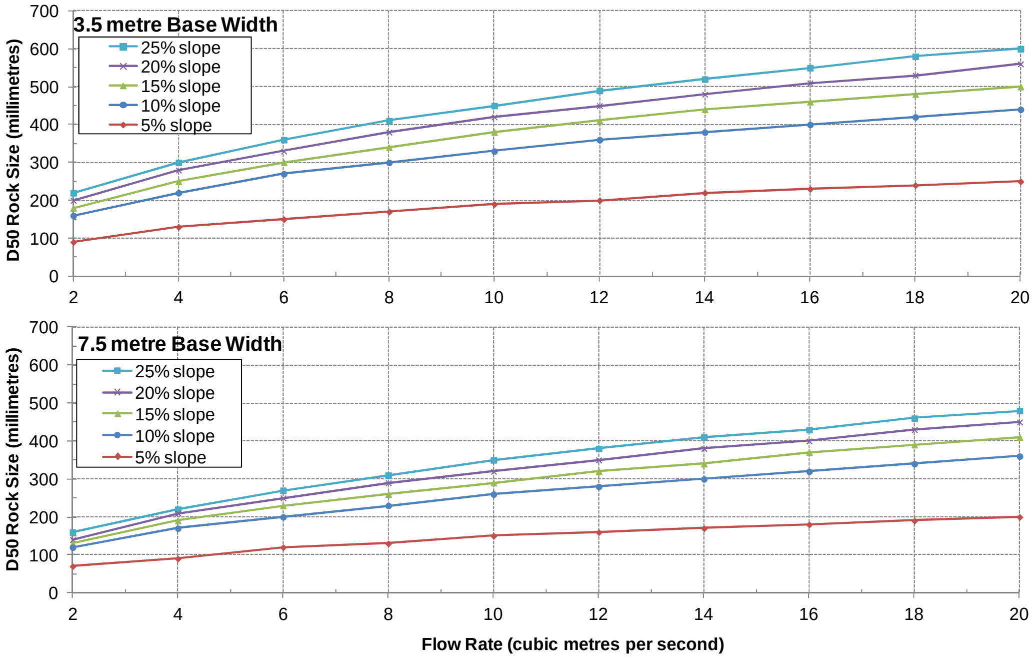


Figure 1

Construction Guidelines

The channel shall be excavated and shaped to the design elevations. The thickness of rock is to be allowed for during excavation to ensure the top of the rock surface is level with the adjacent ground level. The use of a heavy duty geotextile (minimum A24) underlay is advised, especially if the rock lining is to be placed on dispersive soils or if the rock is not well graded i.e. there may be voids in the lining.

Dump rock in the channel ensuring 100% coverage of the flow surface is achieved. A minimum thickness of at least 1.5 times the rock diameter is required and shall extend up the channel banks to reduce scouring of the banks as shown in Figure 2.

The rock lining shall extend at least 1 metre upstream and 1 metre downstream of the channel as shown in Figure 3.

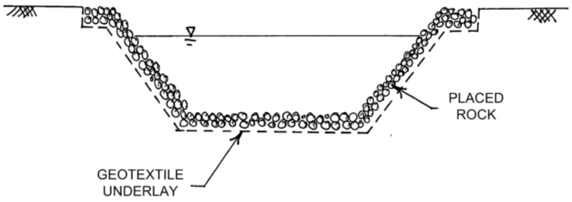


Figure 2

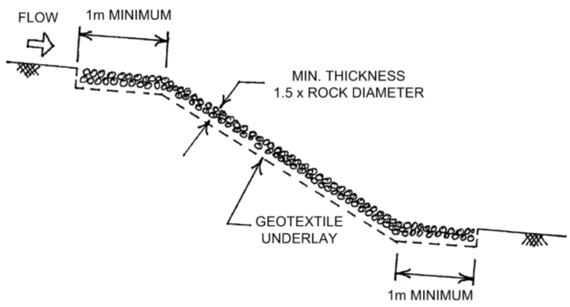


Figure 3

Monitoring

Monitoring and subsequent maintenance of rock lined channels shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

When conducting periodic inspections of the rock lining, identify any:

- Scour occurring below or adjacent to the rock lining
- Displacement of the rock
- Excess deposits of sediment in the channel
- Break down of the rock material

Maintenance

Evidence of scour below the rock lining is generally a result on dispersive soils where a geotextile underlay has not been utilised. Scour occurring adjacent to or downstream of the rock lining should be treated by increasing the rock coverage area. Erosion along the edges may be a result of flows being channelised in to the drain. Extend the rock lining further up the banks and ensure sheet flows can freely enter the drain.

Displacement of rock from sections within the channel indicates that flow velocities exceed the design velocity for the chosen rock size. Larger rock shall be placed in the channel, replacing the original undersized rock.

Excessive vegetation growth within the rock voids can restrict the channel capacity and should be removed. Upstream rock check dams or sediment fences may aid in reducing the amount of sediment transported downstream into the rock lined channel.

Weathering and breakdown of the rock lining may occur if non-durable rock is used. If evidence of weathering is observed, the rock lining may need to be replaced to ensure on-going protection of the drain or chute.

Rock lining can be utilised as a permanent structure and therefore does not need to be removed.

Description

A level spreader is an outlet control structure used in drainage channels. They consist of a small stilling basin at the downstream end of a channel with a small weir outlet discharging perpendicular to the flow direction in the channel. Level spreaders work by converting minor channelised flows back into sheet flows in order to minimise velocity and reduce erosion.

Level spreaders can also be used to divert flows around a soil disturbance area.

Advantages	Limitations
• Relatively inexpensive form of drainage control	• Most effective where outlet is constructed on a non-dispersive and vegetated surface • Outlet velocity limited to 1.5 metres per second • Large footprint required for construction • Construction with a dozer D5 or smaller • Suitable for slopes up to 1V:10H

Design Principles

Upstream flow entering a level spreader can be via pipes or contour banks. The downstream 6 metres of the inlet channel shall have a maximum gradient of 1V:100H to reduce inlet velocities and prevent scouring of the outlet structure. A level spreader should be lined with rock, concrete or grass depending on the application and upstream channel material.

The outlet sill (weir type structure) shall have a minimum length of 4 metres and a maximum length of 25 metres. The length of the sill depends on the contributing catchment, slope and expected flow rates and velocities. The design sill length shall be a maximum of 0.1 cubic metres per second per metre of length based on a 10 year storm event.

The sill must be constructed horizontal to ensure flows are not concentrated over the crest.

Construction Guidelines

Once the channel has been excavated and trimmed, the level spreader can be constructed at the outlet.

The sill is to be constructed to the specified length and level with no crossfall along the outlet weir as shown in Figure 1. An erosion control matting (e.g. jute mesh, geotextile) shall be installed at the sill crest. The matting shall be anchored at least 300 millimetres upstream of the sill and to a minimum depth of 150 millimetres, as illustrated in Figure 2. On dispersive soils, the erosion control matting shall extend a minimum of 5 metres downslope of the sill to ensure scour does not undermine the level spreader structure. A level spreader should discharge on to vegetated or rock mulched areas.

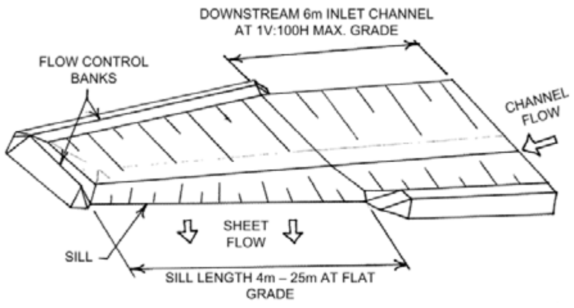


Figure 1

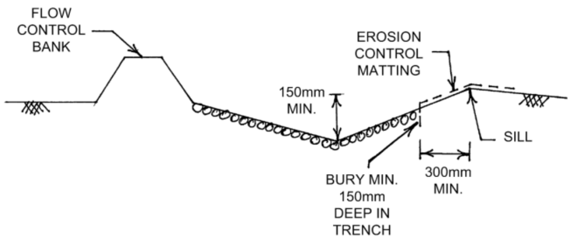


Figure 2

Upon construction completion, vegetation should be established for long term durability of the structure.

Monitoring

Monitoring and subsequent maintenance of level spreaders shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Inspection of the structures shall identify:

- Excess sediment deposits exceeding one third of the total basin depth
- Concentrated flows over and downstream of the sill crest identified by failure of the sill or downstream surface erosion
- Erosion within and adjacent to the structure

Maintenance

The presence of excess sediment in the outlet structure signifies that the in-situ soil material is most likely dispersive. A geotextile material or grass lining shall be installed in the upstream channel to reduce the amount of sediment being dislodged during rain events. Excess sediment needs to be removed from the outlet to ensure capacity is available to allow settling of the flow before discharge.

Concentrated flows over the sill crest identifies that the elevations along the sill are not perfectly horizontal. Ensure there is no crossfall on the sill crest and reconstruct the weir if necessary.

Erosion downstream of the outlet structure suggests that the crest length is too short to spread the flows. Additional construction shall be done to provide a longer crest at the design crest elevation. Flows and velocities may be too high over the outlet weir, causing erosion of both the outlet structure itself and the downstream environment. The flow rate shall be checked to ensure it does not exceed the maximum design flow rate of 0.1 cubic metres per second per metre of sill length in a 1 in 10 year rainfall event.

24Description

Rock chutes are drainage channels designed specifically for steep slopes. They are typically outlet structures for contour banks and primarily convey water from relatively flat longitudinal drains, down a steep slope to a sediment basin or outlet device as shown in Figure 1 and Figure 2.

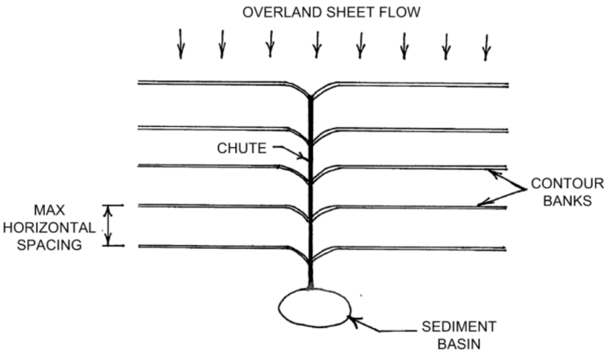


Figure 1

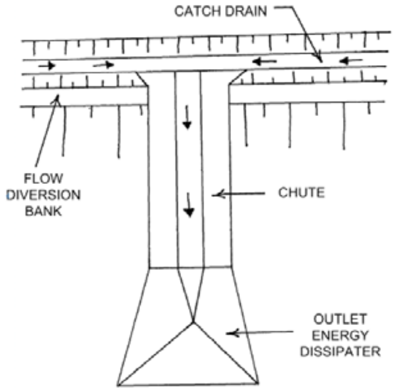


Figure 2

Advantages	Limitations
• Typically constructed on slopes greater than 1V:10H • Relatively cost effective and simple to construct • High flow capacities	• Maximum slope of 1V:2H for rock lining stability • Suitable for flow velocities up to 8 metres per second • Prone to erosion if inadequate design

Design Principles

The design of a chute shall generally be undertaken by a competent person as chutes are susceptible to failure and can fail quite quickly. Inadequate design of a chute can compromise the whole structure including upstream and downstream devices. The construction material must be flexible enough to handle movement when constructed on a spoil pile.

