VULCAN COAL MINE

Erosion and Sediment Control Plan

Prepared for Vitrinite Pty Ltd owner of Qld Coal Aust No. 1 Pty Ltd and Queensland Coking Coal Pty Ltd

5 April 2024

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DETAILS

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Client	Prepared for Vitrinite Pty Ltd owner of Qld Coal Aust No. 1 Pty Ltd and Queensland Coking Coal Pty Ltd

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1 INTRODUCTION

1.1 BACKGROUND

Vitrinite Pty Ltd (Vitrinite) engaged WRM Water & Environment Pty Ltd (WRM) to prepare an Erosion and Sediment Control Plan (ESC plan) for the Vulcan Coal Mine (VCM). The VCM is located north of Dysart in the Bowen Basin in Central Queensland. The location of the project is shown in Figure 1.1.

1.2 DESCRIPTION OF OPERATIONS

The key components of the VCM include:

- two open cut pits:
  - Jupiter pit;
  - Matilda pit;
- two in-pit waste rock dumps;
- an ex-pit waste rock dump;
- a coal handling and preparation plant (CHPP);
- a rail loop and train load out (TLO) facility;
- several topsoil stockpiles located around the Jupiter pit footprint and mine infrastructure area, as well as bunds used to direct diverted runoff around operational areas;
- access and haul roads;
- diversion drains;
- mine infrastructure area (MIA) and ROM stockpile;
- creek crossings over the existing drainage diversion;
- erosion and sediment control structures; and
- mine water management structures.

A detailed description of the VCM is provided in the following documents:

- "Supporting Information for site specific EA Application: Vulcan Complex Project" (MET Serve, 2020)
- "Environmental Authority Amendment Project Description for the Vitrinite Coal Mine – Matilda Pit, Rail Loop & Coal Handling & Preparation Plant" (MET Serve, 2022a); and
- "Progressive Rehabilitation and Closure Plan: Vulcan Complex Project" (MET Serve, 2022b).

Vitrinite propose to extract up to 6 Million tonne (Mt) of hard coking coal from the Jupiter and Matilda pits at a rate of up to 1.95 Million tonnes per annum (Mtpa). The VCM will target the Alex and multiple Dysart Lower coal seams.

Figure 1.2 and Figure 1.3 shows the 2024 mine pit and Life of Mine (LOM) (post mining) conditions concept drainage plans respectively.

1.3 REGULATORY REQUIREMENTS

This ESC plan has been prepared to meet the requirements of the Model Mine Conditions (DES, 2017) and Condition F20 of the Environmental Authority (EA) for the VCM (EA0002912).

Condition F20 - An Erosion and Sediment Control Plan must be developed and implemented for the duration of activities to minimise erosion and the release of sediment to receiving waters.

1.4 PURPOSE AND SCOPE

Surface water at the VCM is categorised into four types, as discussed in the Vulcan Coal Mine Water Management Plan (WRM, 2023):

- 'Diverted' – surface runoff from areas where water quality is unaffected by mining operations. Diverted water includes runoff from undisturbed areas and any fully rehabilitated areas;
- 'Surface' – surface runoff water from areas that are disturbed by mining operations (including out-of-pit overburden dumps and haul roads);
- 'Mine affected' – surface water that has come in contact with operational areas such as in the pit and the industrial area; and
- 'External water' - external water is water sourced external to the mining operation.

The primary purpose of this document is to develop strategies to manage two types of surface water (diverted water and surface water) at the VCM. The management strategies for mine affected and external water are described elsewhere in the Vulcan Coal Mine Water Management Plan (WRM, 2023). With respect to diverted and surface water, this ESC Plan attempts to:

- examine and address all issues relevant to the generation, management, and mitigation of erosion and sediment transport at the VCM;
- provide guidance in erosion and sediment related issues and management techniques applicable to the VCM;
- determine the appropriate requirements for sediment and erosion control and management for all land uses at the VCM; and
- comply with relevant environmental licences and other regulatory requirements.

The benefits of establishing an ESC Plan include:

- minimise off-site impacts (by-products of erosion);
- deliver stable landforms that will not pollute downstream environments;
- provide clear, concise and standardised practices for operations;
- provide clarity for planners, supervisors and contractors; and
- improve auditability and conformance to standards.

1.5 REFERENCE DOCUMENTS

This ESC plan forms part of the water management system for the VCM and should be read in conjunction with the Vulcan Coal Mine Water Management Plan (WRM, 2023).

This ESC plan references the document prepared by the International Erosion Control Association (IECA) entitled *Best Practice Erosion and Sediment Control Guidelines (2008)*.

1.6 REPORT STRUCTURE

This report is structured as follows:

- Section 2 describes the ESC framework including regulatory requirements, environmental values and water quality objectives;
- Section 3 describes the existing environment including expected soil characteristics;
- Section 4 outlines the principles of erosion and sediment control;
- Section 5 provides a description of erosion control measures;
- Section 6 provides a description of drainage control measures;
- Section 7 provides a description of sediment control measures;
- Section 8 outlines the development of ESC plans;
- Section 9 presents the requirements for monitoring, maintenance and reporting on ESC measures; and
- Section 10 gives a list of references.

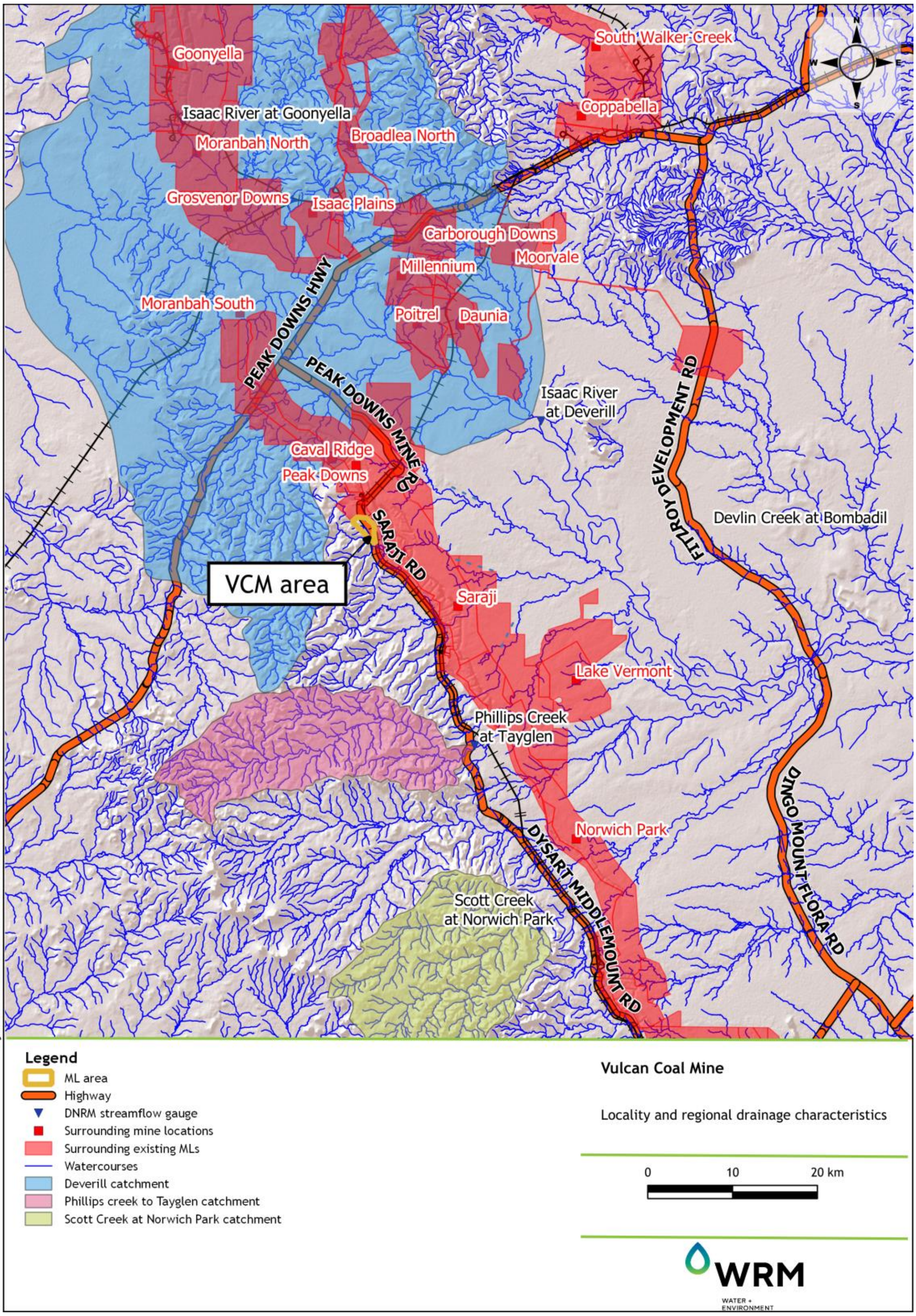

Figure 1.1 Locality plan

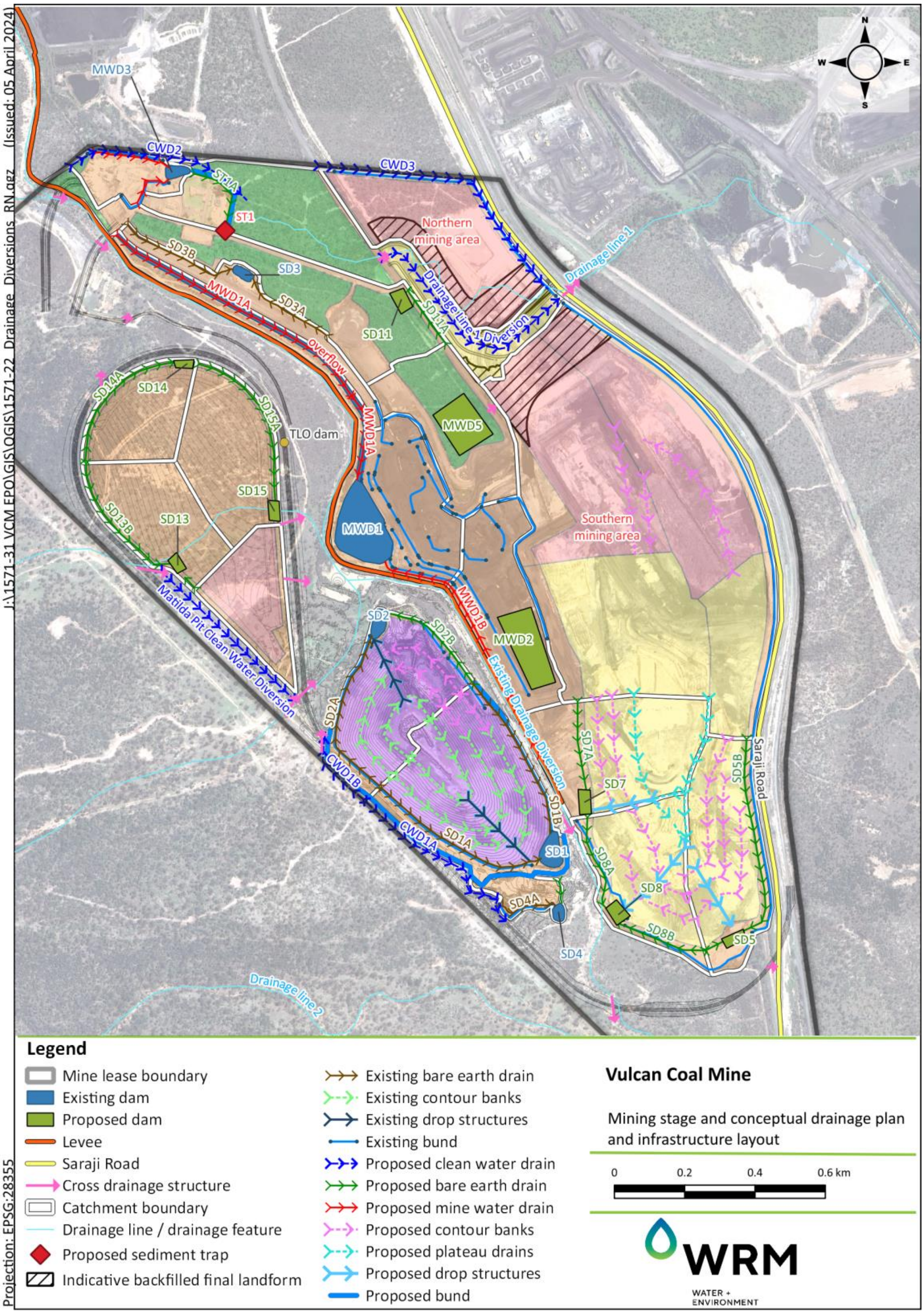

Figure 1.2 Mine pit conceptual drainage plan and infrastructure layout

WRM

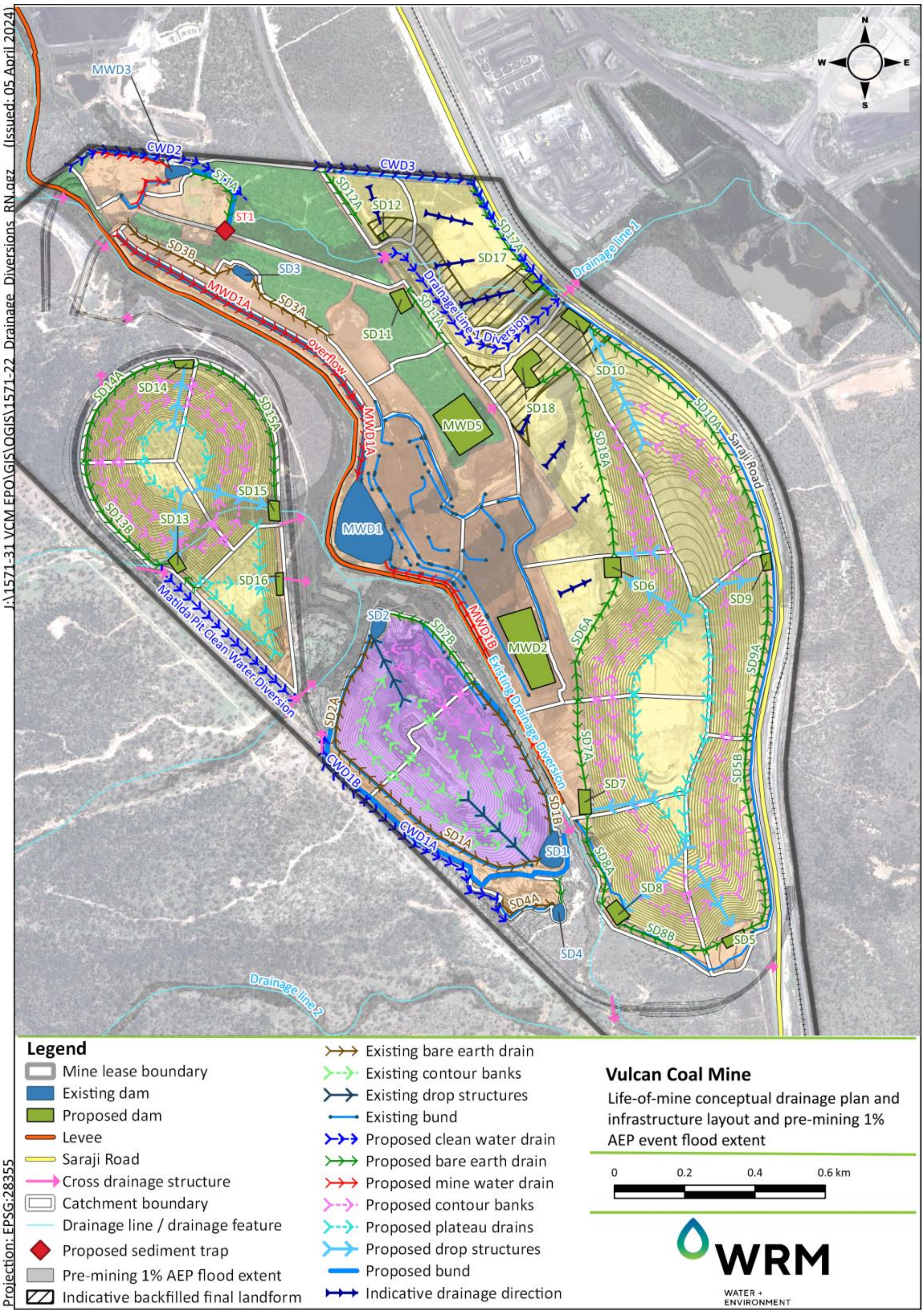

Figure 1.3 LOM (post-mining) conceptual drainage plan and infrastructure layout

2 ESC FRAMEWORK

2.1 REGULATORY FRAMEWORK AND RELEVANT GUIDELINES

The following regulatory framework and relevant guidelines are applicable to the ESC plan for the VCM:

- Environmental Protection Act (EPA) 1994 and Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP Water, 2019);
- Queensland Water Quality Guidelines 2009 (DEHP, 2013);
- Model water conditions for coal mines in the Fitzroy basin (DES, 2013)
- Australian and New Zealand Guidelines for fresh and marine water quality (ANZECC & ARMCANZ, 2018);
- Best Practice Erosion and Sediment Control guidelines (IECA, 2008); and
- Environmental Protection Regulation (EPR) 2019 and Reef discharge standards for industrial activities guideline (DES, 2021).

