1 Cover Page

Codrilla Coal Mine Project
Progressive Rehabilitation & Closure Plan

ML 70450 & ML 70455

Prepared for:	Department of Environment and Science
Prepared by:	Peabody on behalf of the CMJV
EA holders:	Peabody Coppabella Pty Ltd – CITIC Australia Coppabella Pty Ltd – Winchester Coal Operations Pty Ltd – KC Resources Pty. Ltd. – NS Coal Pty Ltd
EA holder contact details:	Level 5, 100 Melbourne Street, South Brisbane, QLD 4101
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2 Table of Contents

1 Cover Page 0
2 Table of Contents 1
3 Rehabilitation planning part 7
3.1 Project planning 7
3.1.1 Baseline Information 7
3.1.1.1 Site topography 8
3.1.1.2 Climate 9
3.1.1.3 Geological setting 12
3.1.1.4 Site hydrology and fluvial networks 14
3.1.1.5 Groundwater levels and properties 20
3.1.1.6 Soil types, properties and productivity 24
3.1.1.7 Land stability 31
3.1.1.8 Flora and Fauna 33
3.1.1.9 Pre-mining land use 51
3.1.1.10 Underlaying landholders 53
3.1.2 Project Description 54
3.1.2.1 Resource tenure 54
3.1.2.2 Primary mine features/infrastructure on site 55
3.1.2.3 Type of mining operation 56
3.1.2.4 Proposed duration of operation 58
3.1.3 Design for closure 58
3.1.4 Rehabilitation/Improvement Planning 58
3.1.4.1 Relevant activities on site 58
3.1.4.2 Rehabilitation Strategy 60
3.1.4.3 PMLU Rehabilitation goals and objectives 62
3.1.4.4 Rehabilitation areas and milestones 63
3.1.4.5 NUMA Rehabilitation goals and objectives 67
3.1.4.6 Improvement areas and milestones 67
3.1.5 Spatial Information 68
3.2 Community Consultation 69
3.2.1 Background 69
3.2.2 Community consultation register 70
3.2.3 Community consultation plan 73
3.2.3.1 Objectives 73

3.2.3.2 Key stakeholders 73
3.3 Post-mining land use (PMLU) 76
3.3.1 Consistency with outcome from community consultation 77
3.3.2 Consistency with Local, State and Commonwealth land use requirements 78
3.4 Non-use management areas (NUMAs) 78
3.4.1 Description of the NUMAs 78
3.4.2 Consistency with outcome from community consultation 80
3.4.3 Consistency with Local, State and Commonwealth requirements 81
3.4.4 Voids in flood plains 81
3.5 Rehabilitation management methodology 83
3.5.1 General rehabilitation practices 83
3.5.1.1 Progressive rehabilitation process 83
3.5.1.2 Hydrogeology 85
3.5.1.3 Flooding 92
3.5.1.4 Soil and capping material assessment 96
3.5.1.5 Waste characterisation 99
3.5.1.6 Landform design 105
3.5.1.7 Cover Design 110
3.5.1.8 Water Management 112
3.5.1.9 Revegetation 114
3.5.2 Tailings storage facilities 116
3.5.3 Voids 119
3.5.3.1 Highwall Slope Design 120
3.5.3.2 Low Wall Slope Design 122
3.5.4 Underground Mining 124
3.5.5 Built infrastructure 124
3.5.5.1 Services 124
3.5.5.2 Buildings 125
3.5.5.3 Water Management Structures 125
3.5.5.4 Access roads, car parks and hardstands 125
3.5.5.5 Hydrocarbon and chemical storage areas 125
3.5.5.6 Haul roads 125
3.6 Risk assessment 127
3.6.1 Risk Identification 128
3.6.2 Risk Analysis & Risk Evaluation 128

3.6.4 Rehabilitation trials 138
3.7 Monitoring and maintenance 139
3.7.1 Rehabilitation Monitoring and Maintenance Program 140
3.7.1.1 Vegetation & Fauna Monitoring 140
3.7.1.2 Final Landform Monitoring 141
3.7.1.3 Water Quality Monitoring 141
3.7.1.4 Baseline Monitoring & Reference Sites 142
3.7.1.5 Sampling Intensity 143
3.7.1.6 Frequency 144
3.7.1.7 Maintenance 144
3.7.1.8 Monitoring and validation methods 145
3.7.1.9 Identification of Actual or Emerging Issues 149
3.7.1.10 Scheduled & Event Based Inspections 149
3.7.1.11 Use of Data to Evaluate Rehabilitation Trends / Trajectory 149
3.7.1.12 Reporting and the identification of Management Requirements 149
4 Appendices and attachments 150
4.1 PRC Plan Schedule 150
4.1.1 Final Site Design 151
4.1.2 Rehabilitation Areas/Improvement Areas, PMLU/NUMA & Relevant Rehabilitation/Management Milestones 157
4.1.3 PMLU Rehabilitation Milestones and Criteria 159
4.1.4 NUMA Improvement Availability and Milestones 161
4.2 Attachment - Codrilla EA EPML00916813 162
4.3 Attachment - EIS Assessment Report for the Codrilla Coal Mine Project 163
4.4 Attachment – Supplementary EIS Groundwater Report (AGE Consultants – April 2011) 164
4.5 Attachment - EIS Soil, Overburden and Land Use Report (GSSE – Sept 2010) 165
4.6 Attachment - Supplementary EIS Surface Water Report (WRM - 10 June 2011) 166
4.7 Attachment - Updated Feasibility Level Geotechnical Study for Codrilla (IMC – 23 March 2012) 167
4.8 Attachment - Millennium Mine Residual Void Slope Stability Study (GCS - August 2017) 168

List of Tables

Table 1 Average Monthly & Annual Temperatures 11
Table 2 Average Monthly & Annual Rainfall 11
Table 3 Average Monthly & Annual Evaporation 11
Table 4 Summary of Geology & Stratigraphic Sequence of the Codrilla Project 13
Table 5 Recorded water quality data, Swampy Creek, Devlin Creek and the Isaac River 17
Table 6 Trace metal water quality data, Swampy Creek, Devlin Creek and the Isaac River 18
Table 7 GW monitoring bores 22
Table 8 Brown Yellow Duplex Soil description 24
Table 9 Brown Grey Duplex Soil description 25
Table 10 Brown Duplex Soil description 26
Table 11 Yellow Duplex Soil description 26
Table 12 Land Capability Classifications 28
Table 13 Land Suitability Classes 29
Table 14 Estimated Erosion Rates using the RUSLE 30
Table 15 Regional Ecosystems and their status 34
Table 16 Trap site details 37
Table 17 Presence and abundance of non-bird ground-active and arboreal vertebrate fauna (Amphibians) 41
Table 18 Presence and abundance of non-bird ground-active and arboreal vertebrate fauna (Reptiles) 42
Table 19 Presence and abundance of non-bird ground-active and arboreal vertebrate fauna (Mammals) 43
Table 20 Presence and abundance of non-bird ground-active and arboreal vertebrate fauna (Species) 45
Table 21 Presence and abundance of birds 45
Table 22 Macroinvertebrate species identified and abundance 51
Table 23 Property Details for ML70450 53
Table 24 Property Details for ML70455 53
Table 25 Codrilla Mining Leases 54
Table 26 Approved Environmentally Relevant Activities 58
Table 27 Disturbance domains and sub-domains that will require rehabilitation 58
Table 28 PMLU Native Bushland 62
Table 29 PMLU Grazing 63
Table 30 Rehabilitation Areas 63
Table 31 Rehabilitation Milestones & Milestone Criteria 64
Table 32 NUMA 67
Table 33 Improvement Areas 67
Table 34 Management Milestones 67
Table 35 Community consultation register 70
Table 36 Key Stakeholders 73
Table 37 Ongoing consultation plan 74
Table 38 Consultation plan for PRC Plan or schedule changes 75
Table 39 PMLU by domain and sub-domain 77
Table 40 Estimated Available Topsoil Quantities 97
Table 41 Stockpile Area Required (ha) 98

Table 42 Pasture Species Mix....114
Table 43 Native Species Seed Mix....115
Table 44 Scoring system used to assess risk....129
Table 45 Risk Assessment PMLU....130
Table 46 Risk Assessment NUMA....135
Table 47 Summary of Rehabilitation Monitoring Methodology....142
Table 48 Maintenance Issues & Treatments....145
Table 49 Monitoring & Validation methods....145
Table 50 Rehabilitation Areas & Milestones....158
Table 51 Rehabilitation Milestones and Criteria....159
Table 52 Management Milestones and Criteria....161

List of Figures

Figure 1 Project location....8
Figure 2 Existing Topography....9
Figure 3 Distribution of Monthly Rainfall & Evaporation....12
Figure 4 Site Hydrology & Fluvial Networks....15
Figure 5 Water Quality Sampling Locations....16
Figure 6 2000 Year ARI Flood Depths, Devlin Creek....19
Figure 7 Conceptual Cross section of Groundwater regime....21
Figure 8 GW Monitoring Bores, Levels and Contours....23
Figure 9 Soil Unit Classification and Sample Locations....27
Figure 10 Vegetation Communities – Regional Ecosystems (REs) on ML70450....36
Figure 11 Vegetation Communities – REs on ML70455....37
Figure 12 Fauna sites, spotlighting routes and features of ML 70450....39
Figure 13 Fauna sites, spotlighting routes and features on ML 70455....40
Figure 14 Freshwater sites on ML 70450....50
Figure 15 Broadsound Shire Planning Scheme....52
Figure 16 Underlaying tenure....53
Figure 17 Primary mine features/Infrastructure....55
Figure 18 Co-disposal & MIA layout....56
Figure 19 Draft EIS Final Landform....80
Figure 20 Supplementary EIS Final Landform....81
Figure 21 Final void location and 2000 Year ARI Flood....82
Figure 22 Groundwater Model 3D Representation....85
Figure 23 Observed and Simulated Pre-Mining Groundwater Levels....86
Figure 24 Current Projected Landform (contours) over Groundwater Model Assumed Landform (shaded)....87
Figure 25 Post Mining Predicted Groundwater Levels....88
Figure 26 Post Mining Groundwater Predicted Drawdown using EIS Groundwater Model....88
Figure 27 Predicted Long-term Groundwater Levels....89
Figure 28 Devlin Creek 2000 Year ARI Flood Depths....93
Figure 29 Levee induced Change in Flood Depth 2000 Year ARI....94
Figure 30 Fully Geotechnical Borehole Plan (2012)....101
Figure 31 Conceptual Waste Dump Encapsulation Strategy....102

Figure 32 Current Proposed Final Landform Design 105
Figure 33 Typical Overburden / Interburden Waste Dump Profile 108
Figure 34 Groundwater Modelled Void (blue shade) versus Current Proposed East Void (contours) 109
Figure 35 Predicted Groundwater Level Recovery 109
Figure 36 Schematic of typical soil cover systems suitable for use on potentially contaminating tailings 111
Figure 37 Final landform conceptual drainage direction 113
Figure 38 Co-disposal Cell Liner Options 117
Figure 39 Infrastructure Area showing Co-Disposal Dam site 118
Figure 40 Generic Cut Slope Design for Highwalls and End Walls 121
Figure 41 Final Highwall Bund Location 122
Figure 42 Generic Cut Slope Design for Low Walls 122
Figure 43 Generic Profile for In Pit Dumped Low Wall 123
Figure 44 Risk Management Process 128
Figure 45 Final Site Design 152
Figure 46 Final Landform Regional Contour Plan 153
Figure 47 Final Landform - oblique view looking northwest 154
Figure 48 Cross Sections through West Pit 155
Figure 49 Cross Sections through East Pit 156
Figure 50 Rehabilitation Areas & Improvement Areas 157

3 Rehabilitation planning part

A Progressive Rehabilitation and Closure Plan (PRC Plan) Transition Notice was issued under section 754 of the *Environmental Protection Act 1994* (EP Act) by the Department of Environment and Science to the holders of Environmental Authority (EA) EPML00916813 for the Codrilla Coal Mine Project (Codrilla Project). The due date for submission of the PRC Plan to the administering authority is the **30th July 2021**.

This PRC Plan has been developed in accordance with sections 126C and 126D of the EP Act and with the requirements specified in the PRC plans Guideline (ESR/2019/4964 – Version 2.00).

Section 750 of the EP Act defines land outcome documents and the PRC Plan guideline (ESR/2019/4964 – Version 2.00) states that the land outcome document list is hierarchical and if there are inconsistencies between these documents on either the final outcomes or details of the outcome, then the document appearing first in the above list will prevail to the extent of the inconsistency. In the context of the Codrilla Project, the following are considered to be land outcome documents:

- EA EPML00916813 dated 6th April 2016
- EIS Assessment Report for the Codrilla Coal Mine Project dated October 2011

This PRC Plan comprises the rehabilitation planning part and the schedule.

Legislative requirements

In accordance with section 126C(1)(b) and (c)(ii) of the EP Act, the rehabilitation planning part of the PRC plan must include a description of:

- each resource tenure, including the area of each tenure
- the relevant activities to which the application relates
- the likely duration of the relevant activities
- how and where the relevant activities are to be carried out, including maps.

3.1 Project planning

3.1.1 Baseline Information

The Codrilla Project is located approximately 45km south-west of the township of Nebo in Central Queensland and approximately 120km south-west of Mackay, the nearest major regional centre. It is situated within the Isaac Regional Council which is a well-established grazing, farming and coal mining region within the Bowen Basin.

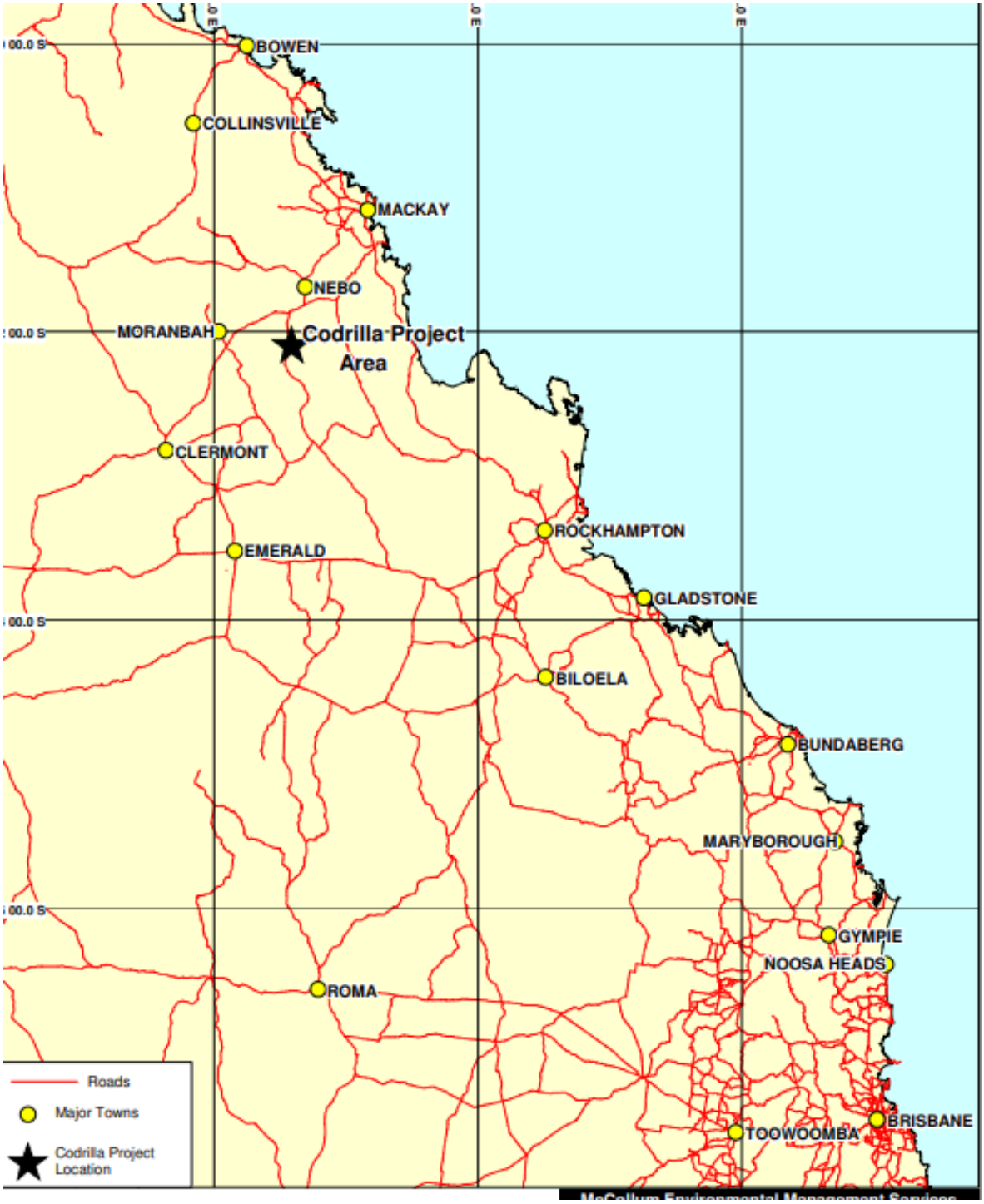


Figure 1 Project location

3.1.1.1 Site topography

To the north of the Codrilla Project area the landform is dominated by a ridge line known as the Flora Range (sometimes referred to as the Orange Range) which includes the topographic features of Mount Orange and Mount Marion, located 10km to 15km respectively to the north and northwest of the Codrilla Project. Approximately 20km to the southwest of the Codrilla Project is Mount Coxendean (also known as Coxen's Peak).

The local catchment area is dominated by Devlin Creek, which flows into the Isaac River approximately 38km to the south east of the Codrilla Project and ultimately into the Fitzroy River. Devlin Creek and its tributaries are ephemeral and only flow for short periods following significant rainfall. The general landfall is from the north west to the south east congruent with the catchment drainage system.

The general topography of the land within and immediately surrounding the Codrilla Project site is flat to gently undulating with surface relief less than 2.3° (4%).

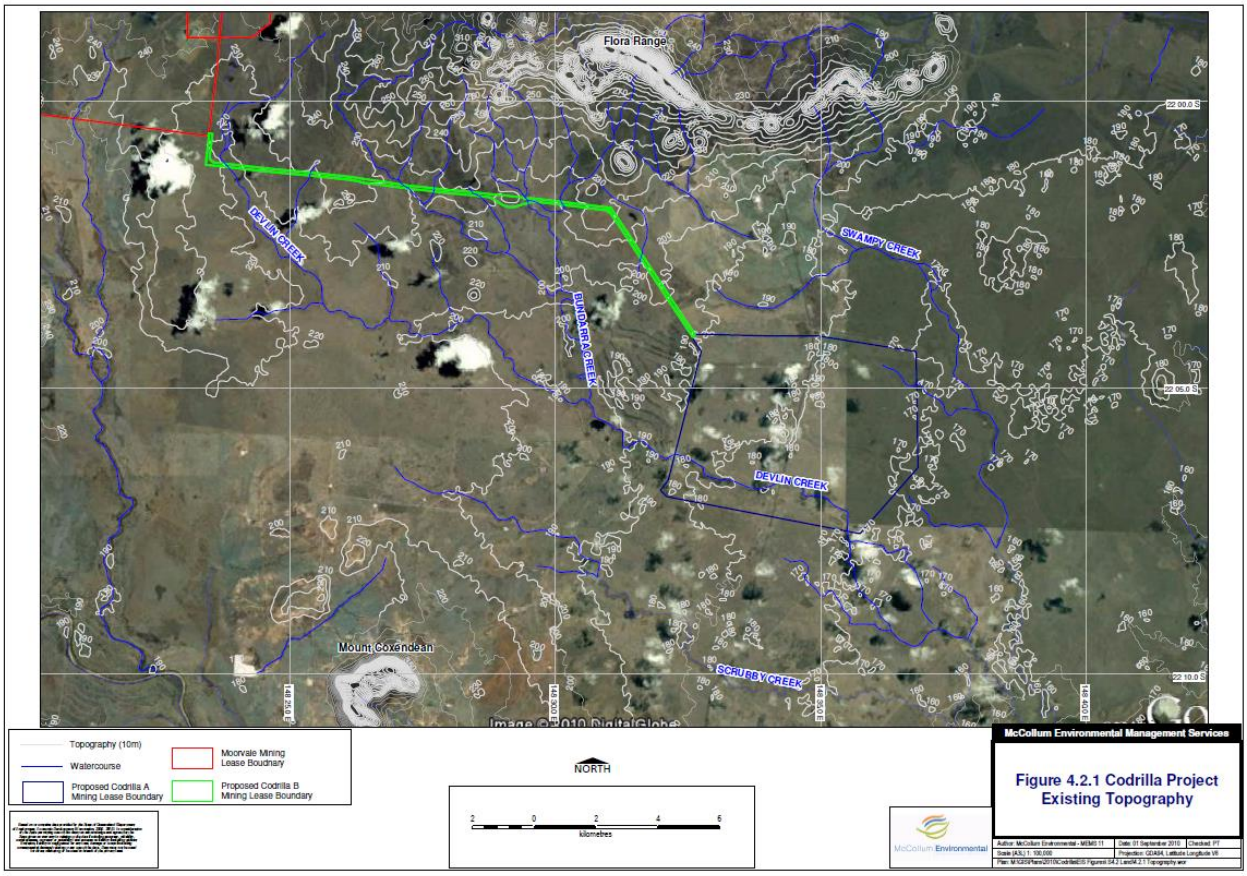


Figure 2 Existing Topography

3.1.1.2 Climate

The climate of the Codrilla Project site and surrounding areas is classified as BSh (hot semi-arid climate), according to the Köppen-Geiger climate classification. These climates tend to have hot summers and warm to cool winters with some to minimal rainfall. High variability in rainfall, temperature and evaporation are common in Central Queensland. The region experiences a predominance of southerly to south-easterly winds of low velocity (less than 10 km per hour).

Local rainfall, evaporation and temperature data has been sourced from surrounding Bureau of Meteorology weather stations:

- Moranbah Water Treatment Plant (station 034028) — operated from 1972 to March 2012.
- Moranbah Airport (station 034035) — operational from March 2012.

Climate Variability

The *State of the Climate Report 2020* (CSIRO and BoM 2020) says that Australian rainfall is highly variable, which makes it difficult to identify significant trends over time. Northern Australian average annual rainfall has increased since national records began in 1900, largely due to increases in rainfall from October to April annually.

The *State of the Climate Report 2020* says Australia's weather and climate are changing in response to a warming global climate system. Australia has warmed by around 1.44 °C (+/-0.24 °C) since 1910, with most warming occurring since 1950 and every decade since then being warmer than the one before. Warming is observed across Australia in all months with both day and night-time temperatures increasing. This warming is leading to an increase in the frequency of extreme heat events. Australia's warmest year on record was 2019, and the seven years from 2013 to 2019 all rank in the nine warmest years. The warming trend occurs against a background of year-to-year climate variability, mostly associated with El Niño and La Niña in the tropical Pacific Ocean.

Rainfall and streamflow have increased across parts of northern Australia since the 1970's. As the climate warms, heavy rainfall events are expected to continue to become more intense.

Sea surface temperatures in the Australian region have warmed by more than 1 °C since 1900, with eight of the ten warmest sea surface years on record occurring since 2010.

The *State of the Climate Report 2020* says Australia's shift to a warmer climate is accompanied by more extreme heat events on daily, multi-day and seasonal timescales.

Modelling indicates that Australia will experience more intense short-duration heavy rainfall events throughout the country. There will be fewer tropical cyclones, but a greater proportion of cyclones are projected to be of high intensity, with ongoing large variations from year to year.

There has been an increase in extreme fire weather, and in the length of the fire season, across large parts of Australia since the 1950s. The Bowen Basin region has seen a significant increase in dangerous fire weather days.

Temperature

The mean daily summer temperature in the region ranges from 20 degrees Celsius (°C) to 35.3 °C while the mean winter temperature ranges from 7.9 °C to 23.7 °C. Heat waves can occasionally be expected between October and March and frosts between May and August. Monthly average minimum and maximum temperatures for both weather stations is shown in Table 1 on the following page.

Rainfall

The Codrilla Project area has a summer dominant rainfall pattern with an average annual rainfall of 614.2 millimetres (mm) measured at the Moranbah Water Treatment Plant and 533.7 mm at Moranbah Airport. Monthly average rainfall for both weather stations is shown in Table 2 on the following page and in the rainfall & evaporation figure on page 11.

Evaporation

Evaporation rates exceed rainfall for all months of the year. Annual evaporation at the Moranbah Water Treatment Plant is approximately four times higher than annual rainfall. This leads to a high

annual net evaporative loss. Monthly average evaporation for the Moranbah Water Treatment Plant (not available for Moranbah Airport) is shown on the following page.

Table 1 Average Monthly & Annual Temperatures

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (°C) — Moranbah Water Treatment Plant	33.8	33.1	32.1	29.5	26.5	23.7	23.7	25.5	29.2	32.3	33.1	34.0	29.7
Mean minimum temperature (°C) — Moranbah Water Treatment Plant	21.9	21.8	20.2	17.6	14.2	11.1	9.9	11.1	14.1	17.6	19.4	21.1	16.7
Mean maximum temperature (°C) — Moranbah Airport	35.3	32.3	32.0	30.0	27.2	24.2	24.2	26.9	30.1	32.9	35.1	35.3	30.3
Mean minimum temperature (°C) — Moranbah Airport	21.5	20.7	19.7	16.4	12.7	9.7	8.1	7.9	12.1	14.9	18.9	20.0	15.2

Table 2 Average Monthly & Annual Rainfall

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall (mm) — Moranbah Water Treatment Plant	103.8	100.7	55.4	36.4	34.5	22.1	18.0	25.0	9.1	35.7	69.3	103.9	614.2
Mean rainfall (mm) — Moranbah Airport	115.7	119.9	73.0	38.8	19.6	22.7	23.7	11.2	11.7	5.0	55.7	54.85	533.7

Table 3 Average Monthly & Annual Evaporation

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Mean evaporation (mm) — Moranbah Water Treatment Plant	248	207.2	210.8	171	133.3	105	114.7	151.9	198	248	255	263.5	2306.4

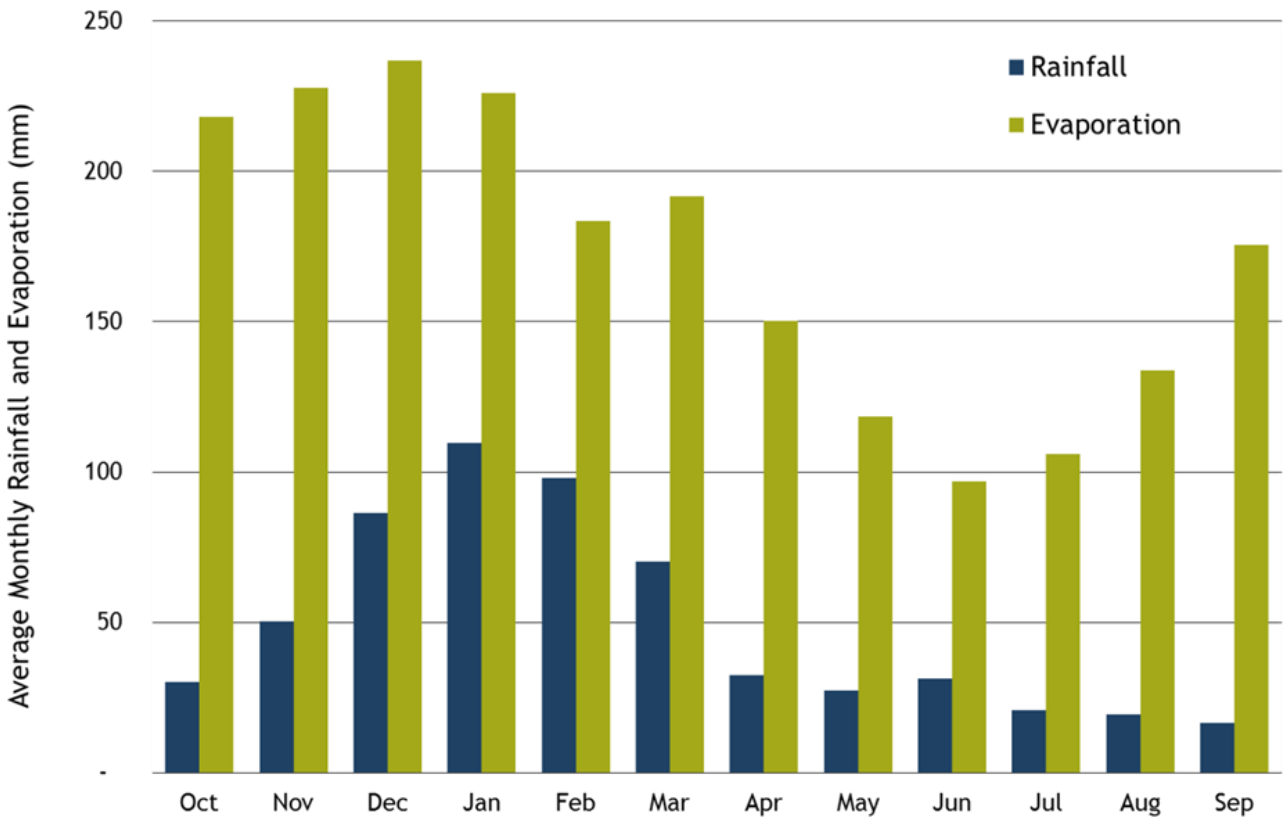


Figure 3 Distribution of Monthly Rainfall & Evaporation

3.1.1.3 Geological setting

The Codrilla Project is located within the Bowen Basin. The Bowen Basin is divided into a number of tectonic units comprising north/north-west – south/ south-east trending platforms or shelves, separated by sedimentary troughs. The Codrilla Project deposit is located within the Collinsville Shelf of the northern Bowen Basin along the eastern edge of the large regional syncline referred to as Coxendean sub-basin. Four Permo-Triassic units have been intersected during exploration drilling at the Codrilla Project, which have been subjected to geological forces and consequently dip towards the south west, relative to the north easterly position of the Codrilla Project site within the Coxendean sub-basin where the northern extents of the sub-basin alignment have been disrupted by doming caused by the nearby Bundara Intrusive Complex. At this location the coal deposit sediments form a syncline gently dipping to the south-west sub-cropping in a U-shaped zone.

The Moranbah Coal Measures (MCM) consists of labile sandstone, siltstone, mudstone and coal seams. Although extensively mined on the western margin of the Bowen Basin, the unit is as yet unworked on the eastern side of the Bowen Basin. The MCM will not be affected by the Project.

Overlying the MCM is the Fort Cooper Coal Measures (FCCM) which are highly deformed and intruded with local dips up to 70°. The formation consists of labile sandstones and siltstones, and a number of thick seams of interbedded coal, carbonaceous mudstone and tuffaceous claystone. The coal seams typically contain high percentages of inherent ash and have no export potential. The best developed of these seams is the Girrah seam, which consists of inter-banded coal, which can be up to 25 metres thick, tuffs and carbonaceous mudstone, with the stone bands comprising greater than 50% of the seam. The Vermont Lower (VL) seam ranges from 1.0 to 5.4 metres thick and is generally heavily

banded with dirt, and in places splits into the Vermont Lower 1 (VL1) and Vermont Lower 2 (VL2) seams.

The Yarrabee Tuff Bed (YTB) is regarded as the top of the FCCM (Matheson, 1990). At the Codrilla Project site the YTB comprises up to 1m of brown, tuffaceous claystone.

Overlying the YTB is the Rangal Coal Measures (RCM) which comprise 140-195 metres of light grey, lithic sandstones (commonly siderite cemented) inter-banded with layers of siltstone, mudstone, minor carbonaceous shale and low to moderate ash coal seams. Two coal seams, the Vermont Upper (VU) seam and the Leichhardt Lower 2 (LL2) seam, reach economic thickness at the Project site. The VU is a clean, bright, unbanded seam which averages 7.5m within the Codrilla Project area. The Leichhardt LL2 averages 1.75m thickness and is comprised of inter-banded dull and bright coal with no significant stone bands. Other minor splits of the Leichhardt Seam occur intermittently, ranging in thickness to 1.4m of dull, but generally clean coal.

The Rewan Group, which conformably overlies the RCM, comprises distinctive greenish-grey labile sandstones and siltstones and mottled red and green mudstones; however, exploration drilling has shown that no coal is present within this formation. The boundary with the underlying RCM occurs at the top of the uppermost carbonaceous bed or at the colour change from the greenish-grey sediments of the Rewan Group, to the grey sandstones and siltstones of the RCM.

The Permo-Triassic sediments are unconformably overlain by unconsolidated Tertiary and Quaternary sediments comprising mainly clays, fine to coarse-grained sands and gravel. Strongly lithified silcrete and ferricrete layers mark buried surfaces. Exploration undertaken indicates that the depth of weathering is generally greater than 55m.

Table 4 Summary of Geology & Stratigraphic Sequence of the Codrilla Project

Geological Sequence and Age (Million Years (My))	Geological Unit	Description of Lithology	Thickness (m)
Quaternary 0 – 1.75 My	Quaternary Alluvium (Qa)	Soils, clays, silts, sands and gravels	0-14
Tertiary and Quaternary 0 to 65 My	Tertiary – Quaternary Sediments (TQa)	Clay, silt, sand and gravel: high level alluvium and colluvium	30-60
Triassic 203 to 250 My	Rewan Formation (Rr)	Coarse green lithic sandstone, pebbles, fine and pebble conglomerate and red and green mudstone	0 – 700
Upper Permian 250 – 295 My	Rangal Coal Measures (Pwj)	Coal seams, carbonaceous shales, and mudstone, light grey litho fieldspathic sandstone, grey to dark grey siltstones and mudstones	140 – 195
	Fort Cooper Coal Measures (Pwt)	Labile sandstones and siltstones with thick seams of interbedded coal, carbonaceous mudstone and tuffaceous claystone	400
	Moranbah Coal Measures	Labile sandstone, siltstone, mudstone and coal seams	400 – 450

The coal seams of the Codrilla Project area are cupped into a syncline dipping southwest, forming a U-shaped crop zone on the far north-eastern flank of the Coxendean Sub-basin. To the north, the Coxendean Sub-basin has been disrupted by doming caused by intrusions related to the Bundarra Intrusive Complex associated with the Flora Range. No intrusions have been intersected in the targeted seams within the Codrilla Project area; however, given the major topographic highs to the north associated with the Flora Range, dykes emanating from this structure could be expected to transect the deposit.

Large displacement faults trending north north-west along the axis of the Coxendean Sub-basin have been detected by two dimensional (2D) seismic traverses undertaken to the west of the Codrilla Project area. These faults are truncated by the doming associated with the Bundarra Intrusive Complex. The current fault regime is based on interpretation of the structure contours and the 2D seismic survey sections.

3.1.1.4 Site hydrology and fluvial networks

The Codrilla Project is located within the Devlin Creek catchment area, forming part of the Isaac-Connors sub catchment of the Fitzroy Basin. The Devlin Creek catchment area covers approximately 1,200km^2, with the major tributaries draining into the catchment including:

- *Swampy Creek;*
- *Bundarra Creek;*
- *An unnamed tributary of Bundarra Creek;*
- *Birdies Gully;*
- *Duck Creek;*
- *Scrubby Creek; and,*
- *South* Creek.

The nearest operational mine to the Codrilla Project is the Moorvale Mine located some 30km to the west and located at the headwaters of Devlin Creek.

The Codrilla Project footprint covers approximately 230km^2 of the Devlin Creek catchment, with Devlin Creek, Bundarra Creek, the unnamed tributary of Bundarra Creek and a tributary of Swampy Creek flowing through the Project areas. Due to the very flat topography of the Devlin Creek floodplain, flow paths for local stormwater drainage are poorly defined. There are also no well-defined watercourses across the floodplain. Devlin Creek has an incised channel with a base width of 5-10m and is 3-5m deep. The creek banks are steep and vegetated with a mixture of native species. Creek bank erosion is evident in areas and old meander bends that are now cut off from the main channel are evident. The floodplain is characteristically wide and flat and, as a result, stormwater flow paths are not distinctly apparent. Creeks in the locality of the Codrilla Project are ephemeral in nature.

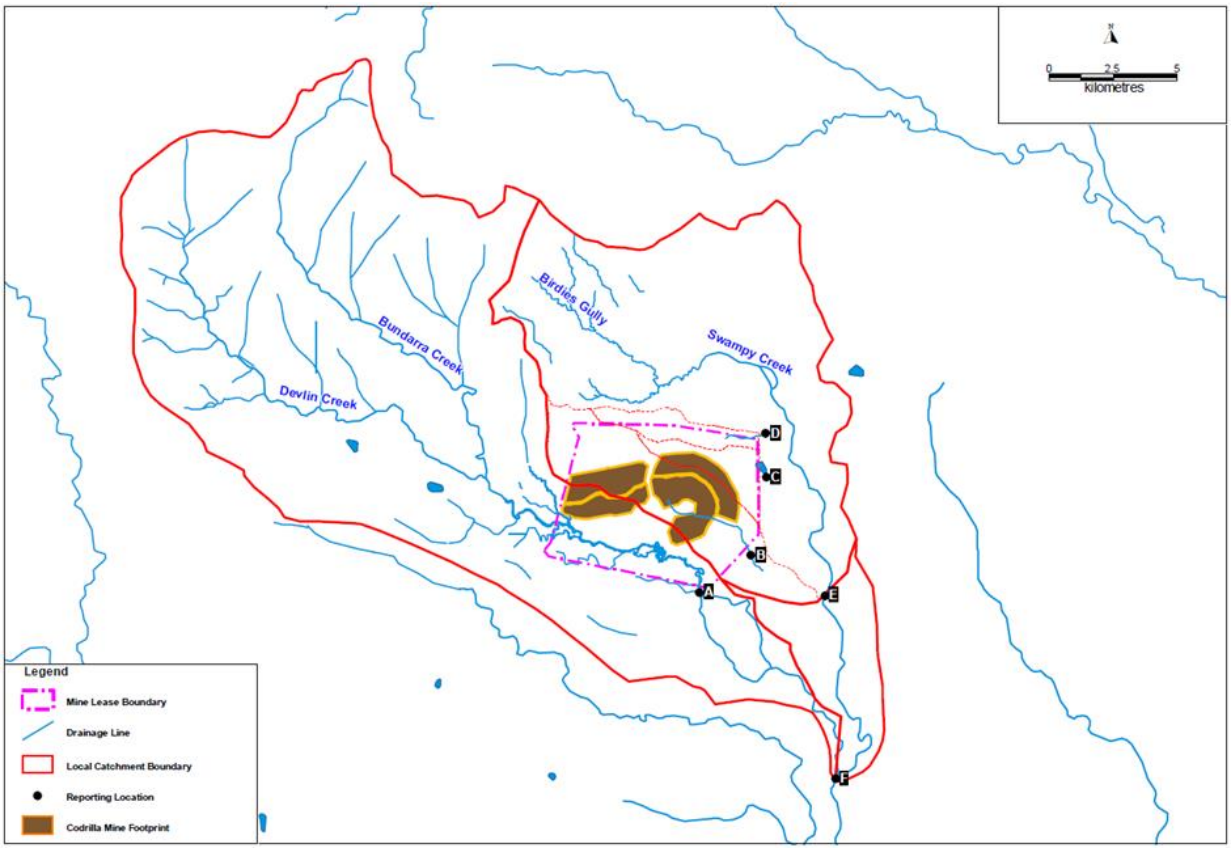


Figure 4 Site Hydrology & Fluvial Networks

Streams in the vicinity of the Codrilla Project are shown in Figure 4 (above).

There are currently no formal water use entitlements along Devlin Creek; however, DERM (now DES) provided advice for the EIS that the owners of Lot 9 on KL119 (located about 23km south-east of the MLs) hold a permit to source water from Devlin Creek for stock and domestic supply. It is also possible that other landholders and livestock may access small volumes of water from Devlin Creek on an informal basis.

Average rainfall in the region surrounding the Codrilla Project occurs primarily in the summer months, with distinct wet and dry seasons. Consequently, stream flow data in the area is limited to historical downstream monitoring due to the ephemeral nature of watercourses in the Devlin Creek catchment.

Data from water sampling conducted at the locations shown in Figure 8 indicate that Devlin Creek, both upstream and downstream of the mining lease, has pH and salinity levels that are lower than the recommended DES Regional Guideline Values. Levels for hardness, total suspended solids, total nitrogen and phosphorus naturally exceed the recommended Regional Guideline Levels. The majority of metal levels in Devlin Creek are below recommended DES Release Contaminant Trigger Levels; however, levels for aluminium, chromium, copper, cadmium, iron, uranium and zinc naturally exceed the Trigger Levels.

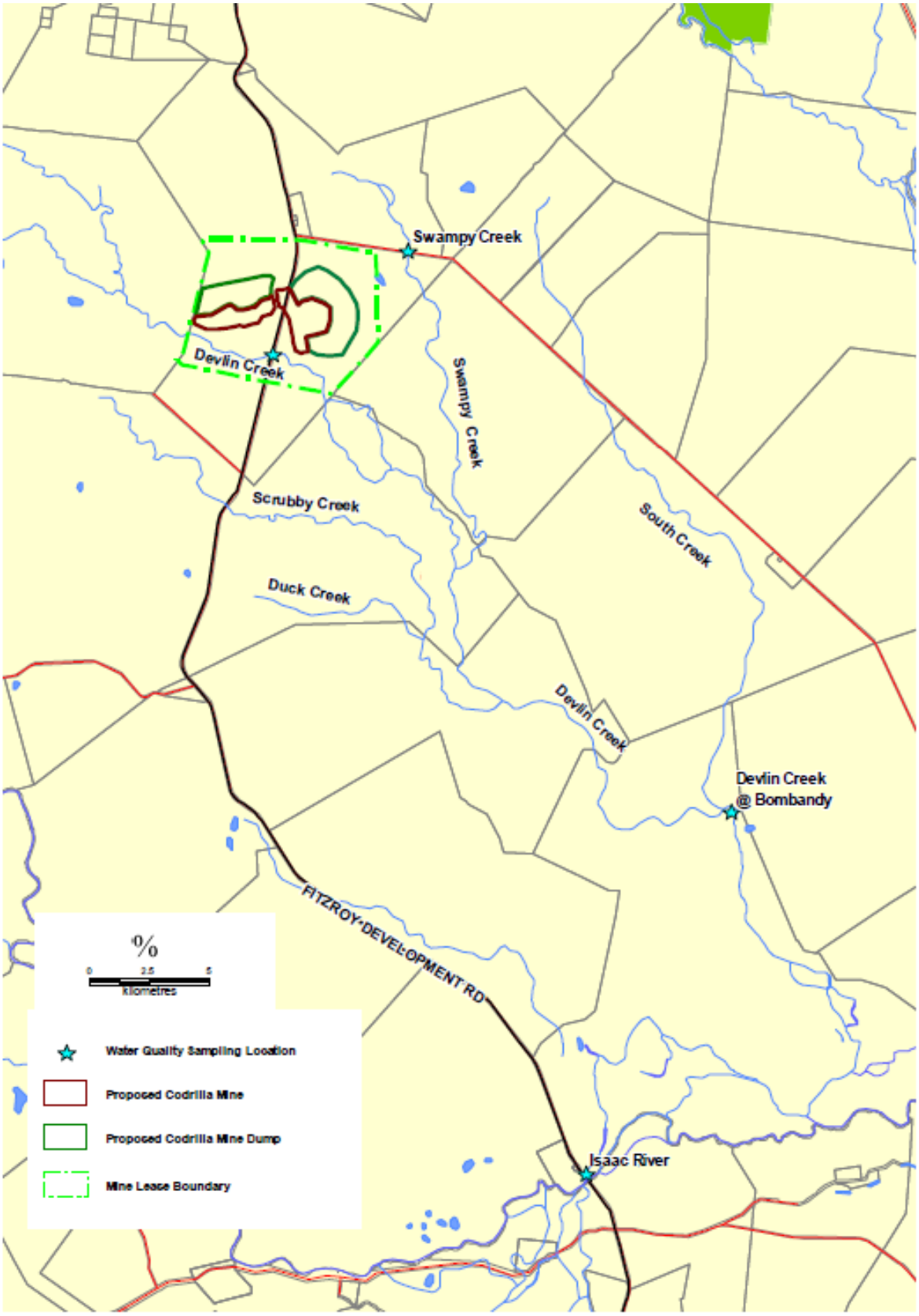


Figure 5 Water Quality Sampling Locations

Sampling results, shown in Table 5 and Table 6 below, demonstrate that the primary environmental values applicable to surface water are biological integrity and agricultural uses.

Table 5 Recorded water quality data, Swampy Creek, Devlin Creek and the Isaac River

Parameter	Units	Mean Water Quality^				DERM Regional Guideline Values
		Swampy Creek at Valkyrie Road	Devlin Creek at FDR	Devlin Creek at Bombandy	Isaac River	
pH	pH Units	6.7 (4)	7.1 (4)	7.4 (21)	7 (3)	6.5-7.5
Temperature	°C	26.4 (4)	26.3 (4)	23.4 (16)	26.7 (3)	-
Conductivity	µS/cm	118.1 (4)	323.4 (4)	152 (21)	234.7 (3)	720
Turbidity	NTU	>322 (4)	>435 (4)	85 (4)	>1000 (3)	25
Dissolved Oxygen	mg/L	5 (4)	5.3 (4)	NA (-)	3.5 (3)	90-110 (%)
Hardness	mg/L	30.3 (4)	40.3 (4)	44.6 (18)	67.7 (3)	-
Total Suspended Solids	mg/L	101 (4)	161.5 (4)	125.5 (14)	166.3 (3)	-
Total Nitrogen	mg/L	<1.3 (4)	<1.5 (4)	NA (-)	1.3 (3)	0.25
Total Phosphorus	mg/L	<0.4 (4)	0.1 (4)	NA (-)	0.2 (3)	0.03
Sulphate	mg/L	<1.6 (4)	<6.5 (4)	3.9 (8)	6.3 (3)	-
Fluoride	mg/L	<0.2 (4)	<0.2 (4)	0.1 (14)	0.2 (3)	-

^ Number in brackets is the number of samples on which the mean value is based.

Table 6 Trace metal water quality data, Swampy Creek, Devlin Creek and the Isaac River

Parameter	Units	Mean Water Quality				DERM Release Contaminant Trigger Levels
		Swampy Creek at Valkyrie Road	Devlin Creek at FDR	Devlin Creek at Bombandy	Isaac River	
Aluminium	µg/L	3460 (4)	3817.5 (4)	NA (-)	12400 (3)	100
Antimony	µg/L	<5 (4)	<5 (4)	NA (-)	<5 (3)	-
Arsenic	µg/L	<5 (4)	<5.8 (4)	NA (-)	<5.3 (3)	13
Beryllium	µg/L	<2 (4)	<2.3 (4)	NA (-)	<1 (3)	-
Boron	µg/L	40 (4)	52.25 (4)	0.04 (4)	<36.7 (3)	370
Cadmium	µg/L	<1.6 (4)	<1.6 (4)	NA (-)	<0.5 (3)	0.2
Chromium	µg/L	<7.8 (4)	<5.5 (4)	NA (-)	<17.3 (3)	1
Cobalt	µg/L	<6.3 (4)	<7.8 (4)	NA (-)	<9 (3)	90
Copper	µg/L	<7.5 (4)	<5.1 (4)	NA (-)	12.7 (3)	2
Lead	µg/L	<6.4 (4)	5.15 (4)	NA (-)	<5.3 (3)	10
Manganese	µg/L	177.5 (4)	161.75 (4)	NA (-)	<171 (3)	1900
Molybdenum	µg/L	<5 (4)	<5 (4)	NA (-)	<5 (3)	34
Nickel	µg/L	<7 (4)	<9.3 (4)	NA (-)	<21.3 (3)	11
Selenium	µg/L	<5 (4)	<5 (4)	NA (-)	<5 (3)	10
Uranium	µg/L	<1.6 (4)	<1.6 (4)	NA (-)	<0.5 (3)	1
Vanadium	µg/L	<13.8 (4)	<14.2 (4)	NA (-)	<23.3 (3)	10
Zinc	µg/L	18.75 (4)	32.5 (4)	NA (-)	<45 (3)	8
Iron	µg/L	3377.5 (4)	3532.5 (4)	1600 (5)	15733.3 (3)	300
Mercury	µg/L	<0.1 (4)	<0.1 (4)	NA (-)	<0.1 (3)	0.2

^ Number in brackets is the number of samples on which the mean value is based.

Flooding

Flood modelling was conducted as part of the EIS (see Appendix 4.6) and existing flood levels in the Codrilla Project area were simulated using the URBS and TUFLOW models. The URBS model was the preferred flood forecast model used by the Bureau of Meteorology. The URBS model estimates the peak flood discharges by modelling how runoff moves through the catchment. Once the peak flood discharges were determined for 2, 10, 100, 2000-year ARI and Probable Maximum Flood (PMF) events, the TUFLOW model was used to estimate flood extents, velocities and behaviour.

The flood modelling was conducted adopting the Australian Rainfall and Runoff (ARR) (1987) and its terminology. The new edition of ARR (2019) adopts probability terminology that differs from that used in ARR87. The adopted terminology meets the requirements of the Engineers Australia's National Committee on Water Engineering. Changes have been summarised as follows:

- The term Annual Exceedance Probability (AEP) will be used for design events (rainfalls and floods) including and rarer (less frequent) than those with a 10% AEP;
- AEPs are to be expressed as an exceedance probability using percentage probability, for example, a design rainfall will be described as having a 1% AEP;
- Events that are more frequent than those with a 50% AEP will be expressed as X Exceedances per Year (EY). For example, a design event (rainfall or flood) with a 6-month recurrence interval will be expressed as having 2 Exceedances per Year (2EY); and,
- The use of Average Recurrence Interval (ARI) is discouraged as it is problematic for frequent events in seasonal climates and leads to confusion with the public for rare events.

Existing flood levels modelled show the following results:

- The 2-year ARI design flood is mostly contained within the Devlin Creek main channel and does not impact on the mine footprint;
- The 10-year, 100-year and 2,000-year ARI design floods do not impact on the eastern pit and overburden dump of the mine; and,
- The western end of the open cut pit is subject to partial backwater flooding during all events of 10-year ARI and larger.

Figure 6 below shows the extent of the existing Devlin Creek in a 2000 Year ARI, which is equivalent to a 0.05% AEP under the ARR Guideline (2019) and is consistent with the requirements under section 126D (3) of the EP Act.

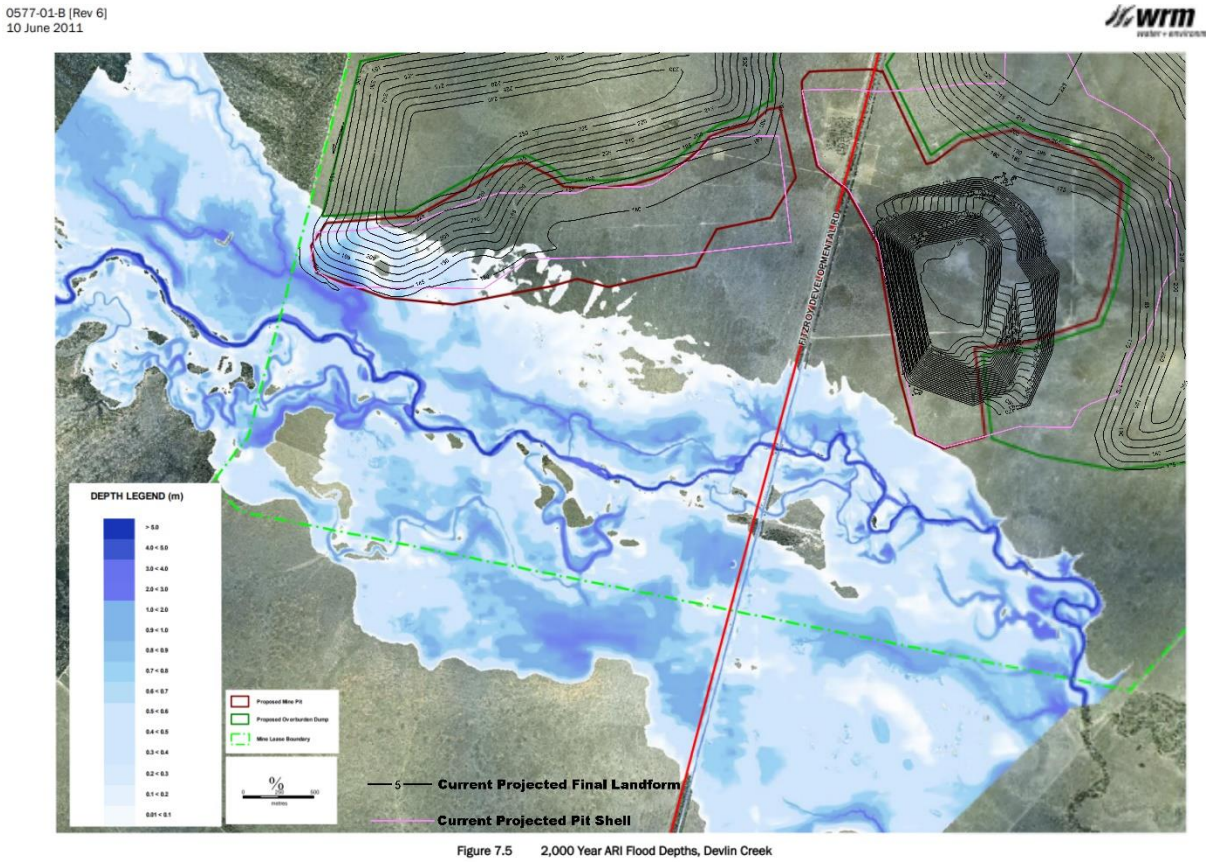


Figure 6 2000 Year ARI Flood Depths, Devlin Creek

3.1.1.5 Groundwater levels and properties

Four aquifer systems have been identified in the area of the Project. Each system is associated with discrete features of the stratigraphic sequence in the area, being:

- Shallow alluvium aquifers which recharge primarily associated with direct infiltration from the surface during rainfall and ephemeral creek flow events. Yields and permeability are expected to be very low, variable and unreliable in these aquifers;
- Tertiary sediment aquifers which recharge and discharge via direct inflow from surface influences such as rainfall and runoff, via inflow from the perched alluvial aquifers and inflow and discharge to and from the underlying Permian / Triassic and Coal Seam aquifers. Yield and permeability are low to moderate within the aquifers;
- Permian and Triassic aquifers which recharge via direct infiltration of rainfall/surface water runoff and groundwater flow into and from the overlying Tertiary aquifer. These aquifers showed significant variability in permeability and yield; and,
- Coal seam aquifers which recharge via direct infiltration of rainfall/surface and groundwater flow into and from the overlying aquifers. These aquifers showed significant variability in permeability and yield.

Generally the alluvial aquifers are associated with watercourses and form a localised perched system above the Tertiary, Permian and Triassic and Coal seam aquifers. The Tertiary, Permian and Triassic and Coal seam aquifers are collectively considered to be the regional aquifer system. The regional aquifer system is believed to be geologically isolated from other mining operations of the region.

The creeks within the Codrilla Project area are ephemeral and recharge of the alluvium is by direct infiltration of rainfall and infiltration of surface water during creek flow. It is likely that water drains to the base of the alluvium relatively quickly after rainfall events with its saturation governed by the lateral extent, depth and interconnection of sandy sediments extending below the base of the creek invert. Groundwater discharge from the alluvium occurs through:

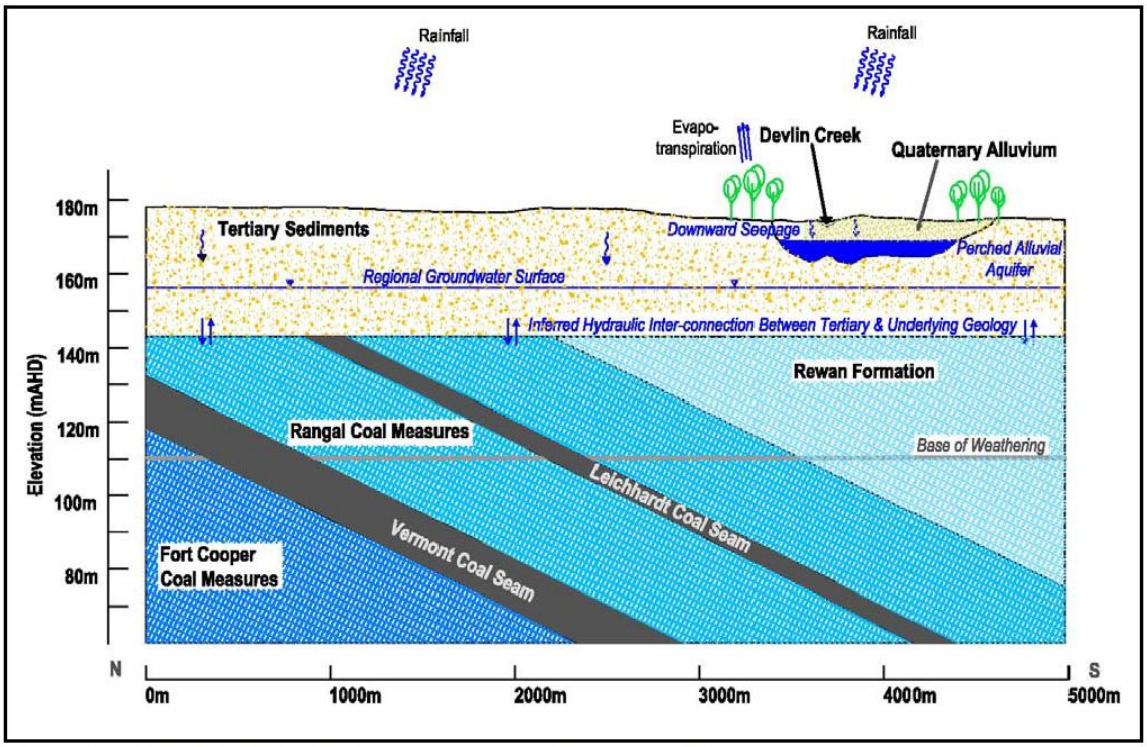
- Evapo-transpiration from vegetation growing in the creek beds and along the banks;
- Baseflow in the permeable sands and gravels; and
- Infiltration and recharge to the underlying older formations where the creeks cross more permeable zones within these units.

Groundwater levels within the alluvium would be sustained principally by rainfall infiltration, whilst those within the regional aquifer by interconnection with the deeper underlying Triassic and Permian aquifers. The regional groundwater levels would therefore be considered a subdued reflection of the ground surface topography being generally flat within the Codrilla Project area to more elevated beneath hill areas. Groundwater discharge within the alluvial aquifer would be from base flows within the more permeable sediments, evaporation and evapo-transpiration through vegetation where the water table is within a few metres of the ground surface (and via extraction from water bores where present).

Groundwater discharge from the deeper regional aquifer would be expected to be into incised creeks/rivers that intersect the regional groundwater surface, considered to occur south-east of the Codrilla Project area.

The general flow of groundwater in the area is towards the south east with piezometric level contours indicating a gradient and direction generally similar to the surface topography of the mine project area catchment.

Figure 7 shows a conceptual cross section of the groundwater regime located in approximately the centre of the Codrilla Project.



Note – this figure is conceptual only – coal seams are not based on actual data

Figure 7 Conceptual Cross section of Groundwater regime

A network of 11 monitoring bores has been established in the Project area. The bores were strategically located outside of the mining footprint and targeted a broad spatial distribution across the Project area, including locations upstream and downstream of the mining activities. Representation of the specific aquifers of the Project area was also targeted.

Table 7 GW monitoring bores

Bore ID	Latitude S (-ve) ° ' " (MGA94)	Longitude E °' " (MGA94)	Ground elevation Metres – Australian Height Datum (mAHD)	Bore Depth Metres Below Ground Level (mBGL)	Aquifer \ Material	Post Construction Standing Water Level (SWL)	
						mBGL	mAHD
MB1	22°5'32.13"	148°32'30.15"	182.890	76	Permian & Triassic	18.90	164.00
MB2	22°5'32.19"	148°32'30.25"	182.859	32	Tertiary Sediments	19.40	163.46
MB3	22°6'13.84"	148°32'16.40"	179.727	130	Permian & Triassic	68.60	111.13
MB4	22°6'13.78"	148°32'16.43"	179.787	12	Alluvium	5.00	174.78
MB5	22°6'3.36"	148°33'36.99"	176.740	84	Permian & Triassic	22.03	154.71
MB6	22°4'48.44"	148°36'17.87"	169.810	86	Coal Seam	16.47	153.34
MB7	22°4'48.57"	148°36'17.94"	169.775	34	Tertiary Sediments	16.54	153.24
MB8	22°5'22.34"	148°34'22.45"	177.730	88	Coal Seam	19.40	158.34
MB8B	22°5'22.24"	148°34'22.56"	177.702	34	Tertiary Sediments	18.50	159.21
MB9	22°7'9.49"	148°34'48.35"	171.117	106	Coal Seam	17.61	153.51
MB10	22°7'9.49"	148°34'48.45"	171.168	7.5	Alluvium	Dry	Dry

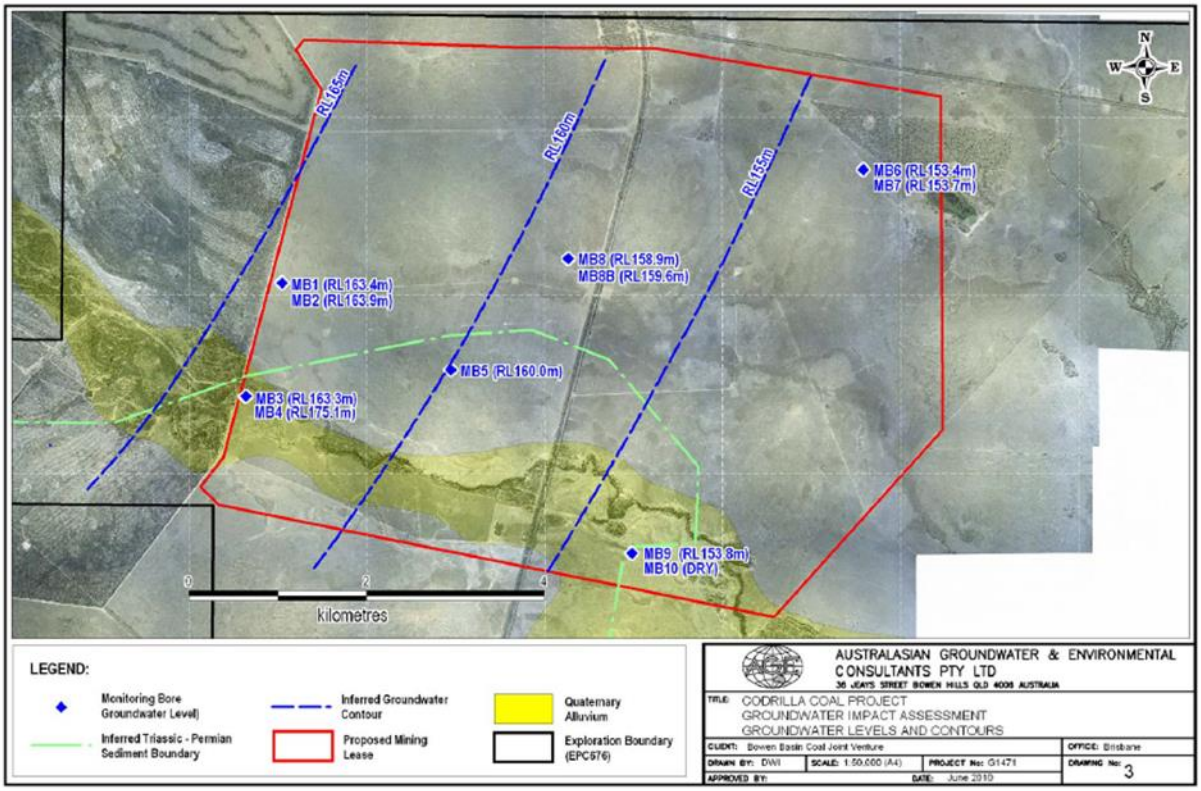


Figure 8 GW Monitoring Bores, Levels and Contours

Water samples were collected from the monitoring bores following their construction and samples were analysed for pH, electrical conductivity a suite of major ions, metals and petroleum hydrocarbons. Water quality results for each aquifer are summarised below. More details can be found in Appendix 4.4.

Alluvium

The analyses indicate that the alluvial groundwater has a slightly alkaline pH and is fresh with total dissolved solids (TDS) less than 500mg/L within ANZECC 2000 livestock watering guidelines. Total petroleum hydrocarbon levels were all below the laboratory detection limits for the fractions analysed.

Tertiary

The analyses indicate that the Tertiary groundwater has a slightly alkaline pH and is dominated by sodium and chloride making it saline with total dissolved solids (TDS) in excess of 13,000mg/L. Metal concentrations were either below the laboratory detection limit or below the relevant livestock guideline. Total petroleum hydrocarbon levels were generally below the laboratory detection limits for the fractions analysed.

Triassic/Permian

The analyses indicate that the Triassic/Permian overburden/interburden aquifer groundwater has a slightly alkaline pH and is dominated by sodium and chloride making it saline with total dissolved solids (TDS) in excess of 19,500mg/L exceeding the guideline levels for cattle. Levels for selenium exceeded the livestock threshold in bore MB1. Other metal concentrations were either below the laboratory detection limit or below the relevant livestock guideline. Total petroleum hydrocarbon levels were all below the laboratory detection limits for the fractions analysed.

Permian Coal Seam

The analyses indicate that the Permian aquifer groundwater has a slightly alkaline pH and is dominated by sodium and chloride making it saline with TDS levels in excess of 24,500mg/L which exceed the guideline levels for cattle. Relatively high sulphate levels were recorded in bore MB6, however these were still within the range for livestock. Total petroleum hydrocarbon levels in all bores other than one (likely sample contamination) were all below the laboratory detection limits for the fractions analysed.

No users of the groundwater in the area were identified. It is considered that one or more of water quality and yield inconsistency and variability in the aquifers precludes their use as a beneficial water source. The alluvial aquifer is considered to have value to aquatic ecosystems, including stygofauna.

3.1.1.6 Soil types, properties and productivity

A soil survey was conducted over the extent of the Codrilla Project by GSS Environmental (GSSE), as part of the baseline study for Soil, Overburden and Land Use, included in Appendix 4.5.

The soil survey identified five key soil types within the Codrilla Project area which are classified as:

- Brown Yellow Duplex;
- Brown Grey Duplex;
- Brown Duplex;
- Yellow Duplex; and,
- Skeletal Soils.

Brown Yellow Duplex Soil:

This soil unit is characterised by a gradual change between the light pale brown sandy loam surface soil and the yellow clay subsurface soil. These moderately structured soils range from neutral to slightly acidic to slightly alkaline at depth. The soils are non-saline and have low to moderate fertility. The topsoil is generally non-sodic whilst the subsoil exhibits non-sodic to moderately sodic characteristics.

Table 8 Brown Yellow Duplex Soil description

Layer	Depth (m)	Description
1	0.00 to 0.25	Pale Brown (10YR 6/3), moderate consistence sandy loam. A moderate pedality (angular blocky 10-50mm) soil, neutral (pH 6.7 to 7.5), low dispersion (EAT 3(1) to 8/3(2)), non-saline (<0.01 – 0.02dS/m), roots common to many and nil stones. Approximate sample depth 0.15m. Gradual even boundary to Layer 2.
2	0.25 to 0.55+	Yellow (10YR 7/6), moderate consistence sandy clay. A moderate pedality (angular blocky 5-50mm) soil with neutral to slight alkalinity (pH 7.3 to 7.6), low to moderate dispersion (EAT 3(2) & 3(3)), non-saline (0.01dS/m), roots few to common and <5% stones (<5mm). Approximate sample depth 0.40m.

Brown Grey Duplex Soil

This soil unit is characterised by an abrupt change between the light pale to brownish grey sandy loam surface soil and the light yellowish to brown sandy clay loam and clayey subsurface soil. These weakly to moderately structured soils range from slightly acidic to moderately alkaline at depth. The topsoil is generally non-sodic whilst the subsoil exhibits moderate to high sodicity.

Table 9 Brown Grey Duplex Soil description

Layer	Depth (m)	Description
1	0.00 to 0.35	Light Brownish Grey (10YR 6/2) moderate consistence sandy loam. A weak pedality (angular blocky 0-10mm) soil, slightly acidic to neutral (pH 6.0 to 7.7), low dispersion (EAT 3(1)), non-saline (<0.01 – 0.02dS/m), roots common to many and <5% stones (<5-10mm). Approximate sample depth 0.25m). Clear and even boundary to Layer 2.
2	0.35 to 0.65+	Light Yellowish Brown (10YR 6/4) moderate consistence sandy clay loam. An apedal massive soil that is neutral to strongly alkaline (pH 7.5 to 9.0), high to very high dispersion (EAT 2(3) & 1), non-saline to moderately saline (0.01 to 0.56dS/m), roots none and stones 10-50% (<10mm). Approximate sample depth 0.50m.

Brown Duplex Soil

The Brown Duplex soil unit generally consists of light brown loam and clay loam surface soils which overlie a texture contrast to pale brown to light yellowish-brown clay subsurface soils. These moderately structured soils range from neutral to strongly alkaline at depth. The soils are non-saline in the upper layers ranging to moderately saline at depth. The topsoil varies in sodicity (low to moderate) and becoming increasingly dispersive at depth.

Table 10 Brown Duplex Soil description

Layer	Depth (m)	Description
1	0.00 to 0.20	Brown (10YR 5/3) moderate consistence loam. A moderate pedality (angular blocky 10-50mm) soil, slightly acidic to neutral (pH 6.4 to 7.4), low dispersion (EAT 3(1)), non-saline (<0.01 to 0.03dS/m), roots common to many and nil stones. Approximate sample depth 0.15m. Boundary is clear and even to Layer 2.
2	0.20 to 0.60	Pale Brown (10YR 6/3) strong consistence clay. A weak pedality (angular blocky 10-20mm) soil, slightly to strongly alkaline (pH 7.8 to 9.2), moderate to high dispersion (EAT 2(2) – 2(3)), non-saline to moderately saline (0.04 - 0.60dS/m), roots few and nil stones. Approximate sample depth 0.40m. Boundary is clear and even to Layer 3.
3	0.60 to 1.00+	Light Yellowish Brown (10YR 6/4) strong consistence medium clay. An apedal massive soil that is generally slightly to strongly alkaline (pH 8.0 – 9.3), high dispersion (EAT 2(3)), moderately saline (0.53 – 0.62dS/m), roots and stones nil. Approximate sample depth 0.80m.

Yellow Duplex Soil

The Yellow Duplex soil unit generally consists of light yellowish brown and greyish brown sandy loam surface soils which overlie a texture contrast to yellowish brown sandy clay and sandy clay loam subsurface soils. These soils range from moderately acidic in the upper layers to neutral at depth. The soils are non-saline. The surface soils are non-sodic ranging to moderate and high at depth.

Table 11 Yellow Duplex Soil description

Layer	Depth (m)	Description
1	0.00 to 0.05	Greyish brown (10YR 5/2) sandy loam. A weak pedality soil with neutral to moderate acidity (pH 7.0 to 5.9). Low to very low dispersion (EAT 3(1) – 8/3(1)), non-saline (0.01- 0.03dS/m), roots common and nil stones. Approximate sample depth 0.02. Boundary is clear and even to layer 2.
2	0.05 to 0.45	Yellowish brown (10YR 5/4) loamy sand. A weak pedality soil with neutral to moderate acidity (pH 6.8 to 5.9). Low dispersion (EAT 3(1)), non-saline (<0.01dS/m), roots few and nil stones. Approximate sample depth 0.30m. Boundary is clear and even to layer 3.
3	0.45 to 1.00+	Yellowish Brown (10YR 5/6) sandy clay. An apedal massive soil that is strongly acidic to neutral (pH 9.2 to 7.0) and low to moderately dispersive (EAT 3(1) to 2(1)). Non saline (0.03 – 0.36dS/m), roots and stones nil. Approximate sample depth 0.80m.

Skeletal Soil

This soil unit is characterised by shallow greyish brown stony sandy clay soils associated with the steeper eroded side slopes and ridgelines throughout the western area of the Codrilla Project site. These soils were sampled; however, they were not analysed for the EIS due to high stone content.

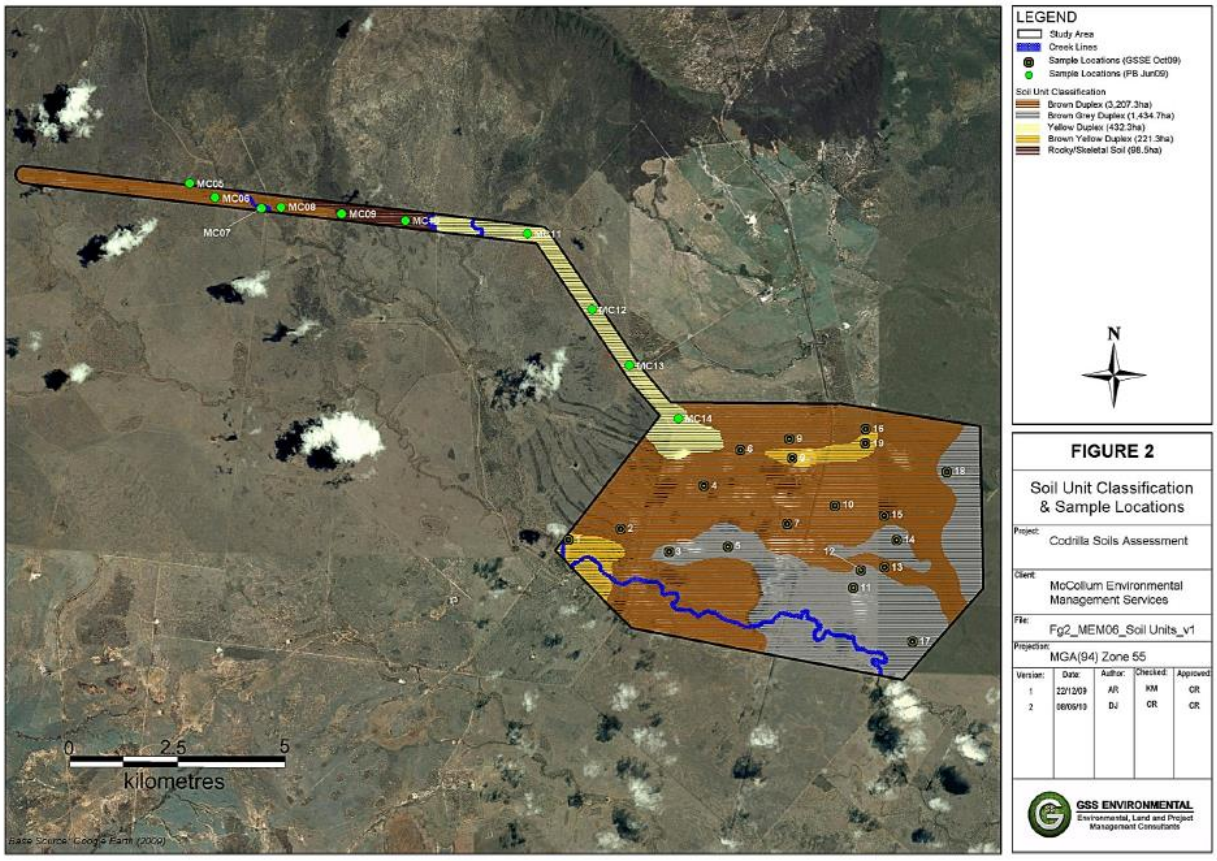


Figure 9 Soil Unit Classification and Sample Locations

Soil testing and analysis was conducted according to the procedure devised by Elliot and Veness (1981). Analysis included:

- Colour;
- Particle Size Analysis (PSA);
- Emerson Aggregate Test (EAT);
- pH;
- Electrical Conductivity (EC); and,
- Cation Exchange Capacity (CEC) and exchangeable cations.

The results of the analysis were used to determine the suitability of the soils for reuse in rehabilitation programs to be carried out as part of the Project.

Pre-mining Land Capability

A land capability assessment was conducted by GSSE (2010) as part of the EIS. Land capability was categorised into eight classes according to a range of naturally limiting factors, as detailed in Table 12 below. Land capability classifications provide a ranking of the capacity of individual sections of a land resource to sustain a broad range of land use classes. GSSE (2010) describe land capability assessment as generally applicable for large areas of land where broad land use choices are to be determined, such as farming, grazing or non-agricultural activities.

Table 12 Land Capability Classifications

Category	Class	Description
Suitable for Cultivation	Class I	No special practices required
	Class II	Simple management practices required
	Class III	Complex or intensive practices required to sustain cropping
	Class IV	Occasional or limited cultivation but with severe management inputs required to prevent degradation
Not Suitable for Cultivation	Class V	Suitable soil and topography for crops but economically not viable. High quality grazing land
	Class VI	Moderately susceptible to degradation requiring proper management to sustain use
	Class VII	Highly susceptible to degradation requiring severe restrictions on use; grazing may be conducted with rigorous management inputs required to prevent degradation
Not Suitable for Grazing	Class VIII	Wildlife reserves, bushland, recreation or water supply catchments

The existing land within the Codrilla Project area comprises capability classes, V, VI and VIII. All of the Codrilla property area located within the ML 70450 has been assessed as Class V. The balance of the Codrilla property assessed is within the easterly extent of ML 70455. This section comprises capability classes V and VI. The existing land use of the Codrilla property is related to cattle grazing only and therefore property management is within the identified capabilities.

The section of ML 70455 to the west of the Codrilla property has been assessed as predominantly Class VI with a small amount of Class VIII land associated with rocky hills and ridgeline sections of the Codrilla to Moorvale Haul Road corridor. Land use within ML 70455 (West of the Codrilla Property) is associated with three properties and comprises grazing related activities. Although it is understood that cattle have access to the class VIII land identified on the affected properties, due to the limited extent of this category and its competent substrate structure it is not anticipated that the interference from cattle would cause additional degradation to this land class. Therefore, existing land use within ML 70455 area is primarily within the identified capabilities.

Pre-mining Land Suitability

A land suitability assessment was conducted by GSSE (2010) as part of the Codrilla Project EIS. Land suitability classifies agricultural land into five suitability classes, as detailed Table 13. The rankings used in land suitability assessment are more refined than the land capability categories. The land suitability rankings apply to the capacity of land resources to sustain specific forms of agricultural land uses within the broader categories offered in land capability assessment. Such uses may include arable farming, irrigated agriculture, forestry, rainfed cropping, beef cattle grazing and conservation areas.

Table 13 Land Suitability Classes

Class	Description
Class 1	Land with negligible limitations, which is highly productive requiring only simple management practices to maintain economic production
Class 2	Land with minor limitations which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production
Class 3	Land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production
Class 4	Marginal lands with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production)
Class 5	Unsuitable land with extreme limitations that preclude its use for the proposed purpose

The GSSE (2010) land capability assessment focused on rainfed broadacre cropping and beef cattle grazing as the two primarily applicable potential uses in the area. The assessment calculated plant available water capacity and effective rooting depth of the surveyed soil types and also considered the soil's Exchangeable Sodium Percentage (ESP), salinity and pH. The results indicate that none of the surveyed soil types are suitable for rainfed broadacre cropping due to low plant available water capacity. Consistent with the existing land uses within the local area, the assessment has determined that the land within the Codrilla Project area is suitable for beef cattle grazing.

Erosion Potential of Soil Types

Figure 9 shows the location of the twenty-eight (28) soil profiles that were assessed at selected sites throughout the project area to enable soil profile descriptions to be made. Subsurface exposure was generally undertaken by backhoe excavation of test pits to 1.2 m deep.

The test pit locations were chosen to provide representative profiles of the soil types encountered during the survey. All soil samples were laboratory tested for dispersion, using the Emerson Aggregate Test (EAT) and sodicity, using the Exchangeable Sodium Percentage (ESP). These tests indicate the susceptibility of a soil to losing its structure and binding capacity when wet, and therefore the erosion potential of the soil. The results showed a similar pattern indicating that soils across the project area are generally sodic.

The middle and lower layers within the Brown Grey Duplex, Brown Duplex and Yellow Duplex soil units generally displayed a moderate to very high potential for erosion with Emerson Aggregate Test ratings of 3 to 1, which indicates a moderate to very high potential for dispersion and surface hardsettingness. Once this material is disturbed, the potential for erosion may be increased. If this disturbance occurs within the vicinity of a drainage line, this could impact on the health of downstream watercourses, through an increase in the sediment load. These soils should, therefore, be managed to ensure that the soils are not disturbed without suitable erosion and sediment controls being implemented. These measures include the construction of structural soil conservation works such as contour, graded and diversion banks and drop structures together with sediment control dams. The use of cover crops and/or organic ameliorants will reduce soil dispersion and surface crusting thereby reducing runoff and increasing infiltration, which will subsequently reduce erosion and sedimentation. The appropriate erosion and sediment control measures should be in place prior to surface disturbance of these soils, as the risk of erosion is high once the subsoil is exposed.

Potential erosion rates

The Revised Universal Soil Loss Equation (RUSLE) has been used in this assessment to estimate the long-time average soil loss rates that may result from sheet and rill flow during various levels of disturbance. The soil erodibility factor (K) has been adjusted for dispersive soil by +20% to take into consideration the test results, which indicated a moderate to very high potential for erosion. It must be noted that wind and gully erosion is discussed separately in the section below. The RUSLE calculates annual erosion rates based on the following equation:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

Where: A = annual soil loss due to erosion [t/ha/yr]
R = rainfall erosivity factor
K = soil erodibility factor
LS = topographic factor derived from slope length and slope gradient
C = cover and management factor
P = erosion control practice factor

The following table offers a comparison of disturbance levels which aims to highlight the higher risk activities in regard to erosion rates. It must be noted that assumptions have been made as to the specific values of soil and overburden characteristics, vegetation establishment success, climatic conditions, slope gradients and lengths and various management practices, and therefore the following values should only be used for comparison purposes. The calculations were made with the 'worst case' scenarios used consistently for all disturbance levels.

Table 14 Estimated Erosion Rates using the RUSLE

Disturbance Level	Rainfall Erosivity Factor (R)	Raw Soil Erodibility Factor	Adjusted* Soil Erodibility Factor (K)	Topographic Factor (LS)	Cover and Management Factor (C)	Erosion Control Practice Factor (P)	Annual Soil Loss (A) (t/ha/yr)
Undisturbed Surface Pre Mining	1804	0.030	0.030	1.00	0.01	1.0	0.54
Surface cleared of vegetation and topsoil	1804	0.017	0.020	1.00	1.00	1.3	47.84
Unshaped Overburden Dumps	1804	0.025	0.030	8.22	1.00	0.8	355.89
Shaped Overburden Dumps with Graded Banks	1804	0.025	0.030	3.07	1.00	0.8	132.92
Newly Rehabilitated Shaped Overburden Dumps	1804	0.030	0.036	3.07	0.45	0.8	71.78
Established Rehabilitated Shaped Overburden Dumps	1804	0.030	0.036	3.07	0.03	0.8	4.79

* Adjusted for dispersive soil by +20%

Table 14 above shows the disturbance level during mining with the highest risk of severe erosion rates is the unshaped overburden scenario. The key factor to observe in this result is the topographic factor (LS) where the overburden is free dumped and left at the angle of repose albeit benched in some cases. This practice is unlikely to be modified due to cost effectiveness and practicalities of dumping activities. However, it is recommended that these areas and times of highest risk should have adequate sedimentation controls in place downstream to capture any material eroded from these slopes. The shaped overburden dumps with graded banks (but without topsoil or vegetation) was the second highest predicted rate of erosion which indicates the need for the reshaping, grading, topdressing and seeding of overburden dumps to be undertaken in the quickest possible timeframe in order to minimise the risk of severe rainfall events impacting on these exposed slopes over a long period of time.

Gully erosion is not considered within the RUSLE equation above, however given the succession of erosion severity from rill to gully erosion, it is predicted that the same disturbance levels will contain the same risk rankings for gully erosion rates as the RUSLE equation has displayed. Once overburden dumps have been shaped and graded banks established, any gully erosion should be repaired and rehabilitated as soon as possible to reduce further erosion and sedimentation downstream.

Wind erosion has the potential to cause loss of material from overburden dumps during the mining process, especially given the raised elevation of the dumps within the landscape. Management practices during mining may limit the extent of wind erosion, by reducing truck movements and earthworks on highly exposed dumps during periods of extreme wind conditions. Furthermore, mine planning considerations for minimising exposed surfaces and timely rehabilitation activities may protect surface soil from wind erosion of overburden dumps.

3.1.1.7 Land stability

Chemical and physical characterisation of overburden and reject materials (coal and partings) undertaken to support the Codrilla Project EIS suggest that these materials are relatively inert and are not likely to present significant management issues in regard to water quality, landform stability and rehabilitation. The materials are generally sodic and alkaline, indicating that conventional planning and management strategies will be required to ensure operational and post-mining impacts are minimised relative to landform stability and water quality. The topsoils of the Codrilla Project area are generally suitable for harvesting for use in rehabilitation.

The EIS provided the following assessment regarding the waste rock characterisation of overburden and inter-burden material:

- All 26 overburden and inter-burden samples are classified as Non-Acid Forming (NAF);
- the total sulphur content of all samples was below 0.1% and is considered inert relative to acid producing potential;
- The concentration of metals in overburden and inter-burden solids is unlikely to present any significant environmental issues associated with rehabilitation of the materials or water quality;
- The pH of leachate from overburden material at the Codrilla Project site is likely to range from slightly acidic to moderately alkaline; however, the majority of material is likely to be neutral;
- The range of EC values in the samples is considered slightly to moderately saline;
- the overburden material is within the moderate to high ranges for Cation Exchange Capacity (CEC) and should therefore provide a reasonable growth medium for vegetation;
- Overburden material is considered to be extremely sodic;

- the overburden and inter-burden material is not expected to require specific management strategies in relation to PAF, metals, pH, Electrical Conductivity (EC) and Cation Exchange Capacity (CEC); and,
- The overburden and inter-burden material is expected to require specific management strategies in relation to Sodicity.

The characterisation of reject and co-disposal analysis involved obtaining, fresh samples of material from above coal seams (roof), within the coal seams and below the coal seams (floor), during exploration drilling and groundwater bore construction. These samples were composited to form two roof samples, one coal sample and two floor samples. The five roof and floor, coal, and floor samples analysed for acid producing characteristics were classified as either 'Uncertain' or 'Uncertain–Potentially Acid Forming', the total sulphur results being in excess of 0.2% for each of the samples analysed. Due to the limited characterisation of coal and partings (coal seam roof and floor) a commitment was made in the Environmental Management Plan (EMP) of ongoing characterisation of overburden, interburden and partings materials to enable selective handling. This commitment has been captured within the site's EA.

In order to obtain additional information, a drilling programme of four fully cored geotechnical boreholes was carried out in 2011. These holes were cored from close to ground level, to enable engineering geological logs to be compiled for the soft overburden strata and coal seams and to provide samples for geomechanical testing. The laboratory program focused on improving the reliability of material properties used for slope stability modelling. This was achieved by targeting specific soft overburden units (Tertiary and weathered Permian) for sampling and testing. In addition to this, a separate program of testing was conducted on samples recovered from the soft overburden units and the sandstone unit below the VU seam, which was aimed at assessing the dispersive characteristics of the soft overburden and sandstone as a potential spoil cover material. All samples were preserved and dispatched to the laboratory in accordance with nominated procedures. Routine soil classification (Atterberg limits), shrinkage, slake durability, unconfined compressive strength (UCS) were conducted on overburden, roof and floor samples by Cardno (Ullman & Nolan Technical Services Pty Ltd) at their Mackay laboratory. Triaxial testing was carried out by Trilab Pty Ltd in Brisbane.

Soil classification testing indicated the soft overburden to comprise primarily silty or sandy clay or clayey silt of low to intermediate plasticity, with minor occurrences of high plasticity clay.

Triaxial testing was conducted on selected samples of soft overburden and one sample of the Yarrabee Tuff to determine shear strength values. These comprised back-saturated, consolidated multistage tests with pore water pressure measurement. A further sample of the Yarrabee Tuff was tested by direct shear. Shear strength parameters derived from these tests indicate significant variability in the shear strength of material at the site. These are also dependent on the nature of the material tested. In this case, soft clayey materials and more competent, highly weathered rock would show variability in shear strength.

Unconfined Compressive Strength (UCS) tests were conducted on rock samples from target coal seam roof and floor with slake durability tests on the latter. This mainly focused on the Leichardt and Vermont Upper seams.

Uniaxial compressive strength (UCS) testing indicated the roof units for all seams to be low strength, averaging approximately 10MPa. The predominant roof material was laminite. Similarly, UCS testing indicated the floor units to be low strength, averaging approximately 8MPa. Floor units generally comprised mudstone, laminite and siltstone, with the occasional occurrence of sandstone.

Specific testing requirements completed for the spoil cover assessment included:

- Emerson Class - conducted to assess the dispersive nature of the material, essentially with respect to rehabilitation of spoil and where the overburden (particularly the Tertiary clay) contained slake susceptible clay or mudstone;
- Atterberg Limits - determines the liquid and plastic limits of clayey materials, which is useful indicator of reactivity. An example of a reactive soil would be volcanically derived clay;
- Slake Durability - indicates of rock degradability, which measures changes in rock properties due to chemical and mechanical breakdown; and
- UCS - the unconfined compressive strength of the material

The sampling undertaken to inform the EIS is considered to be adequate for a site where mine development has not commenced. Additional waste characterisation will be undertaken when the mine is developed and throughout the mining and processing phase of the mine's life as per conditions stipulated within the EA. Further details of the results can be found in Appendix 4.7.

3.1.1.8 Flora and Fauna

The Codrilla Project area is situated on grazing properties approximately 30km southeast of Coppabella in the Isaac Regional Council of Central Queensland and lies within the Northern Bowen Basin of the Brigalow Belt Bioregion. A large portion (89%) of Codrilla Project area has been historically cleared for grazing and most of the Brigalow communities cleared with few scattered remnants remaining in these cleared areas.

During flora, fauna and freshwater biota surveys of both sites two hundred and fifty-eight plant species and one hundred and sixty-three terrestrial vertebrate species were recorded across the entire study area. This included one conservation listed species (the Black Orchid, *Cymbidium canaliculatum*) and one 'vulnerable' reptile (Ornamental Snake, *Denisonia maculata*), one 'vulnerable' bird species (Squatter Pigeon, *Geophaps scripta*) and one Queensland 'near threatened' mammal (Little Pied Bat, *Chalinolobus picatus*) along with three Garnett and Crowley near threatened bird species (Grey-crowned Babbler, *Pomatostomus temporalis*; Australian Bustard, *Ardeotis australis*; and Bush Stone-curlew, *Burhinus grallarius*). Five pest species were also observed on site.

Field Flora assessment

Survey results indicate that the majority of the vegetation (81%) is non-remnant, with a small portion 'endangered' vegetation (2.04%) and 'of concern' vegetation (3.46%). The remainder of the vegetation was listed as 'least concern' (13.47%,).

The Regional Ecosystems and their status are listed in Table 15 below:

Table 15 Regional Ecosystems and their status

Geology	Regional Ecosystem	Vegetation Description	Specht Classification (Specht 1970)	Vegetation Management / Biodiversity Status	Protected Areas: a) within bioregion b) within 150 km	Area in Codrilla A Study Area (ha)	Area in Codrilla B Study Area (ha)	Spp. Rich	Assoc. Fauna Sites
a) Cainozoic alluvial plains with loams or clay soils	11.3.4	*Eucalyptus tereticornis, Corymbia tessellaris, C. clarksoniana* and *E. platyphylla* with sparse understorey	Open forest	Of concern / Of concern	a) 27 b) Dipperu NP(S), Homevale NP, Homevale RR	89.26		75	
	11.3.25	*Eucalyptus tereticornis, Corymbia tessellaris* and *Casuarina cunninghamii* with a grassy understorey on Creek banks	Woodland	Least concern / Of concern	a) 40 b) Dipperu NP(S), Eungella NP, Homevale NP, Homevale RR, Peak Range NP, Tooloombah Creek CP	61.09	49	100	Riparian
	11.3.27	Freshwater wetlands	Wetland	Least concern / Of concern	a) 14 b) None	23.22	1.31		

Geology	Regional Ecosystem	Vegetation Description	Specht Classification (Specht 1970)	Vegetation Management / Biodiversity Status	Protected Areas: a) within bioregion b) within 150 km	Area in Codrilla A Study Area (ha)	Area in Codrilla B Study Area (ha)	Spp. Rich	Assoc. Fauna Sites
b) Cainozoic clay plains not associated with alluvium	11.4.8	*Eucalyptus cambageana* woodland to open forest with *Acacia harpophylla* or *A. argyrodendron* on Cainozoic clay plains	Woodland	Endangered / Endangered	a) 7 b) Dipperu NP(S), Junee NP	94.6	9.71	91	Dawson Gum
	11.4.9	*Acacia harpophylla* shrubby open forest to woodland with *Terminalia oblongata* on Cainozoic clay plains	Woodland	Endangered / Endangered	a) 12 b) Dipperu NP(S), Junee NP, Mazeppa NP, Peak Range NP, Tooloombah Creek CP	3.74	27.81	75	
c) Cainozoic sediments on flat to gently undulating plains	11.5.2	*Eucalyptus crebra, Corymbia* spp., with *E. moluccana* on lower slopes of Cainozoic sand plains/remnant surfaces		Least concern / No concern	a) 6 b) Junee NP		86.03	81	

Geology	Regional Ecosystem	Vegetation Description	Specht Classification (Specht 1970)	Vegetation Management / Biodiversity Status	Protected Areas: a) within bioregion b) within 150 km	Area in Codrilla A Study Area (ha)	Area in Codrilla B Study Area (ha)	Spp. Rich	Assoc. Fauna Sites
	11.5.3	*Eucalyptus populnea* open forest with grassy or shrubby understorey	Woodland	Least concern / No concern	a) 8 b) Dipperu NP(S), Junee NP, Mazeppa NP	314.37	213.79	108	Poplar Box
f) Brown cracking clays on undulating hills	11.9.7/9	*Eucalyptus populnea, Eremophila mitchellii* shrubby woodland mixed with *Eucalyptus crebra* woodland on fine-grained sedimentary rocks	Woodland	Of concern/ Of concern mixed with Least concern / No concern	a) 2 / 4 b) None / Homevale NP, Homevale RR		136.7		
g) Hills and lowlands on metamorphic rocks	11.11.1	*Eucalyptus crebra* ± *Acacia rhodoxylon* woodland on old sedimentary rocks with varying degrees of metamorphism and folding		Least concern / No concern	a) 2 b) Homevale NP		143.85	86	

Geology	Regional Ecosystem	Vegetation Description	Specht Classification (Specht 1970)	Vegetation Management / Biodiversity Status	Protected Areas: a) within bioregion b) within 150 km	Area in Codrilla A Study Area (ha)	Area in Codrilla B Study Area (ha)	Spp. Rich	Assoc. Fauna Sites
	11.11.9	*Eucalyptus populnea* or *E. brownii* woodland on deformed and metamorphosed sediments and interbedded volcanics		Least concern / No concern	a) 4 b) none		3.09		
	11.11.16	*Eucalyptus cambageana, Acacia harpophylla* woodland on old sedimentary rocks with varying degrees of metamorphism and folding		Of concern/ Of concern	b) 3 b) none		3.99	52	
Cleared with some regrowth vegetation	Non-remnant	Grassland with emergent *Acacia harpophylla, Lysiphyllum carronii* and *Eucalyptus* spp.	Grassland			4486.68	900.49	47	Cleared
Road Way	Non-remnant					22.45			

Areas of conservation value in the vicinity of the Project consist of remnant vegetation. State values are associated with Devlin Creek riparian vegetation and some sections of the remnant vegetation within the Codrilla to Moorvale Haul Road corridor. Regional values are associated with most of the

remaining remnant vegetation within the MLs, with a small amount of Local value vegetation intersecting the Codrilla to Moorvale Haul Road corridor in two sections.

The remnant vegetation associated with Devlin Creek is listed as important wildlife corridor of 'State' and 'Regional' significance linking the vegetation remnants along the waterway to the large areas of remnant vegetation associated with Mount Marion in the North to the Isaac and Connors Rivers. There are existing gaps within this corridor where roads (including the Fitzroy Development Road), tracks, property fence line clearing and firebreaks cross the waterways. Typically, these intersecting gaps are narrow and would not be expected to significantly impede movement of wildlife along the corridor. No freshwater wetlands were present within 150km of the mining lease.

Two small areas of Endangered Regional Ecosystems *Acacia harpophylla* and *Eucalyptus cambageana* woodlands on dark clay soils (11.4.8 and 11.4.9) are present within the mining footprint but they are isolated and degraded and do not represent a significant loss of these REs.