A chute has three primary components:

1) Inlet
   - Inflow water received from contour banks
   - Flow diversion bank shall direct flow into the chute, maintaining a minimum 150 millimetre freeboard
2) Chute structure
   - Can be a parabolic, rectangular or trapezoidal profile but must be perfectly straight
   - Can be lined with rock, concrete or flexible fabric depending on the flow velocity and design duration requirements
   - Minimum 300 millimetre chute depth with sufficient capacity to ensure flows do not overtop the structure

3) Outlet energy dissipater
   - Reduces flow energy to minimise scour downstream
   - Constructed at the base of the chute
   - Technical design is required to ensure the outlet does not fail and compromise the stability of the entire chute structure
     - o Can be a flat pad or a sunken basin with sill depending on the tailwater conditions

Construction Guidelines

A chute structure should ideally be constructed after the completion of the outlet sediment basin but prior to the construction of contributing contour banks.

Excavate the chute profile and install a geotextile underlay prior to placing rock in the chute.

Rock lining shall extend a minimum length of 5 times the depth of approach flow upslope of the chute for scour protection as shown in Figure 3. Rock lining shall be extended up the sides of the chute to reduce the effects of scour from adjacent flows. The chute structure shall be sufficiently tied in to upstream and downstream systems to reduce the risk of water flowing under the chute and undermining the structure.

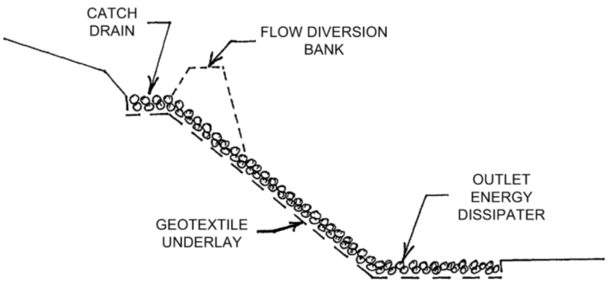


Figure 3

Monitoring

Monitoring and subsequent maintenance of rock chutes shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Monitoring shall identify any:

- Scour at the inlet, outlet, adjacent to or within the chute
- Flows bypassing the chute
- Movement of channel linings

Maintenance

Scour at the inlet to the chute indicates that flows are not freely entering the chute and ponding may be occurring. Ensure the invert of the chute is below the invert of the contributing contour bank. Extend the rock lining into the contour banks to reduce the inlet velocity.

Water must flow into the chute, not divert around the inlet. If flows are bypassing the chute, extend the diversion banks along the catch drains all the way to the edge of the chute. Flows shall not spill out of the chute as this will potentially undermine the chute. If flows are overtopping the chute, increase the depth of the chute to gain additional capacity.

Dislodgement of rocks identifies that the flow turbulence and velocities are too great for the rock sizing. Consider increasing the rock size or lining the chute with a stronger material such as concrete.

Removal of the chute shall occur only after rehabilitation or removal of the contributing contour banks has occurred.

Description

Cellular confinement systems are formed by constructing a series of cells using a high density polyethylene (HDPE) material. Installation of these systems on channel slopes and embankments improves the slope stability and reduces the impact of high velocity/impact water. The creation of small check dams down the slope reduces the flow velocity, in turn reducing the effects of erosion.

The use of this system as a drainage control device is discussed in more detail in Guideline H347052-0000-10-215-0004 Cellular Confinement System (Drainage Control).

Advantages	Limitations
• Can be used on slopes up to 1V:1H • Can be used to stabilise dry, sandy bed streams where temporary vehicle crossing is required • Can be used in shady areas where vegetated erosion control techniques are not suited • Easy to transport and handle, lightweight and collapsible panels • Promotes vegetation • Flexible, durable and easy to install	• Quite expensive and relatively time consuming to construct

Design Principles

Cellular confinement systems are most applicable in the mining sector to stabilise steep embankments and drainage channels. Cell walls can be smooth, textured or perforated. Perforated walls are most commonly used as they allow free-drainage of excess moisture through the structure and add structural integrity by allowing interlocking of particles with the cell walls.

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Standard Cell	203	244
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The three main materials used to fill the cells are:

1) Gravel
   - Best suited to areas where vegetation does not have enough sunlight to establish
   - Suitable for use on slopes where higher velocities are expected (up to 3 metres per second)
   - Recommended nominal rock diameters (in millimetres) are as specified:

Cell Depth (millimetres)	Standard Cell	Large Cell
75	38	75
100	50	100
150	75	150
200	75	150

2) Vegetated soil
   - Environmentally sensitive solution
   - Best suited to areas where low velocity (up to 1.5 metres per second), intermittent flows occur
   - Fill cells with topsoil, then seed and water until vegetation is established

- o A cell depth of 100 millimetres shall be used unless specified in arid regions where larger cell depths may be required.

3) Concrete
- o Durable and erosion resistant
- o Used on embankments when high flow velocities (up to 6 metres per second) and turbulence are expected down a slope
- o Should only be used on slopes less than 1V:3H due to concrete slump

Construction Guidelines

The construction area shall be cleared of vegetation and rocks and a geotextile underlay can be installed if the in-situ soils are dispersive. The geotextile fabric is provided for separation, filtration and stability and should be pinned in a minimum 200 millimetre deep trench at the top of the embankment, as illustrated in Figure 1. The system shall be aligned so cells can be expanded down the slope. Construction of the cellular confinement system is to commence at the top of the slope, ensuring anchor stakes are installed in every cell along the top row in the trench.

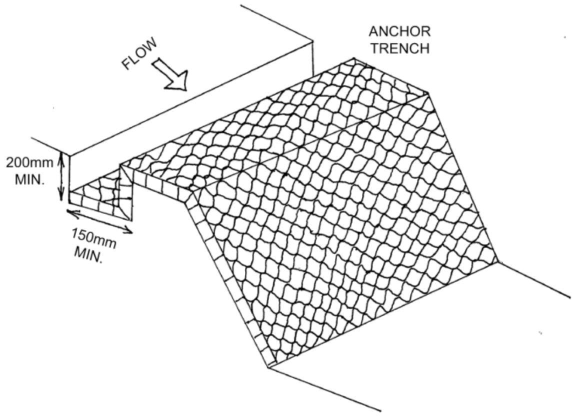


Figure 1

Prior to expanding the cells, as an optional supplied addition, tendons shall be threaded through the tendon slots in the system and knotted at the ends. The tendon strength must be specified by the engineer and must meet design requirements for the application. Stretch the HDPE material to required dimensions, as illustrated in Figure 2, depending on the selected system. Anchors shall be inserted every 2 metres down the embankment on slopes greater than 1V:10H. To ensure the cells are kept open during filling, either anchor the material at the toe of the embankment or fill the bottom row of cells with selected material.

Connection of systems can be achieved by stapling or through the use of a specialised device (e.g. ATRA® key connection device).

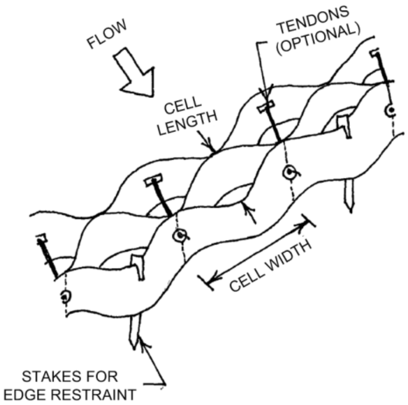


Figure 2

Monitoring

Monitoring and subsequent maintenance of cellular confinement systems shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Monitoring shall ensure:

- The system is still anchored at the top of the slope
- Infill material still fills the cells and dislodgement or settlement has not occurred
- Scour is not evident around or under the system

Maintenance

Scour may occur as a result of poor construction or unfavourable soil conditions. Adequate anchorage at the top of the slope is crucial to ensure runoff does not flow beneath the cells and cause undermining of the structure. If localised failure has occurred, the affected panels must be replaced after the subsoil conditions have been improved (or a geotextile has been installed) and the structure needs to be re-anchored in the trench. Additional infill material will need to be added to the cells if settlement results in an infill depth of less than half of the cell depth. The system should be extended to cover any adjacent areas where scour is evident around the structure.

Cellular confinement systems promote revegetation so can be used as permanent erosion control devices and do not need to be removed.

Description

A compost blanket is formed by applying a thick layer of high quality compost onto a surface. The compost material has already biologically degraded to generate a stable product.

Compost blankets are generally applied as a form of revegetation.

Advantages	Limitations
• Can be used on relatively steep slopes up to 1V:2H • Can withstand larger rainfall events than mulch • Topsoil not required for establishment of vegetation • Does not require tackifiers to anchor the mulch • Environmentally friendly as it reduces the risk of introducing imported weed species due to the biological degradation of organic matter • Highly durable form of erosion control • Effectively controls the impact of raindrops • Can be used with seeding	• Can be quite expensive • Tackifiers may be required to anchor the compost on steep slopes

Design Principles

The selected compost material shall be 100% organic matter produced by controlled aerobic decomposition and must comply with the properties specified in AS4454: Compost, Soil Conditioners and Mulches. Key properties are summarised in the table below.

Property	Acceptable Range
Inert material	1% maximum
Soluble salt concentration	5 dS/m
pH range	5.0 – 8.0
Moisture content	30% - 50% (prior to application)
Electrical Conductivity (EC)	Maximum 10 μS/cm

Compost blankets are suitable to use in wet areas and are twice as effective as hydromulch at reducing the amount of run-off after a rain event.

Construction Guidelines

A layer of compost should be spread evenly over the surface to a thickness specified by the specialist contractor. The general thickness of a compost blanket is around 50 millimetres but will vary depending on the slope and underlying soil composition.

The compost blanket shall be continued at least 1 metre beyond the top of the slope to minimise the risk of water flowing under the blanket and washing the compost away.

Generally tackifiers are not required, however in locations where high rainfall and wind events are experienced, tackifiers may need to be applied.

Monitoring

Monitoring and subsequent maintenance of compost blankets shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Inspections shall be undertaken to identify any:

- Evidence of concentrated flows
- Areas where compost has been displaced

Ongoing monitoring is required until establishment of vegetation is sufficient to reduce the effects of erosion.