2.2 VULCAN COAL MINE SPECIFIC STATUTORY DOCUMENTS

The VCM specific statutory documents are:

- VCM Environmental Authority (EA) 0002912;
- Mining Lease (ML) 700060; and
- Vulcan Coal Mine Water Management Plan (WMP).

2.3 STRATEGIC APPROACH

ESC needs to be evaluated and implemented for the following phases of work:

- planning and design (non-operational);
- operation and construction; and
- rehabilitation and mine closure.

This ESC plan does not specifically include techniques for rehabilitation, although many of the given techniques are relevant.

All parties involved in earthworks engaged on site will be given access to the ESC plan and will be required to adhere to all aspects of the plan in the implementation of works undertaken, unless abnormal circumstances prohibit their use.

In addition, consideration should be given to the inclusion of this ESC plan into tender documents and given to prospective tenderer for mine related activities to enable efficient incorporation into daily mine operational procedures.

2.4 RESPONSIBILITIES AND ACCOUNTABILITIES

The management and implementation of the ESC plan is administered through the following key personnel:

- Mine Site General Manager – accountable for the application of this plan and responsible for documentation and revisions of the plan as well as monitoring and auditing of this plan.

- Contractors engaged to undertake work at the VCM are responsible for implementation of this plan.
- Site supervisors - responsible for implementation of this plan.

2.5 REEF DISCHARGE STANDARDS FOR INDUSTRIAL ACTIVITIES

New or expanded prescribed ERAs and resource activities are assessed against Section 41AA of the EP Regulation in relation to water quality. Since 1 June 2021, the administering authority must consider section 41AA of the EP Regulation when making an environmental management decision (EMD) for an ERA discharging dissolved inorganic nitrogen (DIN)/fine sediment in the GBR catchment waters.

Section 3.2.3 of DES (2021) states that "*triggers for assessment under section 41AA do not include diffuse sources of contaminated stormwater that contains sediment only. This will allow for an exclusion for stormwater proposed to be managed through erosion and sediment control measures.*"

The VCM ESCP has been prepared using the Best Practice Erosion and Sediment Control document (IECA, 2008) and addresses:

- the fullest separation possible of diverted, surface and mine-affected water runoff;
- the diversion of upstream runoff from disturbed areas;
- the stabilisation of soils in disturbed areas; and
- the installation and maintenance of control measures such as sediment and erosion control devices (e.g., silt fences, swales, settling basins, energy dissipaters and vegetated buffers).

Hence surface water and diverted water releases from the VCM do not trigger the need for an assessment under Section 41AA of EPR 2019.

3 EXISTING ENVIRONMENT

3.1 REGIONAL DRAINAGE NETWORK

The Project is located within the Isaac River sub-basin of the greater Fitzroy Basin. Figure 1.1 shows the Isaac River catchment to its confluence with Phillips Creek. The catchment area of the Isaac River to Boomerang Creek is 5,226 square kilometres (km^2).

The Isaac River commences approximately 100 km to the north of the project site within the Denham Range. It drains in a south westerly direction through the Carborough and Kerlong Ranges before turning in a south easterly direction near the Goonyella Riverside Mine. It drains approximately 30 km to the east of the project site, and eventually flows to the Mackenzie River some 150 km to the southeast.

Three open water bodies are located in the upper catchment including Lake Elphinstone, Teviot Creek Dam and Burton Gorge Dam. Lake Elphinstone is a natural lake formed behind the Carborough Range whereas Teviot Creek Dam and Burton Gorge Dam are man-made structures that supply water to Burton and North Goonyella mines in the upper catchment.

Other than along the ranges, the majority of the Isaac River catchment has been cleared for agricultural use or for mining. There are several existing coal mines in the catchment, including Burton, North Goonyella, Goonyella Riverside, Broadmeadow, Broadlea North, Isaac Plains, Moranbah North, Millennium, Daunia, Poitrel, Grosvenor, Peak Downs, Saraji, Norwich Park and Lake Vermont.

3.2 LOCAL DRAINAGE NETWORK

Figure 3.1 and Figure 3.2 shows the drainage features in the vicinity of the VCM ML. The VCM is located in the headwaters of the North Creek and Boomerang Creek catchments. North Creek is a tributary of Boomerang Creek and Boomerang Creek is a tributary of the Isaac River. Ripstone Creek is located immediately north of the VCM. North Creek, Boomerang Creek and Ripstone Creek are ephemeral streams which experience flow only after sustained or intense rainfall in the catchment.

The North Creek, Boomerang Creek and Ripstone Creek catchments commence in the Harrow Range to the west of the VCM and drain in an easterly direction towards Saraji Road and the Norwich Park Branch Railway before entering the existing Peak Downs operations. The predominant catchment land uses include undeveloped with some stock grazing to the west of Saraji Road and stock grazing and coal mining to the east. The catchment area of North Creek, Boomerang Creek and Ripstone Creek is 30.7 km^2, 788 km^2 and 300 km^2 respectively. The Peak Downs operations have existing diversions of North Creek, Boomerang Creek and Ripstone Creek and has approval to release to Ripstone Creek and Boomerang Creek.

The headwaters of Ripstone Creek are diverted through the VCM ML and into North Creek via an existing drainage diversion to allow the construction of a Tailings Dam within Peak Downs operations. The diversion flows in a south to south east direction through the VCM ML and has a catchment area of approximately 16.0 km^2. The diversion discharges into Drainage line 2/North Creek within the VCM ML boundary.

3.3 TOPOGRAPHY

Figure 3.3 shows the slopes across the VCM disturbance area. In general, the slopes are level to very gently inclined, with slopes typically less than 5 %. The top of the disturbed catchment, within the Jupiter pit footprint, reaches a slope of about 40%.

3.4 EXPECTED SOIL CHARACTERISTICS

AARC Environmental Solutions Pty Ltd (2019) completed a *Soil and Land Suitability Assessment* (SLSA) for the VCM. To characterise the soils at the site, AARC collected 42 detailed soil profiles and analysed 12 laboratory samples from the site and surrounds.

The area surrounding the VCM is dominated by clastic sedimentary rocks of marine and lacustrine origin, including sandstones, mudstones, siltstones and coal. Surface geology at the site includes Quaternary clay, silt, sand, gravel and soil with colluvial and residual deposits, as well as late Tertiary to Quaternary poorly consolidated sand, silt, clay, minor gravel and high level alluvial deposits (AARC, 2019).

3.4.1 Soil management units

AARC mapped the Soil Management Units (SMUs) across the site using the methodologies specified in the *Guidelines for Surveying Soil and Land Resources* (McKenzie et al, 2008) based on soil morphology, parent material and land attributes.

A map of the SMUs within the VCM ML and surrounds is shown in Figure 3.4, and a description of each SMU is outlined in Table 3.1. As shown, the majority of the site consists of the Limpopo SMU, with a small southern portion of the VCM site consisting of Crocodile and Zambezi SMUs.

Table 3.1 Soil Management Units surveyed on site (AARC, 2019)

Soil Management Unit	Description
Crocodile	A shallow rocky soil unit associated with hill slopes and plateaus. Soil textures grade from loam at the surface, to loamy sands with depth; often containing rock material with little to no pedologic development throughout the solum.
Limpopo	The Limpopo unit is a brown texture-contrast soil. Soil textures predominantly grade from sands to clay sands in the surface soils to light clays in deeper horizons.
Zambezi	A predominantly grey coloured texture contrast soil with surface soils consisting of sands, increasing in clay content in deeper horizons. Lower horizons display diffuse orange to yellow mottles.

3.4.2 Sodic and dispersive soils

Sodic soils contain large concentrations of Sodium relative to other cations. These soils have a degree of dispersivity and can accelerate erosion.

AARC identified areas of high sodicity on site through the measurement of the Exchangeable sodium percentage and Emerson Class of surveyed soils. The Crocodile SMU was identified as having a low risk of dispersion and was not identified as being sodic.

For the remaining SMUs, AARC (2019) identified the depth horizons with sodic properties as follows:

- Limpopo SMU: Sodic below a depth of 0.5 m; and
- Zambezi SMU: Sodic below a depth of 0.5 m.

To control erosion from sodic dispersive soils, gypsum is added during earthworks and sodic subsoils are demarcated and stockpiled separately to other soils (as outlined in Section 5.2).

3.5 ENVIRONMENTAL VALUES

The Queensland Water Quality Guidelines and Environmental Protection (Water and Wetland Biodiversity) Policy (EPP Water) guidelines establish environmental values (EVs) and water quality objectives (WQOs) for natural waters in Queensland. The VCM is located within the 'Isaac western upland tributaries' area of the Isaac River sub-basin. Under the EPP Water, the following EVs have been nominated for this area:

- Aquatic ecosystems;
- Irrigation;
- Farm supply/use;
- Stock water;
- Aquaculture;
- Human consumption;
- Primary recreation;
- Secondary recreation;
- Visual recreation;
- Drinking water;
- Industrial use; and
- Cultural and spiritual values.