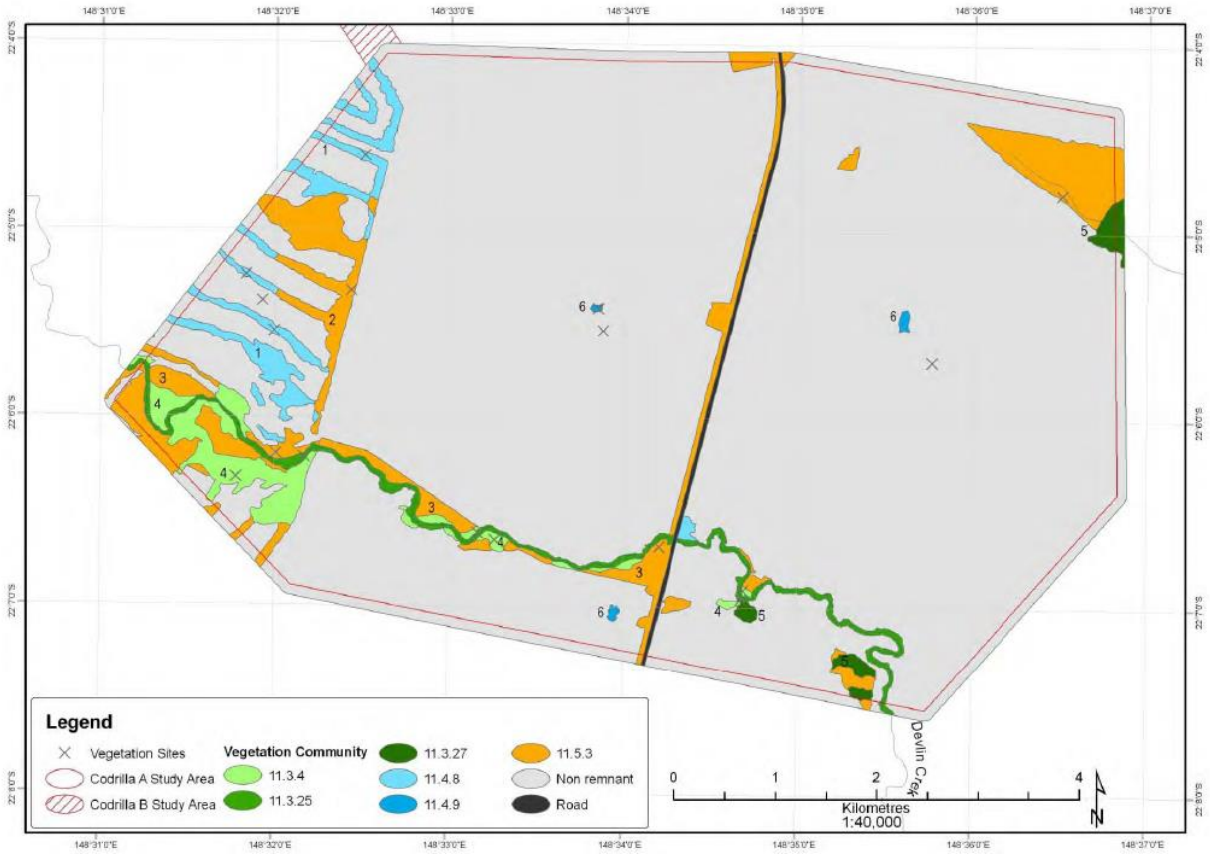


Figure 10 Vegetation Communities – Regional Ecosystems (REs) on ML70450

The areas of sensitive vegetation types within the ML 70455 area were also relatively small, with areas of 'endangered' vegetation making up 2.58%. There were no 'of concern' REs and areas 'not of concern' made up 40.21% of the ML 70455 study area. All vegetation types were represented in protected areas within the Brigalow Belt Bioregion with only 'not of concern' RE Freshwater Wetland not represented in protected areas within 150km of the ML.

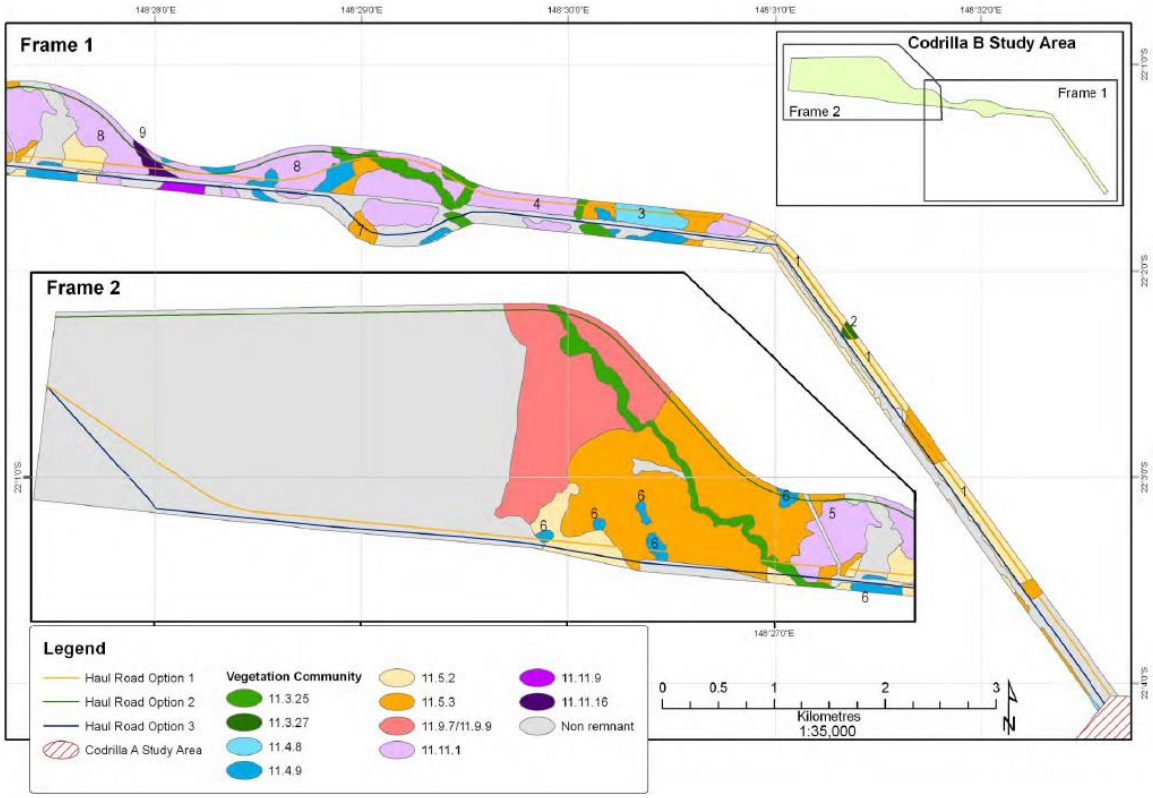


Figure 11 Vegetation Communities – REs on ML70455

Field Fauna Assessment

Four major REs on three different Land Zones (3, 4 & 5) were sampled within ML70450 and three REs on three Land Zones (4, 5 & 11) were sampled within ML70455. Sampling occurred over two field trips with sites varying between sampling trips for the Poplar Box and Riparian due to access restrictions to the original sites on the second field trip. The Poplar Box and Riparian sites used in the second field trip were Vegetation sites from the first field trip and had similar structure and habitat features to the original sites. Locations of sampling sites are shown in Figure 12 and Figure 13 and trap site details of sampling schedule, land zone, soil type and vegetation type are shown in Table 16.

Table 16 Trap site details

Field Site (year sampled)	Regional Ecosystem	Land Zone	Soil	Habitat Description
ML 70450				
Cleared (2009)	Non-remnant	5	brown sandy loam	Non-remnant grassland with scattered shrubs
Dawson Gum (2009 & 2010)	11.4.8	4	brown sandy loam	Eucalyptus cambageana dominated woodland with some Casuarina cristata and shrubby understorey
Poplar Box A (2009)	11.5.3	5	light brown sandy loam	Eucalyptus populnea

Poplar Box B (2010)				dominated open woodland with a shrubby understorey
Riparian A (2009) Riparian B (2010)	11.3.25	3	light brown sandy loam	Eucalyptus tereticornis dominated riparian zone with abundant Melaleuca leucadendra over a grassy understorey on an alluvium channel
ML 70455				
Brigalow (2010)	11.4.9	4	dark brown clay	Acacia harpophylla dominated woodland with shrubby midstorey over sparse grasses
Woodland LZ5 (2010)	11.5.2	5	light brown sandy loam	Eucalyptus crebra woodland with shrubby midstorey and grassy ground cover on open plans
Woodland LZ11 (2010)	11.11.1	11	light brown sandy loam	Eucalyptus crebra woodland with little midstorey and sparse grassy ground cover on low hills

Survey methods

Vertebrate fauna associated with each site in a 3 ha area (approximately a 100 m radius around each trap site within the same habitat, or a linear shape in the case of riparian habitats) was surveyed using standard techniques over a five day survey period in the first of two seasons:

- a 30 m drift fence incorporating 3 shaded 20 litre buckets and eight reptile traps placed on either side of the drift fence at each end and between the buckets;
- twenty-three Elliot A and two Elliot B traps for small mammals baited with a mixture of peanut butter, rolled oats and pet jerky were placed at 5 to 20 m intervals depending on the terrain;
- two large Mawbey Traps for possums, quolls and bandicoots baited with jam coated apple and pet jerky were placed at the base of trees in woodland sites and under grass clumps at the grassland site;
- intensive diurnal searches for reptiles and animal traces such as scats, tracks, skeletal remains, scratch marks on trees and carcasses (2 person hours during the middle part of the day at each site);
- intensive nocturnal searches for nocturnal mammals, birds, geckos, snakes and frogs (1 person hour at each site) and spotlighting from vehicles along the roads and tracks of the property for nocturnal mammals and birds;

- diurnal bird observations based on a minimum of two searches in the early morning (totalling 2 person hours at each site);
- owl audio observations using recorded calls to elicit calls from nearby birds (3 minutes replay of relevant species calls and two minutes listening time); and
- insectivorous bats were recorded for an entire night at each site using ANABAT equipment. These were analysed by Greg Ford using the appropriate referencing (Churchill 1998; Reinhold et al. 2001).

All traps were checked twice daily to avoid trap losses of fauna. In addition, opportunistic sightings were made during the day and night from the vehicle or on foot transects while traversing the study area.

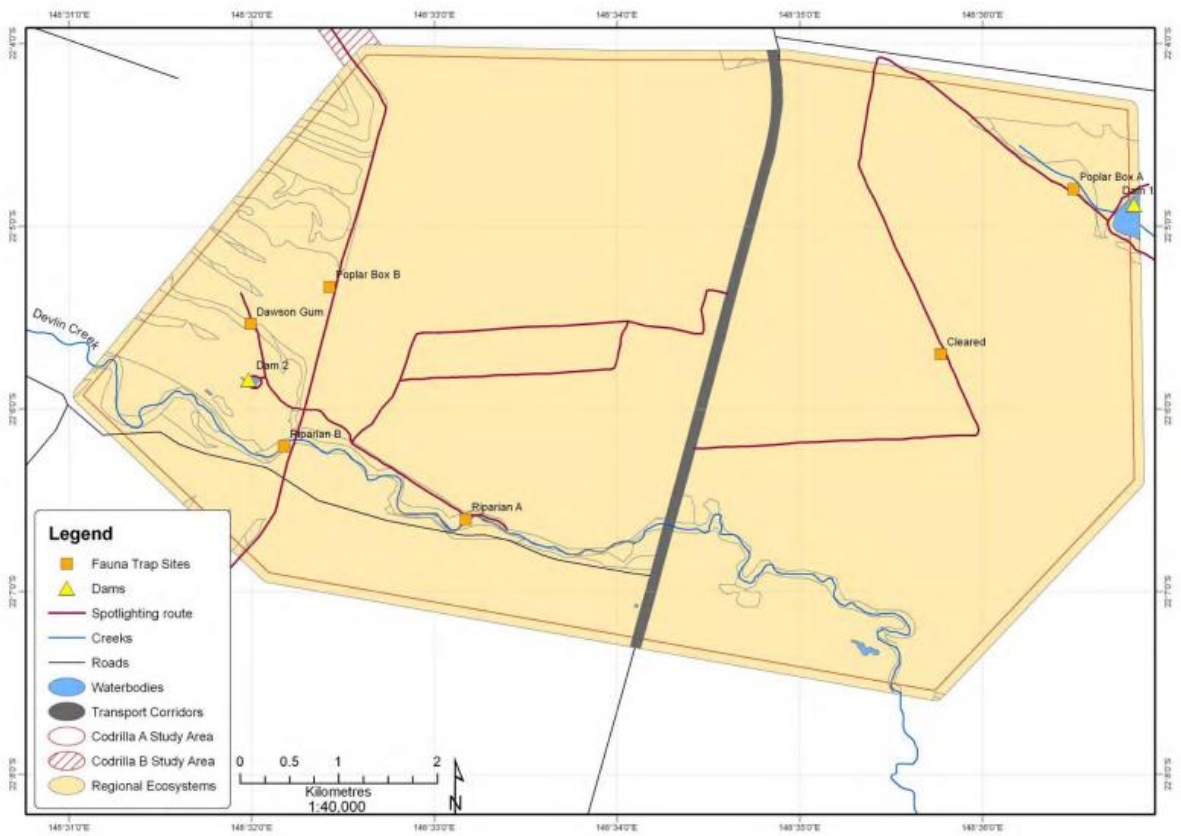


Figure 12 Fauna sites, spotlighting routes and features of ML 70450

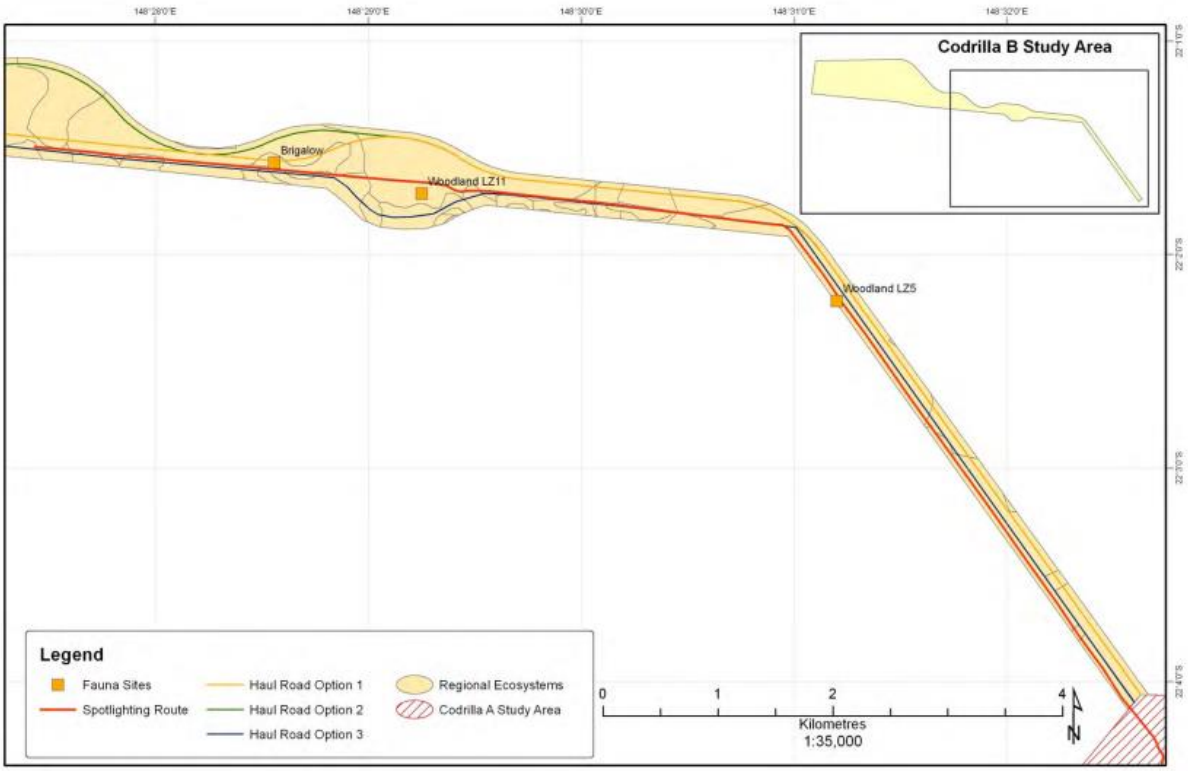


Figure 13 Fauna sites, spotlighting routes and features on ML 70455

Abundance

Estimates of the abundance of species within the study area were made, definitions of abundance class differed for birds and other vertebrates:

- Birds were defined as uncommon (U) - one or two individuals; common (C) - three to 19 individuals at more than one site or locally common (LC) three to 19 individuals at one site only; abundant (A) - 20 to 49 individuals; and very abundant (VA) - ≥50 individuals;
- Abundance classes of other vertebrates were based on a combination of frequency of occurrence at trap sites and abundance (1 trap site only was uncommon (U) while an abundance ≥10 individuals was abundant (A) with the remainder common (C)).
- The trace of a vertebrate or the registering of a bat species by ANABAT at a site was counted as '1' at that site.
- The abundance of any species at a particular site was determined by the most of that species recorded at the site at one time.

Incidental observations of fauna were recorded over the whole study area with additional searches at two dams within the study area done in both 2009 and 2010.

Significant Species

Three threat-listed species of fauna were recorded in the Project Area during surveys completed in 2009 and 2010 (Centre for Environmental Management 2010).

- Squatter Pigeon (*Geophaps scripta scripta*)
- Ornamental Snake (*Denisonia maculata*)

- Little Pied Bat (*Chalinolobus picatus*).

A review of biodiversity databases and literature undertaken for the Project (Centre for Environmental Management 2010) identified an additional 20 threat-listed fauna species as potentially occurring on site. Based on the availability and condition of potential habitat within the Project Area, 14 of these species are considered to occur on site with a moderate or higher likelihood.

Two Migratory birds were recorded within the Project Area during surveys completed in 2009 and 2010 (Centre for Environmental Management 2010):

- Rainbow Bee-eater (*Merops ornatus*)
- Eastern Great Egret (*Ardea modesta*).

Desk-based assessments have nominated an additional 35 species as potentially occurring with the locality; however, the majority of these comprise Migratory shoreline birds, with no habitat in the Codrilla Area.

Table 17, Table 18 and Table 19 below details the combined sightings, trap catches, Anabat detection and traces of non-bird ground-active and arboreal vertebrate fauna and birds.

Table 17 Presence and abundance of non-bird ground-active and arboreal vertebrate fauna (Amphibians)

Taxon	Common Name	Status	I.D.	Abund.	Survey	Cleared	Brig	Daw	PB	Rip	Wood LZ5	Wood LZ11	Inc.	Inc. Hab.	Total
AMPHIBIANS															
Bufonidae															
Rhinella marina (Bufo marinus)	Cane Toad	*	C	A-8	2009/10		7	20	17	13	7	8	169	D	241
Hylidae															
Cyclorana alboguttata	Striped Burrowing Frog		C	A-7	2009/10		2	2	4	56	5	1	13	D	83
Cyclorana novaehollandiae	Giant Waterholding Frog		C	C-3	2010		2		5	4					11
Litoria caerulea	Green Tree Frog		C	A-7	2009/10	11		3	4	6	6	2	2	C	34
Litoria inermis	Floodplain Frog		C	A-3	2009/10					9			27	D	36
Litoria rothii	Roth's Tree Frog		C	U-1	2010						1				1
Litoria rubella	Desert Tree Frog		C	C-3	2009				3				4	Rip, D	7
Myobatrachidae															
Opisthodon (Limnodynastes) ornatus	Ornate Burrowing Frog		C	A-7	2009/10		3	8	4	64	3	10	1	Rip	93
Limnodynastes salmini	Salmon-striped Frog		C	U-1	2009				2						2
Limnodynastes tasmaniensis	Spotted Grass Frog		C	C-3	2009/10			1	10	1					12
Limnodynastes terraereginae	Northern Banjo Frog		C	U-1	2010						1				1

Table 18 Presence and abundance of non-bird ground-active and arboreal vertebrate fauna (Reptiles)

REPTILES															
Chelidae															
Emydura macquarii krefftii	Krefft's River Turtle		F	U-1	2009					1					1
Gekkonidae															
Gehyra catenata			C	U-1	2010		2								2
Gehyra dubia	Dubious Dtella		C	A-5	2009/10		1	4	2	3	2				12
Heteronotia binoei	Bynoe's Gecko		C	4	2009/10		4	4	4		3				15
Nephrurus asper	Prickly Knob-tailed Gecko		C	C-2	2010			1				3			4
Strophurus williamsi	Eastern Spiny-tailed Gecko		C	U-1	2009			1							1
Pygopodidae															
Lialis burtonis	Burton's Snake-lizard		C	U-1	2009					1					1
Scincidae															
Carlia pectoralis			C	A-5	2009/10		4	3		3	2	2			14
Cryptoblepharus pulcher			C	C-3	2009/10			1	1	2					4
Ctenotus robustus	Eastern Striped Skink		C	C-6	2009/10	2	1	1	3		2	1			10
Ctenotus taeniolatus	Copper-tailed Skink		C	U-1	2009			1							1
Menetia greyii			C	U-1	2009				1						1
Morethia taeniopleura			C	C-3	2009/10	1					1	1			3
Tiliqua scincoides	Eastern Blue-tongue		C	U-2	2010					1		1			2
Agamidae															
Amphibolurus nobbi	Nobbi Dragon		C	U-1	2009			1							1
Pogona barbata	Eastern Bearded Dragon		C	U-1	2010			1							1
Varanidae															
Varanus tristis	Freckled Monitor		C	U-1	2010				1						1
Pythonidae															
Antaresia maculosa	Spotted Python		C	C-2	2009				1	1					2
Elapidae															
Cryptophis boschmai	Carpentaria Snake		C	U-2	2010		1	1							2
Demansia psammophis	Yellow-faced Whipsnake		C	C-1	2010					3					3
Demansia vestigiata	Lesser Black Whipsnake		C	U-1	2009/10					1					1
Denisonia maculata	Ornamental Snake	Q-V, F-V	C	U-2	2010		1					1			2
Pseudonaja textilis	Eastern Brown Snake		C	U-1	2009					1					1

Table 19 Presence and abundance of non-bird ground-active and arboreal vertebrate fauna (Mammals)

Taxon	Common Name	Status	I.D.	Abund.	Survey	Cleared	Brig	Daw	PB	Rip	Wood LZ5	Wood LZ11	Inc.	Inc. Hab.	Total
MAMMALS															
Monotremes															
Tachyglossidae															
Tachyglossus aculeatus	Echidna		T	C-3	2010			1	1		1				3
Marsupials															
Peramelidae															
Isoodon macrourus	Northern Brown Bandicoot		T	C-3	2009/10			1	1		1				3
Phalangeridae															
Trichosurus vulpecula	Common Brushtail Possum		T	U-2	2009			1	1						2
Petauridae															
Petaurus norfolcensis	Squirrel Glider		F	U-1	2010					1					1
Potoroidae															
Aepyprymnus rufescens	Rufous Bettong		F	U-1	2009								1	C	1
Macropodidae															
Macropus	Eastern Grey		F,	A-6	2009/10		1	4	3	6	4	2			20
giganteus	Kangaroo		T												
Macropus dorsalis	Black-striped Wallaby		T	C-2	2009			2	1						3
Wallabia bicolor	Swamp Wallaby		T	U-1	2010			1							1
Petrogale inornata.	Unadorned Rock Wallaby		T	U-1	2010				1						1
Placentals															
Muridae															
Mus musculus	House Mouse	*	C	U-1	2009					1					1
Rattus rattus	Black Rat	*	C	U-1	2009					1					1
Canidae															
Canis lupus dingo	Dingo		T	U-1	2010					1					1
Leporidae															
Oryctolagus cuniculis	European Rabbit	*	F	A-5	2009/10			1	3		2		6	PB,C	12
Suidae															
Sus scrofa	Feral Pig	*	F	A-3	2009/10				8				10	PB, SW	18

Emballonuridae															
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat		A	A-8	2009/10	1	1	1	1	1		1	2	D, SW	8
Taphozous troughtoni	Troughton's Sheathtail Bat		B	U-1	2009								1	D	1
Molossidae															
Tadarida australis	White-striped Freetail Bat		A	U-1	2009	1									1
Chaerephon jobensis	Northern Freetail Bat		A	A-7	2009/10	1	1	1	1	1		1	1	D	7
Mormopterus beccarii	Beccari's Freetail Bat		A	C-3	2009/10			1				1	1	D	3
Mormopterus sp. 2	Eastern Freetail Bat		A	C-4	2009/10	1		1	1				1	D	4
Miniopteridae															
Miniopterus orianae oceanensis	Common Bentwing Bat		C	U-2	2009					1			1	D	2
Vespertilionidae															
Chalinolobus picatus	Little Pied Bat	Q-NT	A	C-3	2010		1						2	D, SW	3
Chalinolobus nigrogriseus	Hoary Wattled Bat		A	U-2	2009/10				1				1	D	2
Chalinolobus gouldii	Gould's Wattled Bat		A	C-3	2009/10				1	1			1	D	3
Chalinolobus morio	Chocolate Wattled Bat		A	U-2	2009/10			1					1	D	2
Vespadelus troughtoni	Eastern Cave Bat		C	U-2	2009			1					1	D	2
Vespadelus baverstocki	Inland Forest Bat		A	C-4	2009/10		1			1			2	D, SW	4
Scoteanax rueppellii	Greater Broad-nosed Bat		C	U-2	2009					1			1	D	2
Scotorepens balstoni	Inland Broad-nosed Bat		A	C-4	2009/10			1		1			2	D, SW	4
Scotorepens greyii	Little Broad-nosed Bat		A	C-4	2009/10			1	1	1			1	D	4
Scotorepens sanborni	Northern Broad-nosed Bat		B	U-1	2010								1	D	1

Table 20 Presence and abundance of non-bird ground-active and arboreal vertebrate fauna (Species)

Taxon	Common Name	Status	I.D.	Abund.	Survey	Cleared	Brig	Daw	PB	Rip	Wood LZ5	Wood LZ11	Inc.	Inc. Hab.	Total
Species						**7**	**16**	**31**	**29**	**30**	**15**	**14**	**25**		**65**
Abundance						**18**	**33**	**72**	**87**	**188**	**41**	**35**	**253**		**727**
Abundance - minus *Rhinella marina* (Cane Toads)						18	26	52	70	175	34	27	84		486
Frog Species						1	4	5	8	7	6	4	6		11
Lizard Species						2	5	10	6	5	5	5	0		16
Snake Species						0	2	1	1	4	0	1	0		6
Mammals (Non Micro-bat species)						0	1	7	8	5	4	1	3		14
Micro-bat Species						4	4	8	6	8	0	3	16		17

Status = Conservation status: * - introduced species; Q-E, Q-NT or Q-V – endangered, near threatened or vulnerable under Qld Government legislation; F-V - vulnerable under Federal legislation

ID = Identification category: T - trace only and abundance uncertain, C - specimen captured, positively identified and released; F - specimen positively identified in field; Sc - specimen positively identified from animal traces (scats, hairs contained in predator scats or other sources, tracks, diggings, burrows, scratch marks on trees); AN - Anabat identification

Abund = Abundance: A - abundant, C - common, U – uncommon (with number of sites recording the species)

Habitat: Inc.- Incidental; Hab.-Habitat; C-Cleared Grassland; Brig-Brigalow; Daw-Dawson Gum; PB-Poplar Box, Rip-Riparian, D-Dam; SW-Sedge Wetland; Wood-Ironbark Woodland; LZ-Land Zone

Table 21 Presence and abundance of birds

Common Name	Scientific Name	Status	Abund.	Survey	Cleared	Brig	Daw	PB	Rip	Wood. LZ5	Wood. LZ11	Inc.	Inc. Hab.	Total
Emu														
Emu	*Dromaius novaehollandiae*		C-3	2009/10		1			4			5	C	10
True Quails														
Brown Quail	*Coturnix ypsilophora*		C-2	2009/10					4			4	Rip	8
Swans, Geese & Ducks														
Black Swan	*Cygnus atratus*		U-1	2010								2	D	2
Australian Wood Duck	*Chenonetta jubata*		C-2	2009/10					10			10	D	20
Pacific Black Duck	*Anas superciliosa*		C-2	2009/10					10			10	D	20
Australasian Shoveler	*Anas rhynchotis*		U-1	2009					1			1	D	2
Grey Teal	*Anas gracilis*		A-2	2009/10					20			23	D	43
Hardhead	*Aythya australis*		U-1	2010								2	D	2
Grebes														
Australasian Grebe	*Tachybaptus novaehollandiae*		C-1	2009					5			5	D	10
Cormorants														
Little Pied	*Microcarbo*		U-1	2010								1	D	1
Cormorant	*melanoleucos*													
Little Black Cormorant	*Phalocrocorax sulcirostris*		C-1	2010								3	D	3

Common Name	Scientific Name	Status	Abund.	Survey	Cleared	Brig	Daw	PB	Rip	Wood. LZ5	Wood. LZ11	Inc.	Inc. Hab.	Total
Herons, Egrets & Bitterns														
White-faced Heron	*Egretta novaehollandiae*		C-3	2009/10				1	2			2	D	5
White-necked Heron	*Ardea pacifica*		U-1	2009					2			2	D	4
Eastern Great Egret	*Ardea modesta*	M*	C-1	2009					9			9	D	18
Ibis & Spoonbills														
Straw-necked Ibis	*Threskiornis spinicollis*		C-2	2009					5			5	Wood, D	10
Royal Spoonbill	*Platalea regia*		C-1	2009					6			6	D	12
Yellow-billed Spoonbill	*Platalea flavipes*		C-1	2009					4			4	D	8
Raptors														
Pacific Baza	*Aviceda subcristata*		U-1	2009		2								2
Black-breasted Buzzard	*Hamirostra melanosternon*		U-1	2009			1							1
Black Kite	*Milvus migrans*		C-3	2009/10		1			2			2	PB	5
Whistling Kite	*Haliastur sphenurus*		C-4	2009/10				1	2		1	2	Rip, PB	6
Brown Goshawk	*Accipiter fasciatus*		U-1	2009					1			1	D	2
Wedge-tailed Eagle	*Aquila audax*		C-3	2009/10					2			2	Rip, W	4
Falcons														
Brown Falcon	*Falco berigora*		C-3	2009/10		1			3			3	C	7
Australian Hobby	*Falco longipennis*		C-4	2009/10				2	3			3	PB, D	8
Nankeen Kestrel	*Falco cenchroides*		C-2	2009/10					4			4	C	8
Cranes														
Brolga	*Grus rubicunda*		C-2	2009/10					2			2	C	4
Crakes & Rails														
Eurasian Coot	*Fulica atra*		C-1	2010								6	D	6
Bustards														
Australian Bustard	*Ardeotis australis*		C-1	2009					3			3	C	6
Waders														
Comb-crested Jacana	*Irediparra gallinacea*		C-1	2010								6	D	6
Stone-Curlews														
Bush Stone-curlew	*Burhinus grallarius*		U-1	2010			2							2
Plovers														
Black-fronted Dotterel	*Elseyornis melanops*		U-1	2010								2	D	2
Masked Lapwing	*Vanellus miles*		C-3	2009/10			3		4			4	D	11

Common Name	Scientific Name	Status	Abund.	Survey	Cleared	Brig	Daw	PB	Rip	Wood. LZ5	Wood. LZ11	Inc.	Inc. Hab.	Total
Pigeons & Doves														
Crested Pigeon	*Ocyphaps lophotes*		A-2	2009/10		6			18			18	Wood	42
Squatter Pigeon	*Geophaps scripta*	Q-NT, F-V	C-2	2010							2	2	Wood	4
Peaceful Dove	*Geopelia placida*		C-3	2009/10					4			4	B, Wood	8
Bar-shouldered Dove	*Geopelia humeralis*		U-1	2010						2				2
Cockatoos														
Galah	*Eolophus roseicapillus*		A-7	2009/10		2	36	2	32		3	32	C	107
Little Corella	*Cacatua sanguinea*		C-1	2010						3				3
Sulphur-crested Cockatoo	*Cacatua galerita*		A-7	2009/10		4	3	2	2		4	10	D	25
Cockatiel	*Nymphicus hollandicus*		C-4	2009/10				2	8			8	Wood, C	18
Parrots														
Rainbow Lorikeet	*Trichoglossus haematodus*		A-7	2009/10		18	21	17	30	2	4	30	Rip	122
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*		C-1	2009					5			5	Rip	10
Red-winged Parrot	*Aprosmictus erythropterus*		A-5	2009/10				2		10		8	Dam	20
Pale-headed Rosella	*Platycercus adscitus*		A-5	2009/10		6	2		5			5	Daw,PB	18
Cuckoos														
Horsfield's Bronze-Cuckoo	*Chalcites basalis*		U-1	2009				1						1
Little Bronze-Cuckoo	*Chalcites minutillus*		U-2	2010							1	1	Wood	2
Pheasant Coucal	*Centropus phasianinus*		C-3	2009/10				2	1		1	1	Rip	5
Owls														
Southern Boobook	*Ninox novaeseelandiae*		C-6	2009/10			1	1				2	C	4
Eastern Barn Owl	*Tyto javanica*		C-2	2009/10					2			2	C	4
Frogmouths														
Tawny Frogmouth	*Podargus strigoides*		C-4	2009/10		3			2		1	2	C	8
Nightjars														
White-throated Nightjar	*Eurostopodus mystacalis*		U-1	2010						1				1
Australian Owlet-nightjar	*Aegotheles cristatus*		U-2	2009/10			1							1
Kingfishers														
Laughing Kookaburra	*Dacelo novaeguineae*		A-6	2009/10			2	6	2	4		2	PB	16
Blue-winged Kookaburra	*Dacelo leachii*		C-4	2009/10		6	4		3			3	C, Daw	16
Forest Kingfisher	*Todiramphus macleayii*		U-2	2009/10				1						1

Taxon	Common Name	Status	I.D.	Abund.	Survey	Cleared	Brig	Daw	PB	Rip	Wood LZ5	Wood LZ11	Inc.	Inc. Hab.	Total
Bee-Eaters															
Rainbow Bee-eater	*Merops ornatus*	M		U-1	2010								2	Wood	2
Treecreepers															
Brown Treecreeper	*Climacteris picumnus*			C-1	2009			4							4
Fairy-Wrens															
Variegated Fairy-wren	*Malurus lamberti*			C-2	2009/10					4		4	4	D	12
Red-backed Fairy-wren	*Malurus melanocephalus*			A-5	2009/10			7	5	2			11	C	25
Pardalotes, Scrubwrens, Gerygones & Thornbills															
Striated Pardalote	*Pardalotus striatus*			A-8	2009/10		3	3	6		2	2			16
Weebill	*Smicrornis brevirostris*			A-6	2009/10			4	4		10	3			21
White-throated Gerygone	*Gerygone albogularis*			C-5	2009/10			2	3			1			6
Honeyeaters															
Noisy Friarbird	*Philemon corniculatus*			C-2	2010						2		5	Wood	7
Little Friarbird	*Philemon citreogularis*			A-3	2009/10		3		3	20			20	Rip	46
Blue-faced Honeyeater	*Entomyzon cyanotis*			A-5	2009/10			3	3	8			8	Rip, D	22
Noisy Miner	*Manorina melanocephala*			A-4	2010		5	4	6						15
Yellow-throated Miner	*Manorina flavigula*			A-5	2009/10			5	6	14			14	PB, Rip	39
Singing Honeyeater	*Lichenostomus virescens*			C-3	2009				2	4			4	R, D	10
White-throated Honeyeater	*Melithreptus albogularis*			A-4	2009/10			3	10	4			4	R	21
Robins															
Jacky Winter	*Microeca fascinans*			C-2	2009/10			2					2	Wood	4
Babblers															
Grey-crowned Babbler	*Pomatostomus temporalis*			A-6	2009/10		6	9	8		5				28
Sittellas															
Varied Sittella	*Daphoenositta chrysoptera*			C-1	2009				5						5
Whistlers & Shrike-Thrushes															
Rufous Whistler	*Pachycephala rufiventris*			C-3	2009			1	5	2			2	Rip	10
Monarchs & Flycatchers															
Restless Flycatcher	*Myiagra inquieta*			U-1	2009					2			2	D	4
Magpie-lark	*Grallina cyanoleuca*			A-6	2009/10		4	4	2		2				12

Common Name	Scientific Name	Status	Abund.	Survey	Cleared	Brig	Daw	PB	Rip	Wood. LZ5	Wood. LZ11	Inc.	Inc. Hab.	Total
Grey Fantail	*Rhipidura albiscapa*		A-7	2009/10		2	2	6	4	3		4	Rip	21
Willie Wagtail	*Rhipidura leucophrys*		C-5	2009/10			2	2	2			4	C	10
Spangled Drongo	*Dicrurus bracteatus*		U-1	2009					1			1	Dam	2
Cuckoo-Shrikes & Trillers														
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		C-6	2009/10			2	2	3			3	C, Wood	10
Ground Cuckoo-shrike	*Coracina maxima*		C-1	2009		4								4
Orioles & Figbirds														
Olive-backed Oriole	*Oriolus sagittatus*		U-1	2009				1						1
Woodswallows														
White-breasted Woodswallow	*Artamus leucorynchus*		C-2	2009/10				6				12	Wood	18
Black-faced Woodswallow	*Artamus cinereus*		C-3	2009/10			3		6			6	C	15
Butcherbirds, Magpies & Currawongs														
Grey Butcherbird	*Cracticus torquatus*		A-8	2009/10		6	2	3	2	2	2	2	Rip	19
Pied Butcherbird	*Cracticus nigrogularis*		A-9	2009/10		2	6	4	2	6	2	2	PB	24
Australian Magpie	*Cracticus tibicen*		A-10	2009/10		7	4	8	6	10	2	6	PB, C	43
Pied Currawong	*Strepera graculina*		U-1	2010							2			2
Ravens & Crows														
Australian Raven	*Corvus coronoides*		U-1	2009		2								2
Torresian Crow	*Corvus orru*		A-7	2009/10		4	2	11	2	2	4	2	PB	27
Mud-Nest Builders														
Apostlebird	*Struthidea cinerea*		A-1	2009/10		16								16
Larks														
Horsfield's Bushlark	*Mirafra javanica*		C-3	2009/10	2				4			5	C	11
Pipits & Wagtails														
Australasian Pipit	*Anthus novaeseelandiae*		C-3	2009/10	2				9			9	C	20
Finches														
Zebra Finch	*Taeniopygia guttata*		A-2	2009			3		22			22	C	47
Double-barred Finch	*Taeniopygia bichenovii*		C-2	2009/10					6			6	D	12
Plum-headed Finch	*Neochmia modesta*		U-1	2009					2			2	D	4
Swallows & Martins														
Tree Martin	*Petrochelidon nigricans*		A-2	2009/10					45			45	C	90
Warblers														
Golden-headed Cisticola	*Cisticola exilis*		C-2	2009/10					2			2	C	4

Taxon	Common Name	Status	I.D.	Abund.	Survey	Cleared	Brig	Daw	PB	Rip	Wood LZ5	Wood LZ11	Inc.	Inc. Hab.	Total
Species						2	24	33	36	61	16	17	76		98
Abundance						4	114	153	151	400	66	39	480		1407

Status = Conservation Status: * - introduced species; Q-C, Q-NT, Q-V or Q-E indicates listed as common, near threatened, vulnerable or endangered under *Queensland Nature Conservation Act (1992)*;

F-V, F-E, M or S indicates vulnerable , endangered, migratory or marine species under Federal legislation *EPBC Act (1999)* (M* indicates 'nomadic migratory' birds);

Abund. = Abundance rating: VA - very abundant, A - abundant, C - common, LC - locally common, U – uncommon (with number of sites recording the species).

Habitat: Inc.- Incidental; Hab.-Habitat; C-Cleared Grassland; Brig-Brigalow; Daw-Dawson Gum; PB-Poplar Box, Rip-Riparian, D-Dam; SW-Sedge Wetland; Wood-ironbark woodland; LZ-Land Zone.

Aquatic ecology

Aquatic surveys completed at Devlin Creek during in 2009 and 2010 recorded four common fish species (Agassiz's Glassfish, Eastern Rainbow Fish, Purple-spotted Gudgeon and Hyrtl's Tandan) and one turtle (Krefft's Turtle) (Centre for Environmental Management 2010). No threat-listed aquatic species have been recorded within the Project Area; however, the Fitzroy River Turtle (*Rheodytes leukops*) and Eungella Day Frog (*Taudactylus eungellensis*) have the potential to occur. Details of macroinvertebrate species identified and abundance are shown in Table 22.

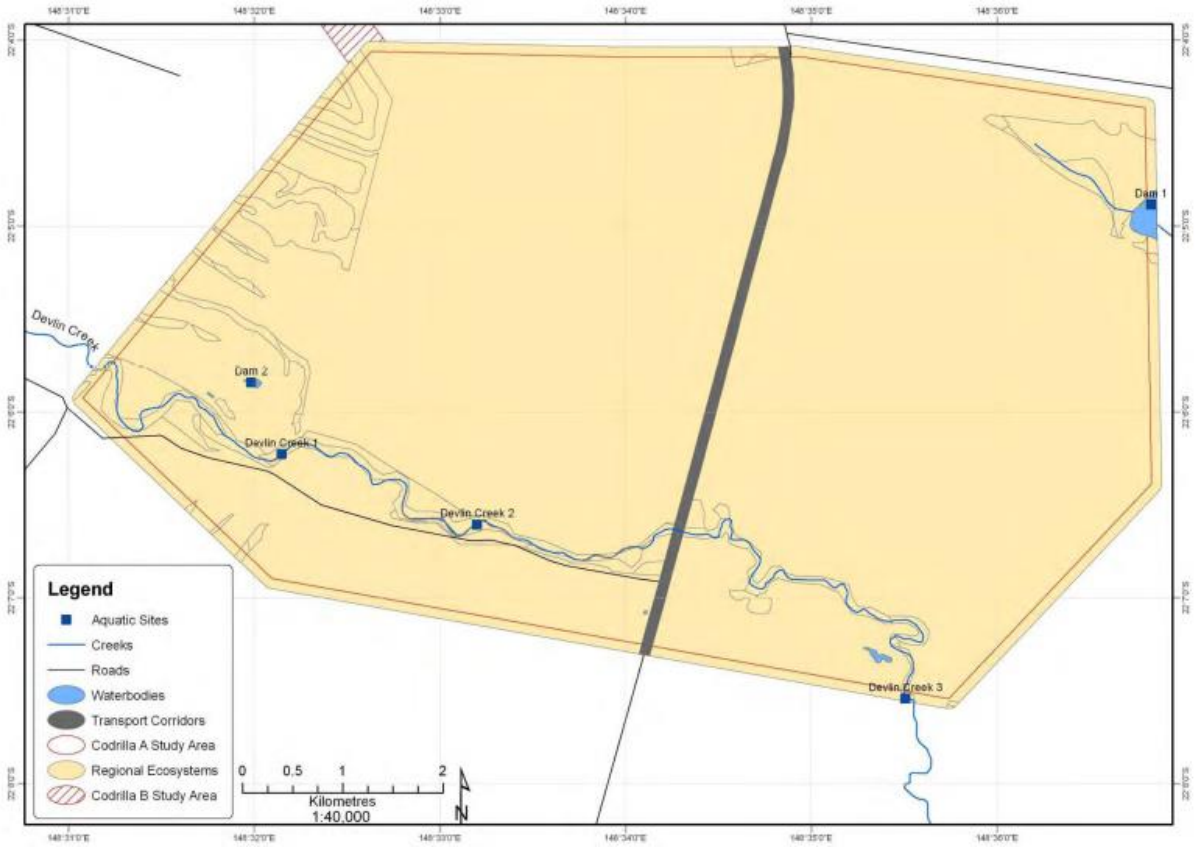


Figure 14 Freshwater sites on ML 70450

Monitoring of groundwater bores during the EIS process identified three taxa of stygofauna within the alluvial aquifer of Devlin Creek (ALS Water Resources Group 2011). The stygofauna specimens collected from inside the Project Area are potentially new species; however, at the taxonomic level of Family or Order, neither are unique to the Project Area. Groundwater monitoring did not record

any stygofauna in the non-alluvial aquifers. The absence of stygofauna during sampling and the highly saline groundwater suggests that stygofauna are unlikely to inhabit these aquifers.

Table 22 Macroinvertebrate species identified and abundance

Site/Habitat		DC1		DC2		DC3		Dam 1		Dam 2	
Order	**Family**	**Edge**	**Pool**	**Edge**	**Pool**	**Edge**	**Pool**	**Edge**	**Pool**	**Edge**	**Pool**
Gastropoda	Ancylidae	0	0	20	0	0	0	0	0	0	0
	Lymnaea	0	0	0	0	0	0	50	10	0	0
	Petterdiana	0	0	0	0	0	0	0	0	40	0
Hydrozoa	Hydra	0	0	0	0	0	0	0	50	0	170
Oligochaetae	Oligochaetae	120	28	0	70	0	0	80	560	50	500
Acarina	Araenae	0	0	0	0	0	0	0	30	0	10
Decapoda	Atyidae	0	0	20	0	10	0	0	0	0	0
Diptera	Chironomidae	1320	596	1090	375	1410	127	1620	1500	1000	1750
	Ceratopogonidae	0	24	0	25	120	20	430	260	170	710
	Chaoboridae	0	0	0	35	0	13.3	90	0	110	0
	Culicidae	0	0	0	0	0	0	180	0	0	40
	Diptera pupae	0	0	10	0	30	0	0	0	0	0
	Simuliidae	0	0	0	0	0	0	110	40	530	140
	Tabanidae	0	0	10	0	0	0	0	0	0	0
Ephemeroptera	Baetidae	0	0	0	0	0	0	30	90	0	60
	Caenidae	10	0	20	0	150	0	20	70	10	70
	Siphlonuridae	0	0	0	0	0	0	0	0	0	50
Hemiptera	Corixidae	0	0	0	0	10	0	0	0	0	0
	Pleidae	0	0	0	0	0	0	20	160	250	60
	Notonectidae	0	0	0	0	0	0	20	0	0	0
Odonata	Coenagrionidae	0	0	0	0	0	0	70	10	0	150
	Corduliidae	0	0	0	0	0	0	80	20	0	80
	Odonata larvae	0	0	20	5	0	0	0	0	0	0
	Zygoptera	0	0	0	0	0	0	60	0	10	0
Trichoptera	Leptoceridae	0	12	10	30	40	6.67	0	0	0	0
	Ecnomidae	0	0	0	5	10	0	0	0	0	0
Coleoptera	Hydrophilidae	10	0	10	0	0	0	0	10	0	70
Orders		**4**	**3**	**7**	**4**	**6**	**2**	**6**	**9**	**6**	**8**
Families		**4**	**4**	**9**	**7**	**8**	**4**	**14**	**13**	**9**	**14**
Abundance		**1352**	**660**	**1210**	**545**	**1780**	**167**	**2860**	**2810**	**2170**	**3860**

3.1.1.9 Pre-mining land use

Land uses in the vicinity of the Codrilla Project include, coal and gas exploration, public road infrastructure, (including the Fitzroy Developmental Road (FDR) and the Valkyrie Road) and the Valkyrie School and school residence, which are located approximately 800m to the north of the ML boundary. The FDR is also a designated stock route.

The existing land uses of the Codrilla Project area and the area immediately surrounding the project are primarily related to production of beef cattle. Typically, the operating properties in this locality are in the order of 5,000 to 20,000 ha in size. The Codrilla property on which the Codrilla mining operation, processing facilities and associated infrastructure are to be located, consists primarily of improved pasture with some small isolated areas of remnant vegetation remaining, much of which is associated with significant drainage channels. The haul road corridor from Codrilla to the Moorvale Mining Lease (ML70455) passes through three additional cattle properties, being Twenty Mile,

Bundarra and Devlin Creek. The areas within and adjacent to the haul road corridor are a combination of cleared areas consisting of improved pastures and remnant native vegetation with an understorey of native and introduced grasses.

The pre-existing and surrounding land use is a mixture of grazing and remnant native vegetation.

The Broadsound Shire Planning Scheme, which was in effect at the time of the approval, identified the preferred use for the Codrilla area as Key Resource Area and within it as a coal/mineral resource as shown in Figure 15.

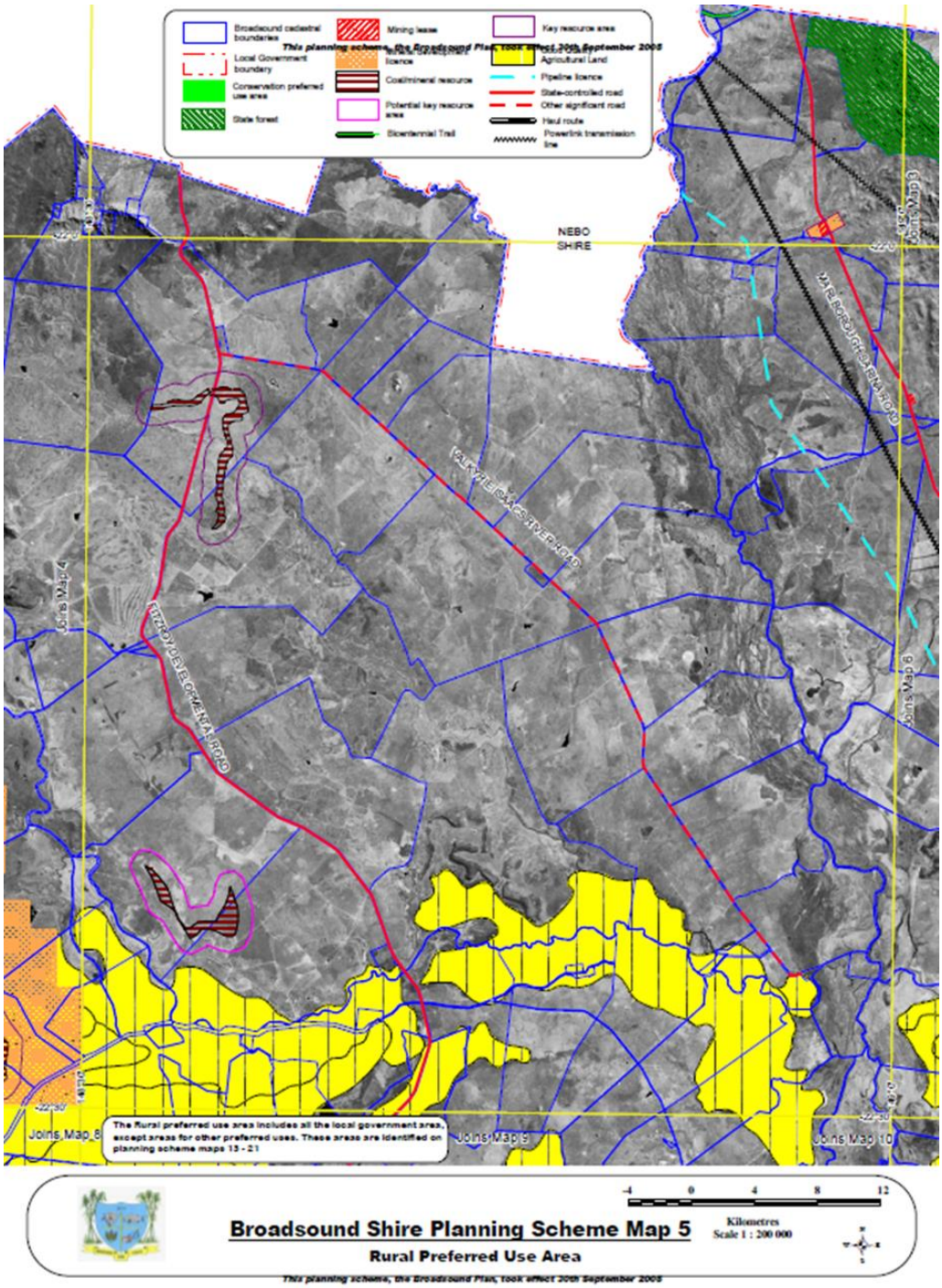


Figure 15 Broadsound Shire Planning Scheme

3.1.1.10 Underlaying landholders

Table 23 and Table 24 below identify the property description details for ML70450 and ML70455 respectively. Bistrotel Pty Ltd, which is a subsidiary of Peabody Energy Australia PCI Pty Ltd, owns most of the land covered by the Project.

Table 23 Property Details for ML70450

RP Description	Landholder	Tenure Type	Parish	ML/Property Area (ha)
Lot 16 on RP845112	Bistrotel Pty Ltd	Freehold	Kerlong	4238 (12722)
Road Reserve Fitzroy Development Road	DTMR	Road Reserve	Kerlong	N/A

Table 24 Property Details for ML70455

RP Description	Landholder	Tenure Type	Parish	Area (ha)
Lot 16 on RP845112	Bistrotel Pty Ltd	Freehold	Kerlong	12,722
Lot 5 on SP113322	Bistrotel Pty Ltd	Freehold	Kerlong	41,529
Lot 20 on KL168 (GHPL 30/4104)	Private Owner	Leasehold	Kerlong	11,900
Lot 1 on RP848589	Private Owners	Freehold	Ilsington	5,558

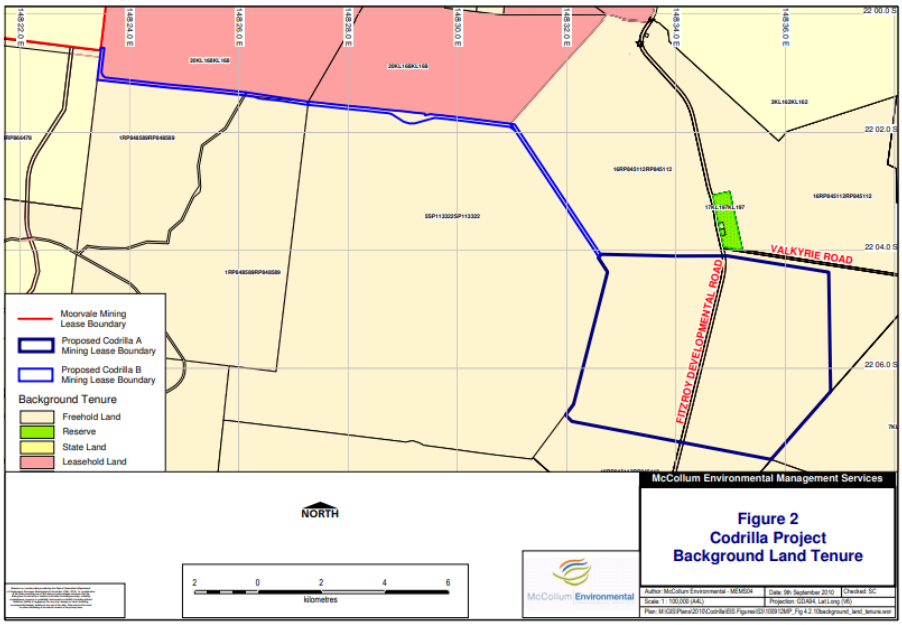


Figure 16 Underlaying tenure

3.1.2 Project Description

3.1.2.1 Resource tenure

The Codrilla Project consists of two mining leases (MLs). Details are shown below in Table 25 below.

Table 25 Codrilla Mining Leases

Mining Lease No.	Area (ha)	Grant Date	Local Government Area	Purpose
ML70450 (Codrilla A)	4252	28/06/2012	Isaac Regional Council	Mining & Infrastructure
ML70455 (Codrilla B)	213	28/06/2012	Isaac Regional Council	Infrastructure

The Codrilla Coal Mine Project is now owned by the participants in the Coppabella and Moorvale Joint Venture (the CMJV), being:

- Peabody Coppabella Pty Ltd (73.3%);
- CITIC Australia Coppabella Pty Ltd (14%);
- Winchester Coal Operations Pty Ltd (7%);
- KC Resources Pty Ltd (3.7%);
- and NS Coal Pty Ltd (2%).

The CMJV have appointed Peabody Energy Australia (C&M Management) Pty Ltd (Peabody) as the manager and operator of the Codrilla Project. Peabody is also the manager and operator for the Coppabella and Moorvale Coal Mines.

3.1.2.2 Primary mine features/infrastructure on site

The primary mine features are shown in Figure 17 and Figure 18 below.

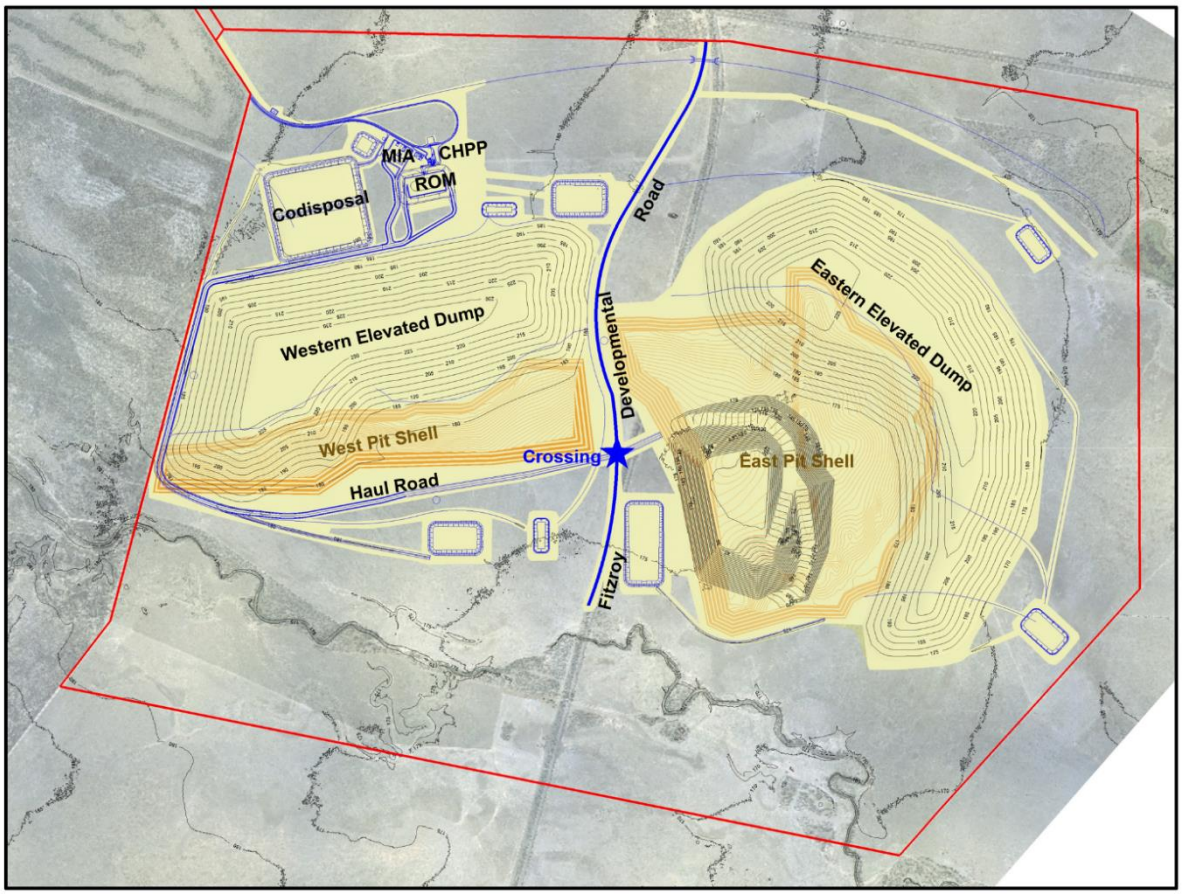


Figure 17 Primary mine features/Infrastructure

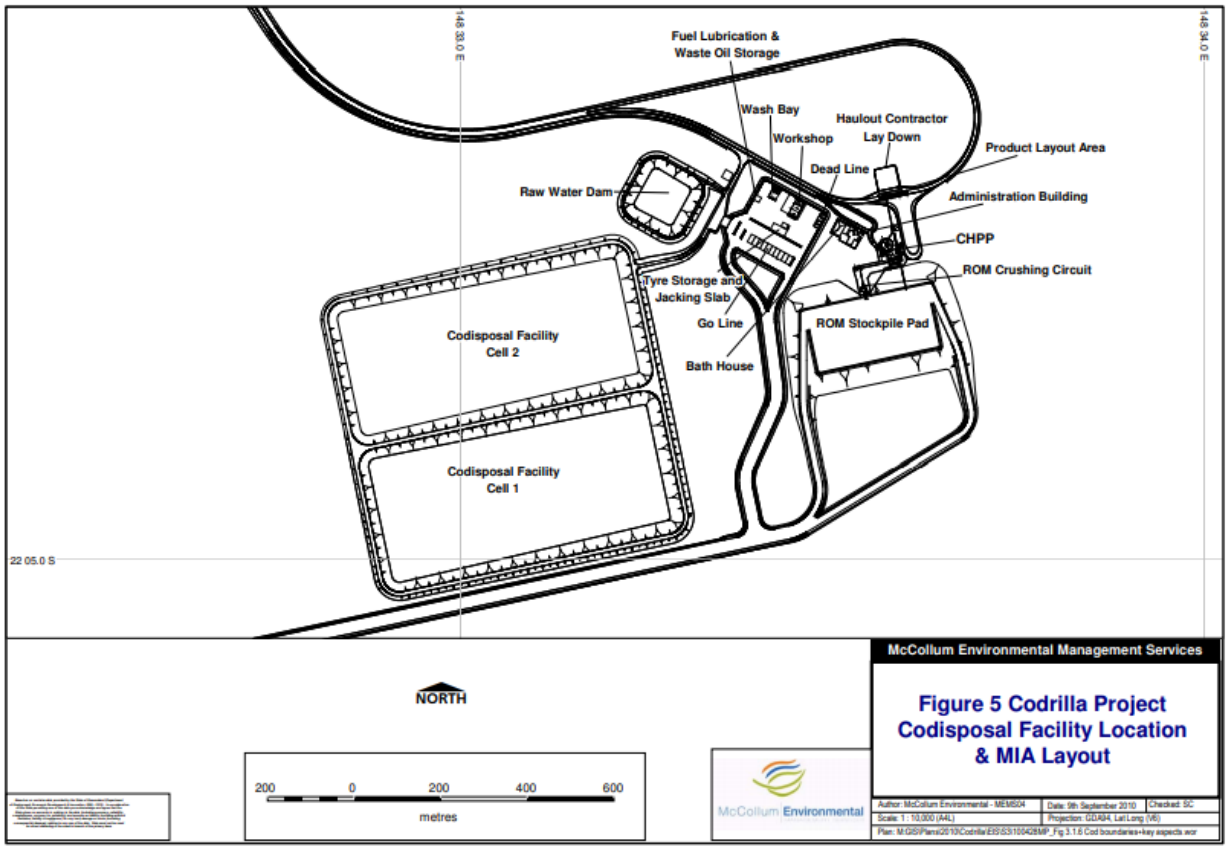


Figure 18 Co-disposal & MIA layout

3.1.2.3 Type of mining operation

The Codrilla Project involves development of a conventional truck and excavator/shovel open cut coal mine which may produce up to 5 million tonnes a year of Run of Mine Coal (ROM) with an average processing yield of 77% generating Pulverised Coal Injection (PCI) product for export. Run of mine coal would be processed on-site using conventional coal handling and preparation plant technologies. Process waste would be co-disposed with tailings, slurry and course rejects at on-site facilities. Product coal would be transported approximately 31 km to the existing Moorvale Mine train loading facility using road trains on a purpose-built private haul road. Coal would then be railed to Dalrymple Bay Coal Terminal for export.

Mining operations are currently proposed to commence in the Western pit progressing in an Easterly direction, after which mining would commence at the northern end of East pit and progress westwards before mining the southern end of the Eastern Pit, also in a westerly direction. The Southern end of the final pit area will be advanced and productively backfilled to ensure there is no residual void wholly or partially in the floodplain. Ongoing exploration activities may result in additional resources being defined and subsequent extension of the mine life. The currently planned ROM coal production rate will remain at approximately three million tonnes (Mt) per annum over the production phase of the operation, however favourable market conditions may see this rate rise to 5Mtpa, which is the approximate design capacity of the planned CHPP.

The selected method of mining is truck and shovel / excavator incorporating throw blasting where appropriate. The nature of the coal resource is such that it is best suited to this method of mining.

Furthermore, experience has been gained in truck / excavator and throw blasting methods within a similarly formed resource at Moorvale Mine.

Typical pit development will be undertaken utilising a dip-line approach which involves overburden excavation in a block perpendicular to the strike of the coal. Overburden within the blocks will be stripped in layers suitable for the size of the excavator being used. Coal seams exposed during this operation will be extracted by the mining fleet. Overburden will initially be transported to the out of pit dump until sufficient room is available to backfill available mined-out sections of pit. Once a block has been completely mined of all overburden and coal, then overburden from the next block in the mining sequence will be used to fill the completed block to final landform levels.

The dip-line method of mining results in the coal seams being mined as they are encountered during each successive section of pit development to final depth. This method has the additional advantage of greater Highwall and Lowwall stability compared to other mining methods.

Water management

The mine's water management system has been designed to divert water from undisturbed areas away from the site whilst preventing discharge from disturbed areas from entering undisturbed areas by capturing and storing runoff from disturbed areas for reuse in activities such as dust suppression and coal processing.

Co-disposal

The processing of coal generates a waste stream that has the potential to produce poor quality leachate that may contain elevated levels of salts, acid and metals. The current preferred option for processing waste storage and encapsulation is co-disposal deposition. Waste will be pumped to the co-disposal area (CDA) from the CHPP. The site for the CDA has been selected due to its proximity to the CHPP and industrial areas, the favourable topographic elevation relative to overland flow, and the location being an area of pasture that was historically cleared of remnant vegetation.

Due to the flat topography of the selected location, the facility will be constructed using a raised turkeys nest configuration. Construction will involve a staged two cell configuration, with the first cell constructed at the commencement of operations and the second cell constructed as co-disposal material storage within the first cell approaches capacity.

The facility is proposed to be constructed as a lined storage to protect against seepage into the surrounding substrate and groundwater. It is proposed that the liner be constructed from suitable clay which is sourced locally, preferably from within the mining footprint. Suitable materials are expected to be available, but if insufficient clay is available a synthetic liner will be installed, most likely from High Density Polyethylene (HDPE).

The facility will contain a dewatering collection sump to which decant water will be directed for return to the CHPP process water system.

The deposited co-disposal material is expected to be in the order of 25 to 40% solids. Given this slurry density and the range of the material sizes the co-disposal will be stackable which will enable deposition strategies to focus on beaching around the internal perimeter of the storage to optimise water drainage and recovery for reuse in the CHPP. Figure 18 shows the proposed location and design of the co-disposal facility. The detailed design will be undertaken by an experienced and RPEQ qualified engineer.

3.1.2.4 Proposed duration of operation

The life of the project depends heavily on the rate of mining, which is influenced by many external factors. Currently, the project is anticipated to produce coal continuously over a period of 19 years, although that may be extended if the ongoing exploration program identifies additional resources, or if the annual mining rate is reduced. Should the prevailing market support a higher production rate, the project duration may be shortened.

3.1.3 Design for closure

Transitional PRC plans are not required to demonstrate how aspects of the mine have been designed for closure; however, wherever possible the refined mine design has been optimised for closure when preparing this Plan.

3.1.4 Rehabilitation/Improvement Planning

3.1.4.1 Relevant activities on site

EPML00916813 is an environmental authority for a resource activity and was granted on the 29th of February 2012 after going through a Voluntary Environmental Impact Statement (EIS) process. A revised EA was issued on the 6th April 2016. Table 26 shows each approved Environmentally Relevant Activity (ERA), all other ancillary activities are carried out under the EA as part of a resource activity.

Table 26 Approved Environmentally Relevant Activities

Activity	Environmentally Relevant Activity
Mining black coal	ERA 13
Chemical storage	ERA 8
Sewage treatment	ERA 63

Mining activities that result in land disturbance include land clearing, topsoil stripping, pit excavation, overburden dump development, infrastructure development, coal hauling, hydrocarbon storage and handling, waste disposal and exploration activities. The Disturbance domains and sub-domains that will require rehabilitation, the predicted duration, size and availability for progressive rehabilitation are shown in Table 27 below as per requirements under sections 126C(1) (b) and (c) (ii).

Table 27 Disturbance domains and sub-domains that will require rehabilitation

Relevant Activity Disturbance Domain	Disturbance Sub-domain	Predicted Duration	Size/Extent of Activity (ha)	Availability for Progressive Rehabilitation
Elevated Landform – Overburden Dumps	Spoil landforms above original ground level (OGL) - Upper Surface Spoil landforms above original ground level (OGL) - Slopes	Western Spoil Landforms are established from 2026 and active for 10 years. Eastern Spoil Landforms commence in 2029 and active for 19 years.	170.1 804.9	Typically 1 year after dump area reaching final design grade with the exception of areas identified for topsoil stockpiling or capping material.

Relevant Activity Disturbance Domain	Disturbance Sub-domain	Predicted Duration	Size/Extent of Activity (ha)	Availability for Progressive Rehabilitation
Backfilled Pits – Overburden Dumps	Spoil landforms to original ground level (OGL)	Western Pit backfill commences from 2027 and active for 9 years with the last 4 years being hauled from East Pit. Eastern Pit backfill commences in 2030 and active for 18 years.	291.3	Typically 1 year after dump area reaching final design grade with the exception of areas identified for topsoil stockpiling or capping material
Infrastructure Areas	1. Haul Roads & access tracks 2. ROM 3. CHPP General Area 4. Mine Infrastructure Area (includes hydrocarbon storage & handling area)	Infrastructure Areas commence in 2026 and active for 20 years	232.3 16.8 3.2 8.1	Roads and Access Tracks are available from 2051 ROM, CHPP General Area and Mine Infrastructure Area are available from 2049
Elevated Landform - Co-disposal	Upper Horizontal Surface Slopes	Co-disposal Landforms commence in 2026 and remain in active operation for 20 years	31 34	Co-disposal Landforms are available from 2049 (4 years following active operation to allow for settling and drainage)
Residual Void including Ramps & Abandonment safety bund	Void includes Highwall and Low wall & Pit Lake	Life of the mine	171.56 (total)	Ramps and bund available to be re-vegetated prior to fencing
Water Management Structures	Surface Water Storages (clean water and sediment dams) Worked Water Storages Temporary drains, levees and erosion control structures Permanent diversions, drains or levees	Water Management Structures commence in 2026 remain active for 26 years	314 (total)	Water Management Structures are available from 2047. Availability is dependent on the rehabilitation upstream of the structures.
Exploration	Drill sites and drill holes			As soon as drill sites and drill holes completed

3.1.4.2 Rehabilitation Strategy

In accordance with condition A15 of the EA "All land subject to mining activities must be rehabilitated to a non-polluting, safe, stable and self-sustaining landform". In addition, conditions F27 to F30 of the EA specify the rehabilitation landform criteria and the requirements of the rehabilitation management plan, which also include defining rehabilitation objectives and completion criteria.

The key features of the land disturbance are described in the EIS assessment report (page 11), which include residual voids that would be about 150m deep (total area ~ 130ha), different elevated landforms such as the out of pit overburden dumps (974ha) elevated co-disposal (79ha) and the elevated ROM pad (16ha).

The landform design criteria captured by the EA seems to have captured the projective surface area of the voids (130ha), the out of pit overburden dumps (974ha) but missed the design criteria for the elevated co-disposal and elevated ROM pad which are captured in the EIS assessment report. Furthermore, projective surface disturbance for Ramps into Voids and Infrastructure Areas described under Table F1 of the EA were to be provided.

The EIS Assessment report (page 49) refers to the Environmental Management Plan (EMP) dated 12 October 2011 to describe the rehabilitation strategy as outlined below:

The rehabilitation strategy for the mine considers the following integrated measures:

- Detailed planning prior to disturbance, such as topsoil harvesting depth, identification of optimum topsoil stockpile locations, minimisation of disturbance footprint, selective handling of waste rock, erosion & sediment control requirements, etc;
- Implementation of practical landform designs, to prevent erosion and establish final erosional and geotechnical landform stability;
- Identification of species and habitat requirements required to create an appropriate post-mine land use consistent with local environmental constraints and values;
- Revegetation trials for the selection of appropriate species and methodology;
- Progressive rehabilitation of disturbed areas, using appropriate rehabilitation procedures for the area having been disturbed;
- Implementation of best practice erosion control measures;
- A rehabilitation monitoring program to assess success, or potential for improvement, of rehabilitation practices; and
- A corrective action program to address failed areas of rehabilitation.

The EIS Assessment report (page 50) also refers to the EMP commitment that rehabilitation areas would be designed to meet specific final rehabilitation design criteria, which are consistent with the criteria in conditions F27 to F30 and also address the design criteria specific to co-disposal and ROM pad outlined in the next section.

Rehabilitation areas are designed to meet the final rehabilitation design criteria outlined below:

- Out of pit overburden dumps;
  - elevated landform will have a maximum 50 m vertical height
  - outer batter slope angle will be a maximum of 5.7°
  - crest slope will be a maximum 2.3°

- Co-disposal and ROM Pad;
  - elevated landform will have a maximum vertical height of 18 m
  - outer batter slope will be 8° or less
  - crest slope will be a maximum of 2.3°
- Coal stockpile areas;
  - flat to undulating with a slope of <4.6°
- In pit overburden backfill;
  - flat to undulating will be a slope of <4.6°
- Infrastructure areas;
  - flat to undulating slope of 2.3°
- Final void;
  - maximum depth of 150m
  - highwall as mined weathered average slope angle of 1V and 0.7H (55°)
  - low wall as backfilled at angle of repose at 1V to 1.35H (36°)
- Design and install perimeter stormwater diversion;
- Fence the perimeter of the residual void to restrict access; and,
- Surface runoff from all rehabilitated areas will be directed to sediment control structures to reduce the amount of final sediment loads reporting to watercourses until vegetation has established and erosion rates are assessed to be acceptable (nominally <40 tonnes / ha / annum).

The EIS Assessment report (page 50) also refers to the EMP commitment to developing a residual void plan that will be developed to manage the residual void and will be based on operational experience and geotechnical assessment. The residual void plan will include consideration of:

- minimisation of the size of the residual void
- development of a detailed plan for post mining management of the void
- groundwater draw down
- long term water quality
- ensuring the void is geotechnical stable
- ensuring exposed coal seams do not present a potential fire risk
- provision of reasonable permanent safety measures to prevent accidental entry to the void by persons, vehicles, stock or wildlife
- provision of water diversion structures to avoid flooding.

As part of the provision of reasonable permanent safety measures to prevent accidental entry to the void by persons, vehicles, stock or wildlife, the construction of a permanent, non-traversable abandonment bund around the perimeter of the residual void will be required. The final ramps into the pit will be inside the fenced area to enable easier construction of the bund and fencing and reduce access to these relatively steep landforms. The ramp grades will be kept in order to facilitate rapid establishment of emergency access to the pit bottom should the need arise. No permanent access will be maintained and to promote long term stability of the lowwall and pit ramp structures, vegetation of native species through ground and aerial methods will be completed. These areas will be accessible

to birds, insects and small mammals, however due to the safety risks associated with the steep slopes and water quality, entry by persons, vehicles, stock or other wildlife will be restricted and as a result are considered part of a NUMA.

3.1.4.3 PMLU Rehabilitation goals and objectives

Table 28 and Table 29 describe the Rehabilitation goals and objectives to achieve the PMLU of Native Bushland and Grazing respectively.

Table 28 PMLU Native Bushland

PMLU	Disturbance domain	Rehabilitation goal	Rehabilitation Objectives
Native Bushland	Elevated overburden dumps & Co-disposal Area	Safe to humans and wildlife	Safety hazards in rehabilitation areas are not significantly different to surrounding undisturbed areas with similar post-mine land use
			Stock are excluded
		Non-polluting	Runoff or seepage discharge water will have acceptable characteristics for the receiving environment
			Seepage does not adversely impact groundwater aquifer quality to the point that renders it unfit for use (where the pre-mining groundwater quality was fit for use)
			Sediment runoff does not impede offsite assets from their intended purpose
		Stable	Final landform slopes are at an angle suitable for the post mine land use of bushland and conform with slope angles and dump height specified in the EA
			Water control structures do not require ongoing maintenance
			Surface erosion does not impede the slopes ability to support native vegetation
		Self-sustaining	Ground cover is sustainable and considered acceptable for support of the designated post- mine land use
			Native vegetation species established have sufficient diversity and density to support native bushland ecosystem function, including providing fauna habitat
			The density of declared weed plants does not compromise the rehabilitated area being used for the intended post-mine land use
			Growth medium (surface 20cm) used in conservation areas can support desired native vegetation community

Table 29 PMLU Grazing

PMLU	Disturbance domain	Rehabilitation goal	Objectives
Grazing	Infrastructure	Safe to humans and wildlife	Safety hazards in rehabilitation areas are not significantly different to surrounding undisturbed areas with similar post-mine land use
			Any hazardous material present does not compromise safety for the intended post-mine land use
			All bore holes are rehabilitated or are converted to water bores or groundwater monitoring points
		Non-polluting	Manage any hazardous material that could compromise the intended post-mine land use
			Runoff or seepage discharge water will have acceptable characteristics for the receiving environment
			Seepage does not adversely impact groundwater aquifer quality to the point that renders it unfit for use
		Stable	Rehabilitation is structurally safe for the intended post-mine land use
			Rehabilitation is erosionally stable
			Final landform slopes are at an angle suitable for the post-mine land use of grazing
		Self-sustaining	Rehabilitation is suitable for sustaining grazing
			The density of invasive plants (weeds) does not compromise the rehabilitated area being used for the intended post-mine land use of grazing
			Growth medium (surface 30cm) used in grazing areas is capable of supporting grazing pasture

3.1.4.4 Rehabilitation areas and milestones

The Rehabilitation Areas and the Rehabilitation Milestones used for the Codrilla Project are summarised in the following tables:

Table 30 Rehabilitation Areas

Rehabilitation Area	
RA1	Elevated Dumps - Upper
RA2	Elevated Dumps - Slopes
RA3	Backfilled Pits
RA4	Tracks, Roads
RA5	ROM
RA6	CHPP
RA7	Mine Infrastructure Area
RA8	Water Management Structures
RA9	Co-disposal - Upper
RA10	Co-disposal - Slopes

Table 31 Rehabilitation Milestones & Milestone Criteria

Milestone reference	Rehabilitation milestone	Milestone criteria
RM1	Infrastructure decommissioning and removal	(a) All services disconnected. Underground services remain buried and surface points sealed. (b) All buildings either demolished and removed or relocated off the mining leases. (c) Concrete slabs and footings removed or buried within overburden dump final rehabilitation areas. (d) Sumps or dams that do not form part of final landform as sediment control structures dewatered and where applicable contaminated silt removed for licensed disposal. (e) Sealed asphalt roads, car parks and hardstand areas will have the asphalt removed for reuse off the mining leases or removed for licenced disposal. Any contamination removed from unsealed roads, car parks and hardstands for licenced disposal. (f) Hydrocarbon and chemical storage areas removed and/or remediated by on-site treatment, if required. (g) All carbonaceous material collected from haul roads and disposed in the co-disposal area or buried within the overburden dump final rehabilitation areas. (h) A contaminated land survey carried out by an AQP[1] confirms that no contamination unsuitable for the post-mining land use is occurring.
RM2	Landform design, reshaping and final contouring, inclusive of drainage features	(a) Landform constructed satisfies the following criteria for each rehabilitation area— (i) RA1 and RA2: • outer batter slope gradient is ≤5.7° • crest of landforms slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 50m (ii) RA3: • flat to undulating slope gradient is ≤4.6° • crest of landforms slope gradient is ≤2.3° (iii) RA5, RA9 and RA10: • outer batter slope gradient is ≤8° • crest of landform slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 18m (iv) RA4, RA6, RA7 and RA8 : • Flat to undulating with slopes ≤2.3° (b) Certification by an AQP[1] that contour drains and rock lined drop structures installed as per appropriate design criteria. (c) The lined co-disposal facility has been signed off by an AQP[1] as constructed to design. (d) Potentially acid forming or carbonaceous waste encapsulated in the centre of landforms.
RM3	Install cover system/cap	Cover installed (minimum 1m inert unweathered overburden)
RM4	Surface preparation (e.g. topsoil, fertiliser, amelioration agents, mulch or woody debris)	(a) Topsoil spread to a minimum depth of 150mm. (b) An assessment of soil/growth medium health and suitability has been completed by an AQP[1] to confirm soil/growth medium is suitable for target vegetation establishment. (c) Gypsum and fertiliser applied at rates determined by an AQP[1]. (d) Cultivation and keying of topsoil to subsoil with suitable multi-type ripper and performed parallel to slope contours.

		(e) Where appropriate, addition of rock and/or log cover to assist erosion resistance of eventual vegetative ground cover.
RM5	Revegetation (grazing)	Completed seeding of target pasture species at rate and species composition in accordance with Table 42 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.
RM6	Revegetation & habitat development (native bushland)	Completed revegetation of target pasturenative bushland species by tube stock and/or direct seeding at rate and species composition in accordance with Table 43 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.
RM7	Achievement of surface requirements (grazing)	(a) Species density and diversity achieved is consistent with the sown seed mix and reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (b) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and of >50% for areas of high rock and log content. (c) No new invasive plants2 and infestation density of invasive plants within the area are contained or reduced and consistent with reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (d) Water control structures are either removed or free of active erosion and integrated into permanent landforms. (e) No active[3] erosion gullies. Erosion rates are less than 5 tonnes/ha/year. A NEPM[4] assessment confirms areas are free of hazardous materials or have been rendered safe.
RM8	Achievement of surface requirements (native bushland)	(a) 80% of the area achieves species density and diversity that is greater than 60% of the reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (b) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and >50% for areas of high rock and log content. (c) No new invasive plants[2] and infestation density of invasive plants in the area are contained or reduced and consistent with reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (d) Evidence of fauna habitat features for invertebrate and vertebrate species (e.g. logs, rock piles, nest boxes, bird nests or perches). (e) Water control structures are either removed or free of active erosion and integrated into permanent landforms. (f) No active[3] erosion gullies. Erosion rates are less than 5tonnes/ha/year. (g) A NEPM[4] assessment confirms areas are free of hazardous materials or have been rendered safe. (h) Certification from an AQP[1] that the cover system is functioning as designed.
RM9	Achievement of a stable condition for the land described as a	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and the landform meets criteria in RM2

	post-mining land use of grazing	(ii) erosionally stable: no active3 erosion is present and groundcover established meets criteria in RM7 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) The rehabilitated land meets Class 4 land suitability for grazing according to the Guidelines for agricultural land evaluation in Queensland (2nd edn) (DSITI & DNRM, 2015)[5]. (e) Species density and diversity achieved is consistent with the sown seed mix and reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (f) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and of >50% for areas of high rock and log content.
RM10	Achievement of a stable condition for the land described as a post-mining land use of native bushland	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and landform meets the criteria in RM2 (ii) erosionally stable: no active[3] erosion is present, and groundcover established and meets criteria in RM8 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) Native bushland established that provides habitat opportunities for native invertebrate and vertebrate species: (i) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs, and >50% for areas of high rock and log content (ii) 80% of the area achieves species density and diversity that is greater than 60% of the reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022 (iii) minimum 14 target vegetation species[6] comprising: • grasses and forbs ≥3 • mid-storey species ≥7 • canopy species ≥4

		(iv) evidence of key invertebrate groups (e.g. ants) and soil faunal communities (v) evidence of key native vertebrate groups (e.g. bird, mammal, reptile and amphibian) in the form of fauna spotting, scats and tracks
RM11	Install fencing or other infrastructure to support the PMLU	Fencing / bunding installed sufficient to exclude stock

3.1.4.5 NUMA Rehabilitation goals and objectives

Table 32 describes the Rehabilitation goals and objectives to manage the NUMA to achieve best practice management and minimise environmental harm.

Table 32 NUMA

NUMA	Disturbance domain	Rehabilitation goal	Objectives
Residual Void, Ramps into Voids & Abandonment safety bund	Mine void, inclusive of highwall, low walls and pit lake	Safe to humans and wildlife	Safe for managing the site, post-mining and does not pose an unacceptable risk to the community or environment
			Safety barriers will not be impacted by erosional or geotechnical failures
		Non-polluting	Pit waters are contained on-site
			Avoidance of creek flooding into pit
			Seepage of pit waters does not impact groundwater aquifer quality to the point that renders it unfit for use
		Stable	Pit stability does not compromise the post-mine land use or surrounding environment
		Self-sustaining	Pit waters are contained on-site
			Seepage of pit waters does not impact groundwater aquifer quality to the point that renders it unfit for use

3.1.4.6 Improvement areas and milestones

The Improvement Areas and the Management Milestones used for the Codrilla Project are summarised in the following tables:

Table 33 Improvement Areas

Improvement Area	
IA1	**Residual Void, Ramps into Voids & Abandonment safety bund**

Table 34 Management Milestones

Milestone reference	Management milestone	Milestone criteria
MM1	Highwall treatment	Highwall crest battered back where required to achieve a stable slope angle as specified by an AQP[1] (geotechnical engineer)
MM2	Achievement of landform design and surface requirements	(a) Highwall as mined weathered average slope angle of 1V and 0.7H (55°) and low wall as backfilled at angle of repose at 1V to 1.35H (36°). (b) Abandonment safety bund setback distance is in accordance with calculated geotechnical factor of safety determined at MM1. (c) Abandonment safety bund constructed of competent rock and to geometry specified (height = 2m, width top = 2m, batters = 1V:3H, width base = 14m) to prevent traversing by vehicles. (d) Maximum depth of residual void is 150m below ground level. (e) The residual void is located outside of the probable maximum flood levels. (f) Abandonment safety bund and ramp into void is revegetated with pasture seed in accordance with Table 42 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.
MM3	Achievement of sufficient improvement not to cause environmental harm and that will be safe and structurally stable	(a) Access to highwall, low wall and ramp batter is restricted by physical barriers. Fencing erected on the outside of the abandonment safety bund to specification (five strand barbed stock fencing). (b) Safety signage designed in accordance with Australian Standard is erected at 100m intervals along the fence line. (c) Certification from an AQP1 that the residual void will not cause environmental harm outside of the relevant tenure boundary. (d) Residual void acts as a groundwater sink to the receiving environment into perpetuity. (e) Certification from an AQP1 that the residual void is safe to humans and livestock. (f) Certification from an AQP1 that the water level and quality in the final void will not cause environmental harm to the surrounding environment.

3.1.5 Spatial Information

The following spatial information is being provided as part of this PRC plan:

- the location and maximum extent of disturbance footprint for the mine life
- the PMLU and NUMAs for the area within the resource tenures
- any sensitive receptors
- all spatial information outlining the rehabilitation and improvement areas that correspond to the PRC Plan schedule
- extent of a floodplain

3.2 Community Consultation

Legislative requirement

In accordance with section 126C(1)(c)(iii) and (iv) of the EP Act, the rehabilitation planning part of the PRC plan must include:

- details of the consultation undertaken by the applicant in developing the proposed PRC plan, and
- details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.

3.2.1 Background

Stakeholder engagement is a critical component of successful mine closure planning. Through effective stakeholder engagement, organisational and community perspectives, goals and knowledge are gathered to inform closure processes.

An initial community consultation program was conducted as part of the EIS process. Its purpose was to provide a forum for information gathering about social and environmental matters, associated with the development of the Codrilla Project, from those who reside in proximity to, or have an interest in, the area.

Engagement with the community and stakeholders occurred through a number of different mediums, such as:

- One on one meetings;
- Community forums;
- Public notices and newsletters; and,
- Fact sheets.

In addition to the secondary data and quantitative methods and tools used to understanding potential impacts of the project, community forums and stakeholder interviews were the qualitative methods used to gather primary data and assist in understanding the depth and breadth of potential impacts upon the community.

The community comments were categorised into five groups of concern, being community values and attitude, business opportunities and constraints and compensation, community and human services, environmental impacts and issues, and mine closure and rehabilitation.

Specific issues relating to mine closure and rehabilitation raised during consultation included potential long-term impacts on soil quality and the physical environment, the need to rehabilitate properly, discussions about planning requirements and design for the mine closure and a rehabilitation plan. The sentiment expressed was a desire to maintain the ecology and economy of the region in the hope that they will have something to pass onto the next generation. Intergenerational transfer of agricultural enterprises was a concept that was mentioned frequently. The community suggested that the Company had to state what shape the land would be after the mine finishes, so that long-term residual land use could be planned. They also suggested that many more things needed to be done compared to the current practice of rehabilitation in the area, such as local 'open box forest' trees need to be replanted in the reclamation areas. Rehabilitation drawn from local knowledge was seen as a preferred way of planning.

3.2.2 Community consultation register

Details of community consultation carried out in relation to the Project are shown in Table 35 below. Consultation that influenced the post-mining land uses, rehabilitation, final landform and closure design aspects was conducted between 2009 and 2012. The Project was put on hold in 2013 and since then there has been ongoing consultation mostly providing updates on the status of the Project.

Table 35 Community consultation register

Consultation date	Consultation method	Stakeholder	Location	Information provided	Issues raised	Outcomes	Ongoing commitments
15/06/2009	Community Forum	Potentially affected landholders, local community members, planners and managers from Isaac Regional Council, lawyers, members of the Fitzroy Basin Association and staff from Department of Education and Department of Mines and Energy	Valkyrie State School	Overview of the likely impact of the Project	EIS to address water and the effect on both water quantity and quality, land values, consideration of surrounding land uses for closure, Valkyrie School, FDR, animal welfare and impacts from dust and noise.	Included information in EIS	N/A
16/06/2009	Community Forum	Potentially affected landholders, local community members, planners and managers from Isaac Regional Council, lawyers, members of the Fitzroy Basin Association and staff from Department of Education and Department of Mines and Energy	Nebo State School	Overview of the likely impact of the Project	Same as above	Same as above	N/A
28/08/2009	Community Forum	Potentially affected landholders, local community members, planners and managers from Isaac Regional Council, lawyers, members of the Fitzroy Basin Association and staff from Department of Education and Department of Mines and Energy	Valkyrie State School	Overview of the likely impact of the Project	Same as above	Same as above	N/A
08/09/2009	Community Forum	Potentially affected landholders, local community members, planners and managers from Isaac Regional Council, lawyers, members of the Fitzroy Basin Association and staff from Department of Education and Department of Mines and Energy	Nebo State School	Overview of the likely impact of the Project	Same as above	Same as above	N/A
09/2009	Written submissions	Various Government Departments, Fitzroy Basin Association, Isaac Regional Council, Capricorn Conservation Council, Robert & Michelle Duckett, Pam MacGibbon, Di Pullen, Ron Pullen, James Pullen, Geoff Bethel, Mel Nelson, Craig Bethel, Donald & Kaye Black, Ross		Draft Terms of References	EIS to address water and the effect on both water quantity and quality, land values, consideration of surrounding land uses, Valkyrie School, FDR, animal welfare and impacts from dust and noise.	Included in draft EIS	N/A

		& Jo-Ellen Banks and Ruth Bethel					
08/09/2009-15/10/2009	Face-to face interviews	15 interviewees (4 landholders or land managers and others drawn from the following: businesses, community/volunteer associations/clubs, emergency services, local/state government, mining, primary industries and youth/education)	At a residence, a workplace or in the local park or club (depending on the preference of the informants) in the Codrilla, Nebo, Moranbah and Mackay areas		The community comments were categorised into five groups of concern, being community values and attitude, business opportunities and constraints and compensation, community and human services, environmental impacts and issues, and mine closure and rehabilitation	Addressed in draft EIS	N/A
	Telephone interviews	6 landholders or land managers			Same as above	Same as above	N/A
	Structured paper survey response	1			Same as above	Same as above	N/A
2010-2011	Phone calls, face-to-face meetings	Sharon Atkinson; Small family; DTMR		Compensation agreements negotiations			N/A
01/2011	Public Forum	Community		Update on Codrilla Project and findings from draft EIS			Ongoing consultation
14/11/2011	Face-to-face meeting	Barada Barna	Woora Consulting Office – Farleigh	Update on Codrilla Project and CHMP			Ongoing consultation
15/12/2011	Face-to-face meeting	Isaac Regional Council		Update on Codrilla Project			Ongoing consultation
06/01/2012	Email/phone call	Affected landholders		Notified that Certificate of Application and Certificate of Public Notice had been issued		Provided copies	Ongoing consultation
10/01/2012	Face-to-face meeting	Ron & Di Pullen	Property		Timing for destocking of property concern with the proposed firebreak on his property (bordering the Bundarra property) as he is of the view it will cause significant erosion on Codrilla	When it comes time to discuss the firebreak with DERM in more detail, we will mention Ron's concerns re erosion	Ongoing consultation
16/01/2012	Phone call	Ron & Di Pullen; Brian & Leigh Small; Craig Bethel; Mike & Leonor Cole		Offered one-on-one briefings on the Codrilla Project			Ongoing consultation
20/01/2012	Phone call	Sharon Atkinson; Ruth and Geoff Bethel;		Offered one-on-one briefings on the Codrilla Project			Ongoing consultation
23/01/2012	Newspaper	Public	Daily Mercury & CQ News	Public Notice MLAs & EA			N/A
24/01/2012	Phone call	Alistair and Pamela Davison		Offered one-on-one briefings on the Codrilla Project			Ongoing consultation
15/03/2012	Phone call	Russell Bailey			Inspect stock route	Organised for an inspection	Ongoing consultation

26/03/2012	Face-to-face meeting	Geoff and Ruth Bethel (owners of Regalo) Craig Bethel (son, lives on Regalo) Richard Bethel (son, lives on Willunga) and Monique	Property		Various questions and issues raised.	Responded to questions and invited Bethel's to Terowie and Moorvale to see how the following aspects are managed: Dust Water Blasting (noise, vibration and fume) Rehabilitation	Ongoing consultation
26/03/2012	Face-to-face meeting	Ron and Di Pullen	Property		Various questions and issues raised.	Responded to questions and invited Bethel's to Terowie and Moorvale to see how the following aspects are managed: Dust Water Blasting (noise, vibration and fume) Rehabilitation	Ongoing consultation
27/03/2012	Face-to-face meeting	Mick, Lenore and Callum Cole	Property		FDR; size of the exclusion zone for blasting; noise and lighting impacts during the night; Impacts on Devril and Swampy Creeks – increased amount of water down Valkyrie Access Road and Morpeth road.	Provided the responses to the questions and invited the Small's to an open day in October	Ongoing consultation
27/03/2012	Face-to-face meeting	Brian and Leigh Small	Property		Concerned about the water run-off from the road, particularly if using water from the mine Concerned about drainage impacts from the road Concerned about the potential for weeds to be transferred on to the property.		Ongoing consultation
28/03/2012	Face-to-face meeting	Alistair Davidson	Property		FDR closure and realignment		Ongoing consultation
28/03/2012	Face-to-face meeting	Sharon Atkinson & Wade Klien	Property		School relocation, construction and maintenance of fire break on Bundarra/Codrilla boundary and if there will be culverts on Devlin Creek and if so what size will they be.	Provided the responses to the questions and invited the Sharon and Wade to an open day in October	Ongoing consultation
05/04/2012	Face-to-face meeting	Pam McGibbon	Property		Requested information on mine plan, water, dust, blasting management and to have a dust	Provided the responses to the questions and invited Pam to an open day at	Ongoing consultation

					monitor at Lillianvale.	Codrilla in October	
2013-2021	Emails; Phone; Face-to-face meetings	Landholders, Isaac Regional Council, Barada Barna, Government Agencies	Various locations	Regular updates on Project status			Ongoing consultation

3.2.3 Community consultation plan

In order to comply with section 126C(1)(c)(iv) of the EP Act, the rehabilitation planning part must include a community consultation plan detailing how ongoing consultation will be carried out in relation to the rehabilitation to be carried out under the PRC plan. The following sections describe the objectives for community consultation, how the community will be engaged, the proposed consultation frequency, what information will be released for community consultation and how feedback and comments will be considered.

3.2.3.1 Objectives

The objectives of the community consultation plan (CCP) include:

- Keep identified stakeholders informed of relevant activities and progress at the mine;
- Maintain and develop stakeholder relationships;
- Record and respond to any complaints in a timely manner;
- Identify stakeholder concerns about rehabilitation and closure of the mine;
- Facilitate consultation feedback and input into mine rehabilitation and closure plans;
- Consider and address broader stakeholder concerns where possible, as they arise; and,
- Provide timely, accurate and credible information to the identified stakeholders until relinquishment is achieved.

3.2.3.2 Key stakeholders

Key stakeholders identified for ongoing consultation in relation to rehabilitation to be carried out under the PRC plan are shown in the table below:

Table 36 Key Stakeholders

Affected	Interested
• Directly affected landholders • Indigenous communities (Barada Barna) • Adjacent landholders • Isaac Regional Council • Overlapping tenure holders • DTMR	• Dept Environment & Science • Dept of Resources • Dept Transport & Main Roads • Dept Education and Training • Nebo, Valkyrie and wider Bowen Basin communities • Local businesses • Neighbouring mines • Elected officials

Considering that the final landform and post-mining land uses have been established in response to consultation it is unlikely that there will be significant changes to what is currently included in this proposed PRC Plan.