Maintenance

Additional upstream flow control structures are required when concentrated flows are evident through the compost blanket. Reshaping of the upslope surface may be required to produce even sheet flows down the slope.

Replacement of compost to the original specified thickness shall be undertaken when compost has been displaced.

Removal of compost blankets is not required as the system aids revegetation.

Description

Organic mulching is the process of spreading a protective layer of organic material on the soil surface. Mulching aims to limit runoff turbidity, reduce erosion caused by sheet flow and promote vegetation regrowth.

Advantages	Limitations
• Particularly useful in tropical areas • Most effective way of reducing rain droplet impact.	• Not suitable in all ecosystems as some seeds are considered weeds • Must have uniform cover to perform effectively • Easily washed away in flood areas and on steep embankments • Short-term option only

Design Principles

Mulching materials include but are not limited to:

- Bark chips
  - Shall not be used on low pH soils
- Hydromulching or hydroseeding
  - Mix of seed, fertilizer, paper pulp and bitumen emulsion or tackifier with water
  - Sprayed on as a slurry mixture
  - Only suitable on slopes up to 1V:6H
- Wood chips
  - Consist of mulched trees or processed hardwood
  - Used as weed control or in areas where not closely mowed
  - Application of nitrogen rich fertilizer may be required
  - Effective on slopes up to 1V:3H
- Straw
  - Most commonly used material
  - Ideal when minimal water is available
  - Effective on sites with high soil erosion hazard or where soil moisture is likely to be inadequate for successful plant establishment
  - Generally applied to small areas such as embankments and stockpiles
  - Should be mechanically anchored as a minimum

Technique	Application Rate
Bark chip	2.5 cubic metres per hectare
Hydromulching or hydroseeding	30,000 to 40,000 litres per hectare (bituminous emulsion 1,500 to 2,000 litres per hectare)
Wood chip	11 to 14 tonnes per hectare
Straw	250 bales per hectare or 3.4 to 4.5 tonnes per hectare

Selection of mulch type must be considered where the mulch may be dispersed should failure occurs e.g. Will it end up in a sensitive ecosystem downstream?

Construction Guidelines

The site shall be cleared of large rocks, logs and other objects which may reduce the effectiveness of the contact between the mulch and the soil. Mulching shall not occur during windy conditions and should occur as soon as practically possible after seeding.

Mulch shall be applied and spread evenly to a maximum depth of 50 millimetres, ensuring a minimum 80 to 100% coverage of the entire surface. An increased depth of 75 to 100 millimetres should be applied where weed control is the primary objective.

Chemical tackifiers may be warranted on slopes greater than 1V:2H and mechanical anchors on slopes up to 1V:2H. Anionic bitumen (AS 1160) is an example of a chemical tackifier and should be covered with a net. Environmental constraints and local jurisdiction should be considered before a tackifier is applied. A mechanical anchor may include running a disk harrow or special crimper over straw to press it into the soil after the mulch is spread.

Monitoring

Monitoring and subsequent maintenance of mulched areas shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Monitoring shall identify:

- Areas where mulch has become dislodged

Maintenance

Mulching aims to provide erosion control during storm events, however it is not uncommon for mulching to fail locally during intense storm events. If local failure occurs, the area will need to be re-established by replacing seed and mulch to the original depths. If mulch continuously dislodges on steep slopes, tacking or netting may need to be applied.

Due to the ability of the mulch to decompose, no removal of the material is required.

Description

Revegetation involves the establishment of trees and grasses to achieve a pre-disturbance habitat.

Revegetation can be applied to disturbed surfaces both on slopes and at the outlet of drainage channels.

Advantages	Limitations
• Can be applied to all sites • Environmentally acceptable approach to controlling erosion	• Vegetation takes time to establish, requiring additional temporary devices to control erosion in the short term • Limited to slopes less than 1V:3H • Not suitable for trafficked areas

Design Principles

Revegetation techniques vary from site to site and must be analysed as location specific. Soil samples shall be taken at the site and analysed to determine the suitability of the soil prior to vegetating. Consultation with the site environmental team will ensure site specific standards are met.

Site revegetation can include the establishment of trees and/or grasses, both of which are typically germinated by spreading seed over a topsoiled and ripped surface. The minimum height of the established grass shall be 5 centimetres and shall cover a minimum of 80% of the surface to effectively dissipate flow energy.

Revegetation can be aided by applying other short-term erosion control devices such as erosion control blankets and mulching.

If revegetation works are undertaken as part of the permanent design, the final landform needs to be considered.

Construction Guidelines

Prior to seeding, the application surface shall be ripped to loosen the soil. The revegetated slope shall be limited to 1V:3H for stable soil conditions or 1V:4H for dispersive soils. Seed shall be applied at a rate as specified in the "Grass" guideline for drainage control or as suggested by the seeding contractor. A uniform spread of seed shall cover a minimum of 80% of the disturbed surface.

Ensure there is good contact between the seed and the topsoil. If applicable, mulch may be spread over the surface once the seed has been sowed. Mulching can provide temporary erosion control until the vegetation is established.

A barrier shall be constructed around the seeded site to prevent vehicles from accessing the area.

Monitoring

Monitoring and subsequent maintenance of revegetated areas shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Inspection shall identify:

- Areas where the vegetation has not established
- Areas where topsoil and seed have been dislodged (whether be from a rain or high wind event)

Maintenance

Until a minimum of 80% coverage of the area is achieved, the effectiveness of the vegetation as an erosion control device is reduced. Ideally, germination should occur within 6 weeks of application. However, when self-germination of the seed is required, growth may not be visible for several months, depending on the regional rainfall and soil moisture conditions. Installation of temporary erosion control devices, such as mulching, is recommended until vegetation is established.

Areas where seed has been washed away by a large storm event shall be re-seeded. If consistent dislodgement is occurring, consider using turf reinforcement matting to add structural integrity to the surface or review the need for upstream contour banks.

Assessment of areas where vegetation has been established but has experienced die-back due to events such as bushfires or drought is required to determine the long-term viability of the vegetation. Revegetation shall take place in areas where losses greater than 20% have occurred. This is only applicable when complete root structure of the vegetation is lost or re-establishment will not occur naturally.

Where necessary, slash the temporary vegetation cover to allow the successful growth of the underlying permanent vegetation cover. Vegetated areas do not need to be removed unless they were established with the primary purpose of only providing temporary erosion control.

Description

Rock mulching is the process of applying a layer of rock on a surface to reduce flow velocities and increase infiltration. Rock mulching is a commonly used alternative to vegetation in arid / semi-arid regions. This technique is effective in reducing erosion on a disturbed site by dampening raindrop impact and reducing turbidity and velocity of runoff.

For rock lining in concentrated flow paths, refer to the drainage control "rock lining" guideline.

Advantages	Limitations
• Can withstand high velocity overland flows • Does not require watering, unlike vegetated surfaces • Increases soil moisture • Provides weed control • Aids rehabilitation as vegetation can be established in rock mulch	• Up to slopes 1V:3H or 1V:2H with the aid of mechanical anchoring or cellular confinement systems • Not to be used in channels

Design Principles

The rock type selected for mulch must be weather resistant, durable, angular and well graded e.g. basalt and sandstone. The average rock size (D_{50}) is can vary between 50 millimetres and 750 millimetres depending on the slope and expected maximum velocity as well as the rock available on site. The thickness of rock mulch shall be a minimum of 1.5 times the average rock size or 300 millimetres, whichever is greater. Thicknesses of up to 1 metre are stable on rehabilitated embankment slopes up to 1V:3H.

Rock mulching is preferred over hydromulching in areas where concentrated overland flows are expected.

Construction Guidelines

Where in-situ soil is dispersive, the top 200 millimetres of soil shall be topsoiled and ripped before the rock mulch is placed. Alternatively, a geotextile can be placed under the rock or an increased thickness can be used to improve the durability of the rock mulch.

Rock shall be placed starting from the downstream slope and continuing up slope. Rock mulching shall have a minimum thickness of 300 millimetres or 1.5 times the average rock size, whichever is greater and must cover the entire surface.

At the downstream end of a slope, a splash apron shall be constructed. By extending the rock a minimum of 1 metre downstream, the splash apron reduces the effects of scour at the toe of the slope. The rock mulch shall be slightly buried in a trench at the upstream face and downstream splash apron so that approximately 50 millimetres of the rock protrudes above the ground.

Where vegetation is to be established, a fine gravel or topsoil mixed with seed can be used to fill the rock voids and promote vegetation growth. The construction of a shade cloth fence across the rock can trap fines and assist with grass growth.

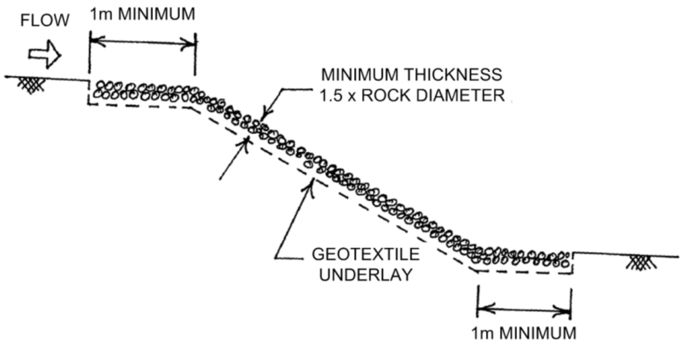


Figure 1

Monitoring

Monitoring and subsequent maintenance of rock mulching shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Inspections should be concentrated on identifying:

- Areas where rock has been displaced and determining why it has occurred
- Evidence of scour under and around the rock mulching footprint
- Concentrated flow paths through the rock mulched area

Maintenance

Displacement of rock indicates that concentrated flows are occurring. Re-shaping the upstream surface may produce more even sheet flows down the slope. Consistent displacement of the rock mulch requires repair of the slope and replacement of the displaced rock with larger diameter rock.

Scour around the rock mulched area shall be fixed by extending the surface of the rock mulching or altering the upslope surface to guide the runoff into the mulched area. If scour is evident under the rock mulch, the inclusion of a geotextile underlay is necessary.

Rock mulch does not need to be removed as vegetation is likely to establish through the rock mulch.

Description

Soil binders are used as a chemical surfacing stabiliser or soil-bonding agent. They are applied on an exposed surface to form a seal and provide temporary erosion control. Soil binders are generally applied in areas where earthworks are expected to resume in a time-frame that will not allow vegetation to establish. Soil binders are effective in preventing both water and wind erosion of soils.

Soil binders can either be sprayed directly over an exposed surface or applied as tackifiers in conjunction with mulching and seeding applications.