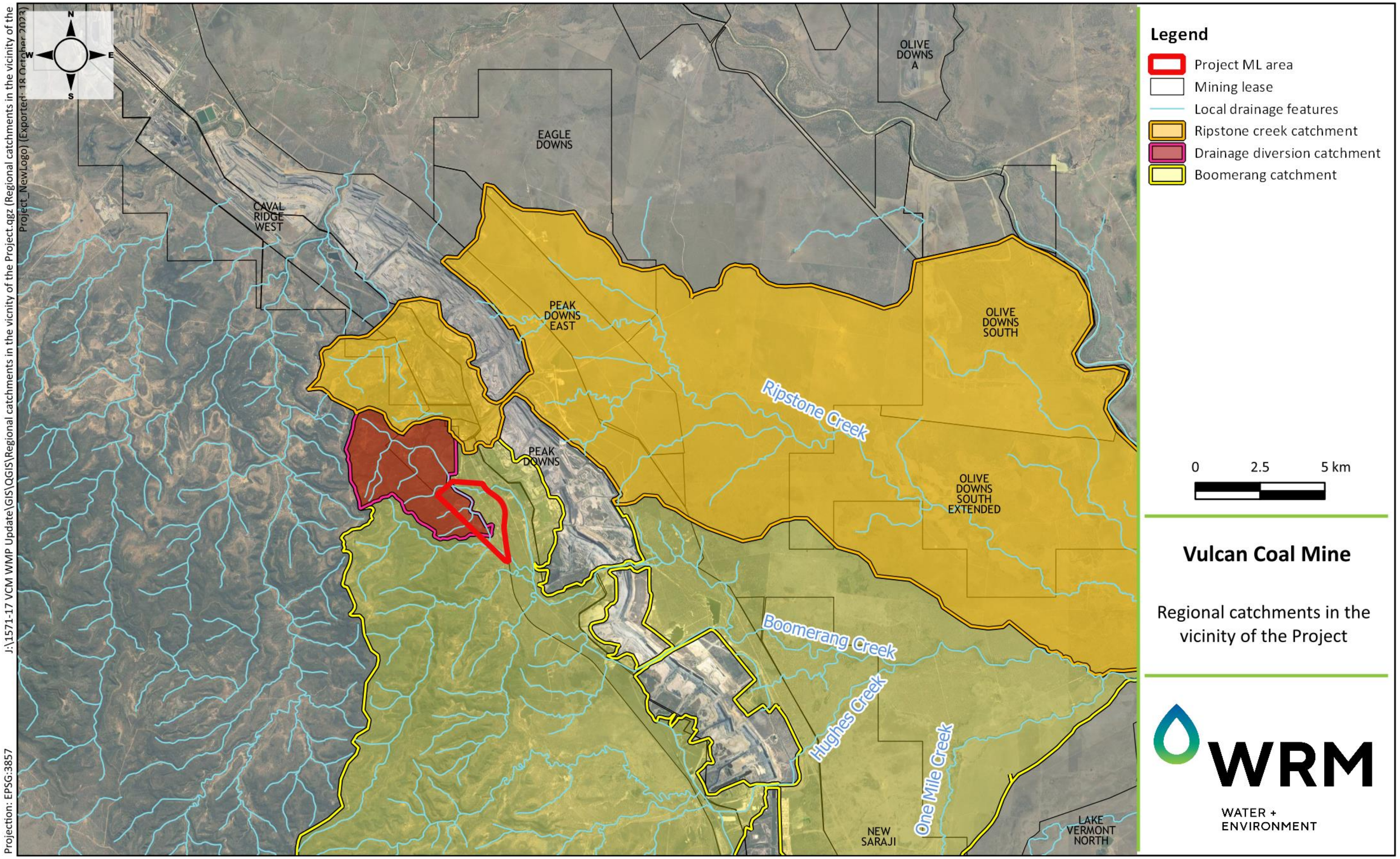

Figure 3.1 Local drainage features

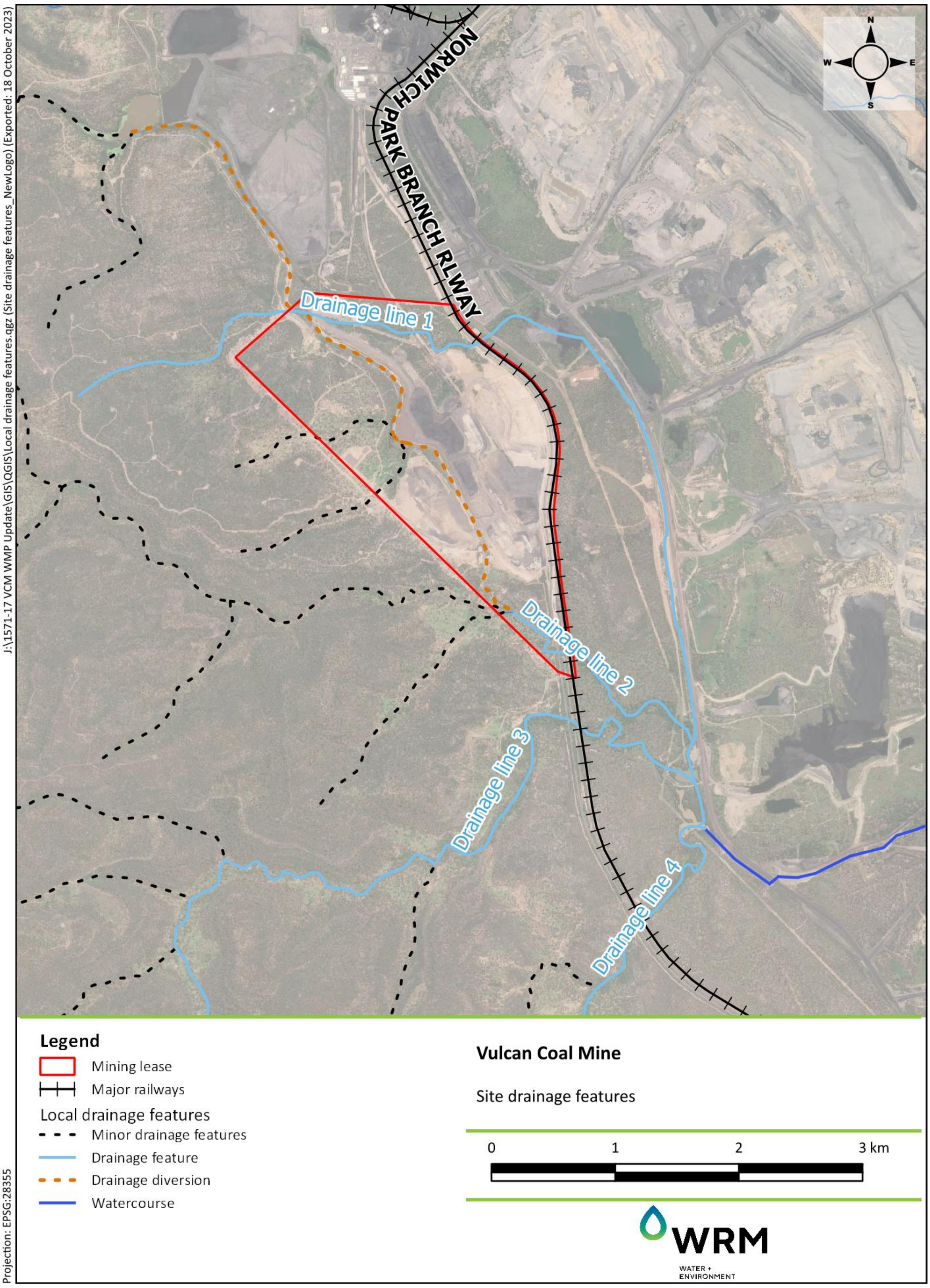

Figure 3.2 Site drainage features

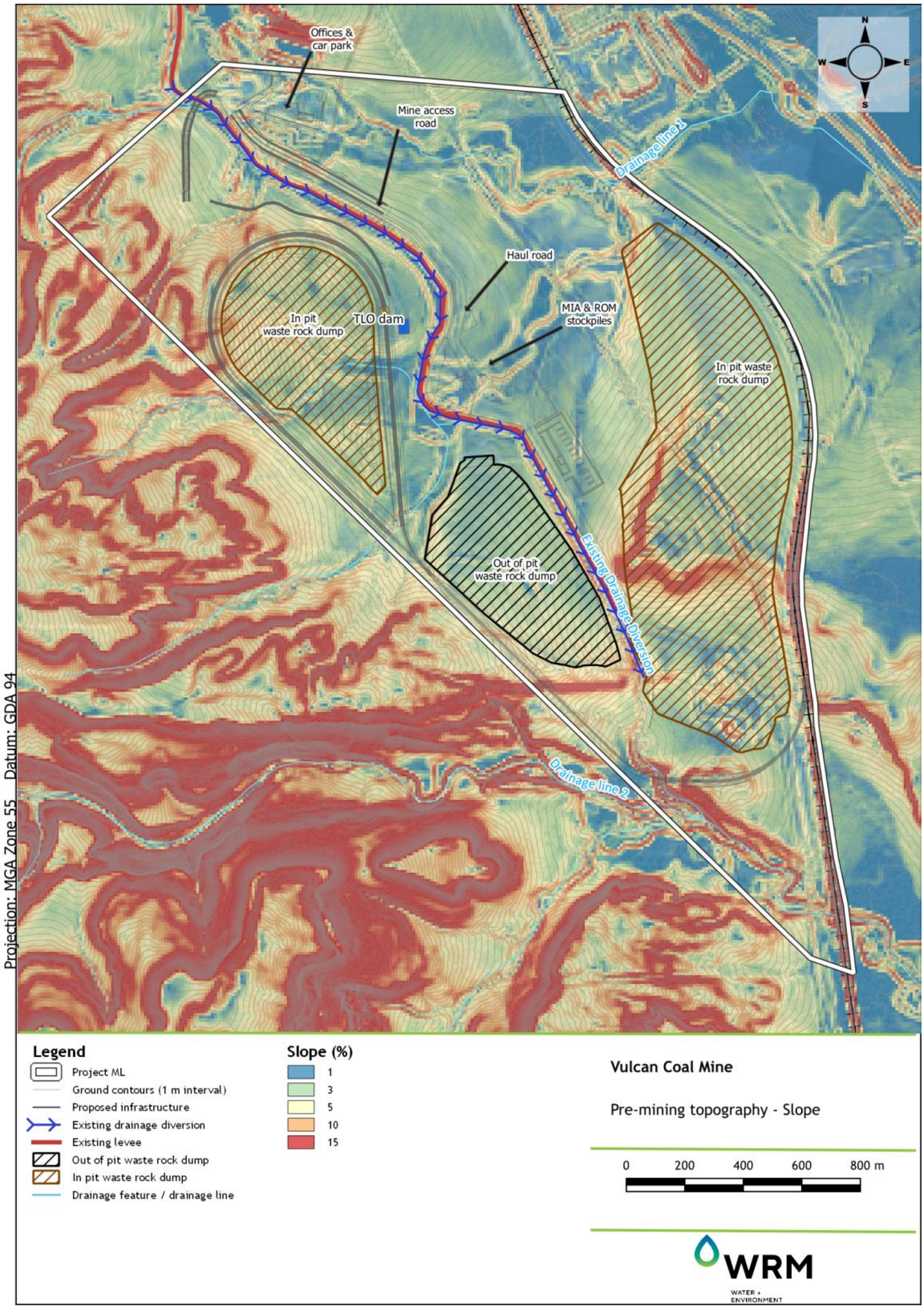

Figure 3.3 Mine Layout and slope

Figure 3.4 Soil Management Units mapped within the Project site and surrounds

4 EROSION AND SEDIMENT CONTROL

4.1 OVERVIEW

This ESC plan is intended to assist in the management, reduction and mitigation of erosion and consequent sediment transport within and from the VCM.

Preventing unacceptable levels of sediment and contaminants from leaving the lease and entering the receiving waters is one of the most important functions of ESC, which is managed by compliance with the Environmental Authority. As per IECA (2008) this ESC plan adopts the three cornerstones of ESC as follows:

- Drainage control – prevention or reduction of soil erosion caused by concentrated flows and appropriate management and separation of the movement of clean and dirty 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.
- Sediment control – trapping or retention of sediment either moving along the land surface, contained within runoff (i.e. from up-slope erosion) or from windborne particles.

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. In general, the most efficient and cost effective way of minimising sedimentation is to minimise the extent, duration and severity of soil erosion. In addition, best practice sediment control measures cannot, on their own, be relied upon to provide adequate environmental protection.

4.2 PRINCIPLES OF ESC

For ESC to be effective, the following fundamentals are required (IECA, 2008):

- ensure ESC measures are designed and constructed effectively;
- minimise the duration and extent of soil exposure;
- promptly stabilise disturbed areas;
- maximise sediment retention on the site;
- control water movement through the site;
- minimise soil erosion wherever possible rather than applying down slope sediment controls;
- utilise existing topography and adopt construction practices that minimise soil erosion and sediment discharge from area;
- integrate erosion and sediment control issues / measures into the planning phases of mine operations;
- choose the ESC technique to account for site conditions such as soil, weather and construction conditions;
- maintain all ESC measures in proper working order at all times; and
- monitor the site and adjust ESC practices to maintain the required performance standard.

4.3 POTENTIAL SOURCES OF EROSION

Operations at the VCM may result in the alteration of existing surface water flow patterns by mining activities and through diversion drains. Erosion may occur due to the following mining activities:

- Waste rock stockpile;
- Topsoil and subsoil stockpiles;
- Open cut mining;
- Cleared land ahead of mining or other mining related activities;
- Installation of services and infrastructure;
- Changes to drainage lines and/or catchment;
- Ore stockpiles and ore handling equipment including mobile equipment, ore crushing equipment and conveyors;
- runoff from construction and maintenance on haul roads;
- runoff from the construction of and maintenance of internal access roads;
- vehicle and equipment movements; and
- disturbed areas not yet rehabilitated.

Potential erosion and sediment sources as well as the potential contaminants and impacts at the VCM are presented in Table 4.1.

Although this ESC plan primarily focuses on erosion and sediment control where water is the causal factor, it should be recognised that, particularly in drier environments, wind also plays a significant role in erosion and the potential for sediment deposition to surrounding receiving environments.

Table 4.1 Potential erosion and sediment sources

Disturbance category	Potential contaminant	Potential impacts
Spoil		
Active/inactive	Unconsolidated material with varying quantities of saline and sediment pre-disposition Bare areas vulnerable to storm activity Acid mine drainage (AMD)	Sheet and rill erosion of potentially alkaline/ acidic/saline deposits leading to deposition of contaminants and sediment volumes. Sediments causing damage to receiving waters through reduction in water quality and degradation of in-stream habitats
Topsoiled (to be revegetated)	Unconsolidated materials, sediment and turbidity	Sheet and rill erosion leading to sedimentation of waterways and loss of valuable rehabilitation material
Topsoiled, ripped and seeded	Unconsolidated materials, sediment and turbidity	Minimal once established
Topsoil		

Disturbance category	Potential contaminant	Potential impacts
Topsoil stripping area	Unconsolidated materials, bare areas vulnerable to storm activity	Sheet, tunnel, rill and gully erosion leading to movement and deposition of sediments, deleteriously impacting on receiving waters
Topsoil stockpiles	Unconsolidated materials, sediment and turbidity	Sheet, rill erosion leading to sedimentation of waterways and loss of valuable rehabilitation material
Peripheral lands		
Exploratory and access tracks	Disturbance of natural landform resulting in possible bare landforms increasing sediments in natural runoff	Exacerbation of rill and gully erosion leading to movement and deposition of sediments potentially causing damage to water quality and in stream habitat of receiving waters
Haul roads	Disturbed materials from surface of the road, erosion of table drain material vulnerable to storm activity	Sedimentation of nearby watercourses
Industrial Areas	Hydrocarbons and hydrocarbon contaminated sediments	Water quality impacts
Sediment runoff from hardstand areas	Leaching and erosion of soils containing hydrocarbons and movement and release of hydrocarbons into surrounding environment	Sedimentation of nearby watercourses
Exploration activity	Disturbed materials, sediment and turbidity	Sedimentation of nearby watercourses
Land clearing (woody vegetation)	Disturbed materials, sediment and turbidity	Sedimentation of nearby watercourses
Drainage channels	Disturbance of landform resulting in possible bare landforms increasing sediments in runoff	Sheet, tunnel, rill and gully erosion leading to movement and deposition of sediments, deleteriously impacting on receiving waters
Licenced stream diversions / levees	Disturbance of landform resulting in possible bare landforms increasing sediments in runoff	Sheet, tunnel, rill and gully erosion leading to movement and deposition of sediments, deleteriously impacting on receiving waters

4.4 EROSION POTENTIAL

Undertaking an assessment for risk of erosion is essential to determine the appropriate ESC technique to apply. There are five main categories that need to be taken into consideration, all of which influence the erosion potential and the type of control measure(s) applicable:

- soil classification;
- average slope of disturbance area;
- area and duration of soil disturbance;
- location within the catchment (and whether run-off from upslope can be controlled); and
- proximity to waterways.

An example of a simple erosion assessment is presented in Appendix A (IECA 2008, Appendix F) that identifies low-risk and high-risk sites. This type of assessment may help to determine the high-risk areas of erosion potential.

4.4.1 Soils

Soils are classified into three categories:

- dispersive soil;
- non dispersive soil; and
- blocky / competent material.

The following is provided as background to identifying soil / material types.

Dispersive soils are structurally unstable in water and tend to break down into their constituent particles which consequently cloud the water. Dispersive soils are highly susceptible to erosion on slopes and drains when exposed. Dispersive soils should be treated or completely buried under a layer of non-dispersive soil before attempting any erosion control measures.

Non-dispersive soils are characterised by large, water-stable aggregates separated by large pore spaces that absorb water rapidly. These soils are typically high in clay content although some clays are highly dispersive and break down when wet making them highly erodible (i.e. dispersive). Sandy soils are generally non-dispersive on gently sloping land, however are dispersive on steep slopes.

Blocky / competent soil material is structurally sound and typically does not contribute a large portion of erosion problems or sediment runoff. These materials may be used to construct various erosion and sediment control techniques.

Reference should be given to AARC (2019) and the SMU's mapped across the Project site when identifying soils for erosion and sediment control. In particular, specific consideration should be given to the location of sodic dispersive soils mapped by AARC (2019) and described in Section 3.4.2.

If there is uncertainty surrounding the soil type for any area of activity where this ESC plan needs to be referenced, appropriate steps will be undertaken to determine soil type. This may include undertaking suitable soil assessment as per published documentation (e.g. IECA 2008).

4.4.2 Slope

The steepness of the slope and slope length are important determinants in the erosion risk of a site. The Australian Soils and Landscapes Handbook identifies that slopes can be categorised by their percentage or degree of slope. These slope categories of relevance to the VCM are defined in Table 4.2.

Table 4.2 Definition of slope class

Slope Class	Approximate Slope Values			
	Tangent (% Slope)		Degrees	
	Boundary	Average	Boundary	Average
Level	1	0.6	0°35′	0°20′
Very Gently Inclined	3	1	1°35′	1°
Gently Inclined	10	6	5°35′	3°
Moderately Inclined	32	20	18°	10°

4.4.3 Area and duration

A principal of ESC is to minimise the extent and duration of soil disturbance. Therefore, mining schedules should aim to minimise the duration for which open soils are exposed to the erosive elements (wind, rain and flowing water). Reducing the period where soils are exposed to erosive elements during the construction phase lessens opportunity for displaced sediment to enter into the surrounding environment.

Strategies to minimise increased risk of erosion during the operational phase of the mine site include:

- minimise the extent of the disturbance;
- prompt revegetation of non-operational disturbed area;
- ensure both temporary earthworks and permanent land-shaping provide a landform that minimises erosion; and
- design temporary runoff collection, conveyance and disposal systems to minimise erosion prior to commencement.

4.4.4 Location within the localised catchments

One of the major principles in achieving effective erosion and sediment control across any site is the necessity to separate run-off from undisturbed catchments and disturbed catchments. Disturbed sites positioned low in a localised catchment with the potential to receive overland or flood flows represent an increased erosion risk. It is therefore necessary to establish site drainage works to convey overland flows safely through or around a site during the disturbance period. Particular attention will need to be paid to the discharge areas of these diversions.

4.4.5 Waterways

The proximity to watercourses may trigger an increased level of planning. Disturbances to existing waterways should be avoided wherever practical.

During operational phases the proximity of ESC measures to watercourses should be undertaken where practicable and reasonable. Design should take into account floodplain extent, soil conditions and flood immunity of the selected ESC measure.

Within this process any mitigation works required to minimise erosion and sediment transport will be detailed. Any discharges to a watercourse are conditional to the environmental authority for the VCM.

4.5 TOPSOIL STOCKPILE MANAGEMENT

Based on the identified soil properties identified at the site, AARC recommended a number of topsoil stockpiling methods, including (AARC, 2019):

- Stockpiles should be less than 2 m high and be contoured and positioned in a manner that encourages water drainage and discourages erosion. If necessary, they should be covered with a water-shedding lining or grass cover.
- If the stockpiles require grass cover, they should be ripped and seeded with a quick establishment pasture, to limit erosion and maintain a viable seed bank. This should be done if the period of stockpiling is greater than one growing season or six months. Topsoil should ideally be stockpiled for the minimum time possible.
- Stockpiles should be monitored for weeds and control measures implemented as appropriate.
- Where soil has been stockpiled for extended periods, soil testing is recommended before use for rehabilitation purposes. If required, fertilizers and soil ameliorants should be applied.

Maximum recommended topsoil stripping depths for soils identified on site (AARC, 2019) are outlined in Table 4.3. AARC (2019) note that Limpopo and Zambezi topsoils would benefit from amelioration measures (e.g. liming agents, fertiliser) or actions (e.g. mixing) to achieve a grazing land use outcome.

Table 4.3 Recommended maximum topsoil stripping depth for Soil Management Units (AARC 2019)

Soil Management Unit	Topsoil Stripping Depth (m)
Crocodile	0.1
Limpopo	0.3
Zambezi	0.3

5 EROSION CONTROL MEASURES

5.1 OVERVIEW

Soil erosion is the process through which the effects of wind, water or physical action displace soil particles, causing them to be transported. This section discusses the potential measures to mitigate or reduce erosion caused by water. The most common forms of water erosion on the VCM are:

- Splash erosion is the spattering of soil particles cause by the impact of raindrops on soil;
- Sheet erosion is the uniform removal of soil in thin layers from sloping land;
- Rill erosion is the removal of soil by water concentrated in small but well-defined channels; and
- Gully erosion produces channels deeper and larger than rills (generally greater than 300 mm deep).