The ongoing community consultation plan mostly consists of keeping stakeholders informed and up to date with development and operation of the mine and rehabilitation progress against the PRC Plan. Table 37 provides an overview of the key engagement objectives, consultation methods and frequency for ongoing consultation.

Table 37 Ongoing consultation plan

Engagement Objectives	**Keep identified stakeholders informed and up to date with development & operation of the mine and rehabilitation progress and continue consulting and taking feedback into consideration in relation to the rehabilitation to be carried out under the PRC plan**	
Stakeholder	**Consultation method**	**Frequency**
Directly affected landholders	Advise affected stakeholders in writing when the PRC plan is approved and provide a copy of the PRC plan for their information; Meet, email or phone call to provide updates on development & operation of the mine; Meet to provide updates on rehabilitation progress against the PRC Plan and discuss any feedback	One-off Ongoing Annually, once rehabilitation commences
Indigenous communities – Barada Barna	Meet with Barada Barna to provide updates on development & operation of the mine; Meet to provide updates on rehabilitation progress against the PRC Plan and discuss any feedback	Ongoing Annually, once rehabilitation commences
Adjacent landholders	Meet, email or phone call to provide updates on development & operation of the mine and rehabilitation progress against PRC Plan	Ongoing Annually, once rehabilitation commences
DTMR	Meet DTMR to negotiate Infrastructure Agreement	One-off
Isaac Regional Council	Meet to provide updates on development & operation of the mine and rehabilitation progress against PRC Plan	At least annually
Overlapping tenure holder – Arrow Energy	Meet to provide updates on development & operation of the mine and rehabilitation progress against PRC Plan	At least annually
Nebo, Valkyrie and wider Bowen Basin community members and groups and neighbouring mines	Use community forums, community networks, site tours, newsletters to provide updates on development & operation of the mine and rehabilitation progress	Ongoing Annually, once rehabilitation commences
Local businesses and suppliers	Use business networks to provide updates on development & operation of the mine and rehabilitation progress	Ongoing
Elected representatives and departmental personnel	Meetings to provide updates on development & operation of the mine and rehabilitation progress against PRC Plan	As agreed with individual elected representatives and Department personnel

Should any proposed changes to the PRC Plan or schedule be required, stakeholders will be engaged as part of the amendment process. Table 38 provides an overview of the key engagement objectives, consultation methods, frequency, the information that will be released and how feedback will be considered during consultation for proposed changes to the PRC Plan or schedule.

Table 38 Consultation plan for PRC Plan or schedule changes

Engagement Objectives	**Consult affected stakeholders and gather feedback in relation to changes to the PRC Plan or schedule**			
Stakeholder	**Consultation method**	**Frequency**	**Information released for consultation**	**How feedback will be considered**
Directly affected landholders	Meet to discuss proposed changes to PRC Plan or schedule and gather feedback	One or more meetings as required	A fact sheet or a summary document providing an outline of the proposed PRC Plan or schedule changes and any additional information requested by the individual stakeholders	Feedback will be considered in the context of the proposed changes and other relevant feedback and if technically viable and reasonably possible it will be incorporated in the final version of the PRC Plan amendment application
Indigenous communities – Barada Barna				
Adjacent landholders				
Isaac Regional Council				
Overlapping tenure holders – Arrow Energy				
Local community members and groups	Use community forums, community networks, site tours, newsletters to discuss proposed changes to PRC Plan or schedule and gather feedback	At least one-off consultation prior to lodgement of PRC Plan or schedule proposed changes	A fact sheet or a summary document providing an outline of the proposed PRC Plan or schedule changes	Feedback will be considered in the context of the proposed changes and other relevant feedback and if technically viable and reasonably possible it will be incorporated in the final version of the PRC Plan amendment application

3.3 Post-mining land use (PMLU)

Legislative requirements

In accordance with section 126C(1)(d) of the EP Act, the rehabilitation planning part of the PRC plan must state the extent to which each post-mining land use for land identified in the PRCP schedule for the plan is consistent with:

a) the outcome of consultation with the community in developing the plan, and
b) any strategies or plans for the land of a local government, the State or the Commonwealth.

Mining lease conditions relating to rehabilitation are described within the site's Environmental Authority. The EA under condition F27 requires all areas significantly disturbed by mining activities to be rehabilitated to a stable landform with self-sustaining vegetation cover in accordance with Table F1 Landform Criteria. The EA does not specify post-mining land use(s), but the EIS Assessment Report (page 49) states that "the EIS included a progressive rehabilitation strategy that generally consists of the development of a stable, self-sustaining final landform, with appropriate post-mining land uses applied". Post-mining land uses have been determined based on the assessed post-mining land capabilities and suitability and input from consultation and primarily consist of native bush land/vegetation for wildlife usage and managed low intensity beef cattle grazing. In the EIS assessment report (page 12) it is noted that some land disturbed by mining would be rehabilitated to support grazing; however, some land would be permanently alienated from productive grazing due to the presence of the residual voids (approximately 130ha). In addition to the void, and in line with commitments under the EMP cited by the EIS Assessment report, additional area will be required for the access ramps and an appropriate offset around the perimeter of the void to provide for geotechnical factor of safety and access exclusion features (fencing, bunds and signage).

This abandonment bund area (Height = 2.0m, Width Top = 2.0m, Batters = 1V:3H - Based on these dimensions the width at the base = 14.0m), together with the residual void and the ramps into voids, will be designated as a NUMA.

The post mining land use for each domain will be as follows:

- Elevated overburden dumps: native bushland for wildlife usage;
- Elevated co-disposal area: native bushland for wildlife usage;
- Areas with a similar gradient to surrounding undisturbed landform, including infrastructure areas: grazing; and
- Stabilised final void areas: NUMA, with some opportunistic use by wildlife

The PMLU of native bushland for the elevated landforms and the backfilled voids recognise that these constructed landforms will have physical and productivity constraints that preclude the use of these areas for grazing.

Should alternate land use options be considered (e.g. installation of commercial solar generation or industrial use of workshop facilities), any required approvals will be sought prior to implementing the alternate land use.

Table 39 PMLU by domain and sub-domain

Domain	Sub-domain	Post mine land use	Projected Area (ha)
Elevated Landform – Overburden Dumps	Upper Surface	Native bushland	170
	Slopes	Native bushland	805
Backfilled Pits – Overburden Dumps	N/A	Native bushland	291
Infrastructure Areas	Access Tracks and Haul Roads	Grazing	232
	ROM	Grazing	17
	CHPP General Area	Grazing	3
	Mine Infrastructure Area	Grazing	8
Elevated Landform Co-disposal	Upper surface	Native bushland	31
	Slopes	Native bushland	34
Residual Void, Ramps into Voids & Abandonment safety bund	N/A	NUMA	172
Water Management Structures	N/A	Grazing	314

3.3.1 Consistency with outcome from community consultation

Stakeholders raised some specific issues in relation to mine closure and rehabilitation such as the need for a final landform that allowed for cattle to be re-introduced, the establishment of a post-mining land use to allow for long term planning, ensuring that the void locations were outside the Probable Maximum Flood (PMF) level, the co-disposal facility design, construction & management of Potentially Acid Forming co-disposal material, and the need to have a mix of vegetation cover, including trees to support a diversity and abundance of flora and fauna typical of the surrounding region. DERM (now DES) provided comments relating to the design of the CDA and characterisation

of material to be deposited in the CDA. DERM also requested inclusion of objectives relating to the strategies and methods for progressive and final rehabilitation of disturbed areas.

Issues raised during community consultation were addressed in the Supplementary EIS. The rehabilitation objectives were amended to reflect the changes sought by DERM, Capricorn Conservation Council, Fitzroy Basin Association and other stakeholders.

3.3.2 Consistency with Local, State and Commonwealth land use requirements

The PMLU of low intensity grazing and native bushland habitat, as described in the EIS, does not require any further State or Local Government approval prior to being implemented. These land uses are compatible with existing surrounding land uses, with the locality dominated by low intensity cattle grazing. These land use options are considered to have the lowest risk of failure as both land uses are prevalent in the region and ongoing management requirements will be minimal.

3.4 Non-use management areas (NUMAs)

Legislative requirements

In accordance with sections 126C(1)(d), (g) and (h) of the EP Act, for each proposed non-use management area, the rehabilitation planning part of the PRC plan must:

- state the reasons the applicant considers the area cannot be rehabilitated to a stable condition
- include copies of reports or other evidence relied on by the applicant for each proposed non-use management area
- state the extent to which the proposed non-use management area is consistent with the outcome of consultation with the community in developing the plan, and
- state the extent to which the non-use management area is consistent with any strategies or plans for the land of a local government, the State or the Commonwealth.

3.4.1 Description of the NUMAs

Pursuant to section 754 (3) of the EP Act and section 6.3.2 of the PRC Plan Guideline, a NUMA will be taken to be pre-approved if a land outcome, the same or substantially similar to a NUMA, is contained in a 'land outcome document'. Land outcome documents are defined in section 750 of the EP Act.

For the Codrilla Project, a residual void is authorised under the EA (Conditions F34 and F35) and the final void is established as a NUMA also within the EIS Assessment Report, which states that approximately 130ha of land "*comprising the residual voids, would be permanently alienated from productive grazing*" (EIS Assessment Report, page 12). Table F1 of the EA also describes the maximum Projected Surface Disturbance for Voids as 130 ha and for Ramps into Voids, which was to be provided and included in the EA. The area is approximately 37ha.

Furthermore, the EIS Assessment report (page 50) refers to the EMP commitment to developing a residual void plan that will be developed to manage the residual void and will be based on operational experience and geotechnical assessment. As part of the provision of reasonable permanent safety measures to prevent accidental entry to the void by persons, vehicles, stock or wildlife, the construction of a permanent, non-traversable abandonment bund around the perimeter of the residual void will be required. The abandonment safety bund is approximately 4ha.

Overall, the pit lake, high walls, end walls, low walls, ramps and protective bunding will be NUMAs and the total area is 171.56ha.

Where a NUMA has been pre-approved and is being translated into the PRC plan, the EA holder is not required to:

- Justify the proposed NUMA;
- Provide evidence to support the justification of the NUMA;
- Go through the Public Interest Evaluation process; or,
- Comply with the prohibition of voids located within a flood plain having to be rehabilitated to a stable condition

However, pursuant to section 754 (4) (b) if the EA or any other LOD does not state sufficient detail to identify the location of the land to which the outcome relates, in this instance the residual void, the proposed PRC plan must state how the EA holder will ensure the location of the land to which the outcome relates minimises risks to the environment.

In order to minimise risks to the environment, the mine design has been optimised and the mine sequencing has been adjusted so that the location of the residual void (East Pit Void) is outside of the Devlin Creek PMF and the area of the void that is closest to the floodplain is backfilled.

Following completion of mining operations, water levels in the East Pit Void are expected to recover to equilibrium within the first 120 years post mining and water levels will remain more than 50 m below the crest of the pit. The water levels within the overburden and voids are expected to recover to levels below pre-mining conditions because the average daily evaporation is around four times the average daily rainfall within the local region. Given the evaporative influences the water level is expected to remain below surface and given the saline nature of groundwater recovering to pits and salt leaching from backfilled overburden, it is expected that over time, the water within East Pit Void will progressively become more saline and eventually approach salinity levels similar to those observed within the regional aquifer system.

Storage of saline water in the East Pit Void will not result in adverse environmental impacts due to the lack of connectivity to any alluvial freshwater deposits; the saline nature of naturally occurring groundwater within coal measures; and, the long-term containment of the water within the pit.

The limited catchment area of where the East Pit Void is located will ensure that it remains as a permanent 'sink', with no potential for overtopping and release of contaminated water to the surrounding environment and to Devlin Creek.

Erosion of the low wall slopes within the residual void may occur over time; however, rates of erosion should reduce over time as slopes naturally self-armour, preferential flow paths develop, and vegetation establishes on the slopes. Erosion of the low wall will not give rise to environmental harm as any sediment will be contained within the void area.

Highwall stability has been addressed via the geotechnical appraisal that accompanied the EIS. Upon cessation of mining an abandonment bund will be constructed at a setback distance from the pit edge that complies with the requisite geotechnical factor of safety. Permanent fencing and signage will be erected to prevent access by people or livestock.

Low wall areas within the residual void, ramps into the voids and the abandonment safety bund will be revegetated and even though no use is assigned they may provide a limited use to wildlife.

One of the options considered for the future is that the provision of final voids in the final landform provides potential coal seam access for highwall mining or underground activities which may become economically viable in the future (EIS Assessment Report, page 12).

3.4.2 Consistency with outcome from community consultation

The Capricorn Conservation Council and other stakeholders during the EIS process raised concerns regarding void size, dump heights and the potential for Devlin Creek to inundate the final void. This resulted in changes in the mine plan to decrease the proposed size of the final void and verification that the void(s) will be outside the Probable Maximum Flood (PMF) level.

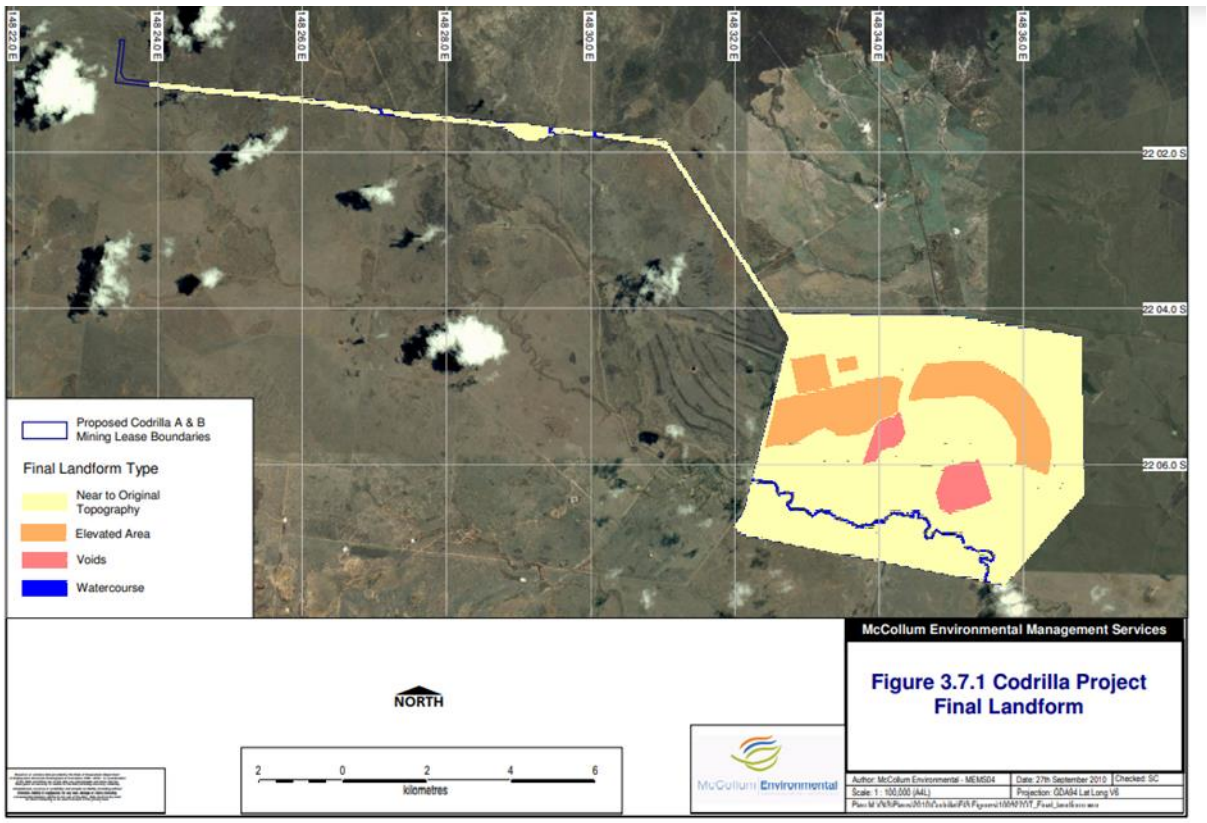


Figure 19 Draft EIS Final Landform

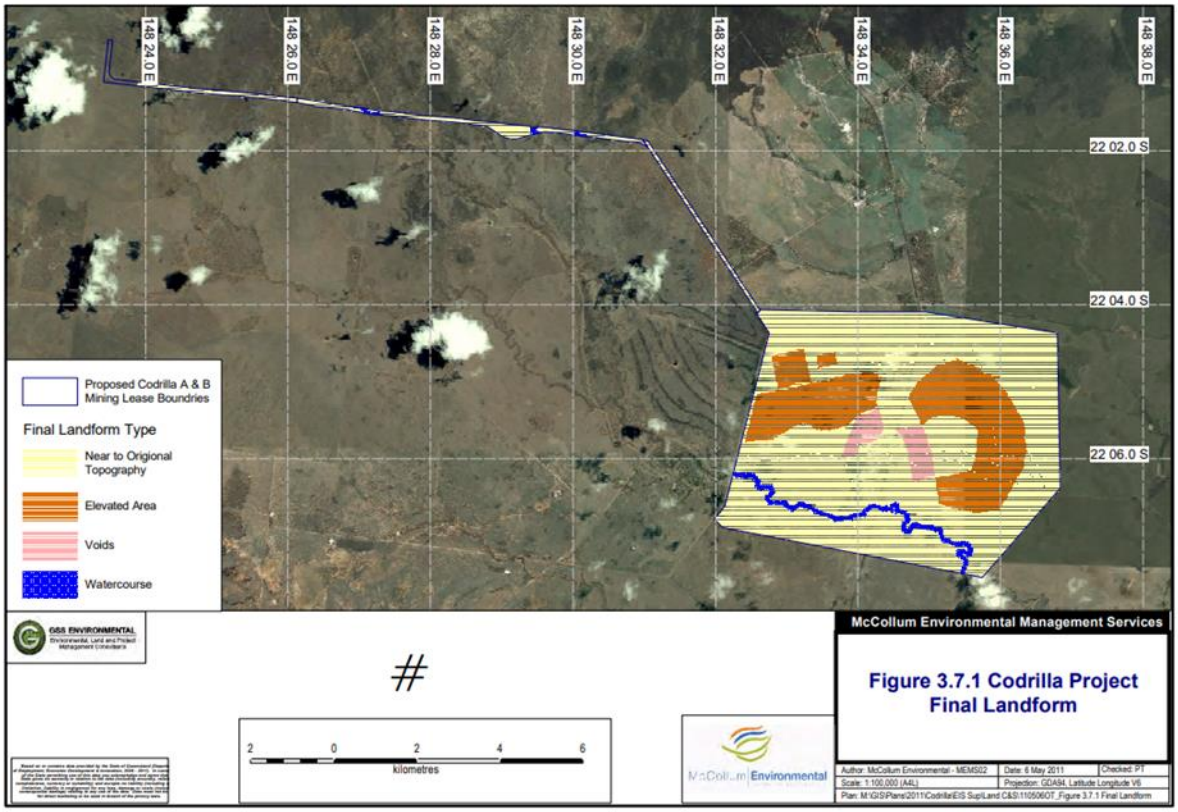


Figure 20 Supplementary EIS Final Landform

3.4.3 Consistency with Local, State and Commonwealth requirements

The NUMA is authorised by the EA and is therefore pre-approved under the EP Act and does not require any further State or Local Government approval.

3.4.4 Voids in flood plains

Legislative requirement

In accordance with section 126D(3) of the EP Act, if land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.

The Codrilla Project does not contain any void in flood plains. The mapped flood plain extent has been modelled to a 0.05% AEP, meeting the modelling requirements under the PRC Plan guideline and section 41C (3) of the *Environmental Protection Regulations 2019* (EP Regs).

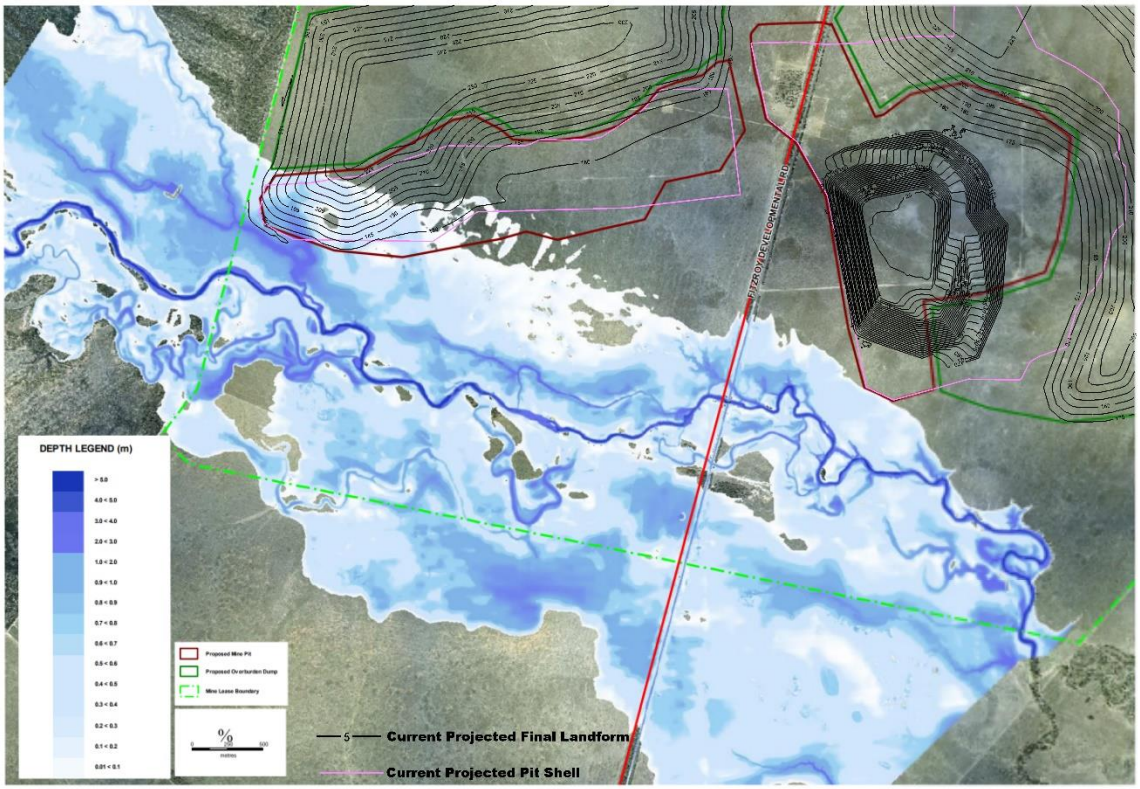


Figure 7.5 2,000 Year ARI Flood Depths, Devlin Creek

Figure 21 Final void location and 2000 Year ARI Flood

3.5 Rehabilitation management methodology

Legislative requirement

In accordance with section 126C(1)(e) and (i), the rehabilitation planning part of the PRC plan must:

- For each proposed post-mining land use for land, state the proposed methods or techniques for rehabilitating the land to a stable condition in a way that supports the rehabilitation milestones under the proposed PRCP schedule.
- For each proposed non-use management area, state the proposed methodology for achieving best practice management of the area to support the management milestones under the proposed PRCP schedule for the area.

The proposed rehabilitation or management methodologies underpin the development of the milestone criteria and support how the proposed PMLU will be achieved or the NUMA will be managed. As per section 126C(1)(j) of the EP Act, the administering authority requires information describing how the proposed rehabilitation or management methodologies have been developed and will be implemented.

3.5.1 General rehabilitation practices

In accordance with condition A15 of EPML00916813 "*All land subject to mining activities must be rehabilitated to a non-polluting, safe, stable and self-sustaining landform*". The PMLUs for the land are grazing and native bushland with one NUMA.

The basic process that will be adopted for each PMLU to rehabilitate the land to a stable condition and for each NUMA for achieving best practice management in a way that supports respectively the rehabilitation milestones and the management milestones under the PRC Plan schedule are:

3.5.1.1 Progressive rehabilitation process

Progressive rehabilitation is very important in stabilising landforms against erosion. The rehabilitation process consists of several stages which progressively occur concurrent to the mining process including:

Topsoil harvesting:

- Topsoil resources will be characterised and mapped ahead of disturbance to inform stripping depths so as to avoid dilution of valuable topsoil will dispersive, sodic or saline sub-soil;
- Soil moisture will be assessed, and the timing of topsoil harvesting scheduled to avoid soil stripping when soils are saturated or when the soil resource is excessively dry to avoid degradation of the soil resource's physical properties;
- Topsoil recovery will occur ahead of disturbance and either stockpiles or, wherever possible, directly used in rehabilitation;

Landform design & preparation:

- Landform construction will be designed to ensure that any potentially acid forming or carbonaceous waste material is encapsulated within the centre of the dump to minimise exposure to moisture or oxygen;
- Landform designs will seek to maximise the flow of surface water and shallow groundwater seepage originating from the dump footprint towards the final void to ensure potentially saline, sediment laden or non-neutral drainage does not flow offsite;
- Competent rock will be sourced and stockpiled for use in armouring slopes and for construction of drainage structures where erosion modelling predicts that slopes are susceptible to erosion;
- Any carbonaceous or salt affected surface material shall be scalped from affected areas prior

to rehabilitation, with the contaminated material to be buried in the final void or the CDA;

- Sediment dams will be dewatered, and any carbonaceous material, salts or sediment removed and disposed of within the in-pit dumps prior to decommissioning;
- Regrading will be undertaken to shape the surface of disturbed areas so that it conforms to the final landform design, with machine guidance systems used to assist in achieving the desired landform contours;
- Drainage construction will follow regrading to ensure protection from erosion whilst vegetation establishes and allow stability of the landform;
- Re-shaping and contouring of overburden dumps;
- Landforms will be signed-off as constructed to design at completion of earthworks;

Topsoil/growth media application:

- Topsoil will be spread over the surface of the final landform following regrading, contouring and drainage construction;
- Organic matter such as straw, hay, mulched native vegetation or cane mulch may be applied and incorporated into the soil to build organic matter content and provide some protection against raindrop-initiated erosion. Where these materials are to be used, they shall be certified as being free of invasive plants. The applied mulch may be 'keyed in' to the topsoil via use of a tractor mounted crimping roller, light harrow or scarrifier;
- Topsoil will be 'keyed' into the underlying spoil or subsoil via light scarification to a depth no greater than 30cm, with cultivating occurring parallel with the slope contours to maximise retention of rainfall and limit erosion arising from uncontrolled overland flow;

Vegetation & fauna habitat establishment:

- Seedbed preparation will occur after the topsoil has been spread and will typically involve ripping along the contour using a dozer with three tynes mounted behind the machine;
- Seeding, fertilising and addition of any other ameliorants will be undertaken as soon as practicable following the preparation of the seedbed. Application of post- mining land use site-specific seed mix and fertiliser blend, which will be progressively developed based on trials and rehabilitation success;
- Seed shall be sourced from local prominence species where possible to improve success of establishment and reduce the potential for the introduction of invasive plants species;
- Seed application shall occur immediately following cultivation to ensure that a friable seed bed has been created to provide for seed lodgement. If a hard crust has formed due to rainfall, application of gypsum and re-cultivation will be carried out prior to seeding. Light scarification with a harrow or similar implement drawn behind the seeding unit will be utilised to achieve partial burial of the seed to enhance seed/soil contact, noting that burial at depths greater than the diameter of the seed may prevent the germinant from successfully emerging;
- Seeding shall be scheduled to occur during optimum establishment times, based on local experience. Nominally, seeding will be conducted in either March/April or September/October. Seeding during summer months should generally be avoided as germinating seedlings may be burnt off due to excessively hot and dry conditions. For native bushland post-mining land use, if required, revegetation will also be augmented by tube stock planting;
- Logs from trees that must be cleared in advance of mining will be stockpiled and subsequently scattered across sections of the CDA and WRD horizontal surfaces to provide habitat for fauna and organic matter to support soil biota and plant growth;
- Areas where stock need to be excluded will be fenced permanently;

Monitoring & maintenance:

- Monitoring and assessment of rehabilitation success through the rehabilitation monitoring program. Monitoring will focus on key indicators relevant to the post-mining land uses of grazing and native bushland and of the NUMA; and,
- Maintenance of rehabilitation and undisturbed areas as required, which may include the need to repair erosion areas, reseeding, supplementary planting with tube stock, additional fertiliser or other ameliorant application and repair to drainage structures.

3.5.1.2 Hydrogeology

The pre-existing groundwater conditions are described in section 3.1.1.5.

An assessment of groundwater impacts was undertaken by Australasian Groundwater and Environmental Consultants Pty Ltd as part of the development of the EIS for the Codrilla Project. A subsequent addendum to that report was made in response to changes in the mine plan for submission with the Supplementary EIS (see Appendix 4.4). These reports deal with groundwater impacts on ML70450 (the Codrilla mining area) only. Impacts on ML70455 (Moorvale haulroad) are considered to be negligible.

Numerical modelling of the groundwater regime was undertaken with consideration of mining specifics to assess potential impacts of the mine development. A 3D representation of the numerical groundwater model is shown in Figure 22 below.

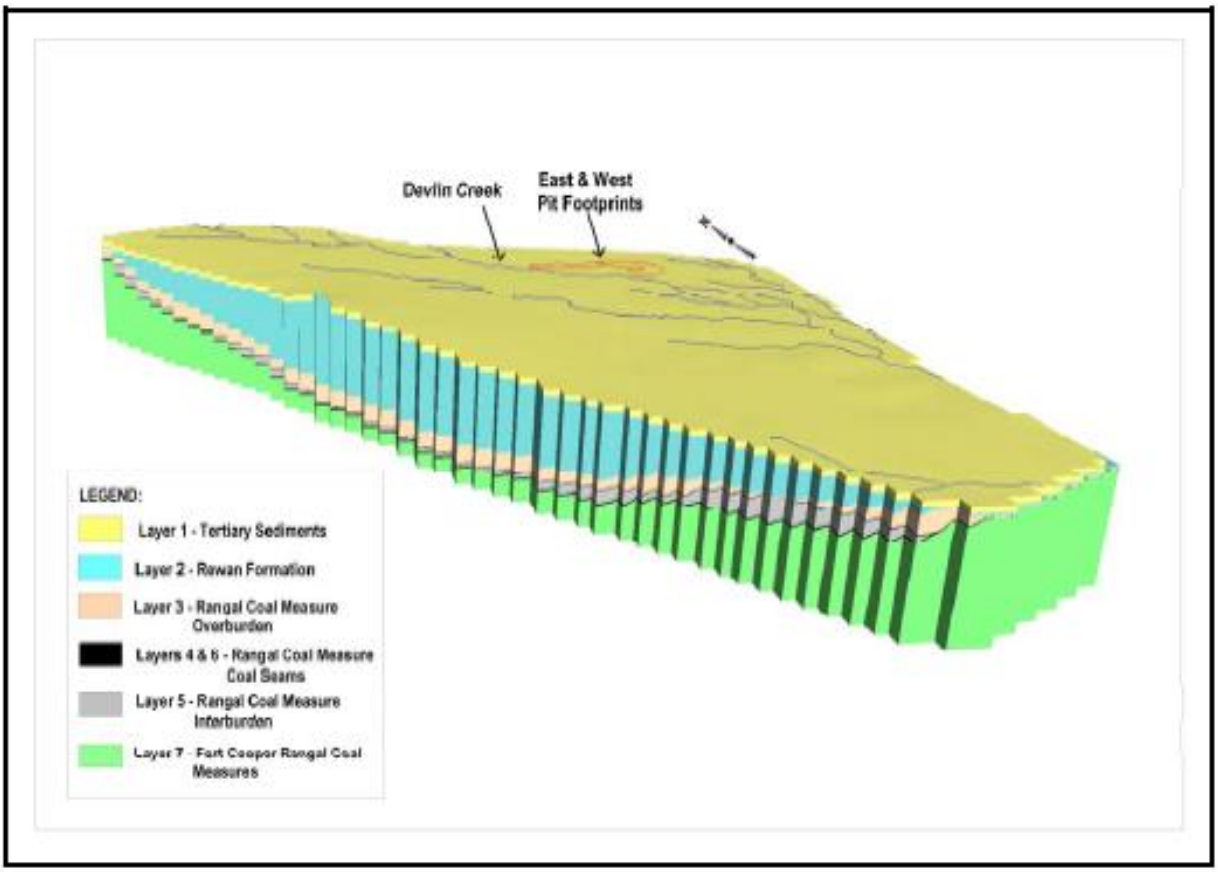


Figure 22 Groundwater Model 3D Representation

Model hydraulic parameters for each of these layers were developed from permeability testing conducted on the monitoring bores, and modified through a 'Steady State' calibration process - comparing modelled with actual groundwater levels observed in the boreholes. The figure below shows the differences between the modelled and actual pre-mining water levels.

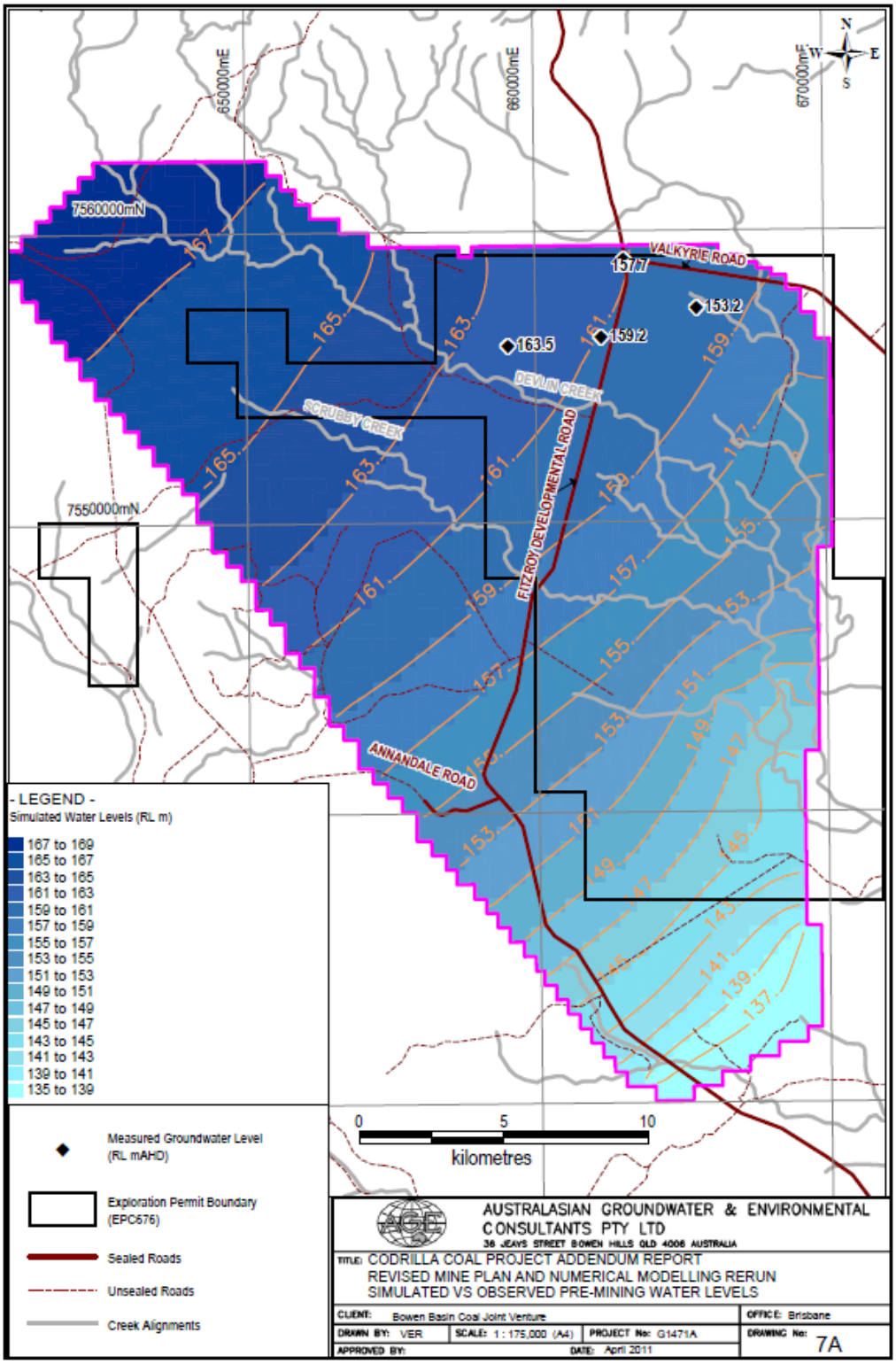


Figure 23 Observed and Simulated Pre-Mining Groundwater Levels

The mining induced impacts on regional and local groundwater were modelled using the mining footprint illustrated below (shaded areas). This footprint is similar to the current plan (shown as contours and magenta outline), except that the West Pit Void has been completely backfilled in the current plan final landform, and the East Pit Void is larger, extending further East than the modelled void.

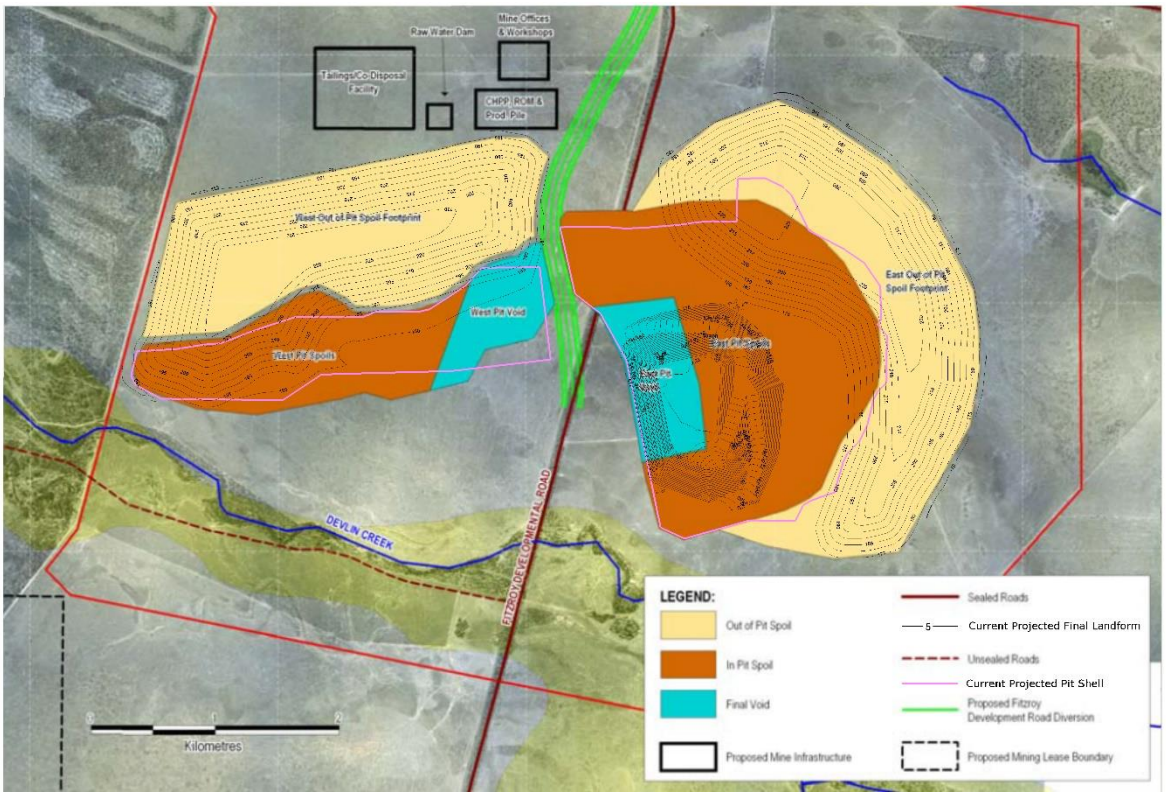


Figure 24 Current Projected Landform (contours) over Groundwater Model Assumed Landform (shaded)

Potential impacts may include drawdown of the regional aquifer and contamination of aquifers resulting from onsite activities such as the storage and handling of chemicals and hydrocarbons and waste materials, (both process and non-process wastes).

The mine development and operation will depressurise the Tertiary, deeper Triassic/ Permian and coal seam aquifers by groundwater inflows into the East and West Pits which will lower the elevation of the piezometric surface of these aquifers and create a cone of depression around the mine. The model simulated extent of the cone of depression in the overburden at the end of mining is shown on Drawing No. 9A (Figure 25 below). The drawdown due to mining is shown in Drawing No. 10A (Figure 26 below).

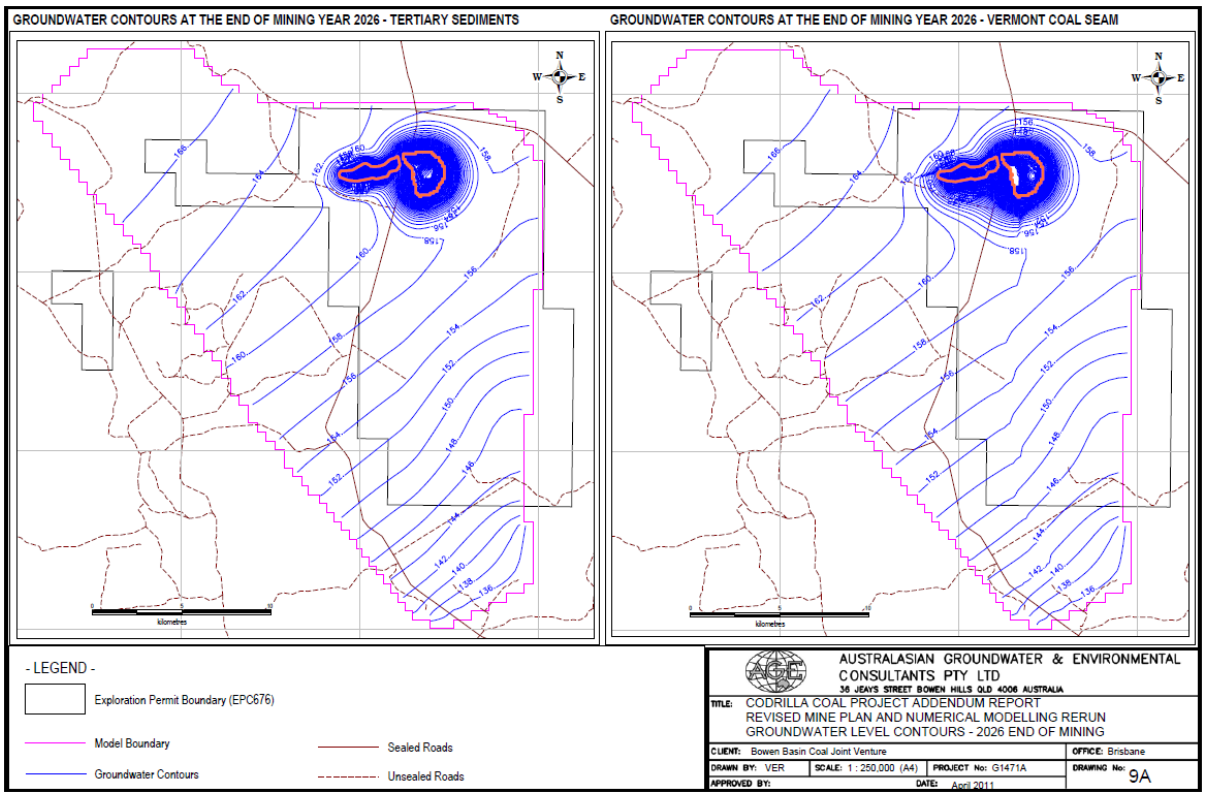


Figure 25 Post Mining Predicted Groundwater Levels

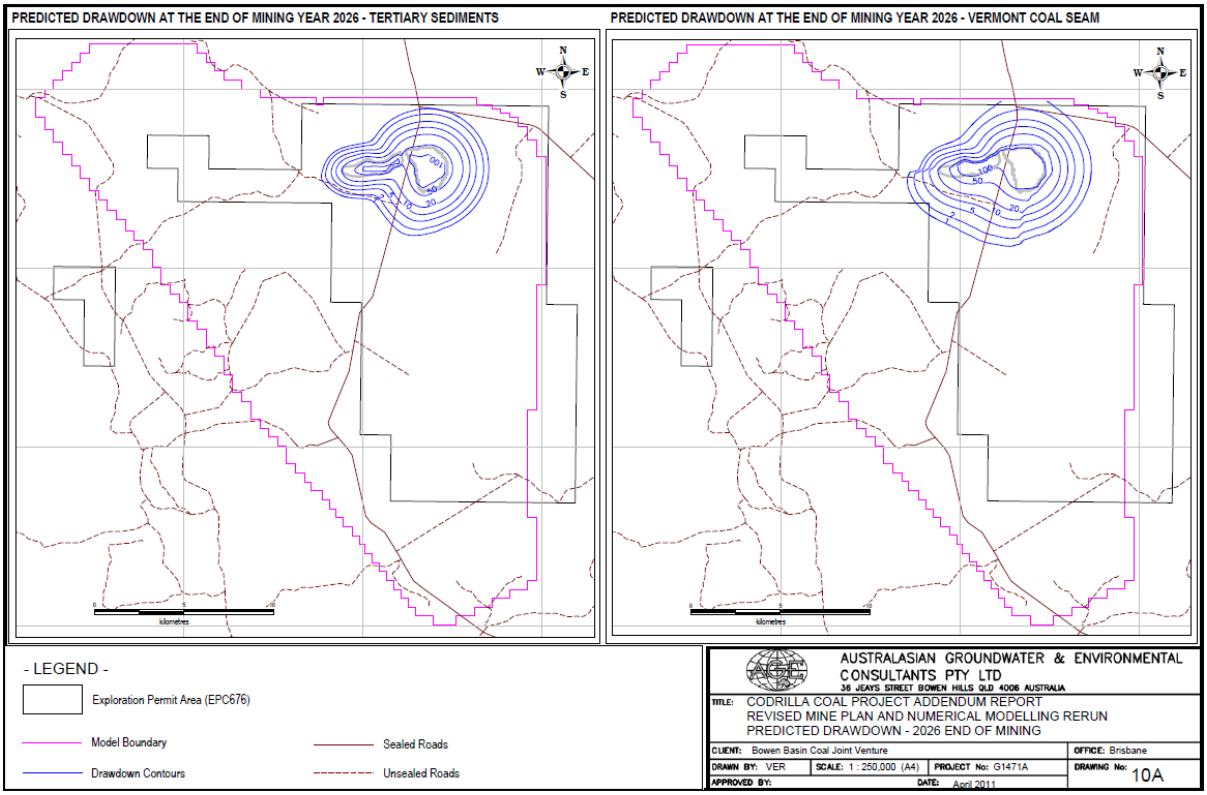


Figure 26 Post Mining Groundwater Predicted Drawdown using EIS Groundwater Model

The drawings indicate that the zone of significant drawdown at the end of mining (i.e., greater than 5m) is limited to the area immediately surrounding the East and West Pits. That is, a generally steep drawdown curve develops a cone of depression up to approximately 4km radius of the northern, southern, eastern and western extents of the mined area. Based on these simulated drawdown levels, the extent of impact on groundwater levels is more prevalent on a local scale immediately adjacent to the mine site, but less so on a regional scale. As there are no other mines within the regional extents of the study area, there will be no cumulative drawdown impacts on the regional aquifer.

It is possible the extent of the simulated drawdown could be less than that predicted, as the numerical model does not include faulting on a local scale which could act as additional hydraulic barriers and limit the effects of aquifer drawdown.

Groundwater inflow to mining pits during operations and post mining were assessed. Predicted inflow volumes are considered manageable within the proposed water management system.

The estimated recovery in water levels in the final voids and spoils is shown in Figure 27.

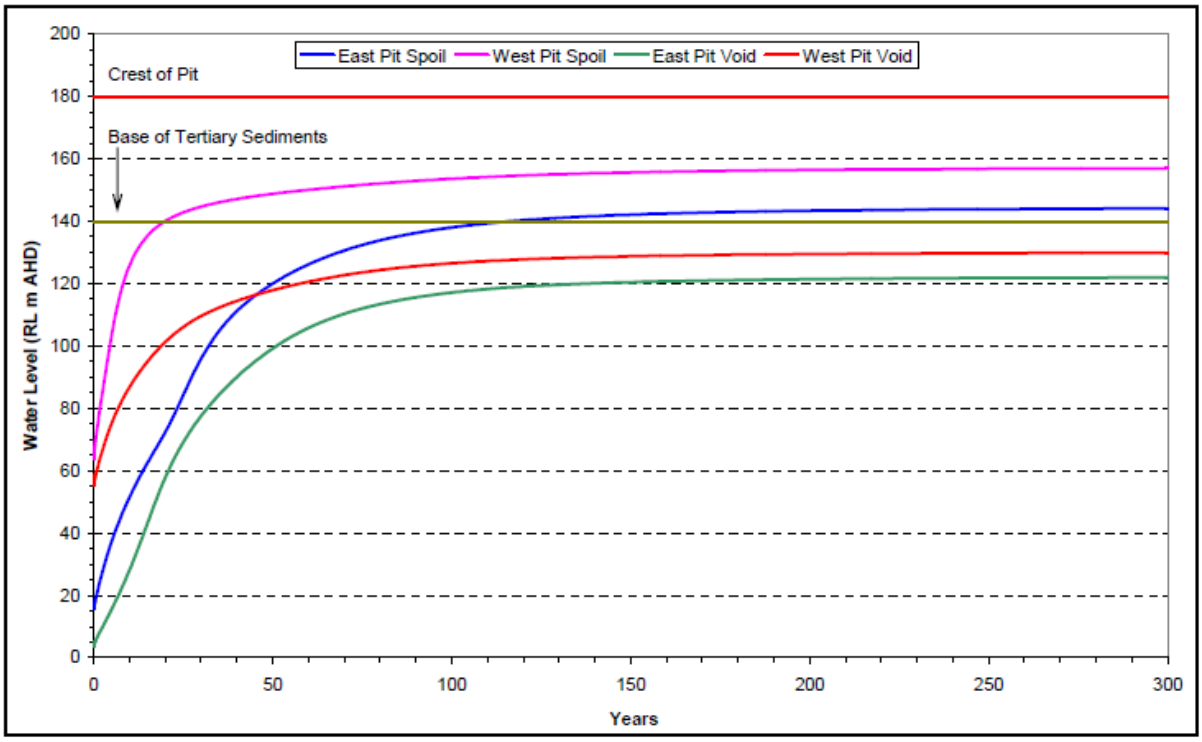


Figure 27 Predicted Long-term Groundwater Levels

The assessment (using the SEIS Mine Plan) indicates groundwater levels in both the East and West Pit voids show a slow recovery rate with water levels rising to a pseudo-equilibrium level around RL120m in East Pit (~60m below the Pit Crest) and RL128m in West Pit after 120 years post mining. Thereafter the water levels still continue to recover but at a very slow rate only reaching RL122m and RL130m in East and West Pit voids respectively after 300 years post mining. Using the current mine plan, long term standing water levels in the East Pit Void are expected to be lower than modelled due to the larger evaporative footprint of the current design, whereas the West Pit Void has been removed from the current design.

Similarly, the water levels within the spoil in each pit initially recover relatively quickly to a pseudo-equilibrium level of around RL120m in East Pit spoil and RL149m in West Pit spoil after 50 years post mining. Thereafter the water levels in East Pit spoil rise very slowly to around RL157m and in West Pit to RL144m after 300 years post mining, generally levelling out after around 100 years.

The evaporative pumping effect in conjunction with the slow rainfall recharge potential for this area will result in the final equilibrium recovered void water levels being somewhere between that predicted for pit void and spoil water levels, which will probably be close to the base of the Tertiary Sediments. Hence the voids will most likely act as a local sink for groundwater and result in a gradual increase in the salinity of the void water over time. The quality of the water will be controlled by the groundwater seepage quality, leaching of salts from the spoil piles and evaporative concentration of rainfall inputs. The salinity of the water would be expected to be brackish, becoming saline over time. The void will act as a sink for the local groundwater and therefore attract water from the surrounding coal measures, with the hydraulic gradients preventing any migration of pit water back into the coal measures. Groundwater contamination is not anticipated as the coal seam aquifers are naturally saline and are not utilised for water supply purposes. The EIS determined that the pit void will not be connected to localised shallow aquifers which contain better quality water and may be utilised for stock water supply in the future.

The water of the alluvial aquifer has aquatic ecosystem values of significance to the local ecology. As no mining activities are planned to intersect the alluvium associated with the aquifer, impacts to water levels within the aquifer are not expected. No potentially contaminating activities are proposed to be undertaken in areas of the Codrilla Project containing alluvium.

The water level in the void is expected to remain below surface with no risk of spillage to local water courses. With the void filled with groundwater and rainfall the risk of spontaneous combustion is minimised because the lower seams will have oxygen exposure excluded.

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** and **Improvement Areas** and **Management Milestones** in the PRC Plan Schedule:

RA1, RA2, RA3, RA7, RA8, RA9 & **RA10 and IA1**

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones and Management Milestones:

RM2	Landform design, reshaping and final contouring, inclusive of drainage features	(a) Landform constructed satisfies the following criteria for each rehabilitation area— (i) RA1 and RA2: • outer batter slope gradient is ≤5.7° • crest of landforms slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 50m (ii) RA3: • flat to undulating slope gradient is ≤4.6° • crest of landforms slope gradient is ≤2.3° (iii) RA5, RA9 and RA10: • outer batter slope gradient is ≤8° • crest of landform slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 18m (iv) RA4, RA6, RA7 and RA8 : • Flat to undulating with slopes ≤2.3°

		(b) Certification by an AQP[1] that contour drains and rock lined drop structures installed as per appropriate design criteria. (c) The lined co-disposal facility has been signed off by an AQP[1] as constructed to design. (d) Potentially acid forming or carbonaceous waste encapsulated in the centre of landforms.
RM9	Achievement of a stable condition for the land described as a post-mining land use of grazing	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and the landform meets criteria in RM2 (ii) erosionally stable: no active3 erosion is present and groundcover established meets criteria in RM7 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) The rehabilitated land meets Class 4 land suitability for grazing according to the Guidelines for agricultural land evaluation in Queensland (2nd edn) (DSITI & DNRM, 2015)[5]. (e) Species density and diversity achieved is consistent with the sown seed mix and reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (f) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and of >50% for areas of high rock and log content.
RM10	Achievement of a stable condition for the land described as a post-mining land use of native bushland	((a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and landform meets the criteria in RM2 (ii) erosionally stable: no active[3] erosion is present, and groundcover established and meets criteria in RM8 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) Native bushland established that provides habitat opportunities for native invertebrate and vertebrate species: (i) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs, and >50% for areas of high rock and log content (ii) 80% of the area achieves species density and diversity that is greater than 60% of the reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022 (iii) minimum 14 target vegetation species[6] comprising: • grasses and forbs ≥3 • mid-storey species ≥7 • canopy species ≥4

		(iv) evidence of key invertebrate groups (e.g. ants) and soil faunal communities (v) evidence of key native vertebrate groups (e.g. bird, mammal, reptile and amphibian) in the form of fauna spotting, scats and tracks
MM1	Highwall treatment	Highwall crest battered back where required to achieve a stable slope angle as specified by an AQP[1] (geotechnical engineer)
MM2	Achievement of landform design and surface requirements	(a) Highwall as mined weathered average slope angle of 1V and 0.7H (55°) and low wall as backfilled at angle of repose at 1V to 1.35H (36°). (b) Abandonment safety bund setback distance is in accordance with calculated geotechnical factor of safety determined at MM1. (c) Abandonment safety bund constructed of competent rock and to geometry specified (height = 2m, width top = 2m, batters = 1V:3H, width base = 14m) to prevent traversing by vehicles. (d) Maximum depth of residual void is 150m below ground level. (e) The residual void is located outside of the probable maximum flood levels. (f) Abandonment safety bund and ramp into void is revegetated with pasture seed in accordance with Table 42 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.
MM3	Achievement of sufficient improvement not to cause environmental harm and that will be safe and structurally stable	(a) Access to highwall, low wall and ramp batter is restricted by physical barriers. Fencing erected on the outside of the abandonment safety bund to specification (five strand barbed stock fencing). (b) Safety signage designed in accordance with Australian Standard is erected at 100m intervals along the fence line. (c) Certification from an AQP1 that the residual void will not cause environmental harm outside of the relevant tenure boundary. (d) Residual void acts as a groundwater sink to the receiving environment into perpetuity. (e) Certification from an AQP1 that the residual void is safe to humans and livestock. (f) Certification from an AQP1 that the water level and quality in the final void will not cause environmental harm to the surrounding environment.

3.5.1.3 Flooding

Flood modelling results for Devlin Creek under existing (pre-mining) conditions show that part of the western pit and some eastern mine infrastructure may be subject to some flood inundation for larger and extreme flood events. The modelling assesses flooding impacts on ML70450 (the Codrilla mining area) only. Impacts on ML70455 (Moorvale haulroad) are considered to be minor.

Modelled flood events include 2, 10, 100 and 2000 year ARI, as well as Probable Maximum Flood (PMF).

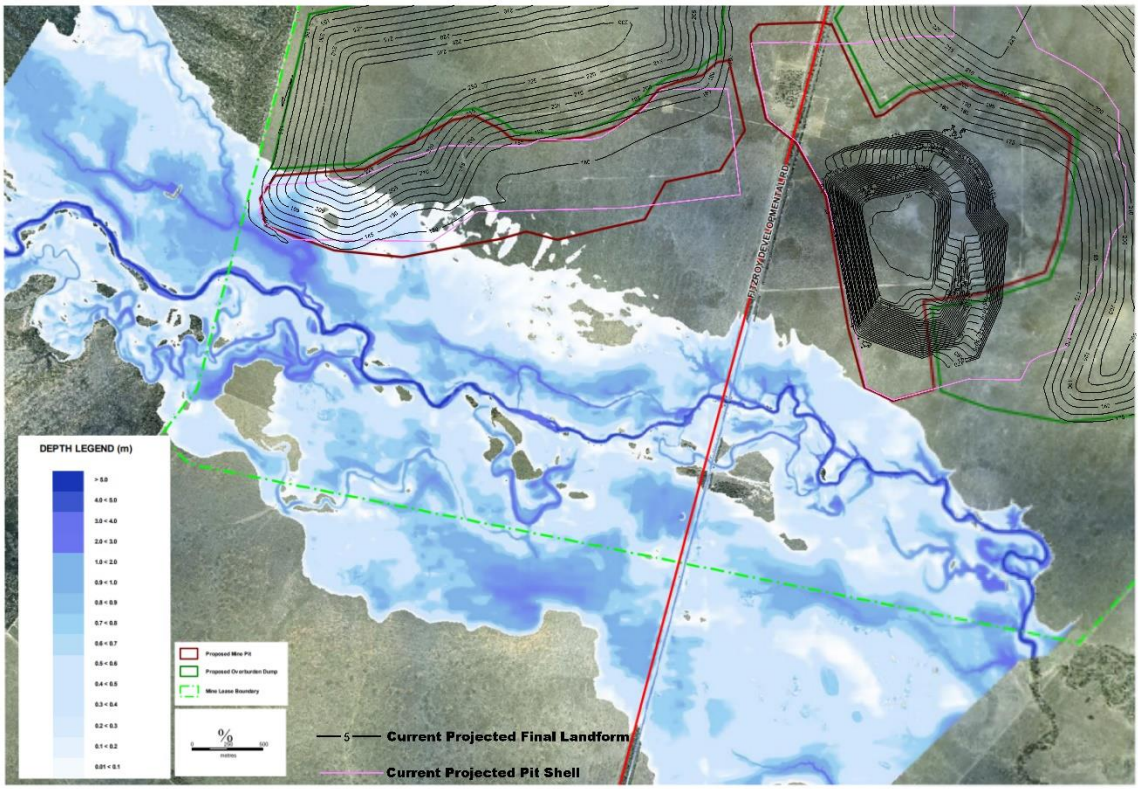


Figure 7.5 2,000 Year ARI Flood Depths, Devlin Creek

Figure 28 Devlin Creek 2000 Year ARI Flood Depths

To reduce flooding risks while the mine is operational, levees will be constructed to the south of the western and eastern pits to prevent inundation from a 10-year ARI or larger. The proposed levees were included in the hydraulic model and the results showed that impacts of levee construction on flood levels in the vicinity of the Codrilla Project will be minimal, with increases in flood levels over 0.1m restricted to just upstream of the western levee (see Figure 29 below). The Codrilla Project will have no impact on regional flooding in waterways downstream of ML 70450.

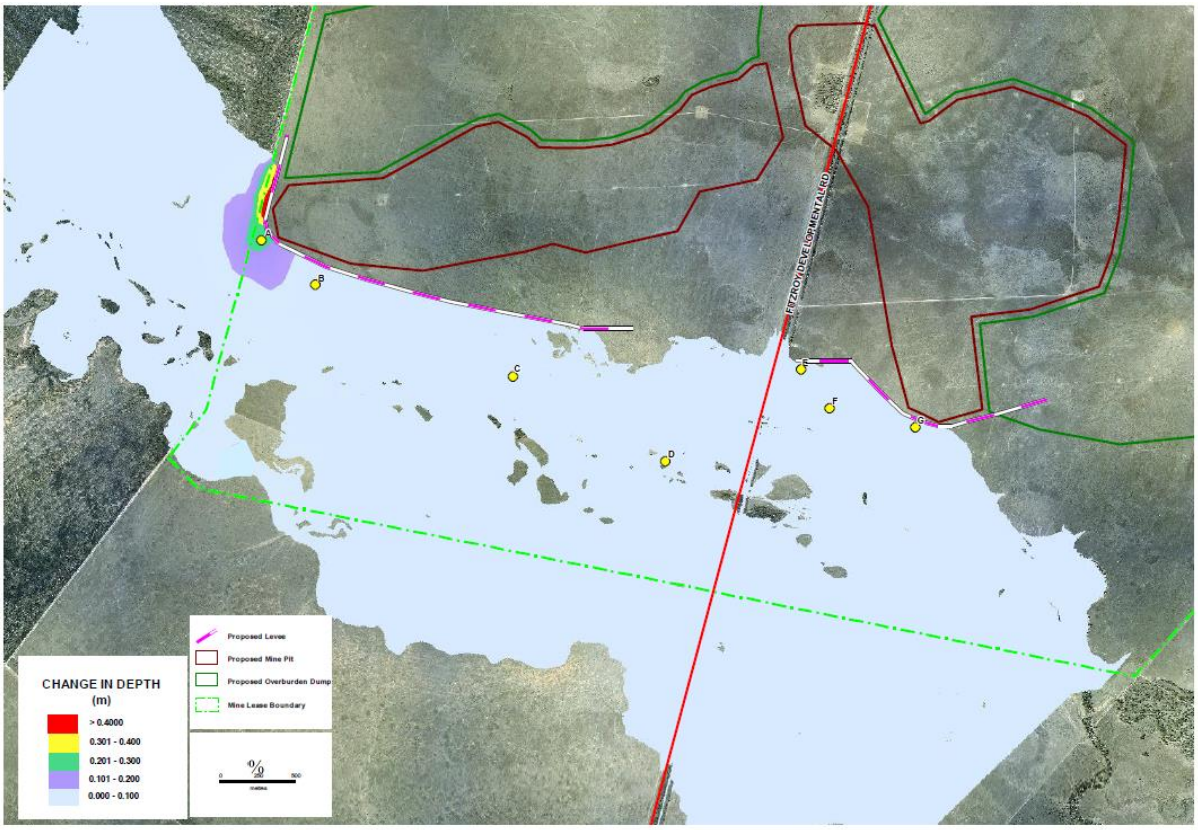


Figure 29 Levee induced Change in Flood Depth 2000 Year ARI

Probable Maximum Flood levels in Devlin Creek range from approximately 0.5m higher than the 2,000 year ARI flood levels to a maximum of 1.5m higher than the 2,000 year ARI flood levels. As it is proposed that the western mine pit will be rehabilitated to at least the pre-mining natural surface level following cessation of mining activities, levee bank protection for the rehabilitated mine pits will not be required. The eastern residual void will be located outside of the PMF and because the water level in the void is expected to remain below surface there is no risk of spillage into Devlin Creek.

Further details of the model are included in Appendix 4.6.

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** and **Management Milestones** in the PRC Plan Schedule:

RA1, **RA2**, **RA3**, **RA4** and **RA8**

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones and Management Milestones:

RM2	Landform design, reshaping and final contouring, inclusive of drainage features	(a) Landform constructed satisfies the following criteria for each rehabilitation area— (i) RA1 and RA2: • outer batter slope gradient is ≤5.7° • crest of landforms slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 50m (ii) RA3:

		• flat to undulating slope gradient is ≤4.6° • crest of landforms slope gradient is ≤2.3° (iii) RA5, RA9 and RA10: • outer batter slope gradient is ≤8° • crest of landform slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 18m (iv) RA4, RA6, RA7 and RA8 : • Flat to undulating with slopes ≤2.3° (b) Certification by an AQP[1] that contour drains and rock lined drop structures installed as per appropriate design criteria. (c) The lined co-disposal facility has been signed off by an AQP[1] as constructed to design. (d) Potentially acid forming or carbonaceous waste encapsulated in the centre of landforms.
RM9	Achievement of a stable condition for the land described as a post-mining land use of grazing	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and the landform meets criteria in RM2 (ii) erosionally stable: no active3 erosion is present and groundcover established meets criteria in RM7 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) The rehabilitated land meets Class 4 land suitability for grazing according to the Guidelines for agricultural land evaluation in Queensland (2nd edn) (DSITI & DNRM, 2015)[5]. (e) Species density and diversity achieved is consistent with the sown seed mix and reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (f) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and of >50% for areas of high rock and log content.
RM10	Achievement of a stable condition for the land described as a post-mining land use of native bushland	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and landform meets the criteria in RM2 (ii) erosionally stable: no active[3] erosion is present, and groundcover established and meets criteria in RM8 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) Native bushland established that provides habitat opportunities for native invertebrate and vertebrate species:

		(i) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs, and >50% for areas of high rock and log content (ii) 80% of the area achieves species density and diversity that is greater than 60% of the reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022 (iii) minimum 14 target vegetation species[6] comprising: grasses and forbs ≥3 mid-storey species ≥7 canopy species ≥4 (iv) evidence of key invertebrate groups (e.g. ants) and soil faunal communities
MM3	Achievement of sufficient improvement not to cause environmental harm and that will be safe and structurally stable	(a) Access to highwall, low wall and ramp batter is restricted by physical barriers. Fencing erected on the outside of the abandonment safety bund to specification (five strand barbed stock fencing). (b) Safety signage designed in accordance with Australian Standard is erected at 100m intervals along the fence line. (c) Certification from an AQP1 that the residual void will not cause environmental harm outside of the relevant tenure boundary. (d) Residual void acts as a groundwater sink to the receiving environment into perpetuity. (e) Certification from an AQP1 that the residual void is safe to humans and livestock. (f) Certification from an AQP1 that the water level and quality in the final void will not cause environmental harm to the surrounding environment.

3.5.1.4 Soil and capping material assessment

An assessment of required capping was completed as part of the EIS. The two largest areas requiring capping are the Overburden/Interburden dumps and the Co-disposal area. The conclusions for each area are summarised below (from Appendix 4.5).

Overburden / Interburden

The results from the Acid Base testing indicates that the overburden material will initially generate neutral to slightly alkaline runoff and seepage due to the current pH of the material. All overburden samples had very low sulphur content of <0.1% and are considered inert. The ANC generally exceeded the MPA for overburden samples indicating that the material has sufficient buffering capacity to neutralise the small amount of acidity that may be generated from sulphide oxidation. All overburden samples were classified as NAF with majority of NAPP values being negative, whilst only 3 samples were slightly positive being 0.6, 0.7 and 1.3 kg H2SO4/t.

The salinity levels of the runoff and seepage water are expected to be moderate. This may cause some vegetation species to be slower growing once the roots penetrate the moderately saline overburden material. Over time it is expected that salinity levels near the surface layers of overburden will lower due to leaching further into the dump profile.

The presence of extremely sodic material throughout the overburden profiles gives rise to the need for implementing appropriate erosion and sediment controls on site prior to and during the development of the overburden emplacements. This sodic material is prone to severe surface crusting, gully erosion and tunnelling. The sodic overburden material will be covered with an inert topdressing sourced from the sites topsoil. The addition of gypsum over the surface may provide an effective reduction of surface crusting and dispersion. The addition of organic matter as an ameliorant into the soil should also reduce the effects of sodicity.

The best suited final land use for the overburden emplacements at Codrilla is native bushland. The final slope of the overburden emplacement will not exceed 10 percent, and graded banks will be constructed at 1.2-1.5 % grade to minimise the chances of ponding and resultant tunnelling.

Co-disposal

CHPP reject is to be stored in the main in a co-disposal facility, that is, the coarse and fine reject streams will be combined at the CHPP and pumped as slurry to the disposal area.

In the context of rehabilitation, the CHPP reject appears to be not particularly saline but poor fertility and combustion risk (from the included coal) dictate that an inert cover will be necessary. The main characteristics required of this cover are low potential to draw moisture out of the co-disposed reject; favourable growth medium properties and erosion resistance appropriate to the landform design.

Existing soil characterisation (including soil quality) is described in Section 3.1.1.6. The total quantity of topsoil planned to be stripped from ML70450 is estimated in the following table:

Table 40 Estimated Available Topsoil Quantities

		Area (ha)	Topsoil Available Thickness Insitu (m)	Topsoil Removed Thickness Removed (m)	Topsoil Volume Removed (m3)	Minimum Topsoil Thickness Placed on Rehab (m)	Topsoil Volume Placed on Rehab (m3)	Topsoil Stockpile Inventory (m3)
RA1	Elevated Landform - Overburden Dumps - Upper	**170.1**	0.25	0.25	425,198	0.10	170,079	255,119
RA2	Elevated Landform - Overburden Dumps - Slopes	**804.8**	0.25	0.25	2,012,078	0.10	804,831	1,207,247
RA3	Backfilled Pits - Overburden Dumps	**291.1**	0.25	0.25	727,835	0.10	291,134	436,701
RA4	Infrastructure Areas - Access Tracks and Haul Roads	**227.9**	0.25	0.25	569,825	0.10	227,930	341,895
RA5	Infrastructure Areas - ROM	**16.8**	0.25	0.25	41,930	1.00	167,720	-125,790
RA6	Infrastructure Areas - CHPP General Area	**3.2**	0.25	0.25	7,933	0.10	3,173	4,760
RA7	Infrastructure Areas - Mine Infrastructure Area	**8.1**	0.25	0.25	20,145	0.10	8,058	12,087
RA8	Water Management Structures	**313.9**	0.25	0.25	784,863	0.10	313,945	470,918
RA9	Elevated Landform Co-disposal - Upper	**31.1**	0.25	0.25	77,750	1.00	311,000	-233,250
RA10	Elevated Landform Co-disposal - Slopes	**34.2**	0.25	0.25	85,465	1.00	341,860	-256,395
IA1	Residual Void, Ramps into Voids & Abandonment safety bund	**171.6**	0.25	0.25	428,908	0.10	171,563	257,345
	Total	**2,072.8**	**5,181,928**		**5,181,928**		**2,811,293**	**2,370,635**

The total required topsoil to cover the rehabilitation footprint is 2,811,293, indicating a surplus of topsoil. Please note that this table assumes Topsoil placement on the Co-disposal and ROM is done to a 1m thickness. The requirement for these areas is for a minimum 1m cap of *inert material*. The calculations assume the unlikely scenario that no inert overburden material will be available at the time of rehabilitation, so is conservative.

A conceptual plan of Topsoil Stockpile areas has been developed and is shown in Table 41 below. The locations have been designed to ensure that both topsoil stripping and placement activities can be done with reasonable haulage distances.

Table 41 Stockpile Area Required (ha)

	Stockpile Area Required (ha)	
	Available to Remove	**Placed on Rehab**
RA1	25	10
RA2	118	47
RA3	43	17
RA4	34	13
RA5	2	10
RA6	0	0
RA7	1	0
RA8	46	18
RA9	5	18
RA10	5	20
IA1	25	10
Total	**305**	**165**

The topsoil resource in Table 40 has been defined by testing to identify the material which is suitable for use as a plant growth medium on rehabilitated surfaces. Although this testing demonstrates the current soil capability to support plant growth, continued sampling and analysis of topsoil resources, whether stockpiled or in-situ, will be undertaken prior to respreading. This will assist in identifying potential soil deficiencies and estimating required rates of fertiliser or ameliorant (i.e. gypsum or lime) application.

Topsoil spreading

Following regrading and the construction of graded banks and rock lined waterways, topsoil will be spread over the surface of the final landform. Topsoil spreading will involve use of various types of mining machinery, which may include:

- scrapers, which are able to directly spread topsoil transported from insitu recovery operations where applicable, or recover the topsoil from stockpiles into the bowl of the equipment and transport to available rehabilitation areas for direct spreading;
- loaders, which will be used to recover topsoil from insitu recovery or stockpile and load to rear dump trucks;
- rear dump trucks, which would used to transport the topsoil to available rehabilitation areas; and
- dozers, which are used to spread topsoil dumped by rear dump trucks to the nominated depth and also to provide final trim to nominated spreading depth where scraper spread has been used.

The equipment type selected will depend on a number of factors, including:

- availability of specific equipment;
- ground conditions of the insitu recovery area, or stockpile area, and ground conditions of the haul route; and
- source to destination haul distance. Scheduling of topsoil spreading activities will be dependent on the availability of regraded areas and where relevant, construction of drainage

controls, equipment availability, direct reuse opportunities, existing soil moisture conditions and seasonal influences and proposed timing of surface preparation and seeding activities.

Generally, topsoil spreading will be scheduled as closely as possible to the seedbed preparation and seeding activities to minimise spread topsoil exposure to erosion potential

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** in the PRC Plan Schedule:

RA1, **RA2**, **RA3**, **RA4**, **RA5**, **RA6**, **RA7**, **RA8**, **RA9** & **RA10**

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones:

RM4	Surface preparation (e.g. topsoil, fertiliser, amelioration agents, mulch or woody debris)	(a) Topsoil spread to a minimum depth of 150mm. (b) An assessment of soil/growth medium health and suitability has been completed by an AQP[1] to confirm soil/growth medium is suitable for target vegetation establishment. (c) Gypsum and fertiliser applied at rates determined by an AQP[1]. (d) Cultivation and keying of topsoil to subsoil with suitable multi-type ripper and performed parallel to slope contours. (e) Where appropriate, addition of rock and/or log cover to assist erosion resistance of eventual vegetative ground cover.

3.5.1.5 Waste characterisation

Chemical and physical characterisation of overburden and reject materials (coal and partings) undertaken to support the Codrilla Project EIS suggest that these materials are relatively inert and are not likely to present significant management issues in regard to water quality, landform stability and rehabilitation. The materials are generally sodic and alkaline, indicating that conventional planning and management strategies will be required to ensure operational and post-mining impacts are minimised relative to landform stability and water quality. The topsoils of the Codrilla Project area are generally suitable for harvesting for use in rehabilitation.

The EIS provided the following assessment regarding the waste rock characterisation of overburden and inter-burden material:

- All 26 overburden and inter-burden samples are classified as Non-Acid Forming (NAF);
- the total sulphur content of all samples was below 0.1% and is considered inert relative to acid producing potential;
- The concentration of metals in overburden and inter-burden solids is unlikely to present any significant environmental issues associated with rehabilitation of the materials or water quality;
- The pH of leachate from overburden material at the Codrilla Project site is likely to range from slightly acidic to moderately alkaline; however, the majority of material is likely to be neutral;
- The range of EC values in the samples is considered slightly to moderately saline;
- the overburden material is within the moderate to high ranges for Cation Exchange Capacity (CEC) and should therefore provide a reasonable growth medium for vegetation;
- Overburden material is considered to be extremely sodic;

- the overburden and inter-burden material is not expected to require specific management strategies in relation to PAF, metals, pH, Electrical Conductivity (EC) and Cation Exchange Capacity (CEC); and,
- The overburden and inter-burden material is expected to require specific management strategies in relation to Sodicity.

The characterisation of reject and co-disposal analysis involved obtaining, fresh samples of material from above coal seams (roof), within the coal seams and below the coal seams (floor), during exploration drilling and groundwater bore construction. These samples were composited to form two roof samples, one coal sample and two floor samples. The five roof and floor, coal, and floor samples analysed for acid producing characteristics were classified as either 'Uncertain' or 'Uncertain–Potentially Acid Forming', the total sulphur results being in excess of 0.2% for each of the samples analysed. Due to the limited characterisation of coal and partings (coal seam roof and floor) a commitment was made in the Environmental Management Plan (EMP) of ongoing characterisation of overburden, interburden and partings materials to enable selective handling. This commitment has been captured within the site's EA.

In order to obtain additional information, a drilling programme of four fully cored geotechnical boreholes was carried out in 2011. These holes were cored from close to ground level, to enable engineering geological logs to be compiled for the soft overburden strata and coal seams and to provide samples for geo-mechanical testing. The laboratory program focused on improving the reliability of material properties used for slope stability modelling. This was achieved by targeting specific soft overburden units (Tertiary and weathered Permian) for sampling and testing. In addition to this, a separate program of testing was conducted on samples recovered from the soft overburden units and the sandstone unit below the VU seam, which was aimed at assessing the dispersive characteristics of the soft overburden and sandstone as a potential spoil cover material. All samples were preserved and dispatched to the laboratory in accordance with nominated procedures. Routine soil classification (Atterberg limits), shrinkage, slake durability, unconfined compressive strength (UCS) were conducted on overburden, roof and floor samples by Cardno (Ullman & Nolan Technical Services Pty Ltd) at their Mackay laboratory. Triaxial testing was carried out by Trilab Pty Ltd in Brisbane.

Soil classification testing indicated the soft overburden to comprise primarily silty or sandy clay or clayey silt of low to intermediate plasticity, with minor occurrences of high plasticity clay.

Triaxial testing was conducted on selected samples of soft overburden and one sample of the Yarrabee Tuff to determine shear strength values. These comprised back-saturated, consolidated multistage tests with pore water pressure measurement. A further sample of the Yarrabee Tuff was tested by direct shear. Shear strength parameters derived from these tests indicate significant variability in the shear strength of material at the site. These are also dependent on the nature of the material tested. In this case, soft clayey materials and more competent, highly weathered rock would show variability in shear strength.

Unconfined Compressive Strength (UCS) tests were conducted on rock samples from target coal seam roof and floor with slake durability tests on the latter. This mainly focused on the Leichardt and Vermont Upper seams.

Uniaxial compressive strength (UCS) testing indicated the roof units for all seams to be low strength, averaging approximately 10MPa. The predominant roof material was laminite. Similarly, UCS testing indicated the floor units to be low strength, averaging approximately 8MPa. Floor units generally comprised mudstone, laminite and siltstone, with the occasional occurrence of sandstone.

Specific testing requirements completed for the spoil cover assessment included:

- Emerson Class - conducted to assess the dispersive nature of the material, essentially with respect to rehabilitation of spoil and where the overburden (particularly the Tertiary clay) contained slake susceptible clay or mudstone;
- Atterberg Limits - determines the liquid and plastic limits of clayey materials, which is useful indicator of reactivity. An example of a reactive soil would be volcanically derived clay;
- Slake Durability - indicates of rock degradability, which measures changes in rock properties due to chemical and mechanical breakdown; and
- UCS - the unconfined compressive strength of the material

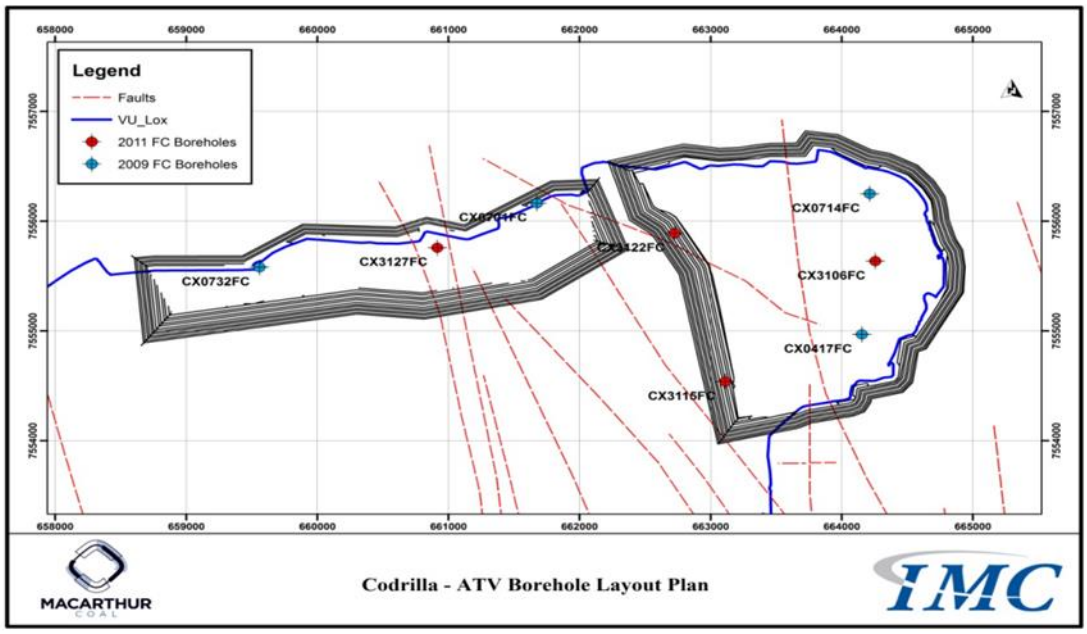


Figure 30 Fully Geotechnical Borehole Plan (2012)

The sampling undertaken to inform the EIS is considered to be adequate for a site where mine development has not commenced. Additional waste characterisation will be undertaken when the mine is developed and throughout the mining and processing phase of the mine's life as per conditions stipulated within the EA.

Sodicity of the overburden and interburden material is the primary limiting factor of potential rehabilitation success due to the risk of erosion and landform destabilisation. In order to minimise risks to the landform and erosion potential the following landform design and rehabilitation criteria are as follows:

- Create overburden dumps as water shedding structures: by reducing the amount of water that will infiltrate the material the risks of tunnel erosion will be minimised.
- Limit batter slope gradient: Although GSSE (2010) recommend slopes of less than 10°, regrading will target a maximum slope gradient of 5.7° for overburden dumps.
- Construction of drainage control structures: by constructing appropriately spaced graded banks and rock lined water ways on batters, surface runoff velocities will be limited and infiltration opportunity will be reduced by removing runoff water from the dump surface.
- Covering of the surface of the regraded overburden with topsoil: this will limit surface exposure of material to runoff and rainfall thus reducing surface erosion risks.

- Establish vegetation cover on the dumps: the root systems of established vegetation will stabilise the surface of the dumps.
- Limit cattle access: by limiting cattle access on the batters of the dumps surface destabilisation will be reduced.

Conceptual landform design is focused on constructing overburden dumps with weathered finer grained material encapsulated within the coarser unweathered material, see Figure 31. The principles of the concept are based on the unweathered material having a higher portion of coarse particles (as indicated by material characterisation to date) and there being no apparent relationship between material location within the overburden profile and distribution of sodicity and or EC. The ongoing characterisation program will further refine the understanding of overburden material distributions within the pit areas and enable selective placement of materials.

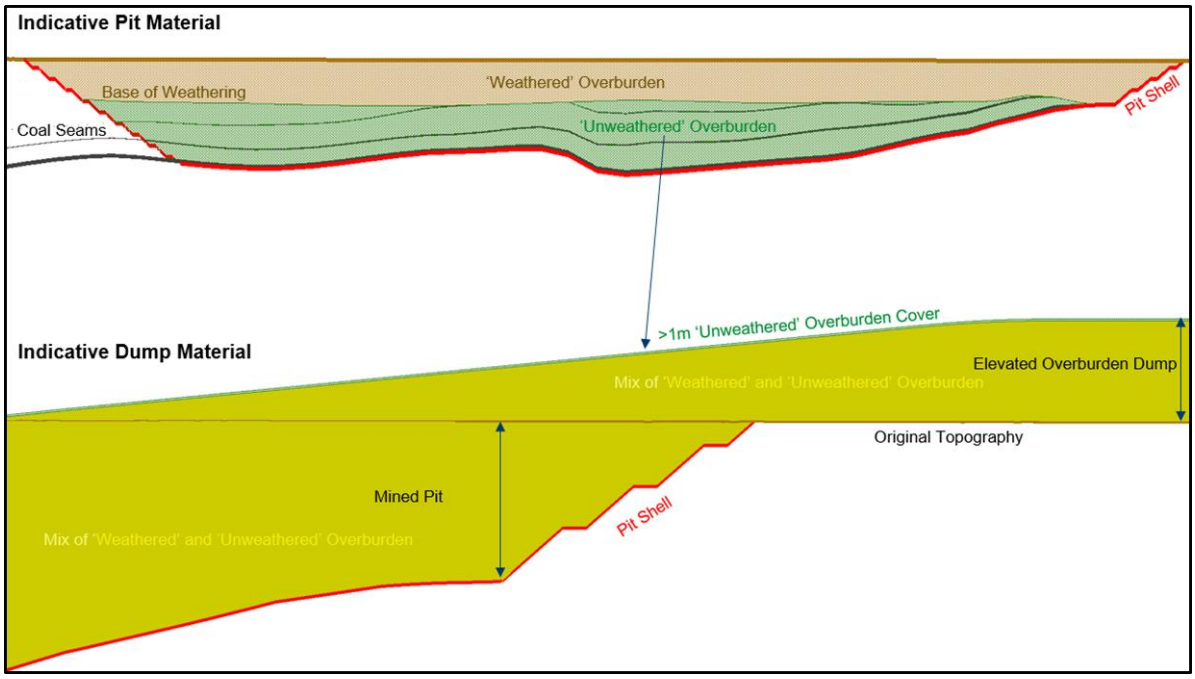


Figure 31 Conceptual Waste Dump Encapsulation Strategy

Relative to coarse reject, co-disposal, ROM pad and coal stockpile and handling areas, the potential for acid production and low fertility of the materials are considered the primary limiting factors. In order to minimise risks to the rehabilitation of these areas the landform design and rehabilitation criteria are as follows:

- Where possible encapsulate materials within overburden dumps with at least 1m of cover: this will limit infiltration of water and oxygen to the materials and reduce the potential for acid production.
- Cover co-disposal, ROM pad and coal stockpile areas with a minimum of 1m inert overburden capping: this will limit infiltration of water and oxygen to the materials and reduce the potential for acid production. Furthermore, the overburden capping will provide a more fertile growth medium than the underlying materials which have poor fertility.
- Create the landforms as water shedding structures: by reducing the amount of water that will infiltrate the underlying material the potential for production of poor quality leachate will be minimised.
- Limit batter slope gradient: regrading will target a maximum slope gradient of equal or less than 8° for the outer batters of the co-disposal facility and ROM pad.

- Construction of drainage control structures: by constructing appropriately spaced graded banks and rock lined water ways on batters, surface runoff velocities will be limited and infiltration opportunity reduced.
- Covering the surface of the overburden capping with topsoil: this will limit surface exposure of overburden material to runoff and rainfall, and provide a more fertile growth medium for vegetation.
- Establish vegetation cover on the landforms: the root systems of established vegetation will stabilise the capping and topsoil surface of the landforms.
- Limit cattle access on slopes exceeding 4.6°: by limiting cattle access on landform batters exceeding 4.6°, surface destabilisation and erosion will be reduced.

The construction of the Haul Road on ML70455 will require cut and fill of material to form a competent subgrade. Geotechnical investigations have identified sections of insitu material that will not be mechanically suitable as a sub grade for the road. This material will be excavated and where necessary replaced with suitable cut material from elsewhere in the Haul Road development. Overall there will be an excess of cut material which will require disposal. The excess excavated material will be chemically and physically characterised and disposed of according to the results of the characterisation. If the material is found to be non-acid forming, generally chemically inert and not highly susceptible to erosion it will spread within the boundary of the haul road Mining Lease (ML70455) and rehabilitated. Alternatively, it will be transported to the Codrilla West Pit overburden dump for incorporation.

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** in the PRC Plan Schedule:

RA1, **RA2**, **RA3**, **RA4**, **RA5**, **RA6**, **RA7**, **RA8**, **RA9** & **RA10**

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones:

RM2	Landform design, reshaping and final contouring, inclusive of drainage features	a). Stable landform and slope angles for out of pit overburden dumps areas as follows: outer batter slopes equal to or less than 5.7°and crest slope a maximum of 2.3° b). Stable landform and slope angles for Co-disposal elevated landform and ROM pads as follows: outer batter slopes equal to or less than 8° and crest slope a maximum of 2.3° c). Stable landform and slope angles for coal stockpiles and in pit overburden backfill flat to undulating with slopes equal to or less than 4.6° crest slope a maximum of 2.3° d). Stable landform and slope angles for infrastructure areas flat to undulating with slopes equal or less than 2.3° e). Maximum vertical height of out of pit overburden dumps elevated landforms up to 50m f). Maximum vertical height of Co-disposal elevated landform and ROM pad areas up to 18m g). All major earthworks completed h). Contour drains and rock lined drop structures installed as per appropriate design criteria i). Landforms such as the Co-disposal facility have been signed-off as constructed to design
RM3	Install cover system/cap	Cover installed (minimum 1m inert unweathered overburden)

RM9	Achievement of a stable condition for the land described as a post-mining land use of grazing	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and the landform meets criteria in RM2 (ii) erosionally stable: no active3 erosion is present and groundcover established meets criteria in RM7 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) The rehabilitated land meets Class 4 land suitability for grazing according to the Guidelines for agricultural land evaluation in Queensland (2nd edn) (DSITI & DNRM, 2015)[5]. (e) Species density and diversity achieved is consistent with the sown seed mix and reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (f) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and of >50% for areas of high rock and log content.
RM10	Achievement of a stable condition for the land described as a post-mining land use of native bushland	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and landform meets the criteria in RM2 (ii) erosionally stable: no active[3] erosion is present, and groundcover established and meets criteria in RM8 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) Native bushland established that provides habitat opportunities for native invertebrate and vertebrate species: (i) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs, and >50% for areas of high rock and log content (ii) 80% of the area achieves species density and diversity that is greater than 60% of the reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022 (iii) minimum 14 target vegetation species[6] comprising: grasses and forbs ≥3 mid-storey species ≥7 canopy species ≥4

		(iv) evidence of key invertebrate groups (e.g. ants) and soil faunal communities (v) evidence of key native vertebrate groups (e.g. bird, mammal, reptile and amphibian) in the form of fauna spotting, scats and tracks
RM11	Install fencing or other infrastructure to support the PMLU	Fencing / bunding installed sufficient to exclude stock

3.5.1.6 Landform design

Transitional PRC plans are not required to demonstrate how aspects of the mine have been designed for closure; however, section 3.6.1 outlines the range of information requirements to be provided, including landform design. The following section includes a summary of design elements considered during the development of the proposed final landform.

3D Design Final Landform

The final landform has been developed in 3-dimensional CAD packages, and the design outcomes are presented as a contour map in Figure 32.

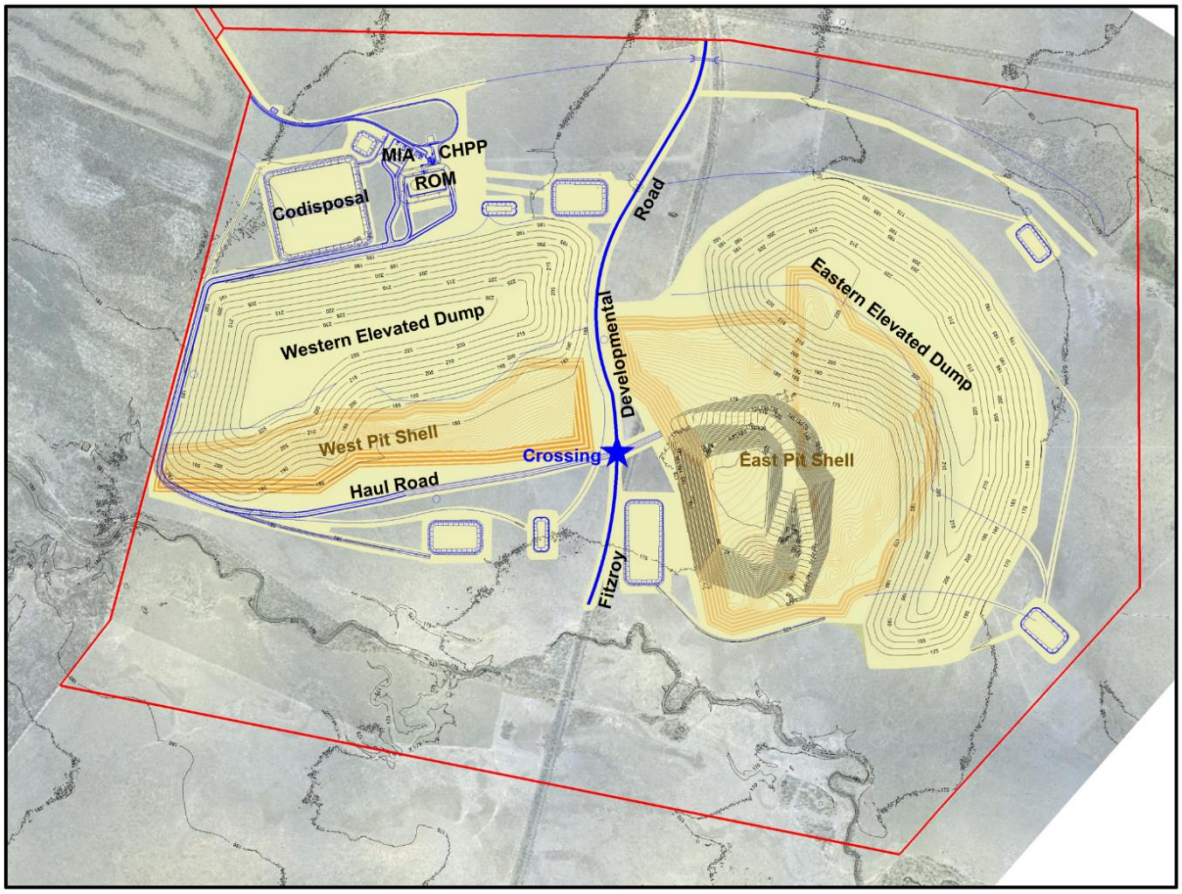


Figure 32 Current Proposed Final Landform Design

Landform Design Method

To determine the final landform a mine schedule was first developed utilising the SPRY software package. The model used to develop this schedule includes 'Destination Scheduling', which enables the planner to place excavated material into logical 3-D dumping locations in a sequence relative to a practical mining excavation sequence.

After the 'as-dumped' landform has been determined, a landform smoothing process has been undertaken using the 3D-Dig Reshape software tool to create 'convex-concave' surfaces that mimic 'natural' stable slope profiles, while staying within the maximum slope criteria specified in the EA. This surface is then inspected visually in 3-D to ensure the software has created an appropriate outcome, and final volumetric checks are performed to ensure that sufficient material is available to construct the overall landform.

Modelling of long-term stability

The Revised Universal Soil Loss Equation (RUSLE) has been used to estimate the long-time annual erosion rate. The soil erodibility factor (K) has been adjusted for dispersive soil by +20% to take into consideration the test results of the samples taken within the Codrilla Project area, which indicated a moderate to very high potential for erosion.

Modelling shows that the unshaped landforms are the scenario of highest risk of erosion, but once the landforms have been regraded to produce the final slope angles, lengths and shapes and rehabilitation is established the erosion rate is low. Further details are discussed in section 3.1.1.6 and in Appendix 4.4.

Proposed Construction Method

The landforms will be constructed using the mine overburden, placed in lifts by haul trucks being loaded by excavator / shovel units. The final surface profile will generally be established utilising large earthmoving bulldozers (e.g. Caterpillar D10, D11, etc…) to regrade these 'as-dumped' lifts according to the final landform design.

Environmentally, the method has advantages in providing for more controlled planning of overburden dump construction, maximising efficiency in landform development and rehabilitation. Additionally, the truck and excavator / shovel method offers advantages for selective encapsulation of potentially problematic materials that may be identified through operational material characterisation and monitoring programs.

Quality Assurance / Quality Control (QA/QC)

Operator and supervisor training will be provided to personnel undertaking rehabilitation earthworks, including the importance of conforming to the design specifications. Works will be supervised to ensure compliance with design specifications and relevant procedures.

High-precision GPS tools may be used on-board construction equipment (or by surveyors) to assist in the development of the landform.

In addition, constructed landforms shall be inspected regularly during the construction phase and signed-off as constructed to design following completion of earthworks. Records shall be retained to demonstrate quality assurance and quality control processes have been met.

Trial Methodology

Once mining activities have commenced, the site is committed to establishing 3 reference sites, and 3 rehabilitation monitoring sites (a requirement of the Environmental Authority) to verify the success of the landform design. As part of the trials to verify the success of the landform design, additional studies will be undertaken, and data will be gathered. Monitoring will be conducted annually.