Advantages	Limitations
• Good alternative to mulches in areas where construction works will soon resume • Can be used on mild and steep slopes	• Not suitable for area with concentrated flows • Require long curing times (up to 24 hours) • Only used in temporary applications generally less than 3 months • Not suitable for trafficked areas • May not be effective on silty or clayey soils or in highly compacted areas • May have impacts on water quality

Design Principles

The selection of a soil binder is dependent on the regional soil type, frequency of application and the intended length of time soil stabilisation is required. There are five primary types of soil binders:

1) Plant-material based short lived binders e.g. Guar, psyllium and starch
   - High resistance to leaching
   - Moderate resistance to abrasion
   - Short to medium longevity
   - 9 to 18 hour curing time
   - Compatible with existing vegetation
2) Plant-material based long lived binders e.g. Pitch and rosin emulsions
   - High resistance to leaching
   - Low resistance to abrasion
   - Medium longevity
   - 19 to 24 hour curing time
   - Not compatible with existing vegetation
3) Polymeric emulsion blend binders e.g. Synthetic composite materials
   - Low to moderate resistance to leaching
   - Moderate to high resistance to abrasion

- Medium to long longevity
- 0 to 24 hour curing time
- Not compatible with existing vegetation

4) Cementitious-based binders e.g. Gypsum

- Forms a crust over the surface which is water permeable
- Moderate resistance to leaching
- Moderate to high resistance to abrasion
- Medium longevity
- 4 to 8 hour curing time
- Not compatible with existing vegetation
- Application rate typically 4,500 to 13,500 kilograms per hectare.

5) Bitumen-based binders

- Consist of a mixture of bitumen, emulsifying agent, stabilising agent and water
- Anionic bitumen emulsion used for erosion control as it is slow-breaking.
- Generally sprayed at an application rate of 2,500 litres per hectare on batters and 4,000 litres per hectare in areas of minor concentrated flow

Construction Guidelines

The application surface shall be prepared before the soil binder is applied. Preparation includes pre-wetting and roughening of the surface. If cementitious-based binders are to be applied, lime shall be used to treat the in-situ soil before application.

The chosen soil binder shall be applied in accordance with the manufacturer's instructions for application rates and specialist procedures. The recommended minimum curing period shall be allowed for before application of a second treatment (if required).

Ensure vehicular and pedestrian traffic are excluded from the treated zone.

Monitoring

Monitoring and subsequent maintenance of soil binders shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Monitoring of the treated areas shall identify:

- Areas where scour has occurred
- Spot failure locations

Maintenance

Soil binders are susceptible to the natural weathering process and may require reapplication after a few months. Heavy rainfall events may cause erosion and areas of spot failure. If erosion is evident, repair areas and reapply original soil binder as needed to maintain effectiveness. Localised spot failure may be caused by water penetrating the soil at the top of the embankment slope and undermining the stabilised soil layer.

Soil binders do not typically need to be removed as they are exposed to the sun, oxidation, heat and biological organisms which break down the binder over time.

Description

Check dams are formed by creating small weir structures at regular intervals along an open channel. They may be used as a sediment control device by capturing bed load sediment washed into the open channel from the upstream catchment. Check dams function as a sediment control device by reducing the flow velocity in the open channel, thus allowing bed load sediment to settle behind the check dam structures.

Check dams may also be used as a drainage control, and although the intended function is different, the design and construction methodology remains the same.

Advantages	Limitations
• Captures sediment without changing channel design • Easy to construct • Effective sediment control in newly formed channels	• Channel banks must not exceed 1V:2H • Suitable for channels with a slope greater than 1V:100H but less than 1V:10H • Catchment area shall not exceed 2 hectares • Designed to contain bed load sediment but less effective in capturing smaller suspended sediment particles

Design Principles

There are three main material types used in the construction of check dams. These are:

1) Sandbags filled with sand, gravel, straw or compost
   - Suitable for shallow drains <500 millimetres deep
2) Rock
   - Suitable for deep drains >500 millimetres deep
   - Typically 200 millimetre mean rock diameter (D50) is used, although larger rock may be warranted on steep slopes

Slope	D_{50} Rock Size (millimetres)
1V:100H – 1V:50H	200
1V:50H – 1V:20H	300
1V:20H – 1V:12.5H	400
1V:12.5H – 1V:10H	500

3) Fibre rolls
   - Biodegradable logs (e.g. Maccaferri Cocologs) made from a fibre blanket filled with organic material
   - Suitable for wide, shallow drains or in vegetated channels
   - Typically last between 4 and 10 years before biodegrading
   - Standard size of 300 millimetre diameter

Check dams should only be used in drains with a slope of less than 1V:10H. They shall not be used in batter chutes.

Construction Guidelines

Construction shall commence at the downstream check dam first then progress upstream. Ensure that the toe of the upstream check dam is at the same elevation as the crest of the downstream check dam.

Although rarely required, a geotextile underlay or rock apron can be installed to reduce erosion in dispersive soils. If required, a rock apron should be installed downstream of the check dam to a length equivalent to twice the height of the structure. See Figure 1.

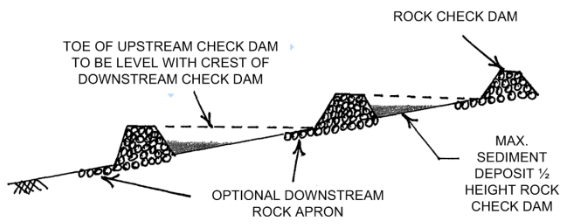


Figure 1

Construction shall extend up the batters of the channel but should be limited to 500 millimetres from the base of the channel to ensure water does not spill at the edges of the check dam, see Figure 2. A weir should be created in the centre of the check dam by allowing at least a 150 millimetre depression. The base of the check dam shall be trenched at least 200 millimetres below the invert of the drain to minimise the risk of undermining or side cutting the structures.

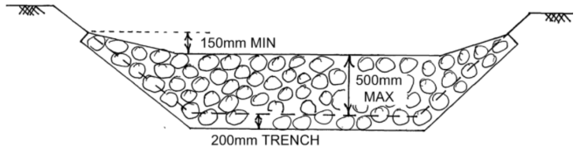


Figure 2

Fibre rolls shall be anchored in a trench to a depth of at least one third of the diameter of the roll and fixed with wooden stakes at a maximum spacing of 1 metre. Logs can be stacked to achieve a higher crest level but remain limited to the 500 millimetre total height restriction, see Figure 3.

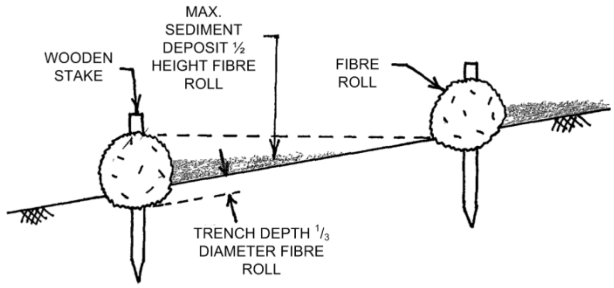


Figure 3

Monitoring

Monitoring and subsequent maintenance of check dam sediment traps shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Inspections shall identify:

- Excessive deposits of sediment behind the check dam
- Failure of a check dam
- Erosion occurring underneath or adjacent to the check dam

Maintenance

Occasional removal and disposal of sediment deposit behind the check dam is required if the sediment build up exceeds half of the height of the original check dam or it is causing flows to be diverted around the ends of the check dams. Ensure the removed sediment is deposited in a location such that it won't end up back in the channel.

If failure of a check dam occurs or erosion is evident, the size of the rock needs to be increased or intermediate check dams could be constructed to further reduce the upstream velocity. Observation to ensure flow is concentrated over the weirs and not around the structures necessary. Inspection to ensure the rocks remain sufficiently anchored after extended storm events is required.

Rock and sandbag type check dams are to be removed once vegetation has established sufficiently to stabilise the channel.

Seedlings can be planted directly into the fibre log as they are 100% biodegradable. The protective netting should be removed once any planting has become established.

Description

A sediment basin is a temporary "dam-like" structure used to capture and retain sediment-laden runoff. It is often the last line of defence in a drainage network to prevent sediment laden runoff from discharging off-site. A sediment basin is designed to reduce the inflow velocities and allow suspended sediment to settle. They also aim to intercept bed load material before it can reach a downstream system.

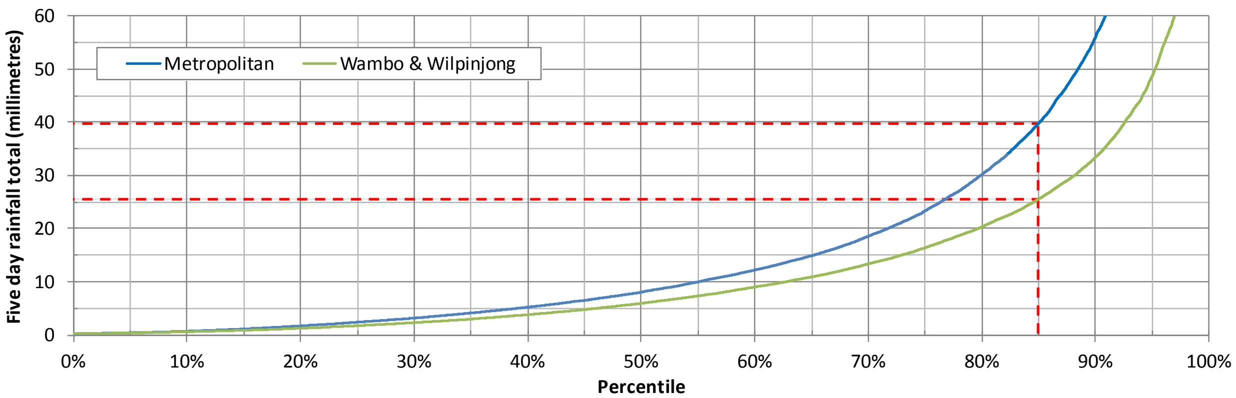
Advantages	Limitations
• Effective form of water treatment	• Should be constructed as low in a catchment as practical but should not be constructed near a watercourse • Construction locations are constrained by appropriate geometry requirements • Not as effective during large storm event

Design Principles

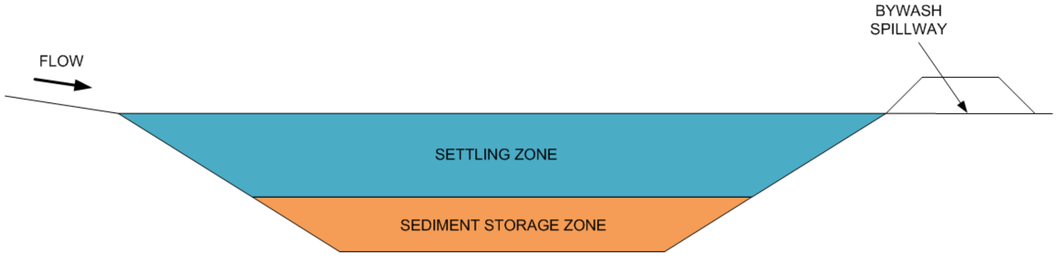
Construction of a sediment basin is generally required on sites where the upstream catchment is greater than 2,500 square metres and upstream erosion and sediment controls are not fully effective.