5.2 EROSION CONTROL TECHNIQUES

5.2.1 Control of erosion on slopes

A list of appropriate erosion control measures to be used on flat, mild and steep slopes is given in Table 5.1.

Table 5.1 Erosion control measures on slopes

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

5.2.2 Soil stabilisation and protection

Generally, erosion control involves engaging rehabilitation methods. A list of additional erosion control techniques is also given in Table 5.2.

Table 5.2 Summary of erosion control techniques

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
Gypsum	Amelioration of sodic soils (identified in Section 3.4.2) through the addition of gypsum during earthworks
Topsoil stockpile management	Erosion management measures as outlined in Section 5
	Segregation of saline or sodic soils and clear demarcation and labelling/recording of stockpiles to ensure appropriate use of the resource

6 DRAINAGE CONTROL MEASURES

6.1 OVERVIEW

This section outlines the measures to be taken when constructing drainage channels at the VCM to minimise erosion and downstream sedimentation. Control measures for four different drainage channels are discussed as follows:

- permanent watercourse drainage (diversions) requiring a licence to disturb under the Water Act 2000 or approval to divert under the Environmental Protection Act 1994. Erosion control measures for these diversions are not specifically addressed in this Plan.
- permanent drainage that does not require regulatory approval but will remain in place at the end of mine life and effectively act as a watercourse.
- operational drainage in low gradient areas such as catch drains, diversion channels or flow diversion banks that either collect concentrated flow or overland flow.
- operational drainage down slopes such as chute drains.

6.2 PERMANENT DRAINAGE

Permanent drainage refers to diversion channels that will be in place at the end of mine life. These channels require a higher level of design to limit the potential maintenance liability once mining has ceased. Given this, it is recommended that permanent drainage channels be designed by a suitably qualified person in accordance with the DNRM guidelines entitled *Guideline: Works that interfere with water in a watercourse—watercourse diversions* (DNRM, 2014).

Any permanent diversion should be designed such that it appears and functions as a natural feature in the landscape largely indistinguishable from the natural watercourses in the area (DNRM, 2014). A natural channel or flow path has features that develop through geomorphologic processes, such as channel and floodplain capacity, meanders, riffles and vegetation, to provide an environment where these conditions can continue to develop at a rate consistent with its environment. This is referred to as dynamic equilibrium. Similar features should be designed into the diversion channel in order to obtain a similar dynamic equilibrium.

Where the diversion is replacing an existing channel such as a gully, the existing gully should be used as a 'template' to design the diversion. That is, the diversion design should mimic the channel shape, floodplain capacity, bed slope etc. of the natural channel it replaces, where possible. Where the diversion collects an increased catchment of overland flow as it traverses downstream, a nearby natural channel that has a similar catchment area could be used as a template. Alternatively, the upper limits of stream powers, velocities and shear stresses for natural Bowen Basin watercourses, given in the DNRM (2014) guideline should be used.

For ALL permanent diversions, vegetation should be used as the primary method of stabilising channel banks, terraces and floodplain drainage paths as engineering methods may not limit the liability for long term maintenance cost post mining.

6.3 OPERATIONAL DRAINAGE CONTROLS

6.3.1 Design standards

Table 6.1 shows the recommended design standard of operational drainage structures at the VCM. Operational drainage controls that are anticipated to last longer than 24 months should be designed to cater for a 100 year Average Recurrence Interval (ARI) design storm to provide effective separation of clean and dirty runoff (IECA, 2008). This may involve a combination of channels and floodplain levees. Temporary culvert crossings should have a hydraulic capacity of the 1 year ARI design storm.

Table 6.1 Drainage design standards for temporary drainage works

Anticipated Design Life (months)	Design Standard (Years ARI)
< 12	2
12 to 24	5
> 24	100

6.3.2 Drainage design techniques

In accordance with IECA (2008), drainage channels, whether permanent or temporary, should be designed and constructed at a gradient that limits the maximum flow velocity for the adopted design event standard (refer Table 6.1) to a value not exceeding the maximum allowable flow velocity for the given surface material. Excessive flow velocities can cause channel erosion, usually along the invert of the drain, which can then lead to bank slumping and widening of the channel. Table 6.2 lists allowable flow velocities for earth lines drains as per IECA (2008).

The flow velocity can be reduced by either:

- Reducing the depth of flow (increasing the width of the channel);
- Reducing the bed slope;
- Reducing the peak discharge (reducing catchment area); or
- Increasing channel roughness.

If the channel width, depth or gradient cannot be altered, then there are two options for controlling erosion as follows:

- Reduce the flow velocity through the placement of rock check dams;
- Increase the effective scour resistance in the channel through the placement of an effective channel liner such as rock or an appropriate liner.

Table 6.2 Allowable flow velocities for open earth lined drains

<table>
<tr><th>Soil description</th><th>Allowable velocity (m/s)</th><th>Comments</th></tr>
<tr><td>Extremely erodible soils</td><td>0.3</td><td rowspan="9">• Dispersive clays are highly erodible at low velocities and therefore must treated (e.g. with gypsum) or covered with a minimum of 100mm of stable soil.
• Highly erodible soils may include: Lithosols, Alluvials, Podzols, Siliceous sands, Soloths, Solodized solonetz, Grey podzolics, some Black earths, fine surface texture-contract soils and Soil Groups ML and CL.
• Moderately erodible may include: Red earths, Red or Yellow podzolics, some Black earths, Grey or Brown clays, Prarie soils and Soil Groups SW, SP, SM, SC.
• Erosion-resistant soils may include: Xanthozem, Euchrozem, Krasnozems, some Red earth soils and Soil Groups GW, GP, GM, GC, MH and CH.</td></tr>
<tr><td>Sandy soils</td><td>0.45</td></tr>
<tr><td>Highly erodible soils</td><td>0.4 to 0.5</td></tr>
<tr><td>Sandy loam soils</td><td>0.5</td></tr>
<tr><td>Moderately erodible soils</td><td>0.6</td></tr>
<tr><td>Silty loam soils</td><td>0.6</td></tr>
<tr><td>Low erodible soils</td><td>0.7</td></tr>
<tr><td>Firm loam soils</td><td>0.7</td></tr>
<tr><td>Stiff clay very colloidal soils</td><td>1.1</td></tr>
</table>

6.3.3 Drain velocity control structures

A list of appropriate check dam velocity control structures is given in Table 6.3.

Table 6.3 Velocity control structures for channels and drains

Technique	Typical use
Fibre roll	• Biodegradable logs • Used in wide shallow drains where logs can be successfully anchored down • Used in locations where it is desirable to integrate into the vegetation, such as vegetated channels • Minor sediment trap
Rock check dams (see Figure 6.1)	• Used in drains with a depth exceeding 0.5 m and a gradient less than 10% • Minor sediment trap
Recessed rock check dams	• Used in wide, high velocity, shallow channels where sandbag check dams would likely wash away. • Recessed into the soil to maintain hydraulic capacity in the channel • Minor sediment trap
Sandbag check dams	• Used in shallow drains with a depth less than 50 mm and gradient less than 10% • These check dams are small and less likely to divert water out of the drain • Minor sediment trap
Triangular ditch check	• Commercially available, reusable product • Commonly used to stabilise newly formed table drains • Used in drains with less than 10% gradient • Minor sediment trap

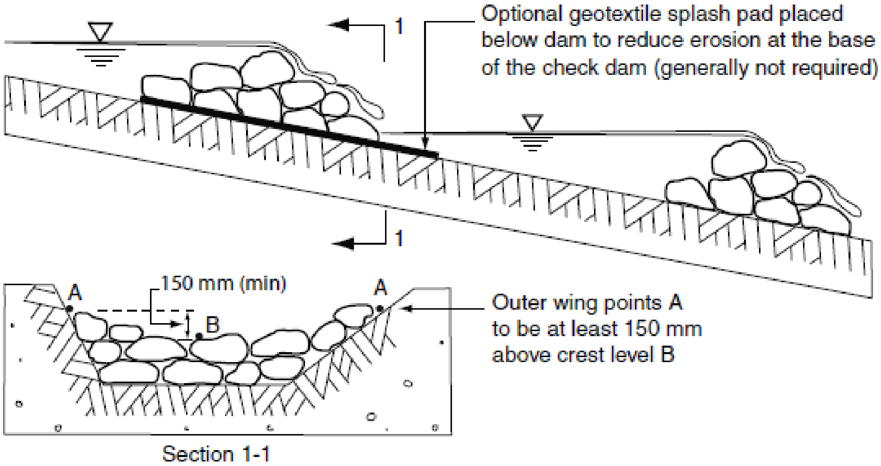

Figure 6.1 Typical rock check dam configuration (IECA, 2008)

6.3.4 Chute and channel linings

A list of appropriate channel linings to provide effective scour protection is given in Table 6.4.

Table 6.4 Scour protection and lining types for chutes and channels

Technique	Typical use
Cellular confinement system	• Typically used to stabilise chutes when the only local supply of rock consists of rock smaller than 200 mm • May be filled with small rocks and grassed to form a permanent reinforced grassed chute • Also used to form a temporary construction access across dry sandy bed streams
Grass lining	• Permanent protection of low to medium velocity chutes and channels • Requires suitable growing medium and time to establish
Hard armouring	• Hard armouring systems include corrugated sheet metal, reinforced concrete and shotcrete
Rock mattresses	• Suitable high velocity chutes and spillways
Rock lining (see Figure 6.2))	• High velocity drainage channels • Drainage chutes • Sediment basin spillways

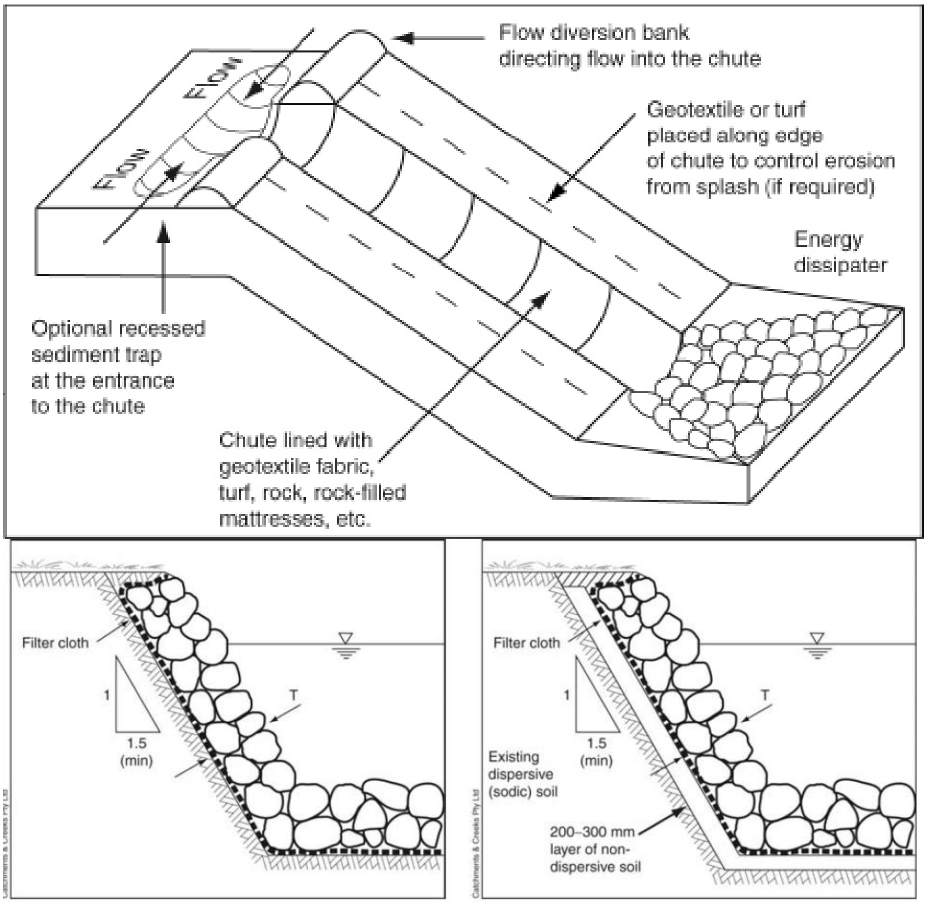

Figure 6.2 Typical rock placement in a chute (IECA, 2008)

6.3.5 Outlet structures

A list of appropriate outlet structures to provide effective scour protection is given in Table 6.5.

Table 6.5 Scour protection for channel and drain outlets

Technique	Typical use
Level spreader (see Figure 6.3)	• Conversion of minor concentrated flows back to sheet flow
Rock protection (see Figure 6.4)	• Used at the end of chute drains to dissipate energy and control scour • Used as a permanent energy dissipater on pipe and culvert outlets

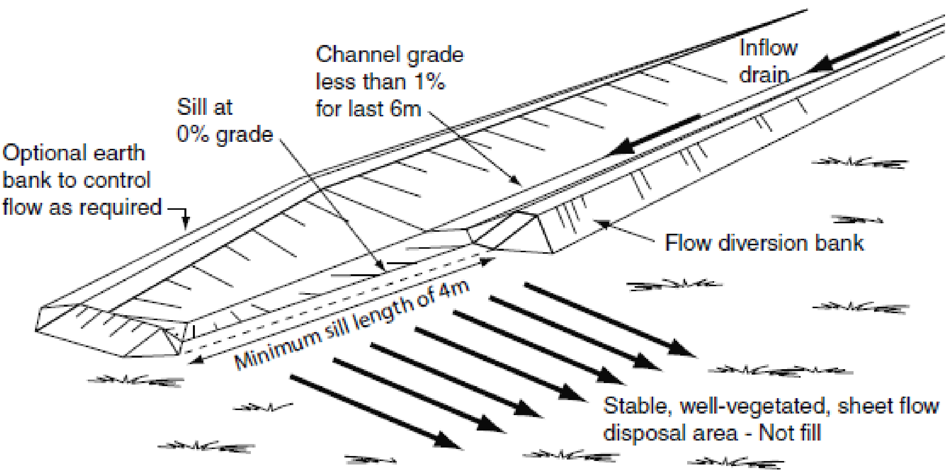

Figure 6.3 Typical level spreader configuration (IECA, 2008)

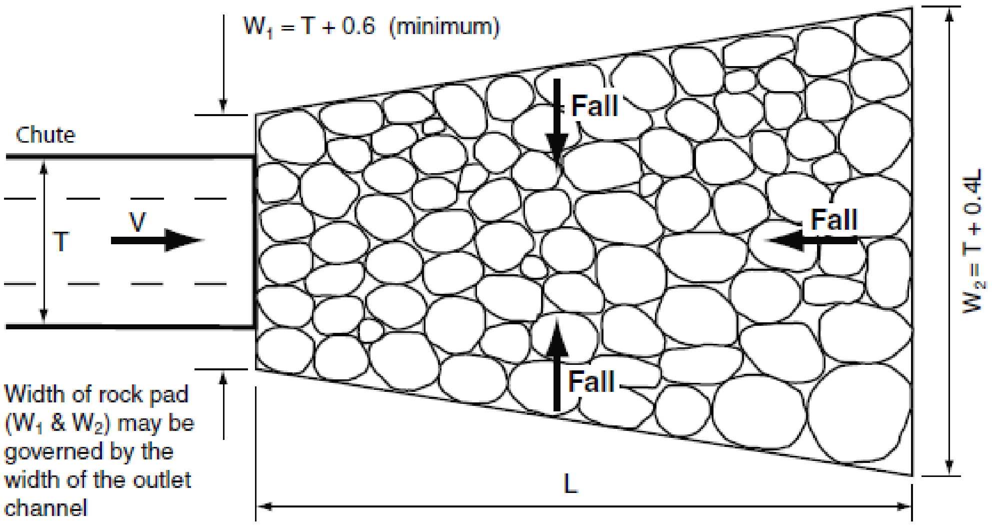

Figure 6.4 Typical energy dissipater configuration (IECA, 2008)

6.3.6 Drainage control on unsealed roads

The following general principals should be followed in the design of drainage controls for unsealed roads:

- Stormwater runoff from unsealed roads should be allowed to shed at regular intervals. The runoff should be discharged into a sediment trap or released as sheet flow via a level spreader into adjacent grassland.
- Where stormwater runoff from unsealed roads collects within table drains adjacent to the roadway, this water should ideally be discharged from the table drain at regular intervals.