Limitations and Assumptions

The results of the landform design work are heavily influenced by several assumptions, particularly the assumption relating to the swell factor of the excavated and dumped material.

The mining process involves the removal of overburden and interburden materials from above the coal seams prior to coal extraction. This excavation process results in the "loosening" of the material, which has been compacted insitu by geological processes over time. The "loosening" results in an increase in the volume that a unit of overburden or interburden will occupy once excavated when compared to the un-excavated (insitu) volume. The increase in the overburden and interburden volume from the insitu to excavated state is known as the swell factor. The swell factor adopted for planning at Codrilla is 25%. This has been based on the material characteristics of the Project and experience at Coppabella and Moorvale Coal Mines.

Furthermore, the overburden and interburden removal and coal mining operations require sufficient room to safely undertake activities and minimise the risk of material encroaching into operational areas. Therefore, to account for the swell factor of excavated material and maintain adequate working room in the operating pit, out of pit overburden dumps are required in conjunction with progressive backfilling of the mined pits.

Small variations in this swell factor assumption can result in differences in the as-dumped profile, including the size and shape of the void. Additionally, mine sequence changes in response to market demands or operational challenges may result in similar differences. As the mine progresses, some variation in the current proposed landform can be expected and will be updated as required via a PRC Plan amendment process.

Key Landform Features

The proposed post-mining landform contains the following key features:

• Elevated areas associated with out of pit overburden dumps, being 50m high and having external batter slopes between 4.6° and 5.7° and crests less than 2.3° slope;

• Elevated co-disposal facility, being up to 10m high with external batter slopes of equal or less than 8° a crest slope of less than 2.3°;

• Elevated ROM pad, being 15 to 18m high with external batter slopes equal or less than 8° and a crest slope of less than 2.3°;

• Areas of similar gradient to the surrounding undisturbed landform such as backfilled pits and areas from where infrastructure is removed; and

• Stable final void areas.

Post-mining land uses have been determined based on the assessed post-mining land capabilities and suitability. The post-mining land uses primarily consist of native bushland for wildlife usage and managed low intensity beef cattle grazing.

Lining Requirements

No lining is required for overburden / interburden dump landforms. The co-disposal is designed to have a 1m inert overburden cap to limit infiltration of water and oxygen to the contained materials. All landforms are designed to be water shedding to reduce infiltration and seepage.

Surface Water Consideration

The landform design has been developed to be generally water-shedding, with only the areas in close proximity to the final void area being water-retaining. During construction of the landform, as part of the operational management of water on-site, much of the surface run-off water will be retained. As

the rehabilitation objectives of the landform are achieved, runoff on these areas will be eventually returned to the natural receiving waterways.

Materials Available for Rehabilitation

Materials to be rehabilitated and/or used in the rehabilitation process have been assessed to determine their suitability relative to vegetation establishment, erosion and landform stability and potential for pollution. The assessments provided information regarding potentially limiting factors which were considered in the development of the proposed final landform and post-mining land use.

Erosion Assessments to determine Landform and Material Placement

Operational experience at Coppabella and Moorvale Coal Mines has demonstrated success with graded banks spaced between 75m and 88m respectively for slopes of 8° on landforms in the order of 50m height. Slopes considered at Codrilla have been reduced to a maximum of 5.7° (<10%) to reduce erosion rates, particularly while vegetative cover is developing.

Codrilla overburden and interburden materials are sodic and susceptible to dispersion and erosion. Broadly, relative to sodicity and erosion susceptibility, the overburden and interburden material at Codrilla is similar to overburden and interburden at Coppabella Coal Mine. Based on experience at Coppabella Mine, a graded bank spacing of 75m is considered appropriate for the maximum design slope of 5.7°. Detailed design and construction, of graded banks and rock lined waterways will be dependent on site specific factors, and will be based on the most relevant industry standards available.

Slope Profile Design

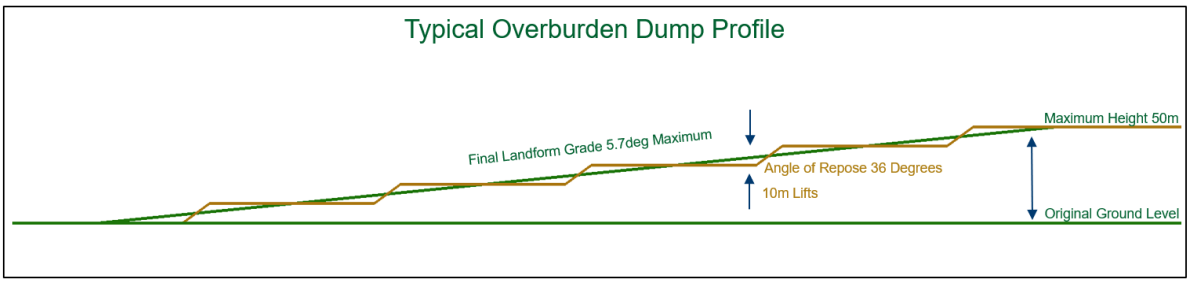


Figure 33 Typical Overburden / Interburden Waste Dump Profile

Settling and Subsidence

There has been no formal study on the impacts of subsidence / settling over time for the design landforms at Codrilla. The main area where settlement is likely to impact the availability for rehabilitation is the co-disposal area. This area will only be active for the first 6-8 years of operation, so an allowance has been made to rehabilitate this towards the end of the mine life to ensure maximum settlement has occurred. The settlement of area will be monitored over time to identify any opportunity to commence rehabilitation earlier.

Hydrological and Hydrogeological Assessments

No formal assessment of the current design final landform surface hydrology has been completed, however the landform and surface water management system has been designed to contain surface water runoff while the mine is operational, but release to the natural receiving waterways on completion of suitable rehabilitation activities.

A hydrogeological assessment has been done on the landform which was considered as part of the development of the EIS. Although the size and location of the final voids have changed, it is believed that the effect of the groundwater in the spoils will be negligible, with the western pit spoil achieving

an equilibrium level of ~RL155 (approx. 25m below surface level) and the eastern spoils groundwater levelling off at ~RL145 (approx. 35m below the surface level).

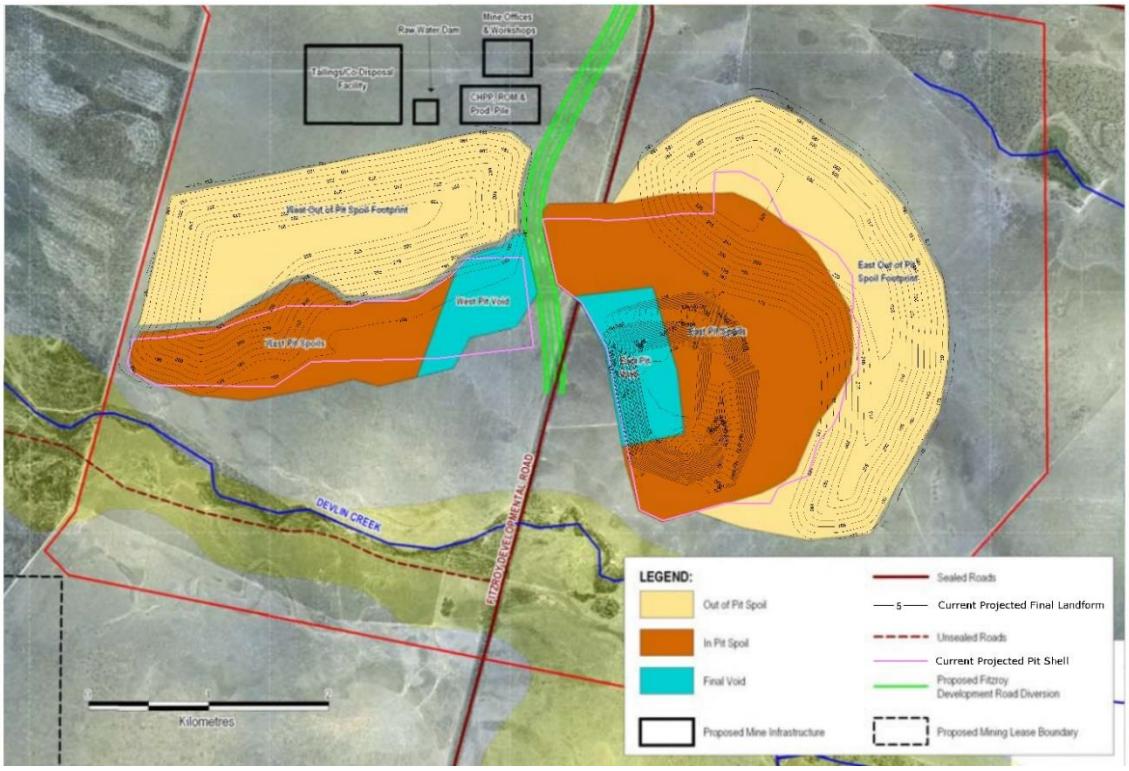


Figure 34 Groundwater Modelled Void (blue shade) versus Current Proposed East Void (contours)

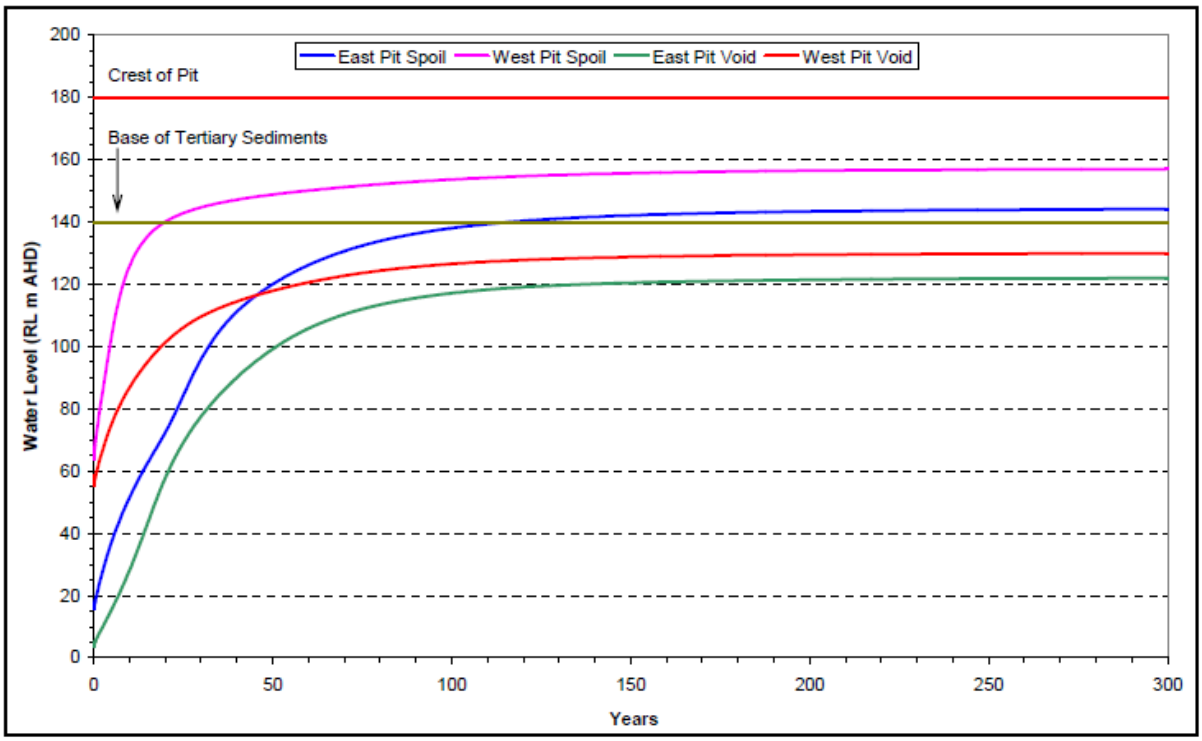


Figure 35 Predicted Groundwater Level Recovery

Note: Long term standing water levels in the Eastern Pit Void are expected to be lower than currently modelled due to the larger evaporative footprint of the current final landform design, whereas the Western Pit Void has been removed from the current design.

Waste Placement Strategy

The landform construction through designed placement and re-shaping of overburden/interburden, and co-disposal will largely be undertaken while the mine is operational, with impacts on the receiving environment limited by conditions contained within the site's Environmental Authority. An initial waste placement strategy, designed to encapsulate finer materials in lower sections of the dump, is illustrated in Figure 31.

Sediment-laden surface water runoff will be managed, with most water retained on-site until rehabilitation objectives have been met.

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** in the PRC Plan Schedule:

RA1, RA2, RA3, RA4, RA5, RA6, RA7, RA8, RA9 & RA10

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones:

RM2	Landform design, reshaping and final contouring, inclusive of drainage features	(a) Landform constructed satisfies the following criteria for each rehabilitation area— (i) RA1 and RA2: • outer batter slope gradient is ≤5.7° • crest of landforms slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 50m (ii) RA3: • flat to undulating slope gradient is ≤4.6° • crest of landforms slope gradient is ≤2.3° (iii) RA5, RA9 and RA10: • outer batter slope gradient is ≤8° • crest of landform slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 18m (iv) RA4, RA6, RA7 and RA8 : • Flat to undulating with slopes ≤2.3° (b) Certification by an AQP[1] that contour drains and rock lined drop structures installed as per appropriate design criteria. (c) The lined co-disposal facility has been signed off by an AQP[1] as constructed to design. (d) Potentially acid forming or carbonaceous waste encapsulated in the centre of landforms.

3.5.1.7 Cover Design

There are two cover design systems proposed for the Codrilla Project, related to the nature of the materials being covered. These are summarised below.

Overburden / Interburden Dumps

- Minimum 0.1m of topsoil
- Vegetation Cover >70% for areas of low rock and logs, >50% for areas of high rock and log content

Coal Stockpiles / ROM Pad / Co-disposal

- Minimum 1m of Inert Material
- Minimum 0.15m of topsoil
- Vegetation Cover >70% for areas of low rock and logs, >50% for areas of high rock and log content

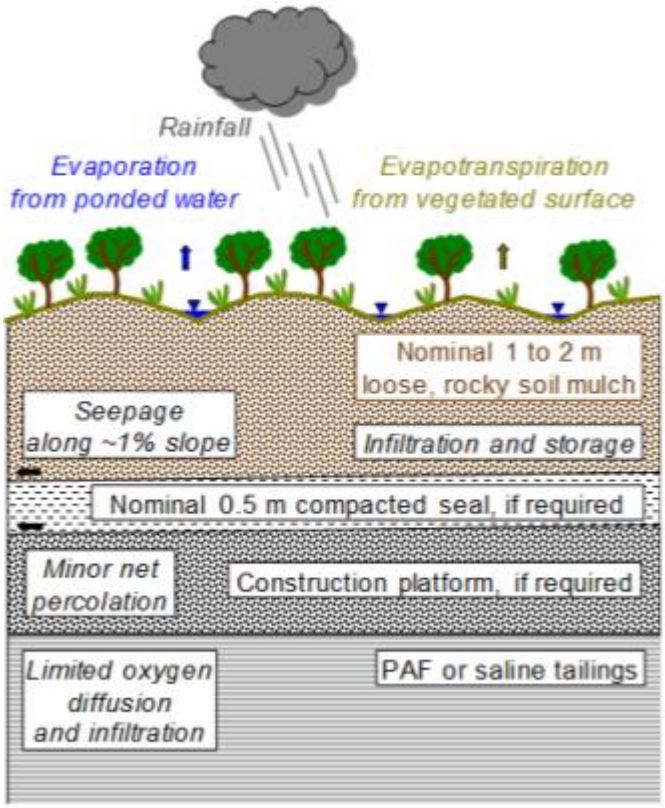


Figure 36 Schematic of typical soil cover systems suitable for use on potentially contaminating tailings

The vegetation ground cover species will vary depending on the land use – these are described in other sections.

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** in the PRC Plan Schedule:

RA1, **RA2**, **RA3** & **RA5**, **RA6**, **RA9 & RA10**

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones and Management Milestones:

RM3	Install cover system/cap	Cover installed (minimum 1m inert unweathered overburden)

RM4	Surface preparation (e.g. topsoil, fertiliser, amelioration agents, mulch or woody debris)	(a) Topsoil spread to a minimum depth of 150mm. (b) An assessment of soil/growth medium health and suitability has been completed by an AQP[1] to confirm soil/growth medium is suitable for target vegetation establishment. (c) Gypsum and fertiliser applied at rates determined by an AQP[1]. (d) Cultivation and keying of topsoil to subsoil with suitable multi-type ripper and performed parallel to slope contours.

3.5.1.8 Water Management

Generally final landform surfaces have been designed or created with the existing soil stockpiles, drains, diversion structures and lay down areas removed to create free flowing landforms removing the requirement for water diversion structures or dams. Part of the design criteria is to keep as much clean water out of the pits as possible to reduce the long-term East Pit Void water levels and return as much water as possible to natural drainage.

Key features of the surface water management system include:

- Overland flow of clean water originating from up-gradient of the dump footprint will be diverted away from the dump to minimise the potential for both surface water contamination and erosion of the dump slopes
- Elevated areas associated with out of pit overburden dumps will be designed to have external batter slopes between 4.6° (8%) and 5.7° (10%) and crests less than 2.3° slope. These areas will have drainage control structures installed and will be topsoiled and revegetated using native tree and shrub species
- Precise construction of drainage paths and networks, including temporary contour drains and engineered drop structures, will be undertaken using survey controls and machine guidance systems. Care will be taken to ensure that machinery does not track downslope over cultivated areas or over drainage features as this may compromise the drainage control performance. Inspection of these features will be undertaken following intense rainfall events to identify areas where remedial actions such as removal of sediment or erosion repairs may be required
- Overland flow of clean water originating from up-gradient of the CDA footprint will be diverted away from the CDA to minimise the potential for both surface water contamination and erosion of the CDA outer slopes
- The final landform will be shaped to shed rainfall and only allow rainfall infiltration to the extent that it can be removed via evapotranspiration
- Allowance will be made for ongoing drainage of water from the CDA following cessation of waste deposition. Measures may include filling of drains with high permeability coarse sand and/or gravel above the underdrain outlets before covering the drains with buttressing material

Key drainage features to avoid impacts on the residual void

- Modelling of overland flow will be used to identify opportunities to construct permanent clean water diversions to direct overland flow away from the residual void. Where this isn't

possible, coarse rubble will be installed at low points along the abandonment bund to allow diffused flow through the bund without compromising safety or the integrity of the bund

- Geotechnical and erosional stability appraisals will be completed to assess the potential for any concentrated water flow paths into the void to cause pit slope instability. Where a risk requiring mitigation is identified, appropriate measures such as placement of coarse rock to dissipate flows or directing flows over the most geotechnically stable sections of the highwall will be adopted. The setback of the abandonment bund from the pit crest will allow for any minor erosion of the pit crest

Figure 37 shows the final landform conceptual drainage direction and streams.

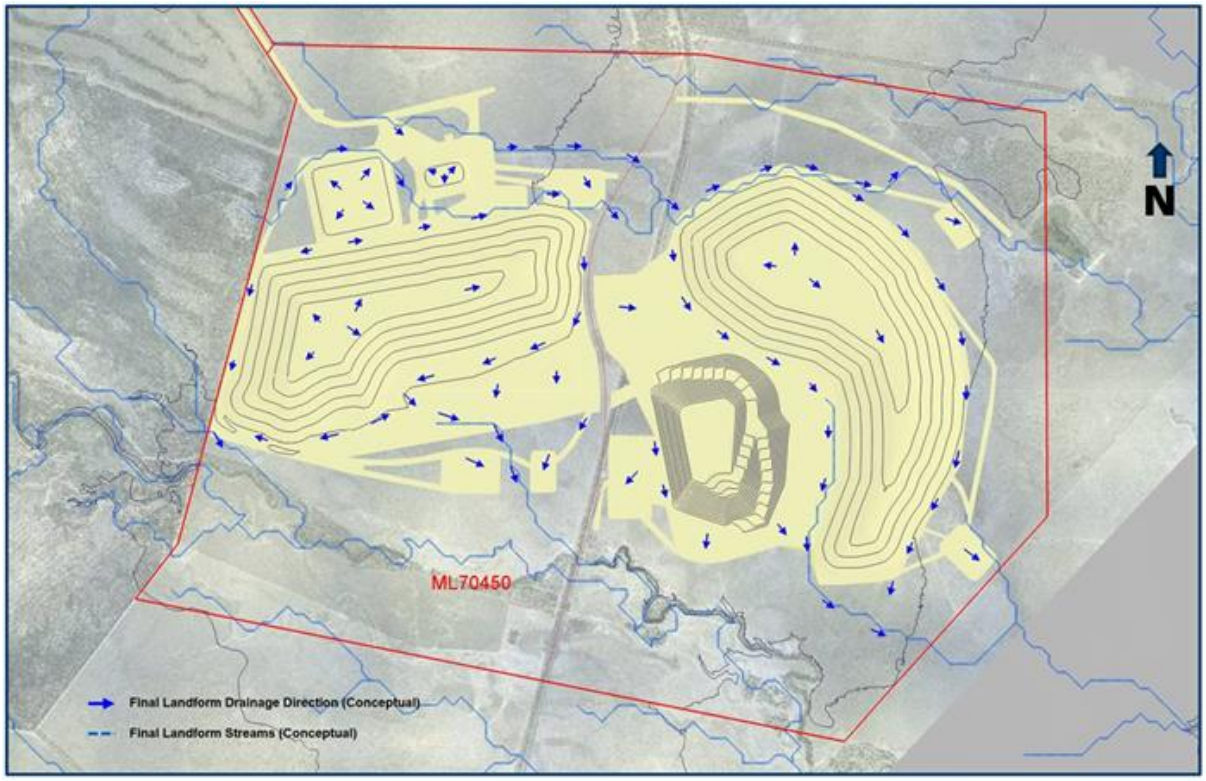


Figure 37 Final landform conceptual drainage direction

Upon establishment of the final landforms and removal of all infrastructure, no ongoing water management requirements are foreseen.

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** in the PRC Plan Schedule:

RA1, RA2, RA3, RA4, RA5, RA6, RA7, RA8, RA9 & RA10

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones:

RM2	Landform design, reshaping and final contouring, inclusive of drainage features	a) Landform constructed satisfies the following criteria for each rehabilitation area— (i) RA1 and RA2: • outer batter slope gradient is ≤5.7° • crest of landforms slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 50m (ii) RA3: • flat to undulating slope gradient is ≤4.6°

	• crest of landforms slope gradient is ≤2.3° (iii) RA5, RA9 and RA10: • outer batter slope gradient is ≤8° • crest of landform slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 18m (iv) RA4, RA6, RA7 and RA8 : • Flat to undulating with slopes ≤2.3° (b) Certification by an AQP[1] that contour drains and rock lined drop structures installed as per appropriate design criteria. (c) The lined co-disposal facility has been signed off by an AQP[1] as constructed to design. (d) Potentially acid forming or carbonaceous waste encapsulated in the centre of landforms.

3.5.1.9 Revegetation

Following the spreading of topsoil on the surface of rehabilitation areas, seedbed preparation will be undertaken. Seedbed preparation will typically involve ripping along the contour using a dozer with three tynes mounted behind the machine. Ripping depth will be between 0.4m and 1m. Ripping along the contour reduces the potential for erosion by creating a key between the topsoil and underlying material, promoting infiltration and providing a barrier to down slope runoff. During the ripping process tynes will be lifted for a distance of approximately two metres following every 200m (approximate) of ripping. This will reduce the potential for channel erosion to develop within rip lines. Seed bed preparation will be undertaken as soon as practicable following the spreading of topsoil on the rehabilitation area to minimise the potential for topsoil loss through erosion.

Timing of seedbed preparation will be dependent on machinery availability, ground conditions and weather conditions. Seeding, fertilising and addition of any other soil ameliorants will be undertaken as soon as practicable following the preparation of the seedbed.

There are several methods available for spreading of seed, fertiliser and other ameliorants, these include:

- direct application at the same time as seedbed preparation using appropriately modified machinery;
- casting over an area of prepared seedbed using ground-based spreaders, mounted either on conventional agricultural equipment or mining machinery; and
- aerial application over the prepared seedbed using light aircraft.

The methods selected for seed and fertiliser application will depend on a number of factors including:

- terrain and ground conditions to be seeded and fertilised;
- availability of equipment and or contractors;
- nature of the seed mix; and
- quantity of fertiliser and or other ameliorants to be applied.

The proposed species mix and seeding rates for establishment of pasture to support the post-mining land use of grazing are as per Table 42:

Table 42 Pasture Species Mix

Common Name or Variety	Scientific Name	Recommended Sowing Rate (kg/ha)
Kangaroo Grass	*Themeda triandra*	3
Japanese Millet	*Echinochloa esculenta*	4
Sabi Grass	*Urochloa mosambicensis*	2
Fine Cut Rhodes Grass	*Chloris gayana*	2
Indian Blue / Indian Couch	*Bothriochloa petusa*	2

Butterfly Pea	*Clitoria ternatea*	3
Seca Stylo	*Stylsanthes scabra*	4

The seed mix composition and seeding rates may be adjusted based on rehabilitation monitoring results.

The revegetation to achieve the post-mining land use of native bushland will require a combination of direct seeding or tubestock/sucker planting.

The proposed species mix and seeding rates for establishment of vegetation to support the post-mining land use of native bushland for overburden dumps and the co-disposal areas are as per Table 43 below:

Table 43 Native Species Seed Mix

Common Name or Variety	Scientific Name	Recommended Sowing Rate (kg/ha)
Brigalow	*Acacia harpophylla*	2
Dawson Gum	*Eucalyptus cambageana*	2
Poplar Box	*Eucalyptus populnea*	2
Red Bauhinia	*Lysiphyllum carronii*	2
Yellowwood	*Terminalia oblongata*	5
Sally Wattle	*Acacia salicina*	2
Soft Acalypha	*Acalypha eremorum*	0.1
Scrub Boonaree	*Alectryon diversifolius*	0.5
Queensland Ebony	*Diospyros humilis*	2
Peach Bush	*Ehretia membrandifolia*	0.2
False Sandlewood	*Eremophila mitchellii*	0.1
Orange Thorn	*Pittosporum spinescens*	0.1
Canthium	*Psydrax odorata*	0.3
Wilga	*Geijera parviflora*	0.3
Scrub Leopardwood	*Flindersia dissosperma*	0.2
Conkerberry	*Carissa ovata*	1.2
Bush Caper	*Capparis lasiantha*	0.3
Kangaroo Grass	*Themeda triandra*	1

The goal is to establish a native ecosystem that has a similar composition to the previous existing woodland (Specht, 1970) ecological communities comprising RE 11.4.8, RE 11.4.9 and RE 11.5.3.

Consideration was given to whether the seed mix was appropriate for the co-disposal area due to the potential for roots to penetrate and physically damage the cap, thereby creating entry points for water, or to open fissures in the protective barrier by excessive moisture reduction. However, ongoing research and a growing body of experience indicate that, if it is properly designed and implemented, the integrity of the co-disposal surface can be maintained while it supports a variety of plants. Root growth depends on the characteristics of the soil, and the presence of a clay liner or geomembrane influences its growth. The key factors that affect the feasibility of planting on a containment system include the characteristics of the landform surface (such as soil depth and soil quality), the desired plant habitat, and the physical setting of the site (for example, topography and climate) (US EPA, 2006). Brigalow has a well-developed lateral (horizontal) root system, and plants are often joined together by these roots, forming colonies (Johnson 1964). Similarly, poplar box has an extensive lateral root development (Philips et al., 2014).

Native plant seed and tubestock will be sourced locally where practicable to optimise results as local provenance species will be more suited to establishment and survival under local climatic and soil conditions. If brigalow seed or tubestock are scarce, transplanting small suckers could be an option. If the new brigalow plants are slow to establish via natural regeneration, then mechanical disturbance could be used to promote brigalow suckering.

The establishment of the native bushland will provide habitat and habitat features used by many species including the significant species that were identified on site such as the little pied bat, the ornamental snake and the squatter pigeon.

The trees and shrubs will provide nesting, shelter and feeding sites for wildlife and particularly for birds, invertebrates, reptiles, frogs and parasitic plants like mistletoe; tree hollows, cracks and crevices will provide shelter, nesting and feeding sites for parrots, treecreepers, bats, gliders and reptiles; fallen timber, leaf litter and rocks will provide a beneficial use for many species. (P.J. Peeters and D.W. Butler, 2014).

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** in the PRC Plan Schedule:

RA1, RA2, RA3, RA4, RA5, RA6, RA7, RA8, RA9 & RA10

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones:

RM5	Revegetation (grazing)	Completed seeding of target pasture species at rate and species composition in accordance with Table 42 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.
RM6	Revegetation & habitat development (native bushland)	Completed revegetation of target native bushland species by tube stock and/or direct seeding at rate and species composition in accordance with Table 43 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.

3.5.2 Tailings storage facilities

The characterisation of reject and co-disposal analysis involved obtaining, fresh samples of material from above coal seams (roof), within coal seams and below coal seams (floor), during exploration drilling and groundwater bore construction. These samples are considered representative of the reject and co-disposal materials. The samples were composited to form two roof samples, one coal sample and two floor samples. An additional 12 samples of coal seam roof, coal and floor were sourced from exploration inventory. The analysis of the samples included a similar suite to the overburden samples for the solids. Metals leachate analysis was also performed on the samples for the same suite as solids plus some additional metals. The roof, coal and floor samples sourced from exploration inventory were not analysed for acid producing characteristics due to the likelihood of inherent sulphur compound oxidation over the 12 months that they had been stored.

Co-disposal was selected as the preferred option for process waste disposal. Waste from the co-disposal tank will be pumped to a dedicated co-disposal facility.

Although the available material characterisation results are limited, they indicate that the co-disposal material may be potentially acid forming (PAF). Therefore, the conceptual design and operation of the

co-disposal facility assumes that the co-disposal material will be acid forming. Should further characterisation of materials indicate otherwise, designs and operational strategies may be revised.

The co-disposal facility will be located to the west of the CHPP - this location was selected based on:

- its proximity to the CHPP and mine industrial area;
- favourable topographic elevation relative to management of stormwater flows; and
- the location being an area of pasture historically cleared of remnant vegetation.

Due to the flat topography of the selected location, the facility will be constructed using a raised turkeys nest configuration. The detailed design of the facility will be undertaken by an experienced and RPEQ qualified engineer.

Construction will involve a staged, two-cell configuration, with the first cell constructed at the commencement of operations and the second cell constructed as co-disposal material storage within the first cell approaches capacity.

The facility is proposed to be constructed as a lined storage to protect against seepage into the surrounding substrate and groundwater. It is proposed that the liner be constructed from suitable clay sourced locally and preferably from within the mining footprint. The clay material would be placed and compacted to appropriate engineering specifications. Geotechnical investigations will determine if suitable quality material is available in sufficient quantities for the co-disposal facility. Suitable materials are expected to be available in areas of the site. However, if insufficient quantities of suitable clay material are identified, a synthetic liner will be installed as part of the facility construction. Such a liner would most likely be constructed from High Density Polyethylene (HDPE). Both clay and synthetic liner options are illustrated in Figure 38.

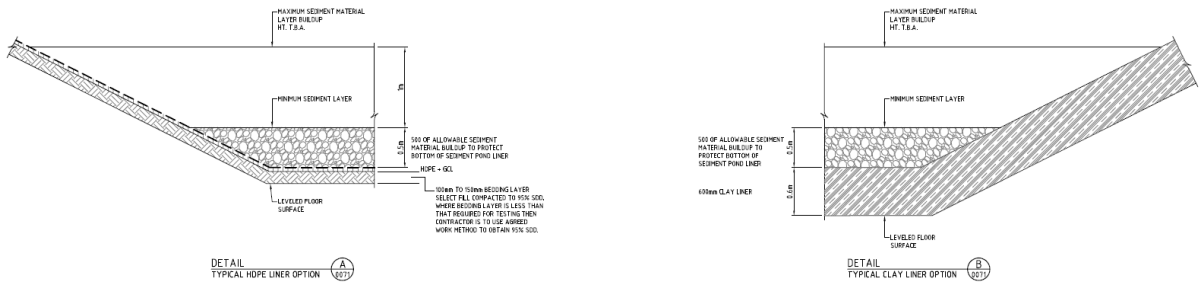


Figure 38 Co-disposal Cell Liner Options

Each cell of the facility will contain a dewatering collection sump to which decant water will be directed for return to the CHPP process water system. Allowance will be made for a lime batching and dosing plant to be installed at the operating sump should the decant water be acidic and require treatment prior to transfer from the facility back into the process water system. The option for lime dosing at the co-disposal collection sump is preferred as it reduces the environmental risk associated with transferring and storing untreated acidic water.

Decant water will be returned to an Environmental Dam for supply to the CHPP. This dam will also receive water pumped from mining pits which results from rainfall runoff inflow and or groundwater inflow to the pits. The Environment Dam will be appropriately lined with either clay or synthetic material to minimise seepage to surrounding substrate and groundwater.

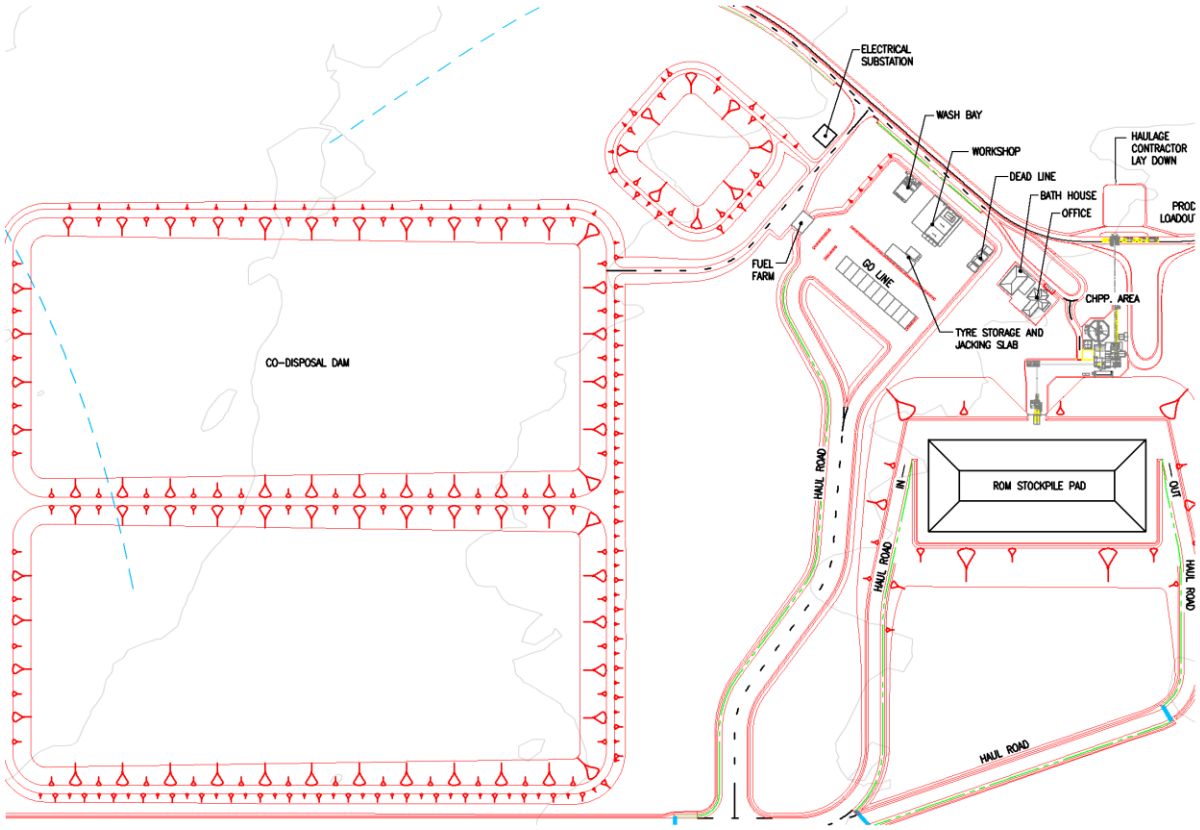


Figure 39 Infrastructure Area showing Co-Disposal Dam site

The footprint of the facility will cover a total of approximately 64 hectares. The total storage capacity of the facility will initially be constructed to approximately 3 million m^3 with the capacity of each cell being ~1.5 million m^3. This equates to a total storage capacity of approximately six years based on expected average co-disposal production rates, or three years per cell. To cater for the post year six storage requirements, a number of options will be considered based on material characterisation information, operational experiences, available construction material, regulatory considerations and design criteria. Potential options include:

1. excavate the dried co-disposal material from the first cell prior to year six and encapsulate the material at depth within in pit overburden dumping operations, reusing the first cell and to be repeated prior to year nine and year 12, and 15 for the second cell;
2. construct smaller internal cells within the facility which may be dried more rapidly and excavated for encapsulation within in pit overburden dumping operations;
3. construct an additional lift on the existing co-disposal facility to provide the required additional capacity; and
4. construct additional cells adjacent to the original facility.

For the purposes of this PRC Plan, the first option is considered most likely, and has been used to develop the Final Landform design which includes a capped co-disposal area in the north west corner of the lease.

The mass balance for Codrilla on the finest feed suggests coarse to fine co-disposal ratios between 1.2:1 and 3.2:1. Generally within the coal industry, co-disposal systems have been successfully managed at coarse to tailings ratios ranging from 1:1 to 6:1. The Moorvale co-disposal facility has operated successfully with coarse to fine ratios varying from 1.2:1 to 2.2:1. Therefore , the Codrilla co-

disposal facility is be expected to operate effectively with adequate beach formation and water drainage, as well as retention of fines within the material matrix. The fines retention will aid in PAF management by minimising void space in the matrix which would provide potential reaction sites. In the situations where coarse reject material is required to be placed into the co-disposal facility, (for example, following a plant upset) it will placed in such a manner that it forms a small embankment upon which regular feed to the facility will encapsulate the coarse material within the co-disposal matrix and aid in dewatering and management of the facility.

The deposited co-disposal material is expected to in the order of 25 to 40% solids. Given this slurry density and the range of material sizes the co-disposal will be stackable which will enable deposition strategies to focus on beaching around the internal perimeter of the storage to optimise water drainage and recovery for reuse in the CHPP as discussed above.

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** in the PRC Plan Schedule:

RA9 & RA10

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones:

RM2	Landform design, reshaping and final contouring, inclusive of drainage features	(a) Landform constructed satisfies the following criteria for each rehabilitation area— (i) RA1 and RA2: • outer batter slope gradient is ≤5.7° • crest of landforms slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 50m (ii) RA3: • flat to undulating slope gradient is ≤4.6° • crest of landforms slope gradient is ≤2.3° (iii) RA5, RA9 and RA10: • outer batter slope gradient is ≤8° • crest of landform slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 18m (iv) RA4, RA6, RA7 and RA8 : • Flat to undulating with slopes ≤2.3° (b) Certification by an AQP[1] that contour drains and rock lined drop structures installed as per appropriate design criteria. (c) The lined co-disposal facility has been signed off by an AQP[1] as constructed to design. (d) Potentially acid forming or carbonaceous waste encapsulated in the centre of landforms.
RM3	Install cover system/cap	Cover installed (minimum 1m inert unweathered overburden)

3.5.3 Voids

A key focus of recent mine planning work has been to develop a suitable Post Mining Landform that satisfies all of the conditions contained within the EA while maintaining a safe and efficient mining operation. The result of this work has reduced the number of voids (from two to one), while maintaining a total final pit area extent approximating to the projected area stated in the EA.

Operating with a smaller pit size is neither safe or practical at the depths of the proposed development.

The current planned final pit void is to be located in the south-central western part of the Eastern Pit, and will be in accordance with condition F35 "protected from the Probable Maximum Floods (PMFs) such that the protection is sustainable for the foreseeable future".

To determine the final landform (including the extent of the final void), a mine schedule was developed utilising the SPRY software package. The model used to develop this schedule included 'Destination Scheduling', which enables the planner to place excavated material into logical dumping locations in a sequence relative to a practical mining excavation sequence. After the 'as-dumped' landform has been determined, a landform smoothing process is undertaken to create 'convex-concave' surfaces that mimic 'natural' slope profiles.

The results of this work are heavily influenced by several assumptions, particularly the assumption relating to the swell factor of the excavated and dumped material. Small variations in this assumption can result in significant differences in the as-dumped profile, including the size and shape of the void. Additionally, mine sequence changes in response to market demands or operational challenges may result in similar differences. As the mine progresses, some variation in the current proposed landform can be expected.

The EA contains a condition limiting the void depth to 150m, although the coal can be found at depths greater than that (up to 185m). The current proposed landform assumes a volume of spoil material is rehandled back into the pit void to limit the depth to 150m in line with the EA requirement; however, this exercise will not likely result in any measurable improvement in the environmental outcomes associated with the final void. The benefits of this backfill will be assessed as the mine nears completion.

The PRC Plan Guideline seeks information on the relative cost for each PMLU rehabilitation option. The transitional provisions apply to this PRC Plan. As such, an evaluation of PMLU option costs is not required; however, a high-level evaluation of the cost associated with backfilling the entire void has determined that this option would be extremely cost prohibitive. The total void volume is expected to be in the order of 100 million cubic metres. With a relatively modest bulk earthmoving cost of ~$3/cubic metre, the total cost would be in the order of $300M.

3.5.3.1 Highwall Slope Design

IMC Mining Group prepared a geotechnical assessment for the Codrilla Project as a component of the EIS. The feasibility level assessment considered overburden and interburden conditions and generic slope stability analysis. An updated feasibility level geotechnical study was completed in March 2012. Operational geotechnical data is not available as development of the mining project has not commenced.

The Codrilla Project coal resource is characterised by a thick cover of soft overburden comprising Tertiary and weathered Permian that is basically a sandy clay or claystone. The nature of this material means that soft highwall and end wall slope batters are required down to at least the base of weathering to ensure a stable cut slope design. The underlying unweathered rock is generally moderately strong to strong; however, based on seismic interpretation, is expected to contain structural discontinuities and associated defects. Consequently, the unweathered material could present areas of instability in cut slopes if appropriate slope angles are not adopted.

A generic slope design has been developed from the report in Appendix 4.7, and operational experience from the Moorvale and Coppabella Mines where areas of similar material stability are encountered. The adopted generic slope angles for highwalls and end walls is characterised by benching and variable slopes, generally resulting in an overall slope angle of 35° from the surface to base of weathering and a maximum 65° slope angle from the base of weathering to pit floor in unweathered rock. The generic highwall and end wall slope profile is presented in Figure 40 below. This design is consistent with the final rehabilitation design criteria outlined in the 2011 EMP referred to in the EIS Assessment Report (page 50).

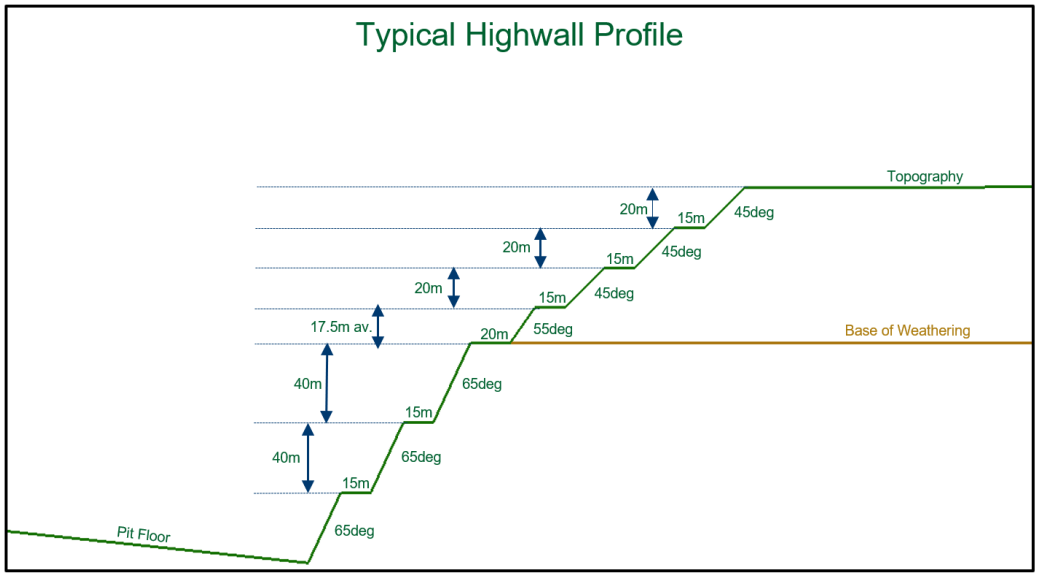


Figure 40 Generic Cut Slope Design for Highwalls and End Walls

To ensure that the final void area is safe, a durable Exclusion Bund will be established behind the final highwall crest. To ensure that this bund will not be impacted by the long-term effects of localised slope erosion and degradation, the bund will be located 10m behind a line defined by a 30° slope from the highwall at the base of weathering as shown below in Figure 41. The design criteria for this bund is based on parameters established for a similar bund considered for the nearby Millennium Mine (see Appendix 4.8). The highwall materials at Codrilla are similar to those at Millennium, with both mines extracting the same coal seams from the Rangal Coal Measures. Although the bund and the unmined surface the excavated highwall crest will be topsoiled and revegetated to reduce potential erosion, the location of the bund (and associated fencing) defines the extent of the NUMA as depicted in Figure 41.

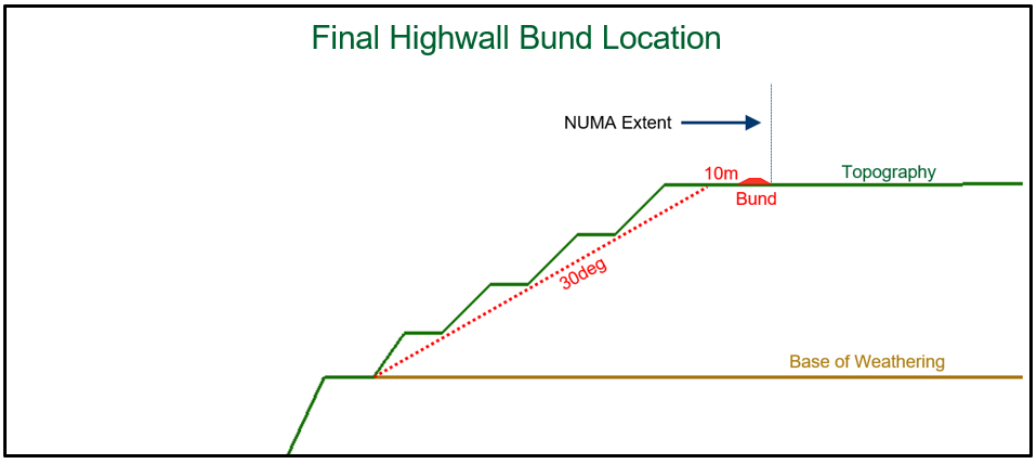


Figure 41 Final Highwall Bund Location

3.5.3.2 Low Wall Slope Design

The initial low wall will be cut into natural Tertiary material and will be constructed to a similar profile as the highwall above the base of weathering. The profile will be constructed in 20m stages with a 10m bench between each stage and batter slopes of 45°. The overall batter angle will be in the order of 35° as a result of the 10m step back between each 20m section. The generic low wall slope profile is presented in Figure 42 below.

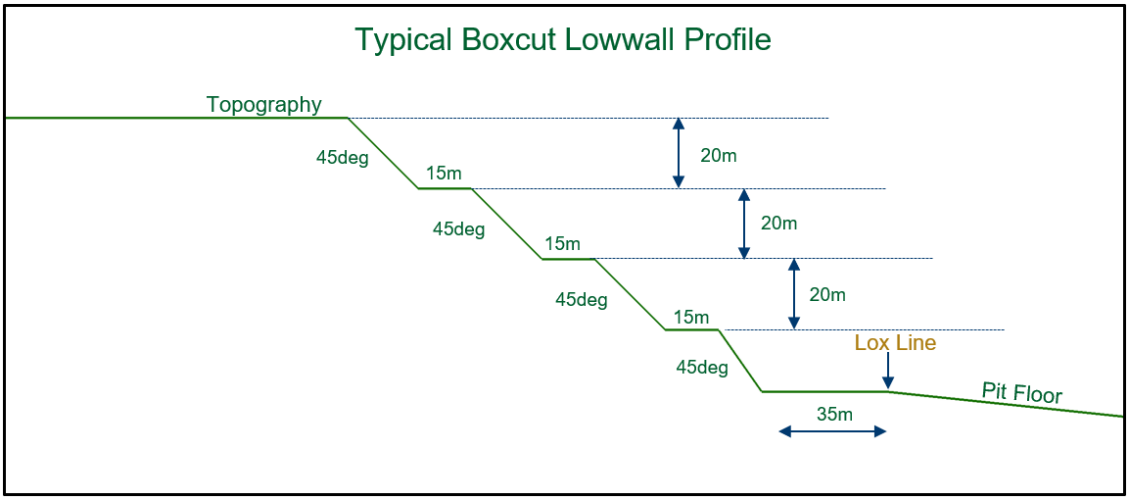


Figure 42 Generic Cut Slope Design for Low Walls

As mining progresses and sufficient room becomes available for pit backfilling with overburden, the initial low wall will be replaced by a dumped low wall. As the selected mining method is dip-line mining, the IMC (2009) report suggests that the dumped in pit low wall will be stable at the angle of repose (approximately 35° to 36°) as it is not prone to basal slippage due to competent floor conditions. The IMC (2009) assessment was based on conservative inputs and incorporated a continuous crest to toe low wall. For safe and practical operation purposes, the dumped in pit low wall will be developed in lifts of approximately 20m until the original topographic level is reached. The batter of each lift will remain at angle of repose. A step back bench in the order of 30m wide will be incorporated between each lift, this effectively further stabilises the low wall, reducing the average slope angle to between 20 and 22 °. Although the floor of the pit is expected to be competent for dumped low wall development, it will be further stabilised by blasting ahead of backfill dumping to

increase stability and enhance operational safety. Ramps will be constructed diagonally along the face of the low wall batter at a slope of approximately 6°. The generic dumped Low wall slope profile is presented in Figure 43 below. This design is consistent with the final rehabilitation design criteria outlined in the 2011 EMP referred to in the EIS Assessment Report (page 50).

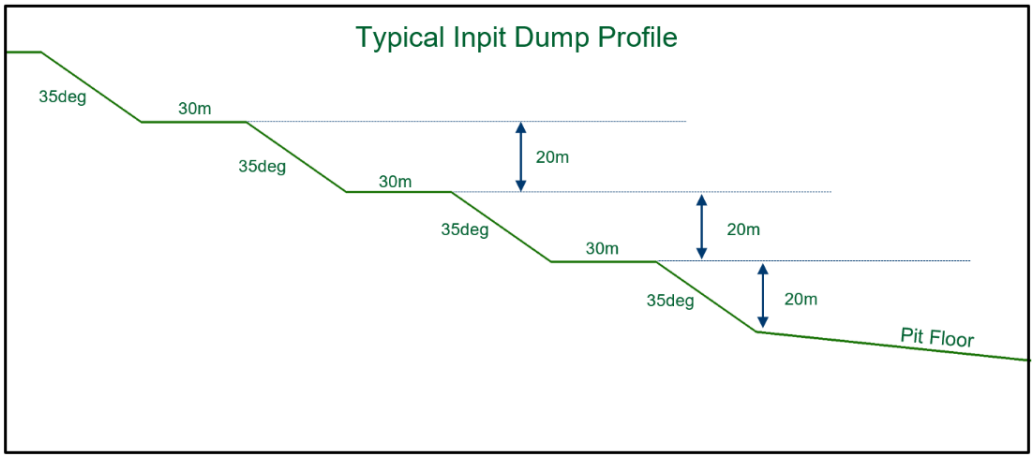


Figure 43 Generic Profile for In Pit Dumped Low Wall

Following completion of mining operations, water levels are expected to recover to equilibrium within the first 120 years post mining and water levels in the void will remain more than 50m below the crest of the pit. Initially two final voids were planned and modelled and the final water level in the voids were predicted to remain between 10 m to 19 m below the base of the Tertiary sediments for the West and East pits respectively and therefore; as the base of the Tertiary sediments is the upper level of the regional aquifer system, the voids will create a groundwater sink. Due to the hydraulic gradient associated with the final void groundwater sink, recharge of the aquifer system from the final void is not expected. The current final landform has reduced the number of voids from two to one. Long term standing water levels in the East Pit Void are expected to be lower than originally modelled due to the larger evaporative footprint of the current design, whereas the West Pit Void has been removed from the current design.

The principle reason that the water levels within the overburden and voids will recover to levels below pre-mining conditions is that average daily evaporation is around four times the average daily rainfall within the local region. Given the evaporative influences, the saline nature of groundwater recovering to pits and salt leaching from backfilled overburden, it is expected that over time, the water within the final void will progressively become more saline and eventually approach salinities similar to those observed within the regional aquifer system.

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Improvement Areas** and **Management Milestones** in the PRC Plan Schedule:

IA1

The following **Milestone Criteria** will demonstrate achievement of the Management Milestones:

MM1	Highwall treatment	Highwall crest battered back where required to achieve a stable slope angle as specified by an AQP[1] (geotechnical engineer)

MM2	Achievement of landform design and surface requirements	(a) Highwall as mined weathered average slope angle of 1V and 0.7H (55°) and low wall as backfilled at angle of repose at 1V to 1.35H (36°). (b) Abandonment safety bund setback distance is in accordance with calculated geotechnical factor of safety determined at MM1. (c) Abandonment safety bund constructed of competent rock and to geometry specified (height = 2m, width top = 2m, batters = 1V:3H, width base = 14m) to prevent traversing by vehicles. (d) Maximum depth of residual void is 150m below ground level. (e) The residual void is located outside of the probable maximum flood levels. (f) Abandonment safety bund and ramp into void is revegetated with pasture seed in accordance with Table 42 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.
MM3	Achievement of sufficient improvement not to cause environmental harm and be safe and structurally stable	(a) Access to highwall, low wall and ramp batter is restricted by physical barriers. Fencing erected on the outside of the abandonment safety bund to specification (five strand barbed stock fencing). (b) Safety signage designed in accordance with Australian Standard is erected at 100m intervals along the fence line. (c) Certification from an AQP[1] that the residual void will not cause environmental harm outside of the relevant tenure boundary. (d) Residual void acts as a groundwater sink to the receiving environment into perpetuity. (e) Certification from an AQP[1] that the residual void is safe to humans and livestock. (f) Certification from an AQP[1] that the water level and quality in the final void will not cause environmental harm to the surrounding environment.

3.5.4 Underground Mining

There is no Underground Mining contemplated for the Codrilla Mining Lease for the purposes of the development of this PRC Plan. Should Underground Mining be required in the future, appropriate approval requests will be submitted.

3.5.5 Built infrastructure

Where infrastructure is not required by the post mining landholder or forms part of the final landform, it will be decommissioned in line with the following processes. The general principles of waste management hierarchy will apply, with materials directed in priority to sources of:

- reuse
- recycling
- energy recovery, and
- disposal

3.5.5.1 Services

Services such as power, communications cabling, water and sewerage pipelines, will be disconnected and terminated to make them safe. Underground services will remain buried and surface interface

points will be sealed. Above ground and overhead services will be removed and managed in accordance with the waste management hierarchy. Areas disturbed by decommissioning of the installed services will be regraded to near original land form, topsoiled and revegetated for grazing as the post-mining land use.

3.5.5.2 Buildings

Buildings will be deconstructed, removed from site and managed in accordance with the waste management hierarchy. It is expected that there will be opportunity to generate reuse of buildings in particular the CHPP components. Concrete footings will be broken down and stripped of reinforced steel for recycling, with the concrete either directed to a reuse source or buried within overburden dump final rehabilitation areas. The areas will be regraded to near original land form, topsoiled and revegetated for grazing as the post-mining land use.

3.5.5.3 Water Management Structures

Sumps and dams that do not form part of the final landform as sediment control structures will be dewatered and where applicable, contaminated silt material will be removed for licensed disposal. Dam walls, levees, and drains will be regraded to near original land form, topsoiled and revegetated for grazing as the post-mining land use.

3.5.5.4 Access roads, car parks and hardstands

Sealed asphalt roads, car parks and hardstand areas will have the asphalt removed for reuse or burial within overburden dump final rehabilitation areas. Unsealed roads, car parks and hardstands will have any contamination removed for licensed disposal, prior to being topsoiled and revegetated for grazing as the post-mining land use.

3.5.5.5 Hydrocarbon and chemical storage areas

Bulk storage tanks will be emptied of contents and directed to reuse or appropriately cleaned and decontaminated prior to recycling or disposal of materials. Concrete footings and bunding will be broken down and depending on contamination status, either directed to a licensed disposal source, or broken down and stripped of reinforced steel for recycling, with the concrete either directed to a reuse source or buried within overburden dump final rehabilitation areas. Any contamination will be removed for licensed disposal or on-site remediation in the case of hydrocarbons. The areas will be regraded to near original land form, topsoiled and revegetated for grazing as the post-mining land use.

3.5.5.6 Haul roads

All carbonaceous material will be collected through scraping and disposed of to the codisposal, or via burial within overburden dump final rehabilitation areas if the codisposal has been decommissioned and rehabilitated. Culverts will be removed and the drainage lines reinstated. Where required, regrading will be undertaken prior to being topsoiled and revegetated for grazing or native bushland (in the case of sections of the Codrilla to Moorvale Haul Road) as the post-mining land use. As an alternative to scraping of material, depending on the depth of carbonaceous material, some areas may be capped with a minimum 1m inert overburden layer following the regrading.

Relationship with PRC Plan schedule

The information in this section is relevant to the following **Rehabilitation Areas** and **Rehabilitation Milestones** in the PRC Plan Schedule:

RA4, RA6, RA7 & RA8

The following **Milestone Criteria** will demonstrate achievement of the Rehabilitation Milestones:

RM1	Infrastructure decommissioning and removal	(a) All services disconnected. Underground services remain buried and surface points sealed. (b) All buildings either demolished and removed or relocated off the mining leases. (c) Concrete slabs and footings removed or buried within overburden dump final rehabilitation areas. (d) Sumps or dams that do not form part of final landform as sediment control structures dewatered and where applicable contaminated silt removed for licensed disposal. (e) Sealed asphalt roads, car parks and hardstand areas will have the asphalt removed for reuse off the mining leases or removed for licenced disposal. Any contamination removed from unsealed roads, car parks and hardstands for licenced disposal. (f) Hydrocarbon and chemical storage areas removed and/or remediated by on-site treatment, if required. (g) All carbonaceous material collected from haul roads and disposed in the co-disposal area or buried within the overburden dump final rehabilitation areas. (h) A contaminated land survey carried out by an AQP[1] confirms that no contamination unsuitable for the post-mining land use is occurring.

3.6 Risk assessment

Legislative requirement

In accordance with section 126C(1)(f) of the EP Act, the rehabilitation planning part of the PRC plan must identify the risks of a stable condition for land described as a post-mining land use not being achieved, and how the applicant intends to manage or minimise the risks.

In accordance with the legislative requirements, a risk assessment was conducted for the Codrilla Project following the Peabody risk management framework and using the Peabody risk matrix and definitions and conducted in accordance with Recognised Standard 02 "Control of Risk Management Practices" (QLD) and AS/NZ ISO 31000 – Risk Management – Principles and Guidelines to identify:

- the risks of a stable condition for the land described as a post-mining land use not being achieved (section 126C(1)(f)); and
- the risks of the NUMA causing environmental harm and not being safe and structurally stable (section 126C(1)(j)).

Under section 111A of the *Environmental Protection Act 1994* a stable condition is defined as:

111A Meaning of *stable condition*

Land is in a ***stable condition*** if—

(a) the land is safe and structurally stable; and

(b) there is no environmental harm being caused by anything on or in the land; and

(c) the land can sustain a post-mining land use.

The risk management process is shown in Figure 44 below:

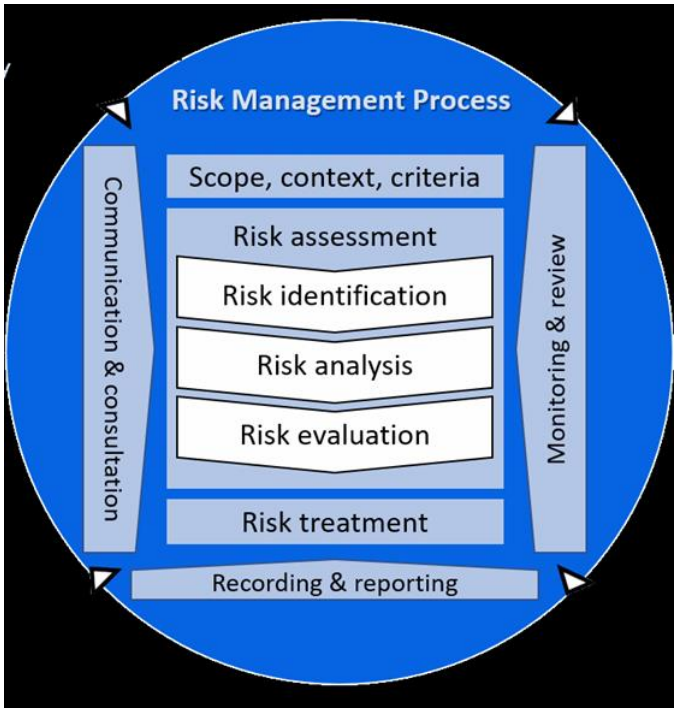


Figure 44 Risk Management Process

Risks were identified for each rehabilitation and management milestone that occur both progressively throughout the mine life, and at the cessation of mining and processing. The post closure monitoring period was also considered along with any potential legacy items that may not be completely rehabilitated and/or remediated.

3.6.1 Risk Identification

The risk identification step was used to:

- Identify and define risks to land being safe and structurally stable;
- Identify and define risks which have the potential to adversely affect environmental values (EVs); and
- Identify and define risks to land sustaining the PMLU.

3.6.2 Risk Analysis & Risk Evaluation

The Peabody Scoring System to assess risks are provided in Table 44 Scoring system used to assess risk.

Table 44 Scoring system used to assess risk

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

The Risk Assessments required under section 126C(1)(f) and section 126C(1)(j) are presented in Table 45 and Table 46 below.

Table 45 Risk Assessment PMLU

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Resource requirements	Performance measures	Reporting and monitoring	Residual risk		
				Consequence	Likelihood	Risk score						Consequence	Likelihood	Risk score
RM1 - Infrastructure decommissioning and removal	Inadequate removal of infrastructure	Safe and stable	- Infrastructure may create erosion points causing instability - Remnant infrastructure is a hazard to fauna or grazing animals -Soil/water contamination from infrastructure such as workshops is a hazard to fauna or grazing animals	2	3	6	- Current mine plans show locations of planned infrastructure - PRC plan & ERC include infrastructure removal - Infrastructure may only be retained with written landholder approval - Contaminated land assessment	Including in PRC and ERC ensures a documented and auditable record of infrastructure removal requirements and provides direction for planning and provisioning.	- Survey support - GIS support	Removal checklist (to be developed)	Visual inspection as per Section 3.7.1.8	2	2	4
	Residual contamination of land	Impact to EV's	Contaminated soil and / or impacts to downstream water quality	4	2	20	- PRC plans for identification, assessment and proper disposal of contaminated soil - Allow for contaminated soil disposal in ERC - Monitor incidents involving hydrocarbon or chemical spills - Develop site Spill Response Plan and implement - AS1940 audits and inspections - Contaminated land assessment - Areas included in the contaminated site register	The inclusion in PRC/ERC allows for proper budgeting and planning of contaminated soil disposal/treatment. Effective spill controls and auditing allows for high-risk areas to be identified and prioritised for treatment. A contaminated land assessment will verify if contamination has been appropriately remediated	- SAP ESHMS system (incident recording) - Spill response procedure - Auditing and inspection tools - Contaminated land assessment (by AQP)	Contaminated land assessment	Contaminated land assessment to be completed post operations and included in the final relinquishment report as per Section 3.7.1.8	2	2	4
		PMLU	Contamination impacts PMLU	3	2	10						2	2	4

RM2 - Landform design, reshaping and final contouring	Excessive slope on landform	Safe and stable	- Increased erosion risk if slope exceeds material limits - Loss of growth medium leading to limited vegetation establishment	4	2	20	- Current final landform slope designs within material limitations - GPS guidance and survey control during landform construction - GPS guidance and survey control during landform reshaping - Landform designed by AQP	Current slopes have been designed with regard to material limitations. GPS and survey controls will ensure the landform is constructed as per design.	- Survey support - GPS machine guidance	Review of survey data vs design by an AQP	LiDAR monitoring as per Section 3.7.1.2	3	2	10
		PMLU	Steep slopes not suitable for cattle and / or landholder access	3	2	10	- Current design slope within accepted limits for grazing / landholder access - GPS guidance and survey control during landform reshaping - Rehabilitation trials	Landform slopes of equal to or less than 4.6° for grazing is well within limits for cattle and landholder access. GPS and survey controls will ensure the landform is constructed as per design. Rehabilitation trials to demonstrate suitability	- Survey support - GPS machine guidance - Rehabilitation trial data	Review of survey data vs design by an AQP	LiDAR monitoring as per Section 3.7.1.2	2	2	4
	Structural stability of landforms not achieved	Safe and stable	Constructed landforms not geotechnically stable	4	2	20	- Current design assessed as geotechnically stable - Geotechnical monitoring during operations - Ensure deviations from design are reassessed by a geotechnical engineer (AQP)	Landforms slopes are designed to be geotechnically stable for the construction (dumped) material. Monitoring during operations can be used to validate the proposed design and update if required.	- Geotechnical monitoring data	As per Section 3.7.1.2	As per Section 3.7.1.2	3	2	10
	Ineffective drainage on final landform	Safe and stable	- Damage to previously completed rehabilitation - Increased likelihood of erosion - Ponding causes instability - Concentrated flows result in erosion, loss of growth medium and incision of slopes	3	3	15	- Drainage requirements included in final landform design - Rehabilitation monitoring - Erosion and sediment control (ESCP) monitoring - Receiving environment monitoring program (REMP)	Rehabilitation planning and methodology includes effective drainage. Rehabilitation and ESCP monitoring will monitor effectiveness of landform drainage	- Rehabilitation monitoring program - ESCP monitoring program	As per Section 3.7.1.2	As per Section 3.7.1.2	3	2	10
		Impact to EV's	Increased risk of downstream sedimentation	3	3	15			- Rehabilitation monitoring program - ESCP monitoring program - REMP monitoring	As per Section 3.7.1.2 & 3.7.1.3	As per Section 3.7.1.2 & 3.7.1.3	3	2	10

	Geochemical & geotechnical unsuitable tailings and reject materials	Safe and stable	Nature of tailings and reject material causes landform instability	5	3	75	- CDA landform design based on known material characteristics - Ongoing material characterisation during operations - Selective handling of materials during operations -Progressive rehabilitation of CDA cells as they become available	Design includes capping and reshaping to a slope suitable for the material type. Material characterisation during operations will determine if material is consistent with design parameter assumptions and allow for selective handling	- Materials characterisation and handling program	Material characterisation results and as per Section 3.7.1.2	As per Section 3.7.1.2	4	3	30
RM3 - Install cover system/cap	Failed or inadequate capping on CDA or overburden dumps	Safe and stable	Landform instability and / or excessive erosion	5	2	50	- Capping thickness based on initial materials characterisation - GPS guidance and survey control during capping - Capping material topsoiled and vegetation established - Ongoing material characterisation during operations - Selective handling of materials during operations - Surface and GW monitoring -Landform (including capping) designed by an AQP	GPS and survey guidance will ensure design capping thickness is achieved. Material characterisation during operations will determine if material is consistent with design parameter assumptions and allow for selective handling. Topsoiling and vegetation establishment on capping material will enhance erosional stability. Surface and GW monitoring will identify potential release of contaminants	- Materials characterisation and handling program - Surface and GW monitoring program	Material characterisation results and as per Section 3.7.1.2 & 3.7.1.3	As per Section 3.7.1.2 & 3.7.1.3	4	3	30
		Impact to EV's	Release of contaminants to surface or GW	5	2	50						4	3	30
	Failed or inadequate lining of CDA	Impact to EV's	Seepage from CDA causes surface or GW contamination	4	3	30	- CDA will be lined to prevent seepage as per design - Surface and GW monitoring -Liner will be designed by AQP	Internal CDA liner designed to prevent seepage to the receiving environment. Water monitoring during operations will demonstrate effectiveness of the liner.	- Surface and GW monitoring program	Section 3.7.1.3	Section 3.7.1.3	3	3	15
RM4 - Surface preparation	Insufficient topsoil reserves	PMLU	Inadequate topsoil to establish vegetation and support PMLU	4	3	30	- Projected inventory of stripped topsoil adequate for rehabilitation - Topsoil inventory and mapping to be maintained during operations - Review of topsoil inventory against rehabilitation requirements - Topsoil volumes and requirements will be included in ERC	Available volume of topsoil is adequate for rehabilitation of disturbed areas. Maintaining a topsoil inventory and mapping allows for regular checks against requirements including ERC.	- Survey support - Topsoil inventory tool - ERC calculator	Topsoil inventory tool and ERC volumes	As per Section 3.7.1.2	3	2	10

	Inadequate topsoil cover	PMLU	Failed vegetation establishment not supporting PMLU	3	2	10	- Projected inventory of stripped topsoil adequate for rehabilitation - GPS and survey control during topsoiling - Supervision during topsoiling - Test-pitting of topsoil depths prior to seeding	Survey and test -pitting checks to ensure minimum topsoil depth is applied	- Survey support - Topsoil inventory tool	- Topsoil depths (field verified) - Survey data (eg. LiDAR)	As per Section 3.7.1.2	2	2	4
	Topsoil not suitable for target vegetation	PMLU	Topsoil unable to support target rehabilitation species	3	2	10	- Topsoil management plan outlines topsoil stripping, handling and storage requirements - Amelioration rates determined by an AQP - Rehabilitation monitoring includes soil analysis - Rehabilitation trials	Rehabilitation species selected grow in surrounding areas and are suitable for the soil type. Appropriate management will maintain the integrity of the topsoil resource. Rehabilitation monitoring and trials will inform success	- Topsoil management plan - Survey support - Topsoil inventory tool - Rehabilitation monitoring program - Rehabilitation trials	- Rehabilitation monitoring data	As per Section 3.7.1.1	2	2	4
	Inadequate ripping (not completed, downslope or insufficient depth)	Safe and stable	Topsoil not keyed into subsoil allows excessive erosion or downslope rip lines create erosion channels	3	2	10	- Rehabilitation methodology includes cross slope ripping - Supervision during ripping operations - Visual inspection of ripped surface - ESCP monitoring	Supervision during ripping to ensure correct direction and depth is achieved. Inspections following ripping provide visual confirmation.	- Rehabilitation monitoring program - ESCP monitoring	- Rehabilitation monitoring data - ESCP monitoring data	As per Section 3.7.1.1 & 3.7.1.2	2	2	4
RM5 & RM6 - Revegetation & habitat development (native bushland) and revegetation (grazing)	Heavy rainfall prior to vegetation establishment	PMLU, safe and stable	Loss of topsoil resource preventing adequate vegetation establishment, excessive erosion and instability of slope	3	3	15	- Seeding to be scheduled immediately following surface preparation - Seeding not scheduled prior to large rain events - Cover crop included in seed mix	Appropriate timing of topsoiling/seeding reduces the risk of weather impacting vegetation establishment	- PRC schedule	PRC schedule audits	As per Section 3.7.1.1	2	3	6
	Seed quality or application not suitable for vegetation establishment	PMLU	Vegetation does not adequately establish to support PMLU	3	3	15	- Seed mix and rate based on local conditions - Seed quality and viability testing included in procurement - Rehabilitation monitoring	Seeding mix and application rate is consistent with local conditions and other mine rehabilitation in the Bowen Basin. Testing of seed ensures viability prior to seeding.	- Seed quality and validation tests - Rehabilitation monitoring program	- Test results	As per Section 3.7.1.1	2	3	6
RM7 & RM8 - Achievement of surface requirements (native bushland and grazing)	Inadequate vegetation cover for native bushland	PMLU	- Vegetation not sufficient for / consistent with the PMLU - Excessive grass growth inhibits tree and shrub establishment -Key invertebrate and vertebrate communities are not re-establishing	3	3	15	- Seed mix and rate based on local conditions and PMLU - Minimal grass in seed mix - Rehabilitation monitoring to inform potential changes to mix or application rate or further planting	Seeding mix is specific to the establishment of native bushland. Monitoring will inform success and potential changes to methodology.	- Rehabilitation monitoring program	- Rehabilitation monitoring data	As per Section 3.7.1.1	2	3	6

	Inadequate vegetation cover for grazing	PMLU	Vegetation cover insufficient to support the PMLU	3	3	15	- Seed mix and rate based on local conditions and PMLU - Rehabilitation monitoring to inform potential changes to mix or application rate	Seed mix is consistent with surrounding grazing land and other mine rehabilitation in the Bowen Basin.	- Rehabilitation monitoring program	- Rehabilitation monitoring data	As per Section 3.7.1.1	2	3	6
	Groundcover not sufficient for surface stabilisation	Safe and stable	Inadequate groundcover establishment causes excessive erosion rates	3	2	10	- Seed mix and rate based on local conditions - Cover crop included in seed mix - Rehabilitation monitoring	Species selection includes appropriate groundcover species. Rehabilitation monitoring will inform success.	- Rehabilitation monitoring program	- Rehabilitation monitoring data	As per Section 3.7.1.1 & 3.7.1.2	2	3	6
	Revegetated areas dominated by weeds (invasive plants)	PMLU	Weeds (Invasive Plants)	3	3	15	- Seed testing requirement is included in procurement - Weed inspections of rehabilitation machinery - Rehabilitation monitoring - Weed management plan to be implemented	Seed testing to verify the quality of seed and the absence of invasive plant species. Inspection and cleaning of equipment to help stop spread of invasive plant species. Weed management plan to outline management options.	- Rehabilitation monitoring program - Equipment inspection checklist - Weed management plan	- Rehabilitation monitoring data	As per Section 3.7.1.1	2	3	6
		Impact to EV's	Untreated invasive plants outbreaks impact surrounding land	3	2	10	- Weed inspections of rehabilitation machinery - Rehabilitation monitoring					2	2	4
RM9 & RM10 - Achievement of a stable condition (native and grazing)	Lack of rehabilitation maintenance ie. repair of significant erosion	Safe and stable	Excessive erosion progressively impacts stability of final landform	4	3	30	- Rehabilitation monitoring determines maintenance requirements - Rehabilitation maintenance program	Regular monitoring and maintenance of rehabilitation allows issues to be addressed promptly.	- Rehabilitation monitoring and maintenance program	As per Section 3.7.1.7	As per Section 3.7.1.7	3	3	15
	Inappropriate final land use	PMLU	Loss of land resource and conflict with stakeholder engagement outcomes	3	2	10	- Soils and rehabilitation design assessed as suitable for the PMLU's - PMLU's compatible with surrounding land uses - Rehabilitation monitoring	The selected PMLU's are consistent with surrounding land uses and would be expected to be suitable	- Rehabilitation monitoring program	As per section 3.7.1.1 & 3.7.1.4	As per section 3.7.1.1 & 3.7.1.4	2	2	4
	Rehabilitation vegetation lost or damaged due to bushfire	Impact to EV's	- Loss of biodiversity - Damage to previously completed rehabilitation	3	3	15	- Rehabilitation monitoring - Bushfire management - Selective grazing	Rehabilitation monitoring will identify areas requiring grazing or fire management to reduce fuel load	- Rehabilitation monitoring program - Bushfire management plan	As per section 3.7.1.1	As per section 3.7.1.1	2	3	6
	Surface water runoff causes environmental harm	Impacts to EV's	Environmental harm from contaminated runoff	4	2	20	- Surface water monitoring -Run off water either treated to eliminate off site impacts or retained on site	Monitoring to provide early indication of potential contamination	Surface water monitoring program	As per Section 3.1.7.3	As per Section 3.1.7.3	3	2	10

	GW contamination from rehabilitated area	Impacts to EV's	Contamination of groundwater	4	3	30	- GW monitoring	Monitoring to confirm modelling predictions of low risk to groundwater or to provide an early indication of potential issues	GW monitoring program	As per Section 3.1.7.3	As per Section 3.1.7.3	3	2	10
RM11 - Fencing / bunding install	Fencing / bunding not installed or ineffective	PMLU	Grazing of native bushland areas impacts PMLU	3	2	10	- Areas progressively fenced during operations (where possible) - Development of a property management plan for transfer to future landholder - Bunding included in PRC / ERC - Safety bunding in placed during operations - Closure risk assessment	Final fencing requirements will be considered when fencing during operational phase including communication with the future landholder where possible. Property management plan will include requirements for fencing and not grazing native bushland areas. Safety bunding will be in place around operational pits. Operational bunds may be repurposed for final bunds.	Property management plan	Visual assessment and mapping	As per Section 3.1.7.2	2	2	4
		Safe and stable	Un-bunded / unfenced areas pose a risk to humans or livestock	5	3	75						5	2	50

Table 46 Risk Assessment NUMA

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Resource requirements	Performance measures	Reporting and monitoring	Residual risk		
				Consequence	Likelihood	Risk score						Consequence	Likelihood	Risk score
MM1 – Highwall treatment	Highwall (HW) and / or low wall (LW) does not achieve geotechnical stability	Safe and stable	HW and LW not geotechnically stable and not considered safe	5	3	75	- Current design angles assessed as geotechnically stable - Pit floor blasted ahead of backfill dumping to enhance stability (LW) - Dip-line mining methodology increases HW and LW stability over other mining methods - Geotechnical monitoring during operations to validate HW and LW design parameters -Landform designed by AQP	Current designs are based on geotechnical assessment, materials characterisation, mining methodology and experience with similar materials at surrounding mines. Ongoing monitoring during operations will validate modelling or provide information for updates.	- Geotechnical monitoring program	As per Section 3.7.1.2	As per Section 3.7.1.2	4	2	20

	Ineffective HW drainage	Safe and stable	Ineffective drainage degrades erosional stability or impacts bunding	4	3	30	- Final drainage slopes away from HW areas - Area between bunding and HW crest to be left vegetated	Sloping drainage away from HW's will minimise water in area and potential erosion. Vegetated area between bunding and highwall crest to reduce erosion	Final drainage plan	Review of final drainage and rehabilitation designs	As per Section 3.7.1.2	3	3	15
MM2 - Achievement of landform design and surface requirements	Fencing / bunding not installed or ineffective	Safe and stable	Un-bunded / unfenced areas pose a risk to humans or livestock	5	3	75	- Abandonment bund setback distance is in accordance with calculated geotechnical factor of safety - Abandonment bund constructed of competent rock and to geometry specified to prevent traversing by vehicles - Fencing erected on the outside of the abandonment bund to specification (nominally five strand barbed stock fencing) - Safety signage (design in accordance with Australian Standard) erected at specified intervals along the fence line (nominally one sign every 100m) - Property management plan Bunding, fencing and signage provisioned in ERC	Sufficient abandonment bund, fencing and signage is an effective method of reducing potential interaction with the residual void	- Property management plan - Final bunding and fencing plan	Visual inspection	As per Section 3.7.1.2	5	2	50
	Flood impacts on residual void	Impact to EV's	Capture of overland flow and potential release of contaminants	6	2	100	- Residual void is located outside of the PMF flood zone	Flood modelling shows void is not at risk of inundation in a PMF event	Flood modelling	Data from actual flood events	Monitor actual flood events	6	1	50

MM3 – Achievement of sufficient improvement not to cause environmental harm and be safe and structurally stable	Residual void water quality causes environmental harm	Impact to EV's	Residual void water causes harm to environmental values	5	3	75	- Final void water modelling indicates that the level of the final void water is significantly below the crest of the pit to avoid risk to receiving environment - No identified users of groundwater in the area - GW monitoring	Modelling indicates minimal risk which will be validated by ongoing monitoring	GW monitoring program	GW monitoring data	As per Section 3.7.1.3	3	3	15

3.6.4 Rehabilitation trials

Rehabilitation trials are yet to be conducted at the Codrilla Project as mine development has not commenced.

The results of trials conducted at other sites in the Bowen Basin will be utilised to inform the site's rehabilitation methodology as appropriate. Learnings from research, including ACARP funded projects, may also be utilised to improve rehabilitation outcomes.

As the pre and post-mining land use for the majority of the site is low intensity cattle grazing, the objective of future trials will focus on aligning research and trials with sustainable cattle grazing and assessing the suitability or rehabilitated land to support commercial grazing activities.

3.6.4.1 How Trials Will be Carried Out

A successful trial of rotational cattle grazing has been carried out previously at PEA's Burton and Wilkie Creek Mines. The trials have been carried out in collaboration with neighbouring graziers who have put stock onto rehabilitated pastures that have been assessed as being sufficiently well established to support grazing on a rotational (short duration, high intensity) grazing. Cattle are weighed individually before and after grazing on the rehabilitated pasture and the daily weight gain is calculated for comparison with the average weight gain achieved on adjoining natural pasture areas. The physical condition of the cattle is assessed by the grazier upon completion of the trial and reported to the site's environmental manager. The trials were conducted over periods from weeks to months.

The trials that were conducted at Burton employed innovative cattle tracking collar technology. The solar powered collars were fitted to fifty cattle prior to introduction into the grazing trial area. The collars are fitted with GPS tracking collars, which allows for both real time and recorded monitoring of the location of the cattle. This enable the movement and preferential grazing practices of the cattle to be recorded. The trials showed that cattle grazed both flats and undulating topography, inclusive of waste rock dumps. Concentration of cattle movement on 'desire lines' up the dump slope, which could give rise to erosion, was not observed. The cattle collars also provided information on the distance from watering points that cattle were prepared to walk and graze. This information can be used to inform the placement of stock watering points across the rehabilitated landscape.

The condition of the grazed area was assessed regularly by the grazier and the site representative to ensure that overgrazing did not occur. Stock were removed from the trial area when biomass was grazed to a level that was adjudged to be appropriate. Recovery of pasture following grazing was assessed via the methodology described within the rehabilitation monitoring section of this PRC Plan. Over time it is anticipated that grazing trial results will inform sustainable stocking rates for rehabilitated pastures under varying seasonal conditions so that stocking numbers can be aligned with the land's sustainable carrying capacity. The results may also be used to inform species selection and sowing rates for areas where grazing has been nominated as the post-mining land use.

Success will be assessed via cattle weight gain, cattle condition at the conclusion of the trial when compared to pre-trial condition, and resilience of the pasture species and total biomass as assessed during the next annual rehabilitation monitoring program.

3.7 Monitoring and maintenance

In order to determine the success of the rehabilitation and as required under condition F31 of the EA, a Rehabilitation Monitoring Program has been developed and it has been designed to provide information for:

- Environmental personnel who need to understand how rehabilitation is developing so that feedback can be provided to Peabody and the Regulator;
- Review and refinement of rehabilitation methodologies to optimise vegetation establishment and align rehabilitation programs with agreed post-mining land use objectives;
- Operations personnel who require feedback on the effectiveness of rehabilitation operations;
- Identification of areas in need of maintenance and the extent of maintenance and management requirements;
- Management who require detail on rehabilitation liability and whether commitments are being met;
- Development and ongoing refinement of rehabilitation success measures/completion criteria;
- Peabody to enable communication on relevant information to external stakeholders
- Support of progressive rehabilitation certification applications; and
- Regulatory authorities (and other relevant external stakeholders) who may wish to determine whether they believe rehabilitation is developing toward or has met rehabilitation commitments.

The rehabilitation assessments will:

- Provide an understanding of the way in which the rehabilitation develops over time (successional patterns and trends);
- Provide an understanding of the chemical properties of the reconstructed topsoil profile;
- Allow for refinement and supplementation of the re-vegetation process;
- Allow for the development and refinement of land use demonstration studies such as grazing;
- Consider the influence of both internal and external factors on rehabilitation development;
- Consider the rate at which the rehabilitated landscapes approach the agreed final land use;
- Identify and summaries opportunities for improvement in the rehabilitation methodology, monitoring methodology and maintenance of rehabilitated land;
- Enable Peabody to establish or improve completion criteria for each post-mine land use; and
- Identify areas and extent of maintenance and management requirements.

3.7.1 Rehabilitation Monitoring and Maintenance Program

The rehabilitation monitoring and maintenance programs, which also address the requirements of the Post Closure Management Plan under condition F42 of the EA, will enable Peabody to measure and calculate a range of vegetation, faunal colonisation, soil and final landform parameters and indices in the developing rehabilitation. The monitoring and maintenance programs can be split into three components:

a) vegetation and fauna monitoring, inclusive of bushland and pasture establishment, habitat development and faunal colonisation and success as required;
b) final landform monitoring; and
c) water quality monitoring.

The objectives of the monitoring program are described in the next three sections.

3.7.1.1 Vegetation & Fauna Monitoring

- To establish and assess practical and applicable reference plots, if not already established.
- To measure total lower-storey cover (foliage and basal), species density and richness in the rehabilitation block and determine any significant differences when compared to reference plots;
- To measure pasture yield within areas where grazing is the post-mining land use and determine any significant differences when compared to reference plots;
- To measure the cover (foliage and basal), presence/absence of upper-storey (tree) and mid-storey (shrub) species in the rehabilitation block;
- To measure fauna colonisation of invertebrates, vertebrates and habitat development;
- To measure the presence of invasive plants, including invasive plants that are restricted matters under the *Biodiversity Act 2014* and to measure changes to the location, extent and density of the invasive plants to enable informed weed (invasive plants) management decisions and controls to be made and updates to the management plan to reflect the findings;
- To assess the success of sown species by comparing seeding mixes to monitoring data;
- To ensure that vegetation monitoring is undertaken on all rehabilitated landform types, including both elevated landforms (i.e. out-of-pit dumps not typical of the surrounding environment) and other lower-lying rehabilitated areas such as rehabilitated ROM pads, infrastructure areas, etc.;
- To assess similarity to reference plots and/or replication across an elevated landform (i.e. upper, middle, lower sections of a rehabilitated out-of-pit dump);
- To assess parameters that relate to pasture productivity;
    - Density and richness of pasture;
    - Groundcover determination (foliage and basal);
    - Pasture yield, to support grazing trials; and
    - Establishment success and sustainability of sown species;
- To gather data which can be used to support demonstration studies, such as grazing; and
- To obtain sufficient relevant data to statistically indicate trends and demonstrate achievement of success/completion criteria.

Monitoring will demonstrate that **RM5** and **RM7** (grazing PMLU) and **RM6** and **RM8** (native bushland

PMLU) and the relevant Milestone Criteria have been achieved.

3.7.1.2 Final Landform Monitoring

- To assess the chemical properties and soil nutrient status of the reconstructed topsoil profile, identifying potential properties that may contribute to any areas of rehabilitation not meeting the desired objectives or that need maintenance such as the application of ameliorants;

Monitoring will demonstrate that **RM4** and the relevant Milestone Criteria have been achieved.

- Record the location of erosion within, or within the vicinity of the plot as per the *Australian Soil and Land Survey - Field Handbook. 3rd ed (2009)* (i.e. active, stable, depth, type etc). Peabody maintains an Erosion and Sediment Control Plan (ESCP) Procedure.

Monitoring will demonstrate that **RM4**, **RM7** or **RM8** and the relevant Milestone Criteria have been achieved.

- To identify and measure landform stability and specifications on the rehabilitated blocks, using LiDAR (as provided by Peabody), with particular attention paid to:
    - determining the post mine landform stability by measuring year on year settlement/subsidence and/or sediment deposition; and,
    - determining the post mine landform stability by measuring the extent and year on year progression of erosion features

Monitoring will demonstrate that **RM2** and **RM3** and **MM1** and **MM2** and the relevant Milestone Criteria have been achieved.

- Determining compliance with the design and final landform specifications (i.e. constructed as per detailed design, slopes angles, length, aspect and ground surface curvature) detailed within the site EA.

Monitoring will demonstrate that **RM1**, **RM2, RM3, RM4, RM7 or RM8, RM9 or RM10 and RM11** and **MM1**, **MM2** and **MM3** and the relevant Milestone Criteria have been achieved.

3.7.1.3 Water Quality Monitoring

Baseline monthly water quality monitoring as part of the receiving environment monitoring program (REMP) was conducted from 2010 to 2016.

Samples were collected in the locations specified under Table C8 of the EA from both the installed Rising Stage Samplers (RSS) sites at Swampy Creek and Devlin Creek and at Devlin Creek Haul Road (DCHR), Bundarra Creek Haul Road (BCHR), Devlin Creek Fitzroy Development Road (DCFDR) and Downstream Devlin Creek (DSDC). Sample analysis included insitu pH, EC, turbidity; selected total and dissolved metals; hydrocarbons and nutrients.

Similarly, baseline groundwater quality monitoring was conducted commencing 2011 utilising the ten groundwater bores as shown in Figure 20 on the following page. These bores are also included in Table C11 of the EA. Groundwater levels were obtained at a monthly interval between July 2011 and June 2012 and then at quarterly intervals. Groundwater quality sample analysis included insitu pH, EC and suspended solids, metals/metalloids and total petroleum hydrocarbons.

To demonstrate the final landform is non-polluting a water quality monitoring program will be conducted:

a) Surface water monitoring will be undertaken post-establishment of the final landforms until the PMLU is achieved. As the creeks and drainage lines within the project area are ephemeral, surface water monitoring will only be undertaken opportunistically during periods of runoff where safe access to the site can be gained.
b) Groundwater samples will be collected and analysed to achieve milestone criteria.

Monitoring will demonstrate that **RM4**, **RM7, RM8**, **RM9**, **RM10** and **MM3** and the relevant Milestone Criteria have been achieved.

3.7.1.4 Baseline Monitoring & Reference Sites

Pasture reference plots are to be located adjacent to the existing mining operations on the mining lease (ML) or Peabody controlled land, but within an area that will not be impacted by future mining activities. The reference plots will be established based on a pasture grass land use and should consider vegetation and soil attributes similar to those used in the rehabilitation. In addition, past and current grazing pressures must be considered when selecting the pasture reference plot. Multiple reference plots (three or more per mine site) should be established to allow statistical analyses to be undertaken. Note, where reference site requirements are similar between Peabody mines, then it may be possible to utilize the same reference site for multiple Peabody mines.

Native vegetation reference plots are to be located adjacent to the existing mining operations on the ML or Peabody controlled land, but within an area that will not be impacted by future mining activities. The native vegetation reference plots should represent the vegetation communities and fauna habitat similar to those the re-vegetation program is aiming to achieve (e.g. open woodland). The native reference sites should consider vegetation, location and soil attributes similar to those used in the rehabilitation, noting that the seed mix composition should align as closely as practicable with the species composition and density occurring in the reference site. Multiple native vegetation reference sites should be established in each vegetation community to allow statistical analyses to be undertaken. Note, where reference site requirements are similar between Peabody mines, then it may be possible to utilize the same reference site for multiple Peabody mines.

The proposed rehabilitation monitoring methodology is as described in Table 47.

Table 47 Summary of Rehabilitation Monitoring Methodology

Plot Area	Parameter Measured	Description
General Description and Supplementary Information	Plot Characteristics	Record the slope, plot landform location (upper, middle, lower slope), post-mining land use (based on relevant EA conditions) and plot aspect.
	Weed (invasive plants) presence/abundance	List all invasive plants and subjectively record their abundance as low, moderately abundant, or abundant. If the invasive plant outbreak is deemed to be a significant outbreak or in a new location, record the GPS location for reporting to Peabody.

	Erosion	Record the location of erosion within, or within the vicinity of the plot as per the *Australian Soil and Land Survey – Field Handbook. 2nd ed (1990)* (i.e. active, stable, depth, type etc)
	Visual Record	Take one photograph at the start of the cover transect and a second at the finish, in both cases looking along the transect.
	Climatic Variables	Recent rainfall events, intensity, duration, measurement in relation to time of seeding. Potential impacts of other climatic events such as intense rainfall events, cyclones, droughts, floods.
	Other Variables	Note any other factors that have adversely affected rehabilitation areas, including fire, predation by insects, excessive grazing impact of herbivores, instances of vegetation die-back or soil disturbance caused by feral animals, e.g. pigs or rabbits
2m x 2m Quadrats	Lower-storey Density and Richness	At 10m intervals along the cover transect record the number of all lower-storey species in each quadrat to obtain total lower-storey species density and richness.
	Lower-storey Cover	Record total lower-storey cover (i.e. ground cover). The contribution of each of the lower-storey species to the live-standing ground cover assessment will be determined. The proportion of bare ground will be assessed by default.
	Pasture Yield (where grazing is the designated post-mining land use)	Harvest a representative 50 x 50 cm sub-quadrat at ground level and weigh in situ to derive the green herbage biomass. Retain biomass from quadrat 3 for drying and weighing in the laboratory. Note that harvesting shall occur after all other data has been collected from the transect.
	Topsoil Properties	Take five 0-15cm soil samples (i.e. one sample taken from each quadrat) and bulk, to produce one composite sample per transect.
50m Cover Transect	Mid-storey and Upper-storey Cover	Using the 50m cover transect, record the start and finish foliage intercepts. These intercepts are then added and divided by the total length (50m), resulting in a percentage cover for the species along the transect.
	Basal	The contribution of groundcover species basal cover will be measured using the '*point frame method*'. A 50 x 50cm quadrats/frame will be located at 10m intervals along, but adjacent to the cover transect. The contribution of competent rock (rock defined as >50mm in diameter) will also be assessed
10m either side of cover transect	Upper-storey & Mid-storey Density/Richness	Record the total number of trees and shrubs for each species located 10m either side of the cover transect.
	Species Inventory	Separately record lower-storey species noted in the vicinity of the plot but not present within the 2m x 2m quadrats enabling a more comprehensive inventory of what species are present.
LIDAR	Landform Stability and Specifications	Assess landform stability (settlement/subsidence), progression of erosion features and compliance of the 'as built' landform with the specifications (i.e. slopes, length) detailed within the site Environmental Authority (EA).

3.7.1.5 Sampling Intensity

The sampling intensity proposed for the rehabilitation monitoring program takes into account:

- Practicality and cost-effectiveness of monitoring techniques;

- Separation of pit locations and therefore rehabilitated land which will allow for progressive certification or partial relinquishment opportunities (i.e. mines are not often one extended tract of land and may contain a variety of rehabilitation years that can be combined for certification/relinquishment);
- The need to capture different final landforms and disturbance types (i.e. elevation, out of pit dumps, infrastructure areas, underground mining gas drainage 'runways' and subsidence areas) and end land uses;
- Sampling in appropriate seasons (post wet) to best capture all desired components, including the presence of annual species that germinate in response to summer rainfall events; and
- The need for broadscale monitoring, ensuring overall site rehabilitation performance is measured.

3.7.1.6 Frequency

As required under condition F31 of the EA, once rehabilitation as commenced, the rehabilitation monitoring program must be conducted yearly. Rehabilitation monitoring of the initial establishment (i.e. Year 1 and 2) will allow Peabody to identify early on, areas for improvements as well as prescribe remedial action where required. Following completion of coal processing on site, in accordance with condition F41, for at least 30 years or a shorter period if proven to be geotechnically and geochemically stable and non-polluting, the site will require maintenance and monitoring on an ongoing basis. Ongoing monitoring after the initial monitoring on a 2 to 5 yearly intervals thereafter and at 5 yearly intervals from Year 10 to Year 30 to assess any trends and to inform amelioration requirements where required.

Vegetation and Fauna Monitoring will be conducted in Year 1 and 2 & at 2 yearly intervals thereafter.

Final Landform Monitoring, which includes soil monitoring, erosion monitoring, geotechnical monitoring and design assessment will be conducted in Year 1 & at 2 to 5 yearly intervals thereafter.

Water Quality Monitoring will be undertaken in Year 1 and a revaluation of the groundwater monitoring requirements will be undertaken at 2 yearly intervals thereafter.

3.7.1.7 Maintenance

Maintenance activities will be undertaken ongoing on a yearly basis over the post-closure period. Detailed records of rehabilitation maintenance activities and the cost of carrying out such works will be compiled and maintained. These records may be used to refine the rehabilitation methodologies adopted at the site and provide accurate tracking of the cost of any rework.

Scheduled inspections will be undertaken to check that fencing, firebreaks, sediment dams, abandonment bunds, signage and any other related features are fit for purpose and maintained in good order and when rehabilitation monitoring and or routing site inspections determine that rehabilitated areas are impacted by a particular issue i.e. erosion, maintenance works will be undertaken. Table 48 provides maintenance issues and treatments that would be undertaken.