The design principles vary depending on whether the soil is classified as coarse, fine or dispersive. It is assumed that the New South Wales Peabody mine sites are likely to be fine or dispersive. Therefore, the construction of a "wet basin" is likely to be the most appropriate for the New South Wales operations. Detailed design and sizing of a sediment basin should be undertaken by a competent person to ensure the basin has sufficient capacity and the water being discharged is of acceptable quality to meet regulatory requirements.

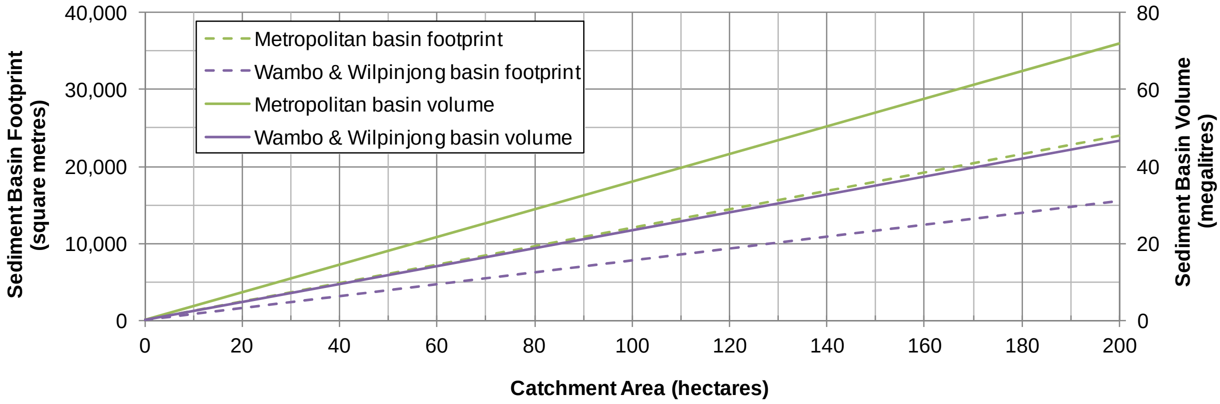
A sediment basin fundamentally consists of an inlet, a sediment storage zone, a settling zone and an outlet. Bypass systems are also constructed when a piped outlet is provided. The sizing of a sediment basin is based on the 85th percentile of the 5-day rainfall depth for the site. For the Wambo and Wilpinjong Peabody sites the 5-day rainfall depth is an average of 26 millimetres and the Metropolitan Mine is 40 millimetres, as shown below:



The upper zone within the sediment basin is the settling zone and slows the velocity of inflow water and allows suspended particles to settle. The lower zone within the sediment basin is the sediment storage zone and is used as a dead storage area to contain the settled particles. The volume of the sediment storage zone shall be approximately half the volume of the settling zone.

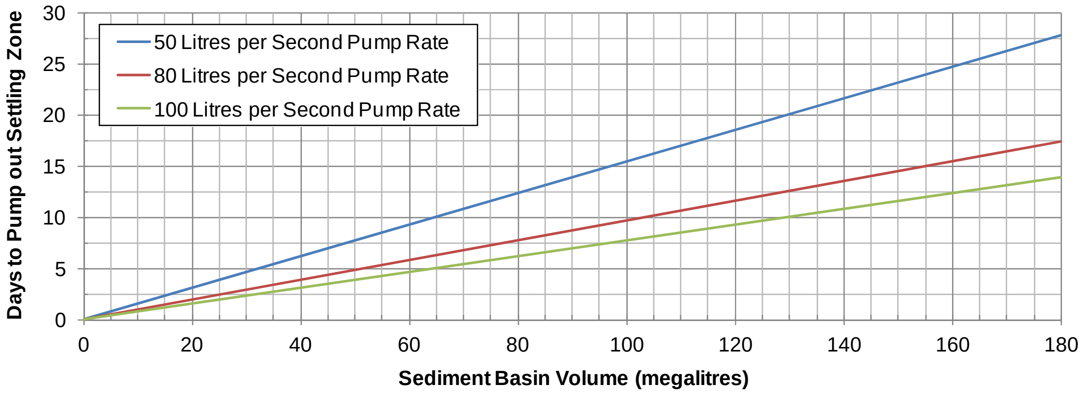


Below is an indicative overview of the required footprint area needed to construct a sediment basin, however advice from a competent person shall be sought to accurately determine the sizing prior to construction commencing.



NB: An assumed basin depth of 3 metres has been used to derive the footprint area.

Wet basins are typically designed to be filled, treated and discharged during a maximum 5 day cycle period.



The figure above should be compared against the pump-out time-frames that a specific site has committed to. Dewatering is undertaken to prevent salinity build-up within the basin.

Clean water catchments shall be diverted away from a sediment basin where possible. Although clean water diversions are still subject to sediment and erosion control standards, correct management of these systems shall reduce the sediment runoff. This will aid in reducing the total storage volume required in the sediment basin as well as reduced costs associated with the construction.

Construction Guidelines

Sediment basins shall be located in an area clear of construction activities and above any existing 1 in 5 year flood level. Planning prior to construction is required to ensure adequate access is provided to and adjacent the sediment basin to allow maintenance and desilting. Clearing of the construction footprint shall be undertaken to ensure the site is free of debris.

The basin shall be excavated and shaped ensuring the final basin length to width ratio is 3:1. Side slopes should not exceed 1V:5H for safe access during maintenance periods. The minimum recommended embankment crest width is 4 metres unless recommended otherwise by a geotechnical professional.

It is recommended that the sediment basin be 5m wide with an access road along one side of the basin if maintenance is expected to be undertaken using a moxy. Alternatively, if the basin is excavated to a width of 10m then an access road shall be provided along both sides of the basin for clean out purposes.

A wet basin overflow shall be lined with a geotextile material before dumping rock over the surface for stability and to dissipate flow energy over the overflow.

Monitoring

Monitoring and subsequent maintenance of sediment basins shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Inspections shall identify:

- Basins which are receiving flows from clean water catchments.
- Excess sediment deposits exceeding the design sediment storage zone volume. This can easily be identified by driving a depth indicator post into the basin clearly indicating the sediment storage depth.
- Erosion occurring downstream of the overflow outlet.

Engineering design of a sediment basin should ensure captured water is discharged with acceptable water quality parameters, negating the need to constantly monitor water quality within the basin after every storm event.

Maintenance

When the basin is full (i.e. exceeds the marked sediment storage zone depth indication) an excavator shall be used to clean out the basin. Prior to de-silting, the basin will need to be drained or pumped completely empty. An additional period shall be allowed for drying of the sediment.

Water quality parameters must meet the regulatory requirements at the point where runoff leaves a site. However, it shall be noted that it may still be acceptable for the water quality at the sediment basin discharge point to not meet these requirements if additional downstream sediment control devices are located downstream of the basin i.e. a grass buffer zone.

Evidence of scour downstream of the sediment basin discharge point indicates concentrated flows with high velocities. Consider rock lining the overflow outlet to aid in dissipating the flow energy. The overflow outlet may be flared to spread the flow and reduce the discharged flow depth.

Sediment basins shall be filled in and rehabilitated only after all construction and rehabilitation works have been finalised. The sediment basin can be abandoned only once sufficient vegetation cover is achieved, minimising erosion. The basins will eventually silt up and disappear into the catchment.

Description

A sediment basin is a temporary "dam-like" structure used to capture and retain sediment-laden runoff. It is often the last line of defence in a drainage network to prevent sediment laden runoff from discharging off-site. A sediment basin is designed to reduce the inflow velocities. Once below a threshold velocity, bed load materials are settled out.

Advantages	Limitations
• Effective form of water treatment	• Should be constructed as low in a catchment as practical but should not be constructed near a named watercourse • Construction locations are constrained by appropriate geometry requirements • Not as effective during large storm events

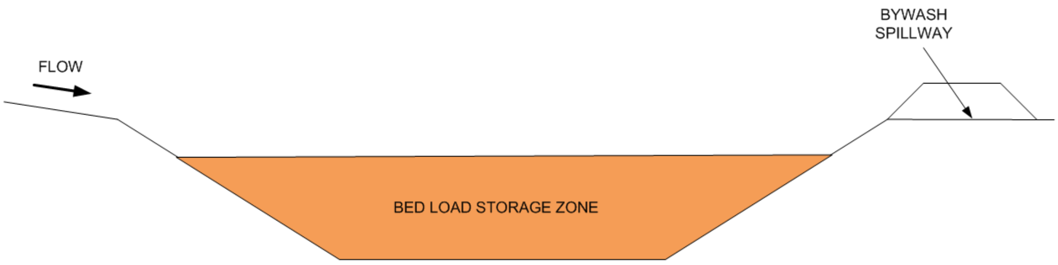
Design Principles

Construction of a sediment basin is generally required on sites where the upstream catchment is greater than 2,500 square metres and upstream erosion and sediment controls are not fully effective.

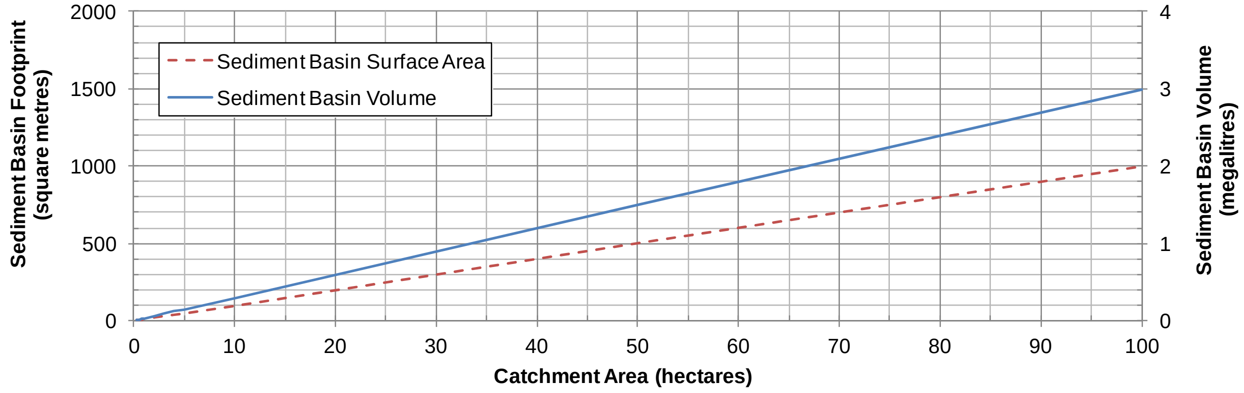
The design principles vary depending on whether the soil is classified as coarse, fine or dispersive. It is assumed that the Queensland Peabody mine sites are likely to be fine or dispersive. Therefore, the construction of a "wet basin" is likely to be the most appropriate for the Queensland operations. Detailed design and sizing of a sediment basin should be undertaken by a competent person to ensure the basin has sufficient capacity and the water being discharged is of acceptable quality to meet regulatory requirements.