Where table drains are steep and water cannot shed, such as through a cutting or into a river channel, the controls given in Table 6.3 and Table 6.4 should be considered.

- When access is required across a slope, the road should be sited as close as possible to the contour of the land. This allows upslope water runoff to pass evenly across the track, thus avoiding concentrated flow.
- When an access road diagonally traverses a slope, the road will likely collect and concentrate upslope stormwater runoff. The collected runoff will need to shed at regular intervals using a level spreader or drainage channels constructed.
- Wherever practical, table drains should form wide U-shaped drains to minimise potential invert erosion. Deep V-shaped drains should be avoided where roads are constructed on steep slopes along a cutting.

6.3.7 Watercourse crossings

Watercourse crossings may consist of fords, culverts, or bridges. The following general principles should be followed in the design of drainage controls for watercourse crossings:

- Where fish passage is to be considered, a bridge structure is preferred otherwise a ford or buried box culvert with earth rock bed.
- Culvert designs should always consider the effects of debris blockages and potential erosive forces caused by overtopping flows. Ideally, culverts should have a flow capacity at least equal to the normal channel capacity of the watercourse when the water level is just below the crest of the culvert deck.
- Where possible, crossings of streams should be constructed at right angles to the flow and in locations where the channel is straight and has well defined banks.

Crossings should be covered with a non-erodible material such as rock or gravel and the upstream and downstream batters should be armoured with rock to control erosion caused by overtopping flows. Figure 6.5 shows the preferred arrangement of a temporary culvert crossing in a minor stream with low gradient overbank areas. Figure 6.6 shows a single cell culvert placed within a constricted channel with steep overbank slopes.

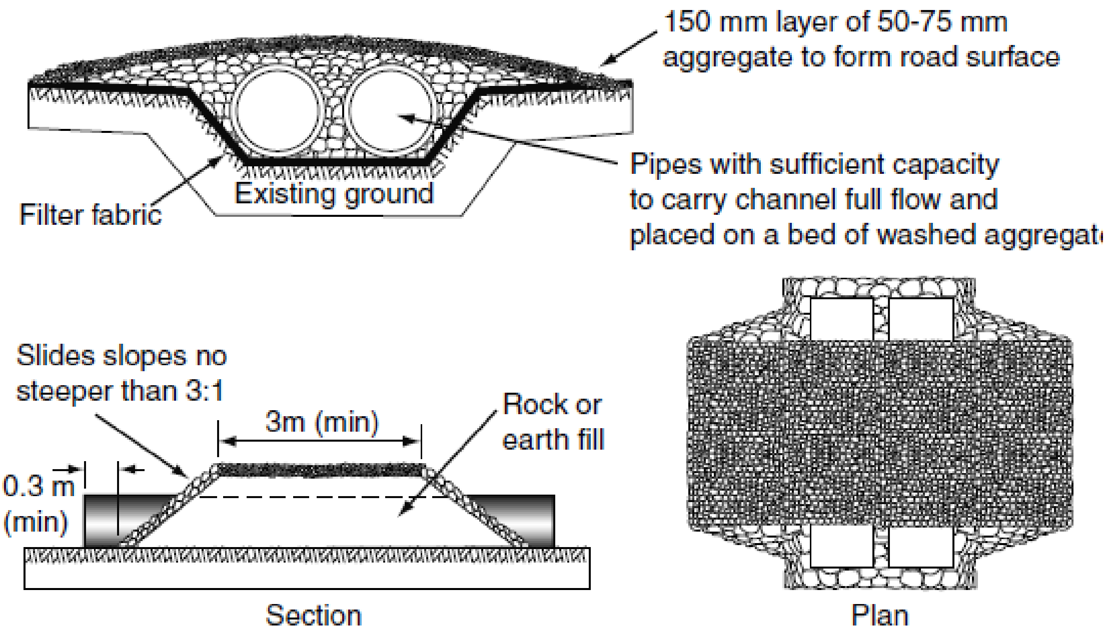

Figure 6.5 Typical temporary culvert crossing in a minor stream with low-gradient overbanks (IECA, 2008)

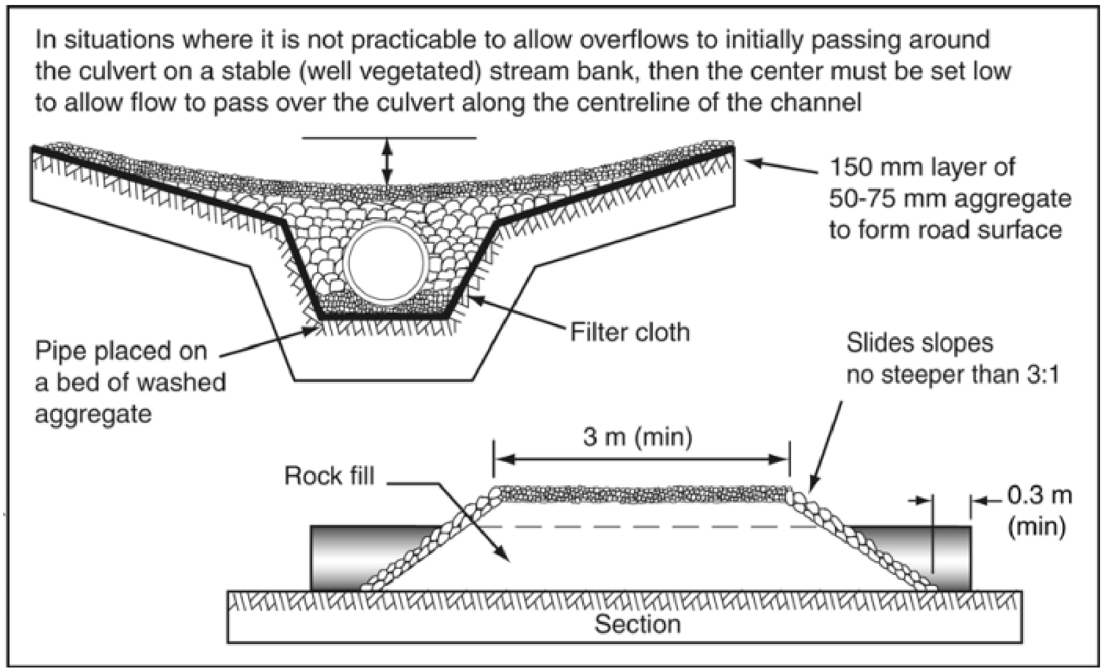

Figure 6.6 Typical temporary culvert crossing in a constricted channel with steep overbanks (IECA, 2008)

6.3.8 Typical configurations – Windrow

The configuration (dimensions) of each drain would be dependent on the upslope catchment area and slope. Upslope diverted water drains should be constructed as a diversion bank (windrow). This prevents excavation into material which may be dispersive. All upslope diverted water drains shall be vegetated, with additional drainage controls as required. Each drain should typically contain the following features identified below and shown in Figure 6.7:

- vegetated earth embankment at least 0.5 m high with 0.5 m crest width;
- channel batters of at least 1(V):2(H), but preferably 1:4 (V:H);
- freeboard of at least 0.15 m above the design depth;
- where necessary check dams will be used to maintain peak velocity below the velocity limit;
- channel grades should not exceed 3%;
- drainage banks will be constructed to appropriate engineering standards;
- stable grass cover to be maintained in the bed and bank of the channel and below the channel outlets (as much as possible); and
- wherever practicable, avoid constructing drains through dispersive topsoil.

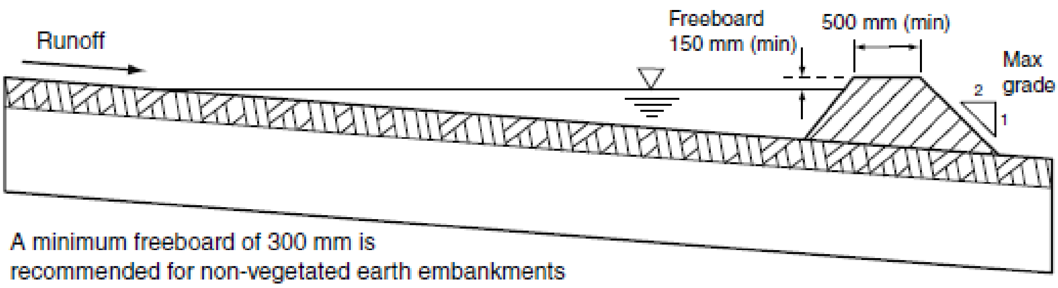

Figure 6.7 Upslope diverted water configuration – diversion bank (IECA, 2008)

6.3.9 Typical drain configurations - Channel

The configuration (dimensions) of each 'diverted' runoff drain would be dependent on the upslope catchment area and slope. Drain design can be broken into two categories of low flows and high flows based on the upslope catchment and slope of the drain. Each runoff drain should typically contain the following features identified below and shown in Figure 6.8:

- trapezoidal channel;
- bank batters of between 1:2 (V:H) and 1:7 (V:H);
- channel batters at least 1(V):2(H), but preferably 1:4 (V:H);
- where necessary rock check dams will be used to maintain specified channel grades;
- channel grades should not exceed 5%;
- bank bottom widths (f) will vary depending on the adopted bank batters;
- diversion banks will be constructed to appropriate engineering standards.

- the channel outlet (level spreader) will be flared out to a minimum width of 1.5 x channel base width. Ground slopes below the channel outlet shall be less than or equal to the channel grade;
- stable grass cover to be maintained in the bed and banks of the channel and below the channel outlets (as much as possible); and
- wherever practicable, avoid cutting drains through dispersive soils. If a drain must be located through dispersive soils, the channel bed and banks should be treated or buried with non-dispersive soils (0.1m minimum cover) before placing any revegetation or channel liner.

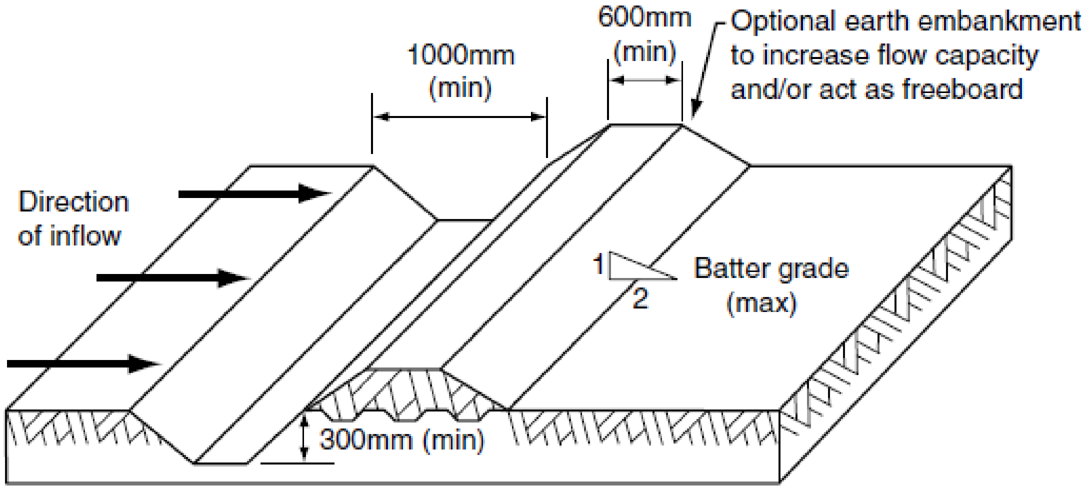

Figure 6.8 Typical drainage configuration - channel (IECA, 2008)

7 SEDIMENT CONTROL MEASURES

7.1 OVERVIEW

The primary function of sediment control measures is to trap the coarser sediment fraction. Sediment basins and some filtration systems used during dewatering operations are possibly the only sediment control techniques that have any significant ability to trap finer sediment particles such as silts or clays. Due to the difficulty of trapping these finer sediments, priority should be given to the use of effective erosion control measures wherever practical.

7.2 SEDIMENT CONTROL TECHNIQUES

7.2.1 Primary controls

Primary control of sediment will be via sediment dams, designed and constructed in accordance with the Best Practice Erosion and Sediment Control guidelines (IECA, 2008). The sediment dam volumes will be based on the following design standards:

- In the absence of detailed information on soil properties across the VCM site, a “Type F” sediment basin has been adopted.
- Total sediment basin volume = settling zone volume + sediment storage volume as shown in Figure 7.1**Error! Reference source not found.**. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted. The settling zone is the minimum required free storage capacity that must be restored within 5 days after a runoff event.
- The settling volume is calculated based on the stormwater runoff from the catchment generated by an 85^{th} percentile 5-day rainfall event.
- Sediment storage volume = 50% of settling zone volume.
- A depth of 2 m is adopted for the sediment dams.

Indicative sediment dam sizing at the VCM are listed in Appendix B (Table B.1).

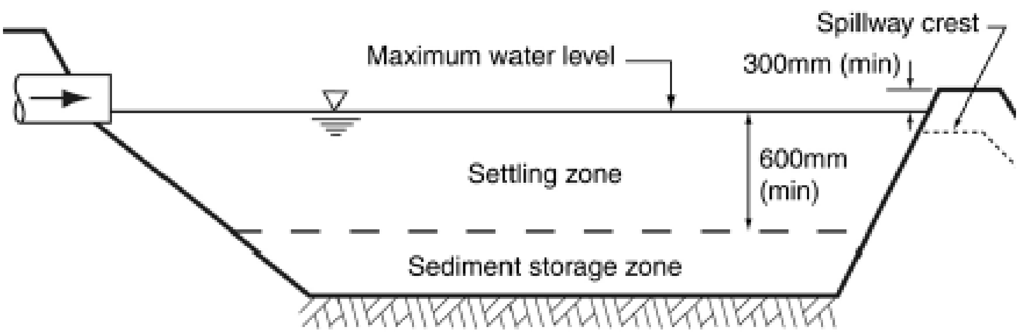

Figure 7.1 Typical type D sediment basin cross-section (Source: IECA, 2008)

7.2.2 Supplementary sediment control techniques

Supplementary sediment controls are used in areas where the sediment producing catchment is small or the potential for producing sediment laden runoff is low. A list of appropriate supplementary sediment control techniques is given in Table 7.1.

Table 7.1 Summary of supplementary sediment control techniques

Technique	Typical use
Rock filter dam	• Locations where there is sufficient room to construct a relatively large rock embankment • The incorporation of a filter cloth is the preferred construction technique if the removal of fine grained sediment is critical (high maintenance)
Check dam sediment trap	• Supplementary sediment trap in minor concentrated flow areas • Trapping sediments in table drains and minor drainage lines • Check dams may be constructed of rock, sand bags or compost filled socks
Buffer zones/ grass filter strips	• Mostly suited to sandy soils • Can provide some degree of turbidity control while the buffer zone remains unsaturated
Sediment fence	• Supplementary device for sheet flow from minor catchment areas • Suitable for all soil types • Require maintenance after every runoff event

8 ESC PLAN

8.1 ESC DECISION PROCESS

The following outlines the steps required to determine the applicable ESC techniques:

1. Identify the need for erosion, drainage and/or sediment control;
2. Define the land disturbance associated with where the control measure will be implemented;
3. Note the priority according to the matrix (Table 8.1) – this may be helpful in assessing which control technique to construct first;
4. What is the erosion potential at the location where the control measure will be implemented (Section 4.4);
5. Apply the ESC matrix (Section 8.4 – Table 8.2) to determine which erosion, drainage and sediment control techniques are applicable;
6. Use IECA (2008) to assess technical requirements of the selected techniques to make an informed decision as to the most appropriate erosion, drainage or sediment control technique to construct;
7. Prepare a plan of the area identifying the adopted techniques and document the measures within GIS that shows the following information:
    a. significant landmark/project boundary;
    b. general soil description;
    c. existing and final contours - including location of cut and fill banks;
    d. existing and final overland flow drainage paths;
    e. limits of clearing where applicable;
    f. location of vegetated buffer strips;
    g. stabilised entry and exit points (rumble pad);
    h. location of soil stockpiles;
    i. location of all proposed temporary drainage control measures;
    j. location of all proposed erosion and sediment control measures including installation sequence and maintenance requirements;
    k. permanent site stabilisation measures; and
    l. a statement of who is responsible for establishing and maintaining all erosion and sediment control measures.
8. Implement maintenance requirements and inspection regime (Section 9.4).