Table 48 Maintenance Issues & Treatments

Issue	Maintenance treatment
Historical rehabilitation	Where maintenance of historical rehabilitation is required augment as per current rehabilitation technical specifications
Gully erosion	Review landform drainage/run on and modify as required. Fill gully and provide appropriate surface protection/armouring
Poor vegetation cover	Adjust fertiliser/soil ameliorant inputs and reseed during appropriate seasonal conditions. If issue persists conduct additional soil sampling and seek input from an AQP
Erosion control device failure	Review design specifications and repair
Sedimentation	Where deemed necessary, excavate sediment build up and repair/reinstate structure rock check dams
Vegetation community developing inconsistent with PMLU	Review rehabilitation strategy and planting lists. Conduct a risk assessment for PMLU not being achieved and develop and implement a treatment response
Poor habitat development & faunal colonisation	Review planting requirements and investigate causes of key groups not recolonising

3.7.1.8 Monitoring and validation methods

The monitoring and maintenance program meet the requirements under section 126C (1) of the EP Act which requires to identify and describe the monitoring systems that will be carried out in order to demonstrate a milestone and milestone criteria have been achieved. Table 49 shows the rehabilitation monitoring and validation methods that will be undertaken once rehabilitation works have been completed in the domains discussed in this plan.

Table 49 Monitoring & Validation methods

Milestone reference	Rehabilitation milestone	Milestone criteria	Monitoring & Validation method	Frequency
RM1	Infrastructure decommissioning & removal	(a) All services disconnected. Underground services remain buried and surface points sealed. (b) All buildings either demolished and removed or relocated off the mining leases. (c) Concrete slabs and footings removed or buried within overburden dump final rehabilitation areas. (d) Sumps or dams that do not form part of final landform as sediment control structures dewatered and where applicable contaminated silt removed for licensed disposal. (e) Sealed asphalt roads, car parks and hardstand areas will have the asphalt removed for reuse off the mining leases or removed for licenced disposal. Any contamination removed from unsealed roads, car parks and hardstands for licenced disposal. (f) Hydrocarbon and chemical storage areas removed and/or remediated by on-site treatment, if required. (g) All carbonaceous material collected from haul roads and disposed in the co-disposal area or buried within the overburden dump final rehabilitation areas. (h) A contaminated land survey carried out by an AQP[1] confirms that no contamination unsuitable for the post-mining land use is occurring.	Visual monitoring Contaminated land assessment	Year 1 Year 1
RM2	Landform design, reshaping and final contouring, inclusive of drainage features	(a) Landform constructed satisfies the following criteria for each rehabilitation area— (i) RA1 and RA2: • outer batter slope gradient is ≤5.7° • crest of landforms slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 50m (ii) RA3:	LiDAR assessment Geotechnical monitoring	Year 1 Year 1 & at 4 yearly intervals thereafter

		• flat to undulating slope gradient is ≤4.6° • crest of landforms slope gradient is ≤2.3° (iii) RA5, RA9 and RA10: • outer batter slope gradient is ≤8° • crest of landform slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 18m (iv) RA4, RA6, RA7 and RA8 : • Flat to undulating with slopes ≤2.3° (b) Certification by an AQP[1] that contour drains and rock lined drop structures installed as per appropriate design criteria. (c) The lined co-disposal facility has been signed off by an AQP[1] as constructed to design. (d) Potentially acid forming or carbonaceous waste encapsulated in the centre of landforms.		
RM3	Install cover system/cap	Cover installed (minimum 1m inert unweathered overburden)	Soil monitoring	Year 1 & at 2 yearly intervals thereafter
RM4	Surface preparation (e.g. topsoil, fertiliser, amelioration agents, mulch or woody debris)	(a) Topsoil spread to a minimum depth of 150mm. (b) An assessment of soil/growth medium health and suitability has been completed by an AQP[1] to confirm soil/growth medium is suitable for target vegetation establishment. (c) Gypsum and fertiliser applied at rates determined by an AQP[1]. (d) Cultivation and keying of topsoil to subsoil with suitable multi-type ripper and performed parallel to slope contours. (e) Where appropriate, addition of rock and/or log cover to assist erosion resistance of eventual vegetative ground cover.	Erosion monitoring Soil monitoring	Year 1 & at 2 yearly intervals thereafter Year 1 & at 2 yearly intervals thereafter
RM5	Revegetation (grazing)	Completed seeding of target pasture species at rate and species composition in accordance with Table 42 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.	Vegetation rehabilitation monitoring	Year 1 and 2 & at 2 yearly intervals thereafter
RM6	Revegetation and *habitat development* (native bushland)	Completed revegetation of target native bushland species by tube stock and/or direct seeding at rate and species composition in accordance with Table 43 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.	Vegetation & habitat development rehabilitation monitoring	Year 1 and 2 & at 2 yearly intervals thereafter
RM7	Achievement of surface requirements (grazing)	(a) Species density and diversity achieved is consistent with the sown seed mix and reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (b) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and of >50% for areas of high rock and log content. (c) No new invasive plants2 and infestation density of invasive plants within the area are contained or reduced and consistent with reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (d) Water control structures are either removed or free of active erosion and integrated into permanent landforms. (e) No active[3] erosion gullies. Erosion rates are less than 5 tonnes/ha/year. A NEPM[4] assessment confirms areas are free of hazardous materials or have been rendered safe.	Vegetation rehabilitation monitoring Erosion monitoring Water quality monitoring NEPM assessment	At 2 yearly intervals At 5 yearly intervals Year 1 & at 2 yearly intervals thereafter
RM8	Achievement of surface requirements (native bushland)	(a) 80% of the area achieves species density and diversity that is greater than 60% of the reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022.	Vegetation & habitat development rehabilitation monitoring	2 yearly intervals

		(b) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and >50% for areas of high rock and log content. (c) No new invasive plants[2] and infestation density of invasive plants in the area are contained or reduced and consistent with reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (d) Evidence of fauna habitat features for invertebrate and vertebrate species (e.g. logs, rock piles, nest boxes, bird nests or perches). (e) Water control structures are either removed or free of active erosion and integrated into permanent landforms. (f) No active[3] erosion gullies. Erosion rates are less than 5tonnes/ha/year. (g) A NEPM[4] assessment confirms areas are free of hazardous materials or have been rendered safe. (h) Certification from an AQP[1] that the cover system is functioning as designed.	Erosion monitoring Water quality monitoring NEPM assessment	5 yearly intervals Year 1 & at 2 yearly intervals thereafter
RM9	Achievement of a stable condition for the land described as a post-mining land use of grazing	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and the landform meets criteria in RM2 (ii) erosionally stable: no active3 erosion is present and groundcover established meets criteria in RM7 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) The rehabilitated land meets Class 4 land suitability for grazing according to the Guidelines for agricultural land evaluation in Queensland (2nd edn) (DSITI & DNRM, 2015)[5]. (e) Species density and diversity achieved is consistent with the sown seed mix and reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (f) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and of >50% for areas of high rock and log content.	Rehabilitation monitoring	Between Year 15 and Year 30
RM10	Achievement of a stable condition for the land described as a post-mining land use of native bushland	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and landform meets the criteria in RM2 (ii) erosionally stable: no active[3] erosion is present, and groundcover established and meets criteria in RM8 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010.	Rehabilitation monitoring	Between Year 15 and Year 30

		(d) Native bushland established that provides habitat opportunities for native invertebrate and vertebrate species: (i) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs, and >50% for areas of high rock and log content (ii) 80% of the area achieves species density and diversity that is greater than 60% of the reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022 (iii) minimum 14 target vegetation species[6] comprising: grasses and forbs ≥3 mid-storey species ≥7 canopy species ≥4 (iv) evidence of key invertebrate groups (e.g. ants) and soil faunal communities (v) evidence of key native vertebrate groups (e.g. bird, mammal, reptile and amphibian) in the form of fauna spotting, scats and tracks		
RM11	Install fencing or other infrastructure to support the PMLU	Fencing / bunding installed sufficient to exclude stock	Visual monitoring	Year 1

Milestone reference	**Management milestone**	**Milestone criteria**	**Monitoring & Validation method**	**Frequency**
MM1	Highwall treatment	Highwall crest battered back where required to achieve a stable slope angle as specified by an AQP (geotechnical engineer)	Geotechnical monitoring	Year 1 & at 2 yearly intervals thereafter
MM2	Achievement of landform design and surface requirements	(a) Highwall as mined weathered average slope angle of 1V and 0.7H (55°) and low wall as backfilled at angle of repose at 1V to 1.35H (36°). (b) Abandonment safety bund setback distance is in accordance with calculated geotechnical factor of safety determined at MM1. (c) Abandonment safety bund constructed of competent rock and to geometry specified (height = 2m, width top = 2m, batters = 1V:3H, width base = 14m) to prevent traversing by vehicles. (d) Maximum depth of residual void is 150m below ground level. (e) The residual void is located outside of the probable maximum flood levels. (f) Abandonment safety bund and ramp into void is revegetated with pasture seed in accordance with Table 42 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.	LiDAR assessment Geotech monitoring Visual monitoring	Year 1 & at 2 yearly intervals thereafter
MM3	Achievement of sufficient improvement not to cause environmental harm and be safe and structurally stable	(a) Access to highwall, low wall and ramp batter is restricted by physical barriers. Fencing erected on the outside of the abandonment safety bund to specification (five strand barbed stock fencing). (b) Safety signage designed in accordance with Australian Standard is erected at 100m intervals along the fence line. (c) Certification from an AQP[1] that the residual void will not cause environmental harm outside of the relevant tenure boundary. (d) Residual void acts as a groundwater sink to the receiving environment into perpetuity. (e) Certification from an AQP[1] that the residual void is safe to humans and livestock.	Geotech monitoring Water monitoring	Year 1 & at 2 yearly intervals thereafter Year 1 & at 2 yearly intervals thereafter

	(f) Certification from an AQP1 that the water level and quality in the final void will not cause environmental harm to the surrounding environment.

3.7.1.9 Identification of Actual or Emerging Issues

The scope for annual rehabilitation monitoring includes provision to record actual or emerging issues and make recommendations on potential improvements to the rehabilitation process. This may include refinement to the species mix used in the rehabilitation process, recommendations for spoil amelioration, weed (invasive plants) control or pest management. The report may also make recommendations on potential improvements to the monitoring program. This may include adoption of emerging technologies.

3.7.1.10 Scheduled & Event Based Inspections

Field inspections may be undertaken in response to events that have the potential to adversely impact rehabilitation areas. This may include intense rainfall events occurring prior to establishment of a dense vegetation cover or impacts arising from the uncontrolled spread of fire within rehabilitation areas.

3.7.1.11 Use of Data to Evaluate Rehabilitation Trends / Trajectory

Data obtained from the annual rehabilitation monitoring program will be utilised to verify whether areas of rehabilitation are developing towards the desired targets described within the site's rehabilitation completion criteria. Where the desired trends are not observed, intervention via implementation of remedial actions may be required.

3.7.1.12 Reporting and the identification of Management Requirements

The results of the monitoring program are analysed and as a minimum, the following documented in monitoring reports:

- Trends in the vegetation and soil data (i.e. how rehabilitation is developing against expected growth patterns, trends towards reference communities, rehabilitation soil properties) including identification of any emerging issues that may compromise rehabilitation success;
- An appraisal of each monitoring location's alignment with the PMLU and associated vegetation communities;
- Recommendations on potential improvements to rehabilitation practices;
- Recommendations on improvements to the rehabilitation monitoring methodology; and
- Recommendations for managing erosion and invasive plants.

4 Appendices and attachments

4.1 PRC Plan Schedule

Legislative requirements:

In accordance with section 126D(1) of the EP Act, the PRCP schedule in the PRC plan must:

a) describe the area of each resource tenure either a post-mining land use or non-use management area, and
b) for each post-mining land use state:
   i. each rehabilitation milestone required to achieve a stable condition, and
   ii. when each rehabilitation milestone is to be achieved, and
c) for each non-use management area state:
   i. each management milestone, and
   ii. when each management milestone is to be achieved, and
d) include maps showing the land mentioned in (a), (b) and (c).

4.1.1 Final Site Design

The final site design is a map showing:

- the maximum disturbance footprint
- resource tenure boundaries
- PMLU(s) and NUMA(s) for the land within the resource tenure(s)
- flood plain extent.

The purpose of the final site design is to show the community what the site will look like post surrender.

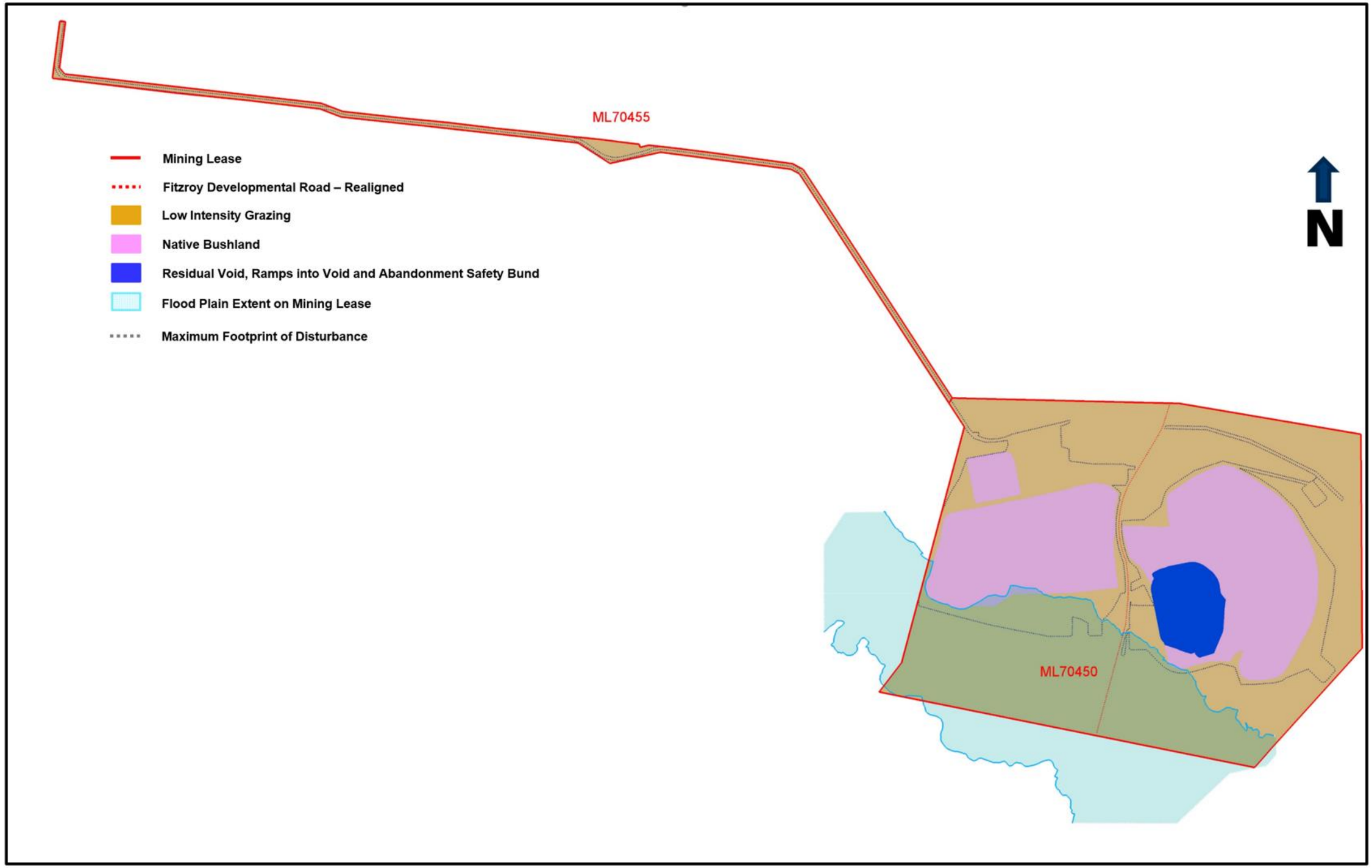


Figure 45 Final Site Design

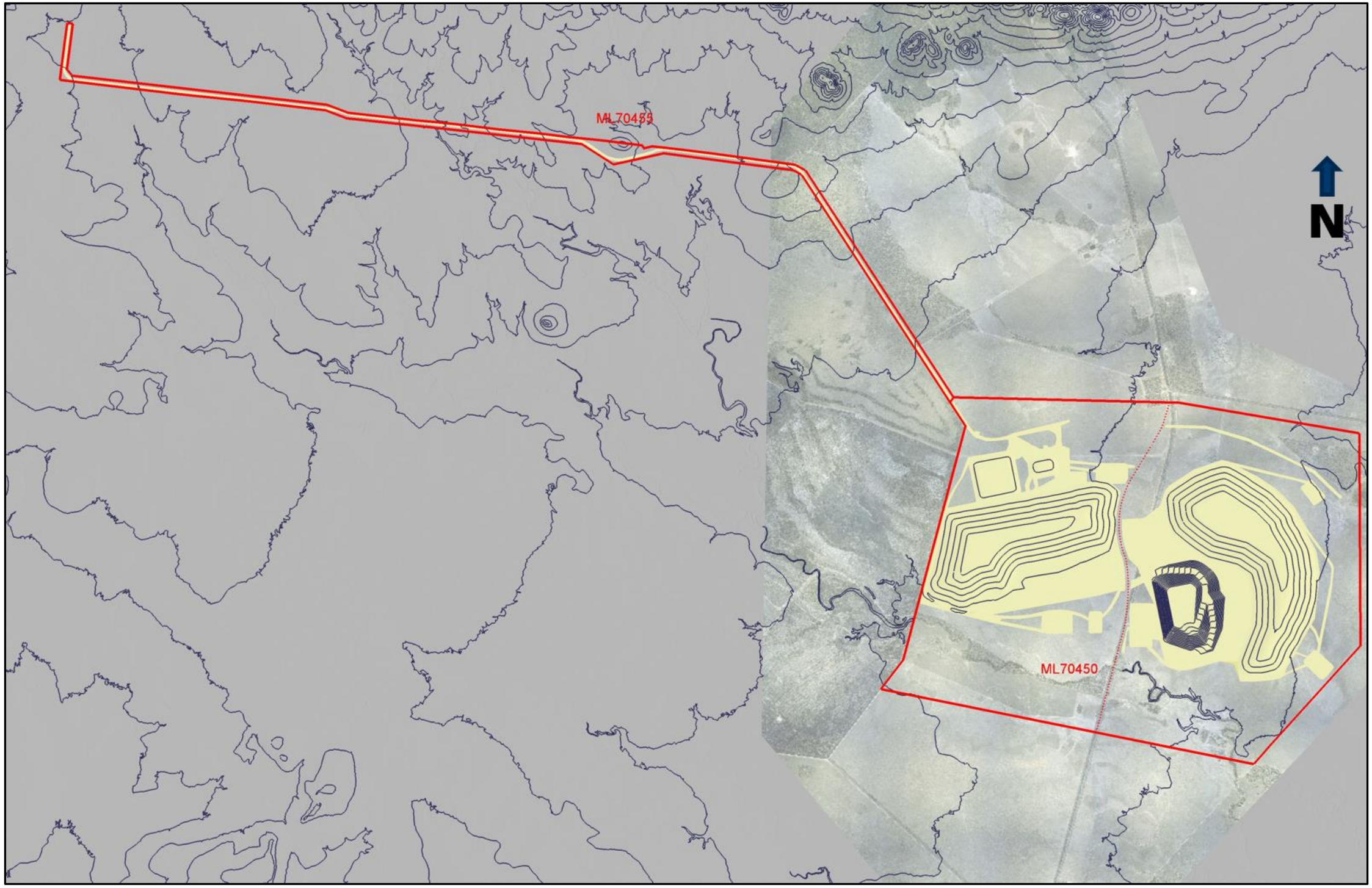


Figure 46 Final Landform Regional Contour Plan

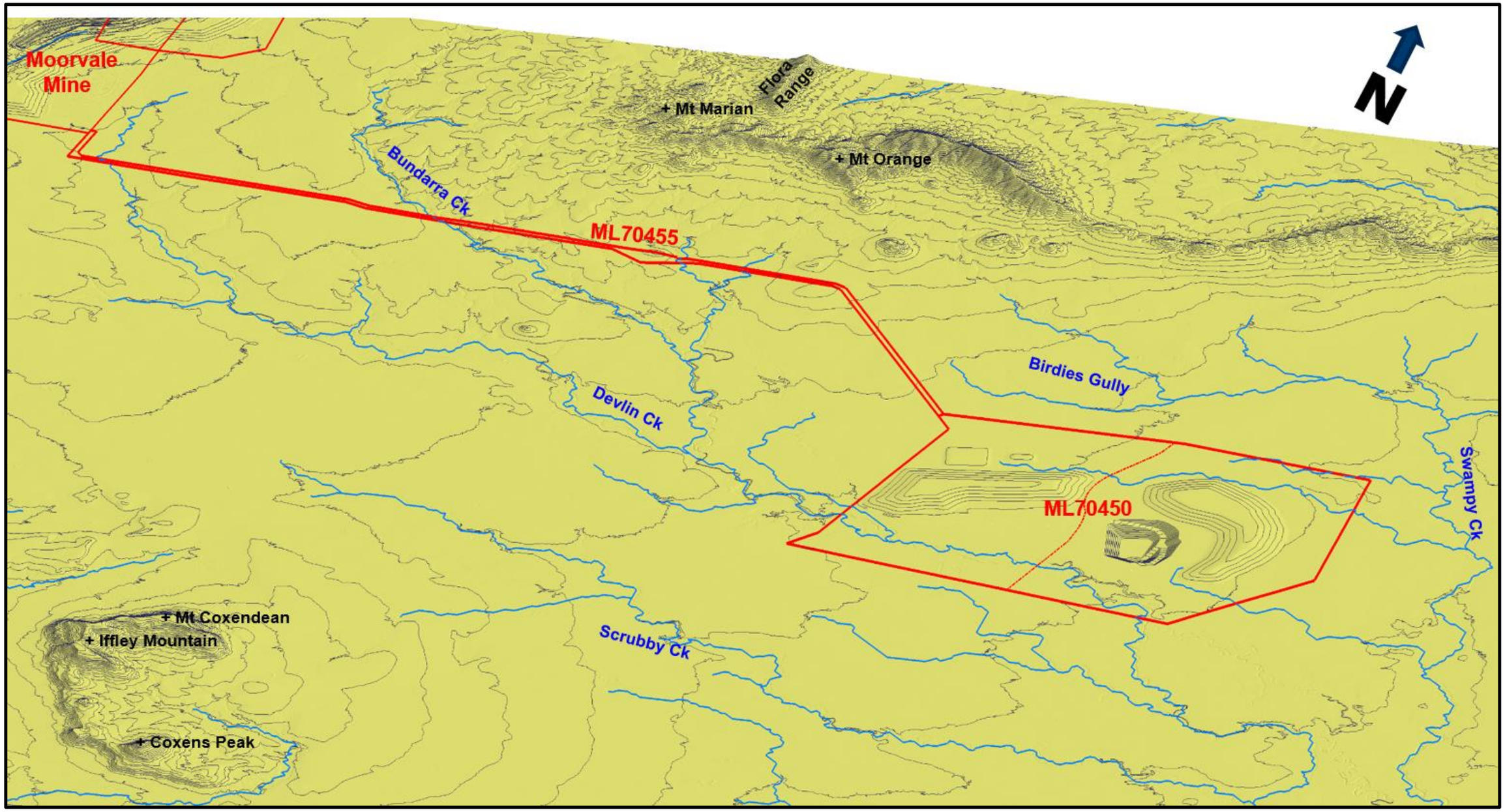
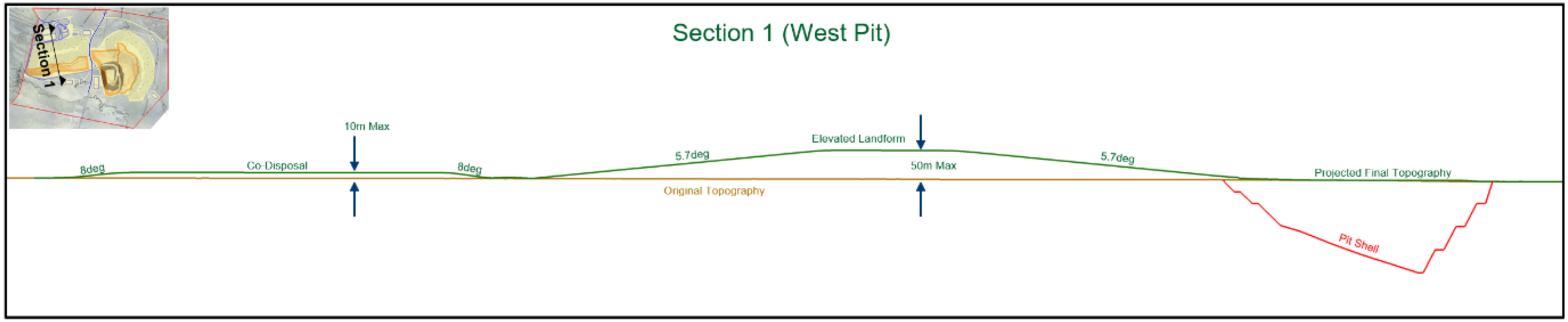


Figure 47 Final Landform - oblique view looking northwest



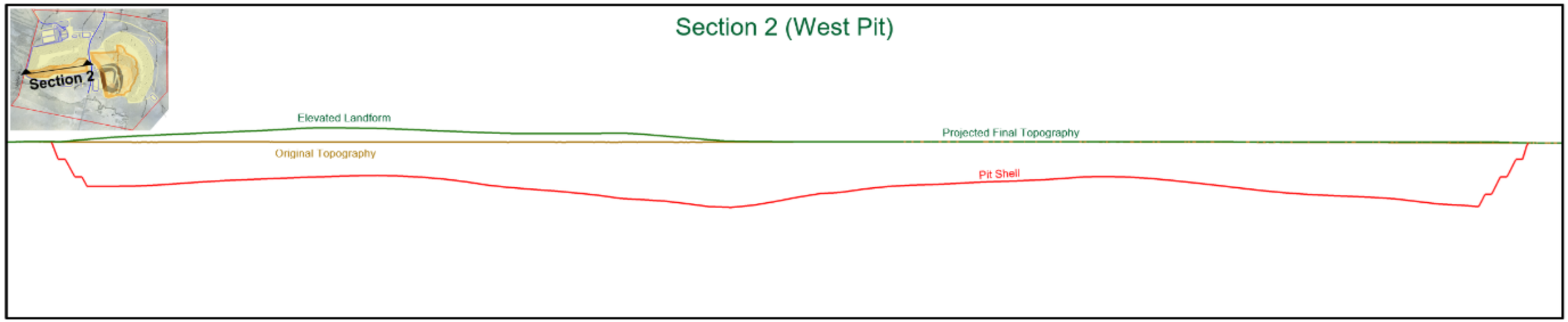
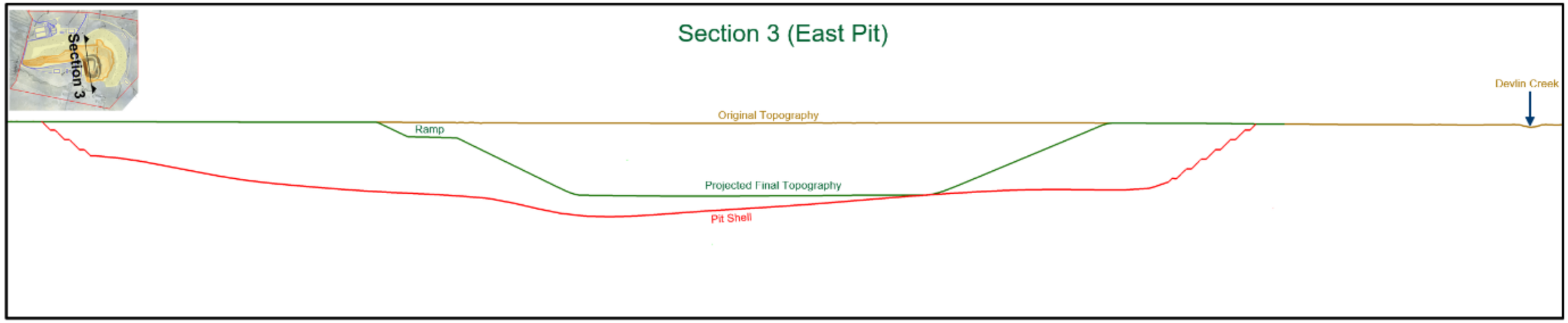


Figure 48 Cross Sections through West Pit



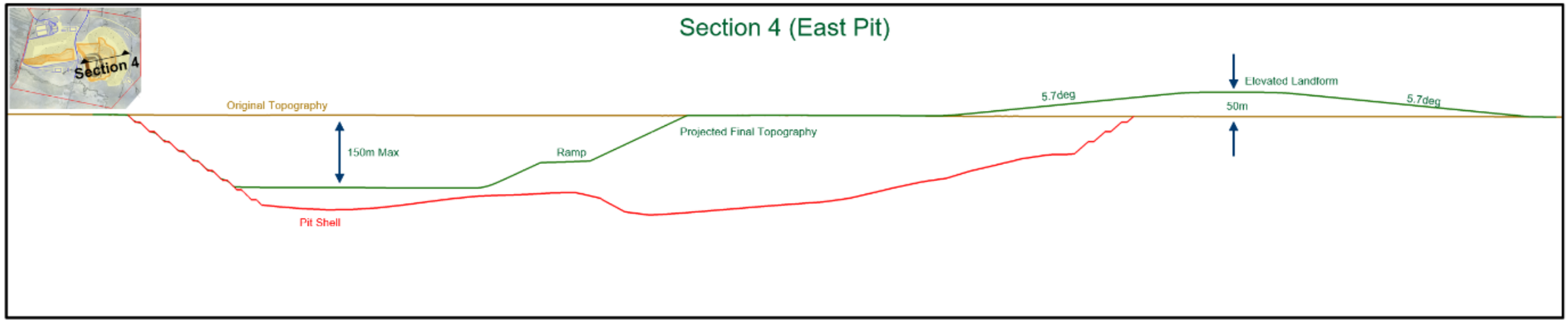


Figure 49 Cross Sections through East Pit

4.1.2 Rehabilitation Areas/Improvement Areas, PMLU/NUMA & Relevant Rehabilitation/Management Milestones

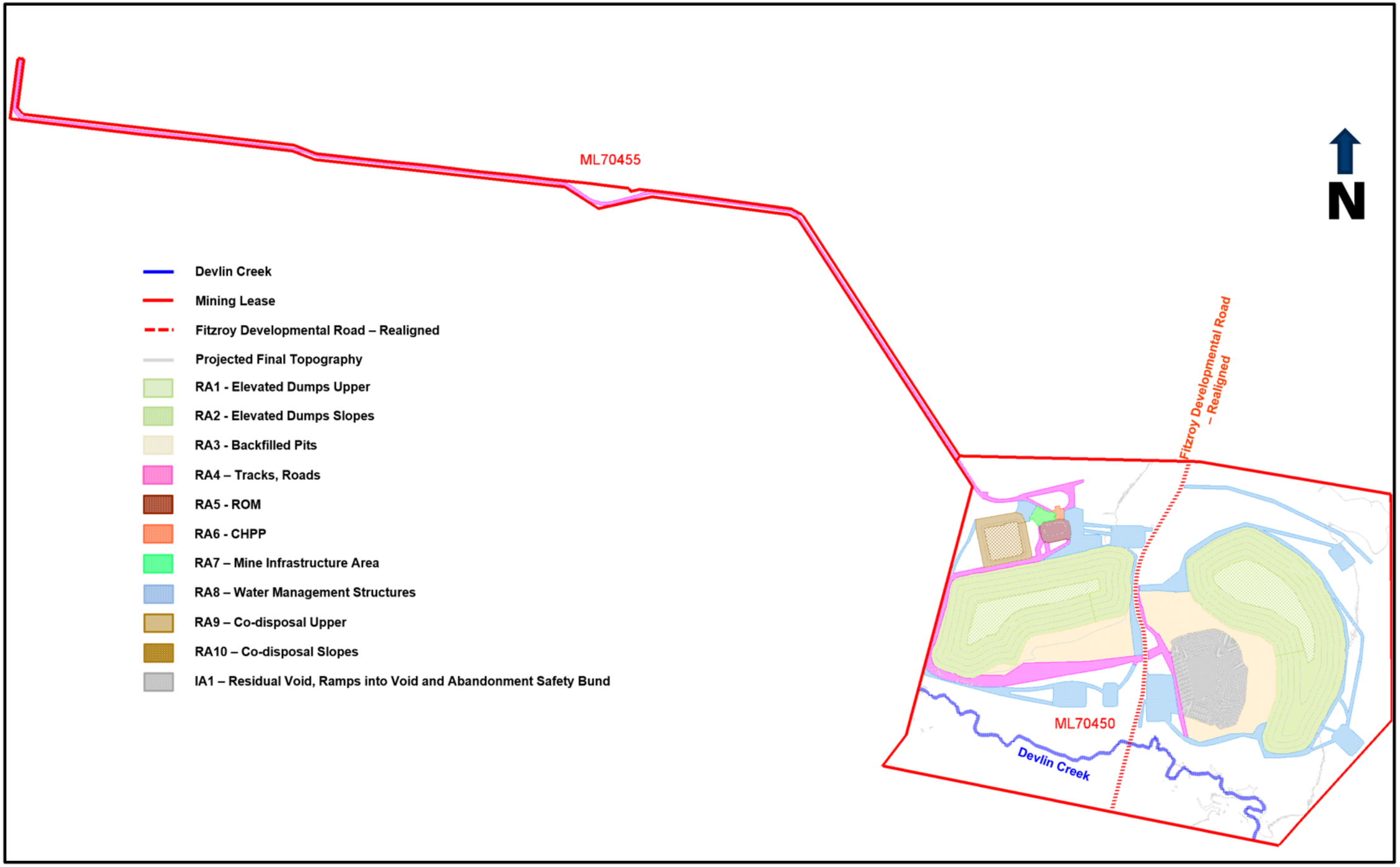


Figure 50 Rehabilitation Areas & Improvement Areas

Table 50 Rehabilitation Areas & Milestones

Rehabilitation Area	PMLU/NUMA	Rehabilitation/Management Milestone
RA1 -Elevated Dumps - Upper	Native Bushland	RM2, RM4, RM6, RM8, RM10 & RM11
RA2- Elevated Dumps - Slopes	Native Bushland	RM2, RM4, RM6, RM8, RM10 & RM11
RA3 - Backfilled Pits	Native Bushland	RM2, RM4, RM6, RM8, RM10 & RM11
RA4 – Tracks, Roads	Grazing	RM1, RM2, RM4, RM5, RM7 & RM9
RA5 - ROM	Grazing	RM1, RM2, RM4, RM5, RM7 & RM9
RA6 - CHPP	Grazing	RM1, RM2, RM4, RM5, RM7 & RM9
RA7 - Mine Infrastructure Area	Grazing	RM1, RM2, RM4, RM5, RM7 & RM9
RA8 - Water Management Structures	Grazing	RM1, RM2, RM4, RM5, RM7 & RM9
RA9 - Co-disposal - Upper	Native Bushland	RM1, RM2, RM3, RM4, RM6, RM8, RM10 & RM11
RA10 - Co-disposal - Slopes	Native Bushland	RM1, RM2, RM3, RM4, RM6, RM8, RM10 & RM11
IA1 – Residual Void, Ramps into Voids and Abandonment safety bund	NUMA	MM1 MM2 MM3

4.1.3 PMLU Rehabilitation Milestones and Criteria

Table 51 Rehabilitation Milestones and Criteria

Milestone reference	Rehabilitation milestone	Milestone criteria
RM1	Infrastructure decommissioning and removal	(a) All services disconnected. Underground services remain buried and surface points sealed. (b) All buildings either demolished and removed or relocated off the mining leases. (c) Concrete slabs and footings removed or buried within overburden dump final rehabilitation areas. (d) Sumps or dams that do not form part of final landform as sediment control structures dewatered and where applicable contaminated silt removed for licensed disposal. (e) Sealed asphalt roads, car parks and hardstand areas will have the asphalt removed for reuse off the mining leases or removed for licenced disposal. Any contamination removed from unsealed roads, car parks and hardstands for licenced disposal. (f) Hydrocarbon and chemical storage areas removed and/or remediated by on-site treatment, if required. (g) All carbonaceous material collected from haul roads and disposed in the co-disposal area or buried within the overburden dump final rehabilitation areas. (h) A contaminated land survey carried out by an AQP[1] confirms that no contamination unsuitable for the post-mining land use is occurring.
RM2	Landform design, reshaping and final contouring, inclusive of drainage features	(a) Landform constructed satisfies the following criteria for each rehabilitation area— (i) RA1 and RA2: • outer batter slope gradient is ≤5.7° • crest of landforms slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 50m (ii) RA3: • flat to undulating slope gradient is ≤4.6° • crest of landforms slope gradient is ≤2.3° (iii) RA5, RA9 and RA10: • outer batter slope gradient is ≤8° • crest of landform slope gradient is ≤2.3° • maximum vertical height of landforms is no more than 18m (iv) RA4, RA6, RA7 and RA8 : • Flat to undulating with slopes ≤2.3° (b) Certification by an AQP[1] that contour drains and rock lined drop structures installed as per appropriate design criteria. (c) The lined co-disposal facility has been signed off by an AQP[1] as constructed to design. (d) Potentially acid forming or carbonaceous waste encapsulated in the centre of landforms.

RM3	Install cover system/cap	Cover installed (minimum 1m inert unweathered overburden)
RM4	Surface preparation (e.g. topsoil, fertiliser, amelioration agents, mulch or woody debris)	(a) Topsoil spread to a minimum depth of 150mm. (b) An assessment of soil/growth medium health and suitability has been completed by an AQP[1] to confirm soil/growth medium is suitable for target vegetation establishment. (c) Gypsum and fertiliser applied at rates determined by an AQP[1]. (d) Cultivation and keying of topsoil to subsoil with suitable multi-type ripper and performed parallel to slope contours. (e) Where appropriate, addition of rock and/or log cover to assist erosion resistance of eventual vegetative ground cover.
RM5	Revegetation (grazing)	Completed seeding of target pasture species at rate and species composition in accordance with Table 42 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.
RM6	Revegetation and habitat development (native bushland)	Completed revegetation of target native bushland species by tube stock and/or direct seeding at rate and species composition in accordance with Table 43 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.
RM7	Achievement of surface requirements (grazing)	(a) Species density and diversity achieved is consistent with the sown seed mix and reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (b) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and of >50% for areas of high rock and log content. (c) No new invasive plants2 and infestation density of invasive plants within the area are contained or reduced and consistent with reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (d) Water control structures are either removed or free of active erosion and integrated into permanent landforms. (e) No active[3] erosion gullies. Erosion rates are less than 5 tonnes/ha/year. A NEPM[4] assessment confirms areas are free of hazardous materials or have been rendered safe.
RM8	Achievement of surface requirements (native bushland)	(a) 80% of the area achieves species density and diversity that is greater than 60% of the reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (b) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and >50% for areas of high rock and log content. (c) No new invasive plants[2] and infestation density of invasive plants in the area are contained or reduced and consistent with reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (d) Evidence of fauna habitat features for invertebrate and vertebrate species (e.g. logs, rock piles, nest boxes, bird nests or perches). (e) Water control structures are either removed or free of active erosion and integrated into permanent landforms. (f) No active[3] erosion gullies. Erosion rates are less than 5tonnes/ha/year. (g) A NEPM[4] assessment confirms areas are free of hazardous materials or have been rendered safe. (h) Certification from an AQP[1] that the cover system is functioning as designed.
RM9	Achievement of a stable condition for the land described as a post-mining land use of grazing	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and the landform meets criteria in RM2 (ii) erosionally stable: no active3 erosion is present and groundcover established meets criteria in RM7 (b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) The rehabilitated land meets Class 4 land suitability for grazing according to the Guidelines for agricultural land evaluation in Queensland (2nd edn) (DSITI & DNRM, 2015)[5]. (e) Species density and diversity achieved is consistent with the sown seed mix and reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022. (f) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs and of >50% for areas of high rock and log content.
RM10	Achievement of a stable condition for the land described as	(a) Rehabilitation has been certified by an AQP[1] to be: (i) structurally stable: the factor of safety value is ≥1.5 and landform meets the criteria in RM2 (ii) erosionally stable: no active[3] erosion is present, and groundcover established and meets criteria in RM8

	a post-mining land use of native bushland	(b) The quality of surface water runoff from all rehabilitation areas has demonstrated no potential impacts to any surface water values as it complies with the trigger values for aquatic ecosystem values defined in Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River), dated September 2011 or a later version. (c) Groundwater quality of each aquifer has demonstrated no potential impacts to any groundwater values by meeting pre-mining baseline values for pH, etc. as detailed in Appendix F of the Codrilla Project Environmental Impact Statement, 'Codrilla Coal Project Groundwater Impact Assessment', dated July 2010. (d) Native bushland established that provides habitat opportunities for native invertebrate and vertebrate species: (i) 80% of the area has a vegetative groundcover of >70% for areas of low rock and logs, and >50% for areas of high rock and log content (ii) 80% of the area achieves species density and diversity that is greater than 60% of the reference sites as selected according to section 3.7.1.4 of the PRC plan, version 3, dated 14 February 2022 (iii) minimum 14 target vegetation species[6] comprising: grasses and forbs ≥3 mid-storey species ≥7 canopy species ≥4 (iv) evidence of key invertebrate groups (e.g. ants) and soil faunal communities (v) evidence of key native vertebrate groups (e.g. bird, mammal, reptile and amphibian) in the form of fauna spotting, scats and tracks
RM11	Install fencing or other infrastructure to support the PMLU	Fencing / bunding installed sufficient to exclude stock

4.1.4 NUMA Improvement Availability and Milestones

Table 52 Management Milestones and Criteria

Milestone reference	Management milestone	Milestone criteria
MM1	Highwall treatment	Highwall crest battered back where required to achieve a stable slope angle as specified by an AQP[1] (geotechnical engineer)
MM2	Achievement of landform design and surface requirements	(a) Highwall as mined weathered average slope angle of 1V and 0.7H (55°) and low wall as backfilled at angle of repose at 1V to 1.35H (36°). (b) Abandonment safety bund setback distance is in accordance with calculated geotechnical factor of safety determined at MM1. (c) Abandonment safety bund constructed of competent rock and to geometry specified (height = 2m, width top = 2m, batters = 1V:3H, width base = 14m) to prevent traversing by vehicles. (d) Maximum depth of residual void is 150m below ground level. (e) The residual void is located outside of the probable maximum flood levels. (f) Abandonment safety bund and ramp into void is revegetated with pasture seed in accordance with Table 42 in section 3.5.1.9 of the PRC plan, version 3, dated 14 February 2022.
MM3	Achievement of sufficient improvement not to cause environmental harm and that will be safe and structurally stable	a(a) Access to highwall, low wall and ramp batter is restricted by physical barriers. Fencing erected on the outside of the abandonment safety bund to specification (five strand barbed stock fencing). (b) Safety signage designed in accordance with Australian Standard is erected at 100m intervals along the fence line. (c) Certification from an AQP[1] that the residual void will not cause environmental harm outside of the relevant tenure boundary. (d) Residual void acts as a groundwater sink to the receiving environment into perpetuity. (e) Certification from an AQP[1] that the residual void is safe to humans and livestock. (f) Certification from an AQP[1] that the water level and quality in the final void will not cause environmental harm to the surrounding environment.

4.2 Attachment - Codrilla EA EPML00916813

4.3 Attachment - EIS Assessment Report for the Codrilla Coal Mine Project

4.4 Attachment – Supplementary EIS Groundwater Report (AGE Consultants – April 2011)

4.5 Attachment - EIS Soil, Overburden and Land Use Report (GSSE – Sept 2010)

4.6 Attachment - Supplementary EIS Surface Water Report (WRM - 10 June 2011)

4.7 Attachment - Updated Feasibility Level Geotechnical Study for Codrilla (IMC – 23 March 2012)

4.8 Attachment - Millennium Mine Residual Void Slope Stability Study (GCS - August 2017)

Permit

Environmental Protection Act 1994

Environmental authority EPML00916813

This environmental authority is issued by the administering authority under Chapter 5 of the Environmental Protection Act 1994.

Environmental authority number: EPML00916813

Environmental authority takes effect on 06 April 2016

Environmental authority holder(s)

Name(s)	Registered address
KC RESOURCES PTY. LTD.	Suite 3B Level 33 52 Martin Place SYDNEY NSW 2000
CITIC AUSTRALIA COPPABELLA PTY LTD	Level 7, CITIC House 99 King Street MELBOURNE VIC 3000
NS COAL PTY LTD	Level 2, Navision House 10 Market Street BRISBANE CITY QLD 4000
PEABODY COPPABELLA PTY LTD	Level 5 100 Melbourne Street SOUTH BRISBANE QLD 4101
WINCHESTER COAL OPERATIONS PTY LTD	Commonwealth Bank Building Level 25 240 Queen St BRISBANE CITY QLD 4000 Australia

Environmentally relevant activity and location details

Environmentally relevant activity/activities	Location(s)
Schedule 3 13: Mining black coal	ML70455
Ancillary 63 - Sewage Treatment 1: Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (b-i) more than 100 but not more than 1500EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme	ML70450

Queensland Government

Environmentally relevant activity/activities	Location(s)
Ancillary 08 - Chemical Storage 3: Storing more than 500 cubic metres of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3 under subsection (1)(c)	ML70455
Ancillary 08 - Chemical Storage 3: Storing more than 500 cubic metres of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3 under subsection (1)(c)	ML70450
Schedule 3 13: Mining black coal	ML70450
Ancillary 63 - Sewage Treatment 1: Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (b-i) more than 100 but not more than 1500EP if treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme	ML70455

Additional information for applicants

Environmentally relevant activities

The description of any environmentally relevant activity (ERA) for which an environmental authority (EA) is issued is a restatement of the ERA as defined by legislation at the time the EA is issued. Where there is any inconsistency between that description of an ERA and the conditions stated by an EA as to the scale, intensity or manner of carrying out an ERA, the conditions prevail to the extent of the inconsistency.

An EA authorises the carrying out of an ERA and does not authorise any environmental harm unless a condition stated by the EA specifically authorises environmental harm.

A person carrying out an ERA must also be a registered suitable operator under the *Environmental Protection Act 1994* (EP Act).

Contaminated land

It is a requirement of the EP Act that an owner or occupier of contaminated land give written notice to the administering authority if they become aware of the following:

- the happening of an event involving a hazardous contaminant on the contaminated land (notice must be given within 24 hours); or
- a change in the condition of the contaminated land (notice must be given within 24 hours); or
- a notifiable activity (as defined in Schedule 3) having been carried out, or is being carried out, on the contaminated land (notice must be given within 20 business days);

that is causing, or is reasonably likely to cause, serious or material environmental harm.

For further information, including the form for giving written notice, refer to the Queensland Government website

www.qld.gov.au, using the search term 'duty to notify'.

Take effect

Please note that, in accordance with section 200 of the EP Act, an EA has effect:

a) if the authority is for a prescribed ERA and it states that it takes effect on the day nominated by the holder of the authority in a written notice given to the administering authority-on the nominated day; or

b) if the authority states a day or an event for it to take effect-on the stated day or when the stated event happens; or

c) otherwise-on the day the authority is issued.

However, if the EA is authorising an activity that requires an additional authorisation (a relevant tenure for a resource activity, a development permit under the *Sustainable Planning Act 2009* or an SDA Approval under the *State Development and Public Works Organisation Act 1971*), this EA will not take effect until the additional authorisation has taken effect.

If this EA takes effect when the additional authorisation takes effect, you must provide the administering authority written notice within 5 business days of receiving notification of the related additional authorisation taking effect.

If you have incorrectly claimed that an additional authorisation is not required, carrying out the ERA without the additional authorisation is not legal and could result in your prosecution for providing false or misleading information or operating without a valid environmental authority.

Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

Date issued: 18 January 2021

Enquiries:
Coal & Gemstone Mining
Department of Environment and Science

Phone: 07 4987 9320
Email: crmining@des.qld.gov.au

Obligations under the *Environmental Protection Act 1994*

In addition to the requirements found in the conditions of this environmental authority, the holder must also meet their obligations under the EP Act, and the regulations made under the EP Act. For example, the holder must comply with the following provisions of the Act:

- general environmental duty (section 319)
- duty to notify environmental harm (section 320-320G)
- offence of causing serious or material environmental harm (sections 437-439)
- offence of causing environmental nuisance (section 440)
- offence of depositing prescribed water contaminants in waters and related matters (section 440ZG)
- offence to place contaminant where environmental harm or nuisance may be caused (section 443)

Obligations under the *Environmental Protection Act 1994*

In addition to the requirements found in the conditions of this environmental authority, the holder must also meet their obligations under the EP Act, and the regulations made under the EP Act. For example, the holder must comply with the following provisions of the Act:

- general environmental duty (section 319)
- duty to notify environmental harm (section 320-320G)
- offence of causing serious or material environmental harm (sections 437-439)
- offence of causing environmental nuisance (section 440)
- offence of depositing prescribed water contaminants in waters and related matters (section 440ZG)
- offence to place contaminant where environmental harm or nuisance may be caused (section 443)

Conditions of environmental authority

The environmentally relevant activity(ies) conducted at the location as described above must be conducted in accordance with the following site specific conditions of approval.

Agency interest: General	
Condition number	**Condition**
A1	**Financial assurance** Provide financial assurance in the amount and form required by the administering authority prior to the commencement of activities proposed under this environmental authority. *NOTE: The calculation of financial assurance for condition **A1** must be in accordance with the most recent version of the administering authority's Financial Assurance Guideline and may include a performance discount. The amount is defined as the maximum total rehabilitation cost for complete rehabilitation of all disturbed areas, which may vary on an annual basis due to progressive rehabilitation. The amount required for the financial assurance must be the highest total rehabilitation cost calculated for any year of the Plan of Operations and calculated using the formula: (Financial Assurance = Highest total annual rehabilitation cost x Percentage required).*
A2	The financial assurance is to remain in force until the administering authority is satisfied that no claim on the assurance is likely. *NOTE: Where progressive rehabilitation is completed and acceptable to the administering authority, progressive reductions to the amount of financial assurance will be applicable where rehabilitation has been completed in accordance with the acceptance criteria defined within this environmental authority.*

A3	**Prevent and /or minimise likelihood of environmental harm** In carrying out the environmentally relevant activities, the holder of this environmental authority must take all reasonable and practicable measures to prevent and / or to minimise the likelihood of environmental harm being caused. Any environmentally relevant activity, that, if carried out incompetently, or negligently, may cause environmental harm, in a manner that could have been prevented, shall be carried out in a proper manner in accordance with the conditions of this authority.
A4	**Maintenance of measures, plant and equipment** The environmental authority holder must ensure: a) that all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority are installed; b) that such measures, plant and equipment are maintained in a proper condition; and c) that such measures, plant and equipment are operated in a proper manner.
A5	**Monitoring and records** Record, compile and keep for a minimum of (five) 5 years all monitoring results required by this environmental authority and make available for inspection all or any of these records upon request by the administering authority.
A6	Where monitoring is a requirement of this environmental authority, ensure that a competent person(s) conducts all monitoring.
A7	**Storage and handling of flammable and combustible liquids** Spillage of all flammable and combustible liquids must be contained within an on-site containment system and controlled in a manner that prevents environmental harm (other than trivial harm) and maintained in accordance with Section 5.8 of *AS 1940 – Storage and Handling of Flammable and Combustible Liquids of 2004.*
A8	**Notification of emergencies, incidents and exceptions** All reasonable actions are to be taken to minimise environmental harm, or potential environmental harm, resulting from any emergency, incident or circumstances not in accordance with the conditions of this environmental authority.
A9	As soon as practicable after becoming aware of any emergency, incident or information about circumstances which results or may result in environmental harm not in accordance with the conditions of this environmental authority, the administering authority must be notified in writing.

A10	Not more than fourteen (14) days following the initial notification of an emergency, incident or information about circumstances which result or may result in environmental harm, written advice must be provided to the administering authority in relation to: a) proposed actions to prevent a recurrence of the emergency or incident; b) the outcomes of actions taken at the time to prevent or minimise environmental harm; and c) proposed actions to respond to the information about circumstances which result or may result in environmental harm.
A11	As soon as practicable, but not more than six (6) weeks following the initial notification of an emergency, incident or information about circumstances which result or may result in environmental harm, conduct of any environmental monitoring performed in relation to the emergency or incident, which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with the conditions of this environmental authority, written advice must be provided of the results of any such monitoring performed to the administering authority.
A12	**Risk management** The environmental authority holder must maintain and implement a risk management system for mining activities which conforms to the *Australian Standard for Risk Management (AS/NZ 4360:2004).*
A13	The environmental authority holder must not implement a risk management system that contravenes or prevents the implementation of any condition of this environmental authority.
A14	An emergency response/contingency plan must be developed and implemented within the current plan of operations to manage the high risk categories identified in the risk management system.
A15	**Activity** All land subject to mining activities must be rehabilitated to a non polluting, safe, stable and self sustaining landform.
A16	Contaminants must not be released to the receiving environment unless they are in accordance with the contaminant limits authorised by this environmental authority.
A17	This environmental authority does not authorise environmental harm unless a condition contained within the authority explicitly authorises that harm. Where there is no condition or the authority is silent on a matter, the lack of a condition or silence shall not be construed as authorising harm.
A18	**Definitions** Words and phrases used throughout this environmental authority are defined in the Definitions section of this authority. Where a definition for a term used in this environmental authority is sought and the term is not defined within this environmental authority, the definitions in the *Environmental Protection Act 1994,* its regulations and policies must be used.

Agency interest: Air	
Condition number	**Condition**
B1	**Dust nuisance** The release of dust and/or particulate matter resulting from the mining activity must not cause an environmental nuisance at any nuisance sensitive or commercial place.
B2	Dust and particulate matter must not exceed any of the following levels when measured at any nuisance sensitive or commercial place: a) a level of deposited dust of 120 milligrams per square metre per day based on a monthly average; b) a concentration of total particulate matter suspended in the atmosphere of 90 micrograms per cubic metre over a one (1) year averaging time; c) a concentration of particulate matter with aerodynamic diameter of less than 10 micrometres (PM_{10}) of 50 micrograms per cubic metres over a 24-hour averaging time with not more than 5 exceedances recorded over twelve (12) months at any sensitive place (5 days exceedances per year are for the natural events such as bushfires and dust storm); d) a concentration of particulate matter with aerodynamic diameter of less than 2.5 micrometres ($PM_{2.5}$) of 25 micrograms per cubic metres over a 24-hour averaging time; and e) a concentration of particulate matter with aerodynamic diameter of less than 2.5 micrometres ($PM_{2.5}$) of 8 micrograms per cubic metres over a one (1) year averaging time.

B3	**Ambient dust monitoring program** Within six (6) months of commencing mining operations, the holder must develop and submit for the approval to the administering authority, an Ambient Dust Monitoring Program (as outlined in **Table B1 (Air Quality Monitoring Details)** to specify how the ambient dust impacts of the project will be monitored. The Program shall include, but not necessarily be limited to: a) procedures for monitoring dust emissions from the project, in accordance with the requirements of this approval; b) locations, frequencies and methods for monitoring PM_{10}, $PM_{2.5}$ and deposited particulate matter; c) provision for the use of at least two (2) Tapered Element Oscillating Microbalance Samplers (TEOMS), five dust depositional gauges and a meteorological station capable of monitoring wind direction and speed; d) investigation of the use of TEOMS as part of the integrated air quality monitoring network. Should an alternative sampling method is required; the holder may seek approval from administering authority to exclude this requirement. In seeking such exclusion, the reasons for the exclusion shall be provided and be fully justified; e) the holder shall utilise real-time monitoring data to inform environmental management decisions associated with the project; f) framework for identifying actual and potential dust impacts, and for applying pro-active and reactive mitigation and management measures to address those impacts; g) provision for independent review and auditing of the Program; and h) mechanisms for updating. NOTE: *A definition of 'Mining Operations' is provided in this Environmental Authority.*
B4	Ongoing monitoring must commence prior to the commencement of mining operations and be conducted in accordance with the standards, and at the locations, specified in **Table B1 (Air Quality Monitoring Details)**.

Table B1 (Air Quality Monitoring Details)

Air Quality Determination	Monitoring Standard	Monitoring Point Description	Approximate Monitoring Point Location	
			Easting GDA94 (MGA Zone 55)	Northing GDA94 (MGA Zone 55)
PM_{10} and $PM_{2.5}$	AS 3580.9.8:2008: Methods for sampling and analysis of	AQM1: Relocated Valkyrie School and residence site	665,444	7,559,041

	ambient air - Determination of suspended particulate matter - PM10 continuous direct mass method using a tapered element oscillating microbalance (TEOM) analyser	AQM2: Regalo Homestead	668,476	7,556,755
Dust deposition	AS 3580.10.1:2003: Methods for sampling and analysis of ambient air - Determination of particulate matter - Deposited matter - Gravimetric method	DG1: Regalo Homestead	669,479	7,557,408
		DG2: Lillianvale property	664,190	7,552,030
		DG3: Western boundary of the Codrilla A ML	658,723	7,555,111
		DG4: Northern boundary of the Codrilla A ML	663,022	7,559,627
		DG5: Adjacent to the Codrilla to Moorvale Haul Road	650,105	7,563,596
Meteorological data[1]	AS 2923:1987: Ambient air - Guide for measurement of horizontal wind for air quality applications	MS1: Regalo Homestead	669,479	7,557,408

Note: [1] Wind speed and direction, humidity, temperature and precipitation.

B5	Where monitoring at locations identified in **Table B1 (Air Quality Monitoring Details)** indicates that the air quality objectives detailed in condition **B2** have been exceeded, the holder of this environmental authority (the holder) must investigate the matter and report to the administering authority within fourteen (14) days: a) the concentration of PM10 particulates or dust deposition rate recorded; b) a description of meteorological conditions occurring at the time; and c) the measures taken to reduce dust generated by the mining activities.
B6	When requested by the administering authority or as a result of a complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer), an additional dust and particulate monitoring (including dust deposition, total suspended particles (TSP), PM10 and PM2.5) must be undertaken, and the results thereof notified to the administering authority within fourteen (14) days following completion of monitoring. This includes providing interim reports if the monitoring lasts for more than one month. Monitoring must be carried out at a place(s) relevant to the potentially affected dust sensitive place. Monitoring must be conducted in accordance with the appropriate standards.

B7	If monitoring conducted as a result of a complaint indicates an exceedance of the guidelines detailed in condition **B2**, the holder must: a) address the complaint through the use of appropriate dispute resolution if required; and b) immediately implement dust abatement measures until compliance is achieved.
B8	The results of PM10, dust deposition and meteorological monitoring must be reported to the administering authority on request. If requested by the administering authority, the results of PM10, dust deposition and meteorological monitoring will be made available for use in any air quality monitoring network in the region operated independently of mining operations.
B9	**Odour nuisance** The release of noxious or offensive odour(s) or any other noxious or offensive airborne contaminant(s) resulting from the mining activity must not cause an environmental nuisance at any nuisance sensitive or commercial place.
B10	When requested by the administering authority, odour monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive or commercial place, and the results must be notified within fourteen (14) days to the administering authority following completion of monitoring**.**
B11	If the administering authority determines the odour released to constitute an environmental nuisance, then the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; and b) immediately implement odour abatement measures so that emissions of odour from the activity do not result in further environmental nuisance.
B12	**General dust control** The holder must design, construct, commission, operate and maintain the project in a manner that minimises or prevents the emission of dust from the site including wind blown and traffic generated dust.

B13	For the purpose of avoiding any release of dust or particulate matter from the approved place which could cause an environmental nuisance, the following measures must be taken: a) stockpiles must be maintained using all reasonable and practicable measures to minimise the release of wind-blown dust or particulate matter to the atmosphere. Reasonable and practicable measures may include, but are not limited to, anemometer switching systems which trigger operation of effective water spray systems during winds likely to generate such releases; use of approved dust suppressants; shielding and storage in bunkers; b) trafficable areas must be maintained using all reasonable and practicable measures to minimise the release of windblown dust or traffic generated dust to the atmosphere. Reasonable and practicable measures may include, but are not limited to, sealing with bitumen or other suitable material; keeping surfaces clean; use of water sprays; adoption and adherence to speed limits (e.g. less than 50 kph for unsealed road); use of approved dust suppressants; and wind breaks; c) raw material preparation plants and external transfer conveyors must be operated and maintained using all reasonable and practicable measures to minimise the release of wind blown dust or particulate matter to the atmosphere. Reasonable and practicable measures may include, but are not limited to, transfer of materials in a moist state; enclosure or sealing of conveyors; use of water sprays at transfer points; shielding; and wind breaks; and d) Water sprays must be installed at all major dust emission sources.
B14	**Meteorological monitoring** The environmental authority holder must establish a permanent meteorological station to continuously measure and record wind, temperature and rainfall prior to commencing mining operations. Measurements will be in accordance with *AS2923-1987 Ambient air – Guide for measurement of horizontal wind for air quality applications*

B15	**Dust Management Plan** The holder of this environmental authority shall prepare and implement a Dust Management Plan prior to commencing mining operations to outline measures to minimise and manage any impacts from the operation of the project on local air quality. The Dust Management Plan must be referred to in the Environmental Management Plan. The Plan shall include, but not necessarily be limited to: a) identification of all major sources of dust emissions that may occur as result of the operation of the project; b) description of the procedures to manage the dust emissions from the sources identified; c) collection of air quality and meteorological data at location and using the methods described in **Table B1 (Air Quality Monitoring Details)**; d) identifying adverse meteorological conditions likely to produce elevated levels of PM10 at a sensitive or commercial place due to the mining activities; e) integration of dust control strategy with weather forecasts to activate the timely management of dust control in addition to the best practice dust control measures during the adverse meteorological conditions; f) protocols for regular maintenance of plant and equipment, to minimise the potential for fugitive dust emissions; and g) description of procedures to be undertaken if any non-compliance is detected.

Agency interest: Water	
Condition number	**Condition**
C1	**Contaminant release** Contaminants that will, or have the potential to cause environmental harm must not be released directly or indirectly to any waters as a result of the authorised mining activities, except as permitted under the conditions of this environmental authority.
C2	Unless otherwise permitted under the conditions of this environmental authority, the release of mine affected water to waters must only occur from the release points specified in **Table C1 (Mine Affected Water Release Points, Sources and Receiving Waters)**.
C3	The release of mine affected water to internal water management infrastructure that is installed and operated in accordance with a water management plan that complies with conditions **C32** to **C37** inclusive is permitted.

C4	The release of mine affected water to waters in accordance with condition **C2** must not exceed the release limits stated in **Table C2 (Mine Affected Water Release Limits)** when measured at the monitoring points specified in **Table C1 (Mine Affected Water Release Points, Sources and Receiving Waters)** for each quality characteristic.

Table C1 (Mine Affected Water Release Points, Sources and Receiving Waters)

Release Point (RP)	Easting GDA94 (MGA Zone 55)	Northing GDA94 (MGA Zone 55)	Mine Affected Water Source and Location	Monitoring Point	Receiving waters description
RP 1	To be provided[1]	To be provided[1]	To be provided[1]	To be provided[1]	Devlin Creek
RP 2	To be provided[1]	To be provided[1]	To be provided[1]	To be provided[1]	Devlin Creek

[1] Mine affected water release points, monitoring points, and receiving waters descriptions to be submitted to the administering authority for approval prior to construction of associated storages.

Table C2 (Mine Affected Water Release Limits)

Quality Characteristic	Release Limits	Monitoring frequency	Comment
Electrical conductivity (uS/cm)	To be provided[1]	Daily during release (the first sample must be taken within 2 hours of commencement of release)	
pH (pH Unit)	6.5 (minimum) 9.0 (maximum)	Daily during release (the first sample must be taken within 2 hours of commencement of release)	
Turbidity (NTU)	To be provided[1]	Daily during release* (first sample within 2 hours of commencement of release)	
Suspended Solids (mg/L)	To be provided[1]	Daily during release* (first sample within 2 hours of commencement of release)	
Sulphate (SO_4^{2-}) (mg/L)	To be provided[1]	Daily during release* (first sample within 2 hours of commencement of release)	

[1] Mine affected water release limits to be submitted to the administering authority for approval prior to construction of associated storages.

C5	The release of mine affected water to waters from the release points must be monitored at the locations specified in **Table C1 (Mine Affected Water Release Points, Sources and Receiving Waters)** for each quality characteristics and at the frequency specified in **Table C2 (Mine Affected Water Release Limits)** and **Table C3 (Release Contaminant Trigger Investigation Levels - Potential Contaminants)**. *NOTE: the administering authority will take into consideration any extenuating circumstances prior to determining an appropriate enforcement response in the event condition **C5** is contravened due to a temporary lack of safe or practical access. The administering authority expects the environmental authority holder to take all reasonable and practicable measures to maintain safe and practical access to designated monitoring locations.*
C6	If quality characteristics of the release exceed any of the trigger levels specified in **Table C3 (Release Contaminant Trigger Investigation Levels - Potential Contaminants)** during a release event, the environmental authority holder must compare the down stream results in the receiving waters to the trigger values specified in **Table C3 (Release Contaminant Trigger Investigation Levels - Potential Contaminants)** and: a) where the trigger values are not exceeded then no action is to be taken; or b) where the downstream results exceed the trigger values specified **Table C3 (Release Contaminant Trigger Investigation Levels - Potential Contaminants)** for any quality characteristic, compare the results of the downstream site to the data from background monitoring sites and; i) if the result is less than the background monitoring site data, then no action is to be taken; or ii) if the result is greater than the background monitoring site data, complete an investigation into the potential for environmental harm and provide a written report to the administering authority in the next annual return, outlining: 1) details of the investigations carried out; and 2) actions taken to prevent environmental harm. *NOTE: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with **C6 2(b)** of this condition, no further reporting is required for subsequent trigger events for that quality characteristic.*
C7	If an exceedance in accordance with condition **C6 2(b)** is identified, the holder of the authority must notify the administering authority within fourteen (14) days of receiving the result.
C8	**Mine affected water release events** The holder must ensure a stream flow gauging station/s is installed, operated and maintained prior to commencing mining operations, to determine and record stream flows at the locations and flow recording frequency specified in **Table C4 (Mine Affected Water Release during Flow Events)**.

C9	Notwithstanding any other condition of this environmental authority, the release of mine affected water to waters in accordance with condition **C2** must only take place during periods of natural flow events in accordance with the receiving water flow criteria for discharge specified in **Table C4 (Mine Affected Water Release during Flow Events)** for the release point(s) specified in **Table C1 (Mine Affected Water Release Points, Sources and Receiving Waters)**.
C10	The release of mine affected water to waters in accordance with condition **C2** must not exceed the Electrical Conductivity and Sulphate release limits or the Maximum Release Rate (for all combined release point flows) for each receiving water flow criteria for discharge specified in **Table C4 (Mine Affected Water Release during Flow Events)** when measured at the monitoring points specified in **Table C1 (Mine Affected Water Release Points, Sources and Receiving Waters)**.
C11	The daily quantity of mine affected water released from each release point must be measured and recorded at the monitoring points in Table C1 (Mine Affected Water Release Points, Sources and Receiving Waters).
C12	Releases to waters must be undertaken so as not to cause erosion of the bed and banks of the receiving waters, or cause a material build up of sediment in such waters.
C13	Notification of release event The environmental authority holder must notify the administering authority as soon as practicable and no later than 24 hours after commencing to release mine affected water to the receiving environment. Notification must include the submission of written advice to the administering authority of the following information: a) release commencement date/time; b) expected release cessation date/time; c) release point/s; d) release volume (estimated); e) receiving water/s including the natural flow rate; and f) any details (including available data) regarding likely impacts on the receiving water(s). NOTE: *Notification to the administering authority must be addressed to the Manager and Project Manager of the local Administering Authority via email or facsimile*.

Table C3 (Release Contaminant Trigger Investigation Levels - Potential Contaminants)

Quality Characteristic	Trigger Levels (µg/L)	Comment on Trigger Level	Monitoring Frequency
Aluminium	55	*For aquatic ecosystem protection, based on SMD guideline*	Commencement of release and thereafter weekly during release
Arsenic	13	*For aquatic ecosystem protection, based on SMD guideline*	
Cadmium	0.2	*For aquatic ecosystem protection, based on SMD guideline*	
Chromium	1	*For aquatic ecosystem protection, based on SMD guideline*	
Copper	2	*For aquatic ecosystem protection, based on LOR for ICPMS*	
Iron	300	*For aquatic ecosystem protection, based on low reliability guideline*	
Lead	4	*For aquatic ecosystem protection, based on SMD guideline*	
Mercury	0.2	*For aquatic ecosystem protection, based on LOR for CV FIMS*	
Nickel	11	*For aquatic ecosystem protection, based on SMD guideline*	
Zinc	8	*For aquatic ecosystem protection, based on SMD guideline*	
Boron	370	*For aquatic ecosystem protection, based on SMD guideline*	
Cobalt	90	*For aquatic ecosystem protection, based on low reliability guideline*	
Manganese	1900	*For aquatic ecosystem protection, based on SMD guideline*	
Molybdenum	34	*For aquatic ecosystem protection, based on low reliability guideline*	
Selenium	10	*For aquatic ecosystem protection, based on LOR for ICPMS*	
Silver	1	*For aquatic ecosystem protection, based on LOR for ICPMS*	
Uranium	1	*For aquatic ecosystem protection, based on LOR for ICPMS*	
Vanadium	10	*For aquatic ecosystem protection, based on LOR for ICPMS*	
Ammonia	900	*For aquatic ecosystem protection, based on SMD guideline*	
Nitrate	1100	*For aquatic ecosystem protection, based on ambient Qld WQ Guidelines (2006) for TN*	
Petroleum hydrocarbons (C6-C9)	20		
Petroleum hydrocarbons (C10-C36)	100		
Fluoride (total)	2000	*Protection of livestock and short term irrigation guideline*	

Note:

1. All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered). Trigger levels for metal/metalloids apply if dissolved results exceed trigger.

2. The quality characteristics required to be monitored as per Table C3 can be reviewed once the results of two years monitoring data is available, or if sufficient data is available to adequately demonstrate negligible environmental risk, and it may be determined that a reduced monitoring frequency is appropriate or that certain quality characteristics can be removed from Table C3 (Release Contaminant Trigger Investigation Levels - Potential Contaminants)by amendment.

3. SMD – slightly moderately disturbed level of protection, guideline refers ANZECC & ARMCANZ (2000).
4. LOR – typical reporting for method stated. ICPMS/CV FIMS – analytical method required to achieve LOR.

Table C4 (Mine Affected Water Release during Flow Events)

Receiving waters/ stream	Release Point (RP)	Gauging station	Gauging Station Easting GDA94 (MGA Zone 55)	Gauging Station Northing GDA94 (MGA Zone 55)	Receiving Water Flow Recording Frequency	Receiving Water Flow Criteria for discharge (m^3/s)	Maximum release rate (for all combined RP flows)	Electrical Conductivity and Sulphate Release Limits
To be provided[1]	To be provided[1]	To be provided[1]	To be provided[1]	To be provided[1]	Continuous (minimum daily)	**Low Flow** To be provided[1]	To be provided[1]	To be provided[1]
						Medium Flow To be provided[1]	To be provided[1]	To be provided[1]
						High Flow To be provided[1]	To be provided[1]	To be provided[1]

[1] Mine affected water release limits to be submitted to the administering authority for approval prior to construction of associated storages.

C14	The environmental authority holder must notify the administering authority as soon as practicable (nominally within 24 hours after cessation of a release event) of the cessation of a release notified under Condition **C14** and within 28 days provide the following information in writing: a) release cessation date/time; b) natural flow volume in receiving water; c) volume of water released; d) details regarding the compliance of the release with the conditions of Agency Interest: Water of this environmental authority (i.e. contamination limits, natural flow, discharge volume); e) all in-situ water quality monitoring results; and f) any other matters pertinent to the water release event. *NOTE: Successive or intermittent releases occurring within twenty-four (24) hours of the cessation of any individual release can be considered part of a single release event and do not require individual notification for the purpose of compliance with conditions **C13** and **C14**, provided the relevant details of the release are included within the notification provided in accordance with conditions **C13** and **C14**.*
C15	**Notification of release event exceedance** If the release limits defined in **Table C2 (Mine Affected Water Release Limits)** are exceeded, the holder of the environmental authority must notify the administering authority within 24 hours of receiving the results.

C16	The authority holder must, within 28 days of a release that exceeds the conditions of this authority, provide a report to the administering authority detailing: a) the reason for the release; b) the location of the release; c) all water quality monitoring results; d) any general observations; e) all calculations; and f) any other matters pertinent to the water release event.
C17	**Monitoring of water storage quality** Water storages stated in **Table C5 (Water Storage Monitoring)** which are associated with the release points must be monitored for the water quality characteristics specified in **Table C6 (Onsite Water Storage Contaminant Limits)** at the monitoring locations and at the monitoring frequency specified in **Table C5 (Water Storage Monitoring)**.
C18	In the event that waters storages defined in **Table C5 (Water Storage Monitoring)** exceed the contaminant limits defined in **Table C6 (Onsite Water Storage Contaminant Limits)**, the holder of the environmental authority must implement measures, where practicable, to prevent access to waters by all livestock.
C19	**Receiving environment monitoring and contaminant trigger levels** The quality of the receiving waters must be monitored at the locations specified in **Table C8 (Receiving Water Upstream Background Sites and Down Stream Monitoring Points)** for each quality characteristic and at the monitoring frequency stated in **Table C7 (Receiving Waters Contaminant Trigger Levels)**.

C20	If quality characteristics of the receiving water at the downstream monitoring points exceed any of the trigger levels specified in **Table C7 (Receiving Waters Contaminant Trigger Levels)** during a release event the environmental authority holder must compare the downstream results to the upstream results in the receiving waters and: a) where the downstream result is the same or a lower value than the upstream value for the quality characteristic then no action is to be taken; or b) where the downstream results exceed the upstream results complete an investigation into the potential for environmental harm and provide a written report to the administering authority in the next annual return, outlining: i) details of the investigations carried out; and ii) actions taken to prevent environmental harm. *NOTE: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with **C20(b)** of this condition, no further reporting is required for subsequent trigger events for that quality characteristic.*

Table C5 (Water Storage Monitoring)

Water Storage Description	Easting GDA94 (MGA Zone 55)	Northing GDA94 (MGA Zone 55)	Monitoring Location	Frequency of Monitoring
Raw Water Dam	To be provided[1]	To be provided[1]	To be provided[1]	Quarterly
Environmental Dam 1	To be provided[1]	To be provided[1]	To be provided[1]	Quarterly
Environmental Dam 2	To be provided[1]	To be provided[1]	To be provided[1]	Quarterly
Environmental Dam 3	To be provided[1]	To be provided[1]	To be provided[1]	Quarterly
Environmental Dam 4	To be provided[1]	To be provided[1]	To be provided[1]	Quarterly
Sedimentation Dam 1	To be provided[1]	To be provided[1]	To be provided[1]	Quarterly
Sedimentation Dam 2	To be provided[1]	To be provided[1]	To be provided[1]	Quarterly
Sedimentation Dam 3	To be provided[1]	To be provided[1]	To be provided[1]	Quarterly
Sedimentation Dam 4	To be provided[1]	To be provided[1]	To be provided[1]	Quarterly

[1] Water storages and monitoring locations to be submitted to the administering authority for approval prior to construction of associated storages.

Table C6 (Onsite Water Storage Contaminant Limits)

Quality Characteristic	Test Value	Contaminant Limit
pH (pH unit)	Range	Greater than 4, less than 9[2]

EC (µS/cm)	Maximum	5970[1]
Sulphate (mg/L)	Maximum	1000[1]
Fluoride (mg/L)	Maximum	2[1]
Aluminium (mg/L)	Maximum	5[1]
Arsenic (mg/L)	Maximum	0.5[1]
Cadmium (mg/L)	Maximum	0.01[1]
Cobalt (mg/L)	Maximum	1[1]
Copper (mg/L)	Maximum	1[1]
Lead (mg/L)	Maximum	0.1[1]
Nickel (mg/L)	Maximum	1[1]
Zinc (mg/L)	Maximum	20[1]

Note:
Total measurements (unfiltered) must be taken and analysed
[1] Contaminant limit based on ANZECC & ARMCANZ (2000) stock water quality guidelines.
[2] Page 4.2-15 of ANZECC & ARMCANZ (2000) "Soil and animal health will not generally be affected by water with pH in the range of 4–9".

Table C7 (Receiving Waters Contaminant Trigger Levels)

Quality Characteristic	Trigger Level	Monitoring Frequency
pH	6.5 – 8.5	Daily during the release
Electrical Conductivity (µS/cm)	1000	
Suspended solids (mg/L)	To be provided[1]	
Sulphate (SO_4^{2-}) (mg/L)	250	

[1] Receiving water contaminant trigger levels to be submitted to the administering authority for approval prior to construction of associated storages.

Table C8 (Receiving Water Upstream Background Sites and Down Stream Monitoring Points)

Monitoring Points	Receiving Waters Location Description	Easting GDA94 (MGA Zone 55)	Northing GDA94 (MGA Zone 55)
Upstream Background Monitoring Points			
USDC	Devlin Creek upstream at the Codrilla A ML boundary.	658,600	7,554,984
SCUS	Swampy creek upstream, at Valkyrie Road.	667,825	7,558,210
Downstream Monitoring Points			
DSDC	Devlin Creek downstream, at the Codrilla A ML boundary.	664,254	7,552,019
DCFDR	Devlin Creek at the FDR crossing.	661,933	7,554,137
DCHR	Devlin Creek immediately downstream of the Codrilla to Moorvale Haul road crossing.	644,328	7,564,375
BCHR	Bundarra Creek immediately downstream of the Codrilla to Moorvale Haul road crossing.	650,123	7,563,624
UNHR	The unnamed tributary of Bundarra Creek immediately downstream of the Codrilla to Moorvale Haul road crossing. Northern boundary of 20 Mile property.	653,821	7,563,263

Data from background monitoring points must not be used where they are affected by releases from other mines

C21	**Receiving Environment Monitoring Program (REMP)** The environmental authority holder must develop and implement a Receiving Environment Monitoring Program (REMP) to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site.
C22	The REMP must: a) assess the condition or state of receiving waters, including upstream conditions, spatially within the REMP area, considering background water quality characteristics based on accurate and reliable monitoring data that takes into consideration temporal variation (e.g. seasonality); b) be designed to facilitate assessment against water quality objectives for the relevant environmental values that need to be protected; c) include monitoring from background reference sites (e.g. upstream or background) and downstream sites from the release (as a minimum, the locations specified in **Table C8 (Receiving Water Upstream Background Sites and Down Stream Monitoring Points)**); d) specify the frequency and timing of sampling required in order to reliably assess ambient conditions and to provide sufficient data to derive site specific background reference values in accordance with the *Queensland Water Quality Guidelines 2009*. This should include monitoring during periods of natural flow irrespective of mine or other discharges; e) include monitoring and assessment of dissolved oxygen saturation, temperature and all water quality parameters listed in **Table C2 (Mine Affected Water Release Limits)** and **Table C3 (Release Contaminant Trigger Investigation Levels - Potential Contaminants)**; f) include, where appropriate, monitoring of metals/metalloids in sediments (in accordance with ANZECC & ARMCANZ 2000, BATLEY and/or the most recent version of AS5667.*1 Guidance on sampling of bottom sediments*); g) include, where appropriate, monitoring of macroinvertebrates in accordance with the AusRivas methodology; h) apply procedures and/or guidelines from ANZECC & ARMCANZ 2000 and other relevant guideline documents; i) describe sampling and analysis methods and quality assurance and control; and j) incorporate stream flow and hydrological information in the interpretations of water quality and biological data.
C23	A REMP Design Document that addresses each criterion presented in Conditions **C21** and **C22** must be prepared and submitted to the administering authority no later than six (6) months after commencing mining operations. Due consideration must be given to any comments made by the administering authority on the REMP Design Document and subsequent implementation of the program.

C24	A report outlining the findings of the REMP, including all monitoring results and interpretations in accordance with conditions **C21** and **C22** must be prepared for any year in which a release has or is occurring and made available on request to the administrating authority. This must include an assessment of background reference water quality, the condition of downstream water quality compared against water quality objectives, and the suitability of current discharge limits to protect downstream environmental values.
C25	**Water reuse** Mine affected water may be piped or trucked or transferred by some other means that does not contravene the conditions of this environmental authority and deposited into artificial water storage structures, such as farm dams or tanks, or used directly at properties owned by the environmental authority holder or a third party for the purpose of: a) supplying stock water subject to compliance with the quality release limits specified in **Table C9 (Stock Water Release Limits)**; or b) supplying irrigation water subject to compliance with quality release limits in **Table C10 (Irrigation Water Release Limits)**; or c) supplying water for construction and/or road maintenance in accordance with the conditions of this environmental authority.

Table C9 (Stock Water Release Limits)

Quality characteristic	Units	Minimum	Maximum
pH	pH units	6.5	8.5
Electrical Conductivity	µS/cm	N/A	5000

Table C10 (Irrigation Water Release Limits)

Quality characteristic	Units	Minimum	Maximum
pH	pH units	6.5	8.5
Electrical Conductivity	µS/cm	N/A	To be provided[1]

[1] *Irrigation water release limits to be submitted to the administering authority for approval prior to construction of associated storages.*

C26	Mine affected water may be piped or trucked or transferred by some other means that does not contravene the conditions of this environmental authority and deposited into artificial water storage structures, such as dams or tanks, for the purpose of supplying water to an adjoining mine. The volume, pH and electrical conductivity of water transferred to the adjoining mine must be monitored and recorded.

C27	If the responsibility for mine affected water is given or transferred to another person in accordance with conditions **C25** or **C26**: a) the responsibility for the mine affected water must only be given or transferred in accordance with a written agreement (the third party agreement); and b) the third party agreement must include a commitment from the person utilising the mine affected water to use it in such a way as to prevent environmental harm or public health incidents and specifically make the persons aware of the General Environmental Duty (GED) under section 319 of the *Environmental Protection Act 1994*, environmental sustainability of the water disposal and protection of environmental values of waters; and c) the third party agreement must be signed by both parties to the agreement.
C28	**Water general** All determinations of water quality and biological monitoring must be: a) performed by a person or body possessing appropriate experience and qualifications to perform the required measurements; b) made in accordance with methods prescribed in the latest edition of the Administering Authority's *Monitoring and Sampling Manual*; c) collected from the monitoring locations identified within this environmental authority, within ten (10) hours of each other where possible; d) carried out on representative samples; and e) analysed at a laboratory accredited (e.g. NATA) for the method of analysis being used. *NOTE: Condition **C28** requires the Monitoring and Sampling Manual to be followed and where it is not followed because of exceptional circumstances this should be explained and reported with the results.*
C29	The release of any contaminants as permitted by this environmental authority, directly or indirectly to waters, other than internal water management infrastructure that is installed and operated in accordance with a water management plan that complies with conditions **C32** to **C37** inclusive: a) must not produce any visible discolouration of receiving waters; and b) must not produce any slick or other visible or odorous evidence of oil, grease or petrochemicals nor contain visible floating oil, grease, scum, litter or other objectionable matter.

C30	**Annual water monitoring reporting** The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the administering authority in the specified format with each annual return: a) the date on which the sample was taken; b) the time at which the sample was taken; c) the monitoring point at which the sample was taken; d) the measured or estimated daily quantity of mine affected water released from all release points; e) the release flow rate at the time of sampling for each release point; f) the results of all monitoring and details of any exceedances of the conditions of this environmental authority; and g) water quality monitoring data must be provided to the administering authority in the specified electronic format upon request.
C31	**Temporary interference with waterways** Temporarily destroying native vegetation, excavating, or placing fill in a watercourse, lake or spring necessary for and associated with mining operations must be undertaken in accordance with the administering authority's guideline, *Activities in a watercourse, lake or spring associated with mining activities*.
C32	**Water Management Plan** A Water Management Plan must be developed by an appropriately qualified person and implemented prior to commencing mining operations.

C33	The Water Management Plan must: a) provide for effective management of actual and potential environmental impacts resulting from water management associated with the mining activity carried out under this environmental authority; and b) be developed in accordance with the administering authority's guideline *Preparation of water management plans for mining activities* and include: i) a study of the source of contaminants; ii) a water balance model for the site; iii) a water management system for the site; iv) measures to manage and prevent saline drainage; v) measures to manage and prevent acid rock drainage; vi) contingency procedures for emergencies; and vii) a program for monitoring and review of the effectiveness of the water management plan.
C34	The Water Management Plan must be reviewed each calendar year and a report prepared by an appropriately qualified person. The report must: a) assess the plan against the requirements under condition **C33**; b) include recommended actions to ensure actual and potential environmental impacts are effectively managed for the coming year; and c) identify any amendments made to the water management plan following the review.
C35	The holder of this environmental authority must attach to the review report required by condition **C34**, a written response to the report and recommended actions, detailing the actions taken or to be taken by the environmental authority holder on stated dates: a) to ensure compliance with this environmental authority; and b) to prevent a recurrence of any non-compliance issues identified.
C36	The review report required by condition **C34** and the written response to the review report required by condition **C35** must be submitted to the administering authority with the subsequent annual return under the signature of the appointed signatory for the annual return.
C37	A copy of the Water Management Plan must be provided to the administering authority on request.
C38	**Saline drainage** The holder of this environmental authority must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of saline drainage.

C39	**Acid drainage** The holder of this environmental authority must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of acid rock drainage.
C40	**Stormwater and water sediment controls** An Erosion and Sediment Control Plan must be developed by an appropriately qualified person and implemented for all stages of the mining activities on the site to minimise erosion and the release of sediment to receiving waters and contamination of stormwater.
C41	Stormwater, other than mine affected water, is permitted to be released to waters from: a) erosion and sediment control structures that are installed and operated in accordance with the Erosion and Sediment Control Plan required by condition **C40**; and b) water management infrastructure that is installed and operated, in accordance with a Water Management Plan that complies with conditions **C32** to **C37** inclusive, for the purpose of ensuring water does not become mine affected water.
C42	The maintenance and cleaning of any vehicles, plant or equipment must not be carried out in areas from which contaminants can be released into any receiving waters.
C43	Any spillage of wastes, contaminants or other materials must be cleaned up as quickly as practicable to minimise the release of wastes, contaminants or materials to any stormwater drainage system or receiving waters.
C44	**Groundwater** Groundwater must be monitored at the locations and frequencies specified in **Table C11 Groundwater Monitoring Locations and Frequencies**, for the parameters identified in **Table C12 Groundwater Investigation Trigger Levels**, and the data supplied in an approved format to the administering authority within forty (40) business days of being collected. The monitoring activities must be carried out in accordance with the latest edition of the administering authority's *Water Quality Sampling Manual*.

Table C11 Groundwater Monitoring Locations and Frequencies

Monitoring Points	Easting GDA94 (MGA Zone 55)	Northing GDA94 (MGA Zone 55)	Aquifer / Material	Frequency*
MB1	659,046	7,556,154	Permian & Triassic	Quarterly
MB2	659,049	7,556,153	Tertiary Sediments	Quarterly
MB3	658,640	7,554,876	Permian & Triassic	Quarterly
MB4	658,641	7,554,879	Alluvium	Quarterly
MB5	660,952	7,555,176	Permian & Triassic	Quarterly
MB6	665,588	7,557,431	Coal Seam	Quarterly
MB7	665,590	7,557,428	Tertiary Sediments	Quarterly
MB8	662,268	7,556,423	Coal Seam	Quarterly
MB8B	662,271	7,556,426	Tertiary Sediments	Quarterly
MB9	662,977	7,553,121	Coal Seam	Quarterly
MB10	662,980	7,553,120	Alluvium	Quarterly

**Note: quarterly monitoring to commence prior to the commencement of mining operations*

C45	Subject to requirements of condition **C44**, if the groundwater investigation trigger levels defined in **Table C12 Groundwater Investigation Trigger Levels** are exceeded, the environmental authority holder must complete an investigation into the potential for environmental harm and notify the administering authority within twenty-eight (28) days of receiving the analysis results.
C46	Groundwater levels affected by the mining activities must be monitored at the locations and frequencies defined in **Table C13 Groundwater Levels**.
C47	Groundwater levels and groundwater drawdown fluctuations in excess of 2m per year, not resulting from the pumping of licensed bores, must be notified within seven (7) days to the administering authority following completion of monitoring.
C48	Background groundwater monitoring program A background groundwater monitoring program must be developed to include bore(s) that are located an appropriate distance from potential sources of impact from mining activities to provide the following: a) representative groundwater samples from the aquifers potentially affected by mining activities; b) at least twelve (12) sampling events (monthly sampling) to determine background groundwater quality as far as practicable; c) background groundwater quality in hydraulically isolated background bore(s) that have not been affected by any mining activities; and d) final groundwater contaminant trigger levels and limits required in Conditions C44 and C45.

Table C12 Groundwater Investigation Trigger Levels

Parameter	Unit	Trigger Levels*	Limit Type
pH		To be provided as per Condition C51	To be provided as per Condition C50
Electrical Conductivity	µS/cm	To be provided as per Condition C51	To be provided as per Condition C50
Total Dissolved Solids	mg/L	To be provided as per Condition C51	To be provided as per Condition C50
Calcium	mg/L	To be provided as per Condition C51	To be provided as per Condition C50
Magnesium	mg/L	To be provided as per Condition C51	To be provided as per Condition C50
Sodium	mg/L	To be provided as per Condition C51	To be provided as per Condition C50
Potassium	mg/L	To be provided as per Condition C51	To be provided as per Condition C50
Chlorine	mg/L	To be provided as per Condition C51	To be provided as per Condition C50
SO4	mg/L	To be provided as per Condition C51	To be provided as per Condition C50
CO3	mg/L	To be provided as per Condition C51	To be provided as per Condition C50
HCO3	mg/L	To be provided as per Condition C51	
Iron	µg/L	To be provided as per Condition C51	To be provided as per Condition C50
Aluminium	µg/L	To be provided as per Condition C51	To be provided as per Condition C50
Silver	µg/L	To be provided as per Condition C51	To be provided as per Condition C50
Arsenic	µg/L	To be provided as per Condition C51	To be provided as per Condition C50
Mercury	µg/L	To be provided as per Condition C51	To be provided as per Condition C50
Antimony	µg/L	To be provided as per Condition C51	To be provided as per Condition C50
Molybdenum	µg/L	To be provided as per Condition C51	To be provided as per Condition C50
Selenium	µg/L	To be provided as per Condition C51	To be provided as per Condition C50
Total Petroleum Hydrocarbons (C6-C9)	µg/L	To be provided as per Condition C51	To be provided as per Condition C50
Total Petroleum Hydrocarbons (C10-C36)	µg/L	To be provided as per Condition C51	To be provided as per Condition C50

* Trigger levels for metals/metalloids apply to dissolved concentration

Table C13 Groundwater Levels

Monitoring Points	Easting GDA94 (MGA Zone 55)	Northing GDA94 (MGA Zone 55)	Surface RL (mAHD)	Frequency*
MB1	659,046	7,556,154	182.890	Quarterly
MB2	659,049	7,556,153	182.859	Quarterly
MB3	658,640	7,554,876	179.727	Quarterly
MB4	658,641	7,554,879	179.787	Quarterly
MB5	660,952	7,555,176	176.740	Quarterly
MB6	665,588	7,557,431	169.810	Quarterly
MB7	665,590	7,557,428	169.775	Quarterly
MB8	662,268	7,556,423	177.730	Quarterly
MB8B	662,271	7,556,426	177.702	Quarterly
MB9	662,977	7,553,121	171.117	Quarterly
MB10	662,980	7,553,120	171.168	Quarterly

**Note: quarterly monitoring to commence prior to the commencement of mining operations*

C49	The groundwater monitoring data must be reviewed on an annual basis. The review must include the assessment of groundwater levels and quality data, and the suitability of the monitoring network. The assessment must be submitted to the administering authority within twenty-eight (28) days of receiving the report.
C50	Groundwater contaminant trigger levels as per **Table C12 Groundwater Investigation Trigger Levels** must be finalised based on a background groundwater monitoring program defined in condition **C48** and submitted to the administering authority prior to commencing mining operations.
C51	Groundwater monitoring The following information must be recorded in relation to all groundwater water sampling: a) the date on which the sample was taken; b) the time at which the sample was taken; c) the monitoring point at which the sample was taken; and d) the results of all monitoring.

Agency interest: Noise and Vibration	
Condition number	**Condition**

D1	Noise from activities must not cause an environmental nuisance at any noise sensitive or commercial place.
D2	All noise from activities must not exceed the levels specified in **Table D1 Noise Limits** at any noise affected place.
D3	**Noise monitoring** When requested by the administering authority, noise monitoring must be undertaken to investigate any complaint of noise nuisance, and the results notified within fourteen (14) days to the administering authority. Monitoring must include: a) LA 10, adj, 10 mins; b) LA 1, adj, 10 mins; c) the level and frequency of occurrence of impulsive or tonal noise; d) atmospheric conditions including wind speed and direction; e) effects due to extraneous factors such as traffic noise; and f) location date and time of recording.
D4	Noise is not considered to be a nuisance under condition **D1** if monitoring shows that noise does not exceed the following levels in the time periods specified in **Table D1 Noise Limits**.
D5	The method of measurement and reporting of noise monitoring must comply with the current edition of the administering authority's *Noise Measurement Manual*.
D6	If monitoring indicates exceedance of the relevant limits in condition **D4**, then the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; and b) immediately implement noise abatement measures so that emissions of noise from the activity do not result in further environmental nuisance.

Table D1 Noise Limits

Noise level dB(A)	**Monday to Sunday**		
	7am - 6pm (Daytime)	**6pm - 10pm** (Evening)	**10pm - 7am** (Night time)
	Noise measured at a 'Sensitive place'		
Noise Level dB(A)	40	40	35
	Noise measured at a 'Commercial place'		
Noise Level dB(A)	45	45	40

D7	**Vibration nuisance** Vibration from the licensed activities must not cause an environmental nuisance at any sensitive or commercial place.
D8	When requested by the administering authority, vibration monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive or commercial place, and the results must be notified within fourteen (14) days to the administering authority following completion of monitoring.
D9	Vibration monitoring must include the following descriptors, characteristics and conditions: a) location of the blast(s) within the mining area (including which bench level); b) atmospheric conditions including temperature, relative humidity and wind speed and direction; and c) location, date and time of recording.
D10	If monitoring indicates exceedance of the relevant limits in **Table D2 Vibration Limits**, the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; and b) immediately implement vibration abatement measures so that vibration from the activity does not result in further environmental nuisance.

Table D2 Vibration Limits

Location	Vibration measured at a sensitive place	
	Monday to Sunday 9am – 7pm	**Other times and public holidays**
Peak particle velocity (mm/s)	5 mm/s peak particle velocity for nine (9) out of ten (10) consecutive blasts and not greater than 10 mm/s peak particle velocity at any time	No blasting to occur

NOTE: The method of measurement and reporting of vibration levels must comply with the latest edition of the administering authority's vibration and air blast overpressure monitoring guideline.

D11	**Airblast overpressure nuisance** The airblast overpressure level from blasting operations on the premises must not exceed the limits defined in **Table D3 Airblast Overpressure Level** at any nuisance sensitive or commercial place.
D12	When requested by the administering authority, airblast overpressure monitoring must be undertaken within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is neither frivolous nor vexatious nor based on mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive or commercial place, and the results must be notified within fourteen (14) days to the administering authority following completion of monitoring.

D13	Airblast overpressure monitoring must include the following descriptors, characteristics and conditions: a) location of the blast(s) within the mining area (including which bench level); b) atmospheric conditions including temperature, relative humidity and wind speed and direction; and c) location, date and time of recording.
D14	If monitoring indicates exceedance of the relevant limits in **Table D3 Airblast Overpressure Leve**l, the environmental authority holder must: a) address the complaint including the use of appropriate dispute resolution if required; and b) immediately implement airblast overpressure abatement measures so that airblast overpressure from the activity does not result in further environmental nuisance.
D15	The method of measurement and reporting of airblast overpressure levels must comply with the current edition of the administering authority's *Noise Measurement Manual.*

Table D3 Airblast Overpressure Level

Location	**Airblast Overpressure Measured**	
	Monday to Sunday 9am – 7pm	**Other times and public holidays**
Sensitive or commercial place	Air blast overpressure level of 115 db (Linear peak) for nine (9) out of ten (10) consecutive blasts initiated and not greater than 120 db (Linear peak) at any time.	No blasting to occur

Agency interest: Waste	
Condition number	**Condition**
E1	**General** For the purpose of conditions **E2** to **E16**, effluent, waste rock, concrete, spoil, overburden, rejects and tailings generated on ML70450 (Codrilla A) and ML70455 (Codrilla B) are not defined as 'waste'.
E2	**Storage of tyres** Scrap tyres stored awaiting disposal or transport for take-back and recycling, or waste-to-energy options must be stored in stable stacks and at least 10m from any other scrap tyre storage area, or combustible or flammable material, including vegetation.
E3	All reasonable and practicable fire prevention measures must be implemented, including removal of grass and other materials within a 10m radius of the scrap tyre storage area.