In Queensland, a sediment basin fundamentally consists of an inlet, a bed load storage zone and an outlet. Queensland sites only capture bed loads (not suspended sediment) and hence the generic sediment basin sizing guidelines are not applicable to the Queensland operations.

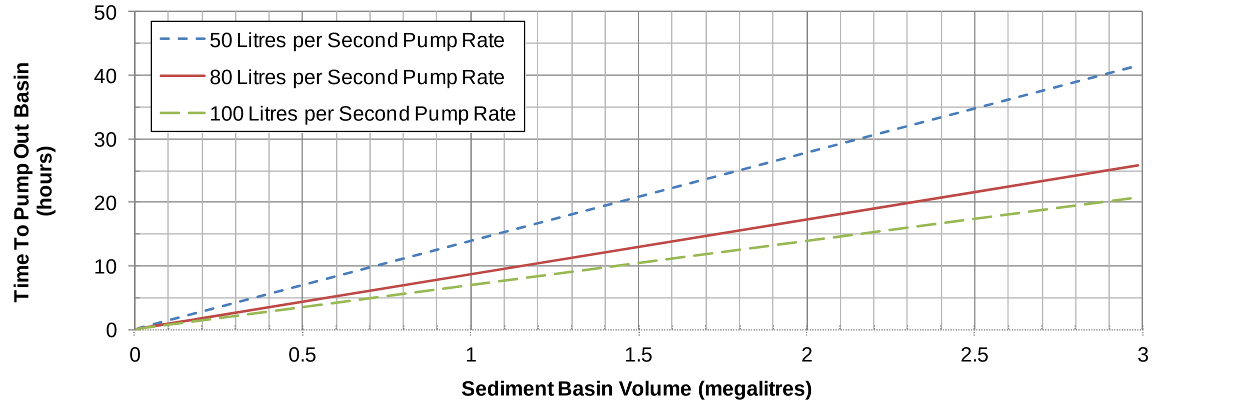
The bed load storage zone is used as a dead storage area to contain the settled particles.



Below is an indicative overview of the required footprint area needed to construct a sediment basin, however advice from a competent person shall be sought to accurately determine the sizing.



NB: An assumed basin depth of 3 metres and a target particle size of 500 micrometres has been used to derive the footprint area.



The figure above should be compared against the pump-out time-frames that a specific site has committed to. Dewatering is undertaken to prevent salinity build-up within the basin. Similarly, the geometry of the basin is also an effective way of controlling salinity, i.e. the design of a shallow basin ensures water spills regularly.

Construction Guidelines

Sediment basins shall be located in an area clear of construction activities and above any existing 1 in 5 year flood level. Clearing of the construction footprint shall be undertaken to ensure the site is free of debris. The basin shall be constructed so the overflow is at natural ground level, negating the need to build a dam wall and engineer a major spillway.

The basin shall be excavated and shaped ensuring the final basin length to width ratio is 3:1. Side slopes should not exceed 1V:5H for safe access during maintenance periods. The minimum recommended embankment crest width is 4 metres unless recommended otherwise by a geotechnical professional.

It is recommended that the sediment basin be 5 metres wide with an access road along one side of the basin if construction is undertaken using a moxy. Alternatively, if the basin is excavated to a width of 10 metres then an access road shall be provided along both sides of the basin or an internal access ramp would be required.

A wet basin overflow shall be lined with a geotextile material before dumping rock over the surface for stability and to dissipate flow energy over the overflow.

Monitoring

Monitoring and subsequent maintenance of sediment basins shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Inspections shall identify:

- Basins which are receiving flows from clean water catchments.
- Excess sediment deposits exceeding the design sediment storage zone volume. This can easily be identified by driving a depth indicator post into the basin clearly indicating the sediment storage depth.
- Erosion occurring downstream of the overflow outlet.

Engineering design of a sediment basin should ensure captured water is discharged with acceptable water quality parameters.

Maintenance

Clean water catchments and drains shall not be discharged into a sediment basin. Catch drains shall divert clean water around a sediment basin and discharge directly into the environment. This will aid in reducing the total storage volume required in the sediment basin as well as reduced costs associated with the construction.

When the basin is full (i.e. exceeds the marked sediment storage zone depth indication) an excavator shall be used to clean out the basin. Prior to de-silting, the basin will need to be drained or pumped completely empty. An additional period shall be allowed for drying of the sediment.

Water quality parameters must meet the regulatory requirements at the point where runoff leaves a site. However, it shall be noted that it may still be acceptable for the water quality at the sediment basin discharge point to not meet these requirements if additional downstream sediment control devices are located downstream of the basin i.e. a grass buffer zone.

Evidence of scour downstream of the sediment basin discharge point indicates concentrated flows with high velocities. Consider rock lining the overflow outlet to aid in dissipating the flow energy. The overflow outlet may be flared to spread the flow and reduce the discharged flow depth.

Sediment basins shall be filled in and rehabilitated only after all construction and rehabilitation works have been finalised. The sediment basin can be abandoned only once sufficient vegetation cover is achieved. The basins will eventually silt up and disappear into the catchment.

HATCH

Peabody ENERGY

Description

A buffer zone is a vegetated area, generally a grassed area, provided around the perimeter of an earthworks footprint. Its primary purpose is to reduce sediment transportation by acting as a 'sediment trap'. The zone reduces velocities of overland flow to allow settlement and entrapment of suspended particles.

A strip of vegetation should be well established prior to utilising the buffer zone for sediment control.

Advantages	Limitations
• Mostly suited to sandy soil to control bed load sediment runoff • Can provide some degree of turbidity control while the buffer zone remains unsaturated	• Appropriate for sheet flows only • Limited to slopes less than 1V:10H • Most suitable for bed load sediment but less effective for capturing suspended solids

Design Principles

Buffer zones are formed by establishing vegetation around the perimeter of the disturbed site. The wider and more dense the buffer zone is, the more effective this control method is at reducing sediment runoff. Buffer zones shall be a minimum width of 6 metres or 5 times the upstream slope percentage, whichever is greater.

Buffer zones need to be of adequate length that sheet flow does not run off the surface and around the vegetated zone. As a general rule, the minimum length of a buffer zone should be the same as a sediment fence. That is, 15 metres or 5 times the percentage of the upstream slope, whichever is greater.

Upstream Slope	Buffer Zone Length (metres)
Up to 1V:33H	15
1V:25H	20
1V:20H	25
1V:10H	50

If a large amount of sediment is expected, the construction of a sediment fence upstream of the buffer zone will improve the overall performance of the sediment control. The upstream erosion controls shall also be improved to limit the amount of sediment in a buffer zone.

Construction Guidelines

A buffer zone shall generally be located at least 50 metres from the earthworks clearance footprint. A visible structure, such as a fence, should generally be constructed around the buffer zone to clearly identify the area and prevent traffic from driving over it.

The upstream surface must be shaped to ensure sheet flows are produced evenly along the buffer zone. Similarly, the buffer zone shall be a constant grade and free of gullies and rills.

Buffer zones are most effective in areas where vegetation is well established prior to allocation of the buffer zone. Vegetation shall be a minimum of 50 millimetres high and must cover at least 80% of the surface to be effective in controlling bed load sediment runoff.

Monitoring

Monitoring and subsequent maintenance of a buffer zone shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*.

Monitoring inspections should involve:

- Identifying concentrated flow paths within the buffer zone and bypassing flows around the zone.
- Investigation into where excess sediment deposits are coming from and why they are occurring. It is to be noted that sediment is expected to be contained within the first half of the buffer zone.
- Ensuring no traffic disturbance in the area.

Maintenance

Channels and deformations in the ground shall be filled in and re-seeded. If concentrated flow persists, upstream conditions shall be investigated or an alternative type of sediment control should be utilised.

Removal of excess sediment deposits in the buffer zone should be undertaken when they exceed the minimum grass length of 50 millimetres. Broadleaf weed control must be maintained during the construction period to promote the growth of grass vegetation.

Maintenance of fences around the zone shall occur until construction works are complete. Buffer zones do not need to be removed upon completion of the works.

Oc Description

Sediment fences are temporary devices constructed to reduce sediment transportation by intercepting sheet flows. Settlement of entrained sediment particles is achieved by reducing the velocity of the overland flow and creating small ponds of water on the upstream side of the fence. Sediment fences should be installed around all construction footprints, as a last line of defence system to contain sediment.

Sediment fences are created using special purpose synthetic material laid vertically by securing to stakes and anchored the toe of the fence in to a trench.

Advantages	Limitations
• Cost effective • Easy to install • Can be installed at any construction site • Suitable for all soil types • Highly visible form of sediment control	• Should only be used as temporary structures • Traps course sediments only • Not to be used in concentrated flow paths • Suitable in low flow situations only • Limited to contributing catchment areas up to 0.6 hectares per 100 metres of fence

Design Principles

There are two main material types used for sediment fences and selection typically depends on soil classification and duration of use.

1) Woven fabric
   - Sandy soils
   - Longer duration construction sites
   - Used when water control required
2) Non-woven composite fabric
   - Clayey soils
   - Short duration construction sites

Hardwood timber stakes (minimum 1250 square millimetre cross section) or steel star pickets (minimum 1.5 kilograms per metre) can be used as support posts depending on availability. Posts are to be spaced at 3 metre centres if wire backing is used, or 2 metre centres if no wire backing. The minimum total length of any sediment fence is 15 metres or 5 times the upstream percentage slope, whichever is greater. Spacing between sediment fences depends on the slope of the upstream catchment.

Slope	Max fence spacing (metres)
1V:50H – 1V:12.5H	35 - 28
1V:12.5H – 1V:8H	28 - 23
1V:8H – 1V:6H	23 - 18
1V:6H – 1V:4H	18 - 15

Construction Guidelines

Sediment fences should be installed prior to and maintained during all construction earthworks. A clear width of 2 metres between the toe of an embankment or stockpile and the fence shall be maintained, or greater if construction access requires. Installation of sediment fences should be in line with contours and have returns every 20 metres that extend at least 1 metre upslope. The ends of the fence should turn upslope to prevent water from diverting around the end of the structure and discharging to surrounds. If for construction reasons the fence needs to be installed at an angle to the contours, then regular returns with 5 to 10 metre spacing will promote ponding along the length of the fence.

Adequate anchorage at the fence base is essential for the long-term durability of these structures. The synthetic material shall be buried at least 200 millimetres into the trench and backfilled and compacted using in-situ material. If a woven material is used, a wire mesh backing is normally placed behind the fabric to provide additional support. If a non-woven material is used, the non-woven (green) face must point up-slope.