8.2 ESC CRITERIA

The decision as to which combination of ESC measures will be adopted lies with the Mine Site General Manager with input from the site team. The decision will be based on several factors as follows:

- site topography;

- material / soil / surface / strata type – where the control measure will be implemented and downstream of the control measure;
- current disturbance category;
- site specific constraints e.g. proximity of local watercourse;
- length of time that area will remain at this disturbance category;
- overall purpose of implementing ESC at a particular location; and
- applicability of ESC measure as per ESC Matrix.

The selection criteria that should be applied when choosing the most appropriate ESC measure(s) are (refer IECA, 2008):

- applicability to the full range of site conditions considered reasonable (construction phase and operational phase of ESC measure);
- availability of materials from onsite operations;
- cost-effectiveness based upon overall life of the work involved; and
- durability in relation to hydraulic and structural design during the life of the control measure performance in relation to purpose and control standard requirements.

8.3 ESC HAZARD ASSESSMENT

Table 8.1 shows a hazard assessment of the environmental aspects and impacts of the land uses at the VCM. The risk rating of each land use determines the ESC control measures that can be implemented to control drainage, erosion and sediment for each land use type shown in Table 8.2. Note the risk rating for each land use in Table 8.1 has been adopted as the priority rating in Table 8.2.

8.4 ESC MATRIX

Table 8.2 shows a matrix of land uses and ESC measures developed to assist in determining which ESC measure is applicable.

This tool for selecting appropriate ESC measures is based on:

- the phase of the mine site (operational, non-operational or construction);
- land use type (specific to mining applications), adjacent land usage / classification and proximity to watercourses; and
- level of priority in providing ESC measures.

Where multiple ESC measures can be applied to the same situation, the Mine Site General Manager will be consulted. The decision should refer to the factors noted above in Sections 5, 6 and 7.

Once an ESC measure has been selected from the matrix, reference can be made to the IECA (2008) guidelines, which summarise design aspects for each of the ESC measures.

8.5 INSTALLATION SEQUENCE

1. Establish the entry and exit points;
2. Divert upslope catchment around the work site and appropriately stabilise any drainage channels;
3. Install primary sediment control structures;
4. Construct drainage controls (and secondary sediment control structures if required) along the low side of the work site to the primary sediment control structure;

5. Clear only areas needed for works to occur;
6. Stockpile soil within the sediment-controlled area;
7. Stabilise exposed earth with erosion control structures;
8. Commence works;
9. Maintain all control structures in good working order; and
10. Revegetate or otherwise stabilise the site.

Table 8.1 ESC hazard assessment for land uses at the Vulcan Coal Mine

Sources/Domains	Environmental Aspects	Environmental Impacts	Risk
Spoil pile - draining externally	Erosion potential due to exposure and no vegetation cover, potential for material transport offsite	Mobilisation of sediment into waterways resulting in reduction in waterways water quality	HH
Spoil pile - draining internally	Erosion potential due to exposure and no vegetation cover	Inadequate sediment controls prior to release offsite could impact waterways water quality	M
Spoil pile - topsoiled	Erosion potential due to exposure and no vegetation cover, potential for material transport offsite	Mobilisation of sediment into waterways resulting in reduction in waterways water quality	H
Spoil pile – topsoiled/ripped/seeded	Erosion potential due to exposure and no vegetation cover, potential for material transport offsite	Mobilisation of sediment into waterways resulting in reduction in waterways water quality	M
Land clearing	Erosion of topsoil/subsoil surfaces were the material is exposed due to overland flow	Mobilisation of sediment into waterways resulting in reduction in waterways water quality	M
Soil stripping area	Erosion of topsoil/subsoil surfaces were the material is exposed due to overland flow	Mobilisation of sediment into waterways resulting in reduction in waterways water quality	H
Topsoil stockpile	High erosion potential due to lack of vegetation cover and negligible to highly dispersive soils. Potential for material transport offsite and loss of topsoil and subsoil material	Mobilisation of sediment into waterways resulting in reduction in waterways water quality. Loss of topsoil, impacting rehabilitation success	HH
Exploratory and access tracks	Erosion of topsoil/subsoil surfaces were the material is exposed	Mobilisation of sediment into waterways resulting in reduction in waterways water quality	M
Exploration activity	Erosion of topsoil/subsoil surfaces were the material is exposed	Mobilisation of sediment into waterways resulting in reduction in waterways water quality	M
Haul roads	Erosion of engineered earthworks due to overland flow, potential build up of fine grained material due to transport and traffic	Mobilisation of sediment into waterways resulting in reduction in waterways water quality	H
Industrial areas	Limited erosion due to hardstand surface, potential for build up of fine grained material due to transport and traffic. Potential migration of hydrocarbon and chemical substances into dams	Mobilisation of sediment and potentially hydrocarbon and chemical substances which could contaminate ESC structures and downstream waterways	HH

Sources/Domains	Environmental Aspects	Environmental Impacts	Risk
Drainage channels	Erosion of engineered earthworks due to concentrated flow. Build-up of sediment from previous flow events	Potential erosion/gullying of structure due to water volume, potential to impact ESC storage capacity. Mobilisation of sediment into waterways resulting in reduction in waterways water quality	H
Licenced stream diversions / levees	Erosion of engineered earthworks due to concentrated flow, build up of sediment from previous flow events	Potential erosion/gullying of structure due to water volume. Mobilisation of sediment into waterways resulting in reduction in waterways water quality	HH
Construction / excavation work	Erosion of topsoil/subsoil surfaces were the material is exposed due to overland flow	Mobilisation of sediment into waterways resulting in reduction in waterways water quality	M

Table 8.2 ESC Matrix

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				
				Catch Drains	Check Dams (incl. fibre	Grass	Cellular Confinement	Hard Armouring	Rock Mattress	Rock Lining	Level Spreader	Rock Protection	Cellular Confinement	Compost Blanket	Gravelling	Mulching	Revegetation	Rock Mulch	Soil Binders	Rock Filter Dam	Check Dam Sed. Trap	Sediment Basin	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	M	✓	✓	✓														✓	✓	✓	✓	✓
5	O	Topsoil stripping area	M	✓	✓											✓				✓	✓	✓	✓	✓
6	O	Topsoil Stockpiles	HH	✓	✓	✓								✓	✓	✓	✓			✓	✓	✓	✓	✓
7	O	Exploratory and access tracks	M	✓	✓	✓	✓				✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
8	O	Haul Roads	H	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓					✓	✓	✓	✓	✓
9	O	Industrial Areas	HH	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓	✓
10	N	Exploration Activity	M	✓	✓	✓	✓				✓			✓	✓	✓	✓		✓	✓		✓	✓	✓
11	C	Land clearing (woody vegetation)	M	✓	✓						✓					✓				✓		✓	✓	✓
12	O	Drainage channels	H	✓	✓	✓	✓	✓	✓	✓	✓	✓								✓				
13	N	Licenced stream diversions / Levees	HH			✓	✓	✓	✓	✓		✓					✓	✓						
14	C	Construction / excavation work	M	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓

8.6 MAINTENANCE REQUIREMENTS

Maintenance and routine inspection should be undertaken as follows:

- Prior to 1 November each year (prior to onset of wet season); and
- After each significant rainfall event that may have impacted the functionality of the ESC measure.

8.7 ESC INVENTORY REGISTER

An asset register database will be prepared for all ESC structures at the mine site. These assets will be located in a GIS map and a unique identification number (asset number) will be given to them. An inspection proforma template (Appendix C) should be used yearly to assess the condition of all ESC structures on site. Each ESC catchment should have its own inspection template which details the conditions of each control and any actions required.

9 MONITORING AND EMERGENCY REPORTING

9.1 OVERVIEW

This section of the ESCP provides an overview of the surface water monitoring program to assess compliance with the *Model mining conditions* (DES, 2017) in accordance with the WMP. Surface water monitoring locations for the VCM are shown in Figure 9.1.

Monitoring will be undertaken by a suitably qualified person in accordance with the methods prescribed in the latest edition of the administering authority's *Monitoring and Sampling Manual* (DES, 2018).

9.2 SURFACE WATER

9.2.1 Water quantity

The volumes of overflows from sediment dams can be estimated from the level and duration of overflow. Flow volume in North Creek and Boomerang Creek is to be measured using a flow gauge at monitoring point VSW2 shown in Figure 9.1.

9.2.2 Release to receiving waters

The conditions of the VCM EA (Condition F5) specifies that release of water from sediment dams must be monitored at the release locations detailed in Table 9.1, and downstream monitoring point locations specified in Table 9.2, for each quality characteristic specified in Table 9.3.

9.2.3 Water quality

Surface water quality monitoring includes onsite water storages, receiving water and release water monitoring on both a rainfall event and monthly basis. The event based sampling enables quantification of any pollutant loads from the site and their corresponding impact on the receiving water quality. The locations of the monitoring sites are shown in Figure 9.1 and should be undertaken within 2 hours of a release event. Samples will be taken from the following locations:

- Sediment dam release locations as shown in Table 9.1;
- Mine affected water monitoring locations as shown in Table 9.1; and
- Receiving water sites located upstream and downstream of the Project area to assess the potential impact of the project on the existing environment as shown in Table 9.2.

The water quality in receiving waters should meet the contaminant trigger values specified in Table 9.3 (from Table F2 of the Project EA). In the event that water quality is above the trigger level on three consecutive occasions, an investigation on the cause of the exceedance will be undertaken in accordance with Condition F6 of the Project EA.

Table 9.1 Water Release Locations from Dams

Storage name	Latitude	Longitude	Water source	Downstream monitoring point	Receiving waters description
SD1	-22.29314	148.18773	Out of pit spoil dump	VSW2	Drainage line 2 via the existing drainage diversion
SD2	-22.28712	148.18329	Out of pit spoil dump	VSW2	
SD3	-22.27813	148.17893	Northern mine access road	VSW8	Drainage line 1
SD4	-22.29449	148.18781	Topsoil stockpile south of the out of pit spoil dump	VSW2	Drainage line 2 via the existing diversion drain
SD5	-22.29493	148.19295	Southern in pit spoil dump	VSW2	Drainage line 2
SD6*	-22.28537	148.18923	Southern in pit spoil dump	VSW8	Drainage line 1 via the proposed diversion drain
SD7	-22.29197	148.18849	Southern in pit spoil dump	VSW2	
SD8	-22.29452	148.18914	Southern in pit spoil dump	VSW2	Drainage line 2 via the existing drainage diversion
SD9	-22.28529	148.19332	Southern in pit spoil dump	VSW8	Drainage line 1
SD10	-22.27911	148.18782	Southern in pit spoil dump	VSW8	Drainage line 1
SD11*	-22.27850	148.18340	Northern mine access road	VSW8	Drainage line 1 via the proposed diversion drain
SD12*	-22.27721	148.18278	Northern in pit spoil dump	VSW8	
SD13	-22.28572	148.17715	Matilda in pit spoil dump	VSW2	Drainage line 2 via the existing drainage diversion
SD14	-22.28043	148.17748	Matilda in pit spoil dump	VSW2	
SD15	-22.28432	148.17995	Matilda in pit spoil dump	VSW2	
SD16*	-22.28607	148.18011	Matilda in pit spoil dump	VSW2	
SD17*	-22.27835	148.18718	Northern in pit spoil dump	VSW8	Drainage line 1
SD18*	-22.28046	148.18655	Southern in pit spoil dump	VSW8	Drainage line 1 via the proposed diversion drain

Mine water dam monitoring locations / release points			Description
MWD1	-22.28347	148.18218	MWD1 spillway
MWD2	-22.28670	148.18700	MWD2 spillway
MWD3	-22.27556	148.17703	MWD3 spillway
MWD5	-22.28160	148.18550	MWD5 spillway

Note:

* SD6, SD11, SD12, SD16, SD17, and SD18 are release points in the post mining stage and not during the mining stage. During the mining stage, SD6 releases report to the mining pit and will not require monitoring. SD11, SD12, SD16, SD17 and SD18 will be constructed when the in-pit dump begins to discharge off site within their respective catchments.

Locations may change slightly depending on finalisation of in pit spoil dump

Table 9.2 Receiving Waters Quality Monitoring Locations

Description	Latitude (GDA 2020)	Longitude (GDA 2020)	Description
Receiving water monitoring sites			
Upstream sites			
VSW1	-22.27659	148.17451	Diversion bund approximately 3.1 km upstream of Drainage line 2. Used as an upstream monitoring site for the Project.
VSW11	-22.29794	148.18932	Minor drainage line, upstream of confluence of Drainage line 2.
VSW12	-22.275014	148.178265	Minor drainage line, upstream of Drainage line 1.
Downstream sites			
VSW2	-22.30104	148.19523	Drainage Line 2 upstream of the railway. Used as a downstream monitoring site for MWD2, SD1, SD2, SD4, SD5, SD7, SD8, SD13, SD14, SD15 and SD16.
VSW8	-22.27859	148.18782	Drainage Line 1 upstream of the railway. Used as a downstream site for DD1, MWD1, MWD3, MWD4, MWD5, and MWD6 as well as SD3, SD6, SD9, SD10, SD11 and SD12.

Table 9.3 Contaminant trigger investigation levels

Parameter	Dam release point trigger value	Downstream monitoring point trigger value	Source	Frequency
pH (pH units)	6.5 - 8.5	6.5 - 8.5	WQO (aquatic ecosystem)	Upon commencement (the first sample must be taken within 2 hours of commencement of release), daily during release, and within 2 hours after cessation of release.
Electrical Conductivity (µS/cm)	873	727	Locally derived	
Total suspended solids (mg/L)[1]	102	85	Locally derived	
Turbidity (NTU)[1]	352.3	293.6	Locally derived	
Dissolved oxygen	64% - 132% saturation	80% - 110% saturation	WQO (aquatic ecosystem)	
Sulphate (mg/L)	139.2	116	Locally derived	
	Filtered metals and metalloids			
Filtered Lead (µg/L)	4.8	4	MMC (aquatic ecosystem)	Upon commencement (the first sample must be taken within 2 hours of commencement of release), daily during release, and within 2 hours after cessation of release.
Filtered Mercury (µg/L)	0.72	0.6	WQO (aquatic ecosystem)	
Filtered Arsenic (µg/L)	28.8	24	WQO (aquatic ecosystem)	
Filtered Aluminium (µg/L)	76.8	64	Locally derived	
Filtered Molybdenum (µg/L)	40.8	34	WQO (aquatic ecosystem)	
Filtered Selenium (µg/L)	13.2	11	WQO (aquatic ecosystem)	

Note:
1 = Per Condition F19 of the Project EA, dam release point trigger values for Total Suspended Solids and Turbidity can be exceeded for water discharged from the sediment dam during uncontrolled releases during a heavy rainfall event over and above the sediment dam's design storage capacity specified in Table B.1.

9.3 PIPELINE CORRIDOR

The pipeline corridor shown in Figure 9.1 will comply with Conditions F25, F26 and F27 of the VCM EA which state:

- Condition F25 – The pipeline must be designed by and constructed under the supervision of a suitably qualified and experienced person;
- Condition F26 - Hydrostatic Testing of the pipeline after construction must not be completed using mine affected water; and
- Condition F27 - During pumping activities, the holder must inspect the pipeline daily for leaks and hazards with the potential to cause leaks.

9.4 MAINTENANCE AND INSPECTIONS

In accordance with IECA (2008) all ESC measures will be inspected as follows:

- at least daily when rain is occurring;
- within 24 hours prior to expected rainfall; and
- as soon as practicable following a rainfall event of sufficient intensity and duration to cause on-site runoff.

Daily site inspections taking place during periods of runoff inducing rainfall must check:

- all drainage, erosion and sediment control measures;
- occurrences of excessive sediment deposition (whether on-site or off-site); and
- all site discharge points.

Site inspections immediately prior to anticipated runoff inducing events must check:

- all drainage, erosion and sediment control measures; and
- all temporary (i.e. overnight) flow diversion and drainage works.