E4	Disposing of scrap tyres resulting from the authorised activities in spoil emplacements is acceptable, provided tyres are placed as deep in the spoil as reasonably practicable. A record must be kept of the number and location for tyres disposed.
E5	**Waste management** A Waste Management Plan, in accordance with the *Waste Reduction and Recycling Act 2011,* must be implemented prior to commencing mining operations and must include: a) describe how the environmental authority holder recognises and applies the waste management hierarchy; b) identify characterisations of wastes generated from the project and general volume trends over the past five (5) years; c) a program for safe recycling or disposal of all wastes - reusing and recycling where possible; d) waste commitments with auditable targets to reduce, reuse and recycle; e) the waste management control strategies must consider: i) the type of wastes; ii) segregation of the wastes; iii) storage of the wastes; iv) transport of the wastes; v) monitoring and reporting matters concerning the waste; vi) emergency response planning; vii) disposal, reused and recycling options; and f) identify the potential adverse and beneficial impacts of the wastes generated; g) detail the hazardous characteristics of the waste generated (if any); h) outline the process to be implemented to allow for continuous improvement of the waste management systems; i) identify responsible staff (positions) for implementing, managing and reporting the Waste Management Plan; and j) cover a staff awareness and induction program that encourages re-use and recycling.
E6	**Waste storage** Waste is not permitted to be disposed of within ML70450 (Codrilla A) and ML70455 (Codrilla B).
E7	General waste may be temporarily stored on ML70450 (Codrilla A) and ML70455 (Codrilla B) before being directed to a facility that can lawfully accept such waste.

E8	Subject to conditions **E1** to **E5**, the following regulated waste may be temporarily stored on ML70450 (Codrilla A) and ML70455 (Codrilla B) before being directed to a facility that can lawfully accept such waste: a) tyres; b) batteries; c) hydrocarbons d) oils; e) oil interceptor sludges; f) oil water emulsions and mixtures; and g) chemicals listed under the *Environmental Protection Act 1994* and subordinate legislation.
E9	A designated area or storage containers must be set aside for the laydown and segregation of wastes.
E10	An effective fire break must be provided and maintained around all waste laydown areas.
E11	All reasonable and practicable fire prevention measures must be implemented, including removal of grass and other materials within a 10m radius of all waste laydown areas.
E12	Waste must not be burned or allowed to be burned on the mining lease unless by approval of the administering authority.
E13	Waste batteries must be stored: a) in a bunded and roofed area; or b) palletised and plastic wrapped.
E14	A record of all wastes must be kept detailing the following information: a) date of pickup of waste; b) description of waste; c) quantity of waste; d) origin of the waste; and e) destination of the waste. *NOTE: Trackable wastes as listed in Schedule 2E of the Environmental Protection Regulation 2008 are not covered by this condition. Trackable wastes have similar recording requirements to this condition in accordance with a waste tracking system established under the above Regulation.*
E15	All regulated waste removed from the site must be removed by a person who holds a current approval to transport such waste under the provisions of the *Environmental Protection Act 1994.*

E16	Each container of regulated waste must be marked to identify the waste contained therein.

Agency interest: Land	
Condition number	**Condition**
F1	**Topsoil** Topsoil must be strategically stripped ahead of mining in accordance with a Topsoil Management Plan. The topsoil management plan must be developed prior to the commencement of mining operations.
F2	A topsoil inventory which identifies the topsoil requirements for the Codrilla Mine project and availability of suitable topsoil on site must be detailed in the Plan of Operations.
F3	**Preventing contaminant release to land** Contaminants must not be released to land in a manner which constitutes nuisance, material or serious environmental harm.
F4	The environmental authority holder must take all practicable actions necessary to secure loads prior to transporting materials off site to minimise emissions or spillage of any material from vehicles or other transport infrastructure.
F5	**Chemicals and flammable or combustible liquids** All flammable and combustible liquids must be contained within an on-site containment system and controlled in a manner that prevents environmental harm and maintained in accordance with the current edition of *AS 1940 – Storage and Handling of Flammable and Combustible Liquids.*
F6	Spillage of all flammable and combustible liquids must be controlled in a manner that prevents environmental harm.
F7	All chemicals must be contained within an on-site containment system and controlled in a manner that prevents environmental harm and maintained in accordance with the current version of the relevant Australian Standard.
F8	Spillage of all chemicals must be controlled in a manner that prevents environmental harm.
F9	All explosives, corrosive substances, toxic substances, gases and dangerous goods must be stored and handled in accordance with the relevant Australian Standard.

F10	All chemicals and flammable or combustible liquids stored on site that have the potential to cause environmental harm must be stored in or serviced by an effective containment system that is impervious to the materials stored and managed to prevent the release of liquids to waters or land. Where no relevant Australian Standard is available, the following must be applied: a) storage tanks must be bunded so that the capacity and construction of the bund is sufficient to contain at least 110% of a single storage tank or 100% of the largest storage tank plus 10% of the second largest storage tank in multiple storage areas; and b) drum storages must be bunded so that the capacity and construction of the bund is sufficient to contain at least 25% of the maximum design storage volume within the bund.
F11	**Spill Kit** An appropriate spill kit, personal protective equipment and relevant operator instructions/emergency procedure guides for the management of wastes, chemicals and flammable and combustible liquids associated with the activity must be kept at the site.
F12	Anyone operating with wastes, chemicals or flammable and combustible liquids under this approval must be trained in the use of the spill kit.
F13	All infrastructure, constructed by or for the environmental authority holder during the licensed activities including water storage structures, must be removed from the site prior to surrender, except where agreed in writing by the post mining landowner / holder. *NOTE: This is not applicable where the landowner / holder is also the environmental authority holder.*
F14	**Mining waste** For the purpose of conditions **F15** to **F20**, waste rock, spoil and overburden generated on ML70450 (Codrilla A) and ML70455 (Codrilla B) are defined as ‘mining waste’.

F15	**Mining waste management** The environmental authority holder will develop and maintain a Mining Waste Management Plan to be submitted to the administering authority within twelve (12) months of commencing mining operations. The plan must at a minimum include: a) characterisation programs to ensure that all mining waste is progressively characterised during disposal for net acid producing potential, salinity and the following contaminants: Iron (Fe), Aluminium (Al), Copper (Cu), Magnesium (Mg), Manganese (Mn), Calcium (Ca), Sodium (Na) and Sulphate (SO_4); b) characterisation programs to ensure that the physical properties of the mining waste is progressively characterised during disposal; c) the availability or leachability of metals from the mining waste; d) quantification of PAF from mining waste present; e) review impacts of the PAF mining waste on the rehabilitation; f) management actions for mining waste that has been identified as having a high availability or leachability of metals in accordance with condition **F17**; g) management actions for mining waste that has been defined as PAF in accordance with condition **F18**; and h) identification of environmental impacts and potential environmental impacts; i) control measures for routine operations to minimise likelihood of environmental harm; j) contingency plans and emergency procedures for non-routine situations; and k) periodic review of environmental performance and continual improvement.
F16	**Acid mine drainage and leachate management** The management of mining waste emplacement must be in accordance with the following: a) all mining waste must be progressively characterised prior to emplacement for net acid producing potential and the following contaminants: Iron (Fe), Aluminium (Al), Copper (Cu), Magnesium (Mg), Manganese (Mn), Calcium (Ca), Sodium (Na) and Sulphate (SO4); b) records must be kept of the waste rock, spoil or overburden emplacement to indicate locations and characteristics of mining waste located on ML70450 (Codrilla A) and ML70455 (Codrilla B) and c) where the acid producing potential of mining waste material has not been conclusively determined, geochemical kinetic testing must be conducted to indicate oxidation rates, potential reaction products and effectiveness of control strategies.
F17	Subject to the release limits defined in Department Interest: Water, all mining waste, identified by condition **F16**, as having a high availability or leachability of metals, must be disposed of in a manner that prevents contaminants being directly or indirectly released or likely to be released to any groundwater or water course.

F18	Subject to the release limits defined in Department Interest: Water, all reasonable and practicable measures must be implemented to prevent hazardous leachate being directly or indirectly released or likely to be released as a result of the activity to any groundwater or water course.
F19	All PAF mining waste, identified by condition **F16**, must be disposed of in a manner that ensures contaminants are not released to the environment.
F20	Areas that are, or are proposed, to contain PAF mining waste emplacement areas must be identified in the current Plan of Operations.
F21	**Tailings and rejects** The environmental authority holder will develop and maintain a Coarse and Fine Reject Waste Management Plan to be submitted to the administering authority within twelve (12) months of commencing mining operations. The Plan will include at a minimum: a) chemical analysis of tailings material from each sub-cell to determine the net acid producing potential immediately prior to placement in waste rock, spoil or overburden emplacements in accordance with conditions **F22** to **F26**; b) the availability or leachability of metals from the tailings; c) placement strategies for tailings material within the Tailings Storage Facility; d) placement strategies for tailings in mining waste emplacement areas to enable successful rehabilitation outcomes in accordance with the conditions of this environmental authority; e) identification of environmental issues and potential environmental impacts; f) control measures for routine operations to minimise the likelihood of environmental harm; g) contingency plans and emergency procedures for non-routine situations; h) periodic review of environmental performance and continual improvement; and i) the progressive 3D survey of all tailings disposal locations within the mining waste emplacement areas.

F22	The management of tailings disposal must be in accordance with the following: a) all tailings material must be progressively characterised prior to disposal within 'in pit' mining waste emplacement areas for net acid producing potential and the following contaminants: Iron (Fe), Aluminium (Al), Copper (Cu), Magnesium (Mg), Manganese (Mn), Calcium (Ca), Sodium (Na) and Sulphate (SO_4); b) records must be kept of the tailings disposal to indicate locations and characteristics of tailings disposed of within mining waste emplacement areas; c) records must be kept of the tailings disposal for identified PAF tailings to indicate locations and characteristics of tailings stored within the tailings storage facility; and d) where the acid producing potential of tailings material has not been determined, geochemical kinetic testing must be conducted to indicate oxidation rates, potential reaction products and effectiveness of control strategies.
F23	All PAF tailings, identified by condition **F22**, must be disposed of in a certified Tailings Storage Facility subject to the Course and Fine Reject Management Plan for the project.
F24	NAF tailings, identified by condition **F22**, may be disposed of within mining waste emplacement areas located within the open pit.
F25	The waste rock emplacement areas situated within the open pit must be located on a drainage control zone and be designed to ensure all seepage from beneath the waste rock emplacement areas is directed towards the open pit prior to decommissioning and rehabilitation.
F26	Areas that are, or are proposed, to contain tailings within waste rock, spoil or overburden emplacement areas must be identified in the current Plan of Operations.
F27	**Rehabilitation landform criteria** All areas significantly disturbed by mining activities must be rehabilitated to a stable landform with a self-sustaining vegetation cover in accordance with **Table F1 Landform Design Criteria**.
F28	Progressive rehabilitation must commence within two (2) years when areas become available within the operational land.
F29	Areas that are, or are becoming, available for rehabilitation must be identified in the current Plan of Operations.

Table F1 Landform Design Criteria

Disturbance Type	Maximum Projective Surface Area (ha)	Maximum Slope Range	Vertical Height Range (m)
Elevated Landforms	974	4.6° to 5.7°	Up to 50m
Infrastructure Areas	To be provided[1]	2.3°	Up to 18m
Ramps into Voids	To be provided[1]	To be provided[1]	
Voids	130	To be provided[1]	150m

[1]*Information to be provided to the administering authority prior to commencement of construction.*

F30	A rehabilitation management plan for disturbed areas must be submitted to the administering authority proposing acceptance criteria within twelve (12) months of commencing mining operations. The rehabilitation management plan must, at a minimum: a) map existing areas of rehabilitation; b) develop rehabilitation objectives; c) develop design criteria for rehabilitation of disturbed areas; d) detail rehabilitation methods applied to areas; e) identify success factors for areas; f) detail future rehabilitation actions to be completed on areas; g) identify 3 reference and 3 rehabilitation sites to be used to develop rehabilitation success criteria; h) description of monitoring of reference sites and rehabilitated areas inclusive of statistical design; i) contain landform design criteria including end of mine design; j) detail how landform design will be consistent with the surrounding topography; k) provide schematic representation of final landform inclusive of: i) drainage design and features; ii) slope designs; iii) cover design; iv) erosion controls proposed on reformed land; l) specify future planned rehabilitation methods for disturbed areas; m) explain planned native vegetation rehabilitation areas and corridors; n) describe rehabilitation monitoring and maintenance requirements to be applied to all areas of disturbance; o) itemise revegetation criteria; p) describe end of mine landform design plan and post mining land uses across the mine; q) specify spoil characteristics, soil analysis, soil separation for use on rehabilitation; r) include a triple bottom line assessment (or an alternative assessment method) of the proposed final landform design criteria and alternatives; and s) identify potential problems and how they will be addressed.

F31	**Rehabilitation monitoring program** Once rehabilitation has commenced, the holder of the environmental authority must conduct a Rehabilitation Monitoring Program on a yearly basis, which must include sufficient spatial and temporal replication to enable statistically valid conclusions as established under the rehabilitation program.
F32	The Rehabilitation Monitoring Program must be developed and implemented by a person possessing appropriate qualifications and experience in the field of rehabilitation management, nominated by the environmental authority holder.
F33	Verification of rehabilitation success, determined by the rehabilitation success criteria developed as per condition **F30** is to be carried out as follows: a) the minimum sampling intensity must be specified for the monitoring of progressive rehabilitation; b) justification of the suitability of the minimum sampling intensity must be provided; c) monitoring must include sufficient replication to enable statistical analysis of results at an acceptable power; and undertaken at twelve monthly intervals.
F34	**Residual void outcome** Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within this environmental authority.
F35	At the completion of decommissioning and rehabilitation, the residual void must be protected from Probable Maximum Floods (PMFs) from nearby watercourses such that the protection is sustainable for the foreseeable future.

F36	Complete an investigation into residual voids and submit a report to the administering authority proposing acceptance criteria to meet the outcomes in conditions **F34** and **F35** and landform design criteria within eighteen (18) months of commencing mining operations. The investigation must at a minimum include the following: a) a study of options available for minimising final void area and volume; b) develop design criteria for rehabilitation of final voids; c) a void hydrology study, addressing the long-term water balance in the voids, connections to groundwater resources and water quality parameters in the long term; d) a pit wall stability study, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events; e) a study of void capability to support native flora and fauna; and f) a proposal/s for end of mine void rehabilitation success criteria and final void areas and volumes. *NOTE: These studies will be undertaken during the life of the mine, and must include detailed research and modelling.*
F37	The environmental authority holder will submit a status report detailing the progression of the development of the Residual Voids Plan and content requirements as specified in condition **F36** within twelve (12) months of commencing mining operations.
F38	All reasonable and practical measures must be taken to minimise the size of the void remaining after mining activities cease.
F39	**Residual void water quality** The holder of this environmental authority must complete and submit to the administering authority a Residual Void Water Quality Management Study within eighteen (18) months of commencing mining operations.

F40	The Residual Void Water Quality Management Study must include: a) modelling and assessment of the predicted quality of void water between cessation of mining and the post mining equilibrium; b) the predicted catchment area for the void at the cessation of mining; c) the predicted storage capacity of void water during AEP 1 in 25, 1 in 50, 1 in 100, 1 in 200 and 1 in 1000 year rainfall events and potential for discharge; d) the predicted dilution of void water during AEP 1 in 25, 1 in 50, 1 in 100, 1 in 200 and 1 in 1000 year rainfall events; e) modelling of predicted evaporation, including the correlation of predicted evaporation rates with AEP 1 in 25, 1 in 50, 1 in 100, 1 in 200 and 1 in 1000 year rainfall events; f) the predicted quality of void water during potential release events; g) the predicted impact on the environment caused by the release of any void water; h) the predicted quality of void water correlated with predicted evaporation rates; i) physical, chemical and biological assessment of void water and habitat quality; j) modelling and assessment of practicable management measures to mitigate contaminant increases; k) develop a monitoring program to be undertaken both during and after mining, to assess the performance of any management measures required; and l) the ability of the void water to meet the rehabilitation criteria of a safe, stable and non-polluting land form.
F41	**Post Closure Management Plan** A Post Closure Management Plan for the site must be developed and submitted to the administering authority at least eighteen (18) months prior to the final coal processing on site and implemented for a nominal period of: a) at least 30 years following final coal processing on site; or b) a shorter period if the site is proven to be geotechnically and geochemically stable and it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the site will result in environmental harm.

F42	The Post Closure Management Plan must include the following elements: a) operation and maintenance of: i) wastewater collection and reticulation systems; ii) wastewater treatment systems; iii) the groundwater monitoring network; iv) final cover systems of spoil dumps; and v) vegetative cover; and b) monitoring of: i) surface water quality; ii) groundwater quality; iii) seepage rates; iv) erosion rates; v) the integrity and stability all slopes, ramps and voids; and vi) the health and resilience of native vegetation cover.
F43	**Exploration** Disturbance due to exploration activities in areas not scheduled to be mined must be rehabilitated In accordance with provisions detailed in the *Code of Environmental Compliance for Exploration and Mineral Development Projects (EM586).*

Agency Interest: Dams	
Condition	**Condition number**
G1	**Assessment of consequence category** The consequence category of any structure must be assessed by a suitably qualified and experienced person in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (EM635) at the following times: a) prior to the design and construction of the structure, if it is not an existing structure; or b) prior to any change in its purpose or the nature of its stored contents.
G2	A consequence assessment report and certification must be prepared for each structure assessed and the report may include a consequence assessment for more than one (1) structure.
G3	Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (EM635).

G4	**Design and construction[1] of a regulated structure** Conditions **G5** to **G9** inclusive do not apply to existing structures.
G5	All regulated structures must be designed by, and constructed[2] under the supervision of, a suitably qualified and experienced person in accordance with the requirements of the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.
G6	Construction of a regulated structure is prohibited unless the holder has submitted a consequence category assessment report and certification to the administering authority which has been certified by a suitably qualified and experienced person for the design and design plan and the associated operating procedures in compliance with the relevant condition of this authority.
G7	Certification must be provided by the suitably qualified and experienced person who oversees the preparation of the design plan in the form set out in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (EM635), and must be recorded in the Regulated Dams/Levees register.
G8	Regulated structures must: a) be designed and constructed in accordance with and conform to the requirements of the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635);* b) be designed and constructed with due consideration given to ensuring that the design integrity would not be compromised on account of: i) floodwaters from entering the regulated dam from any watercourse or drainage line; and ii) wall failure due to erosion by floodwaters arising from any watercourse or drainage line.
G9	Certification by the suitably qualified and experienced person who supervises the construction must be submitted to the administering authority on the completion of construction of the regulated structure, and state that: a) the 'as constructed' drawings and specifications meet the original intent of the design plan for that regulated structure; b) construction of the regulated structure is in accordance with the design plan.

[1] Construction of a dam includes modification of an existing dam—refer to the definitions.
[2] Certification of design and construction may be undertaken by different persons.

G10	**Operation of a regulated structure** Operation of a regulated structure**,** except for an existing structure, is prohibited unless: a) the holder has submitted to the administering authority: i) one paper copy and one electronic copy of the design plan and certification of the 'design plan' in accordance with condition **G9**, and ii) a set of 'as constructed' drawings and specifications, and iii) certification of those 'as constructed drawings and specifications' in accordance with condition **G6**, and iv) where the regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, a copy of the certified system design plan. v) the requirements of this authority relating to the construction of the regulated structure have been met; vi) the holder has entered the details required under this authority, into a Register of Regulated Dams; and vii) there is a current operational plan for the regulated structures.
G11	Each regulated structure must be maintained and operated, for the duration of its operational life until decommissioned and rehabilitated, in a manner that is consistent with the current operational plan and, if applicable, the current design plan and associated certified 'as constructed' drawings.
G12	**Mandatory reporting level** Conditions **G13** to **G16** inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain – overtopping'.
G13	The Mandatory Reporting Level (the MRL) must be marked on a regulated dam in such a way that during routine inspections of that dam, it is clearly observable.
G14	The holder must, as soon as practical and within forty-eight (48) hours of becoming aware, notify the administering authority when the level of the contents of a regulated dam reaches the MRL.
G15	The holder must, immediately on becoming aware that the MRL has been reached, act to prevent the occurrence of any unauthorised discharge from the regulated dam.
G16	The holder must record any changes to the MRL in the Register of Regulated Structures.
G17	**Design storage allowance** The holder must assess the performance of each regulated dam or linked containment system over the preceding November to May period based on actual observations of the available storage in each regulated dam or linked containment system taken prior to 1 July of each year.

G18	By 1 November of each year, storage capacity must be available in each regulated dam (or network of linked containment systems with a shared DSA volume), to meet the Design Storage Allowance (DSA) volume for the dam (or network of linked containment systems).
G19	The holder must, as soon as possible and within forty-eight (48) hours of becoming aware that the regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, notify the administering authority.
G20	The holder must, immediately on becoming aware that a regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, act to prevent the occurrence of any unauthorised discharge from the regulated dam or linked containment systems.
G21	**Annual Inspection Report** Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.
G22	At each annual inspection, the condition and adequacy of all components of the regulated structure must be assessed and a suitably qualified and experienced person must prepare an annual inspection report containing details of the assessment and include recommended actions to ensure the integrity of the regulated structure**.**
G23	The suitably qualified and experienced person who prepared the annual inspection report must certify the report in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.
G24	The holder must: a) within twenty (20) business days of receipt of the annual inspection report, provide to the administering authority: i) the recommendations section of the annual inspection report; and ii) if applicable, any actions being taken in response to those recommendations; and b) if, following receipt of the recommendations and (if applicable) actions, the administering authority requests a full copy of the annual inspection report from the holder, provide this to the administering authority within ten (10) business days[3] of receipt of the request.
G25	**Transfer arrangements** The holder must provide a copy of any reports, documentation and certifications prepared under this authority, including but not limited to any Register of Regulated Structures, consequence assessment, design plan and other supporting documentation, to a new holder on transfer of this authority.

[3] Please note that for some model conditions, such as model conditions for dams associated with a resource activity - non mining activity, the notification requirements may be located in a separate part of the conditions of an environmental authority (e.g. under notification requirement conditions).

G26	**Register of Regulated Dams** A Register of Regulated Dams must be established and maintained by the holder for each regulated dam.
G27	The holder must provisionally enter the required information in the Register of Regulated Dams when a design plan for a regulated dam is submitted to the administering authority.
G28	The holder must make a final entry of the required information in the Register of Regulated Dams once compliance with condition **G10** has been achieved.
G29	The holder must ensure that the information contained in the Register of Regulated Dams is current and complete on any given day.
G30	All entries in the Register of Regulated Dams must be approved by the chief executive officer for the holder of this authority, or their delegate, as being accurate and correct.
G31	The holder must, at the same time as providing the annual return, supply to the administering authority a copy of the records contained in the Register of Regulated Dams, in the electronic format required by the administering authority.

Agency interest: Biodiversity Offsets	
Condition number	**Condition**
H1	Impacts to prescribed environmental matters as per the *Environmental Offsets Act 2014,* are only authorised to occur if: a) for the prescribed environmental matters specified in **Table H1: Authorised Impacts to Prescribed Environmental Matters**, and as indicated in Attachment 1: Location of Authorised Impacts to Prescribed Environmental Matters; and b) for the prescribed environmental matters specified in **Table H1: Authorised Impacts to Prescribed Environmental Matters**, the impacts do not exceed the maximum extent of impact specified for that prescribed environmental matter.
H2	An environmental offset must be delivered for each specified matter in **Table H1: Authorised Impacts to Prescribed Environmental Matters**.
H3	A notice of election must be provided to the administering authority no less than three months before the proposed commencement of the impacts to the prescribed environmental matters.

Table H1 – Authorised Impacts to Prescribed Environmental Matters

Prescribed environmental matter	Maximum extent of impact	Environmental offset required
Endangered regional ecosystem – 11.4.8	*0.428ha*	*No*
Endangered regional ecosystem – 11.4.9	*3.353ha*	*Yes*
Least concern regional ecosystem (not in an urban area) within a defined distance from the defining banks of a relevant watercourse – 11.3.25	*1.488ha*	*Yes*
Habitat for an animal that is vulnerable wildlife – Ornamental Snake	*3.781ha*	*Yes*

Agency Interest – Cultural Heritage	
Condition number	**Condition**
I1	A report detailing the results of the Non-Indigenous cultural heritage field survey and historical background study, including methodology, results and proposed mitigation measures for any identified cultural heritage values, is to be provided to administering authority prior to the commencement of any construction works. Any identified cultural heritage values should be assessed for significance against the criteria in *Queensland Heritage Act 1992*. A Historic Heritage Management Plan is to be provided to the administering authority prior to construction.

Agency interests: Community	
Condition number	**Condition**
J1	**Complaint response** All environmental complaints received must be recorded including investigations undertaken, conclusions formed and action taken. This information must be made available to the administering authority on request.

J2	The holder of this environmental authority must record the following details for all complaints received and provide this information to the administering authority on request: a) name, address and contact number for complainant (if not available; record – not identified); b) time and date of complaint; c) investigations undertaken; d) conclusions formed; e) actions taken to resolve complaint; f) any abatement measures implemented; and g) person responsible for resolving the complaint.
J3	When requested by the administering authority, the environmental authority holder must undertake relevant specified monitoring within a reasonable and practicable timeframe nominated by the administering authority to investigate any complaint (which is not frivolous nor vexatious nor based on misbelieve in the opinion of the administering authority) of environmental harm at any sensitive place or commercial place. The results of the investigation (including an analysis an interpretation of the monitoring results) and abatement measures implemented must be provided to the administering authority within fourteen (14) days of completion of the investigation.
J4	In consultation with the administering authority, the environmental authority holder must cooperate with and participate in any appropriate community environmental liaison committee.

Definitions

Key terms and/or phrases used in this document are defined in this section and **bolded** throughout this document. Applicants should note that where a term is not defined, the definition in the *Environmental Protection Act 1994*, its regulations or environmental protection policies must be used. If a word remains undefined it has its ordinary meaning.

"acceptance criteria" means the measures by which the actions implemented to rehabilitate the land are deemed to be complete (same as completion criteria). The acceptance criteria indicate the success of the decommissioning and rehabilitation outcomes or remediation of areas which have been significantly disturbed by the environmentally relevant activities. Acceptance criteria may include information regarding:

a) stability of final land forms in terms of settlement, erosion, weathering, ponding and drainage;

b) control of geochemical and contaminant transport processes;

c) quality of runoff waters and potential impact on receiving environment;

d) vegetation establishment, survival and succession;

e) vegetation productivity, sustained growth and structure development;

f) fauna colonisation and habitat development;

g) ecosystem processes such as soil development and nutrient cycling, and the re-colonisation of specific fauna groups such as collembola, mites and termites which are involved in these processes;

h) microbiological studies including recolonisation by mycorrhizal fungi, microbial biomass and respiration;

i) effects of various establishment treatments such as deep ripping, topsoil handling, seeding and fertiliser application on vegetation growth and development;

j) resilience of vegetation to disease, insect attack, drought and fire; and

k) vegetation water use and effects on ground water levels and catchment yields.

"accepted engineering standards" in relation to dams, means those standards of design, construction, operation and maintenance that are broadly accepted within the profession of engineering as being good practice for the purpose and application being considered. In the case of dams, the most relevant documents would be publications of the Australian National Committee on Large Dams (ANCOLD), guidelines published by Queensland government departments, and relevant Australian and New Zealand Standards.

"acid rock drainage" means any contaminated discharge emanating from a mining activity formed through a series of chemical and biological reactions, when geological strata is disturbed and exposed to oxygen and moisture as a result of mining activity.

"active waste disposal cell" means a cell currently being used for the disposal of wastes accepted under a condition of this approval and includes all or part of a disposal cell.

"administering authority" means the Department of Environment and Heritage Protection or its successor.

"affected person" is someone whose drinking water can potentially be impacted as a result of discharges from a dam or their life can be put at risk due to dwellings or workplaces being in the path of a dam break flood.

"aged biosolids" means biosolids (sewage sludge) that has been aged for a period of not less than three (3) years.

"annual inspection report" means an assessment prepared by a suitably qualified and experienced person containing details of the assessment against the most recent consequence assessment report and design plan (or system design plan);

"annual exceedance probability" or **"AEP"** means the probability that at least one event in excess of a particular magnitude will occur in any given year.

"airblast overpressure" means energy transmitted from the blast site within the atmosphere in the form of pressure waves. The maximum excess pressure in this wave, above ambient pressure, is the peak airblast overpressure measured in decibels linear (dBL).

"ambient (or total) noise" at a place, means the level of noise at the place from all sources (near and far), measured as the Leq for an appropriate time interval.

"ANZECC" means the Australian and New Zealand Guidelines for Fresh Marine Water Quality 2000

"appropriately qualified person" means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relative to the subject matter using the relevant protocols, standards, methods or literature.

"ARD" means acid rock drainage and refers to the low pH, high heavy metal pollutant typical of sulphidic mine wastes, and most commonly associated with the production of ferrous iron and sulphuric acid through the oxidation of sulphide minerals.

"assessed" or **"assessment"** by a suitably qualified and experienced person in relation to a hazard assessment of a dam, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit at any time:

a) exactly what has been assessed and the precise nature of that assessment;

b) the relevant legislative, regulatory and technical criteria on which the assessment has been based;

c) the relevant data and facts on which the assessment has been based, the source of that material, and the efforts made to obtain all relevant data and facts; and

d) the reasoning on which the assessment has been based using the relevant data and facts, and the relevant criteria

"associated works" in relation to a dam, means:

a) operations of any kind and all things constructed, erected or installed for that dam; and

b) any land used for those operations.

"authority" means environmental authority (mining activities) under the *Environmental Protection Act 1994*.

"bed and banks" for a waters, river, creek, stream, lake, lagoon, pond, swamp, wetland or dam means land over which the water of the waters, lake, lagoon, pond, swamp, wetland or dam normally flows or that is normally covered by the water, whether permanently or intermittently; but does not include land adjoining or adjacent to the bed and banks that is from time to time covered by floodwater.

"beneficial use" in respect of dams means that the current or proposed owner of the land on which a dam stands, has found a use for that dam that is:

a) of benefit to that owner in that it adds real value to their business or to the general community;

b) in accordance with relevant provisions of the *Environmental Protection Act 1994*;

c) sustainable by virtue of written undertakings given by that owner to maintain that dam; and

d) the transfer and use have been approved or authorised under any relevant legislation.

"biosolids" means the treated and stabilised solids from sewage.

"blasting" means the use of explosive materials to fracture-

a) rock, coal and other minerals for later recovery; or

b) structural components or other items to facilitate removal from a site or for reuse.

"bunded" means within bunding consistent with Australian Standard 1940.

"capping" means the covering of a landfill with impervious material to inhibit penetration by liquids.

"certification", **"certifying"**, **"certify"** or **"certified"** by a suitably qualified and experienced person in relation to a design plan or an annual report regarding dams, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit of:

a) exactly what is being certified and the precise nature of that certification.
b) the relevant legislative, regulatory and technical criteria on which the certification has been based;
c) the relevant data and facts on which the certification has been based, the source of that material, and the efforts made to obtain all relevant data and facts; and
d) the reasoning on which the certification has been based using the relevant data and facts, and the relevant criteria.

"chemical" means –

a) an agricultural chemical product or veterinary chemical product within the meaning of the *Agricultural and Veterinary Chemicals Code Act 1994* (Commonwealth); or

b) a dangerous good under the dangerous goods code; or

c) a lead hazardous substance within the meaning of the *Workplace Health and Safety Regulation 2008*; or

d) a drug or poison in the Standard for the Uniform Scheduling of Drugs and Poisons prepared by the Australian Health Ministers' Advisory Council and published by the Commonwealth; or

e) any substance used as, or intended for use as –

   i) a pesticide, insecticide, fungicide, herbicide, rodenticide, nematocide, miticide, fumigant or related product; or
   ii) a surface active agent, including, for example, soap or related detergent; or
   iii) a paint solvent, pigment, dye, printing ink, industrial polish, adhesive, sealant, food additive, bleach, sanitiser, disinfectant, or biocide; or
   iv) a fertiliser for agricultural, horticultural or garden use; or

f) a substance used for, or intended for use for –

   i) mineral processing or treatment of metal, pulp and paper, textile, timber, water or wastewater; or

ii) manufacture of plastic or synthetic rubber.

"clinical waste" means waste that has the potential to cause disease including, for example, the following:

a) animal waste;
b) discarded sharps;
c) human tissue waste; or
d) laboratory waste.

"commercial place" means a work place used as an office or for business or commercial purposes, which is not part of the mining activity and does not include employees accommodation or public roads.

"competent person" means a person with the demonstrated skill and knowledge required to carry out the task to a standard necessary for the reliance upon collected data or protection of the environment.

"construction" or "constructed" in relation to a dam includes building a new dam and modifying or lifting an existing dam, but does not include investigations and testing necessary for purposes of preparing a design plan.

"consequence" in relation to a structure as defined, means the potential for environmental harm resulting from the collapse or failure of the structure to perform its primary purpose of containing, diverting or controlling flowable substances.

"consequence category" means a category, either low, significant or high, into which a dam is assessed as a result of the application of tables and other criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*.

"contaminate" means to render impure by contact or mixture.

"contaminated" means the substance has come into contact with a contaminant.

"contaminant" A contaminant can be –

a) a gas, liquid or solid;

b) an odour;

c) an organism (whether alive or dead), including a virus;

d) energy, including noise, heat, radioactivity and electromagnetic radiation; or

e) a combination of contaminants.

"control measure" means any action or activity that can be used to prevent or eliminate a hazard or reduce it to an acceptable level.

"cover material" means any soil or rock suitable as a germination medium or landform armouring.

"critical duration" is the storm duration which, for a given notional AEP, would cause the maximum discharge through the spillway of a regulated dam if the dam were full at the commencement of the storm.

"dam" means a land-based structure or a void that is designed to contain, divert or control flowable substances, and includes any substances that are thereby contained, diverted or controlled by that land-based structure or void and associated works. A dam does *not* mean a fabricated or manufactured tank or container, designed and constructed to an Australian Standard that deals with strength and structural integrity of that tank or container.

"dam crest volume" means the volume of material that could be within the walls of a dam at any time when the upper level of that material is at the crest level of that dam. That is, the instantaneous maximum volume within

the walls, without regard to flows entering or leaving (eg via spillway).

"dB" means decibel. The unit used to measure sound level.

"designer" for the purposes of a regulated dam, means the certifier of the design plan for the regulated dam.

"design plan" is the documentation required to describe the physical dimensions of the dam, the materials and standards to be used for construction of the dam, and the criteria to be used for operating the dam. The documents must include all investigation and design reports, plans and specifications sufficient to hand to a contractor for construction, and planned decommissioning and rehabilitation outcomes; so as to address all hazard scenarios that would be identified by a properly conducted hazard assessment for the structure. Documentation must be such that a 'suitable qualified and experience person' could conduct an independent review without seeking further information from the designer.

"design storage allowance" or **"DSA"** means an available volume, estimated in accordance with the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* published by the Department of Environment and Heritage Protection, that must be provided in a dam as at the first of November each year in order to prevent a discharge from that dam to an annual exceedance probability (AEP) specified in that Manual.

"designer" for the purposes of a regulated dam, means the certifier of the design plan for the regulated dam.

"development approval" means a development approval under the *Sustainable Planning Act 2009* in relation to a matter that involves an environmentally relevant activity under the *Environmental Protection Act 1994*.

"domestic waste" means waste, other than domestic clean-up waste, green waste, recyclable waste, interceptor waste or waste discharged to a sewer, produced as a result of the ordinary use or occupation of domestic premises.

"dwelling" means any of the following structures or vehicles that is principally used as a residence –

a) a house, unit, motel, nursing home or other building or part of a building;

b) a caravan, mobile home or other vehicle or structure on land; or

c) a water craft in a marina.

"effluent" treated waste water discharged from sewage treatment plants.

"emergency action plan" means documentation forming part of the operational plan held by the holder or a nominated responsible officer, that identifies emergency conditions that sets out procedures and actions that will be followed and taken by the dam owner and operating personnel in the event of an emergency. The actions are to minimise the risk and consequences of failure, and ensure timely warning to downstream communities and the implementation of protection measures. The plan must require dam owners to annually update contact details that are part of the plan, and be comprehensively reviewed at least every five years.

"existing structure" means a structure that was in existence prior to the adoption of this schedule of conditions under the authority.

"extreme storm storage" – means a storm storage allowance determined in accordance with the criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)* published by the administering authority.

"end of pipe" means the location at which water is released to waters or land.

"environmental authority" means an environmental authority under Chapter 5 of the *Environmental Protection*

Act 1994.

"environmental authority holder" means the holder of this environmental authority.

"environmentally relevant activity" means an environmentally relevant activity as defined under Section 18 of the *Environmental Protection Act 1994* and listed under Schedule 2 and 2A of the *Environmental Protection Regulation 2008.*

"equivalent passenger-tyre unit (EPU)" is equivalent to one passenger tyre from a normal sedan or station wagon.

"financial assurance" means a security required under the *Environmental Protection Act 1994* by the administering authority to cover the cost of rehabilitation or remediation of disturbed land or to secure compliance with the environmental authority.

"floodwater" means water overflowing, or that has overflowed, from waters, river, creek, stream, lake, pond, wetland or dam onto or over riparian land that is not submerged when the watercourse or lake flows between or is contained within its bed and banks.

"flowable substance" means matter or a mixture of materials which can flow under any conditions potentially affecting that substance. Constituents of a flowable substance can include water, other liquids fluids or solids, or a mixture that includes water and any other liquids fluids or solids either in solution or suspension.

"foreseeable future" is the period used for assessing the total probability of an event occurring. Permanent structures and ecological sustainability should be expected to still exist at the end of a 150 year period.

"general waste" means waste other than regulated waste.

"hazardous waste" means a substance, whether liquid, solid or gaseous that, if improperly treated, stored, disposed of or otherwise managed, is likely to cause environmental harm.

"hazard" in relation to a dam as defined, means the potential for environmental harm resulting from the collapse or failure of the dam to perform its primary purpose of containing, diverting or controlling flowable substances.

"hazard category" means a category, either low, significant or high, into which a dam is assessed as a result of the application of tables and other criteria in the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams*.

"holder" means:

a) where this document is an environmental authority, any person who is the holder of, or is acting under, that environmental authority; or

b) where this document is a development approval, any person who is the registered operator for that development approval.

"hydraulic performance" means the capacity of a regulated dam to contain or safely pass flowable substances based on a probability (AEP) of performance failure specified for the relevant hazard category in the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams*.

"infrastructure" means water storage dams, roads and tracks, buildings and other structures built for the purpose of mining activities but does not include other facilities required for the long term management of mining impacts or the protection of potential resources. Such other facilities include dams, waste rock dumps, voids, or ore stockpiles and buildings as well as other structures whose ownership can be transferred and which have a residual beneficial use for the next owner of the operational land or the background land owner.

"LA 10, adj, 10 mins" means the A-weighted sound pressure level, (adjusted for tonal character and impulsiveness of the sound) exceeded for 10% of any 10-minute measurement period, using Fast response.

"LA 1, adj, 10 mins" means the A-weighted sound pressure level, (adjusted for tonal character and impulsiveness of the sound) exceeded for 1% of any 10-minute measurement period, using Fast response

"LA, max adj, T" means the average maximum A-weighted sound pressure level, adjusted for noise character and measured over any 10 minute period, using Fast response.

"lake" includes –

a) lagoon, swamp or other natural collection of water, whether permanent or intermittent; and

b) the bed and banks and any other element confining or containing the water.

"land" in the 'land schedule' of this document means land excluding waters and the atmosphere "noise sensitive place" or a "commercial place"

"land use" term to describe the selected post mining use of the land, which is planned to occur after the cessation of mining operations.

"landfill" means land used as a waste disposal site for lawfully putting solid waste on the land.

"leachate" means a liquid that has passed through or emerged from, or is likely to have passed through or emerged from, a material stored, processed or disposed of at the operational land which contains soluble, suspended or miscible contaminants likely to have been derived from the said material.

"leaching contaminant levels" means the results of the "T*oxicity Characteristic Leaching Procedure (TCLP)*" means the test described in "*U.S. EPA: Toxicity Characteristic Leaching Procedure (TCLP)*" Federal Register, 40 CFR, Vol. 51, No. 286, Appendix 2, Part 268, page 40643 or as modified to reflect non-acidic leaching procedures suitable for waste characteristic assessment where co-disposal with putrescible wastes will not occur.

"levee" means an embankment that only provides for the containment and diversion of stormwater or flood flows from a contributing catchment, or containment and diversion of flowable materials resulting from releases from other works, during the progress of those stormwater or flood flows or those releases; and does not store any significant volume of water or flowable substances at any other times.

"long term 50th percentile" means that not more than twenty-six (26) of the measured values of the quality characteristic are to exceed the stated release limit for any fifty-two (52) consecutive samples where:

a) the consecutive samples are taken over a one (1) year period;
b) the consecutive samples are taken at approximately equal periods; and
c) the time interval between the taking of each consecutive sample is not less than three (3) days or greater than eleven (11) days.

"low consequence dam" means any dam that is not a high or significant consequence category as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (EM635); and

"mandatory reporting level" or **"MRL"** means a warning and reporting level determined in accordance with the criteria in the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* published by the Department of Environment and Heritage Protection.

"manual" means the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures*

(EM635) published by the administering authority.

"Mining Operations" authorised activities:

a) including mine construction, resource extraction, mineral processing, mine site management, rehabilitation and decommissioning; and
b) excluding exploration activities detailed in the current Plan of Operations.

"modification or modifying" (see definition of 'construction')

"operational plan" includes:
a) normal operating procedures and rules (including clear documentation and definition of process inputs in the DSA allowance);

b) contingency and emergency action plans including operating procedures designed to avoid and/or minimise environmental impacts including threats to human life resulting from any overtopping or loss of structural integrity of the regulated structure.

"register of regulated dams" includes**:**
a) date of entry in the register;

b) name of the dam, its purpose and intended/actual contents;

c) the consequence category of the dam as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (EM635);

d) for the regulated dam, other than in relation to any levees –

   i) the dimensions (metres) and surface area (hectares) of the dam measured at the footprint of the dam;
   ii) coordinates (latitude and longitude in GDA94) within five metres at any point from the outside of the dam including its storage area
   iii) dam crest volume (megalitres);
   iv) spillway crest level (metres AHD).
   v) maximum operating level (metres AHD);
   vi) storage rating table of stored volume versus level (metres AHD);
   vii) design storage allowance (megalitres) and associated level of the dam (metres AHD);
   viii) mandatory reporting level (metres AHD);

e) the design plan title and reference relevant to the dam;
f) the date construction was certified as compliant with the design plan;
g) the name and details of the suitably qualified and experienced person who certified that the constructed dam was compliant with the design plan;
h) details of the composition and construction of any liner;
i) the system for the detection of any leakage through the floor and sides of the dam;
j) dates when the regulated dam underwent an annual inspection for structural and operational adequacy, and to ascertain the available storage volume for 1 November of any year;
k) dates when recommendations and actions arising from the annual inspection were provided to the administering authority;
l) dam water quality as obtained from
m) dates, names, and reference for the design plan plus dates, names, and reference numbers of all document(s) lodged as part of a design plan for the dam;
n) name and qualifications of the suitably qualified and experienced person who certified the design plan and 'as constructed' drawings;

"measures" includes any measures to prevent or minimise environmental impacts of the activity such as

bunds, silt fences, diversion drains, capping, and containment systems.

"metalliferous mine drainage" means any waters, contaminated with metals / metalloids or other contaminants as a result of the mining activities.

"mg/L" means milligrams per litre.

"mineral" means a substance which normally occurs naturally as part of the earth's crust or is dissolved or suspended in water within or upon the earth's crust and includes a substance which may be extracted from such a substance, and includes—

a) clay if mined for use for its ceramic properties, kaolin and bentonite;
b) foundry sand;
c) hydrocarbons and other substances or matter occurring in association with shale or coal and necessarily mined, extracted, produced or released by or in connection with mining for shale or coal or for the purpose of enhancing the safety of current or future mining operations for coal or the extraction or production of mineral oil there from;
d) limestone if mined for use for its chemical properties;
e) marble;
f) mineral oil or gas extracted or produced from shale or coal by in situ processes;
g) peat;
h) salt including brine;
i) shale from which mineral oil may be extracted or produced;
j) silica, including silica sand, if mined for use for its chemical properties;
k) rock mined in block or slab form for building or monumental purposes;

But does not include—

a) living matter;
b) petroleum within the meaning of the *Petroleum Act 1923*;
c) soil, sand, gravel or rock (other than rock mined in block or slab form for building or monumental purposes) to be used or to be supplied for use as such, whether intact or in broken form;
d) water.

"mine affected water" means the following types of water:

a) pit water, tailings dam water, processing plant water;
b) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the *Environmental Protection Regulation 2008* if it had not formed part of the mining activity;
c) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage runoff containing sediment only, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water;
d) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated;
e) groundwater from the mine's dewatering activities;
f) a mix of mine affected water (under any of paragraphs i)-v)) and other water.

"mining related infrastructure" The facilities, structures and installations needed for mining including but not limited to mining transportation networks, processing plant, communications systems and tailings storage

facilities.

"NAF" means non-acid forming waste rock.

"natural flow" means the flow of water through waters caused by nature.

"nature" includes:

a) ecosystems and their constituent parts; and
b) all natural and physical resources; and
c) natural dynamic processes.

"noxious" means harmful or injurious to health or physical wellbeing, other than trivial harm.

"non-polluting" means having no adverse impacts upon the receiving environment.

"nuisance sensitive place" includes –

a) a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises; or
b) a motel, hotel or hostel; or
c) a kindergarten, school, university or other educational institution; or
d) a medical centre or hospital; or
e) a protected area under the *Nature Conservation Act 1992*, the *Marine Parks Act 1992* or a World Heritage Area; or
f) a public thoroughfare, park or gardens; or
g) a place used as a workplace, an office or for business or commercial purposes and includes a place within the curtilage of such a place reasonably used by persons at that place.

"offensive" means causing reasonable offence or displeasure; is disagreeable to the sense; disgusting, nauseous or repulsive, other than trivial harm.

"operational land" means the land associated with the project for which this environmental authority has been issued.

"operational plan" means a document that amongst other things sets out procedures and criteria to be used for operating a dam during a particular time period. The operational plan as defined herein may form part of a plan of operations or plan otherwise required in legislation.

"PAF" means potentially acid forming waste rock.

"palletised" means stored on a movable platform on which batteries are placed for storage or transportation.

"peak particle velocity (ppv)" means a measure of ground vibration magnitude which is the maximum rate of change of ground displacement with time, usually measured in millimetres/second (mms).

"permeability" means a measure of the rate at which a fluid will pass through a medium. The coefficient of permeability of a given fluid is an expression of the rate of flow through unit area and thickness under unit differential pressure at a given temperature. Synonymous with hydraulic conductivity when the fluid is water.

"probable maximum flood (PMF)" is the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area.

"protected area" means:

a) a protected area under the *Nature Conservation Act 1992*;

b) a marine park under the *Marine Parks Act 2004*; or
c) a World Heritage Area.

"progressive rehabilitation" means rehabilitation (defined below) undertaken progressively or a staged approach to rehabilitation as mining operations are ongoing.

"process water" means water used or produced during the mineral development activities.

"receiving environment" means all groundwater, surface water, land and sediments that are not disturbed areas authorised by this environmental authority.

"receiving waters" means all groundwater and surface water that are not disturbed areas authorised by this environmental authority.

"recycled water" means appropriately treated effluent and urban stormwater suitable for further use.

"reference site" (or analogue site) may reflect the original location, adjacent area or another area where rehabilitation success has been completed for a similar biodiversity. Details of the reference site may be as photographs, computer generated images and vegetation models etc.

"regulated dam" means any dam in the significant or high hazard category as assessed using the *"Manual for Assessing Hazard Categories and Hydraulic Performance of Dams"* published by the Administering Authority.

"regulated waste" means non-domestic waste mentioned in schedule 7 of the *Environmental Protection Regulation 2008* (whether or not it has been treated or immobilised), and includes –

a) for an element – any chemical compound containing the element; and
b) anything that has contained the waste.

"rehabilitation" the process of reshaping and revegetating land to restore it to a stable landform and in accordance with the acceptance criteria set out in this environmental authority and, where relevant, includes remediation of contaminated land.

"representative" means a sample set which covers the variance in monitoring or other data either due to natural changes or operational phases of the mining activities.

"residual void" means an open pit resulting from the removal of ore and/or waste rock which will remain following the cessation of all mining activities and completion of rehabilitation processes.

"saline drainage" the movement of waters, contaminated with salt(s), as a result of the mining activity.

"self sustaining" means an area of land which has been rehabilitated and has maintained the required acceptance criteria without human intervention for a period nominated by the administering authority.

"sensitive place" means:

a) a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises;
b) a motel, hotel or hostel;
c) an educational institution;
d) a medical centre or hospital;
e) a protected area under the *Nature Conservation Act 1992*, the *Marine Parks Act 2004* or a World Heritage Area;
f) a public park or gardens; or
g) a place used as a workplace, an office or for business or commercial purposes which is not part of the

mining activity and does not include employees accommodation or public roads.

"sewage" means the used water of person's to be treated at a sewage treatment plant.

"short term 50th percentile" means not more than five (5) of the measured values of the quality characteristic are to exceed the stated release limit for any ten (10) consecutive samples for a release/monitoring point at any time during operation.

"spillway" means a weir, channel, conduit, tunnel, gate or other structure designed to permit discharges from the dam, normally under flood conditions or in anticipation of flood conditions.

"stable" in relation to land, means land form dimensions are or will be stable within tolerable limits now and in the foreseeable future. Stability includes consideration of geotechnical stability, settlement and consolidation allowances, bearing capacity (trafficability), erosion resistance and geochemical stability with respect to seepage, leachate and related contaminant generation.

"stormwater" means all surface water runoff from rainfall.

"suitably qualified and experienced person" in relation to dams means a person who is a Registered Professional Engineer of Queensland (RPEQ) under the provisions of the *Professional Engineers Act 2002*, or at the relevant time holds a 'deemed registration' within the meaning of the *Mutual Recognition (Queensland) Act 1992*; and has knowledge, suitable experience and demonstrated expertise in relevant fields, as set out below:

a) knowledge of engineering principles related to the structures, geomechanics, hydrology, hydraulics, chemistry and environmental impact of dams;
b) a total of five years of demonstrated expertise in the geomechanics of dams with particular emphasis on stability, geology and geochemistry;
c) a total of five years of demonstrated expertise in at least three of the following categories:
    i) investigation and design of dams;
    ii) construction, operation and maintenance of dams;
    iii) hydrology with particular reference to flooding, estimation of extreme storms, water management or meteorology;
    iv) hydraulics with particular reference to sediment transport and deposition, erosion control, beach processes;
    v) hydrogeology with particular reference to seepage, groundwater;
    vi) solute transport processes and monitoring thereof; or
    vii) dam safety.

"trackable waste" means a waste or combination of waste stated in Schedule 2E of the *Environmental Protection Regulation 2008.*

"terminal dam, pond, storage or component" are elements of containment systems, when overfull, overflow directly to the environment.

"trivial harm" means environmental harm which is not material or serious environmental harm and will not cause actual or potential loss or damage to property of an amount of, or amounts totalling more than $5,000.

"tolerable limits" means a range of parameters regarded as being sufficient to meet the objective of protecting relevant environmental values. For example, a range of settlement for a tailings capping, rather than a single value, could still meet the objective of draining the cap quickly, preventing pondage and limiting infiltration and

percolation.

"void" means any man-made, open excavation in the ground.

"waste" as defined in section 13 of the *Environmental Protection Act 1994*.

"water" means –

a) water in waters or spring;
b) underground water;
c) overland flow water; or
d) water that has been collected in a dam.

"waste water" means used water from the activity, process water or contaminated storm water.

"water quality" means the chemical, physical and biological condition of water.

"waters" includes –

a) river, creek, stream in which water flows permanently or intermittently either:
   i) in a natural channel, whether artificially improved or not; or
   ii) in an artificial channel that has changed the course of the river, creek or stream;
b) lake, lagoon, pond, swamp, wetland, dam;
c) unconfined surface water;
d) storm water channel, storm water drain, roadside gutter;
e) bed and banks and any other element of a river, creek, stream, lake, lagoon, pond, swamp, wetland, storm water channel, storm water drain, roadside gutter or dam confining or containing water;
f) groundwater;
g) non-tidal or tidal waters (including the sea); or
h) any part-thereof.

"water release event" means release of any waters that are or maybe contaminated by the mining activity.

"µg/L" means micrograms per litre.

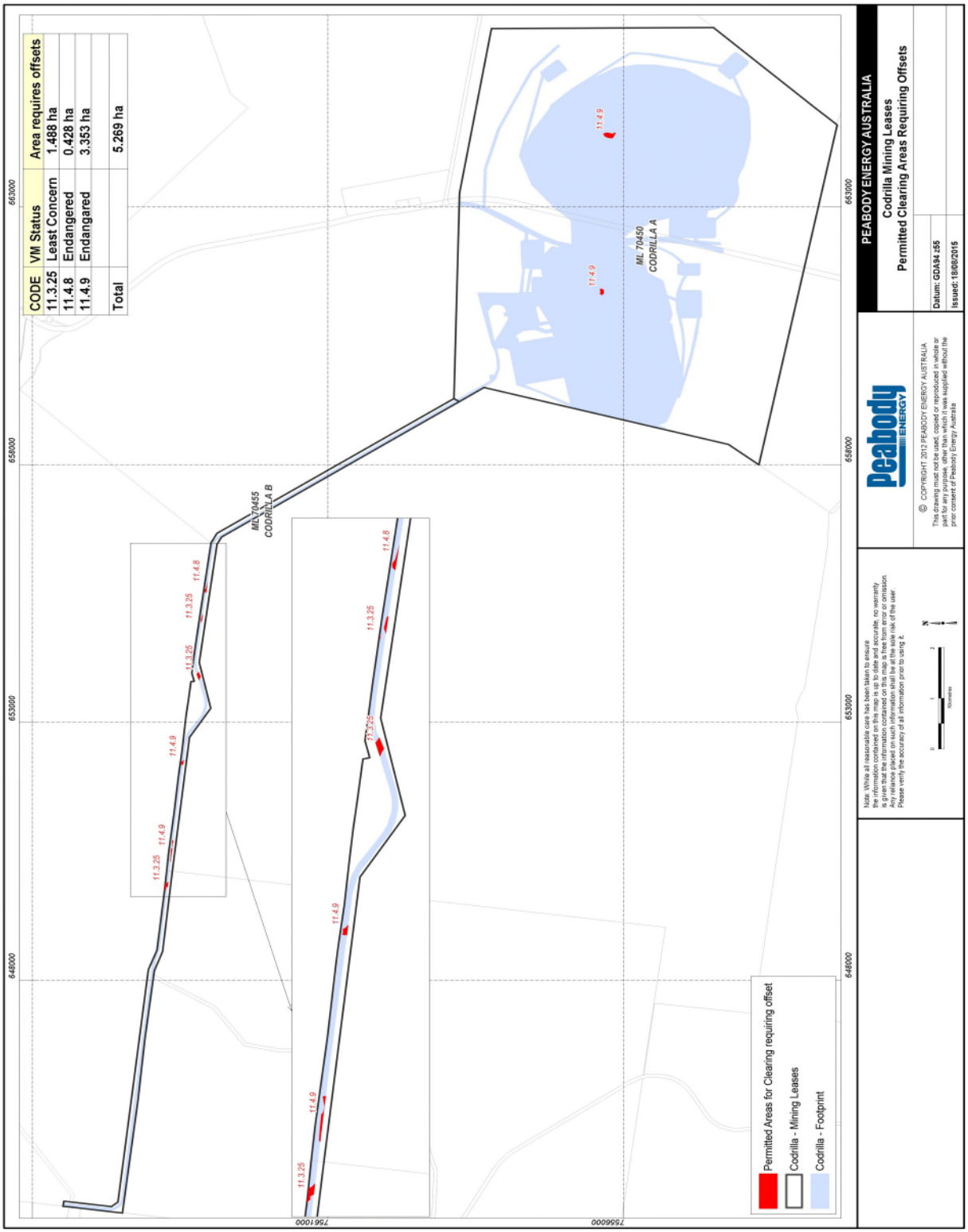
"µS/cm" means microsiemens per centimetre.

END OF CONDITIONS

Attachments

Attachment 1: Location of Authorised Impacts to Prescribed Environmental Matters

Attachment 1: Location of Authorised Impacts to Prescribed Environmental Matters



END OF PERMIT

Department of Environment
and Resource Management

EIS Assessment Report for the Codrilla Coal Mine Project

October 2011

Tomorrow's Queensland: strong, green, smart, healthy and fair

Toward Q2 Tomorrow's Queensland

Queensland Government

[For science/technical publications only. Citation reference to be supplied by author of the work.]

Prepared by:
[Insert business unit or group here]
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Contact (07) 322 48412 or email <library@derm.qld.gov.au>

October 2011

Contents

1 Introduction i

2 Project details 2

3 The EIS process 3

3.1 Timeline of the EIS process 3

3.2 Environmental Approvals 4

3.3 Consultation program 4

3.4 Matters considered in the EIS assessment report 5

3.5 Environment Protection and Biodiversity Conservation Act 1999 8

4 Adequacy of the EIS in addressing the TOR 9

4.1 Introduction 10

4.2 Project need and alternatives 10

4.3 Project description 11

4.4 Climate 11

4.5 Land 11

4.6 Transport 14

4.7 Waste 20

4.8 Water resources 24

4.9 Air quality 30

4.10 Noise and vibration 32

4.11 Nature conservation 35

4.12 Matters of National Environmental Significance 39

4.13 Cultural heritage 42

4.14 Social issues 43

4.15 Health and safety 46

4.16 Hazard and risk 48

4.17 Rehabilitation 49

5 Adequacy of the environmental management plan 51

6 Suitability of the project 51

7 Recommended conditions 51

8 Completion of this EIS process 52

List of tables

Table 4.1 - Summary of the adequacy of the EIS in addressing the TOR 9

Table 4.2 - Approvals for the Codrilla Coal Mine Project 10

Table 4.3 - Notifiable activities 13

Table 4.4- Sensitive Locations 30

Table 4.5 - Recommended Noise Limits 33

Table 4.6 - Predicted Noise Limits for All Years of Operation 33

Table 4.7 - Extent of clearing REs required for the project 35

Table 4.8 - Risk Assessment Table 48

1 Introduction

This report provides an evaluation of the environmental impact statement (EIS) process pursuant to Chapter 3 of the *Environmental Protection Act 1994* (EP Act) for the Codrilla Coal Mine Project (Codrilla Project) proposed by the Coppabella and Moorvale Joint Venture

The Department of Environment and Resource Management (DERM) as the administering authority for the EP Act, coordinated the EIS process. This assessment report has been prepared pursuant to Sections 58 and 59 of the EP Act. Section 58 of the EP Act lists the criteria that the DERM must consider when preparing an EIS assessment report, while section 59 of the Act states what the content must be.

The Act requires that this EIS assessment report must:

(a) address the adequacy of the EIS in addressing the final terms of reference (TOR)

(b) address the adequacy of the draft environmental management plan (EM plan)

(c) make recommendations about the suitability of the project

(d) recommend any conditions on which any approval required for the project may be given.

In providing the required content, this assessment report will summarise key issues associated with the potentially adverse and beneficial environmental, economic and social impacts of the project. It will discuss the management, monitoring, planning and other measures proposed to minimise any adverse environmental impacts of the project. It will also discuss those issues of particular concern that were either not resolved or require specific conditions for the project to proceed.

Chapter 2 of this EIS assessment report outlines the project to provide context for the findings of the report. Chapter 3 outlines the EIS process that has been followed for the project and the approvals that will be necessary for its commencement. Chapter 4 addresses the adequacy of the EIS, discusses the main issues with regard to the environmental management of the project, and outlines the environmental protection commitments made in the EIS. Chapter 5 of this EIS assessment report assesses the adequacy of the environmental management plan (EM plan) for the project in incorporating the environmental protection commitments, and meeting the content requirements of section 203 of the EP Act. Chapter 6 discusses the suitability of the project and chapter 7 makes recommendations for conditions to be included in the draft environmental authority.

The giving of this EIS assessment report to the proponent completes the EIS process under the EP Act.

2 Project details

Initially the Codrilla Project was proposed by the Bowen Basin Coal Joint Venture (BB Coal JV), which was a joint venture arrangement between Bowen Basin Investments Pty Ltd (85 per cent) and CITIC Bowen Basin Pty Ltd (15 per cent). BB Interests Pty Ltd is a 100 per cent owned subsidiary of Macarthur Coal Limited and CITIC Bowen Basin Pty Ltd is a 100 per cent subsidiary of CITIC Australia Pty Ltd.

On 30 June 2011, the joint venture parties entered an arrangement to sell the Codrilla Project to the Coppabella and Moorvale Joint Venture (CMJV). The sale involved Macarthur Coal and CITIC's subsidiaries selling a 19.7% interest in the project to the CMJV, with Macarthur Coal retaining a 73.3% ownership of the Codrilla Project and CITIC retaining a 7% ownership through their subsidiaries' participation in the CMJV (reflecting the ownership of the Coppabella and Moorvale mines).

The proposed mine, located approximately 120 km south-west of Mackay, involves two mining lease (ML) applications. The main lease (Codrilla A ML) containing the mining operations and infrastructure would be located within Exploration Permit Coal 676 (EPC) tenement. The second lease (Codrilla B ML) would be for infrastructure and would contain the haul road from the Codrilla Coal Mine to the Moorvale Mine on ML 70290 (EPCs 676, 1044, 1146 and 649).

The proposed project involves development of a conventional truck and excavator open cut coal mine producing an average of approximately 4 million tonnes a year of Run of Mine Coal (ROM) which following processing would produce an average of 3.2 million tonnes a year of pulverised coal injection product for export. Run of mine coal would be processed on-site using conventional coal handling and preparation plant technologies. Process waste would be co-disposed with tailings, slurry and course rejects at on-site facilities. Product coal would be transported approximately 31 km to the existing Moorvale Mine train loading facility using road trains on a purpose built private haul road. Coal would then be railed to Dalrymple Bay Coal Terminal for export. The expected life of the project is 13 and a half years although that may be extended if the ongoing exploration program identifies additional resources.

It is anticipated that the project would involve significant associated civil works, including:

- realignment of the Fitzroy Developmental Road to enable full recovery of the economic coal resource,
- relocation of the Valkyrie School and school residence,
- a grade separated crossing of the Fitzroy Developmental Road by an internal mine haul road, and
- crossing of Devlin Creek and minor tributaries by the haul road.

The Codrilla Project is a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The State's environmental impact statement (EIS) process has been accredited for assessment under Part 8 of the EPBC Act in accordance with the Bilateral Agreement between the Commonwealth of Australia and the State of Queensland (2009). The controlling provisions are sections 18 and 18A (listed threatened species and communities).

3 The EIS process

3.1 Timeline of the EIS process

The EIS for the Codrilla Project was conducted under Chapter 3 of the EP Act. The EIS process was initiated by the proponent on 29 June 2009 by application to DERM to prepare a voluntary EIS under section 70 of the EP Act. DERM approved the application to undertake a voluntary EIS on 3 July 2009.

DERM issued a notice of publication of the draft TOR to the proponent on 24 July 2009. DERM placed a public notice on the DERM website on Friday 31 July 2009, in the Courier Mail and Mackay Daily Mercury on Saturday 1 August 2009 and the Emerald Central Queensland News on Wednesday 5 August 2009. The draft TOR were made available for public comment from Monday 3 August 2009 to Monday 14 September 2009. The proponent issued copies of the TOR notice to affected and interested persons.

Twenty six submissions were received by DERM on the draft TOR within the public comment period. These submissions, together with one from DERM, were forwarded to the proponent on 25 September 2009.

On 8 October 2009, the proponent requested an extension to the deadline for responding to comments on the draft TOR to 16 November 2009 and this was granted on 13 October 2009. DERM considered all submissions received on the draft TOR and the proponent's response, prior to issuing the final TOR on 17 December 2009.

On 30 September 2010, the proponent submitted the EIS to DERM for review prior to public notification. DERM compared the EIS to the final TOR and on 11 November 2010, DERM issued the proponent a notice of decision to proceed with the draft EIS. The public notification and submission period was set at 30 business days.

DERM placed a public notice on its website on 19 November 2010 and advertised in the Courier Mail and Mackay Daily Mercury on 20 November 2010 and the Central Queensland News on 19 November 2010. The EIS was made available for public comment from 22 November 2010 to 19 January 2011. The proponent also provided copies of the public notice of the EIS to affected and interested persons.

DERM received nine submissions on the EIS within the submission period. Three late submissions were also received and accepted by DERM. Six submissions were received from State Government Departments, one from the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), one from Isaac Regional Council, two from non-government organisations and two from land holders. These submissions, together with a submission from DERM, were forwarded to the proponent on 3 February 2011. On 14 March 2011 DERM also provided a late submission to the proponent. The late submission by DERM resulted from DERM being unable to provide a full submission due to the exceptional circumstances caused by flooding and cyclones between December 2010 and January 2011.

On 1 March 2011, the proponent held a meeting with DERM to give an update on the project status and discuss outstanding issues with the EIS.

On 2 March and again on 21 April 2011, the proponent requested an extension to the period required to provide responses to submissions. DERM agreed to these requests, seeking a final period ending on 30 June 2011.

On 16 March 2011, the proponent applied for an environmental authority for their mining lease application (ML 70450) that would cover the mining infrastructure area. On 2 June 2011, the proponent applied for ML 70455 that would cover the haul road for the project. DERM approved the application to be assessed as a Non-code Compliant Level 1 mining project requiring an Environmental Impact Statement (EIS). Consequently, the EIS process ceased to be voluntary and became required.

On 29 June 2011, the proponent held a meeting with DERM to give an update of the project. On 30 June 2011, DERM received a response to submissions for the project from the proponent. Copies of the response to submissions were forwarded to the advisory group and public members who commented on the EIS.

On 11 July 2011, DERM received a notice of amendment of EIS from the proponent under section 66 of the EP Act.

A review of the response to submissions by DERM showed that the proponent needed to provide additional information that would comprise part of the EIS. An extension notice was issued on 28 July 2011 with the deadline for making a s56A decision under the EP Act extended to 29 August 2011.

On 18 August 2011, the proponent held a meeting with DERM to discuss their proposed response to outstanding EIS issues.

On 24 August 2011, the proponent lodged a response to the DERM Notice of extension of decision dated 28 July 2011, that included a supplementary EIS V2 and an amended EM plan.

DERM decided under s56A of the EP Act on 29 August 2011 that the submitted EIS should proceed under Division 5 (EIS assessment report) and Division 6 (Completion of process) of the EP Act. A notice of the decision to allow the submitted EIS to proceed was issued to the proponent on 12 September 2011.

During the preparation of this EIS assessment report, DERM advised the proponent of its concerns with the contents of the EM plan as submitted.. Consequently, on 7 October 2011 and again on 12 October 2011, the proponent provided DERM with revised EM plans.

In the preparation of this EIS assessment report, DERM considered submissions and comments from members of the advisory body and other interested parties made throughout the EIS process. This EIS assessment report will be made available on DERM's website (www.derm.qld.gov.au).

3.2 Environmental Approvals

The Codrilla Project will require a mining lease for the mining infrastructure area (Codrilla A ML) and for the haul road (Codrilla B ML).

The project will also require an environmental authority under Chapter 5 of the EP Act. The environmental authority will need to cover the following activities that are directly associated with, or facilitate or support, the mining activities, and which would otherwise require approval under the *Sustainable Planning Act 2009*:

- ERA 8 (1)(c) - Chemical Storage
- ERA 21 - Motor Vehicle Workshop
- ERA 63 (1) - Sewage Treatment.

3.3 Consultation program

3.3.1 Public consultation

In addition to the statutory requirements for public notification of the TOR, the EIS, and identification of interested and affected parties, the proponent undertook community consultation with the affected landowners and government agencies during the public submission period on the EIS. The proponent also circulated information on the project to the community.

3.3.2 Advisory Body

DERM invited the following organisations to assist in the assessment of the TOR and EIS by participating as members of the advisory body for the project:

- Department of Communities
- Department of Community Safety
- Department of Education and Training
- Department of Employment, Economic Development and Innovation
- Former Department of Infrastructure and Planning
- Former Commonwealth Department of Environment, Water, Heritage and Arts
- Commonwealth Department of Sustainability, Environment, Water, Population and Communities

- Department of Transport and Main Roads
- Queensland Health
- Queensland Police Services
- Queensland Rail
- Queensland Treasury
- Isaac Regional Council
- North Queensland Land Council Native Title Representative Body
- Barada Barna People
- Construction, Forestry, Mining & Energy Union, Mining & Energy Division
- Fitzroy Basin Association
- Capricorn Conservation Council.

Advisory body meetings were held in Brisbane on 14 December 2010 and in Mackay on 11 January 2011 during the EIS public submission period.

3.3.3 Public notification

Due to Machinery of Government changes from 21 February 2011 (see Public Service Department Arrangements Notice No.1 2011), changes occurred to a number of Queensland Government departments. Consequently, the functions of the Coordinator General in the Department of Infrastructure and Planning (DIP) transferred to the Department of Employment, Economic Development and Innovation. Also the Planning Unit of DIP was separated from that department and became the Department of Local Government and Planning.

3.3.4 Public notification

In accordance with the statutory requirements, advertisements were placed in the Courier-Mail, Mackay Daily Mercury and Emerald Central Queensland News to notify the availability of the draft TOR and EIS for review and public comment as stated in Section 3.1. In addition, notices advising the availability of the draft TOR and the EIS for public comment were displayed on the DERM website.

The draft TOR and draft EIS were placed on public display at the following locations during their respective public notification/submission periods:

- DERM website
- DERM Customer Referral Centre, 400 George Street, Brisbane
- DERM Mackay Office, Level 1, 22-30 Wood Street
- Moranbah Town Library
- Macarthur Coal Limited, 100 Melbourne Street, South Brisbane.

The EIS was also made available for public viewing on the Macarthur Coal's website at <www.macarthurcoal.com.au>.

Copies of the EIS were made available from the proponent's consultants McCollum Environmental Management Services.

3.4 Matters considered in the EIS assessment report

Section 58 of the EP Act requires, when preparing an EIS assessment report, the consideration of the following matters:

- the final TOR for the EIS
- the submitted EIS
- all properly made submissions and any other submissions accepted by the chief executive

- the standard criteria
- another matter prescribed under a regulation.

These matters are addressed in the following subsections.

3.4.1 The final TOR

The final TOR document, issued on 17 December 2009, was considered when preparing this EIS assessment report. While the TOR was written to include all the major issues associated with the project that were required to be addressed in the EIS, they were not exhaustive, nor were they to be interpreted as excluding all other matters from consideration.

Where matters outside of those listed in the final TOR were addressed in the EIS, those matters have been considered when preparing this EIS assessment report.

3.4.2 The submitted EIS

The "submitted EIS" was considered when preparing this EIS assessment report. The "submitted EIS" comprised the following:

- the EIS that was publicly released on 22 November 2010
- the proponent's response to submissions report (supplementary EIS & amended EM plan) received by DERM on 30 June 2011 that was provided to relevant advisory body members
- the proponent's response to DERM Notice of extension of decision dated 28 July 2011 received by DERM on 24 August 2011 that included a supplementary EIS V2 and an amended EM plan,
- additional information provided by the proponent on 28 September 2011
- amended EM plans submitted to DERM on 7 October and 12 October 2011.

3.4.3 Properly made submissions

DERM received nine submissions on the submitted EIS within the submission period and three after the submission period ended. However, all twelve of the submissions were accepted under section 55 of the EP Act. Those submissions were received from the following stakeholders:

- Capricorn Conservation Council
- Department of Communities
- Department of Community Safety
- Department of Employment, Economic Development and Innovation
- The former Department of Infrastructure and Planning
- Department of Sustainability, Environment, Water, Population and Communities
- Department of Transport and Main Roads
- Eungy Pastoral Co
- Fitzroy Basin Association
- Isaac Regional Council
- Queensland Police
- Mr Ron Pullen.

DERM provided two submissions on the EIS to the proponent, including a late submission made on14 March 2011. This lateness was due exceptional circumstances, whereby DERM was required to respond to major flooding and a cyclone events during early 2011.

In addition, there has been correspondence from stakeholders regarding the proponent's response to submissions on the EIS and supplementary information. All submissions and other comments made by stakeholders on the EIS documents were considered when preparing this EIS assessment report.

3.4.4 The standard criteria

Section 58 of the EP Act requires that, among other matters, the standard criteria listed in Schedule 3 of the EP Act must be considered when preparing the EIS assessment report. The standard criteria are:

a. the principles of ecologically sustainable development as set out in the *National Strategy for Ecologically Sustainable Development*; and

b. any applicable environmental protection policy; and

c. any applicable Commonwealth, State or local government plans, standards, agreements or requirements; and

d. any applicable environmental impact study, assessment or report; and

e. the character, resilience and values of the receiving environment; and

f. all submissions made by the applicant and submitters; and

g. the best practice environmental management for activities under any relevant instrument, or proposed instrument, as follows:

   i. an environmental authority;

   ii. a transitional environmental program;

   iii. an environmental protection order;

   iv. a disposal permit;

   v. a development approval; and

h. the financial implications of the requirements under an instrument, or proposed instrument, mentioned in paragraph (g) as they would relate to the type of activity or industry carried out, or proposed to be carried out, under the instrument; and

i. the public interest; and

j. any applicable site management plan; and

k. any relevant integrated environmental management system or proposed integrated environmental management system; and

l. any other matter prescribed under a regulation.

DERM has considered the standard criteria when assessing the project.

3.4.5 Prescribed matters

In addition, section 58 of the EP Act requires that the following prescribed matters, under the Environmental Protection Regulation 2008, are considered when making an environmental management decision for this project:

- Section 51, matters to be considered for environmental management decisions
- Section 52, conditions to be considered for environmental management decisions
- Section 53, matters to be considered for decisions imposing monitoring conditions
- Section 55, release of water or waste to land
- Section 56, release of water, other than stormwater, to surface water
- Section 57, release of stormwater
- Section 60, activity involving storing or moving bulk material
- Section 62, activity involving acid-producing rock
- Section 64, activity involving indirect release of contaminants to groundwater.

3.5 Environment Protection and Biodiversity Conservation Act 1999

On 11 May 2009, the Codrilla Project was referred (EPBC 2009/4892) for consideration under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) to the (then) Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA). On 4 June 2009, DEWHA decided that the project was a controlled action and the controlling provisions are sections 18 and 18A (Listed threatened species and ecological communities) of the EPBC Act. The State's EIS process was accredited for the assessment under Part 8 of the EPBC Act in accordance with the Bilateral Agreement between the Commonwealth of Australia and the State of Queensland (2009). DEWHA, and subsequently the Department of Sustainability, Environment, Water, Population & Communities (SEWPaC), was included in the advisory body for the project and provided comments on the draft TOR and the EIS documents.

This EIS assessment report is required to contain sufficient information about the relevant impacts of the action and the proposed mitigation measures to allow the Commonwealth Environment Minister to make an informed decision on whether to approve the taking of the action pursuant to the provisions of the EPBC Act.

A copy of this EIS assessment report will be given to the Commonwealth Environment Minister for consideration when deciding, under section 133 of the EPBC Act, whether to approve the taking of the action. Matters of national environmental significance are discussed in section 4.13 of this EIS assessment report.

4 Adequacy of the EIS in addressing the TOR

Table 4.1 lists the main aspects of the Codrilla Project addressed in the EIS and highlights the significant issues associated with those aspects. The table notes whether the submitted EIS adequately addressed the matters described in the TOR. The subsections of this chapter enlarge on some of those significant issues, discuss the findings of the EIS in regard to them and outline the environmental protection commitments made by the proponent.

Table 4.1 - Summary of the adequacy of the EIS in addressing the TOR

Matters included in the TOR	Significant issues	Were issues adequately addressed in the EIS?
Introduction	Overview of the project, its objectives and scope. Outline of the necessary approvals and their assessment processes.	Yes to both.
Project need and alternatives	Project justification and any alternatives.	Yes
Project description	Location of the project in the regional and local contexts. Description of the construction phase of the project. Description of the operational phase of the project.	Yes to all.
Climate	Climatic conditions at the site	Yes
Land	Topography & geomorphology Geology Mineral resources Soils Land contamination Land use Existing infrastructure Sensitive environmental values Landscape character and visual amenity.	Yes to all.
Transport	Transportation of personnel by road. Impacts on air traffic of fly-in, fly-out workforce. Transportation of ore concentrates by road.	Yes to all.
Waste	Waste Waste rock characterisation Regulated and other waste	Yes to all.
Water resources	Groundwater Surface watercourses and overland flow	Yes to both.
Air quality	Dust Greenhouse gases Other air emissions	Yes to all.
Noise and vibration	Noise at sensitive receptors Noise impacts on wildlife Vibration due to blasting	Yes to all.
Nature Conservation	Terrestrial plants Terrestrial animals Aquatic ecology Groundwater dependent ecosystems	Yes

Cultural heritage	Indigenous cultural heritage Non-indigenous cultural heritage	Yes to both.
Social issues	Impacts on local community, housing and services Impacts due to fly-in, fly-out workforce	Yes to both.
Health and safety	Air and water emissions. Road haulage, and traffic regimes	Yes to both.
Economy	Alienation of grazing land Effects on the local and regional economy Effects on the state economy	Yes to all.
Hazard and risk	Unplanned discharges to air, water or land Transportation, storage and use of hazardous substances Emergency response	Yes to all.
Rehabilitation	Rehabilitation of areas affected by mining activities	Yes

4.1 Introduction

The EIS provided an adequate introduction to the Codrilla Project, its objectives and scope. It adequately identified the necessary approvals and outlined the assessment and approval processes.

4.1.1 Regulatory approvals

The EIS provided an adequate summary of the purpose of legislation and regulatory approvals required for the project.

Table 4.2 - Approvals for the Codrilla Coal Mine Project

Approval	Legislation
Environmental authority (mining activities)	*Environmental Protection Act 1994* (Department of Environment and Resource Management)
Mining Leases (for the mining and infrastructure area and the haul road)	*Mineral Resources Act 1989* (Mines and Energy, Department of Employment, Economic Development and Innovation)
Cultural Heritage Plan for land within the boundaries of the project	*Aboriginal Cultural Heritage Act 2003* (Department of Environment and Resource Management)
Clearing permits for endangered, vulnerable or near threatened species	*Nature Conservation Act 1992* (Department of Environment and Resource Management)
Permit for works in a state controlled road corridor for the diversion of the Fitzroy Developmental Road	*Transport Infrastructure Act 1994* (Department of Transport and Main Roads)
Riverine Protection Permit for proposed Codrilla to Moorvale Haul Road crossing of Bundarra and Devlin Creek tributaries. Required if the Project is unable to comply with DERM Departmental Guideline – Activities in a watercourse lake or spring associated with mining operations. However, it is expected that the project activities will comply with the Departmental Guideline.	*Water Act 2000* (Department of Environment and Resource Management)
Development approval (Operational work for a referrable dam by constructing a Water Storage Facility) may be required for the 2,600 ML temporary dam.	*Water Supply (Safety and Reliability) Act 2008*

4.2 Project need and alternatives

The EIS adequately described the need for the project, and briefly outlined the social, economic and environmental benefits and costs, which were addressed in more detail in later sections of the EIS. This section of the EIS considered the principles of Ecologically Sustainable Development (ESD) which were further considered in the design and planning of the project.

Also, this section briefly discussed a number of options that were considered for the project, including:

- open cut mining methods and underground mining, with open cut truck shovel being the selected option
- water supply, with the preferred option being the use of the existing Sunwater allocation that would be piped from the Moorvale Coal Mine
- waste management processes for the Coal Handling and Preparation Plant (CHPP) with codisposal the selected option
- transporting product coal to the rail transport system, with the selected option being a dedicated haul road to the Moorvale Coal Mine train loadout facility
- road alignment configurations for the Codrilla to Moorvale haul road, with the selected road alignment being the Northern Option 3
- alignment of the Fitzroy Developmental Road (FDR), with the selected option involving realigning the FDR to the west so that it passes between the east and west pits.

Additional information on the above selected options was contained in the EIS.

4.3 Project description

The EIS adequately described the location, scope and phases of the project. No submissions on the EIS requested additional information to describe the project. An outline of the project is provided in section 2 of this report.

4.4 Climate

The EIS adequately described the local climate with regard to how the climate could affect the potential for environmental impacts and the management of operations at the site.

The climate of the area is monsoonal, with relatively dry winters and wet summers with over two thirds of the 756 mm average annual rainfall occurring in the wet season months from December to March. The average daily maximum temperature range in summer is 33.1^{o}C to 34.1^{o}C and in winter is 23.7^{o}C to 25.5^{o}C. The winds are predominantly from the east.

4.5 Land

The final EIS adequately described those aspects of the site and project related to the existing and proposed qualities and characteristics of the land. The following subsections address those qualities and characteristics in more detail.

4.5.1 Land disturbance

Key features of the land disturbance for the project, include:

- two residual voids would be about 150 m deep with a total area of about 130 ha
- out of pit overburden dumps would reach a maximum of 50 m above natural ground level with a footprint of approximately 974 ha
- elevated codisposal facility, being up to 10m high and with a footprint of approximately 79 ha
- elevated run of mine [ROM] pad, being 15 to 18m high and approximately 16 ha in area
- areas of similar gradient to the surrounding undisturbed landform such as backfilled pits and areas from where infrastructure is removed with an area of approximately 836 ha.

4.5.2 Land use

The existing land uses within the project area are predominantly cattle grazing and mining. Typically the cattle grazing properties of the area are in the order of 5,000 to 20,000 ha in size. Codrilla Station, on which the proposed mining operation, processing facilities and associated infrastructure are to be located, is 4,359 ha in area and is one

of the largest producers of Romagnola cattle in Queensland. The cattle station has been in operation for the last 26 years.

The land on Codrilla Station consists primarily of improved pasture with some small isolated areas of remnant vegetation remaining, much of which is associated with significant drainage channels.

The areas within and adjacent to the haul road corridor are a combination of cleared areas consisting of improved pastures and remnant native vegetation with an understorey of native and introduced grasses. Other land uses in the vicinity of the project include, coal and gas exploration, public road infrastructure (including the Fitzroy Developmental Road (FDR)), and the Valkyrie School and school residence which are located approximately 800 m to the north of the proposed ML boundary. The FDR is also a designated stock route.

No Good Quality Agricultural Land occurs on or near the project site. The areas that would be disturbed by mining activities and the haul road were classified as Land Suitability Class 4 and 3 (grazing). [NB: Land Suitability Class 1 is the highest, while Land Suitability Class 5 is the lowest.]

Some disturbed land will be rehabilitated to support grazing. However, approximately 130 ha of land, comprising the residual voids, would be permanently alienated from productive grazing.

4.5.3 Soils and land suitability

The proponent undertook a soil survey over the extent of the proposed Codrilla A and Codrilla B MLs. A total of 59 samples were collected from the various horizons within 24 of the 28 profile excavations to a depth of between 1.2 m to 1.5 m.

DERM advised the proponent that it considered the soil survey to be below the minimum intensity of 1 site per 100 ha, as set out in the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (1995). In response, the proponent provided further details and clarification on the soil survey work undertaken for the project. DERM was satisfied with the proponent's response regarding the soil survey.

DERM considered the estimated rooting depth (ERD) used to calculate plant available water capacity (PAWC) in the EIS conflicted with data provided within some soil profile descriptions. As a result of this, DERM advised the proponent to recalculate the PAWC using deeper rooting depths as per soil profile descriptions or provide further evidence to demonstrate that shallow ERDs would be appropriate. In response to this issue, the proponent reviewed the PAWC and confirmed that the land covered by the Brown Duplex soil has Land Suitability Class 4[1] and Agricultural Land Class of C3. However, the review brought about an amendment for the land covered by the Yellow Duplex soil with Land Suitability increasing from Class 4 to Class 3[2], and Agricultural Land Class increasing from C3[3] to C2[4]. Amendments were made by the proponent to the Land Suitability and Agricultural land classes.

4.5.4 Resource utilisation

The EIS adequately addressed resource utilisation.

The EIS provided the following adequate strategies to minimise potential sterilisation of coal and coal seam gas resources which may be economically viable in the future:

- consultation with the Authority To Prospect (ATP) holder in relation to potential impacts of the Codrilla Project on future coal seam gas resources
- mine and processing design optimising the recovery of coal resources and minimising coal loss
- overburden dumps and infrastructure have been located up dip of the coal weathering zone
- the provision of final voids in the final landform provides potential coal seam access for highwall mining or underground activities which may become economically viable in the future.

[1] Land Suitability Class 4 is marginal lands with severe limitations which make it doubtful whether the inputs required achieving and maintaining production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production)

[2] Land Suitability Class 3 is land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production.

[3] Agricultural Land Class 3 means low quality grazing, grazing of native pastures with limited suitability for pasture development.

[4] Agricultural Land Class 2 means moderate quality grazing and or moderately suitable for pasture improvement.

The proponent adequately addressed a concern raised by DEEDI in relation to resource sterilisation.

4.5.5 Land contamination

The EIS included a preliminary site investigation (PSI) for contaminated land as required by the TOR. The PSI suggests that a low risk of past and present potentially contaminating activities exists within the project area. Potentially contaminating activities identified in the EIS include above ground bulk hydrocarbon storage tanks, chemical storage areas, cattle dips, machinery/vehicle maintenance areas, and a domestic rubbish dump.

The PSI included a desk top search of the Environmental Management Register (EMR) and Contaminated Land Register (CLR). The PSI identified activities on background tenures which will be impacted by the project, including:

- lot 20 on KL 168 contains an abandoned cattle dip which is listed on the EMR. However, the specific location was not described in the EMR search result;
- lot 16 on RP845112 contains an abandoned cattle dip which is not listed on the EMR; and
- minor contamination observed at the base of the hydrocarbon and fuel storage tanks on Lot 16 on RP845112 limited to the surface soil.

The EIS states that, due to the low risk of the identified sites, no further investigation was undertaken.

The construction and operation of the project will involve a series of notifiable activities as listed in Schedule 3 of the EP Act. Therefore the locations where these activities will occur will be required to be entered onto the EMR. The notifiable activities and locations on site are listed below in Table 4.3.

Table 4.3 - Notifiable activities

Notifiable activity	Lot on Plan	Description
7. Chemical storage (>10 tonnes)	16 RP 845112	Storage of chemicals in the CHPP
15. Explosive production or storage	16 RP 845112	Storage of explosives on site
24. Mine wastes	16 RP 845112	Overburden dumps and codisposal facility
29. Petroleum product or oil storage - (iii) combustible liquids in class C1 or C2 - more than 25,000 L capacity	16 RP 845112	Storage of diesel and lubricating oils for use in fixed and mobile mining equipment

The proposed mining activities will potentially result in some contamination of land. The EIS proposed a range of mitigation measures to reduce the potential negative impacts to land and waters from operational activities, including accidental spills of hydrocarbons and chemicals.

The EM plan included an adequate commitment that any sites that become contaminated will be investigated and managed in accordance with the requirements of the contaminated land provisions of the EP Act.

4.5.6 Landscape character and visual amenity

The project will consist of a number of visually prominent structures that will impact on the character of the landscape. These will include:

- waste rock and overburden dumps
- administrative buildings and infrastructure
- dams and water storages
- coal handling preparation plant
- the realignment of the Fitzroy Developmental Road (FDR).

The EIS states that whilst the project will alter the visual characteristics and amenity of the immediate area from the outset, the existence of numerous open cut coal mines in the regional landscape indicates that the visual impact of the project will not be unique or unusual when viewed at a regional level.

The project will be visible from traffic travelling along the FDR. Following realignment of the FDR, the current vegetation screening by mature trees will be further reduced. In the EIS, the proponent commits to manage the visual impact from the project by the replanting of roadside vegetation once realignment is complete. Furthermore, the rehabilitation and revegetation of disturbed areas progressively throughout the life of the project will assist in reducing the visual impact of the project when viewed from the roadside.

The EIS states that whilst the proximity of the Codrilla Homestead to the project site indicates a major impact on the visual amenity when viewed by the occupants, it is intended that the Codrilla Homestead will be vacated during the project development and will remain unoccupied throughout the mine life. Similarly it is anticipated that the Valkyrie School and school residence will be relocated some distance from the project site, removing the potential for the project to impact upon views from either place.

The EIS states that the project is unlikely to be visible from other surrounding residences, given distance, topography and natural view obstruction.

4.6 Transport

The EIS assessed four key means of transport that will be utilised for the project, being road, rail, air and sea.

4.6.1 Existing road network

Road links

The initial access to the project site will be from the FDR. The existing road network will form the primary mode of transport to and from the project site during the construction phase. The majority of vehicles travelling to and from the project site will utilise the:

- Peak Downs Highway (PDH) – a State controlled road (SCR) connecting Clermont to Mackay and functioning as a link for a number of towns and existing mines
- Fitzroy Developmental Road (FDR) – a SCR providing a north-south connection between the Peak Downs Highway and the Capricorn Highway
- Capricorn Highway (CH) – a SCR connecting the east coast to western Queensland, in particular Rockhampton to Emerald
- Moorvale mine and accommodation access road – a privately owned access connecting the Moorvale mine and accommodation camp to the Peak Downs Highway.

It is proposed in the EIS that a dedicated haul road will be constructed between the project and the Moorvale Mine with the main purpose of transporting product coal to the train load out facility. It will also serve as the primary site access point to the project, facilitating the transport of personnel, equipment, plant and materials to and from site.

Key Intersections

Three intersections were identified in the traffic impact assessment (TIA) as key to the project road network:

- Peak Downs Highway/FDR intersection
- Capricorn Highway/FDR intersection
- Peak Downs Highway/Moorvale Mine & Moorvale accommodation camp access road intersection.

4.6.2 Construction or alteration to existing transport infrastructure

The road transport infrastructure to be constructed or altered specifically to accommodate the project requirements includes:

- the construction of the dedicated Codrilla to Moorvale Haul Road
- the construction of a site access intersection on the FDR
- the realignment of the FDR and construction of the Haul Road underpass.

Codrilla-Moorvale haul road

The EIS states that based on an annual average production of 3.2 Mtpa of product coal, the haul road will carry approximately 16,000 loaded trips per annum. This figure is based on 200 tonne trucks, operating two eight hour shifts per day, 363 days per year.

FDR Project access

The EIS states that an intersection on the FDR will be constructed for the purpose of access to the Mine Infrastructure Area (MIA) of the project. This access point to the MIA will serve as the main access during the construction phase of the project. During the operational phase it will serve as a secondary access point, in particular for emergency vehicles, over-dimensional loads and site visitors.

FDR realignment and haul road underpass

Construction work associated with the realignment of the FDR would be expected to commence during the initial construction phase of the project to allow for the east pit development. A permanent 5.02 km long relocation of the FDR would need to be constructed to allow development of the mine. The existing length of the FDR between the deviation start and end point is 4.8 km, thus the actual increase in length of the road would be relatively insignificant (0.4 km) to road users.

In conjunction with the realignment, it is anticipated that a haul road underpass would be constructed, linking the eastern pit to the MIA and CHPP located on the western side of the mine.

Changes to the use of the existing road network

There would be changes to the use of the roads through increased traffic and transportation of materials, particularly wastes and hazardous materials. The EIS mentions that various liquid and solid wastes will be generated by the project and will be transported off site by a licensed contractor for disposal. Wastes such as sewage are expected to be transported via truck once or twice per fortnight. Other potentially hazardous materials to be transported may include further regulated wastes, fuels and other hydrocarbons and explosives.

4.6.3 Impacts to road network

Construction and operation traffic

The majority of the construction and operation personnel would be housed at the Terowrie Camp, or alternatively at a local commercial accommodation camp. Rostered personnel would be transported from the camp accommodation, via an internal Moorvale-Codrilla haul road (once constructed), to site by bus thereby reducing the number of vehicles utilising the SCRs.

The TIA indicates that the increase in traffic volumes on the SCRs during the construction phase of the project would be less than 5% of the overall predicted Annual Average Daily Traffic (AADT), with the exception of the FDR between the project and the Peak Downs Highway which has been predicted to experience an increase in daily traffic flow of 8.75%. The EIS considers the impacts of the heavy vehicle component of the additional traffic (the main contributor to pavement degradation) by considering the increased loading in terms of Equivalent Standard Axles (ESA). The results of this analysis was that the increase in ESA loading would be less than 5% of the existing ESA on any road link.

The Queensland Government's Department of Transport and Main Roads (DTMR) Guidelines for Assessment of Road Impacts of Development (the Guidelines) stipulates that increases in traffic volume (determined by either number of vehicles or ESA) of below 5% are considered to be insignificant impacts that do not require further impact assessment. However, DTMR stated in its submission to DERM that the DTMR Guidelines also stipulate that traffic volume increases above 5% do require impact assessments. The EIS mentions that, as the 8.75% increase in traffic volume on the FDR is mainly made up of light vehicular traffic rather than heavy commercial vehicular traffic (the major contributor to adverse impacts to road pavement surfaces), adverse impacts to roads would be unlikely.

Also the TIA indicates that the increase in traffic volumes on the SCRs during the operational phase of the project are less than 5% of the overall predicted AADT. When focusing on the heavy vehicle component of the additional traffic, the increased loading was also converted to Equivalent Standard Axles (ESA).

The results of which were that all ESA loading increases would be less than 5% of the existing ESA on any road link. Therefore the EIS states that the impacts on these road link networks during the operations phase of the project are likely to be insignificant and no further assessments of this aspect of the mine development are necessary.

However, DTMR will require the proponent to review and reassess the road impact on the FDR as stated in section 4.6.4, Department of Transport and Main Roads requirements, of this Assessment Report.

Impacts to intersections

Two of the three intersections identified in the TIA as relevant to the project were analysed using a desktop traffic analysis package which uses traffic volume data to calculate the intersection performance based on the level of service and the degree of saturation. The level of service is an assessment of the impact an intersection has on the flow of traffic whereas the degree of saturation is a 'volume to capacity' ratio which is calculated for each movement through the intersection. A degree of saturation of 0.80 or more for an un-signalised priority intersection indicates the movement is approaching practical capacity. The intersection for the Moorvale Mine and Terowrie Accommodation Camp access was not assessed due to the lack of available data for this intersection. However, the EIS predicts that the intersection for the Moorvale Mine and Terowrie Accommodation Camp is expected to be performing adequately in its current form.

The analysis undertaken indicates that during the construction and operational phase of the project, both the Peak Downs Highway/FDR and Capricorn Highway/FDR intersections would not be expected to exceed the 0.80 degree of saturation limit and the level of service is anticipated to be below the capacity for the intersections. Therefore, the proponent concludes that no road intersections are likely to be significantly impacted during either the construction or operational phases of the project.

The proponent will be required to upgrade the Fitzroy Developmental/Mine Access Road as mentioned in section 4.6.4 of this EIS assessment report.

Impacts associated with project road infrastructure construction or alteration

The EIS identified that the construction, alteration or changed use of road transport infrastructure associated with the project has the potential to impact the road link network through:

- obstructions and delays to traffic flow
- changes to general road safety
- obstructions to the operation of the stock route along the FDR
- disruption to school bus services
- obstructions to emergency access vehicles
- contamination of land and water resources, though minimal, through the transportation of hazardous materials.

The EIS states that obstructions or delays to traffic flows caused by project activities will be mitigated through the implementation of management procedures to ensure disruption is minimal. In particular, the construction of the project access intersection and the realignment of the FDR will be undertaken in close collaboration with DTMR, to ensure that the works are carried out pursuant to the relevant guidelines and regulations.

The proponent makes planning commitments in the EISs to ensure that obstructions are minimised through:

- timing of construction activities to ensure that road works do not coincide with peak traffic periods where practicable
- scheduling works around existing planned road disruptions such as those described in the Road Implementation Program
- ensuring that the works are undertaken by suitably qualified contractors and that all legislative requirements are met with the appropriate approvals in place.

To address impacts to road safety as a result of the increase in traffic from the project, particularly heavy vehicle movements, the proponent proposes the following adequate strategies in the EIS:

- the provision of traffic management controls which will facilitate the safe movement of goods, people and pedestrians, in particular throughout the FDR realignment works
- provision of appropriate signage to identify haul routes and the project boundaries (where access restrictions may apply)
- requirement for appropriate driver training for handling heavy vehicles and oversize loads
- operational procedures for activities undertaken during wet weather periods.

Also consultation with the local communities (including the nearby schools) will occur prior to any additional changes to the road network.

Stock route operation

The EIS states that realignment of the FDR will be designed to ensure that the stock route capacity is maintained. Detailed design considerations will include the continuation of the stock route through the maintenance of the road corridor width or alternatives if required.

Rail

The project will utilise the existing coal transport contracts held between the proponent and QR National and Pacific National, and will not require an additional allocation as the capacity of the current contract will accommodate the project product coal.

As the project output will form part of the existing contractual allocation, impacts to the existing rail infrastructure are expected to be minimal.