A minimal number of joins should be used when construction a sediment fence. Joins are to be created by overlapping the ends of the fabric and securing to the posts.

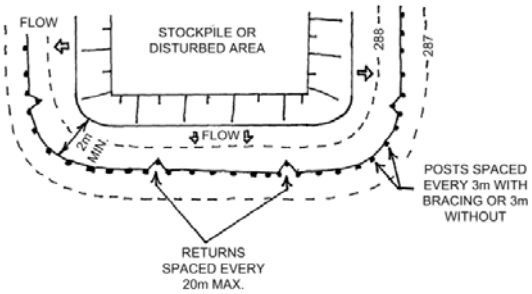


Figure 1

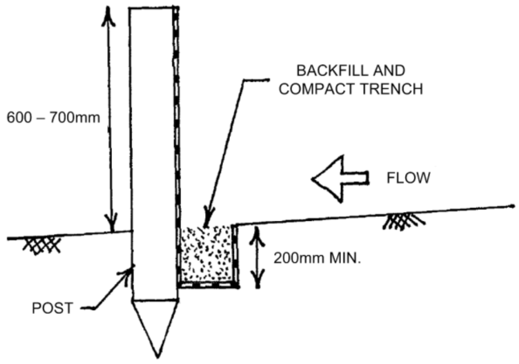


Figure 2

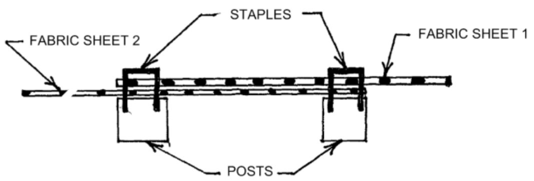


Figure 3

Monitoring

Monitoring and subsequent maintenance of sediment fences shall occur pre and post wet season and after specific rainfall events as identified in the *Monitoring Schedule guideline*. Monitoring shall identify:

- Excess sediment deposit against the fence
- Tears in the fence material
- Failure of a sediment fence or evidence of concentrated flow paths

Maintenance

Sediment deposits exceeding one quarter of the fence height shall be removed and disposed of in a location not within the fence catchment area. The condition of the fencing material should be inspected to ensure there are no tears in the fabric or sagging in localised areas and the material remains anchored in the trench. Replacement or repair of the fence shall occur before the next rainfall event. During the inspection process, it is vital to ensure the sediment fence is not creating adverse results by concentrating flow to a particular point along or at the end of the fence.

Sediment-laden water should be contained by a singular sediment fence. If a fence fails, additional posts with a spacing of approximately 0.5 metres should be used for additional strength or intermediate fences should be constructed to reduce the catchment area.

Sediment fences should be removed upon completion of the works and rehabilitation of the site. This is applicable after a minimum of 80% of seed has germinated.

Overview

The philosophy behind the erosion and sediment control (ESC) management for each operation relies on the ability of Peabody to demonstrate that each catchment has suitably designed ESC works that have been installed and maintained. As such, monitoring and maintenance of the ESC works is a commitment by Peabody to demonstrate on-going regulatory compliance. This guideline covers the monitoring requirements deemed to meet this commitment.

Erosion and sediment control (ESC) works are generally designed to perform during the less intense, more frequent rainfall events. Although some works may be designed to withstand the more intense and less frequent rainfall events (e.g. sediment basins), damage may be sustained to the works during these larger events. As such, the monitoring and subsequent maintenance of ESC works is imperative to ensure that the performance of the devices is not compromised due to damage or excessive wear.

A monitoring regime needs to be implemented that ensure the integrity of the devices is maintained while not placing an unnecessary burden on operational personnel. An indicative monitoring regime has been established that includes consideration the ESC works location, pre wet season preparedness, post wet season condition and the intensity of site rainfall. Based on these items, the proposed monitoring regime is summarised in Table 1. Definitions for the items in the table are detailed in the following sections.

Table 1 – Monitoring regime requirements

ESC Works	Pre wet season	Post wet season	Trigger storm event	Significant storm event
Critical	✓	✓	✓	✓
Non-critical	✓	✓	✗	✓

Location of the Works

Failure of ESC works may have varying impact on the off-lease receiving environment depending on the works and location within the mining operation. As such, it is recommended that classification of ESC works be undertaken to identify the critical and non-critical works, defined as:

- **Critical ESC works** are those that through poor performance or failure of the works are likely to result in release of sediment either off-lease or on-lease into areas of identified sensitive or protected vegetation, or failure is likely to result in a cascading failure of downstream ESC devices (e.g. failure of large areas revegetation erosion control located upstream of grass buffer strip sediment control works).
- **Non-critical ESC works** are works that are unlikely to result in loss of sediment off-lease through poor performance or failure. This includes works where sediment release will be captured by downstream on-lease ESC works or captured into the site's worked water dams or mining pits.

Identification of c*ritical* and *non-critical* works shall be undertaken by site personnel through a risk review process.

Post Wet Season

At the end of the wet season, all ESC works (critical and non-critical) shall be inspected during April. The intent of this inspection is to monitor the ESC works to ensure that over the preceding five month wet season, damage or loss of performance of the ESC works has not occurred.

The condition and any identified remedial works identified during the inspection shall be documented for each ESC structure. Identified maintenance requirements shall be undertaken during May to reinstate the ESC works to the design condition to ensure continued performance and compliance with the site's ESC commitments.

Pre Wet Season

For both the New South Wales and Queensland operations, the wet season is generally defined as 1st November to the 31st March, although the distinction is more pronounced in Queensland due to the influence of tropical weather conditions. Remedial works identified in the post wet season inspection should have occurred in the post wet season maintenance period. To ensure the ESC works are in a functional condition prior to the wet season, inspection of the ESC works shall be undertaken again during September, with the intent that any additional identified maintenance will be undertaken in October, prior to the wet season.

The pre wet season inspection is required for all ESC works (critical and non-critical). The condition and any identified remedial works identified during the inspection shall be documented for each ESC structure. Identified remedial works shall be undertaken during October to ensure the ESC works are fit for use.

Storm Events

The intent of the storm event triggers is to ensure that monitoring of the ESC works is responsive to the climate conditions experienced at the site. It is recommended that two trigger values be selected, defined as:

- **Trigger storm event** is the rainfall depth that if received in a 24 hour period will require site personnel to inspect and document the condition of the *critical* ESC works.
- **Significant storm event** is the rainfall depth that if received in a 24 hour period will require site personnel to inspect and document the condition of the *critical* and *non-critical* ESC works.

Review of long term historical rainfall data for a number of the New South Wales and Queensland operations has been undertaken to establish a relationship between daily rainfall totals and average yearly occurrence. It was found that this relationship did not vary greatly between the operations, with the developed trend shown in Figure 1.

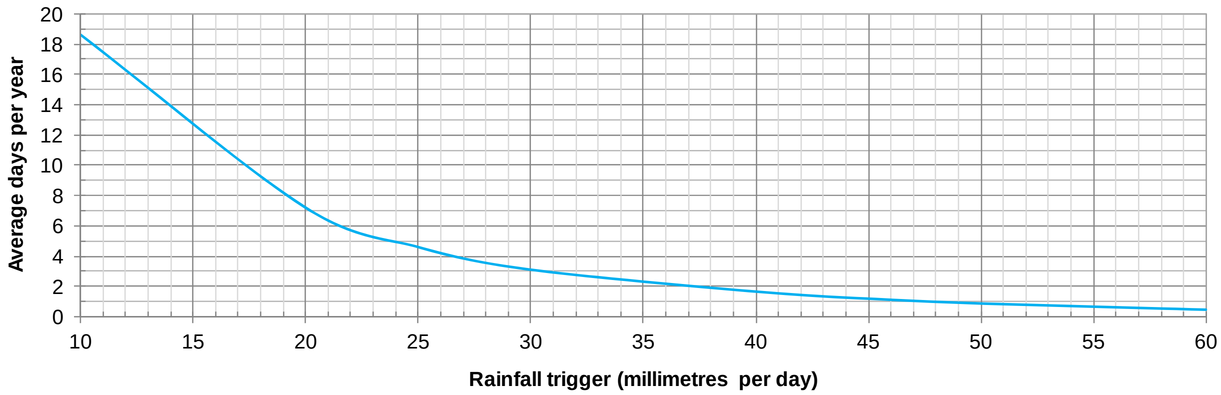


Figure 1 – Rainfall trigger

Based on the Figure 1, it is recommended that the following trigger values be adopted:

- **Trigger storm event**: 22 millimetres per day to 25 millimetres per day
- **Significant storm event:** 45 millimetres per day to 50 millimetres per day

Documentation Requirements

At a minimum, each inspection shall be documented by photographs and a summary of the identified maintenance requirements for each inspected ESC device. This information shall be captured into the site's data management system to ensure that required maintenance may be tracked.

Capture of the monitoring inspections into the data system forms part of the requirements to demonstrate compliance with regulatory requirements. Failure to suitably document monitoring inspections may expose Peabody to regulatory non-compliance risk.

APPENDIX E

SEDIMENT CONTROL STRUCTURE INSPECTION CHECKLIST

Wambo Coal Sediment Control Structure Inspection Checklist

Rainfall (mm) in last 24 hrs*:
Date of Inspection:
*During consecutive days of rain, a new inspection is only required after 48 hours of no rain following the first

Site	Purpose	Inspected	Inspected by (initial)	Comments/ Remedial works required
Admin Box Cut	Clean Water Storage/Sediment Control	Y/N		
Eagles Nest Dam	Mine Water Management	Y/N		
Gordon Below Franklin Dam	Sediment Control/Mine Water Management	Y/N		
C11 Area Dam	Sediment Control/Mine Water Management	Y/N		
West Cut Dam	Sediment Control/Mine Water Management	Y/N		
West Cut Sedimentation Dam (Wollemi Pump Out)	Sediment Control/Mine Water Management	Y/N		
Wollemi Box Cut Dam	Mine Water Management	Y/N		
Wollombi Brook Sediment control structures (Hales Crossing)	Sediment Control/Mine Water Management	Y/N		
Wambo Rail Line Catchment Dams	Sediment Control/Mine Water Management	Y/N		
North Wambo Creek Diversion	Diverted Water	Y/N		
South Dam	Mine Water Management	Y/N		
Montrose East 1	Sediment Control	Y/N		
Montrose East 2	Sediment Control	Y/N		
Milk Can Dam	Sediment Control	Y/N		
Rug Dump	Sediment Control	Y/N		
Wombat Dam	Sediment Control	Y/N		
Pluver Sump	Sediment Control	Y/N		

APPENDIX F

EXAMPLE OF CERTIFICATION OF SEDIMENT DAM CONSTRUCTION

Certification of Sediment Basin Construction

BASIN IDENTIFICATION CODE/NUMBER: ....

LOCATION: ....