Site inspections as soon as practicable following runoff producing rainfall must check:

- treatment and dewatering requirements of sediment basins;
- sediment deposition within sediment basins and requirements for its removal;
- the integrity of all drainage, erosion and sediment control measures;
- occurrences of excessive sediment deposition (whether on-site or off-site);
- occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements; and
- occurrences of excessive erosion, sedimentation, or mud generation around the site office, car park and/or material storage area.

In addition to the above, monthly site inspections must check:

- surface coverage of finished surfaces (both area and percentage cover);
- health of recently established vegetation; and
- proposed staging of future land clearing, earthworks, pre-strip activities and site/soil stabilisation.

The inspection and monitoring regime should collect and record the following key information:

- the previous condition of the infrastructure and any recommendations or works actioned since the last inspection;
- the current condition of the ESC infrastructure;
- the ESC controls currently in place, and their condition; and
- recommendations on remedial measures or additional ESC controls.

Any failure of effectiveness of structure will be reported to the Mine Site General Manager. The implementation plan should include the recommendations for the incident report. An example inspection template is shown in Appendix C.

9.5 DAM MONITORING

The embankments of all dams will be monitored annually before the wet season, and during and after flow events to ensure they are operating satisfactorily and have not been damaged through erosion.

Should a dam become damaged, the stored water will be pumped to a suitable water storage facility to minimise the risk of an uncontrolled release to the downstream waterway. The Mine Site General Manager will be responsible for communicating with regulators. A suitably qualified person shall be used to inspect the dam. Repair work will occur as soon as practicable after damage has occurred.

9.6 EMERGENCY RESPONSE

9.6.1 Overview

The proposed water management strategy for the VCM has been developed for both normal operations and during extreme wet weather events in order to:

- minimise the risk of uncontrolled releases from mine-affected water dams; and
- ensure compliance with the *Model mining conditions* (DES, 2017) and the VCM EA.

The emergency response plan for the site is managed in the Project Safety and Health Management System. A summary of the emergency response, should a failure of the water management strategy occur, is given below.

9.6.2 Uncontrolled releases

In the event of an uncontrolled release the administering authority will be contacted in accordance with Condition A12 and Condition A14 of the Project EA as follows:

- Condition A12 - The environmental authority holder must notify the administering authority by written notification within 24 hours of becoming aware of any emergency or incident which:
    a. results in the release of contaminants not in accordance; or
    b. is reasonably expected to be not in accordance with, the conditions of this environmental authority.
- Condition A14 - Within 10 business days following the initial notification of an emergency or incident under Condition A12, or receipt of monitoring results, whichever is the latter, written advice must be provided to the administering authority, including the following:
    c. results and interpretation of any samples taken and analysed;
    d. outcomes of actions taken at the time to prevent or minimise unlawful environmental harm; and
    e. proposed actions to prevent a recurrence of the emergency or incident.

9.7 WET WEATHER ACCESS

During wet weather, site access is restricted due to impassable dirt roads, flooding and safety issues. It is proposed that waterways and sediment dam spillways which have short duration flows and are inaccessible in wet conditions have rising stage sample bottles which can be used to take water samples, minimising exposure of personnel to extreme weather events. It is a requirement under the Project EA that water samples are collected within 2 hours after the start of releases from sediment dams.

9.8 POST-EVENT MONITORING

Dams and drains onsite will be inspected after any significant rainfall event where overflows from sediment dams occur.

Drains and dam spillways will be checked for erosion damage and repaired when required.

9.9 AUDIT SCHEDULE

In addition to the routine maintenance inspections outlined in Section 8.6 and above, an overall audit of the ESCP will be undertaken by the Mine Site General Manager at least annually, following the wet season. The audit will be undertaken to ensure that all ESCP controls on site are being maintained and implemented as required by this ESCP.

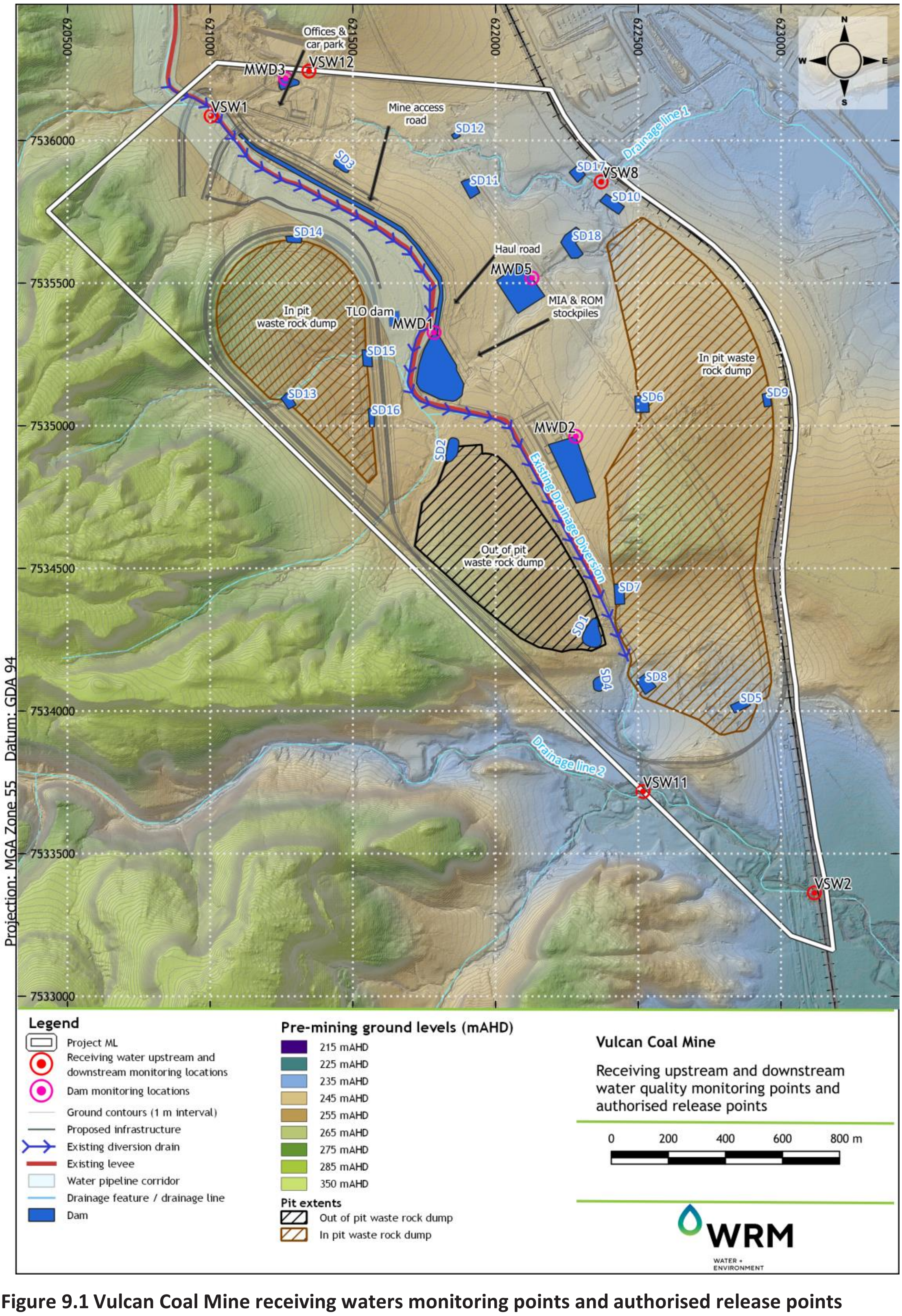

Figure 9.1 Vulcan Coal Mine receiving waters monitoring points and authorised release points

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APPENDIX A EROSION HAZARD ASSESSMENT (IECA, 2008)

Appendix F

Erosion hazard assessment

This appendix provides example procedures for conducting an Erosion Hazard Assessment on a proposed land development. Its function within this document is both educational and prescriptive.

F1. Introduction

Erosion Hazard Assessment is a procedure for undertaking a "preliminary" assessment of the environmental hazard associated with the construction of a given land development. The assessment is based on the land development as a whole, and does not look at individual drainage catchments within the development. Erosion hazard within individual sub-catchments of a development can be assessed using soil loss prediction tools such as RUSLE, for more information refer to Appendix E – *Soil loss estimation.*

An erosion hazard assessment may be performed for a number of reasons, including:

- to identify those land developments that require a preliminary assessment of ESC issues during the planning phase;
- to identify those developments that require a review of the Erosion and Sediment Control Plan (ESCP) by an ESC specialist, such as a Certified Professional in Erosion and Sediment Control (CPESC), an accreditation system administered by the International Erosion Control Association (IECA).

As an example, proponents of developments assessed as high-risk may be required to:

- submit a draft ESCP during the development planning phase;
- submit to the regulatory authority the results of specific soil testing;
- have their final ESCP reviewed by an ESC specialist.

Two methods for assessing the Erosion Hazard are provided within this appendix. Regulatory authorities may choose either system, or an alternative system that better satisfies their needs.

An alternative erosion hazard assessment form for small building sites is provided in Appendix H – *Building sites.*

Technical Note F1 – Erosion Hazard Assessment vs erosion risk rating

Erosion Hazard Assessment is different from the erosion risk rating systems introduced in Section 4.4 (Chapter 4 – *Design standards and technique selection*) of this document for the determination of the Erosion Control Standard. The adoption of an erosion risk rating system allows regulatory authorities to relate the Erosion Control Standard to either the estimated soil loss rate (i.e. RUSLE analysis), the monthly erosivity (i.e. monthly R-factor), or the average monthly rainfall depth.

The Erosion Control Standard can be linked to just the rainfall erosivity or monthly rainfall depth—without consideration of other factors such as surface area, land slope and soil type—because the focus is primarily on raindrop impact erosion rather than sheet and rill erosion. It is noted that the Sediment Control Standard is best linked to the estimated soil loss rate which considers both sheet and rill erosion rates.

F2 TASK number erosion hazard assessment system

The following Erosion Hazard Assessment system is based on a modification of the Revised Universal Soil Loss Equation (RUSLE). The TASK number is directly proportional to the estimated total soil loss within a given region (i.e. for a given rainfall erosivity).

$$H = T \cdot A \cdot S \cdot K \quad \text{(F1)}$$

where:

- H = Numerical value of the TASK number
- T = Duration of soil disturbance [months]
- A = Total area of soil disturbance [m^2]
- S = Slope factor (Table F2 or Equation F3)
- K = Soil erosivity factor (RUSLE K-factor)

The TASK number is used to identify low-risk and high-risk short-term land disturbances within a given region. Regulatory authorities may assign their own trigger value for high-risk sites, however, if a local trigger value has not been adopted, then a default value of 200 is recommended as per Table F1.

Table F1 – Default high-risk trigger value

Hazard Rating	Low-risk	High-risk
TASK Number	< 200	200 or greater

If at the planning stage it is possible to subdivide the soil disturbance area into sub-areas of near-uniform land slope, then the TASK number represents the sum of TASK values determined for each sub-area with soil erodibility K-factor values determined for each sub-area as per Equation F2.

$$\text{TASK Number} = \sum (T.A.S.K) \quad \text{(F2)}$$

T-factor:

The duration of disturbance refers to the total amount of time that the site will be exposed to potential rainfall for the duration of the construction project, or a given stage of the project (if known) up until a time when there is at least 70% vegetative cover, or 100% synthetic cover of all areas of disturbed soil.

In regions where seasonal rainfall is well defined, then the duration of exposure should not include those periods when rainfall is not considered likely to occur.

A-factor:

Note: the A-factor used in the TASK number is **not** the same as the "A" term determined from a RUSLE analysis.

The total area of soil disturbance refers to the maximum area of the disturbance that will occur at any given time over the duration of the project. If at the planning stage it is possible to determine the staging of works, then the area of disturbance must be taken as the total area of disturbance for all stages of the project.

Well-vegetated (protected) land not disturbed by the development project should not be included in the analysis.

S-factor:

The slope factor (S) is based on that land slope of which no more than 10% of the land is steeper. Values of the S-factor are provided in Table F2 and Equation F3. These values are based on the RUSLE's LS-factor for a slope length limited to the best management practice values presented in Table 4.3.2 of Chapter 4 – *Design standards and technique selection*.

Table F2 – Slope factor

Slope (%)	1%	2%	3%	4%	5%	6%	8%	10%	15%	20%	30%
S-factor	0.21	0.35	0.48	0.61	0.73	0.85	1.08	1.29	1.75	2.12	2.58

$$\text{S-factor} = 0.071 + 0.141\,(\text{Slope \%}) - 0.0019\,(\text{Slope \%})^2 \qquad \text{(F3)}$$

K-factor:

The soil erodibility K-factor is the same as the term used in the RUSLE analysis. Preliminary soil testing (refer to Chapter 3 – *Site planning*) will be required to determine the soil classification group.

Table F3 – Nominal K-factors based on Unified Soil Classification System

Brief description	Code	Typical values	Default [1]
Silty gravels, poorly graded gravel-sand-silt	GM	0.00 – 0.06	0.053
Clayey gravels, poorly graded gravel-sand-clay	GC	0.00 – 0.05	0.042
Well graded sands, gravelly sands, little fines	SW	0.00 – 0.04	0.036
Poorly graded sands, gravelly sands, few fines	SP	0.00 – 0.03	0.027
Silty sands, poorly graded sand-silt mixtures	SM	0.01 – 0.05	0.043
Clayey sands, poorly graded sand-clay mixtures	SC	0.02 – 0.05	0.044
Inorganic silts, clayey sands with slight plasticity	ML	0.03 – 0.07	0.062
Inorganic clays of low to medium plasticity	CL	0.02 – 0.06	0.058
Organic silts and organic silt-clay of low plasticity	OL	0.01 – 0.04	0.033
Inorganic silts, fine sands or silty soils, elastic silts	MH	0.02 – 0.07	0.066
Inorganic clays of high plasticity, elastic soils	CH	0.00 – 0.05	0.047

Notes: [1] Default values should be adopted in absence of local site data. The default values have been developed from a statistical analysis of NSW soil data (Landcom, 2004) and represent the statistical average plus one standard deviation for each soil type.

F3. Point score erosion hazard assessment system

The following erosion hazard assessment form is presented as an example. Regulatory authorities may choose to modify its contents and/or trigger value to better address local issues and conditions (e.g. within the catchment of sensitive receiving waters).

The ***total score*** is used to identify certain actions required by the proponent, or may simply be used to identify *low-risk* and *high-risk* sites. Within the attached form, a total scour of 17 (default value) or greater may be considered *high-risk*.

The ***trigger values*** are used to identify issues of particular importance and to trigger specific actions required by the proponent, such as the submission of a preliminary ESCP during the planning phase of the development.

Table F4 – Erosion hazard assessment form

Condition	Points	Score	Trigger value
AVERAGE SLOPE OF DISTURBANCE AREA [1]			
• not more than 3% [3% ↘ 33H:1V]	0		4
• more than 3% but not more than 5% [5% = 20H:1V]	1		
• more than 5% but not more than 10% [10% = 10H:1V]	2		
• more than 10% but not more than 15% [15% ↘ 6.7H:1V]	4		
• more than 15%	6		
SOIL CLASSIFICATION GROUP (AS1726) [2]			
• GW, GP, GM, GC	0		
• SW, SP, OL, OH	1		
• SM, SC, MH, CH	2		
• ML, CL, or if *imported fill* is used, or if soils are untested	3		
EMERSON (DISPERSION) CLASS NUMBER [3]			
• Class 4, 6, 7, or 8	0		6
• Class 5	2		
• Class 3, (default value if soils are untested)	4		
• Class 1 or 2	6		
DURATION OF SOIL DISTURBANCE [4]			
• not more than 1 month	0		6
• more than 1 month but not more than 4 months	2		
• more than 4 months but not more than 6 months	4		
• more than 6 months	6		
AREA OF DISTURBANCE [5]			
• not more than 1000 m^2	0		4
• more than 1000 m^2 but not more than 5000 m^2	1		
• more than 5000 m^2 but not more than 1 ha	2		
• more than 1 ha but not more than 4 ha	4		
• more than 4 ha	6		
WATERWAY DISTURBANCE [6]			
• No disturbance to a watercourse, open drain or channel	0		2
• Involves disturbance to a constructed open drain or channel	1		
• Involves disturbance to a natural watercourse	2		
REHABILITATION METHOD [7] Percentage of area (relative to total disturbance) revegetated by seeding without light mulching (i.e. worst-case revegetation method).			
• not more than 1%	0		
• more than 1% but not more than 5%	1		
• more than 5% but not more than 10%	2		
• more than 10%	4		
RECEIVING WATERS [8]			
• Saline waters only	0		
• Freshwater body (e.g. creek or freshwater lake or river)	2		
SUBSOIL EXPOSURE [9]			
• No subsoil exposure except of service trenches	0		
• Subsoils are likely to be exposed	2		
EXTERNAL CATCHMENTS [10]			
• No external catchment	0		
• External catchment diverted around the soil disturbance	1		
• External catchment not diverted around the soil disturbance	2		
ROAD CONSTRUCTION [11]			
• No road construction	0		
• Involves road construction works	2		
pH OF SOILS TO BE REVEGETATED [12]			
• more than pH 5.5 but less than pH 8	0		
• other pH values, or if soils are untested	1		
Total Score [13]			

Explanatory notes (Point Score system)

Requirements: Specific issues or actions required by the proponent.