4.6.4 Department of Transport and Main Roads requirements

DTMR provided submissions on the EIS and subsequent supplementary EIS information, stating the EIS had adequately addressed the TOR with regard to transport issues. The DTMR will require a permit for works in a state controlled road corridor for the diversion of the Fitzroy Developmental Road under the *Transport Infrastructure Act 1994*.

The proponent agreed to continue liaising with the Assets and Operations Division of the DTMR to discuss and resolve the outstanding issues associated with the project in a timely manner. In order to address outstanding issues, the proponent agreed to discuss the following work with DTMR.

State Controlled Road Access

Prior to the commencement of construction on site, the proponent shall be required to undertake the following:

- upgrade the following intersection/access as determined and agreed upon with DTMR Mackay/Whitsunday Regional Office:
  - Fitzroy Developmental /Mine Access Road to provide a minimum Channelised Right Turn (CHR) and Basic Right Turn (BAR) as per Figures 13.60 and 13.80 of the DTMR Road Planning and Design Manual (RP&DM)
  - provide all necessary access to the SCR to a standard agreed upon by DTMR
- provide to DTMR: rehabilitation, bring forward, and maintenance contributions and/or works associated with project traffic as calculated and agreed upon with DTMR Mackay/Whitsunday Regional Office
- prior to undertaking any works, obtain the relevant licenses and permits under the *Transport Infrastructure Act (Qld) 1994* for works within the SCR corridor.

In the EIS the proponent commits to constructing a CHR as a minimum access for the Fitzroy Developmental/Mine Access intersection.

In addition the proponent commits to obtaining the relevant licenses and permits under the *Transport Infrastructure Act 1994* as necessary prior to undertaking works related to state controlled road corridors.

The proponent commits to ongoing consultation with DTMR in relation to these issues.

Fitzroy Developmental Road Realignment - Infrastructure Agreement

The mining lease boundary includes a section of the Fitzroy Developmental Road. As described in the sEIS, the proponent is proposing to construct a realignment of the Fitzroy Developmental Road by providing a diversion road on the western side along with a haul road overpass. Figure 2.2.2 of the supplementary EIS shows the proposed realignment of the Fitzroy Developmental Road.

DTMR advised that any deviation from the direct route would increase travel times. DTMR's preference was for an overpass to be constructed on the existing highway alignment, so as to retain optimal travel time. However, DTMR agreed to accept a permanent deviation subject to a review of the vertical and horizontal geometry and provided there would be no significant increase in road length/travel time. DTMR requested that the proponent continue to liaise with its Regional Office to ensure a design that would satisfactorily address this issue as well as any road safety issues.

Prior to the commencement of project construction the proponent shall enter into Infrastructure and Compensation Agreements with the State of Queensland (DTMR) to address all aspects of the design, construction and maintenance of the overpass, deviation and new intersections.

The Infrastructure Agreement is to address funding, construction and maintenance of key infrastructure that impacts on the SCR network and will specifically address:

- provision of the proposed overpass that crosses the haul road
- deviation of the Fitzroy Developmental Road during construction of the mine haul overpass
- temporary access and state-controlled road crossings
- dealing with utilities in the road reserve
- ongoing maintenance of the overpass
- access intersections to the mining operations
- maintenance contributions associated with project traffic
- traffic management plan
- approval for works under the *Transport Infrastructure Act 1994*.

This infrastructure agreement between the proponent and DTMR shall be concluded prior to commencement of any project construction.

In the supplementary EIS the proponent commits to enter into an Infrastructure and Compensation Agreement with the State of Queensland (DTMR) prior to commencement of any SCR-related project construction.

Road Impact Assessment and Road Use Management Plan Requirement

DTMR drew attention to the section of the supplementary EIS showing that a section of the State Controlled Road (SCR) Network (on the Fitzroy Developmental Road, north of the Capricorn Highway) where there may be an increase of more than 5% in pavement loadings from project traffic related to the construction phase of the project.

DTMR requires that, prior to the commencement of construction, when further information is available on vehicle types and numbers, the impact on the SCR Network, such as pavement loadings on the Fitzroy Developmental Road, shall be reassessed. DTMR also requires that, 6 months prior to the commencement of any project construction works, the proponent shall:

- review and finalise the road impact assessment (RIA) to include details of all project transport impacts on the safety and efficiency of state controlled roads in accordance with Guidelines for Assessment of Road impacts of Development (2006) in consultation with the Manager of DTMR Mackay/Whitsunday Regional Office, then submit the updated RIA to the Manager of DTMR Mackay/Whitsunday Office for review and approval.
- prepare a road-use management plan (RMP) which updates and summarises all use of state-controlled and other roads for each phase of the project. The RMP must receive DTMR's approval prior to its implementation and must include:
  - latest traffic generation (vehicle numbers etc.)

  - finalised assessment of impacts on safety and efficiency at intersections, on road links and on pavements etc.
  - updated impact mitigation strategies such as road maintenance or necessary improvements
- provide any necessary road maintenance contributions identified in the finalised RIA and RMP to ameliorate any adverse impacts of the road use by the project on State-Controlled Roads
- reassess any effect of changes to the method of operation of the mine involving a significant change in traffic from that stated in the EIS, especially heavy vehicle movements, and address mitigation of impacts.

The proponent has committed in the EIS to developing a RMP in conjunction with DTMR. Also, in the response to comments dated 28 September 2011, the proponent commits to ongoing liaison with DTMR in relation to:

- road maintenance requirements which may potentially occur as a direct result of the project
- undertaking further assessments of the road impact
- pavement loading assessments.

Traffic Management Plan (TMP)

Prior to commencement of any project construction works, the proponent shall prepare detailed drawings and traffic management plans to ensure safe undertaking of all construction and other activities in the state-controlled road corridor.

The proponent shall present detailed drawings and traffic management plans for review by DTMR, the Queensland Police Service, and Isaac Regional Council, and take account of the reviews.

The proposed plan shall incorporate a provision that, prior to commencing any program of oversize transport movements that may be required for the construction of the project, the proponent will consult with DTMR, the Queensland Police Service, and Isaac Regional Council.

The proponent shall obtain the necessary permits for any excess mass or over-dimensional loads associated with the project as required under the *Transport Operations (Road Use Management) Act (Qld) 1995*.

The proponent shall implement the traffic management plan during construction and commissioning of the project and construction of all access road intersection/s.

In the EIS, the proponent commits to developing a TMP prior to the construction of the project and being undertaken in conjunction with DTMR and Queensland police Service (QPS). Additionally, the proponent agrees to consultation with the Isaac Regional Council (IRC) in relation to the TMP.

In the response to comments dated 28 September 2011, the proponent agrees:

- to incorporate into the TMP a notification process in relation to oversize transport movements which will include DTMR, QPS and IRC
- the TMP will be implemented during construction and commissioning of the project and construction of all access road intersections/s
- undertaking further assessments of the road impact
- pavement loading assessments.

Valkyrie School Access Requirement

The proponent is committed to funding the relocation of Valkyrie School in order to avoid dust and noise nuisance impacts on the school, although the decision on relocation is a matter for the Department of Education and Training. Once the school is to be relocated as outlined in the sEIS, this will require a new access/intersection with the Fitzroy Developmental Road. The proponent will be required to obtain all necessary permits and approvals from DTMR to approve the location and design of the access and to undertake the works.

All intersection/access works to the school shall be undertaken at no cost to DTMR and in accordance with its standards and specifications. The relocation of the access/intersection shall be undertaken at a time which is acceptable to Department of Education and Training. If agreed to by the proponent and DTMR, provisions to

undertake the design and funding of the relocated school access/intersection may be included as part of the Fitzroy Developmental Road Realignment Infrastructure Agreement.

4.7 Waste

The EIS discussed excavated and process wastes generated by the Codrilla Project that includes overburden, interburden and processing waste from the CHPP.

Overburden production (includes interburden) is expected to total approximately 695 million tonnes (Mt) over the life of mine, of which approximately 283 million loose cubic metres will be placed in out-of-pit overburden dumps, with the balance being placed within in-pit overburden dumps.

Processing (codisposal) of wastes from the Coal Handling Preparation Plant (CHPP) will be disposed of in a codisposal facility on site to ensure containment. The EIS states that the project will produce 10.39 Mt (dry) of codisposal waste over the life of the mine.

Other waste streams to be generated by the project and identified in the EIS, include: regulated waste, general waste, recyclable waste, scrap metal, used tyres and sewage effluent.

The proponent has committed to managing all waste generated by the project in accordance with the waste management hierarchy (i.e. avoidance, recycling, waste to energy and disposal) and in accordance with relevant legislation, including the Queensland Environmental Protection (Waste Management) Policy 2000 (EPP Waste). The proponent has committed to incorporating a program of best practice waste management, including the ongoing assessment of cleaner production and waste management opportunities for the life of the project. Regulated waste will be removed off site by an appropriately licensed waste contractor for disposal at a facility that is appropriately licensed to accept such waste.

The proponent is committed to developing a Waste Management Plan to manage and reduce the potential environmental impacts that may result from generation and disposal of waste.

Recommended waste management conditions have been provided in Appendix 1.

4.7.1 Waste Rock Characterisation

Overburden and interburden waste

The EIS includes a baseline overburden and interburden characterisation study that involved a total of 26 samples from seven bore holes within the east and west pit areas.

The proponent made the following assessment regarding the waste rock characterisation of overburden and interburden material:

- all 26 overburden and interburden samples are classified as Non Acid Forming (NAF)
- the total sulphur content of all samples was below 0.1% and is considered inert relative to acid producing potential
- the concentration of metals in overburden and interburden solids is unlikely to present any significant environmental issues associated with rehabilitation of the materials or water quality
- the pH of leachate from overburden material at the Codrilla site is likely to range from slightly acidic to moderately alkaline, however the majority of material is likely to be neutral
- the range of EC values in the samples is considered slightly to moderately saline
- the overburden material is within the Moderate to High ranges for Cation Exchange Capacity (CEC) and should therefore provide a reasonable growth medium for vegetation
- overburden material is considered to be extremely sodic
- the overburden and interburden material is not expected to require specific management strategies in relation to PAF, metals, pH, Electrical Conductivity (EC) and Cation Exchange Capacity (CEC)
- the overburden and interburden material is expected to require specific management strategies in relation to Sodicity.

DERM raised issues with the management of overburden dumps due to the extremely sodic nature of the material and this is discussed in section 4.17 Rehabilitation, of this EIS assessment report.

Codisposal waste and coarse reject

The characterisation of codisposal waste for the EIS involved the sampling of material from above coal seams (roof), within coal seams and below coal seams (floor), during exploration drilling and groundwater bore construction. These samples were composited to form two roof samples, one coal sample and two floor samples. The five roof and floor, coal, and floor samples analysed for acid producing characteristics were classified as either 'Uncertain' or 'Uncertain–Potentially Acid Forming', the total sulfur results being in excess of 0.2% for each of the samples analysed.

The EIS states that, due to the limited characterisation of coal and partings (coal seam roof and floor) undertaken (samples that were taken were inconclusive for potentially acid forming material), it is assumed that the codisposal material may be potentially acid forming (PAF). Due to this limitation in available material characterisation results, the conceptual design and operation of the codisposal facility is based on the assumption that the codisposal material will be acid forming.

DERM advised the proponent that the geochemical properties of the codisposal material were not well characterised overall due to the insufficient number of samples and the compositing of samples. The proponent was also advised that the compositing of samples could have masked variability and may have led to an underestimation of the need for special handling of reject material, particularly for excess coarse rejects. The proponent was advised of the need to provide a more detailed geochemical characterisation of waste reject material before commencing mining operation. This is consistent with commitments given by the proponent in the EM plan.

In the response to submissions, the proponent states that no additional sampling opportunities have been available since submission of the draft EIS. The proponent states that a resource definition drilling program is proposed to be undertaken and additional samples of material which may be indicative of codisposal and coarse reject material will be obtained. Sampling and analysis will be undertaken in accordance with industry practice.

The proponent will need to meet the commitment made in the EM plan of ongoing characterisation of overburden, interburden and partings materials to enable selective handling. Also it is recommended that the draft EA contains conditions on ongoing waste rock characterisation and the management of acid producing material.

The proponent will also need to meet the commitment of treating codisposal waste as acid forming and disposing this material in an approved codisposal facility.

The EIS states that process anomalies may occasionally result in coarse reject being required to be managed separately. Industry experience has determined coarse reject has the potential to generate acid seepage and runoff and also runoff containing salts and metals, as with the codisposal material discussed above. Characterisation of coarse reject material was undertaken through coal and partings analysis. The results of the characterisation of coarse rejects indicates that the material may be PAF. The supplementary EIS version 2 (v2) contained adequate management strategies for the handling miscellaneous coarse rejects so as to minimise the potential for land contamination. Coarse rejects requiring management separate to the codisposal stream will be stockpiled in the CHPP area, loaded onto rear dump trucks and directed to the codisposal facility for disposal. The mass balance for the Codrilla deposit does not indicate excess coarse reject material. In the situations where coarse reject material is required to be placed into the codisposal facility, (for example following a plant upset) it would be placed in such a manner that it would form a small embankment upon which regular feed to the facility would encapsulate the coarse material within the codisposal matrix and aid in dewatering and management of the facility.

4.7.2 Codisposal facility

The EIS proposes the disposal of fines and coarse rejects from the Coal Handling Preparation Plant in a dedicated codisposal storage facility. DERM advised the proponent that the EIS inadequately described the design, construction and operation of the codisposal facility. In particular the EIS did not provide sufficient information for an assessment of whether the proposed design would be suitable to contain the codisposal material and any leachate. DERM also raised additional concerns about the proposed codisposal storage facility, including:

- that the EIS did not identify the optimum ratio of fine to coarse rejects in the codisposal material, nor how much coarse reject material would be likely to be in excess of that needed for the optimum codisposal mixture
- while the EIS mentions that excess coarse rejects would be deposited in the codisposal cells, it does not assess how feasible it would be to encapsulate that material in a way that would mitigate the oxidation of any sulfides in those coarse rejects that were not embedded in the matrix of fine rejects
- that more information is required on the proposed management of decant water from the codisposal cells.

In the supplementary EIS and supplementary EIS v2 the proponent did adequately addressed DERM's issues with the management of codisposal waste. The proponent provided additional information, including:

- That the detailed design of the codisposal facility will be undertaken by an experienced and RPEQ qualified engineering consultant, and comply with relevant engineering guidelines. Liaison with DERM will be undertaken throughout the detailed design process to ensure the facility meets with the relevant regulatory requirements. DERM will require the codisposal facility to be regulated as a hazardous dam. Subsequently, DERM will require the facility to be designed, approved and operated in accordance with the appropriate regulatory guidelines.
- The mass balance for the Codrilla Project on the finest feed suggests coarse to fine disposal rations between 1.2:1 and 3.2:1. The supplementary EIS v2 mentions the Moorvale codisposal facility is currently operating successfully with coarse to fine ratios varying from 1.2:1 to 2.2:1. Thus the proponent claims that the Codrilla codisposal facility is expected to operate effectively with adequate beach formation and water drainage, as well as retention of fines within the material matrix.
- The fines retention in the codisposal facility will aid in the PAF management by minimising void space in the matrix which would provide potential reaction sites.
- In situations where coarse reject material is required to be placed into the codisposal facility (for example a plant upset), it will be placed in such a manner that it forms a small embankment upon which regular feed to the facility will encapsulate the coarse material within the codisposal matrix and aid in dewatering.
- The proponent states in the EIS that the proposed codisposal facility will only have storage capacity for approximately six years based on expected average codisposal production rates. To cater for the post six year storage requirements, a number of options were proposed by the proponent. DERM advised the proponent to discuss the selection and timing of the preferred option for the codisposal facility. In response to DERM's issue on the preferred option for the codisposal facility, the proponent provided the following commitments in the EM plan:
- the best post year 6 codisposal option will be determined during the first six years of operation, based on site specific data collected including codisposal materials and volumes
- a management option will be collated, reviewed and assessed (including construction details and ongoing management plans) to determine one proposed codisposal option
- the preferred codisposal option will be presented to DERM no later than 2 years prior to the new management option being required.

4.7.3 Partings

The proponent was advised that the EIS did not propose adequate mitigation measures for the disposal of partings. The method proposed in the EIS consisted of collection and burial of partings exposed on overburden dumps during progressive regrading and rehabilitation activities. This approach was considered by DERM to be unacceptable as acid production from partings may be an issue and the management proposed could leave some partings at or near the surface of the dump.

The EIS mentions that some partings materials have the potential to generate acid seepage and runoff, runoff containing salts and metals, and sediment laden runoff.

In response to DERM's issues, the proponent provided a satisfactory response and made amendments to the supplementary EIS.

The EM plan, received by DERM on 24 August 2011, contained commitments to manage partings including:

- identified partings to be excavated and selectively placed in overburden dumps to ensure encapsulation to avoid surface exposure
- ongoing characterisation of partings materials to enable selective placement within dump structure to enhance landform stability.

DERM advised the proponent that due to the risk of partings producing acid drainage, this material should be preferably disposed and encapsulated within in-pit overburden dumps. Consequently, in the EM plan dated 7 October 2011, the proponent provided an adequate commitment to encapsulate the majority of partings within in-pit overburden dumps or, should this not be possible, the material to be encapsulated deep in the out of pit overburden dumps. The partings are to be buried and encapsulated deep so that when contour profiling occurs for rehabilitation, this material is not near to the surface.

4.7.4 Overburden and interburden material

The proponent provided adequate commitments to manage overburden and interburden material, including

- ongoing characterisation of overburden materials to enable selective placement within dump structure to enhance landform stability
- ongoing overburden rehabilitation trials
- out of pit dumps will be constructed as water shedding landforms with slopes less than 5.7º (10%) to minimise erosion potential
- out of pit dumps will be constructed in lifts of 10 m to a maximum height of 50 m. Each progressive lift will be stepped back a minimum of 85 m from the crest of the underlying lift, to provide for the proposed final landform batter gradient. The dumped batter of each lift will remain at the angle of repose until regrading commences in the rehabilitation process
- encapsulate materials within overburden dumps with at least 1m of cover limiting infiltration of water and oxygen to the materials and reduce the potential for acid production
- coarser unweathered materials will be directed to upper and surface sections of the dumps
- constructing spaced and sloped graded banks and rock lined water ways on batters thereby limiting surface runoff velocities and infiltration opportunities
- cover surface of overburden capping with topsoil to limit exposure of overburden material to runoff and rainfall, and support revegetation
- shallow surface ripping
- limiting cattle access on slopes exceeding 4.6°.

4.7.5 Regulated and other waste

The EIS adequately addressed the management of regulated waste and other waste generated by the Codrilla Project that includes:.

- general waste such as food waste, packaging and food containers will be temporarily stored on site in appropriate containers and transported off site by a contractor to a licensed landfill site
- recyclable waste such as paper, cardboard, plastics, glass and aluminium cans will be segregated and temporarily stored on site in appropriate containers and transported off site by a contractor to a licensed recycling facility
- wood waste such as timber, pallets, and off-cuts will be limited by procurement policies. Undamaged pallets will be returned to the supplier for reuse. Also the proponent proposes to store any excess wood on site for future requirements

- used tyres will be collected and temporarily stored on site. Light and medium tyres will be transported off site by a licensed regulated waste contractor for recycling or disposal. Heavy earthmoving tyres will be disposed of within in pit overburden dumps and the locations recorded
- scrap metal and off-cuts such as drums, cans, scrap, containers, nails and screws will be minimised by limiting the quantity required and excess will be segregated and temporarily stored on site. Metal waste will be transported off site by a contractor to a licensed recycling facility
- concrete waste will be minimised by procuring only the amount required and excess will be disposed of in the waste rock dump
- sewage effluent and sludge will be treated on site in a waste water treatment plant designed to meet Class A+ recycled water effluent quality, treating up to 15 kL/day. Following treatment, the sewage effluent will be removed from site and disposed of by a licensed waste contractor as required
- grease trap waste will be collected and stored, and transported off site by a licensed regulated waste contractor for recycling
- paint and resin waste will be minimised by procuring only the amount required. Excess will be segregated and stored on-site. Transport off site will be by a licensed regulated waste transporter, and disposal at a licensed facility
- waste oil and containers will be collected and stored on-site in a bunded area in accordance with AS1940, The Storage and Handling of Flammable and Combustible Liquids. Transport off-site will be by a licensed regulated waste transporter to a licensed facility for recycling
- oil contaminated wastes including oil sludge, oily rags and oil filters will be segregated and stored in a bunded area in accordance with AS1940: The Storage and Handling of Flammable and Combustible Liquids. Transport off-site will be by a licensed regulated waste transporter to a licensed facility for recycling.

4.8 Water resources

The EIS was adequate with respect to the TOR requirements in relation to water resources.

4.8.1 Groundwater

The EIS assessed four aquifer systems within the proposed mining lease that are associated with the following strata:

- Shallow alluvium along Devlin Creek
- Regolith zones in Tertiary sediments
- Deeper Permian and Triassic overburden/interburden units
- Coal seams.

The EIS discussed the following groundwater issues:

- aquifer drawdown and regional impacts
- impacts to mining operations from groundwater
- groundwater quality and potential contamination
- impacts to surrounding groundwater users
- impacts to aquatic ecology.

As a result of proposed changes to the mine plan that included changes to the progression of mining, the proponent repeated the groundwater modelling and results were included in the sEIS v2.

The EIS claims that the mine development and operation will depressurise the Tertiary, deeper Triassic/Permian and Coal Seam aquifers by groundwater inflows into the East and West Pits which will lower the elevation of the piezometric surface of these aquifers and create a cone of depression around the mine. The cone of depression is predicted to extend approximately 3.5 km north, 3.5 km south, 4.5 km east and 5 km west for the Tertiary aquifer.

The supplementary EIS v2 states that drawdown depths at the western extremity of the cones of depression are expected to be between one and two metres with corresponding depths in the order of 50 m to 100 m in both the East and West Pit final voids. Therefore, it is considered by the proponent that the drawdown effect on the regional aquifer will remain localised and within 6 km of the nominal centre point of the mining operations.

The proponent claims that there are no operational domestic or stock bores located within or adjacent to the mining lease area and that no water supply bores will be affected by the lowering of the water levels predicted. Any significant impacts on groundwater levels would be detected through the groundwater monitoring program. Also in the EM plan dated 12 October included a commitment that should unexpected impacts to groundwater users occur, the proponent will explore appropriate "make good" measures (as defined in the *Water Act 2000*) in consultation with the impacted user and regulatory authority.

The supplementary EIS v2 predicted higher groundwater inflows than the previous mining scenario modelling predictions. Groundwater inflow predictions include:

- inflows to the East Pit are predicted to be in the order of 3.1 ML/day during the early stages of pit operations, increasing to approximately 5.6 ML/day as operations progress towards the year 4 stage following which inflows steadily decrease to 2.6 ML/day as the pit approaches it's final stages
- inflows to the West Pit are predicted to increase to in the order of 5.3 ML/day, sharply decreasing to 1.2 ML/day as backfilling of the East Pit is completed and dewatering of that pit ceases.

Groundwater inflow to the open working highwall sections of the mine should be controlled by sumps located in the pit for pumping pit water to surface storages to be used as water in the CHPP.

The EIS identified that there is the potential for contamination of the groundwater to occur from spills and contamination by metals and hydrocarbons from the mine workshop, waste disposal and fuel storage areas. Any spills from these areas are typically very localised and not regionally significant. The proponent's commitments to provide adequate bunding and immediately cleaning up of spills are considered adequate to prevent contamination of the shallow groundwater system. The proposed ground water monitoring program is considered adequate by DERM for detecting any previously unforeseen impact due to mining on the groundwater.

In considering the geochemistry of the overburden and reject material, the EIS states that it is unlikely any leachate generated from these materials will adversely impact groundwater quality. The EIS states that groundwater quality in the overburden and coal seam aquifers is of poor quality (saline) and would only be suitable for limited use. The proponent states that, based on the results of this geochemical characterisation, interaction between in pit disposal of overburden, interburden and potential coal rejects material with recovering (rising) groundwater levels and surface water (rainfall) runoff is not considered likely to result in poorer quality water in the Tertiary and Permian aquifer systems following cessation of mining. DERM considers the risk of impacts from any leachate generation should be minimised through the proponent implementing the mitigation measures proposed in the EM plan.

The EIS states that the water of the alluvial aquifer has aquatic ecosystem values of significance to the local ecology. As no mining activities are planned to intersect the alluvium associated with the aquifer, impacts to water levels within the aquifer are not expected. No potentially contaminating activities are proposed to be constructed or undertaken in areas of the project containing alluvium. The only potential impact the project could have on the alluvium would be the discharge of water to Devlin Creek which may be of lesser quality to the groundwater in the aquifer.

The EIS included adequate mitigation measures to prevent potential impacts to groundwater quality through contamination, including:

- the appropriate design and construction of the codisposal facility in accordance with statutory requirements, standards and codes, and industry best practice
- monitoring of groundwater bores for potential seepage and contamination as part of the groundwater monitoring program, including installation of additional monitoring bores immediately surrounding the codisposal facility
- inclusion of codisposal material, coarse reject and overburden in an operational waste characterisation program
- designated storage areas for hydrocarbons, chemicals and waste materials

- appropriate design of hydrocarbon and chemical storage facilities, in accordance with AS 1940, The Storage and Handling of Flammable and Combustible Liquids, 2004
- development and implementation of appropriate procedures for servicing and shutdown activities (both within workshop and in field), including spill management and waste management protocols
- development and implementation of an appropriate water management system that includes environmental dams for retention of mine water from pit dewatering activities; sediment dams for retention of sediment contaminated stormwater runoff from disturbed areas, overburden dumps and rehabilitated landforms
- levees to protect pits, overburden dumps and infrastructure from inundation during flood events
- drains to direct runoff away from the pits.

Residual void

Following completion of mining operations, water levels are expected to recover to equilibrium within the first 120 years post mining and water levels will remain more than 50 m below the crest of the pits. The final water level in the voids will remain between 10 m to 19 m below the base of the Tertiary sediments for the West and East pits respectively and therefore, as the base of the Tertiary sediments is the upper level of the regional aquifer system, the voids will create a groundwater sink. Due to the hydraulic gradient associated with the final void groundwater sink, recharge of the aquifer system from the final void is not expected.

The supplementary EIS v2 states that the principle reason that the water levels within the overburden and voids will recover to levels below pre-mining conditions is that average daily evaporation is around four times the average daily rainfall within the area. Given the evaporative influences, the saline nature of groundwater recovering to pits and salt leaching from backfilled overburden, it is expected that over time, the water within the final voids will progressively become more saline and eventually approach salinities similar to those observed within the regional aquifer system.

No active mitigation strategy is proposed by the proponent in relation to the post mining recovery of groundwater. Monitoring will be undertaken as part of the groundwater monitoring program.

Furthermore, the proponent commits to developing a residual void plan that is discussed in section 4.17 Rehabilitation of this EIS assessment report.

The recommended groundwater conditions for the draft environmental authority are outlined in Appendix 1.

4.8.2 Surface waters

The Codrilla Project footprint covers approximately 230 km^2 of the Devlin Creek catchment, with Devlin Creek, Bundarra Creek, the unnamed tributary of Bundarra Creek and a tributary of Swampy Creek flowing through the project areas. Devlin Creek and its tributaries are ephemeral and only flow for short periods following significant rainfall. Devlin Creek is the primary watercourse in the vicinity of the project. The EIS mentions that due to the flat topography of the Devlin Creek floodplain, flow paths for local stormwater drainage are poorly defined. Also the proponent claims that there are no well defined watercourses across the floodplain.

The Wetland Protection Area on Swampy Creek is a constructed dam and will not be impacted by mining activities and will continue to receive inflow of diverted clean water from the project.

There are currently no formal water use entitlements along Devlin Creek. However, owners of Lot 9 on Kl119 located about 23 km south east of the proposed MLs hold a permit to source water from Devlin Creek for stock and domestic supply.

DERM advised the proponent that the Water Resources (Fitzroy Basin) Plan 1999 is currently under review and that potential changes to the review may impact on the overland flow provisions for the mine development.

DERM advised the proponent of a number of issues with the description of surface water including:

- the maps showing the stormwater management structures were inadequate
- lack of information on stream flow at the time of sampling, using old (1971 to 1988) water quality data from the Bombandy gauging station

- inadequate assessment of seasonal variation of water quality or variation of water quality with flow of water quality samples due to the short period between the sampling occasions (end of January to end of March)
- lack of monitoring of sites in permanent and semi permanent waterholes, known aquatic habitats or reservoirs weirs
- not correctly comparing the physio-chemical indicators using the medium value of parameters for comparison to guidelines values, not using the 95th percentile of results for toxicants to compare with guideline values
- not supporting the claim that the project will not contribute to cumulative impacts of mining in the Fitzroy Basin
- not identifying the downstream users of the water for drinking purposes.

The above issues were adequately addressed by the proponent including:

- modifying stormwater maps in the sEIS to improve contour visibility and reflect mine footprint changes
- additional water sampling during stream flow events during the 2010/2011 wet season was undertaken to provide further information on seasonal variations which was presented and discussed the sEIS
- providing cross referencing in the sEIS regarding the monitoring of waterholes as part of the fauna survey.

Also the proponent revised the water balance to include data for 2010 which was the wettest year on record. The results of the revised modelling indicates that there should be no need to discharge water from the mine water management system. Based on the water balance results, the proponent claims that the mine should not contribute to cumulative impacts in the Fitzroy Basin.

However, as a result of the revised water balance the proponent proposes an additional 2,600 ML dam required to ensure adequate capacity for East Pit dewatering following an extreme event. This dam is proposed to be a temporary dam and located within the West Pit footprint. DERM raised a concern in relation to the management of water from this dam on completion of mining. The proponent provided an adequate response regarding the management of water from the temporary dam.

The description of the temporary mine dewatering dam was inadequate with no structural details due to the dam being only conceptual. In the detailed design of the temporary dam, the proponent will need to consider whether the dam requires a development approval for operational work for a referrable dam (constructing a Water Storage Facility under the *Water Supply (Safety and Reliability) Act 2008)*.

4.8.3 Surface water impacts and mitigation measures

The EIS states that potential impacts of the Codrilla Project on surface waters are likely to include impacts on watercourse structure and flow rates, flood depths, and water quality.

4.8.3.1 Watercourse structure

The EIS identified project activities that may impact on the structure of watercourses and drainage lines including:

- construction activities related to the proposed Codrilla to Moorvale Haul Road, incorporating clearing of vegetation and construction of concrete floodways over Devlin Creek, Bundarra Creek and the unnamed tributary of Bundarra Creek
- construction activities associated with the site water management system, incorporating construction of drainage channels, culverts, dams and levees around the site to separate mine affected water from clean water
- discharge of dams during flow events.

4.8.3.2 Flow rates

The proposed mining pit and overburden dump locations for the project are outside the banks of the Devlin Creek and Swampy Creek main channels. The EIS claims that the proposed mine will not affect the geomorphology or flow dynamics of Devlin Creek or Swampy Creek. The proposed development will obstruct flow paths for local stormwater runoff. However, it is considered that there will be no measurable impact on the quantity of water available to downstream users.

The proposed mine water management system has been sized to contain runoff from disturbed areas for reuse within the Coal Handling and Preparation Plant (CHPP) and a low risk of off site discharge. As a consequence the EIS claims that the project will have an impact on flow volumes only within poorly defined minor tributaries leaving the site.

As a result of mine plan changes with resulting changes to the mine footprint, the proponent remodelled the impact on flows in the watercourse immediately downstream of the project. The sEIS v2 states that at Devlin Creek, immediately downstream of the Swampy Creek confluence, the modelled median annual flow is predicted to be reduced by 7.0% in 2015 and by 10.8% when the mine footprint is largest.. However, at Reporting Point C situated on a Tributary of Swampy Creek at the mining lease boundary, flows will be increased in the order of 57%, due to the diversion of flow from undisturbed catchments around the disturbed areas.

4.8.3.3 Flooding

Existing flood levels modelled in the project area indicate the requirement for construction of a flood levee around the West Pit and out of pit overburden dump. Modelling indicates that there is potential for areas where infrastructure may be located in proximity to East Pit to be impacted by flooding. Therefore, flood levees are proposed to protect pits, overburden dumps and mine infrastructure. Levee heights are proposed which would ensure protection against flood levels of a 2,000 year Annual Recurrence Interval (ARI[5]).

To examine impacts of the project on flood levels in the area, TUFLOW modelling was repeated with the inclusion of site infrastructure and proposed levee. Flood modelling showed that impacts of levee construction on flood levels in the vicinity of the project will be minimal, with increases in flood levels over 0.1 m restricted to just upstream of the western levee. The proponent claims that the project will have no impact on regional flooding in waterways downstream of the mining lease.

4.8.3.4 Water quality

The EIS identified activities associated with the project that may impact on the water quality of Devlin Creek and smaller drainage lines in the project area including:

- runoff from rainfall events in areas subject to construction, earth moving activities, vehicle movements and dust suppression
- erosion of drainage lines, overburden dumps, stockpiles or other open areas
- leaching of contaminants from fuel, chemical or waste storage areas, overburden dumps or codisposal
- discharges of mine affected water from environmental dams
- overflows of sediment and environmental dams during significant rainfall events
- spills of hydrocarbons or chemicals
- failure of the project's proposed Water Management System.

In the supplementary EIS v2 it is stated that the simulation of the site water balance indicates that, under the range of historical rainfall conditions used in the modelling, there should be no need to discharge water from the mine water management system. For this reason, assuming the mine water management system performs in accordance with the modelling assumptions, the mine should have no downstream impacts. The mine water balance modelling has been revised to include data for 2010 which was the wettest year on record. The results of the revised modelling also indicate that no discharges should be required.

However, it is possible that discharges from the mine water management system may occur should scenarios beyond the range of conditions used in the model simulation prevail. For this reason, the revised surface water assessment in the supplementary EIS v2 includes recommended discharge criteria to ensure that any emergency releases that are required will occur at a time of high flow in the receiving watercourse when substantial dilution of mine water discharges and post discharge flushing will occur.

[5] ARI is a measure of the rarity of a rainfall or flood event

4.8.3.5 Receiving environment monitoring program (REMP)

DERM raised a number of issues with the proposed REMP in the EIS that was available for public viewing, including:

- discharge locations were not specified so it was not possible to determine the appropriateness of monitoring locations
- no suitable background monitoring sites downstream of the project site
- upstream and downstream receiving environment monitoring should occur during all flow events, whether or not discharges are taking place to allow for assessing the condition of the waterways
- maximum height indicators and gauge boards should be installed as a back up for estimating maximum stream heights should the loggers fail
- not all the likely affected downstream areas of the mine were included in the monitoring locations.

The proponent provided an adequate response in the sEIS v2, including:

- discharge locations from all dams and an emergency release point in Environmental Dam 3 were included in the figure showing proposed surface water management
- additional reference sites have been proposed for other local creeks, including Swampy Creek, to provide further information on water quality from local streams which are located in catchments not containing mining activities [check]
- identification of the flow measurement locations for the REMP
- proposing to monitor flow events regardless of discharge status
- monitoring of minor streams proposed to provide additional data collection relevant? to reference water quality
- additional downstream monitoring locations.

DERM was satisfied with the response on issues in relation to receiving environment (water). However, the proponent will be required to provide the exact location details of all contaminant release points prior to operating.

4.8.3.6 Mitigation measures

In order for potential impacts from surface water contamination to be satisfactorily mitigated, the proponent will need to meet their commitments in the EM plan, including:

- establishing and implementing a site water management plan that includes a description of the water management system, operating rules, water monitoring and infrastructure inspection requirements
- investigating all substantial water related complaints
- implementing corrective action resulting from complaint investigations as required
- separating runoff from disturbed and undisturbed areas
- minimising the contamination of surface water on site
- monitoring activities conducted in accordance with the DERM Water Quality Sampling Manual and laboratory analysis conducted by a NATA accredited laboratory
- storing and handling of chemicals, fuels and hazardous wastes will comply with regulatory requirements and applicable Australian Standards
- containing, treating and reusing surface water on site in preference to discharge
- managing unavoidable releases in accordance with DERM conditions to protect downstream environmental values, such as stock water.

Furthermore, the proponent will need to meet their commitment to developing a controlled release procedure as part of the site water management plan that includes release rules, release locations, monitoring and analysis requirements, stakeholder notification, reporting requirements and positional responsibilities.

The recommended surface water conditions for the draft environmental authority are outlined in Appendix 1.

4.9 Air quality

The EIS was adequate with respect to the TOR regarding air matters. The proponent adequately addressed air issues during the EIS process, including dust emissions and greenhouse gas emissions.

The proponent was advised that DERM was not satisfied with the EIS presenting 6th highest values for predicted PM_{10} concentrations on the basis that the EPP (Air) goal allows for five exceedences of the goal per year. The proponent was advised that the intent of the five exceedences was to recognise elevated PM_{10} levels from extreme, natural meteorological events rather than project related causes.

In the EIS that was available for public viewing, the predicted 24 hour average (6th highest) PM_{10}[6] and the 24 hour average $PM_{2.5}$[7] concentration exceeded respective EPP(Air) goals at a number of receptor sites, for all three mine operations scenarios investigated. Consequently, DERM advised the proponent that dust mitigation must be reviewed and additional measures proposed that would maintain acceptable air quality.

The proponent proposed changes to mining schedule and fleet composition and the air quality model was rerun with the results included in the response to submissions. The supplementary EIS received by DERM on 30 June 2011, states that the predicted impacts from the project on sensitive locations have reduced significantly from the predictions of the initial modelling presented in the EIS available for public viewing.

In the response to submissions on the supplementary EIS dated 30 June 2011, the proponent remodelled air emissions using the following three modelling scenarios:-

Year 1 - Pit cutting face at the eastern end of the eastern pit

Year 6 - Pit cutting face at the western end of the eastern pit

Year 11 - Pit cutting face at the western end of the western pit

Each scenario was modelled using the highest annual run of mine (ROM) coal and overburden production rates from within the schedule, being 5.25Mt of ROM coal and 54.7Mt of overburden. Years 1 and 6 are expected to have the highest potential impact on sensitive locations (listed below in Table 4.4) due to proximity of the mining activity within the eastern pit to the sensitive locations.

Table 4.4- Sensitive Locations

Location Identifier	Location Name	Distance from nearest mining pit (km)	Distance from CHPP (km)
L1	Devlin Creek Homestead	15.3	16.5
L2	Lillianvale Homestead	10	13.7
L3	Regalo Homestead	4.6	8.4
L4	Weamber Homestead	7.0	9.4
L5	Codrilla Homestead	4.9	4
L6	Moorpeth Homestead	13.6	16.7
L7	Valkyrie School building	2.9	2.8
L8	Valkyrie School residence	2.8	2.7
L9	Bundarra Homestead	15.1	13.3
L10	Iffley Homestead	19.0	21.7
L11	Deveril Homestead	18.2	20.5
L12	Valkyrie Homestead	12.2	11.3

From the air modelling, the predicted air emissions were compared against the air criteria under the Environmental Protection (Air) Policy 2008 (EPP Air) that indicated the following:

[6] PM_{10} means particles in the air environment with an equivalent aerodynamic diameter of not more than 10 microns.
[7] $PM_{2.5}$ means particles in the air environment with an equivalent aerodynamic diameter of not more than 2.5 microns.

- annual average $PM_{2.5}$ concentrations are within the air quality criteria values determined for the project at all sensitive locations during all three modelled years. The predicted maximum annual average $PM_{2.5}$ concentration is 4 µg/m^3 which occurs at Locations 5, 7 and 8 during years 1 and 6
- $PM_{2.5}$ 24 hour concentrations are within the air quality criteria values determined for the project at all sensitive locations during all three modelled years. The highest predicted $PM_{2.5}$ 24-hour concentration is 21 µg/m^3 which occurs at Locations 7 and 8 during years 1 and 6
- maximum 24 hour average PM_{10} concentrations are within the air quality criteria values determined for the project for all locations during all three modelled years except at locations 3, 4, 5, 7 and 8 during year 1; locations 3, 5, 7 and 8 during year 6 and Locations 5, 7 and 8 during year 11
- maximum 24 hour average PM_{10} concentration is 129 µg/m^3, which occurs at Location 7 during year 11 operations
- 6th highest 24 hour average PM_{10} concentrations are within the air quality criteria values determined for the project for all locations during all three modelled years except at Locations 7 and 8 during years 1 and 6 and Locations 5, 7 and 8 during year 11
- maximum 6th highest 24 hour average PM_{10} concentration is 79 µg/m^3, which occurs at Location 7 during year 11 operations
- annual average TSP concentrations are within the air quality criteria values determined for the project for allocations during all three modelled years. The predicted maximum annual average TSP concentration is 43 µg/m^3 which occurs at Locations 7 and 8 during year 1
- monthly dust deposition rates are within the air quality criteria values determined for the project for all locations during all three modelled years. The predicted maximum monthly dust deposition rate is 3 g/m^2/month which occurs at Locations 7 and 8 during year 1.

To address air impacts, the proponent is committed to relocating the Valkyrie School and school residence and to having the Codrilla Homestead vacated throughout the life of the mine project.

DERM's submission on the supplementary EIS asked the proponent to expand on commitments in the EM plan in relation to dust monitoring and dust control actions to ensure the project meets the air quality objectives under the EPP (Air).

Mitigation measures that are proposed in the EM plan to manage potential air impacts from the project include:

- haul road watering, watering of stockpiles and dump areas
- managing blasting operations
- minimising disturbed areas
- progressive rehabilitation
- water sprays throughout the Coal Handling Preparation Plant
- enclosure of transfer points within the coal processing system.

Also in the EM plan, the proponent commits to providing air monitoring that will include:

- Five depositional dust gauges located at the Regalo Homestead, around the Codrilla A ML and along the Codrilla to Moorvale Haul Road
- Two Tapered Element Oscillating Microbalances (TEOM), will be installed at the relocated Valkyre School and residence site and the Regalo Homestead to monitor PM_{10} and $PM_{2.5}$ concentrations during the construction phase and the first year of operations
- The EIS also commits to locating a weather station adjacent to the Regalo Homestead.

The proponent has adequate commitments in the EM plan to engaging with all residents and users of sensitive locations which do not meet the EPP (Air) goals. The proponent commits to liaison with these parties in relation to potential impacts, mitigation measures and monitoring outcomes throughout the life of the project.

The EIS states that information received from dust monitoring and the weather station will enable mitigation strategies to be further developed based on actual site specific conditions. Such mitigation measures include:

- modifying mining operation under certain meteorological conditions, for example overburden dumping to an alternative area of a dump from which a particular potentially affected location is shielded
- additional emission attenuation at a source
- attenuation measures at sensitive locations.

The proponent needs to implement the EM plan commitments to address air issues, including:

- Dust management measures will be implemented during construction activities and the operational and rehabilitation phases
- Nuisance complaints will be investigated and resolved in a reasonable and practicable manner, and the proponent will respond to complaints within 48 hours
- All monitoring and sampling techniques will be consistent with the DERM's Air Quality Sampling Manual and applicable Australian Standards
- Regular consultation with the residents of Regalo and Weamber homesteads will be ongoing to address the potential air quality impacts
- Engaging with Queensland Rail in relation to the potential for dust mitigation of product coal loading to trains at the Moorvale load out facility and rail transport of coal.

Wheel generated dust associated with trucks travelling on unpaved haul roads is a major source of particulate matter emissions. According to Table 9 of the EM Plan, wheel generated dust from unpaved roads contributes about 83.6% of the total suspended particulate emissions. A commitment is made, in the EM Plan dated 7 October 2011, to further address dust emissions from the haul road in the event that monitoring indicates additional mitigation measures are necessary to comply with conditions of the environmental authority.

The EIS included a satisfactory assessment of potential Greenhouse gas (GHG) emissions using the National Greenhouse Accounts Factors published by the Commonwealth Department of Climate Change and Energy Efficiency.

The direct and indirect GHG emissions generated from the project include:

- Fuel consumption by mining equipment
- Fuel consumption of stationary sources (pumps, generators and lights)
- Combustion of Ammonium Nitrate/Fuel Oil Emulsion for blasting
- Electricity purchased from the grid
- Fugitive methane emissions.

The recommended conditions for management of environmental impacts of air emissions are outlined in Appendix 1.

4.10 Noise and vibration

The EIS adequately addressed the TOR in regard to noise and vibration matters.

The area within and surrounding the Codrilla Project can be described as a quiet rural setting with the primary noise sources being from traffic travelling the Fitzroy Developmental Road (FDR), cattle, farm machinery and natural influences such as rustling trees and native fauna. The EIS found that background noise levels were very low at the project site.

The EIS assessed the potential impacts from noise and vibration from the project on 12 sensitive locations (listed in Table 4.4). The closest sensitive locations were the Valkyrie School and school residence about 2.8 km from the project and the Codrilla Homestead about 4 km from the project.

The noise assessment in the EIS included the development of a predictive model that considered different meteorological conditions and mining scenarios. Also the predictive model considered proposed control strategies

to be incorporated into the project. The predictive model indicated exceedences of the Environmental Protection (Noise) Policy 2008 (EPP Noise) and DERM guidelines that may occur at up to seven of the sensitive locations during operation of the project. Exceedences were found highest during stable night time meteorological conditions. The three most significantly impacted sensitive receptors were the Valkyrie School and school residence and the Codrilla Homestead.

DERM advised the proponent of a number of noise issues from the EIS study that needed to be addressed, including:

- use of the noise levels at the Valkyrie School for the assessment and proposal of noise limits that appeared highly irregular and possibly spurious with the very high values of LAeq for three time periods compared to relatively low values for LA90[8]
- elevation of the relatively low values of background level to higher values by using the superseded E3 guideline that dealt with noise from extractive industries
- noise limits proposed for the project in the EM plan could be exceeded by 5 dB(A) or more
- the provision of only general recommendations for noise mitigation.

Furthermore, the proponent was advised to reassess and improve the proposed noise mitigation measures so that substantial specific noise reductions can be achieved.

In response to DERM's issues and changes to the mine schedule, the proponent provided a revised noise and vibration assessment for the project in the response to submissions received by DERM on 30 June 2011. DERM considered that the revised noise and vibration assessment adequately addressed DERM's issues.

In the response to submissions, the proponent repeated the noise modelling incorporating changes to mining schedule and fleet composition. The predicted impacts from the operation on sensitive locations were found to be reduced compared to predictions in the EIS that was available to the public. The proponent proposed the noise limits for the project in Table 4.5 Recommended Noise Limits below. These limits assumed a minimal 5 dB(A) reduction through a light weight building façade with open windows.

Table 4.5 - Recommended Noise Limits

Leq, adj,T9 (T=15 minutes to 1 hour) dB(A10)		
Daytime	**Evening**	**Night time**
40	40	35

A comparison of the proposed limits in Table 4.5 Recommended Noise Limits above to the predicted noise levels for all years of operation indicates that exceedences will occur at locations 3,5,7 and 8 under the noisiest conditions and some median meteorological conditions (shown highlighted below in Table 4.6).

Table 4.6 - Predicted Noise Limits for All Years of Operation

Highest Noise Level Predictions - years 1,6 & 11 Leq, dB(A)							
		Noisiest 10%			**Median Case**		
ID	**Location**	**Day**	**Eve**	**Night**	**Day**	**Eve**	**Night**
1	Devlin Creek	15	25	25	9	14	14
2	Lillianvale	29	30	30	15	17	18
3	Regala (N3)	33	40	36	27	32	29
4	Weamber	26	35	34	23	28	27
5	Codrilla	36	40	39	32	35	34
6	Morpeth	25	28	27	12	20	13

[8] L90 means the noise level exceeded for 90% of the measurement period. This is commonly referred to as the background.

[9] $L_{Aeq,add,T}$ means an A-weighted sound pressure level of a continuous steady sound, adjusted for tonal character, that within a measuring period (T) has the same mean square sound pressure as a sound level that varies over time.

[10] dB(A) means decibels measured on the 'A' frequency weighting network.

7	Valkyrie School	42	46	45	38	40	40
8	School House	43	46	46	38	41	40
9	Bundarra	9	27	26	5	14	13
10	Iffley	2	22	22	1	11	11
11	Deveril	3	23	23	1	12	12
12	Valkyrie	11	29	29	6	19	14

The proponent recommends that a night time limit of 35 dB(A) and a daytime and evening limit of 40 dB(A) be applied to the project. DERM is satisfied with the proposed noise limits for the Codrilla Project and these limits are included in the recommended conditions in Appendix 1 for the draft environmental authority (EA).

The EIS states that exceedences of the proposed noise limits will occur at the Codrilla Homestead, Valkyrie Homestead and Valkyrie school and residence. Also noise levels at the Regalo Homestead may just exceed the proposed noise limit during the night time under the noisiest and worst case meteorological conditions. The proponent will need to meet their commitments made in the EM plan to address noise impacts, including:

- relocation of Valkyrie School and school residence
- having the Codrilla Homestead vacated during the life of the project
- modifying mining operation under adverse meteorological conditions
- a complaints register and an investigation and response procedure will be implemented and maintained as part of the site Environmental Management System (EMS)
- all machinery on site will be properly maintained and operated in accordance with manufacturers specifications
- speed limits will be imposed onsite
- all mobile equipment to be fitted with appropriate silencing equipment
- additional noise attenuation at the source in the event that monitoring indicates levels are in exceedence of the EA conditions for the project
- noise attenuation measures at sensitive locations in the event that monitoring indicates levels are in exceedence of the EA conditions for the project
- regular consultation with the local residents will be ongoing in relation to the potential noise impacts
- information from noise monitoring equipment and the weather station will be correlated to enable mitigation strategies to be further developed based on actual site specific conditions as they develop.

The EIS states that vibration from blasting activities will not affect any of the sensitive locations in excess of levels in DERM guidelines. However, air blast levels from blasting were predicted to exceed DERM criteria at up to six sensitive locations. The proponent will need to meet the commitments made in the EM plan to minimise the impacts of blasting activities including:

- incorporation of measures into blast design to minimise ground vibration and airblast
- monitoring of initial blasting activities at selected locations to establish the accuracy of the predicted vibration and airblast levels
- consultation with surrounding landholders in relation to developing protocols for notification of blasts
- consultation with the Isaac Regional Council in relation to the use of the camping and water reserve located adjacent to the Valkyrie School and potential management strategies to minimise impacts of blasting on users of the reserve
- reconnaissance of the stock route which runs concurrent with the Fitzroy Developmental Road (FDR) for travelling stock within the potential impact zone
- traffic control on the FDR when blasting is undertaken within a nominated distance of the road.

Furthermore, it is important that the proponent maintain ongoing consultation with the Department of Transport and Main Roads regarding issues of traffic control during blasting and appropriate design of the FDR realignment to incorporate any necessary criteria relative to ground vibration.

The EIS states that low frequency noise was expected to exceed the legislative goal at the Valkyrie School and school residence and at the Codrilla Homestead. The EIS further states that the Valkyrie School and school residence will be relocated and the Codrilla Homestead will be vacated. DERM considers low frequency noise should be managed through the EA conditions that will require the proponent to investigate any complaint about low frequency noise by conducting noise monitoring and implementing any necessary mitigation measures.

The recommended EP Act noise conditions for the draft environmental authority are outlined in Appendix 1.

4.11 Nature conservation

4.11.1 Impact on vegetation communities

The EIS identified potential impacts on vegetation communities, including:

- clearing of vegetation for the construction of mine infrastructure within the Codrilla Project area including a number of dams, sediment basins, the initial open cut pits and the haul road to Moorvale Coal Mine
- clearing of vegetation progressively during operation of the mine for open cut pit extensions and stockpile extensions.

The project will require the disturbance of approximately 2,056 hectares (ha) over the life of the project. However, 2,004 ha has been previously cleared for agricultural use, the remaining 52 ha comprises of remnant regional ecosystems detailed below in Table 4.7 Extent of clearing REs required for the project. Seven regional ecosystems (REs) will be impacted by the project. The Vegetation Management status of one of these REs is listed as endangered (11.4.9 Brigalow) with the remaining six being listed as of 'Least Concern'.

The remaining issues relating to the removal of vegetation are covered by the controlling provision for the Codrilla Project under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) as well as by the provisions of the Environmental Authority under the EP Act. Impacts on vegetation communities are covered in section 4.12, Matters of National Environmental Significance, of this EIS assessment report.

Table 4.7 - Extent of clearing REs required for the project

Regional Ecosystem	VM Act Status	Description	Proposed area to be cleared (ha)
11.11.1	Least Concern	*Eucalyptus crebra* ± *Acacia rhodoxylon* woodland on old sedimentary rocks with varying degrees of metamorphism and folding	2.9
11.3.25	Least Concern	*Eucalyptus tereticornis*, *Corymbia tessellaris* and *Casuarina cunninghamii* with a grassy understorey on creek banks	1.7
11.3.27	Least Concern	Freshwater wetlands with variable vegetation, including open water with or without aquatic species and fringing sedgelands and Eucalypt woodlands.	0.05*
11.11.9	Least Concern	*Eucalyptus populnea* or *E. brownii* woodland on deformed and metamorphosed sediments and interbedded volcanics	1.0
11.4.9	Endangered	*Acacia harpophylla* shrubby open forest to woodland with *Terminalia oblongata* on Cainozoic clay plains	3.8
11.5.2	Least Concern	*Eucalyptus crebra*, *Corymbia* spp., with *E. moluccana* on lower slopes of Cainozoic sand plains/remnant surfaces	15.8

11.5.3	Least Concern	*Eucalyptus populnea* open forest with grassy or shrubby understorey	25.9
Total			**51.29**

* 11.3.27 is likely to not be cleared or impacted during the construction of the Codrilla to Moorvale Haul Road if a 35m running surface is implemented.

Source – Table 4.10.17 in the EIS.

4.11.2 Impacts on flora

Two hundred and fifty nine plant species were recorded in twelve vegetation types including non-remnant status communities.

The Black Orchid (*Cymbidium canaliculatum*) was the only plant species of conservation significance found at the site.

The proponent provided adequate mitigation commitments, including:

- *Cymbidium canaliculatum* – If any specimens were to be salvaged a permit from DERM would be required
- other Conservation listed species – If any populations are located, avoid disturbance if it is reasonably possible and make provision for relocation of individuals if necessary.

4.11.3 Impacts on fauna

One hundred and sixty three terrestrial vertebrate species were found over the duration of the two surveys including eleven amphibians, sixteen lizards, six snakes, one turtle, ninety eight birds, seventeen microchiropteran bats and fourteen other mammals.

Significant fauna species

One conservation listed mammal (Little Pied Bat -'near threatened') and one ‘vulnerable’ bird species (Squatter Pigeon) were found at the project site and another five mammal species have been identified as possibly in the area. Also two migratory species were found in the proposed mining lease.

One vulnerable listed reptile (Ornamental Snake) was found at Codrilla and a number of near threatened and threatened reptiles listed as possibly in the area included:

- Brigalow Scaly-foot ('vulnerable' under the NC Act)
- Short-necked Worm-skink ('non threatened' under the NC Act)
- Yakka Skink ('vulnerable' under the NC Act)
- Dunmall’s Snake ('vulnerable' under the NC Act).

A small loss of potential habitat for these species may occur due to the mining operations, but would not be significant in the regional context.

The impacts on the Squatter Pigeon, Ornamental Snake , migratory species and the above reptiles are discussed in section 4.12 on Matters of National Environmental Significance, of this EIS assessment report.

Little Pied Bat (*Chalinolobus picatus*)

The Little Pied Bat ('near threatened' under the NC Act) was found in the proposed ML area at the Brigalow and Poplar Box sites. Minor impact is anticipated to occur to the habitat of the Little Pied Bat as a result of the very small loss of woodlands associated with the project site.

4.11.4 Loss of habitat for significant fauna

The EIS states that the very small loss of woodlands associated with the Codrilla Project would not significantly reduce regional habitat of fauna species identified in the project area.

The EIS contained adequate commitments to address impacts on the loss of habitat for significant fauna that are mentioned in section 4.12.3 Mitigation measures in this EIS assessment report.

4.11.5 Loss of important microhabitats

The EIS mentions that many hollow nesting birds and bats were recorded at the project's study area, including fourteen microbat species, and at least 18 bird species. Brown Treecreepers were observed nesting, and a Southern Boobook roosting, in hollows at the Poplar Box site. The EIS states that the moderate to high densities of hollow-bearing trees in small remnant woodland habitats at the project site provide ample nesting and denning opportunities for hollow-dependent fauna. These hollow bearing trees are concentrated along the riparian zones and in the open *Eucalyptus populnea* woodlands in the north-east of the area. Other woodland areas are low in mature hollow-bearing trees, and continuity across the landscape is limited. Eucalyptus and Corymbia trees take more than 150 years to form hollows. This time frame means replacement of hollows during rehabilitation can only occur through the installation of nest-boxes onto regrowth trees, an expensive process that can only be done when the trees reach a reasonable size (approx. 20 years old). The EIS states that it is more practical to preserve the existing hollow-bearing trees where possible and maturing trees should also be retained to ensure continuity of habitat.

The EIS states that ground litter and logs are an important microhabitat for a wide range of fauna (reptiles and small mammals) and would require lengthy time periods to be replaced by the normal processes during rehabilitation. These processes include the growth of overstorey tree species and understorey shrubs, the fall of leaves and small branches from trees, the falling of trees, and the deaths and decay of small shrubs.

The Fitzroy Basin Association (FBA) raised an issue in its submission on the supplementary EIS documents about the loss of important microhabitat due to the project. This issue was addressed by the proponent providing further commitments in the supplementary EIS relating to the development of a Species Management Program prior to any clearing as per the Nature Conservation (Wildlife Management) Regulation 2006.

4.11.6 Impacts on habitat corridors

The vegetation along Devlin Creek provides an important state corridor linking the vegetation remnants along the waterway to the large areas of remnant vegetation associated with Mount Orange and Mount Marion in the north to the Isaac River and Connors Rivers. These vegetation corridors have several small gaps already from road easements within the study area. The linkage values of the above corridors will be impacted by the construction of the haul road to Moorvale by isolating vegetation patches from the north of the proposed routes and the corridors along Devlin Creek.

The proponent provided adequate commitments in the EIS to address impacts on habitat corridors that are mentioned in section 4.13.3 Mitigation measures of this EIS assessment report.

Also the proponent has provided an adequate commitment of developing an offset for clearing.

4.11.7 Weed species

The Codrilla Study Area contained a total of 32 exotic pest species. Of the 32 species, nine are declared pest species under provisions of the *Land Protection (Pest and Stock Route Management) Act 2003* and/or require management indicated by the Local Government Management Plan. These species included:

- Parthenium - *Parthenium hysterophorus*
- Harrisia Cactus - *Eriocereus martinii*
- Prickly Pear - *Opuntia stricta*
- Velvety Tree Pear - *Opuntia tomentosa*
- Parkinsonia - *Parkinsonia aculeata*
- Flannel Weed - *Sida cordifolia*
- Giant Rat’s Tail Grass - *Sporobolus natalensis*
- Lantana - *Lantana camara*

- Blue Snakeweed - *Stachytarpheta jamaicensis.*

The EIS mentions that the management options for weed control will include those in the Isaac Regional Council pest management plans (Nebo Shire Council, 2005) and by the Capricorn Pest Management Group (Capricorn Pest Management Group, 2006).

4.11.8 Aquatic ecology

Three waterholes were chosen as sample sites on Devlin Creek (DC1-3) in the May 2009 survey and two major dams were sampled in April 2010 survey to assess the freshwater biota.

There was no flowing water at the time of the May 2009 survey, with the creek bed and edges predominately sandy. There was 10-30m of riparian vegetation on each side of the creek, with little or no weed infestation. All of the sites showed evidence of siltation.

Water quality parameters were similar over the three sample sites. Water quality parameters did not exceed the ANZECC guidelines for water for livestock but some water quality parameters were outside the limits set by the Queensland Water Quality Guidelines including:

- turbidity at the Devlin Creek sampling site DC1
- suspended solids at all sites
- total Nitrogen at all sites
- total Phosphorous at the Devlin Creek sampling sites DC2 and DC3.

The aquatic ecology section in the EIS states:

- five species of macroinvertebrates were identified within the Codrilla Project Study area
- of the ten aquatic plant species identified in the Queensland Herbarium database search three species were identified as present by the aquatic assessment: *Ludwigia*, *Cyperus* and *Potamogeton* species.

The EIS states that no aquatic species of conservation significance were identified in waterways and dams within the project area and it is unlikely that any conservation significant species occupy the project area.

4.11.9 Impacts on stygofauna

The EIS states that *Bathynella*, *Cyclopidae* and *Harpacticoid* spp collected from monitoring bore 4 (MB4) near Devlin Creek confirms that Stygofauna occur in the Alluvial aquifer inside the proposed Codrilla A ML boundary. The EIS claims that no stygofauna have yet been found in the deeper aquifers of Codrilla Project, therefore the only threat would have come from diverting Devlin Creek. As diversion of Devlin Creek is not proposed as part of the project, there are no impacts predicted to the identified stygofauna species. Mining operations are not predicted to intersect the alluvium of Devlin Creek in which the Stygofauna are located, and the Alluvial aquifers are not hydraulically connected to the underlying Regional aquifer system. Therefore the predicted drawdown of the Regional aquifer as a result of mining operations is not expected to impact the Alluvial aquifers.

DERM advised the proponent that there is was inconsistency in the EIS between the statement made that the main threat to stygofauna would come from diverting Devlin Creek (which is not proposed) and the information about alluvial groundwater resources provided. The EIS notes some variable connectivity between the Quaternary alluvial sediments of Devlin Creek and the adjacent Tertiary sediments, and that the Tertiary aquifer receives some recharge from the overlying perched aquifer associated with Devlin Creek. The pit will intersect and drain groundwater from the Tertiary sediments, and because of the connection between the aquifers there is the potential for the groundwater level in the Quaternary alluvial sediments of Devlin Creek to be lowered by in-flow into the pit through the Tertiary sediments. That appears to be the main potential impact on stygofauna, and it may occur despite Devlin Creek remaining undiverted. The proponent was advised to reassess the potential impact of mining operations at Codrilla on stygofauna due to the lowering of groundwater levels in nearby sediments, and propose mitigation measures.

The proponent provided an adequate response to DERM's issue on stygofauna. The proponent advised that the Alluvial aquifers were assessed as being perched aquifers located above a thick clay layer of tertiary sediments with low permeability. During groundwater monitoring bore construction, the clay layer remained essentially dry

and the tertiary aquifer is confined below this layer. The hydraulic regime in the alluvial aquifer is not expected to alter, provided there is no intersection by mining activities. Drawdown of the Regional aquifer (inclusive of the Tertiary aquifer) is not expected to impact the water levels within the Alluvial aquifers and impacts to Stygofauna associated with the Alluvial aquifer are not expected. Ongoing monitoring of water levels within the Alluvial aquifer is proposed throughout operations. The ongoing monitoring results will be reviewed as they are received and annual formalised review will also be undertaken.

The EIS proposes the following adequate mitigation measures to address potential impacts on stygofauna:

- to keep the alluvial aquifer intact, Devlin Creek will not be diverted
- additional Stygofauna assessment will be undertaken in the Alluvial aquifers with sampling from the existing bores and three new alluvial bores that are yet to be constructed
- a groundwater monitoring program will be implemented to encompass alluvium water quality parameters where any Stygofauna species are located from past and future surveys

4.12 Matters of National Environmental Significance

The controlling provisions for the Codrilla Project are sections 18 and 18A (Listed threatened species and communities) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The project area contains endangered ecological communities listed under the EPBC Act, namely Brigalow (*Acacia harpophylla* dominant and subdominant communities). The ornamental snake (*Denisonia maculata*) and Squatter Pigeon (*Geophaps scripta scripta*), species listed as 'vulnerable' under the EPBC Act, were identified by surveys as being present in the project area. Also, two listed migratory species were identified within the project area including Great Egret (*Ardea alba*) and Rainbow Bee-eater (*Merops ornatus*).

A coastal Ramsar wetland is located approximately 60km to the north of the Fitzroy River mouth and 170km to the south east of the project. Lake Elphinstone located 70km to the north west is listed as an important wetland under the EPBC Act. The EIS states that the project will not impact on any Wetlands of International Importance.

4.12.1 Impact on vegetation communities

The project area contains the following Brigalow REs, 11.4.9 (*Acacia harpophylla* shrubby open forest to woodland with *Terminalia oblongata* on Cainozoic clay plains) and 11.4.8 (*Eucalyptus cambageana* woodland to open forest with *Acacia harpophylla* or *A. argyrodendron* on Cainozoic clay plains) that are listed as endangered ecological communities under the EPBC Act. The EIS states that RE 11.4.8 will not be impacted by mining operations or the recommended Northern Haul Road Option 3.

Minor impacts on RE 11.4.9 were identified in the EIS. The total area of Brigalow community proposed to be cleared is 3.8 ha. The impacted areas of RE 11.4.9 within the Codrilla mining area include two small isolated and degraded patches. The EIS mentions that there will be a loss of some vegetation along the preferred Northern Haul Road Option 3. However, vegetation impacts will be minimised by the utilisation of existing cleared areas bypassing the significant vegetation with the exception of encroaching on some thin strips (<40m) of RE 11.4.9. The total area of RE 11.4.9 to be impacted along the haul road route is 1.28 ha.

The EIS states that the clearing procedures will ensure that any clearing of remnant vegetation will be restricted to the minimum necessary to enable the safe construction, operation and maintenance of the project. Also the clearing procedures have measures to deal with any encountered threatened species under the EPBC Act and NC Act. These measures include obtaining any necessary permits under the NC Act for relocating any threatened species.

4.12.2 Impacts on listed species of flora and fauna

The EIS states that no threatened flora species listed under the EPBC Act were recorded within the project area during the field surveys in May 2009 and April 2010.

The Ornamental Snake and the Squatter Pigeon are listed 'vulnerable' under the EPBC Act and were recorded within the project area during the field surveys.

Rainbow Bee-eater and the Eastern Great Egret are species listed as migratory under provisions of the EPBC Act and were recorded within the Codrilla study area during the field surveys.

Also a number of reptiles listed as near threatened under the EPBC Act possibly occur in the area including Brigalow Scaly-foot; Short-necked Worm-skink; Yakka Skink and Dunmall's snake.

Ornamental Snake (*Denisonia maculata*)

Two Ornamental Snakes (*Denisonia maculata*) listed as vulnerable under NC Act and EPBC Act were located within the Land Zone 11 Woodlands and Brigalow fauna sites. This species may also occur in the *Eucalyptus cambageana* woodlands within the project area. The EIS states that the Ornamanental Snake favours Brigalow and riparian woodlands and feeds almost exclusively on frogs. Due to the high rainfall event prior to the 2010 survey there were a high number of frogs near waterways and extending into hilly woodland areas. The EIS states that this could be a factor contributing to the Ornamental Snake being located within the Woodland and Brigalow Sites. However, habitat for the ornamental snake is typically freshwater waterholes/creeks and under litter/fallen timber and in wide soil cracks on deep cracking clay and sandy loam soils in riparian woodland/open forest and shrub/woodland including Brigalow, consistent with survey findings.

The proposed haul road will encroach on some ornamental snake habitat: 4.2 ha of Brigalow and 5.02 ha of Land Zone 11 Woodland. The haul road follows an existing fire break and encroaches no more than 40m into the REs and 50 m into Land Zone 11 Woodland. The EIS states that frequent culverts under the haul road will provide corridors for the Ornamental Snake to access habitats both sides of the haul road.

An assessment of significance was prepared for this species within the EIS and the assessment found that project is not expected to cause a significant impact. Furthermore, the proponent states that the proposed offset will provide additional habitat for this species.

Squatter Pigeon (*Geophaps scripta scripta*)

The Squatter Pigeon was recorded at two sites, both in and near remnant *E. crebra* woodlands during the April 2010 Survey. Their preferred habitat is grassy woodlands with regular access to water. Squatter Pigeons are known to prefer short sparser grasses to dense longer grasses allowing ease of movement when feeding and provision of nesting habitat. The EIS states that the retention of grassy woodlands in the western and southern portions of the project area will ensure that suitable habitat remains available. The majority of the proposed mining activities are to be located in non-remnant areas which exhibit signs of degradation. The retention of this habitat will ensure the area of occupancy will not be reduced and habitat important to this population will not be adversely affected.

The assessment of significance for the Squatter Pigeon indicates that due to the majority of the proposed mining activities being restricted to non-remnant, degraded vegetated areas, and the limited disturbance to suitable habitat from development of infrastructure, the impacts of the proposed project will not be significant. Furthermore, the proponent states that the proposed offset will provide additional habitat for this species.

Migratory listed bird species - Rainbow Bee-eater (*Merops ornatus*) and Eastern Great Egret (*Ardea modesta*)

The Rainbow Bee-eater was recorded incidentally within the project area and utilises areas of open woodland with sandy and loam soils. The EIS states that this species is more likely to breed in sandy habitats along river and creek systems outside the mine footprint.

The Eastern Great Egret was recorded at a farm dam at the project site. This species has a widespread distribution and utilises shallow rivers, wetlands and large dams.

The EIS states that the loss of habitat for terrestrial migratory bird species listed under the EPBC Act would not be significant due to the very small loss of woodland habitat within the project area. The remnant woodland is only a small proportion of the site, but it is listed as an important corridor and will not be cleared where practically possible. Migratory and nomadic species that use wetlands and dams will not have any habitat loss due to the proposed mining operations. However, the EIS notes that there may be an increase in stopover points for waterbirds through more dams being constructed on the mine site.

Reptiles

The following reptiles were not recorded at the project site but have been recorded in the region:

- Brigalow Scaly-foot (*Paradelma orientalis*), listed as 'vulnerable' under the EPBC Act, is found in the litter or under logs of sandy dry sclerophyll woodlands with relatively high shade. However, little of this habitat occurs at the project site. Impacts on its habitat will be minor as much sandy woodland habitat in the region is still in remnant condition, and the areas impacted by mining activity, if any, will be small in the wider area context.
- Short-necked Worm-skink (*Anomalopus brevicollis*), listed as 'not significant' under the EPBC Act), is found in the litter or logs of dry sclerophyll woodlands with relatively high shade and sandy soils. Can be quite common in suitable habitat which may occur at Codrilla. Impacts on its habitat will be minor as the areas impacted by mining activity will be small in the wider area context
- Yakka Skink (*Egernia rugosa*), listed as 'vulnerable' under the EPBC Act, is found in the litter or under logs of dry sclerophyll woodlands with relatively high shade, often with sandy soils. However, little suitable habitat occurs within the Codrilla study area. It is a furtive species which is hard to detect, but impacts on its potential habitat will be minor as the areas impacted by mining activity will be small in the wider area context
- Dunmall's snake (*Furina dunmalli*), listed as 'vulnerable' under the EPBC Act, is found in the litter or under logs of dry sclerophyll woodlands with relatively high shade, often with sandy soils, so little suitable habitat occurs within the Codrilla study area.

4.12.3 Mitigation measures

The proponent has provided commitments in the EM plan to avoid, mitigate and offset impacts of the mining project on matters of national environmental significance, including:

- significant weed infestations will be controlled in all areas of the project. Species targeted for control or eradication will include those declared under legislation in accordance with the *Land Protection (Pest and Stock Route Management) Act 2001*
- vegetation will only be removed where required. Vegetation outside mining and infrastructure areas will remain undisturbed
- existing tracks and cleared areas will be utilised
- cleared areas will be progressively rehabilitated
- implementation of a fauna and flora habitat monitoring program to measure rehabilitation success
- a biodiversity offset management plan will be developed and implemented to manage the offsetting of cleared significant vegetation communities in keeping with the principles of relevant policies and guidelines such as:
  - Draft policy statement Use of environmental offsets under the EPBC Act 1999 (DEWHA 2007)
  - Queensland Policy for Vegetation Management Offsets (DNRW, 2007)
  - Queensland Government Environmental Offset Policy
  - Queensland Biodiversity Offset Policy (3 October 2011)
- a Species Management Program (under provisions of the NC Act) will be developed prior to construction activities being undertaken.

DERM is satisfied that the information presented in the EIS provides a suitable assessment of the significance of the potential impacts of the project on nature conservation and matters of national environmental significance, and specifically the listed threatened species and communities under the EPBC Act.

4.13 Cultural heritage

The EIS has adequately addressed the TOR with respect to both Indigenous cultural heritage and non-Indigenous cultural heritage issues.

4.13.1 Indigenous cultural heritage

The EIS stated that a cultural heritage management plan (CHMP) has been developed between the proponent and the Barada Barna People in accordance with Part 7 of the *Aboriginal Cultural Heritage Act 2003* (ACH Act), and has been submitted for approval to the Cultural Heritage Coordination Unit of the DERM on 8 July 2010. Unless the CHMP is approved under the ACH Act before the environmental authority is issued, the environmental authority must include conditions requiring the approval of the CHMP prior to any disturbance due to mining activities for the project.

Coal mining exploration works have been undertaken on the project site including the drilling of bore holes and clearing of tracks to allow for seismic testing. In accordance with the Duty of Care requirements under section 23 of the ACH Act, these activities were carried out in full consultation with, and involvement of, the Barada Barna People, as the aboriginal party for the area under their native title claim.

The EIS states that cultural heritage inspections were undertaken by the Barada Barna People for drilling activities in August 2008. Based on these inspections, the Barada Barna People granted a "blanket" clearance over the blade plough areas of the project, allowing for drilling to occur without individual site inspections. The clearance was granted with the exception of areas surrounding creeks and areas with vegetation cover. In September 2009, a number of other sites were also inspected. No items of cultural heritage significance were identified in the inspected areas.

The proponent conducted a search of the Cultural Heritage Register maintained by DERM. No cultural heritage has been recorded on the register.

The EIS states that an archaeological study has not been conducted for the entire project area due to time constraints and the availability of the Barada Barna People and their archaeological advisers. However, the CHMP allows for full archaeological investigations to be carried out prior to the occurrence of any disturbance activities associated with the project.

4.13.2 Non-Indigenous cultural heritage

The EIS mentions that Leichhardt's diaries provide the first account of European exploration into the project region in 1845. Leichhardt's expedition party followed the course of the Isaac River to the west of the project site, and in the following two decades the area was taken up as pastoral leases and stocked with sheep and cattle. The closest township of Nebo was surveyed in 1865 under the original name of Fort Cooper. Whilst the area has largely been devoted to pastoral use since European settlement, copper and gold mining constituted other historical industries in the region, with the Mount Orange copper mine once operating to the north of the project. Some of the original copper smelters remain intact and one has been restored on Bundarra Station, approximately 20km from the project site.

A physical historical archaeological study of the Codrilla Project site has not yet been undertaken. The EIS states that information currently available indicates a fairly low potential for significant historical cultural heritage to be present within the project site. Under the EM plan, it is intended that historical cultural heritage will be investigated in conjunction with the Aboriginal archaeological surveys prior to the commencement of works. The study will be undertaken by an appropriately qualified archaeologist and will include a study of the project area, an assessment of the significance of any cultural heritage found, and recommendations on the management of cultural heritage as the project progresses.

The proponent has provided adequate commitments in the EM plan to address impacts on cultural heritage, including:

- Indigenous cultural heritage matters will be managed in accordance with the CHMP
- procedures will be developed detailing the actions required in the event that any discovery, damage or destruction of culturally significant places or artefacts occurs
- a complete archaeological study will be conducted in accordance with the CHMP prior to any site disturbance
- an Historic Heritage Management Plan (HHMP) will be developed prior to construction as per proposed EA condition K1.

Also the proponent provided adequate steps in the EM plan that should be undertaken to manage the cultural heritage values on site including:

- cultural heritage inductions and training programs to include cultural awareness and identification of significant aboriginal objects, significant aboriginal areas, personnel responsibilities under the CHMP and the relevant legislation, and appropriate protocols for the management of Cultural Heritage finds
- throughout the life of the operation, the Barada Barna People will be engaged to present Aboriginal Cultural Heritage training programs to key site personnel
- a Cultural Heritage Committee meeting will be held annually or as agreed between the parties and will include discussions on:
  - project progress
  - cultural heritage training programs
  - any disputes
  - any assessments being carried out
  - any shortfalls in respect to the CHMP
- Cultural Heritage Field survey or inspection to be carried out prior to any proposed construction, mining and/or exploration activities in accordance with the CHMP
- identified cultural areas of significance are to be demarcated in such a way as not to be ambiguous to mine site personnel
- a register of cultural areas of significance will be maintained and will contain information relating to artefact, the date discovered and its location
- a plan of cultural areas of significance will be maintained and kept on file
- in the event that unrecorded cultural heritage sites or materials are discovered during future operations, works at that particular location will cease and be cordoned off as a ‘no-go’ zone until traditional owner representatives are contacted to provide advice on significance of the finds and management options
- if fossils are located during the development and operation of the project, the proponent will advise the Queensland Museum.

The cultural heritage conditions recommended to be included in the draft environmental authority are contained in Appendix 1.

4.14 Social issues

The Codrilla Project is located within the Mackay Statistical Division (SD), which comprises the three local government areas of Mackay, Whitsunday and Isaac Regional Councils, and includes approximately 34 urban centres and localities There were 167,666 residents in the Mackay SD at the time of estimation of resident population on 30 June 2008. The region's principal economic base derives from mining and minerals followed by agricultural production.

The closest towns to the project are Nebo and Moranbah within the Isaac Regional Council (IRC). Nebo is approximately 45 km away from the project and is a small town with a resident population of 343. Moranbah, situated about 57 km from the project, is a town predominantly supporting the local mining industry with a resident population of 8,087 persons. A range of government and community facilities are provided for in Moranbah as well as a number of accommodation types.

The IRC was home to 21,993 people in 2009, about 13.1% of the regional population and a 1.8% increase in the population the previous year. Unemployment in the IRC is very low at 1.3% in 2009, compared to the State average at 6.0%

The closest major regional centre to the project is Mackay being 120 km from the project. Mackay has a population of approximately 74,236 and is one of the fastest growing regions in Queensland. The city acts as the main regional service centre in the northern part of Central Queensland and includes health facilities such as hospitals, sporting and recreation facilities, and specialist health and finance services.

The area on and around the proposed project site is currently used for beef cattle production and grazing and residential purposes. The project is situated on the Codrilla cattle station, which is one of the largest cattle stations in the Central Queensland Region.

The closest coal mine to the project is the Moorvale Coal Mine, which is located approximately 20 km north west. Other mine sites also located in the vicinity of Nebo and Moranbah include Coppabella, South Walker Creek, Carborough Downs, Isaac Plains, Millennium and Poitrel.

The nearest existing public buildings are the Valkyrie State Primary School and school residence about 2.9 km from the mining pit at the project. A number of submissions were received about environmental impacts to the school and school residence. The proponent commits to relocating the Valkyrie School and school residence and have included in the Draft Social Impact Management Plan (SIMP) a commitment to developing a process for addressing the relocation of the school and the principal's residence. The proponent advised that a potential preferred site for the relocated Valkyrie School has been identified by the Valkyrie School Community Working Group (VSCWG), consisting of representatives of the Proponent, the School Community and the regional Department of Education and Training (DET). However, the ultimate relocation decisions are a matter for DET.

The project is expected to require 170 construction personnel and 240 permanent operational personnel. The project would commence construction in 2012 and continue for about 13 and a half years. Staff are planned to be housed at the Moorvale (Terowie) camp that may expand to 500 accommodation units in 2011. Staff will be transported to the project site via bus along the Codrilla - Moorvale Haul Road. The EIS states that, should the Moorvale Camp fill to capacity, staff would be accommodated at either the Coppabella or Nebo camps.

The Department of Communities (DoC) raised an issue in their submission that the EIS should acknowledge the small proportion of workers who may opt to reside in local towns such as Nebo and Moranbah. The proponent addressed the DoC issue by making a commitment in the sEIS of identifying strategies to assist employees and their families with accommodation who show an interest in relocating to local towns.

The EIS states that the local community potentially impacted by the project includes the landholders and families centred around the Valkyrie State School with associated community and recreation facilities. Concerns held by that community can be summarised by following:

- social impacts of demographic changes through some landholders having to relocate from the area, as well as mining bringing in a large transient workforce with a different culture to rural people
- environmental impacts, with concerns about increased dust and noise impacting on local residents and the Valkyrie State School, and other potential impacts on water resources and the natural environment
- concerns about increased traffic on both the public highways and internal haul roads
- impacts on the location and future viability of the Valkyrie State School.

The above issues were also raised through submissions received by DERM on the EIS from landholder and advisory body members including the Isaac Regional Council, Department of Communities, Queensland Police and the Department of Employment, Economic Development and Innovation. Issues raised by landholders and the advisory body were adequately addressed through the EIS.

The EIS discusses the regional communities potentially impacted by the project including the local towns of Nebo and Moranbah. The EIS mentions that some of the impacts on these towns will occur through limited population increases, with subsequent impacts on housing markets and service requirements. The EIS states that there may also be some impacts on local employment markets, with increased demands for labour making it harder for local businesses to attract and retain labour force. Increased traffic, particularly with a large non-resident workforce commuting to the area, and associated issues of road safety and accidents are another key area of impact for regional communities. The developing pattern of a large non-resident workforce in the area brings additional challenges of supplying infrastructure and core services (e.g. accommodation, emergency and health services) with only a limited population base. These issues for the regional communities are compounded by cumulative effects from multiple projects in the region.

The proponent noted in the EIS that the mining industry does place increased demand for infrastructure and services within the region. The resource industry, in partnership with Local Government and the Queensland Government are seeking to address these impacts through the 'Building Better Communities' initiative. The proponent is fully supportive of this initiative.

Potential impacts at the regional level will largely accrue in the Mackay City region as a consequence of rapid employment, population and business services growth. The population and business growth will bring additional requirements for infrastructure and services, particularly increased housing and community services. Some pressure on housing markets can be expected as a consequence of rapid growth in demand, while some pressure on employment markets will be generated by the direct and indirect employment generated by the project. The size and diversity of Mackay City and surrounding areas, together with the level of available infrastructure and services, means that there is substantial potential to cater for these growth pressures. However, the cumulative impact of a number of other mining and industrial projects may increase growth pressures, particularly in the short term.

The proponent has provided adequate commitments in the EM plan to address the potential negative impacts at the local community, sub-regional and regional levels, including:

- develop and implement policies relating to service provision and purchasing hierarchies, e.g. local personnel and business first if qualified and commercially competitive
- Community Investment Programs – including mix of apprenticeships, scholarships and vocational training opportunities
- continue the ongoing development and implementation of the Community Consultation Program. The program will be implemented specifically to reflect the stages of project development, namely project application stage, pre-development and construction, ongoing operation and mine closure/post-mine land use
- provide bus transport arrangements from worker accommodation to the project site to minimise traffic flows on the surrounding road network
- investigate bus transport options for employees between work accommodation and Mackay and/or Rockhampton during roster change-over
- ensure that project lighting is oriented to minimise light spill beyond what is required for project operations
- develop and maintain a complaints management system during construction and operation of the Codrilla Project:
  - maintenance of a register of complaints to be held on site
  - procedures for receiving, handling and investigating complaints
  - expeditious investigation of complaints and a response as soon as practicable
  - a non-compliance notification will be given to any party whose actions have caused a complaint as a result of non-compliance with site environmental requirements
- consultation to be maintained with the Isaac Regional Council, which serves as a forum for progressing community based initiatives and infrastructure programs
- develop and maintain the Social Impact Management Plan (SIMP) for the life of the project.

The proponent has drafted a SIMP for the project. The SIMP provides an ongoing mechanism for identifying social and economic impacts and progressing mitigation measures, and will help to plan and coordinate response strategies into the future. The recommended strategies and mitigation measures that have been identified in the EIS are summarised in the draft SIMP.

The Social Impact Assessment Unit (SIAU) in the Office of the Coordinator General in DEEDI is the lead agency on social issues and will assess the SIMP. The SIAU provided comments on the project including the SIMP. The SIAU recommended that the proponent's housing and accommodation strategy take into account the recently approved Major Resource Project Housing Policy. The policy outlines that the Queensland Government believes that resource workers should have a choice of where and how they live, and the need for proponents to work with local communities, Councils, unions and the State Government to make sure the liveability and sustainability of towns is protected, and that workers have a choice about where they live. Furthermore, the policy states that the proponent must, where practicable and sustainable, locate a proportion of their operational workforce in resource towns to support the growth and liveability of these towns and should provide evidence that they have considered this option in consultation with the relevant State and Local Government and community.

In the response to comments dated 28 September 2011, the proponent disagrees that the current proposal for housing operational workforce in workers camps needs reviewing as the proponent claims that this is the expected preference of the workforce. Furthermore, the proponent adds that even though it is expected that the majority of the workforce will be housed in camps, they will be offered other options as per the Housing and Accommodation Strategy(HAS). It is recommended that the proponent and the SIAU continue to liaise in order to resolve outstanding issues with having employees housed in workers camps.

The proponent, in the response to comments dated 28 September 2011, commits to submitting a final SIMP to the SIAU, Office of the Coordinator General that includes:

- developing a Housing and Accommodation Strategy (HAS)
- reviewing the Major Resource Housing Policy when developing the HAS.

4.15 Health and safety

The Health and Safety section of the EIS adequately addressed the TOR with respect to the potential impacts of the Codrilla Project on the health and safety of the community. The potential impacts on the workforce are covered by other legislation and are not subject to approvals under the EP Act.

The project is located in close proximity to a number of homesteads including the Codrilla homestead, and the project is close to the Valkyrie State Primary School and the school residence. The EIS identified potential impacts to the local community relating to air, noise, traffic, water quality and social values. Mitigation measures are proposed in the relevant sections of the EIS and incorporated as commitments in the EM plan.

Also, the EIS identified the potential impacts of the project on the health and safety of the community in relation to surface water, including potential for:

- flood events to cause damage to improperly constructed or located coal haul roads and mining infrastructure, posing a danger to life and property
- contamination of usable alluvial aquifers downstream from mining operations from poor quality mine water.

The monitoring, auditing and management of water quality impacts are incorporated in the EM plan and conditioned in the Environmental Authority.

Due to the remote location of the project, the proponent anticipates that the residences of Nebo, Moranbah and Mackay will not be affected by dust, air emissions or odours; noise and vibration; or changes to water quality.

Queensland Police raised issues regarding traffic safety such as fatigue management, increased traffic and wide load movements, speeding and drink driving. These matters should be appropriately addressed by the proponent through the traffic management plan in the EIS.

The proponent commits to implementing a Health and Safety Management Plan during all stages of the project. The Health and Safety Management Plan will document the systems, standards, methods and procedures necessary to ensure mitigation of risks relevant to the stages of the Codrilla Project to ensure legislative compliance. The aim

of the management plan will be to maintain the health, safety and quality of life of the project workforce, contractors and visitors.

4.15.1 Economy

The project is situated in the Isaac Regional Council (IRC) area. While the IRC area contributes to the Mackay regional economy in a number of sectors, including agriculture and service industries, the largest contribution is from the mining sector. The region contributes 52.1% of the Gross Regional Product (GRP), and represents 3.7% of the Queensland economy. The economy has very limited diversity and is dominated by the mining sector, which represents 77% of the output in the Isaac subregion. The Isaac subregion also accounts for 80% of the mining income into the Mackay regional economy.

As part of the EIS, a benefit-cost analysis was undertaken to identify the economic costs and benefits of the Codrilla Project.

The EIS discussed the loss of approximately 4,540 hectares of agricultural (beef cattle) production land due to the total footprint of mining activities over the life of the mine. The EIS stated that some beef cattle production may continue on mining land over the period, and production should be restored in the future after rehabilitation of mining lands is completed, except for the final voids and reduced productivity of the mine dumps.

DERM received a submission from a landholder regarding the EIS failing to undertake a proper and balanced cost-benefit analysis. The proponent provided an adequate response to landholder issues and provided amendments to the revised social and economic assessment.

The EIS identified the following opportunity costs should the Codrilla Project proceed:

- increased export income to Australia, of approximately $410 M per annum from average sales of up to 3.8Mtpa
- net profits to the project proponent from annual operating revenue less all costs and return on capital, estimated at $41 M per annum. This income will flow to operators and owners, and ultimately to shareholders
- royalty payments to the Queensland Government of approximately $35M per annum over 12 and a half years
- increased income and company tax receipts to the Australian Government
- increased direct employment in the regional area of 170 full time employee (FTE) workers in the construction phase and 240 FTE workers in the operating stage
- increased indirect employment in the regional, state and national economies, with a total of 2,048 extra jobs created nationally
- further development of the mining services supply chain in the Mackay region and other parts of Queensland.

DEEDI raised an issue in their submission to DERM that the EIS does not include reference to Queensland Government's Local Industry Policy. The purpose of the Policy is to ensure capable competitive local industry is provided with full, fair and reasonable opportunity to tender for infrastructure and resource based projects. However, since the Codrilla Project is not a significant project under the *State Development and Public Works Organisation Act 1971*, this policy does not apply to the Codrilla Project. The proponent addressed DEEDI's issue by committing in their SIMP to implementing an appropriate strategy or policy in regard to ensuring local goods and service providers are given opportunity to provide to the project.

The proponent provided adequate economic commitments in their EM plan, including:

- develop and implement policies relating to service provision and purchasing hierarchies, e.g. local personnel and business first if qualified and commercially competitive
- community Investment Programs – including mix of apprenticeships, scholarships and vocational training opportunities
- develop and maintain the SIMP for the life of the Codrilla Project.

The EIS has adequately addressed the TOR with respect to economic issues.

4.16 Hazard and risk

The EIS conducted a preliminary hazard and risk assessment (PHA) of the potential hazard and risks to people and property associated with the Codrilla Project. The EIS presented an acceptable Risk Management Framework and Risk Assessment Methodology and Criteria for the project.

The PHA considered natural disasters, dangerous goods, waste materials (process and non process), air and noise, surface and groundwater, cultural heritage, wildlife, landform failure, disease and other construction and operational activities that may impact the health and safety of humans and the environment.

The breakdown of the hazards by risk ranking was as follows:

- 11 high risk
- 28 medium risk
- 3 low risk.

The EIS then considered the risks after application of mitigation strategies, and the residual risk ranks were grouped as follows:

- 0 high
- 8 medium
- 34 low.

The medium residual risks that were identified in the EIS with their proposed mitigation strategies are shown below in Table 4.8.

Table 4.8 - Risk Assessment Table

Aspect/Activity	Impact	Proposed Mitigation Strategies
Off-site transport – increase in movements of heavy vehicles and traffic during construction and operation.	Increased risk of accidents and injury/death	Traffic management plan Police escorts Public notices regarding timing and anticipated route. Development of right hand turn lane into mine at Fitzroy Developmental Road access Driver fatigue management incorporated into Health & Safety Management Plan
Onsite transport – heavy vehicle and light vehicle movement during construction and operation.	Risk of accident and injury/death	Traffic management plan Health & Safety inductions Competency based driving assessment for relevant workforce Workforce to be transported by bus between accommodation camp at Moorvale Mine and project
Construction Activities	Risk of injury/death	Health and Safety Management Plan Formal safety practice design Experienced supervisors Contractor and supplier selection Equipment selection Equipment inspection Fall from heights controls Welding safety practices Personal Protective Equipment (PPE)
Blasting during operation	Potential risk of injury/death to person	Relevant staff to complete fire safety training during initial induction and on an annual basis Regular fire safety testing of mine operation facilities and equipment Liaison with landowners and local authorities regarding fire breaks and ongoing maintenance programs to minimise bush fire risk Documented Emergency Response Plan
Electricity, during	Contact with high	Restricted access to high voltage areas

operation.	voltage electricity	Use of qualified electricians Isolation procedures for control of energy SOPs and MOPs for general electricity including cable management Application of relevant standards relating to Electricity Act Compliance check on contractors Contractor management system Overhead lines marked Clearance for overhead lines
Final Void during decommissioning	Falling Hazard	Maximum slope of final landform no more than 8° Assess possible tools to restrict access, for example fencing In pit dumping Clear signage DERM guidelines to be adhered to when managing final voids

Source Table from Tables 4.12.7, 4.15.8 and 4.15.9 [of the EIS?]

The EIS states that if the proposed mitigation measures are adhered to, no residual risk will remain that exceeds generally accepted community standards.

The EIS satisfactory addressed the requirements of the TOR matters in relation to hazard and risk .

4.17 Rehabilitation

The EIS included a progressive rehabilitation strategy that generally consists of the development of a stable, self sustaining final landform, with appropriate post-mining land uses applied.

DERM advised the proponent of issues regarding rehabilitation, including:

- the proponent to revise the rehabilitation objectives in accordance with specified objectives and completion criteria provided by DERM
- an alternative method to be adopted for overburden placement, encapsulation and rehabilitation that is suitable for the highly sodic waste material that would be excavated, having an exchangeable sodium percentage of between 17.8% to 60.6%
- need to amend the statement made about the success of rehabilitation at the Coppabella Coal Mine given that DERM is aware of significant issues with gully and rill erosion and difficulties in meeting rehabilitation acceptance criteria in the overburden stockpiles at Coppabella Coal Mine.

The proponent provided an adequate response to DERM issues that included providing additional information on the rehabilitation of overburden dumps and amendments to the EIS.

DERM is satisfied that the EIS has adequately addressed the TOR with regard to the proposed rehabilitation of the Codrilla Project site.

The EM plan dated 12 October 2011, states that the rehabilitation strategy for the mine will consider the following integrated measures:

- detailed planning prior to disturbance, such as topsoil stockpile locations, etc
- implementation of practical landform designs, to prevent erosion and establish final landform stability
- identification of an appropriate post-mine land use consistent with local environmental constraints and values
- revegetation trials for the selection of appropriate species and methodology
- progressive rehabilitation of disturbed areas, using appropriate rehabilitation procedures for the area having been disturbed
- implementation of best practice erosion control measures
- a rehabilitation monitoring program to assess success, or potential for improvement, of rehabilitation practices
- a corrective action program to address failed areas of rehabilitation

- prepare a Final Rehabilitation Report within 2 years prior to the surrender of the MLs.

The EM plan dated 12 October 2011 contained a commitment that rehabilitation areas will be designed to meet the final rehabilitation design criteria outlined below:

- out of pit overburden dumps
  - elevated landform – maximum 50 m vertical height
  - outer batter slope – maximum 5.7°
  - crest slope – maximum 2.3°
- codisposal and ROM Pad
  - elevated landform – 15 - 18m vertical height
  - outer batter slope – 8° or less
  - crest slop – maximum 2.3°
- coal stockpile areas
  - flat to undulating - <4.6° slope
- in pit overburden backfill
  - flat to undulating - <4.6° slope
- infrastructure areas
  - flat to undulating - <4.6° slope
- final void
  - depth – 150m
  - highwall as mined weathered average slope angle - 1V and 0.7H (55°)
  - lowwall as backfilled at angle of repose - 1V to 1.35H (36°)
- design and install perimeter stormwater diversion
- fence the perimeter of the residual void to restrict access
- surface runoff from all rehabilitated areas will be directed to sediment control structures to reduce the amount of final sediment loads reporting to watercourses.

The EM plan states that the basic process that will be adopted to achieve the desired outcomes of the rehabilitation strategies, are:

- clearing and piling up of vegetation ahead of mining
- topsoil recovery as per the Topsoil Management Plan to be developed for the operation
- management of poor quality overburden materials within dumps
- contouring of overburden dumps
- construction of drainage structures if required
- spreading of topsoil on contoured surface as detailed in the Topsoil Management Plan
- ripping along the contour
- application of relevant seed mix and fertiliser
- monitoring and success assessment of rehabilitation areas
- maintenance of rehabilitation as required.

The EM plan dated 12 October 2011 contained a commitment to developing a residual void plan that will be developed to manage the residual void and will be based on operational experience and geotechnical assessment.

The residual void plan will include consideration of:

- minimisation of the size of the residual void
- development of a detailed plan for post mining management of the void
- groundwater draw down
- long term water quality
- ensuring the void is geotechnical stable
- ensuring exposed coal seams do not present a potential fire risk
- provision of reasonable permanent safety measures to prevent accidental entry to the void by persons, vehicles, stock or wildlife
- provision of water diversion structures to avoid flooding.

The rehabilitation conditions recommended to be included in the draft environmental authority are contained in Appendix 1.

5 Adequacy of the environmental management plan

An EM plan was included with the EIS that was released for public notification. A number of submissions on the EIS raised issues that required amendments to the EM plan and many of these amendments were included by the proponent in the amended EM plans dated 30 June and 24 August 2011. DERM reviewed the latest amended EM plan dated 24 August 2011, but considered that the following recommendations needed to be included:

- the proposed management strategies for miscellaneous coarse rejects
- commitments to further address dust emissions from the haul road in the event
- a commitment to correlation of information from noise monitoring equipment and the weather station to enable mitigation strategies to be further developed based on actual site specific conditions
- change the Government Biodiversity Offset Policy (Draft) to the Queensland Biodiversity Offset Policy (version 1) 3 October 2011.

The proponent has included the above recommendations in the final EM plan (12th October 2011) and therefore DERM has decided that the EM plan complies with the content requirements of s203 of the EP Act.