Legend: ✓ OK ✗ Not OK N/A Not applicable

Construction:

Item	Consideration	Assessment
1	Sediment basin located in accordance with approved plans.	....
2	Embankment material compacted in accordance with specifications.	....
3	Critical basin and spillway dimensions and elevations confirmed by as-constructed survey.	....
4	Required freeboard adjacent embankments and spillway confirmed by as-constructed survey.	....
5	Placement of rock on chute and upstream face of spillway in accordance with design details and standards.	....
6	Placement of rock within energy dissipation zone downstream of spillway in accordance with design details and standard.	....
7	All other sediment basin requirements in accordance with design details and standards.	....
8	As-constructed plan prepared for basin and spillway.	....

INSPECTION OFFICER .... **DATE** ....

SIGNATURE ....

Geotechnical:

Item	Consideration	Assessment
9	Suitable material used to form all embankments.	....
10	Appropriate compaction achieved in embankment construction (if observed).	....
11	No foreseeable concerns regarding stability or construction of the basin and spillway.	....

INSPECTION OFFICER .... **DATE** ....

SIGNATURE ....

APPENDIX G

RISK ASSESSMENT MATRIX

			Consequence					
Likelihood	*Likelihood description*	*Probability*	Low (1)	Minor (2)	Moderate (5)	Significant (10)	Major (25)	Catastrophic (50)
5 - Very Likely	Likely to occur repeatedly – Expected in the work team	10% - 100%	5	10	25	50	125	250
4 - Likely	Probably will occur several times - Expected at this location	1% - 10%	4	8	20	40	100	200
3 - Possible	Could occur intermittently - Expected within Peabody	0.1% - 1%	3	6	15	30	75	150
2 - Unlikely	Could occur but hardly ever - Expected within the mining industry	0.01% - 0.1%	2	4	10	20	50	100
1 - Rare	Improbable or unrealistic - Not expected in the mining industry but seen in other industries	< 0.01%	1	2	5	10	25	50

		Consequence descriptions					
Consequence Category		Low	Minor	Moderate	Significant	Major	Catastrophic
Harm to People	P	Near miss, near hit, no medical treatment, report only (RO)	Slightly injured, first aid treatment (FAI)	Medical treatment (MTI), disabling reversible impairment, restricted work (RWI) or lost time (LTI)	Serious bodily injury or disabling irreversible impairment, permanent partial disability (PPD)	Single fatality incident. Total and permanent disability (TPD). Major irreversible health effects	Multiple fatality incident. Major injury / disease among multiple employees
Environmental	E	Negligible or reversible environmental impact Nil to minor remediation (typically a shift) No breach of regulations or requirement to report to regulators	Minor reversible environmental impact, minor remediation (typically < 5 days) Non-compliances and breaches of regulation that may result in a citation (NOV) May require reporting to the regulators	Incident resulting in moderate reversible onsite and/or off-site impact causing short term effect. Moderate remediation required (typically a month) Non-compliances and breaches of regulation that may result in prosecution or citation or punitive fine. Requirement or obligation to report to the regulators	Incident resulting in significant onsite or off-site environmental impact causing medium to long term environmental harm Significant remediation required (typically less than 12 months) Significant legal issues, non-compliances and breaches of regulation that results in a prosecution or citation or fine Moderate litigation issues involving many weeks of senior management time	A major incident resulting in regional environmental impact causing long term environmental harm Major long term remediation required (greater than 12 months) Major litigation or prosecution resulting in long term interruption to operations or loss of licence at a site	Incident resulting in catastrophic widespread regional environmental harm causing disastrous effect Major long term remediation required (over multiple years) Major litigation or prosecution , Loss of License to operate at Multiple sites
Finance (higher of cost or NPV)	F	<$10,000	$10,000 - $100,000	$100,000 - $1 mil	$1 mil - $20 mil	$ 20 mil-$100 mil	>$100 mil
Impact on reputation	R	Minor impact, no public concern; Market cap impact < $20 M (< $0.07 per share)	Local media or public concern; Market cap impact $20 M - $30 M ($0.07 - $0.12 per share)	Regional media or public concern. Local criticism; Market cap impact $30 M - $100 M ($0.12 - $0.40 per share)	National adverse media or public criticism; Market cap impact $100 M - $250 M ($0.40 - $1.00 per share)	International adverse media or public criticism. International public concern; Market cap impact $250 M - $500 M ($1.00 - $1.85 per share)	Significant international public or media criticism or condemnation; Market cap impact > $500 M (> $1.85 per share)
Law / Compliance / regulatory	C	Minor, one-off violations of law, regulation, permit or policy; minimal fines, penalties or costs	Recurring or systemic minor violations of law, regulation, permit or policy	Violations of law, regulation, permit or policy with moderate fines or penalties, Moderate Litigation, MSHA imminent danger order or similar	Significant violation of law or permit with material fines, penalties or costs. Serious dispute with strategic customer. Major Litigation	Material Litigation. Serious investigation by SEC, DOJ or foreign equivalent. Code of Conduct violations	Criminal investigation or proceedings involving officers or directors. Litigation with allegations of executive fraud or misappropriation
Strategic risk	SR	Event does not have a meaningful impact to Strategic Outlook	Event does not have meaningful impact to Strategic Outlook, but may require further monitoring	Event may have a material impact on near-term outlook for a region or mine	Event has a material impact on strategic outlook for a region or basin that may require a change to operations to mitigate risk	Event causes mines in a region or basin to cease current operations	Event or threat such that BTU would cease to exist as an ongoing concern in coal operations

Risk Score	Notification	Level	Action (H&S)
<11	Crew / team	Same level	Develop a plan (formal or informal) with crew or continue with and established plan (SOP etc.) that ensures the task can be completed safely. Team should remain aware for changing conditions.
11 to 30	Supervisor	.+1	Develop a formal safe action plan with supervisor and others within the crew (SOP) that identifies all known hazards and details what controls need to be in place and how the task should be performed to ensure it can be completed safely.
31 to 50	Area manager or site GM	.+2	Conduct a formalized risk review of existing work process and controls. Explore additional control options that eliminate, substitute or reduce the risk. Monitor controls for effectiveness during the task.
51 - 100	BU Mgt	.+3	Controls should be reviewed to ensure risk is as low as reasonably practicable (ALARP), critical controls must be identified and monitored for effectiveness. If risk is not at ALARP, additional controls must be identified and a plan developed for implementation.
101 to 199	ELT	.+4	Controls should be added / improved and an additional risk assessment completed for activity to proceed.
200 or greater	CEO	.+5	Controls should be added / improved and an additional risk assessment completed for activity to proceed.

APPENDIX H

SUMMARY OF COMMITMENTS

Note: The list of commitments in this appendix is in addition to those explicitly required by Development Consent or EPL conditions.

ESCP Section	Commitment	Timing
4.1	• Erosion and sediment control measures are designed and constructed effectively.	Ongoing
	• Surface disturbance is minimised and access to undisturbed areas is restricted.	Ongoing
	• Rehabilitation is progressive and disturbed areas are stabilized.	Ongoing
	• Disturbed and undisturbed catchment runoff will be separated, where practicable.	Ongoing
	• Soil erosion will be minimized rather than employing downslope sediment controls.	Ongoing
	• Erosion and sediment control will form part of the planning phases of the mine operation.	Ongoing
	• Erosion and sediment control measures will be maintained in proper working order.	Ongoing
	• Employees and contractors working on-site must complete a general site induction, including details on erosion and sediment control and environmental management.	Ongoing
	• A Surface Disturbance Permit (SDP) (Appendix C), must be completed for ground disturbance activities.	As required
	• As part of the SDP process, the potential erosion and sediment issues (Section 4.0) and controls will be documented.	As required
	• Sediment control structures will be monitored and practices will be adjusted to maintain the required performance standard.	As required
	• Construction of diversion drains, sediment dams and other erosion and sediment control structures, will be undertaken in accordance with (but not limited to) the ESCP, design guidelines and planning phases in Section 4.2 and Section 5.1.	As required
	• Berms, levees and catch drains will be constructed as described Section 5.1 and Section 6.0.	As required
	• Construction or mining activities will not commence until all relevant erosion and sediment controls are in place.	Ongoing
	• The person seeking to undertake the surface disturbance activities will prepare an ESCIP (an Erosion and Sediment Control Implementation Plan).	As required

ESCP Section	Commitment	Timing
4.2	• The Erosion & Sediment Control Implementation Plan (ESCIP), will generally be split into four phases: o Planning; o Mobilisation / Pre-Construction; o Construction; and o Post-construction. The final ESCIP will detail the type, location, specification and installation, timing and removal of all control devices.	As required
	• Control strategies will be tailored to the level of risk of the activities.	As required.
4.2.2	• When the need for a sediment dam and type of sediment dam i.e. Type C, F of D has been determined; a risk assessment must be completed (Appendix G), prior to the activity commencing. If the risk assessment determines an activity with a score ≥ 51, then the activity must not proceed.	Ongoing
5.1	• Sediment control structures shall be constructed in accordance with Blue Book design guidelines (Table 6). However, if risk is deemed significant, sediment dams will require construction design by certified engineer.	As required
	• The person seeking to the undertake surface disturbance activity will select the appropriate erosion and sediment control measures (Tables 6 to 8) in consultation with the Environment and Community Manager (or delegate).	As required
6.7	• Topsoil will be stripped in accordance with the SDP and procedures outlined in the MOP.	Ongoing
6.8	• Where cracking occurs on sloped areas, sediment control measures will also be used down slope.	As required
6.9	• The performance indicators in Table 9 will be used to assess the performance of the Mine against the predicted impacts.	Ongoing
	• WCPL will report on progress against performance indicators in the Annual Review.	Annually
7.1	• Sediment control structures will be inspected monthly and/or following rainfall events ≥ 20 mm/day (midnight to midnight), as recorded by the Mine's meteorological station.	As required
	• Details of inspections and monitoring results will be recorded on the erosion and sediment structure inspection sheet.	As required
	• Required maintenance will be scheduled following the inspection.	As required

ESCP Section	Commitment	Timing
	• During construction of sediment control dams, the frequency of inspections will be proportional to the level of risk posed by the sediment dam as follows: o Low-moderate risk - daily inspections and/or key construction milestones by the Mine's Project Engineer to ensure the dam is being constructed to design; o Significant risk - daily inspections by the Mine's Project Engineer, in concurrence with staged inspections by an independent certified engineer to ensure the dam is being constructed to design.	Ongoing
	• Post construction, sediment dams will be inspected weekly by the Mine's E & C Manager (or delegate) to verify dam walls, drainage channels etc have been successfully stabilised by revegetation methods.	Weekly
8.0	• Erosion and sediment control related community complaints will be recorded within the Community Complaints Register	Ongoing
9.1	• Review of the ESCP will occur as outlined in Section 9.1.	As required
9.4	• Government departments will be notified if an incident occurs.	As required