Warnings: Issues that should be considered by the proponent.

Comments: General information relating to the topic.

[1] **REQUIREMENTS:**
For sites with an average slope of proposed land disturbance greater than 10%, a preliminary ESCP must be submitted to the regulatory authority for approval during planning negotiations.

Proponents must demonstrate that adequate erosion and sediment control measures can be implemented on-site to effectively protect downstream environmental values.

If site or financial constraints suggest that it is not reasonable or practicable for the prescribed water quality objectives to be achieved for the proposal, then the proponent must demonstrate that alternative designs or construction techniques (e.g. pole homes, suspended slab) cannot reasonably be implemented on the site.

WARNINGS:
Steep sites usually require more stringent drainage and erosion controls than flatter grade sites.

COMMENTS:
The steeper the land, the greater the need for adequate drainage controls to prevent soil and mulch from being washed from the site.

[2] **REQUIREMENTS:**
If the actual soil K-factor is known from soil testing, then the Score shall be determined from Table F5.

If a preliminary ESCP is required during planning negotiations, then it must be demonstrated that adequate space is available for the construction and operation of any major sediment traps, including the provision for any sediment basins and their associated embankments and spillways. It must also be demonstrated that all reasonable and practicable measures can be taken to divert the maximum quantity of sediment-laden runoff (up to the specified design storm) to these sediment traps throughout the construction phase and until the contributing catchment is adequately stabilised against erosion.

WARNINGS:
The higher the point score, the greater the need to protect the soil from raindrop impact and thus the greater the need for effective erosion control measures. A point score of 2 or greater will require a greater emphasis to be placed on revegetation techniques that do not expose the soil to direct rainfall contact during vegetation establishment, e.g. turfing and *Hydromulching*.

COMMENTS:
Table F6 provides an *indication* of soil conditions likely to be associated with a particular Soil group based on a statistical analysis of soil testing across NSW. This table provides only an initial estimate of the likely soil conditions.

The left-hand-side of the table provides an indication of the type of sediment basin that will be required (Type C, F or D). The right-hand-side of the table provides an indication of the likely erodibility of the soil based on the Revised Universal Soil Loss Equation (RUSLE) K-factor.

Table F7 provides some general comments on the erosion potential of the various soil groups.

Table F5 – Score if soil K-factor is known

	RUSLE soil erodibility K-factor			
	K < 0.02	0.02<K<0.04	0.04<K<0.06	K > 0.06
Score	0	1	2	3

Table F6 – Statistical analysis of NSW soil data [1]

Unified Soil Class System	Likely sediment basin classification (%)			Probable soil erodibility K-factor (%) [2]			
	Dry	Wet		Low	Moderate	High	Very High
	Type C	Type F	Type D	K < 0.02	0.02<K<0.04	0.04<K<0.06	K > 0.06
GM	30	**58**	12	12	**51**	26	12
GC	**42**	33	25	13	**71**	17	0
SW	40	**48**	12	**49**	39	12	0
SP	**53**	32	15	**76**	18	5	1
SM	21	**67**	12	26	**48**	25	1
SC	26	**50**	24	16	**64**	18	2
ML	5	**63**	32	4	35	**45**	16
CL	9	**51**	39	12	**56**	19	13
OL	2	**80**	18	34	**61**	5	1
MH	12	41	**48**	15	19	**41**	25
CH	5	44	**51**	39	**43**	11	7

Notes: [1] Analysis of soil data presented in Landcom (2004).
[2] Soil erodibility based on Revised Universal Soil Loss Equation (RUSLE) K-factor.

Unified Soil Classification System (USCS)

GW Well graded gravels, gravel-sand mixtures, little or no fines
GP Poorly graded gravels, gravel-sand mixture, little or no fines
GM Silty gravels, poorly graded gravel-sand-silt mixtures
GC Clayey gravels, poorly graded gravel-sand-clay mixtures
SW Well graded sands, gravelly sands, little or no fines
SP Poorly graded sands, gravelly sands, little or no fines
SM Silty sands, poorly graded sand-silt mixtures
SC Clayey sands, poorly graded sand-clay mixtures
ML Inorganic silts & very fine sands, rock flour, silty or clayey fine sands with slight plasticity
CL Inorganic clays, low–medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
OL Organic silts and organic silt-clays of low plasticity
MH Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
CH Inorganic clays of high plasticity, fat clays
OH Organic clays of medium to high plasticity

Table F7 – Typical properties of various soil groups [1]

Soil Groups	Typical properties [2]
GW, GP	• Low erodibility potential.
GM, GC	• Low to medium erodibility potential. • May create turbid runoff if disturbed as a result of the release of silt and clay particles.
SW, SP	• Low to medium erodibility potential.
SM, SC	• Medium erodibility potential. • May create turbid runoff if disturbed as a result of the release of silt and clay particles.
MH, CH	• Highly variable (low to high) erodibility potential. • Will generally create turbid runoff if disturbed.
ML, CL	• High erodibility potential. • Tendency to be dispersive. • May create some turbidity in runoff if disturbed.

Note: [1] After Soil Services & NSW DLWC (1998).
[2] Any soil can represent a high erosion risk if the binding clays or silts are unstable.

Table F8 provides **general** guidelines on the suitability of various soil groups to various engineering applications.

Table F8 – Engineering suitability based on Unified Soil Classification [1]

Unified Soil Class	USC Group	Embankments		Fill	Slope stability	Untreated roads
		Water retaining	Non water retaining			
Well graded gravels	GW	Unsuitable	Excellent	Excellent	Excellent	Average
Poorly graded gravel	GP	Unsuitable	Average	Excellent	Average	Unsuitable
Silty gravels	GM	Unsuitable	Average	Good	Average	Average
Clayey gravels	GC	Suitable	Average	Good	Average	Excellent
Well graded sands	SW	Unsuitable	Excellent	Excellent	Excellent	Average
Poorly graded sands	SP	Unsuitable	Average	Good	Average	Unsuitable
Silty sands	SM	Suitable [2]	Average	Average	Average	Poor
Clayey sands	SC	Suitable	Average	Average	Average	Good
Inorganic silts	ML	Unsuitable	Poor	Average	Poor	Unsuitable
Inorganic clays	CL	Suitable [2]	Good	Average	Good	Poor
Organic silts	OL	Unsuitable	Unsuitable	Poor	Unsuitable	Unsuitable
Inorganic silts	MH	Unsuitable	Poor	Poor	Poor	Unsuitable
Inorganic clays	CH	Suitable [2]	Average	Unsuitable	Average	Unsuitable
Organic clays	OH	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable
Highly organic soils	Pt	Unsuitable	Unsuitable	Unsuitable	Unsuitable	Unsuitable

Notes: [1] Modified from Hazelton & Murphy (1992)
[2] Suitable only after modifications to soil such as compaction and/or erosion protection

[3] If the soils have not been tested for Emerson Class, then adopt a score of 4.

REQUIREMENTS:
Works proposed on sites containing Emerson Class 1 or 2 soils have a very high pollution potential and must submit a conceptual ESCP to the regulatory authority for review and/or approval (as required by the authority) during planning negotiations.

WARNINGS:
Class 3 and 5 soils disturbed by cut and fill operations or construction traffic are highly likely to discolour stormwater (i.e. cause turbid runoff). Chemical stabilisation will likely be required if these soils are placed immediately adjacent to a retaining wall. Any disturbed Class 1, 2, 3 and 5 soils that are to be revegetated must be covered with a non-dispersive topsoil as soon as possible (unless otherwise agreed by the regulatory authority).

Class 1 and 2 soils are highly likely to discolour (pollute) stormwater if exposed to rainfall or flowing water. Treatment of these soils with gypsum (or other suitable substance) will most likely be required. These soils should not be placed directly behind a retaining wall unless it has been adequately treated (stabilised) or covered with a non-dispersible soil.

[4] The duration of disturbance refers to the total duration of soil exposure to rainfall up until a time when there is at least 70% coverage of all areas of soil.

REQUIREMENTS:
All land developments with an expected soil disturbance period greater than 6 months must submit a conceptual ESCP to the regulatory authority for review and/or approval (as required by the authority) during planning negotiations.

COMMENTS:
Construction periods greater than 3 months will generally experience at least some significant storm events, independent of the time of year that the construction (soil disturbance) occurs.

[5] **REQUIREMENTS:**
Development proposals with an expected soil disturbance in excess of 1ha must submit a conceptual ESCP to the regulatory authority for review and/or approval (as required by the regulatory authority) during planning negotiations.

The area of disturbance refers to the total area of soil exposed to rainfall or dust-producing winds either as a result of:

(a) the removal of ground cover vegetation, mulch or sealed surfaces;
(b) past land management practices;
(c) natural conditions.

WARNINGS:
A *Sediment Basin* will usually be required if the disturbed area exceeds 0.25ha (2500m^2) within any sub-catchment (i.e. land flowing to one outlet point).

COMMENTS:
For soil disturbances greater than 0.25ha, the revegetation phase should be staged to minimise the duration for which soils are exposed to wind, rain and concentrated runoff.

[6] **REQUIREMENTS:**
All developments that involve earthworks or construction within a natural watercourse (whether that watercourse is in a natural or modified condition) must submit a conceptual ESCP to the regulatory authority for review and/or approval (as required by the regulatory authority) during planning negotiations.

Permits and/or licences may be required from the State Government, including possible submission of the ESCP to the relevant Government department.

COMMENTS:
The management of works within a natural watercourse is discussed in Appendix I – *Instream works*.

[7] **REQUIREMENTS:**
No areas of soil disturbance shall be left exposed to rainfall or dust-producing winds at the end of a development without an adequate degree of protection and/or an appropriate action plan for the establishment of at least 70% cover.

COMMENTS:
Grass seeding without the application of a light mulch cover is considered the least favourable revegetation technique. A light mulch cover is required to protect the soil from raindrop impact, excessive temperature fluctuations, and the loss of essential soil moisture.

[8] **COMMENTS:**
All receiving waters can be adversely affected by unnatural quantities of sediment-laden runoff. Freshwater ecosystems are generally more susceptible to ecological harm resulting from the inflow of fine or dispersible clays than saline water bodies. The further inland a land disturbance is, the greater the potential for the released sediment to cause environmental harm as this sediment travels towards the coast.

For the purpose of this clause it is assumed that all sediment-laden runoff will eventually flow into saline waters. Thus, sediment-laden discharges that flow first into freshwater are likely to adversely affect both fresh and saline water bodies and are therefore considered potentially more damaging to the environment.

This clause does **not** imply that sediment-laden runoff will not cause harm to saline waters.

[9] **COMMENTS:**
This clause refers to subsoils exposed during the construction phase either as a result of past land practices or proposed construction activities. The exposure of subsoils resulting from the excavation of minor service trenches should not be considered.

[10] **WARNINGS:**
The greater the extent of external catchment, the greater the need to divert up-slope stormwater runoff around any soil disturbance.

COMMENTS:
The ability to separate "clean" (i.e. external catchment) stormwater runoff from "dirty" site runoff can have a significant effect on the size, efficiency and cost of the temporary drainage, erosion, and sediment control measures.

[11] **REQUIREMENTS:**

Permission must be obtained from the owner of a road reserve before placing any erosion and sediment control measures within the road reserve.

WARNINGS:

Few sediment control techniques work efficiently when placed on a road and/or around roadside stormwater inlets. Great care must be taken if sediment control measures are located on a public roadway, specifically:

- safety issues relating to road users;
- the risk of causing flooding on the road or within private property.

The construction of roads (whether temporary or permanent) will usually modify the flow path of stormwater runoff. This can affect how "dirty" site runoff is directed to the sediment control measures.

COMMENTS:

"On-road" sediment control devices are at best viewed as secondary or supplementary sediment control measures. Only in special cases and/or on very small projects (e.g. kerb and channel replacement) might these controls be considered as the "primary" sediment control measure.

[12] **WARNINGS:**

Soils with a pH less than 5.5 or greater than 8 will usually require treatment in order to achieve satisfactory revegetation. Soils with a pH of less than 5 (whether naturally acidic or in acid sulfate soil areas) may also limit the choice of chemical flocculants (e.g. Alum) for use in the flocculation of *Sediment Basins*.

[13] **REQUIREMENTS:**

A preliminary ESCP must be submitted to the local government for approval during the planning phase for any development that obtains a total point score of 17 or greater or when any trigger value is scored or exceeded.

APPENDIX B SEDIMENT DAM SIZING

Table B.1 Sediment dam sizing

Storage name	Max. catchment area (ha)	Storage volume required (ML)	Dam surface area (ha)	5-day dewatering rate (ML/d)	Sediment dam water source
SD1^	17.9	4.0 (5.9)	0.26 (0.38)	0.8	Out of pit spoil dump
SD2^	12.1	2.7 (5.6)	0.18 (0.36)	0.7	Out of pit spoil dump
SD3^	9.6	2.1 (3.8)	0.14 (0.25)	0.5	Northern mine access road
SD4^	2.1	0.5 (0.5)	0.03 (0.07)	0.1	Topsoil stockpile south of the out of pit spoil dump
SD5	12.6	2.8	0.18	0.4	Southern in pit spoil dump
SD6	18.0	4.0	0.26	0.5	Southern in pit spoil dump
SD7	13.9	3.1	0.20	0.4	Southern in pit spoil dump
SD8	11.1	2.5	0.16	0.3	Southern in pit spoil dump
SD9	8.2	1.8	0.12	0.2	Southern in pit spoil dump
SD10	19.9	4.4	0.29	0.6	Southern in pit spoil dump
SD11	14.9	3.3	0.21	0.4	Northern mine access road
SD12	3.6	0.8	0.05	0.1	Northern in pit spoil dump
SD13	8.9	2.0	0.13	0.3	Matilda in pit spoil dump
SD14	7.0	1.6	0.10	0.2	Matilda in pit spoil dump
SD15	10.7	2.4	0.16	0.3	Matilda in pit spoil dump
SD16	6.9	1.5	0.10	0.2	Matilda in pit spoil dump
SD17	10.1	2.2	0.14	0.3	Northern in pit spoil dump
SD18	30.5	6.8	0.44	0.9	Southern in pit spoil dump

Notes: Surface areas (based on dam depth of 2 m) are concept sizes only and to be confirmed during detailed design.
^ Existing Dam – Existing dam capacities and surface areas based on Jan 2024 survey are provided in brackets

APPENDIX C SITE-SPECIFIC ESC INSPECTION TEMPLATE

ESCP Inspection Proforma			
Date:	Time:	Name/Department:	
Regiter ID:	Mining Area:	Description:	Type:
Previous Inspection Date		Previous Report :	
Does the Catchment drain off lease?			No

Outstanding actions	Action

ESCP controls	Condition at inspection	Action
Drain		Yes
Drain		Yes
Dam Spillway		Yes
Rehab Slope		Yes
Drain		Yes

Action Number	Actions required	Time Frame
1		Before Next Inspection
2		Before Wet Season
3		ASAP
4		
5		
6		
7		
8		

ASAP Action Assignment

Person/s Responsible	SAP EHSM	Due Date

Additional Controls required in compliance with ESCP

Location of controls	Comments
	•
	•
	•
	•
	•
	•
	•

Action required to allow catchment to drain off lease in compliance with ESCP

-
-
-
-
-
-

OTHER COMMENTS

-
-
-
-
-

Feature Diagram
Inspection Photo/s

Figure C.1 Example ESC inspection template

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