6 Suitability of the project

DERM has considered the TOR, the submitted EIS, all submissions on the submitted EIS, and the standard criteria. The submitted EIS has not identified impacts of sufficient magnitude to prevent the project from proceeding.

7 Recommended conditions

The proponent has provided a list of draft conditions for an environmental authority and DERM has provided recommended amendments to these conditions. It is recommended that the conditions provided in Appendix 1 of this report should be included in the environmental authority for the project.

8 Completion of this EIS process

Once this EIS assessment report has been approved by the delegate for the chief executive, the giving of this EIS assessment report to the proponent completes the EIS process.

Approved by

Signature: SIGNED Date: 24 October 2011

Lindsay Delzoppo
Director, Environmental Impact Assessments
Department of Environment and Resource Management
Enquiries: EIS Coordinator, Ph. (07) 3330 5599; Fax. (07) 3330 5754

McCollum Environmental
MANAGEMENT SERVICES

FINAL

Codrilla Coal Mine Project

Soil, Overburden and Land Use Survey

September 2010

MEM06-002

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

TABLE OF CONTENTS

1.0 INTRODUCTION 1
1.1 PROJECT BACKGROUND 1
1.2 LOCATION 1
2.0 EXISTING ENVIRONMENT SUMMARY 2
2.1 GEOLOGY 2
2.2 TOPOGRAPHY 2
2.3 VEGETATION 2
3.0 SOIL SURVEY ASSESSMENT & MANAGEMENT RECOMMENDATIONS 3
3.1 INTRODUCTION & OBJECTIVES 3
3.2 SOIL SURVEY METHODOLOGY 3
3.2.1 Mapping 3
3.2.2 Soil Profiling 3
3.2.3 Field Assessment 3
3.2.4 Laboratory Testing 4
3.3 SOIL SURVEY RESULTS 5
3.3.1 Brown Yellow Duplex 6
3.3.2 Brown Grey Duplex 7
3.3.3 Brown Duplex 8
3.3.4 Yellow Duplex 9
3.3.5 Skeletal Soil 10
3.4 EROSION POTENTIAL 11
3.4.1 Erosion Potential of Soil Types 11
3.4.2 Potential Erosion Rates 11
3.5 ACID SULFATE SOIL POTENTIAL 13
3.6 TOPSOIL SELECTION & MANAGEMENT FOR REHABILITATION 13
3.6.1 Topsoil Stripping Criteria 13
3.6.2 Topsoil Stripping and Handling 16
3.6.3 Landform Design and Erosion Control Measures 17
3.6.4 Topsoil Respreading & Seedbed Preparation 18
4.0 LAND RESOURCE ASSESSMENTS 19
4.1 LAND CAPABILITY ASSESSMENT 19
4.2 LAND SUITABILITY ASSESSMENT 20
4.2.1 Land Suitability Assessment Scheme 20
4.2.2 Calculation of Plant Available Water Capacity and Effective Rooting Depth 21
4.2.3 Land Suitability Rankings 22
4.2.4 Post-mining Land Suitability 24
4.3 AGRICULTURAL LAND CLASS ASSESSMENT & GQAL 24
5.0 OVERBURDEN & REJECTS GEOCHEMICAL ASSESSMENTS 27
5.1 GEOCHEMICAL CHARACTERISATION TESTING PROCEDURES 27

5.1.1 pH *27*
5.1.2 Electrical Conductivity (EC) *27*
5.1.3 Exchangeable Cations & Exchangeable Sodium Percentage (ESP) *27*
5.1.4 Acid Base Account *28*
5.1.5 Metal Scans *30*
5.2 GEOCHEMICAL CHARACTERISATION RESULTS OF OVERBURDEN MATERIAL 31
5.2.1 pH *31*
5.2.2 EC *31*
5.2.3 Cation Exchange Capacity and Sodicity *31*
5.2.4 Acid Base (NAPP) Results *31*
5.2.5 Metal Scans *32*
5.3 CHEMICAL CHARACTERISATION OF TAILINGS & REJECT MATERIAL 34
5.4 CONCLUSIONS AND MANAGEMENT OF OVERBURDEN & REJECT MATERIAL 37
5.4.1 Overburden *37*
5.4.2 Reject Material *37*
6.0 REFERENCES 38

TABLES

TABLE 1 – FIELD ASSESSMENT PARAMETERS 4
TABLE 2 – BROWN YELLOW DUPLEX PROFILE 6
TABLE 3 – BROWN GREY DUPLEX PROFILE 7
TABLE 4 – BROWN DUPLEX PROFILE 8
TABLE 5 – YELLOW DUPLEX PROFILE 9
TABLE 6 – ESTIMATED EROSION RATES USING THE RUSLE 12
TABLE 7 – TOPSOIL STRIPPING CRITERIA 14
TABLE 8 – RECOMMENDED STRIPPING DEPTHS 16
TABLE 9 – LAND CAPABILITY CLASSES 19
TABLE 10 – PRE MINING RURAL LAND CAPABILITY CLASSES 19
TABLE 11 – SCHEME FOR CLASSIFYING LAND SUITABILITY 20
TABLE 12 – COMPARISON OF CURRENT AND *IN PREP* LAND SUITABILITY GUIDELINES FOR PLANT AVAILABLE WATER CAPACITY (PAWC) 21
TABLE 13 – EFFECTIVE ROOTING DEPTH CRITERIA 22
TABLE 14 – EFFECTIVE ROOTING DEPTH (ERD) AND PLANT AVAILABLE WATER CAPACITY (PAWC) 22
TABLE 15 – LAND SUITABILITY (LS) RANKING FOR RAINFED BROADACRE CROPPING 23
TABLE 16 – LAND SUITABILITY (LS) RANKING FOR BEEF CATTLE GRAZING 23
TABLE 17 – LAND SUITABILITY (LS) PRE AND POST MINING 24
TABLE 18 – SCHEME FOR CLASSIFYING AGRICULTURAL LAND 25
TABLE 19 – BROADACRE CROPPING LAND SUITABILITY (LS) RANKING AND AGRICULTURAL LAND CLASS (ALC) 25
TABLE 20 – CODRILLA SOIL TYPES AND AGRICULTURAL LAND CLASS (ALC) 26

TABLE 21 – SAMPLE CLASSIFICATION OF ACID PRODUCING POTENTIAL 30
TABLE 22: RATINGS FOR CATION EXCHANGE CAPACITY 31
TABLE 23: CODRILLA OVERBURDEN METAL SCAN RESULTS 33
TABLE 24: CODRILLA REJECT SOLIDS CHEMISTRY 35
TABLE 25: CODRILLA REJECT LEACHATE CHEMISTRY 35

FIGURES

FIGURE 1 – LOCALITY PLAN 1
FIGURE 2 – SOIL CLASSIFICATIONS AND SAMPLE LOCATIONS 5
FIGURE 3 – SELECTION PROCESS FOR TOPDRESSING MATERIAL LOCALITY PLAN 15
FIGURE 4 – EXISTING LAND CAPABILITY 19
FIGURE 5 – POST MINING LAND CAPABILITY 19
FIGURE 6 – EXISTING AGRICULTURAL LAND SUITABILITY 23
FIGURE 7 – POST MINING AGRICULTURAL LAND SUITABILITY 23
FIGURE 8 – AGRICULTURAL LAND CLASSES 26
FIGURE 9 – CORRELATION BETWEEN OVERBURDEN TOS AND NAPP VALUES 32

PLATES

PLATE 1 – BROWNISH YELLOW DUPLEX PROFILE 6
PLATE 2 - BROWNISH YELLOW DUPLEX LANDSCAPE 6
PLATE 3 - BROWN GREY DUPLEX PROFILE 7
PLATE 4 - BROWN GREY DUPLEX LANDSCAPE 7
PLATE 5 - BROWN DUPLEX PROFILE 8
PLATE 6 - BROWN DUPLEX LANDSCAPE 8
PLATE 7 - YELLOW DUPLEX PROFILE 9
PLATE 8 - YELLOW DUPLEX LANDSCAPE 9
PLATE 9 - SKELETAL SOIL PROFILE 10
PLATE 10 - SKELETAL SOIL LANDSCAPE 10

APPENDICES

APPENDIX 1 – FIELD ASSESSMENT PROCEDURE
APPENDIX 2 – SOIL INFORMATION
APPENDIX 3 – SOIL TEST RESULTS

1.0 INTRODUCTION

1.1 Project Background

GSS Environmental (GSSE) was commissioned by McCollum Environmental Management Services (MEMS) on behalf of Bowen Basin Coal Joint Venture (BB Coal JV) to undertake a soil survey and land resource assessment for the Codrilla Project, located in Central Queensland. The Codrilla Project is a proposed open cut coal mining and processing operation located approximately 57 km to the east south east of Moranbah and 45 km to the south south west of Nebo. For the remainder of this report, the area of the Codrilla Project studied during this survey will be referred to as the "project site". The project site covers an area of approximately 5,010 ha.

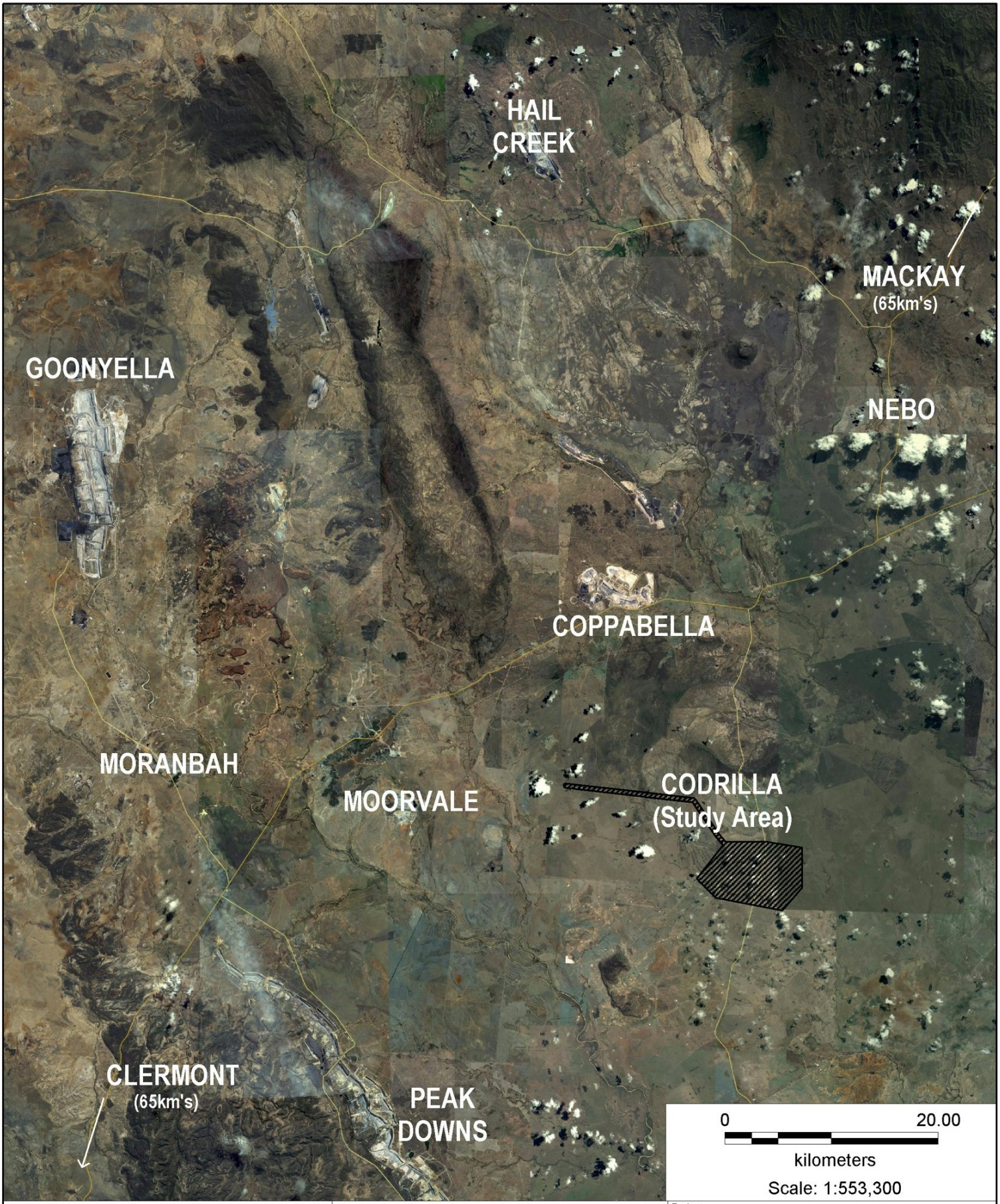
As the Codrilla Mine will be developed within the project site, soil resources will be impacted by mining operations. Excavation of the open cut pit and construction of out-of-pit overburden stockpiles, haul roads, other service roads, dams, drains and administration area will result in ground disturbance. To ensure sufficient topsoil resources are available for post-mining rehabilitation, it is important that all suitable natural topsoil reserves are identified and recovered ahead of this disturbance. If not adequately managed, impacts within the project sites may also cause impacts further downstream through the sedimentation of watercourses, especially with the potential for exposing saline and sodic soils. Disturbance to the ground surface and landscape character may also impact the agricultural suitability of land within the project site or downstream.

1.2 Location

The project is located in the Central Queensland Bowen Basin. The project lies 120 km south west of Mackay and 45 km to the south south west of Nebo. The project site is bisected by the Fitzroy Development Road approximately 25 km south of where this road intersects the Peak Downs Highway.

The region contains rich thermal and metallurgical coal resources at depth, and several open-cut and underground coal mines operating nearby supply both domestic and export markets. The Moorvale and Coppabella mines lie to the north and northwest approximately 25 km and 30 km respectively. The Peak Downs mine lies approximately 50 km to the west of the project site. Other regional industries include beef cattle grazing and limited cropping.

A locality map, showing the project site in a regional context, is provided in **Figure 1**. The specific study is shown in all subsequent Figures in this report.



LEGEND

Major Roads

FIGURE 1

Regional Location Plan

Version:	Date:	Author:	Checked:	Approved:
1	22/12/09	AR	KM	CR

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Project: Codrilla Soils Assessment

Client: McCollum Environmental Management Services

File: Fg1_MEM06-002_Location Plan_v1

Projection: MGA(94) Zone 55

2.0 EXISTING ENVIRONMENT SUMMARY

2.1 Geology

The geology of the project area consists of; Permian, sedimentary rock comprised of sandstone, siltstone and carbonaceous shale overlaid by unconsolidated Tertiary sediments. The geology varies along the northern haul road routes and in addition to the geology described above would pass through; Permian, sandstone, conglomerate, mudstone, carbonaceous shale, coal and cherty tuff geology with undefined cover material.

2.2 Topography

The topography of the project area is typically flat to gently undulating varying between 1 and 4% relief. The project area naturally drains via tributaries to Devlin Creek, which flows from west to east through the project area and on to the Isaac River. The project area is located 25km to the south east of the head of the Devlin Creek Catchment Area. The majority of the site, including the proposed pit locations tend to have aggraded gradational geomorphology, with an interrupted convergent tributary channel pattern.

2.3 Vegetation

The vast majority of the project area has been cleared of the original vegetation cover as a result of historical clearing and grazing activities. There is little remaining remnant vegetation within the project area. The Devlin Creek riparian zone, a small area in the north east of the project area, and the northern haul road routes, have not been cleared of the remnant vegetation. Declared weeds are known to occur throughout the general area including Parthenium (Parthenium hysterophorus) and Harisia Cactus (Eriocereus spp), however inspections of the site indicate weed infestation is not significant.

3.0 SOIL SURVEY ASSESSMENT & MANAGEMENT RECOMMENDATIONS

3.1 Introduction & Objectives

A soil survey was undertaken in October 2009 by GSSE to:

1. classify and determine the soil profile types of the study area;
2. assess the suitability of the current topsoil material for future rehabilitation;
3. assess the pre-mine landform in terms of agricultural land suitability and extent of GQAL likely to be affected by the mining operations, together with an assessment of the post-mine landform land use options and land capability; and
4. identify any potentially unfavourable soil material for rehabilitation within the Project Area.

The survey was conducted in accordance with the methodology outlined in this section. The soils and land resource assessment results are presented in **Section 3** of this report.

3.2 Soil Survey Methodology

3.2.1 Mapping

An initial soil map was developed using the following resources and techniques.

1) Aerial photographs and terrain maps - Aerial photo and terrain map interpretation was used as a remote sensing technique, allowing detailed analysis of the landscape and mapping of features related to the distribution of soils within the project site. Google Earth Pro (2010) was used to identify terrain units and landform features along with aerial image interpretation. The Broadsound Shire Planning Scheme Map 5 (2005) was also used to identify potential high value agricultural soils.

2) Stratified Observations - Following production of a base soils map, surface soil exposures, topography and vegetation throughout the potential disturbance areas were visually assessed to verify potential soil units, delineate soil unit boundaries and determine preferred locations for targeted subsurface investigations.

3.2.2 Soil Profiling

Twenty Eight (28) soil profiles were assessed at selected sites throughout the project area to enable soil profile descriptions to be made. Subsurface exposure was generally undertaken by backhoe excavation of test pits to 1.2 m deep. The test pit locations were chosen to provide representative profiles of the soil types encountered during the survey. The soil layers were generally distinguished on the basis of changes in texture, structure and colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994). Photographs of soil profile exposures and associated landscape were also taken (refer to **Plates 1** to **10**). Soil profiles were also observed through the use of surface exposures located in existing track cuttings, gullies and creek banks. Soil profile site locations are shown in **Figure 2.**

3.2.3 Field Assessment

Soil profiles within the survey area were assessed generally in accordance with the Australian Soil and Land Survey Field Handbook soil classification procedures (McDonald et al, 1998). Soil layers at each profile site were also assessed according to a procedure devised by Elliot and Veness (1981) for the recognition of suitable topdressing material. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence. The system remains the benchmark for land resource assessment in the Australian coal mining industry. A more detailed explanation of the Elliot and Veness procedure is presented in **Appendix 1** to this report. Detailed soil profile descriptions recorded information that covered a variety of parameters as specified in **Table 1**. Soil profile logging was undertaken by

completing soil data sheets. GPS recordings were taken for all sites where detailed soil descriptions were made. Vegetation type and land use were also recorded. Soil exposures from excavated pits were photographed during field operations as colour photography of profile sites is a useful adjunct to description of land attributes.

Table 1 – Field Assessment Parameters

Descriptor	Application
Physical:	
Horizon Depth	Weathering characteristics, soil development
Field Colour	Permeability, susceptibility to dispersion /erosion
Field Texture Grade	Erodibility, hydraulic conductivity, moisture retention, root penetration
Boundary Distinctness and Shape	Erosional / dispositional status, textural grade
Consistence Force	Structural stability, dispersion, ped formation
Structure Pedality Grade	Soil structure, root penetration, permeability, aeration
Pore Number and Size	Soil structure, root penetration, permeability, aeration
Structure Ped & Size	Soil structure, root penetration, permeability, aeration
Stones – Amount & Size	Water holding capacity, weathering status, erosional / depositional character
Roots – Amount & Size	Effective rooting depth, vegetative sustainability
Ants, Termites, Worms etc	Biological mixing depth

3.2.4 Laboratory Testing

Soil samples were collected from the exposed soil profiles and subsequently sent to the NSW Land and Property Management Authority Soil Conservation Service Laboratory at Scone, NSW for analysis. Samples were analysed to establish the suitability of surface and near-surface soil horizons as potential growth media, and identify high value soils and, conversely, soils that may have properties that are deleterious to vegetation establishment. Samples were analysed from the following sites (as shown on **Figure 2**):

- Test Pit 1 – 1/1, 1/2, & 1/3
- Test Pit 2 – 2/1, 2/2 & 2/3
- Test Pit 3 – 3/1& 3/2
- Test Pit 4 – Not Analysed
- Test Pit 5 – 5/1 & 5/2
- Test Pit 6 – Not Analysed
- Test Pit 7 – 7/1& 7/2
- Test Pit 8 – 8/1 & 8/2
- Test Pit 9 – 9/1, 9/2 & 9/3
- Test Pit 10 – 10/1, 10/2 & 10/3
- Test Pit 12 – 12/1 & 12/2
- Test Pit 13 – 13/1 & 13/2
- Test Pit 14 – 14/1 & 14/2
- Test Pit 15 – 15/1 & 15/2
- Test Pit 16 – 16/1 & 16/2
- Test Pit 17 – 17/1 & 17/2
- Test Pit 18 – 18/1 & 18/2
- Test Pit 19 – 19/1 & 19/2

Parsons Brinckerhoff Samples – Haul Road Alignment

- Test Pit MC05 – 5/1, 5/2, & 5/3
- Test Pit MC06 – 6/1, 6/2, & 6/3
- Test Pit MC07– 7/1, 7/2, & 7/3
- Test Pit MC08 –8/1, 8/2, & 8/3
- Test Pit MC09 – Not analysed
- Test Pit MC10 – Not analysed
- Test Pit MC11 –11/1, 11/2, & 11/3
- Test Pit MC12 –12/1, 12/2, & 12/3
- Test Pit MC13 –13/1, 13/2, & 13/3
- Test Pit MC14 –14/1 & 14/2

Soil horizons are signified by /1 /2 in the sample ID with the surface horizon being /1 and subsoil horizons being /2 and /3. The samples were subsequently analysed for the following parameters.

- Colour;
- Particle Size Analysis;
- Emerson Aggregate Test;
- pH;
- Electrical Conductivity; and
- Cation Exchange Capacity and Exchangeable Cations

A description of the significance of each test and typical values for each soil characteristic is included in **Appendix 2**.

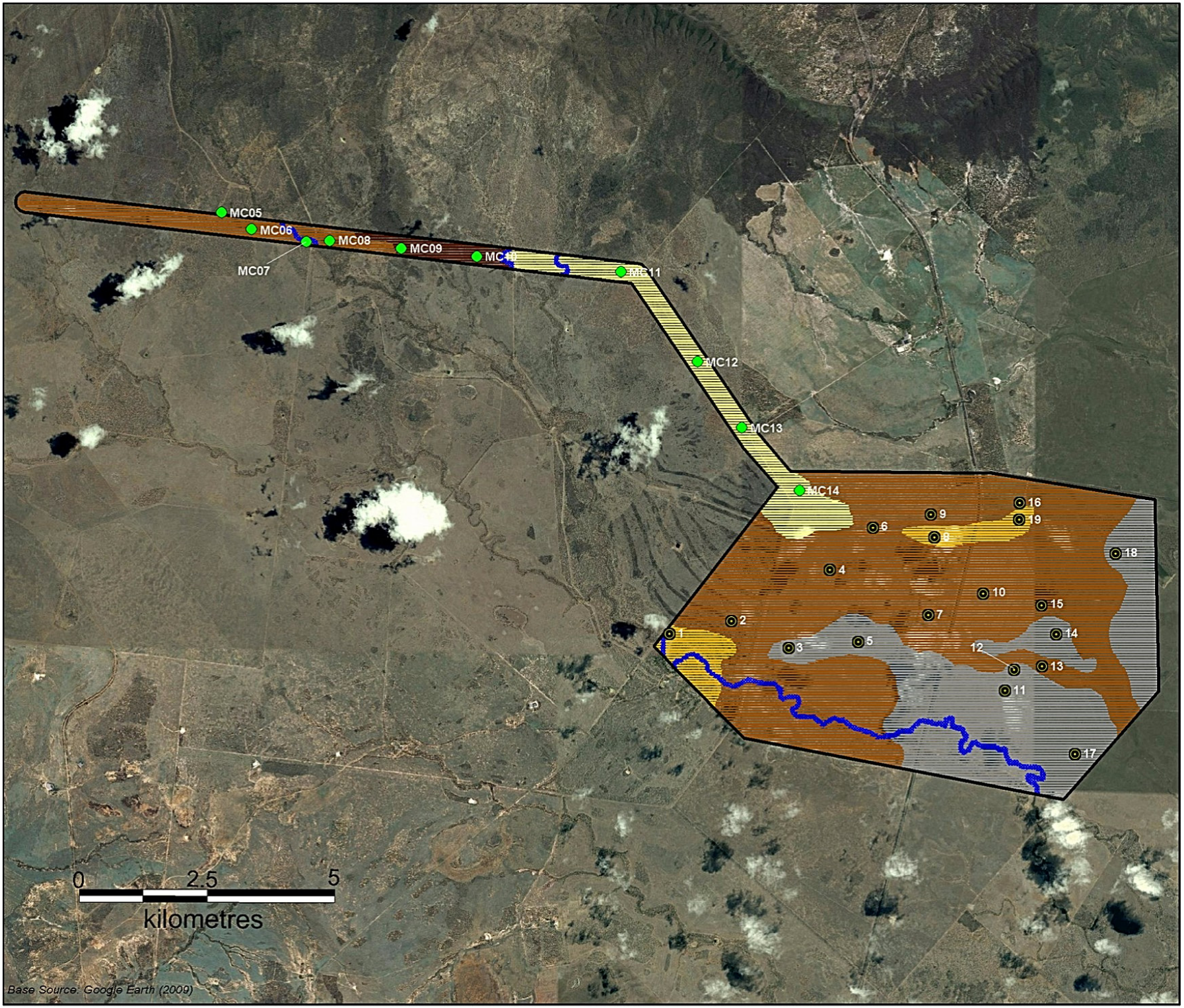
The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for recovery and use as a growth medium for rehabilitation of disturbed areas. Similarly, potentially unfavourable soil material was identified. The soil test results for the soil survey are provided in **Appendix 3**.

3.3 Soil Survey Results

A site inspection was undertaken in October 2009 to classify the soil profile types associated with Codrilla. The objective of the field assessment was to observe soil profiles (to a maximum depth of 1.5 m). The following soil units were identified within the study area:

- Brown Yellow Duplex (221.3 ha);
- Brown Grey Duplex (1434.7 ha);
- Brown Duplex (3,208.3ha);
- Yellow Duplex (432.3 ha); and
- Skeletal Soils (98.5 ha)

The distribution of these soils is illustrated in **Figure 2**. Exposed profiles of major soil units are shown in **Plates 1, 3**, **5, 7** & **9.** Landscape photos of areas where each soil unit was observed are shown in **Plates 2, 4, 6, 8** & **10**.



LEGEND

- Study Area
- Creek Lines
- Sample Locations (GSSE Oct09)
- Sample Locations (PB Jun09)

Soil Unit Classification

- Brown Duplex (3,207.3ha)
- Brown Grey Duplex (1,434.7ha)
- Yellow Duplex (432.3ha)
- Brown Yellow Duplex (221.3ha)
- Rocky/Skeletal Soil (98.5ha)

N

FIGURE 2

Soil Unit Classification & Sample Locations

Project: Codrilla Soils Assessment

Client: McCollum Environmental Management Services

File: Fg2_MEM06_Soil Units_v1

Projection: MGA(94) Zone 55

Version:	Date:	Author:	Checked:	Approved:
1	22/12/09	AR	KM	CR
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3.3.1 Brown Yellow Duplex

Description: This soil unit is characterised by a gradual change between the light pale brown sandy loam surface soil and the yellow clay subsurface soil. These moderately structured soils range from neutral to slightly acidic to slightly alkaline at depth. The soils are non-saline and have low to moderate fertility. The topsoils are generally non-sodic whilst the subsoils exhibit non-sodic to moderately sodic characteristics.

Location: These soils cover 5% or 221.3 ha of the project area and are present on the lower slopes and flat areas near the south western boundary of the project area and in the central north of the project area. Profile sites 1, 8 and 19 occur within this unit.

Landuse: The land overlying these soils is dominated by open grazing farmland. Farm tracks and sparse low lying shrubs transect the area.

Management: The top 0.25 m of this soil is suitable for stripping and reuse as a topdressing medium in rehabilitation. The lower layers are generally unsuitable due to the limiting factors of massive structure (at increased depth) moderate potential for dispersion and slight alkalinity. Whilst this subsoil is unsuitable for use as a topdressing material, consideration may be given to selectively stripping and conserving this material for use as an intermediate layer between reshaped overburden and the final topdressing layer. This soil requires only the standard erosion and sediment control measures if disturbed.

Table 2 – Brown Yellow Duplex Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.25	Pale Brown (10YR 6/3), moderate consistence sandy loam. A moderate pedality (angular blocky 10-50mm) soil, neutral (pH 6.7 to 7.5), low dispersion (EAT 3(1) to 8/3(2)), non-saline (<0.01 – 0.02dS/m), roots common to many and nil stones. Approx sample depth 0.15m. Gradual even boundary to Layer 2.
2	0.25 to 0.55+	Yellow (10YR 7/6), moderate consistence sandy clay. A moderate pedality (angular blocky (5-50mm) soil with neutral to slight alkalinity (pH 7.3 to 7.6), low to moderate dispersion (EAT 3(2) & 3(3), non-saline (0.01dS/m), roots few to common and <5% stones (<5mm). Approx sample depth 0.40m.

Plate 1 –Brown Yellow Duplex Profile

Plate 2 –Brown Yellow Duplex Landscape

3.3.2 Brown Grey Duplex

Description: This soil unit is characterised by an abrupt change between the light pale to brownish grey sandy loam surface soil and the light yellowish to brown sandy clay loam and clayey subsurface soil. These weakly to moderately structured soils range from slightly acidic to moderately alkaline at depth. The topsoils are generally non-sodic whilst the subsoils exhibit moderate to high sodicity.

Location: These soils cover 26% or 1434.7 ha of the project area and are present on the eastern and central flat slopes of the project area. Profile sites 3, 5,12,14,17 and 18 occur within this unit.

Landuse: The land overlying these soils is dominated by open grazing farmland. Farm tracks transect the area with sparse low lying shrubs.

Management: The top 0.35 m of this soil is suitable for stripping and reuse as a topdressing medium in rehabilitation. The lower layers are generally unsuitable due to the limiting factors of massive structure, high to very high potential for dispersion and moderate alkalinity. This soil requires only the standard erosion and sediment control measures if disturbed, however given the sodicity at depth, if the topsoil is removed, it may lead to dispersion and erosion in wet conditions.

Table 3 – Brown Grey Duplex Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.35	Light Brownish Grey (10YR 6/2) moderate consistence sandy loam. A weak pedality (angular blocky 0-10mm) soil, slightly acidic to neutral (pH 6.0 to 7.7), low dispersion (EAT 3(1)), non-saline (<0.01 – 0.02dS/m), roots common to many and <5% stones (<5-10mm). Approx sample depth 0.25m). Clear and even boundary to Layer 2.
2	0.35 to 0.65+	Light Yellowish Brown (10YR 6/4) moderate consistence sandy clay loam. An apedal massive soil that is neutral to strongly alkaline (pH 7.5 to 9.0), high to very high dispersion (EAT 2(3) & 1), non-saline to moderately saline (0.01 to 0.56dS/m), roots none and stones 10-50% (<10mm). Approx sample depth 0.50m.

Plate 3 –Brown Grey Duplex Profile

Plate 4 –Brown Grey Duplex Landscape

3.3.3 Brown Duplex

Description: The Brown Duplex soil unit generally consists of light brown loam and clay loam surface soils which overlie a texture contrast to pale brown to light yellowish brown clay subsurface soils. These moderately structured soils range from neutral to strongly alkaline at depth. The soils are non-saline in the upper layers ranging to moderately saline at depth. . The topsoil varies in sodicity (low to moderate) and becoming increasingly dispersive at depth.

Location: These soils cover 59% or 3208.3 ha of the project area and are generally present throughout the western and central regions of the project area on low lying flat areas. In addition, these soils occur along the far western haul road option of the project area. Profile sites 2, 4, 6, 7, 9, 10, 13, 15, 16, MC 05, MC 06, MC 07 and MC 08 occur within this unit.

Landuse: The land overlying these soils is dominated by open grazing farmland. Farm tracks with sections of bush land along the haul road corridor.

Management: The top 0.20 m of this soil is suitable for stripping and reuse as topdressing medium in rehabilitation; however sites 10, 15 and 16 are unsuitable for stripping and reuse due to a moderate to high potential for dispersion in the topsoil layer. The lower layers are generally unsuitable due to the limiting factors of massive structure, moderate to high potential for dispersion and moderate to strong alkalinity. This soil requires only the standard erosion and sediment control measures if disturbed, however given the sodicity at depth, if the topsoil is removed, it may lead to dispersion and erosion in wet conditions.

Table 4 – Brown Duplex Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.20	Brown (10YR 5/3) moderate consistence loam. A moderate pedality (angular blocky 10-50mm) soil, slightly acidic to neutral (pH 6.4 to 7.4), low dispersion (EAT 3(1)), non-saline (<0.01 to 0.03dS/m), roots common to many and nil stones. Approx sample depth 0.15m. Boundary is clear and even to Layer 2.
2	0.20 to 0.60	Pale Brown (10YR 6/3) strong consistence clay. A weak pedality (angular blocky 10-20mm) soil, slightly to strongly alkaline (pH 7.8 to 9.2), moderate to high dispersion (EAT 2(2) – 2(3), non-saline to moderately saline (0.04 - 0.60dS/m), roots few and nil stones. Approx sample depth 0.40m. Boundary is clear and even to Layer 3.
3	0.60 to 1.00+	Light Yellowish Brown (10YR 6/4) strong consistence medium clay. An apedal massive soil that is generally slightly to strongly alkaline (pH 8.0 – 9.3), high dispersion (EAT 2(3), moderately saline (0.53 – 0.62dS/m), roots and stones nil. Approx sample depth 0.80m.

Plate 5 –Brown Duplex Profile

Plate 6 –Brown Duplex Landscape

3.3.4 Yellow Duplex

Description: The Yellow Duplex soil unit generally consists of light yellowish brown and greyish brown sandy loam surface soils which overlie a texture contrast to yellowish brown sandy clay and sandy clay loam subsurface soils. These soils range from moderately acidic in the upper layers to neutral at depth. The soils are non-saline. The surface soils are non-sodic ranging to moderate at depth.

Location: These soils cover 8% or 432.2 ha of the project area and are present on the proposed haul road option and in the north western boundary of the project area. Profile sites MC 11, MC 12, MC 13 and MC 14 occur within this unit.

Landuse: The land overlying these soils is dominated by remnant vegetation.

Management: Generally, the top 0.30 m of this soil is considered marginally suitable for stripping and reuse as topdressing medium in rehabilitation due to high sand content and massive structure with depth. However, if mixed with other material that has a finer texture; or used for areas to be direct seeded with trees this soil can be used in rehabilitation. This soil requires only the standard erosion and sediment control measures if disturbed, however given the sodicity at depth, if the topsoil is removed, it may lead to dispersion and erosion in wet conditions.

Table 5 – Yellow Duplex Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.05	Greyish brown (10YR 5/2) sandy loam. A weak pedality soil with neutral to moderate acidity (pH 7.0 to 5.9). Low to very low dispersion (EAT 3(1) – 8/3(1)), non-saline (0.01- 0.03dS/m), roots common and nil stones. Approx sample depth 0.02. Boundary is clear and even to layer 2.
2	0.05 to 0.45	Yellowish brown (10YR 5/4) loamy sand. A weak pedality soil with neutral to moderate acidity (pH 6.8 to 5.9). Low dispersion (EAT 3(1)), non-saline (<0.01dS/m), roots few and nil stones. Approx sample depth 0.30m. Boundary is clear and even to layer 3.
3	0.45 to 1.00+	Yellowish Brown (10YR 5/6) sandy clay. An apedal massive soil that is strongly acidic to neutral (pH 9.2 to 7.0) and low to moderately dispersive (EAT 3(1) to 2(1)). Non saline (0.03 – 0.36dS/m), roots and stones nil. Approx sample depth 0.80m.

Plate 7–Yellow Duplex Profile

Plate 8 –Yellow Duplex Landscape

3.3.5 Skeletal Soil

Description: This soil unit is characterised by shallow greyish brown stony sandy clay soils associated with the steeper eroded side slopes and ridgelines throughout the western area of the project site. These soils (sites MC 09 & MC 10) were sampled however not analysed due to high stone content.

Location: These soils cover 2% or 98.5 ha of the project area and are present on the steeper eroded slopes along the haul road option of the project area. Profile sites MC 09 and MC 10 occur within this unit.

Landuse: The land overlying these soils is dominated by remnant native vegetation, native grasses and shrubs. Farm tracks transect the area.

Management: This soil unit is generally unsuitable due to the limiting factors of high stone content, poor structure and shallow depth to bedrock.

Plate 9 – Skeletal Soil Profile

Plate 10 – Skeletal Soil Landscape

3.4 Erosion Potential

3.4.1 Erosion Potential of Soil Types

All soil samples were laboratory tested for dispersion, using the Emerson Aggregate Test (EAT) and sodicity, using the Exchangeable Sodium Percentage (ESP). These tests indicate the susceptibility of a soil to losing its structure and binding capacity when wet, and therefore the erosion potential of the soil. The results showed a similar pattern indicating that soils across the project area are generally sodic.

The middle and lower layers within the Brown Grey Duplex, Brown Duplex and Yellow Duplex soil units generally displayed a moderate to very high potential for erosion with Emerson Aggregate Test ratings of 3 to 1, which indicates a moderate to very high potential for dispersion and surface hardsettingness. Once this material is disturbed, the potential for erosion may be increased. If this disturbance occurs within the vicinity of a drainage line, this could impact on the health of downstream watercourses, through an increase in the sediment load. These soils should, therefore, be managed to ensure that the soils are not disturbed without suitable erosion and sediment controls being implemented. These measures include the construction of structural soil conservation works such as contour, graded and diversion banks and drop structures together with sediment control dams. The use of cover crops and/or organic ameliorants will reduce soil dispersion and surface crusting thereby reducing runoff and increasing infiltration, which will subsequently reduce erosion and sedimentation.

The appropriate erosion and sediment control measures should be in place prior to surface disturbance of these soils, as the risk of erosion is high once the subsoil is exposed. Appropriate measures are outlined in **Section 3.6.3** of this report, with further detailed measures to be developed in the erosion and sediment control plan which will be developed in conjunction with mine approvals.

3.4.2 Potential Erosion Rates

The Revised Universal Soil Loss Equation (RUSLE) has been used in this assessment to estimate the long time average soil loss rates that may result from sheet and rill flow during various levels of disturbance. It must be noted that wind and gully erosion is discussed separately in the section below.

The RUSLE calculates annual erosion rates based on the following equation:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

Where: A = annual soil loss due to erosion [t/ha/yr]
R = rainfall erosivity factor
K = soil erodibility factor
LS = topographic factor derived from slope length and slope gradient
C = cover and management factor
P = erosion control practice factor

The following table offers a comparison of disturbance levels which aims to highlight the higher risk activities in regard to erosion rates. It must be noted that assumptions have been made as to the specific values of soil and overburden characteristics, vegetation establishment success, climatic conditions, slope gradients and lengths and various management practices, and therefore the following values should only be used for comparison purposes. The calculations were made with the 'worst case' scenarios used consistently for all disturbance levels.

Table 6 – Estimated Erosion Rates using the RUSLE

Disturbance Level	Rainfall Erosivity Factor (R)	Raw Soil Erodibility Factor	Adjusted* Soil Erodibility Factor (K)	Topographic Factor (LS)	Cover and Management Factor (C)	Erosion Control Practice Factor (P)	Annual Soil Loss (A) (t/ha/yr)
Undisturbed Surface Pre Mining	1804	0.030	0.030	1.00	0.01	1.0	0.54
Surface cleared of vegetation and topsoil	1804	0.017	0.020	1.00	1.00	1.3	47.84
Unshaped Overburden Dumps	1804	0.025	0.030	8.22	1.00	0.8	355.89
Shaped Overburden Dumps with Graded Banks	1804	0.025	0.030	3.07	1.00	0.8	132.92
Newly Rehabilitated Shaped Overburden Dumps	1804	0.030	0.036	3.07	0.45	0.8	71.78
Established Rehabilitated Shaped Overburden Dumps	1804	0.030	0.036	3.07	0.03	0.8	4.79

* Adjusted for dispersive soil by +20%

Table 6 above shows the disturbance level during mining with the highest risk of severe erosion rates is the unshaped overburden scenario. The key factor to observe in this result is the topographic factor (LS) where the overburden is free dumped and left at the angle of repose albeit benched in some cases. This practice is unlikely to be modified due to cost effectiveness and practicalities of dumping activities. However it is recommended that these areas and times of highest risk should have adequate sedimentation controls in place downstream to capture any material eroded from these slopes. The shaped overburden dumps with graded banks (but without topsoil or vegetation) was the second highest predicted rate of erosion which indicates the need for the reshaping, grading, topdressing and seeding of overburden dumps to be undertaken in the quickest possible timframe in order to minimise the risk of severe rainfall events impacting on these exposed slopes over a long period of time.

Gully erosion is not considered within the RUSLE equation above, however given the succession of erosion severity from rill to gully erosion, it is predicted that the same disturbance levels will contain the same risk rankings for gully erosion rates as the RUSLE equation has displayed. Once overburden dumps have been shaped and graded banks established, any gully erosion should be repaired and rehabilitated as soon as possible to reduce further erosion and sedimentation downstream.

Wind erosion has the potential to cause loss of material from overburden dumps during the mining process, especially given the raised elevation of the dumps within the landscape. Management practices during mining may limit the extent of wind erosion, by reducing truck movements and earthworks on highly exposed dumps during periods of extreme wind conditions. Furthermore, mine planning considerations for minimising exposed surfaces and timely rehabilitation activities may protect surface soil from wind erosion of overburden dumps.

3.5 Acid Sulfate Soil Potential

The potential for acid generation from regolith material (topsoil and subsoil) within the project site is low. This does not include acid generation potential within the overburden material (consolidated bedrock below 2-3 m depth), which was addressed separate in **Section 5** of this report.

Acid Sulphate Soils (ASS), which are the main cause of acid generation within the soil mantle, are commonly found less than 5 m above sea level, particularly in low-lying coastal areas such as mangroves, salt marshes, floodplains, swamps, wetlands, estuaries, and brackish or tidal lakes. The project site is located within the Central Highlands region (which is located approximately 150 km from the coast at > 260 m AHD). There has been little history of acid generation from regolith material with this region.

3.6 Topsoil Selection & Management for Rehabilitation

The following management and mitigation strategies are recommended for implementation during mining, in order to reduce the potential for degradation within the project site and adjoining lands. These recommendations are based on the assessment of the existing site conditions and experience with the management of mining surface impacts at sites throughout New South Wales and Central Queensland.

3.6.1 Topsoil Stripping Criteria

The potential for major land disturbance is likely to result from excavation of the open cut pit, out-of-pit overburden dumps, haul road construction and infrastructure areas. It is recommended that topsoil be recovered in these areas of disturbance.

Soil analysis results were used in conjunction with the field assessment to determine the depth of soil materials suitable for recovery. Structural and textural properties of subsoils are the most significant limiting factors in determining depth of soil suitable for re-use. Salinity levels, pH and dispersion potential are also limiting factors in some soils in some project sites. Elliot and Veness (1981) described the basic procedure, adopted in this survey, for the recognition of suitable topdressing materials (refer **Table 7**). This procedure has been adapted to include sandy loams as suitable.

Table 7 – Topsoil Stripping Criteria

Descriptor	Reasoning	Desirable criteria
Structure Grade	Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade (Charman, 1978) and depends on the proportion of coarse peds in the soil surface. Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.	- 30% peds present - coherent when wet or dry - EAT: < 2 (2) - conductivity: < 1.5 dS/m - exchangeable Na% < 12% - pH: > 4.5 & < 8.4 - no mottle present - finer than sandy loam - sand & gravel content < 60%
Consistence – Shearing Test	The shearing test is used as a measure of the ability of soils to maintain structure grade. Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the extraction, transportation and spreading of topdressing material. Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.	
Consistence – Disruptive Test	The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates	
Mottling	The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeability's; however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.	

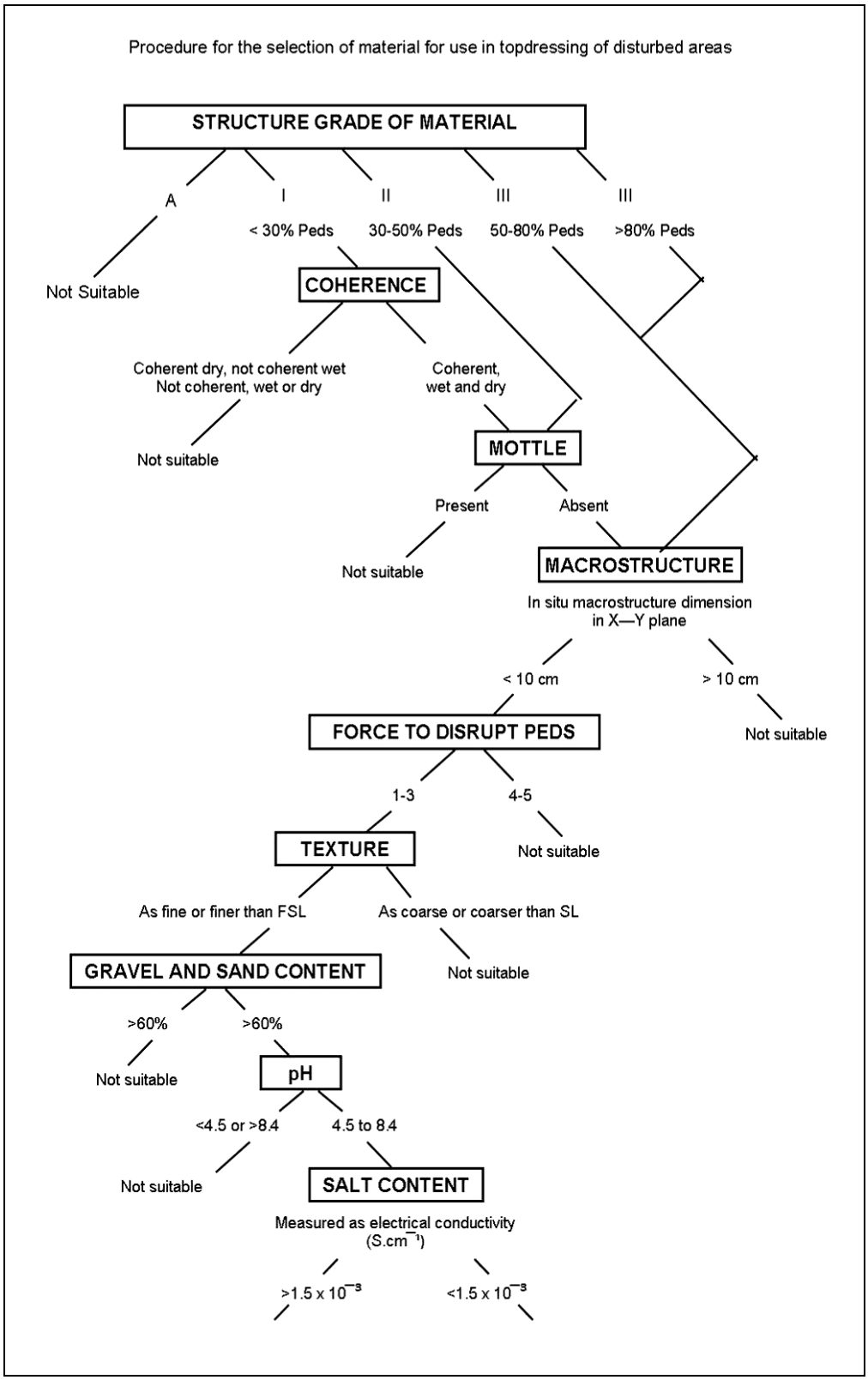


Figure 3: Selection process for topdressing material (Source: Elliot and Veness; 1981)

The recommended stripping depth for each soil unit, together with area of land and calculated volume are provided in **Table 8** below.

Table 8 – Recommended Stripping Depths

Soil Unit Type	Recommended Stripping Depth (m)	Area (ha)	Volume (m^3)	Disturbance Area (ha)	Disturbance Area Volume (m^3)
Brown Yellow Duplex	0.25	221.3	553,250	25.9	64,750
Brown Grey Duplex	0.35	1,434.7	5,021,450	346.2	1,211,700
Brown Duplex	0.20	3,208.3	6,416,600	1,019.6	2,039,200
Yellow Duplex	0.30	432.3	1,296,900	7.0	21,000
Skeletal Soil	Not recommended for stripping				
		Total Volume	**13,288,200**		**3,336,650**
		Total Volume (10% handling loss allowance)	**11,959,380**		**3,002,985**

Allowing for a 10% handling loss, approximately **3,002,985 m^3** of suitable topdressing is available within the disturbance area. The majority of topsoil disturbance will result from the excavation of the open cut pit, out of pit overburden dumps, dams and the infrastructure area.

3.6.2 Topsoil Stripping and Handling

Where topsoil stripping and transportation is required, the following topsoil handling techniques are recommended to prevent excessive soil deterioration.

- Strip material to the depths stated in **Table 8**, subject to further investigation as required.
- Topsoil should be maintained in a slightly moist condition during stripping. Material should not be stripped in either an excessively dry or wet condition.
- Place stripped material directly onto reshaped overburden and spread immediately (if mining sequences, equipment scheduling and weather conditions permit) to avoid the requirement for stockpiling.
- Grading or pushing soil into windrows with graders or dozers for later collection by elevating scrapers, or for loading into rear dump trucks by front-end loaders, are examples of less aggressive soil handling systems. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.
- Soil transported by dump trucks may be placed directly into storage. Soil transported by bottom dumping scrapers is best pushed to form stockpiles by other equipment (e.g. dozer) to avoid tracking over previously laid soil.
- The surface of soil stockpiles should be left in as coarsely textured a condition as possible in order to promote infiltration and minimise erosion until vegetation is established and to prevent anaerobic zones forming.
- As a general rule, maintain a maximum stockpile height of 3 m. Clayey soils should be stored in lower stockpiles for shorter periods of time (i.e. less than 12 months) compared to sandier soils, selected from the alluvial soils.
- If long-term stockpiling is planned (i.e. greater than 12 months), seed and fertilise stockpiles as soon as possible. An annual cover crop species that produce sterile florets or seeds should be sown. A rapid growing and healthy annual pasture sward provides sufficient competition to

minimise the emergence of undesirable weed species. The annual pasture species will not persist in the rehabilitation areas but will provide sufficient competition for emerging weed species and enhance the desirable micro-organism activity in the soil.

- An inventory of available suitable surface cover material should be maintained to ensure adequate topsoil materials are available for planned rehabilitation activities.

3.6.3 Landform Design and Erosion Control Measures

Rehabilitation strategies and concepts proposed below have been formulated according to results of industry-wide research and experience.

The main objective of regrading is to produce slope angles, lengths and shapes that are compatible with the proposed land use and not prone to an unacceptable rate of erosion. Integrated with this is a drainage pattern that is capable of conveying runoff from the newly created catchments whilst minimising the risk of erosion and sedimentation. Final slope gradient should not exceed 17%, or approximately 10^0.

The most significant means of controlling surface flow on disturbed areas is to construct contour furrows or contour banks at intervals down the slope. The effect of these is to divide a long slope into a series of short slopes with the catchment area commencing at each bank or furrow. This prevents runoff from reaching a depth of flow or velocity that would cause erosion. As the slope angle increases, the banks or furrows must be spaced closer together until a point is reached where they are no longer effective.

Contour ripping across the grade is by far the most common form of structural erosion control on mine sites as it simultaneously provides some measure of erosion protection and cultivates the surface in readiness for sowing.

Graded banks are essentially a much larger version of contour furrows, with a proportionately greater capacity to store runoff and/or drain it to some chosen discharge point. The banks are constructed away from the true contour, at a designed gradient (0.5% to 1%) so that they drain water from one part of a slope to another; for example, towards a watercourse or a sediment control dam.

Eventually, runoff that has been intercepted and diverted must be disposed of down slope. The use of engineered waterways using erosion blankets, ground-cover vegetation and/or rip rap is recommended to safely dispose of runoff downslope.

The construction of sediment control dams is recommended for the purpose of capturing sediment laden runoff prior to off-site release. Sediment control dams are responsible for improving water quality throughout the mine site and, through the provision of semi-permanent water storages, enhance the ecological diversity of the area.

The following points should be considered when selecting sites for sediment control dams.

- Each dam should be located so that runoff may easily be directed to it, without the need for extensive channel excavation or for excessive channel gradient. Channels must be able to discharge into the dam without risk of erosion. Similarly, spillways must be designed and located so as to safely convey the maximum anticipated discharge.
- The material from which the dam is constructed must be stable. Dispersive clays will require treatment with gypsum to prevent failure of the wall by tunnel erosion. Failure by tunnelling is most likely in dams which store a considerable depth of water above ground level, or whose water level fluctuates widely. Dams should always be well sealed, as leakage may lead to instability, as well as allowing less control over the storage and release of water.
- The number and capacity of dams should be related to the total area of catchment and the anticipated volume of runoff. The most damaging rains, in terms of erosion and sediment problems are localised, high intensity storms.

3.6.4 Topsoil Respreading & Seedbed Preparation

Sampling and analysis of topsoil resources, whether stockpiled or in-situ, is recommended prior to respreading. This will assist in identifying potential soil deficiencies and estimating required rates of fertiliser or ameliorant (i.e. gypsum or lime) application.

Where possible, suitable topsoil should be re-spread directly onto reshaped areas. Where topsoil resources allow, topsoil should be spread to a minimum depth of 10 cm on all regraded spoil. Topsoil should be spread, treated with fertilizer or ameliorants (if required) and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion.

Prior to re-spreading stockpiled topsoil onto reshaped overburden (particularly onto designated tree seeding areas), an assessment of weed infestation on stockpiles should be undertaken to determine if individual stockpiles require herbicide application and / or “scalping” of weed species prior to topsoil spreading.

Thorough seedbed preparation should be undertaken to ensure optimum establishment and growth of vegetation. All topsoiled areas should be contour ripped (after topsoil spreading) to create a “key” between the soil and the spoil. Ripping should be undertaken on the contour and the tynes lifted for approximately 2 m every 200 m to reduce the potential for channelised erosion. Best results will be obtained by ripping when soil is moist and when undertaken immediately prior to sowing. The respread topsoil surface should be scarified prior to, or during seeding, to reduce run-off and increase infiltration. This can be undertaken by contour tilling with a fine-tyned plough or disc harrow.

4.0 LAND RESOURCE ASSESSMENTS

4.1 Land Capability Assessment

The project site was assessed in accordance with Rosser et al (1974) for pre-mining land capability. The system includes eight (8) possible classifications and refers to the overall agricultural potential of the land. Land capability classifications provide a ranking of the capacity of each part of a land resource to sustain broad land use classed (with lower number classes suited to more intense uses, and higher number classes suited to low intensity rural use, conservation and the like). Land capability assessment is more appropriate to broad hectare areas where the land choices are farming, grazing and non agricultural. The various classes are provided in **Table 9**. The pre-mining rural land capability classification of the study area is provided in **Table 10**.

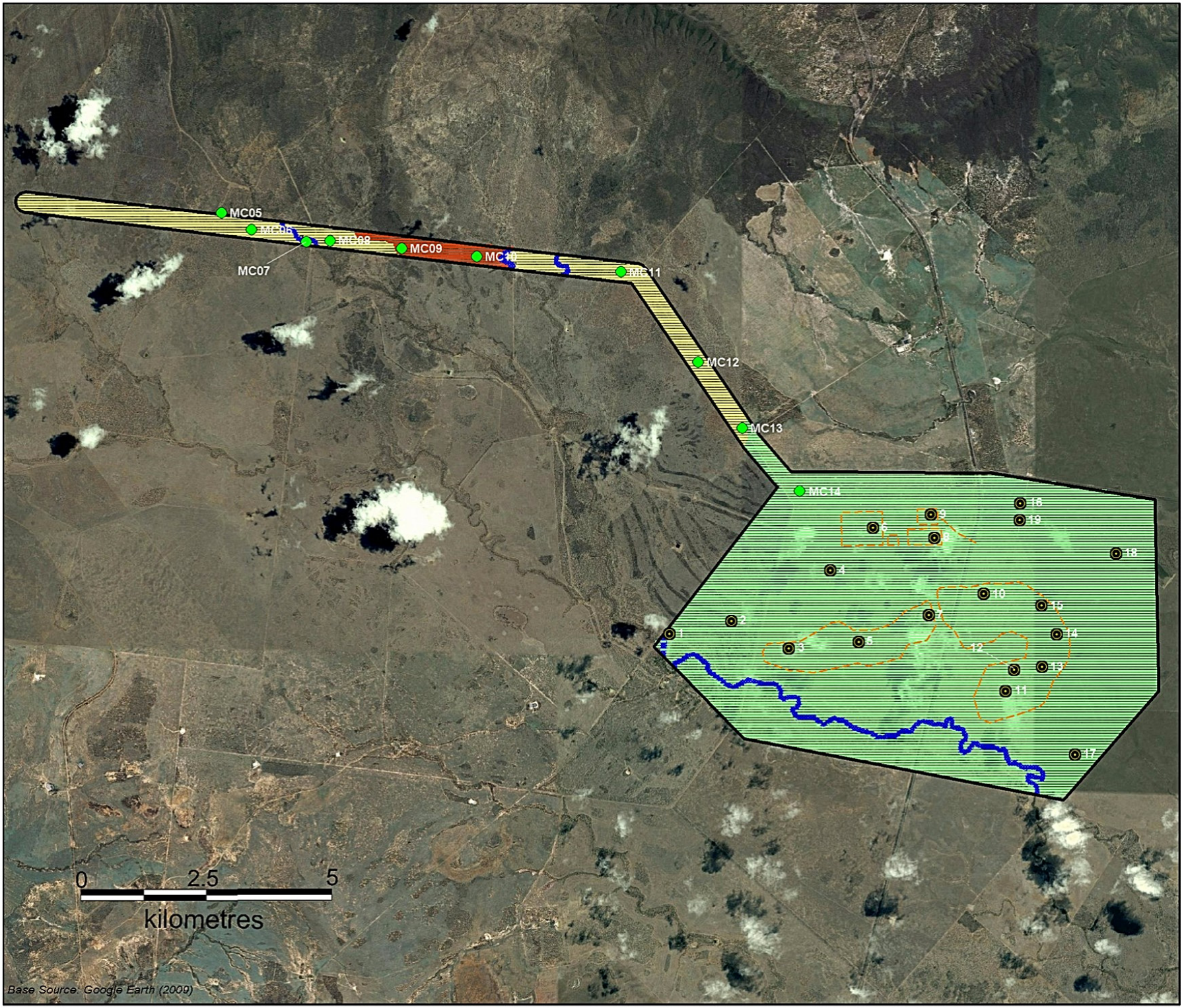
Table 9 – Land Capability Classes

Category	Class	Description
Suitable for Cultivation	**Class I**	No special practices required.
	Class II	Simple management practices required.
	Class III	Complex or intensive practices required to sustain cropping.
	Class IV	Occasional or limited cultivation but with severe management inputs required to prevent degradation.
Not Suitable for Cultivation	**Class V**	Suitable soil and topography for crops but economically not viable. High quality grazing land.
	Class VI	Moderately susceptible to degradation requiring proper management to sustain use.
	Class VII	Highly susceptible to degradation requiring severe restrictions on use; grazing may be conducted with rigorous management inputs required to prevent degradation.
Not Suitable for Grazing	**Class VIII**	Wildlife reserves, bushland, recreation or water supply catchments.

Table 10 – Pre Mining Rural Land Capability Classes

Land Capability Class	Pre Mining		Post Mining	
	ha	%	ha	%
Class V	4,774.6	88.5	3,336.0	61.8
Class VI	521.0	9.7	1,218.0	22.6
Class VII	0.0	0.0	568.0	10.5
Class VIII	98.5	1.8	272.1	5.0
Total	**5,394.1**	**100.0**	**5,394.1**	**100.0**

Figure 4 illustrates the existing rural land capability classification and **Table 10** quantifies the area of each class. The study area encompasses classes V, VI and VIII lands. The majority of the project site is Class V – Suitable soil and topography for crops but economically not viable, however it is high quality grazing land. The rocky hills and ridgelines, within the vicinity of the haul road option, are considered to be Class VIII – land that is highly susceptible to degradation requiring severe restrictions for use. Highly eroded Skeletal Soils occupy this area. Grazing may be conducted with rigorous management inputs required to prevent degradation.



LEGEND

- Study Area
- Creek Lines
- Sample Locations (GSSE Oct09)
- Sample Locations (PB Jun09)
- Proposed Disturbance Areas

Land Capability Classes

- Class V (4,774.6ha)
- Class VI (521.0ha)
- Class VIII (98.5ha)

N

FIGURE 4

Existing Land Capability Classes

Project: Codrilla Soils Assessment

Client: McCollum Environmental Management Services

File: Fg4_MEM06_Land Cap_v2

Projection: MGA(94) Zone 55

Version:	Date:	Author:	Checked:	Approved:
1	22/12/09	AR	KM	CR
2	08/06/10	DJ	CR	CR

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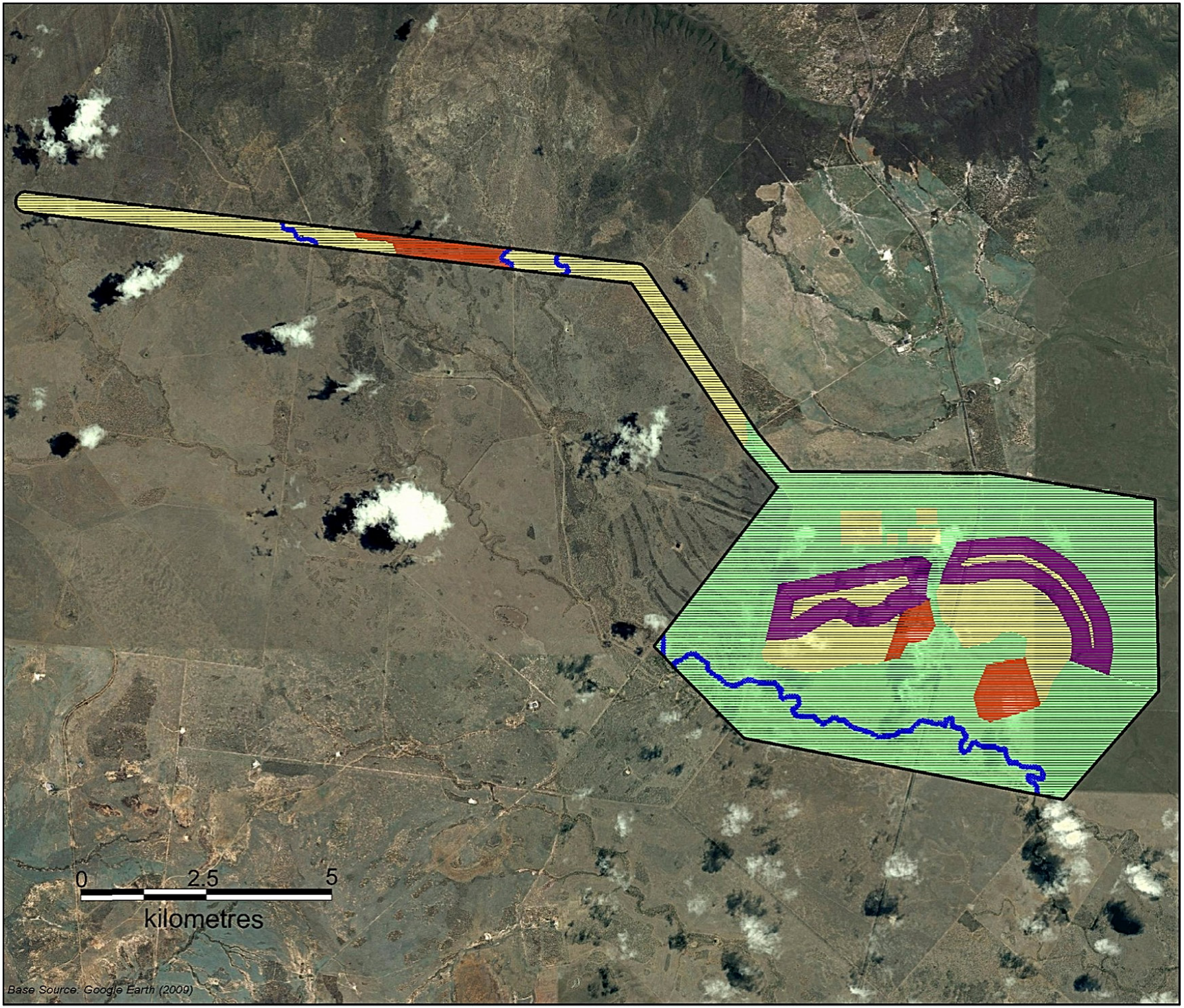

LEGEND

- Study Area
- Creek Lines
- Proposed Disturbance Areas

Land Capability Classes

- Class V (3,336ha)
- Class VI (1218ha)
- Class VII (568ha)
- Class VIII (272.1ha)

N

FIGURE 5

Post Mining Land Capability Classes

Project:	Codrilla Soils Assessment
Client:	McCollum Environmental Management Services
File:	Fg5_MEM06-002
Projection:	MGA(94) Zone 55

Version:	Date:	Author:	Checked:	Approved:
1	08/06/10	DJ	CR	CR

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Class V, VI & VII are all grazing land classes and are not suitable for cultivation. **Figure 5** illustrates the post mining rural land capability classification and **Table 10** quantifies the area of each class.

4.2 Land Suitability Assessment

4.2.1 Land Suitability Assessment Scheme

Agricultural land suitability of the project site has been assessed largely using criteria provided in the *Guidelines for agricultural land evaluation in Queensland* (Queensland Department of Primary Industries, Land Resources Branch, 1990).

The method of land suitability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography and the effects of past land uses. The classification does not necessarily reflect the existing land use. Rather, it indicates the potential of the land for such uses as crop production, pasture improvement and grazing.

The system allows for land to be allocated into five possible classes (with land suitability decreasing progressively from Class 1 to Class 5) on the basis of a specified land use that allows optimum production with minimal degradation to the land resource in the long term. Land is considered less suitable as the severity of limitations for a land use increase. Increasing limitations may reflect any combination of:

- reduced potential for production;
- increased inputs to achieve an acceptable level of production; and/or
- increased inputs required to prevent land degradation.

The agricultural land suitability classes are described in **Table 11**.

Table 11 – Scheme for Classifying Land Suitability

LS Class	Orders	LS Class Descriptor	Description
1	S Suitable	S1 None/Minor Limitations (Highly Suitable)	Land with negligible limitations, which is highly productive requiring only simple management practices to maintain economic production.
2		S2 Minor Limitations (Moderately Suitable)	Land with minor limitations which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production.
3		S3 Moderate Limitations (Marginally suitable)	Land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production.
4	N Not Suitable	N1 (or S4) Marginal Land (Presently Unsuitable)	Marginal lands with severe limitations which make it doubtful whether the inputs required achieving and maintaining production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production)
5		N2 (or S5) Unsuitable	Unsuitable land with extreme limitations that preclude its use for the proposed purpose.

Reproduced from CSIRO, 2008.

A land suitability assessment provides an analysis on how 'fit' a given area of land is for a specific type of land utilisation (e.g. rainfed cropping or grazing). The analysis considers the area's land use characteristics (e.g. soil pH), land quality attributes (e.g. moisture availability) and how these match conditions that are necessary for 'successful and sustained' implementation of a specific land utilisation type (CSIRO, 2008; DME, 1995; Shields and Williams, 1991).

The expression of land suitability assessments is commonly reported using a rating system that uses five discrete classes (1 through to 5) with 1 being the most suitable and 5 being the least suitable (refer **Table 11**) (CSIRO, 2008; DME, 1995). Classes 1 to 3 (also known as S1 to S3) are generally considered suitable and classes 4 and 5 unsuitable (also known as N1 and N2) for the specific type of land utilisation (CSIRO, 2008).

GSSE's land suitability analysis provides a proportional land suitability assessment whereby each soil type's characteristics and attributes are cross-referenced against the DME (1995) 'criteria checklist' for 'rainfed broadacre cropping' and 'beef cattle grazing'. GSSE understands that Mr John Burgess is preparing an agricultural suitability framework for the Isaac–Connors and McKenzie River Catchments. The framework may be incorporated into new Technical Guidelines, which are *in prep*. In the meantime the moisture limitations attributes and subclasses can be used for land suitability assessments. The aforementioned document will be referred to hereafter as 'Burgess 2010 guidelines *in prep'*.

The overall land suitability ranking for each specific soil type is determined by the most severe limitation, or a combination of the varying limitations. For this reason the major limiting factors determining land suitability will be presented.

Table 12 – Comparison of Current and *in prep* Land Suitability Guidelines for Plant Available Water Capacity (PAWC)

Guideline Source	Land suitability ranking for rainfed cropping				
	1	**2**	**3**	**4**	**5**
DME (1995)	PAWC > 150 mm	PAWC 125-150mm	PAWC 100-125mm	PAWC 75-100mm	PAWC < 75mm
Burgess 2010 guidelines *in prep.*	PAWC > 150mm	PAWC 130-150mm	PAWC 115-130mm	PAWC 70-115mm	PAWC < 70mm
	Land suitability ranking for beef cattle grazing				
	1	**2**	**3**	**4**	**5**
DME (1995)	PAWC > 125mm	PAWC 100-125mm	PAWC 75-100mm	PAWC 50-75mm	PAWC < 50mm
Burgess 2010 guidelines *in prep.*	PAWC > 90mm	PAWC 70-90mm	PAWC 35-70mm	PAWC < 35mm	-

Source: Table Reproduced from *pers comm*. B. Forster 11.02.10.

4.2.2 Calculation of Plant Available Water Capacity and Effective Rooting Depth

The primary land suitability assessment attribute is 'moisture'. The indicator for moisture is Plant Available Water Capacity (PAWC). PAWC is an estimate of the amount of moisture stored in the soil profile that is available for plant extraction. It is generally defined as the difference between field capacity and permanent wilting point. PAWC is calculated for the soil profile by summing the available water capacity over the soil's effective rooting depth (ERD).

ERD is defined as the soil depth to which 90% of the plant roots will extract water (Burgess, 2005). ERD can be estimated through observed rooting depth, soil chemical parameters or a standardised depth can be used (*Soil Physical Measurement and Interpretation for Land Evaluation*, 2008). For the purposes of this

project area assessment ERD has been determined from both observed rooting depth and the chemical parameters as defined in **Table 13**.

PAWC can be directly measured in the field, estimated from textural classes or interpolated using a QLD approved software program (PAWCER). GSSE calculated PAWC using the PAWCER software program for each soil unit. Each soil unit's PAWC is detailed in **Table 14.**

Table 13 – Effective Rooting Depth Criteria

Limitation #	Descriptor	ERD occurs where:
1	$EC_{1:5}$ for sorghum and wheat[1] (90% yield reduction threshold)	>0.8 dS/m
2	Cl 1:5	>1,000 ppm
3	ESP	>20% where clay content is >25%
4	pH	<5.5
5	Depth to C horizons	--
6	Unsuitable subsoil structure	moderate or strong columnar structure sandy free draining horizons significant rock content

Source: Burgess, 2003

Table 14 – Effective Rooting Depth (ERD) and Plant Available Water Capacity (PAWC)

Soil Unit	ERD		
	Limitations	Average Depth (m)	Average PAWC (mm)
Brown Yellow Duplex	6	0.53	58
Brown Grey Duplex	1,3,6	0.27	35
Brown Duplex	1,3,6	0.18	32
Yellow Duplex	1,3,6	0.36	33
Shallow Soil (Skeletal)	-	N/A	N/A

4.2.3 Land Suitability Rankings

The project area's soil units have been assessed against the criteria for 'rainfed cropping' and 'broadacre grazing' land utilisation types as per the guidelines. The first limitation for land utilisation is moisture and each soil unit's average PAWC is provided in **Table 14**. Where soil units have been classified as unsuitable for cropping, (Class 5; **Table 15**), these soil units have been subsequently assessed for their suitability for pastoral activities (refer **Table 16**). **Figure 6** illustrates their spatial distribution. All soil units have been assessed as not suitable for Rainfed Cropping. All soil units were assessed as marginally suitable for grazing. The Brown Yellow Duplex soil unit has been classed as Land Suitability 3 and is considered moderately suitable for grazing. This soil type has moderate moisture limitation and minor sanity limitation. In addition, the subsoils are generally non-sodic to moderately sodic. This soil unit should be able to support grazing using native pastures providing the soil is managed to limit ground disturbance.

The Brown Grey Duplex soil unit is moderately suitable for grazing and has been classified as Land Suitability 3. This soil type has a moderate PAWC limitation whilst the subsoils within this unit are generally sodic, moderately alkaline and saline, and high in clay content which may restrict plant rooting depth and growth. This soil unit should be able to support grazing using native pastures providing the soil is managed to limit ground disturbance.

The Brown Duplex soil unit has been classed as Land Suitability 4 and is considered marginally suitable for grazing. This soil unit has marginal topsoil structure texture as it is easily erodible and a marginal PAWC limitation. Subsoils within this unit are generally saline, alkaline, sodic and high in clay content which may restrict plant rooting depth and growth. This soil unit should be able to support intermittent low-quality grazing of native pastures with no pasture improvement.

The Yellow Duplex soil unit is considered marginally suitable for grazing and has been classified Land Suitability 4. The Yellow Duplex Sandy Loam is considered marginally suitable for grazing and has also been classified as Land Suitability 4. This soil unit has marginal topsoil texture as it is easily erodible, low fertility and a high PAWC limitation. Subsoils within this unit are moderately sodic and high in clay content which may restrict plant rooting depth and growth. This soil unit should be able to support intermittent low-quality grazing of native pastures with no pasture improvement.

The Skeletal soil unit is considered marginally suitable for grazing and has been classified Land Suitability 4. This soil unit covers 2% of the project site and is generally rocky and occurs with the steeper side slopes and ridgelines in the west. Where accessible for grazing animals, this land should be able to support intermittent low-quality grazing of native pastures with no pasture improvement.

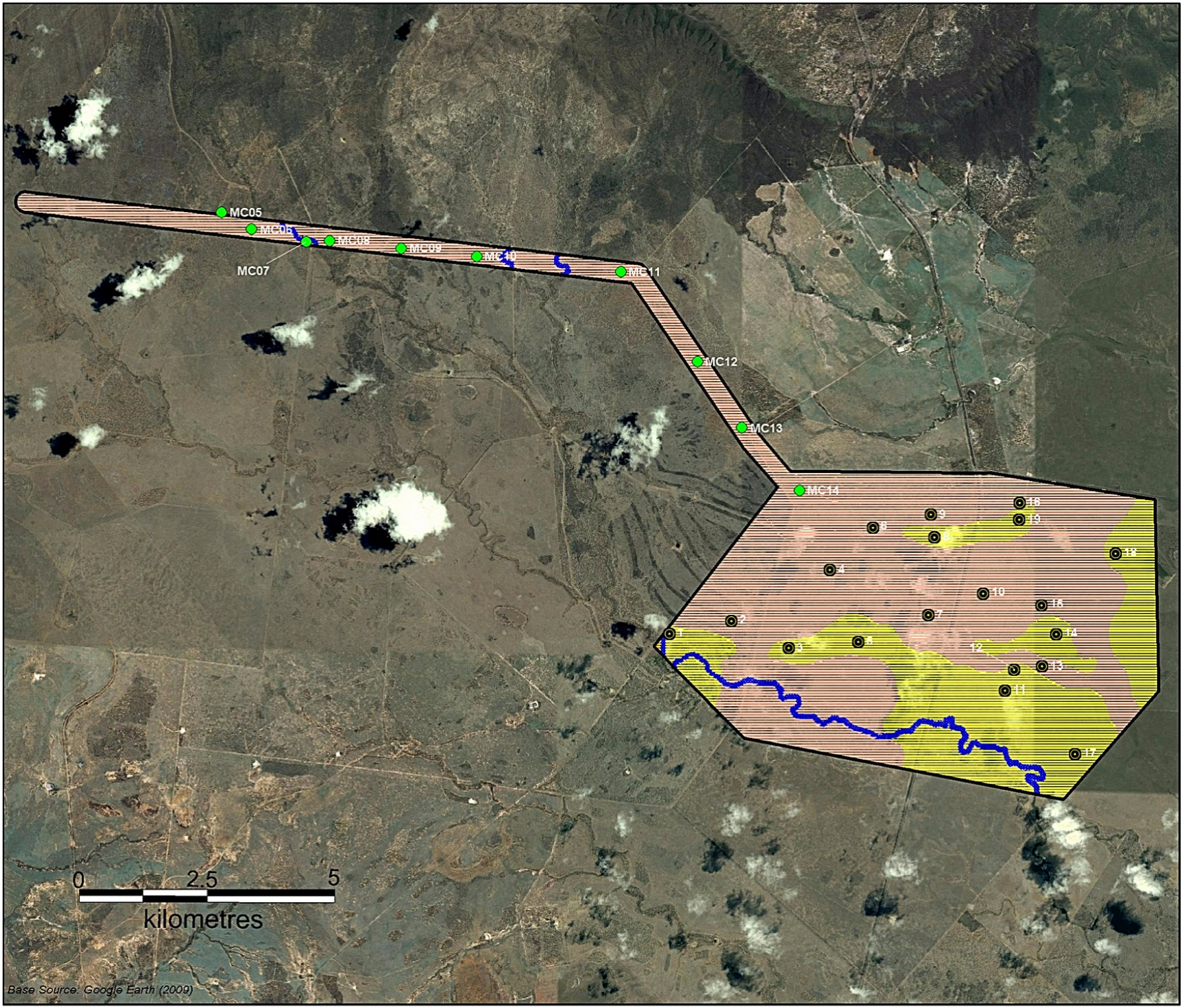
Table 15 – Land Suitability (LS) Ranking for Rainfed Broadacre Cropping

Soil Type	LS ranking	Overall LS Ranking	Suitable/ unsuitable
	Moisture		
Brown Yellow Duplex	5	**5**	Unsuitable
Brown Grey Duplex	5	**5**	Unsuitable
Brown Duplex	5	**5**	Unsuitable
Yellow Duplex	5	**5**	Unsuitable
Shallow Soil (Skeletal)	-	**-**	Unsuitable

Table 16 – Land Suitability (LS) Ranking for Beef Cattle Grazing

Soil Type	LS ranking				Overall LS Ranking	Suitable/ Unsuitable
	Moisture[1]	ESP %	Salinity	pH		
Brown Yellow Duplex	3	2	1	2	**3**	Suitable
Brown Grey Duplex	3	2	1	2	**3**	Suitable
Brown Duplex	4	2	1	2	**4**	Suitable
Yellow Duplex	4	1	1	2	**4**	Suitable
Shallow Soil (Skeletal)	-	-	-	-	**4**	Suitable

1 Criteria used from reference 'Burgess 2010 guidelines *in prep'*.



LEGEND

- Study Area
- Creek Lines
- Sample Locations (GSSE Oct09)
- Sample Locations (PB Jun09)

Land Suitability

- Class 3 (1656ha)
- Class 4 (3738.1ha)

N

FIGURE 6

Existing Land Suitability (Beef Cattle Grazing)

Project: Codrilla Soils Assessment

Client: McCollum Environmental Management Services

File: Fg6_MEM06-002

Projection: MGA(94) Zone 55

Version:	Date:	Author:	Checked:	Approved:
1	08/06/10	DJ	CR	CR

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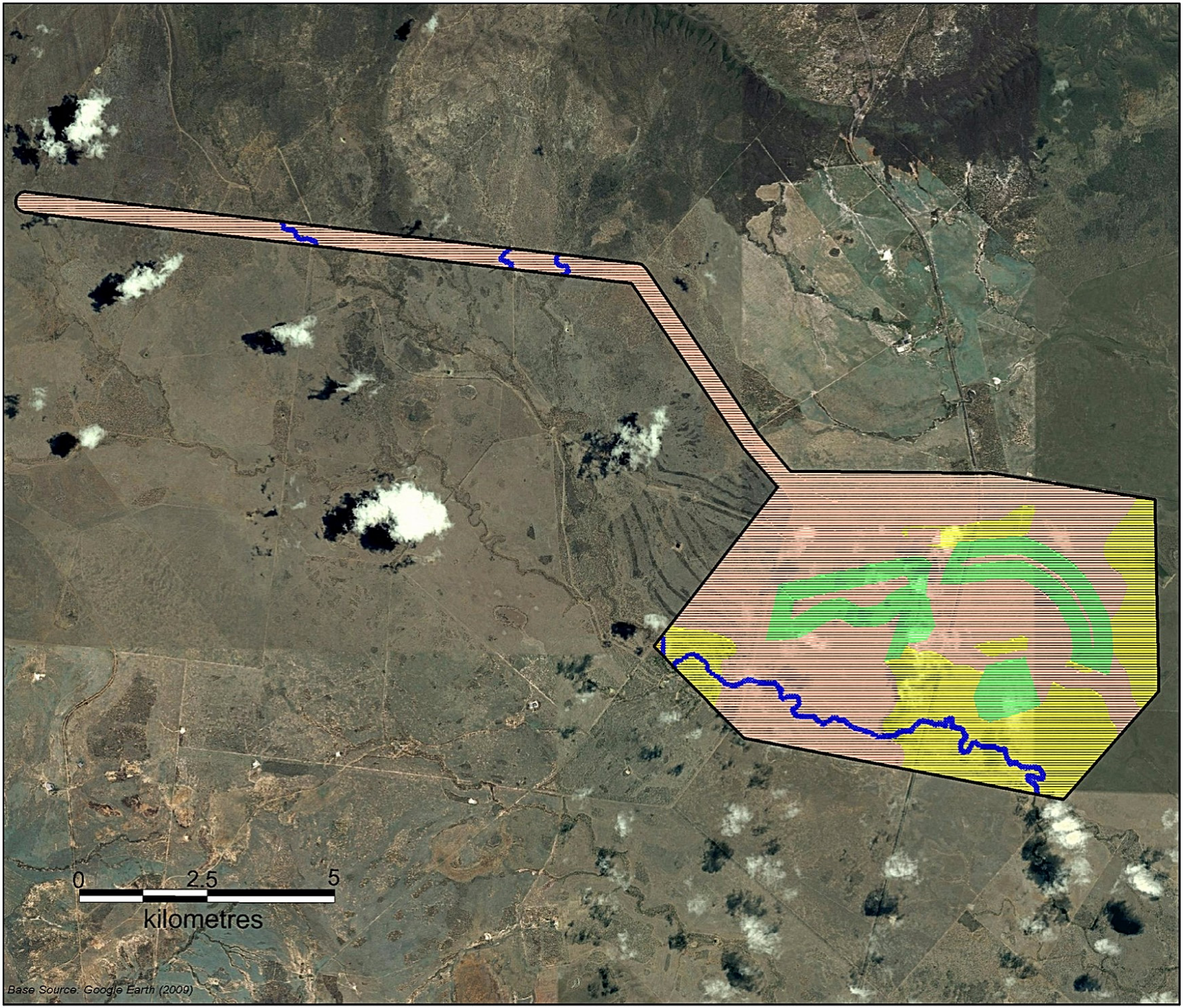

LEGEND

Study Area

Creek Lines

Land Suitability

Class 3 (1265.6ha)

Class 4 (3389ha)

Class 5 (739.5ha)

N

FIGURE 7

Post Mining Land Suitability (Beef Cattle Grazing)

Project: Codrilla Soils Assessment

Client: McCollum Environmental Management Services

File: Fg7_MEM06-002

Projection: MGA(94) Zone 55

Version:	Date:	Author:	Checked:	Approved:
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4.2.4 Post-mining Land Suitability

Although detailed closure options were not available during the production of this report, the proposed post-mining land use for the project sites is expected to be a mosaic of grassland and bushland. In terms of soil conservation and agricultural land suitability, the predicted changes in land suitability class for the project area are outlined in **Table 17** below.

Table 17 – Land Suitability (LS) Pre and Post Mining

Land Suitability Class	Existing Area	Post Mining Area
	ha	ha
3	1,656.0	1,265.6
4	3,738.1	3,389.0
5	0.0	739.5
Total Area	**5,394.1**	**5,394.1**

In order to sustain the desired land use without degradation, it is important that the post-mining land only be used in accordance with the limits of the agricultural suitability class. Soil conservation practices such as stocking rate control and establishment or re-establishment of permanent pasture are recommended for areas of mining impact. The overriding principle is to maintain the most beneficial future use of land that can be sustained in view of the range of limiting factors. The proposed post-mining land must provide and sustain a sufficient bulk of nutritious forage in addition to the following management considerations in the event of future low density grazing.

- The ability to access and manage livestock.
- Flood free and relatively dry ground conditions.
- Adequate stock drinking water and shelter.
- Stock routes throughout the land.

Provided that environmental controls such as structural soil conservation works (refer **Section 3.3**) and effective revegetation are in place and operating properly during mine construction and operation, there should be no adverse effects to the project site or the surrounding grazing land.

4.3 Agricultural Land Class Assessment & GQAL

The project site, and immediately surrounding land, was also assessed against the Agricultural Land Class (ALC) system, which is used to identify potential Good Quality Agricultural Land (GQAL) in accordance with the *Guidelines for the identification Good Quality Agricultural Land* (Qld DPI & DHLG&P, 1993) (referred to as the Good Quality Agricultural Land guidelines*)*. Agricultural land is defined as land used for crop or animal production, but excluding intensive animal uses (i.e. feedlots and piggeries). Good quality agricultural land is land which is capable of sustainable use for agriculture, with a reasonable level of inputs, and without causing degradation of land or other natural resources.

The DPI guidelines have been introduced to provide local authorities and development proponents with a system to identify areas of good quality agricultural land for planning and project approval purposes. Descriptions of the agricultural land classes are provided in **Table 18**.

The ALC classification system combines land suitability assessments for a number of specific land utilisation types into a single land classification. This ALC classification system has four categories: Arable (A), Limited arable (B), Pastoral (C) and Non-agricultural (D) (refer **Table 18**).

Table 18 – Scheme for Classifying Agricultural Land

Class	Name	Description
A	Arable land (Crop land)	Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels.
B	Limited arable land (Limited crop land)	Land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping.
C	Pastoral land	Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.
D	Non-agricultural land	Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage.

Source: QDPI (1993).

The overall land suitability rating of 1-5 is translated into an ALC rating of A-D, additionally, for the Central West QLD region, ALC C is further divided into three sub-classes of C1, C2 and C3, according to potential grazing quality, as outlined in **Table 19** below.

Table 19 – Broadacre Cropping Land Suitability (LS) Ranking and Agricultural Land Class (ALC)

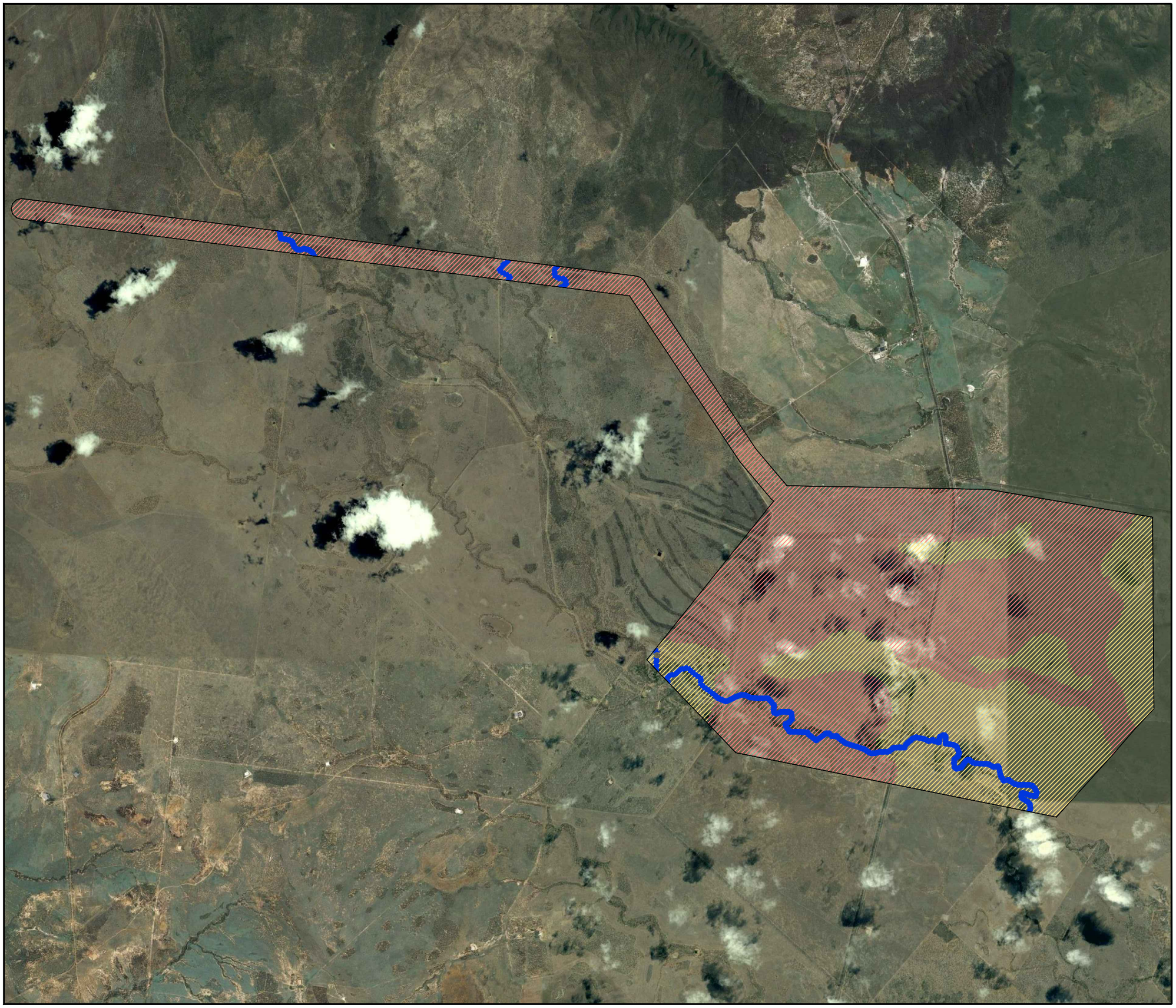
LS Rating	Land Suitability Description (DME, 1995)	ALC	Pastoral Management (ref)	B. Forster (per comm., 2010))
1	High quality land with few or minor limitations	C1	Good quality grazing and/or highly suitable for pasture improvement	Brigalow vegetation; appropriate for fattening beef cattle; good grazing on sown pastures and can withstand ground disturbance.
2	Land with minor limitations	C1		Brigalow vegetation and/or transitional vegetation to Poplar Box vegetation communities.
3	Moderate limitations to sustaining its use	C2	Moderate quality grazing and/or moderately suitable for pasture improvement.	Eucalypt woodland, Poplar Box, narrow-leaved Eucalyptus, gum-top woodlands; low-moderate PAWC and low-moderate fertility; good grazing on native pastures without ground disturbance; appropriate for beef cattle breeders.
4	Marginal land requiring major inputs to sustain the use	C3	Low quality grazing, grazing of native pastures with limited suitability for pasture improvement.	Tea-tree vegetation; usually characterised by steep country or mangrove flats.
5	Unsuitable due to extreme limitations.	D	Not suitable	Unsuitable due to extreme limitations.

The relationship(s) between soil type, land suitability rating and ALC for the Codrilla project area are outlined below in **Table 20** and shown in **Figure 8**.

Table 20 – Codrilla Soil Types and Agricultural Land Class (ALC)

Soil Type	Overall LS Rating	ALC
Brown Yellow Duplex	**3**	C2
Brown Grey Duplex	**3**	C2
Brown Duplex	**4**	C3
Yellow Duplex	**4**	C3
Shallow Soil (Skeletal)	**4**	C3

The results in **Table 20** above show the land is suitable for grazing between C2 and C3 Agricultural Land Class. According to the Isaac Regional Shire Council Planning Scheme Agricultural Land Class A, B & C1 is considered 'Good Quality Agricultural Land' (GQAL), therefore the assessment has found that the Codrilla project area contains no GQAL under the above definitions. The post mining conditions for assessing Land Suitability and Agricultural Land Class are predictive only, however given there was no GQAL found within the study site, there will be no loss of such land. Following mining there is expected to be a shift in Agricultural Land Classes from Class C2 to C3 or D, given the modifications to slopes and the establishment of a rudimentary soil profile.



LEGEND

Study Area

Creek Line

Agricultural Land Class

C2

C3

FIGURE 8

Pre-Mining Agricultural Land Class

Project: Codrilla Soils Assessment

Client: McCollum Environmental Management Services

File: Fg8_MEM06-002_Ag Class_100608.dwg

Projection: MGA(94) Zone 55

Version:	Date:	Author:	Checked:	Approved:
1	8/06/2010	TC	CR	CR

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5.0 OVERBURDEN & REJECTS GEOCHEMICAL ASSESSMENTS

5.1 Geochemical Characterisation Testing Procedures

GSS Environmental and Henderson Geotech developed a geochemical sampling and testing program which focused on utilising representative samples of overburden and potential reject material from the roof, floor and coal seam. The geochemical properties of overburden material likely to report as spoil from open cut mining and of roof, coal and floor that will comprise CHPP waste were evaluated. Whilst there are no specific regulatory requirements in Queensland that dictate the density of sampling and testing of overburden and potential reject materials, adequate overburden samples have been tested to give a representative assessment of material on the proposed Codrilla site. A total of 26 overburden samples and 5 tailings component samples were tested. A key requirement of the sampling strategy was to ensure that drill samples were selected to represent the various overburden rock types likely to be associated with the mine development.

Overburden and potential reject samples were screened using a series of standard static physical geochemical tests including Particle Sizing, pH, Electrical Conductivity (EC), Moisture Content, Total Sulfur by LECO, Exchangeable Cations, Acid Neutralising Capacity (ANC), Net Acid Generation, Net Acid Producing Potential (NAPP), Total Metals by ICP-AES (including Arsenic, Boron, Cadmium, Chromium, Cobalt, Copper, Lead, Nickel, Selenium & Zinc) and Total recoverable Mercury. The Net Acid Generation (NAG) test was only used for overburden testing and not the coal rejects testing as recent research into the veracity of the NAG test indicates that the presence of organic matter in samples can cause erroneous results to be recorded (Stewart et al., 2003). The potential for a sample to generate acid was derived from the Total Oxidisable Sulfur (TOS) content and the calculated NAPP value.

All analytical tests were conducted by Australian Laboratory Services (ALS). The laboratory results received from ALS are provided in **Appendix 3**.

The details of the above tests are outlined in the sections below.

5.1.1 pH

The 14 overburden samples from 2009 were tested for pH using the saturated paste pH test. This was carried out by equilibrating crushed solid sample in deionised water for approximately 16 hrs at a solid to water ratio of 1:2. The pH is then measured and gives an indication of the inherent acidity of the waste material when initially exposed in a waste emplacement area.

The 12 overburden samples from 2008 were tested for pH using the soil pH value, KCl pH and OX pH values. For this assessment, the soil pH value was used for these 12 overburden samples.

5.1.2 Electrical Conductivity (EC)

The 14 overburden samples from 2009 were tested for EC using the saturated paste method. The 2008 samples were not assessed for EC. The 5 coal composite samples were assessed for EC using PC titrator @ 25°C.

5.1.3 Exchangeable Cations & Exchangeable Sodium Percentage (ESP)

The cation exchange capacity (CEC) is a measure of the total capacity of a soil to hold exchangeable cations and therefore indicates the negative charge present per unit mass of soil, generally cmolc/kg or mequiv./100g. Much of the behaviour of soils is governed by the nature of the surfaces of soil particles, particularly the surface area and charge. The CEC provides a buffering effect to changes in pH, available nutrients, calcium levels and soil structural changes. Therefore CEC is a major controlling agent of soil structure, nutrient availability for plant growth, soil pH, and the soils reaction to fertilisers and other ameliorants. In general, a low CEC means the soil has low resistance to changes in soil chemistry.

Sodic soils are dispersible under wet conditions and therefore are susceptible to the following problems:

Very severe surface crusting;

Very low infiltration and hydraulic conductivity;

Severe gully erosion; and

Severe tunnelling.

The region of Central Queensland, where the Codrilla site is located, has a long history with attempting to manage the effects of sodic overburden material. The Exchangeable Sodium Percentage (ESP) is calculated by dividing the exchangeable sodium value by the total cation exchange capoacity and multiplying by 100. Soils with an ESP of 0-6% are considered non-sodic, 6-14% are considered marginally sodic to sodic, and greater than 14% are considered strongly sodic (Hazelton & Murphy 2007)

5.1.4 Acid Base Account

Acid rock drainage (ARD) is a result of the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. The ability to identify in advance any mine materials that could potentially produce ARD is essential for timely implementation of mine waste management strategies.

The procedure used for the Codrilla samples to help assess the acid forming characteristics of mine waste material is the Acid-Base Account (ABA). This method is referred to as a static procedure because it involves a single measurement in time.

The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates). The values arising from the acid-base account are referred to as the maximum potential acidity (MPA) and the acid neutralising capacity (ANC), respectively. The difference between the MPA and ANC value is referred to as the net acid producing potential (NAPP).

Total Sulfur

Total sulfur content was determined by the Leco high temperature combustion method. The total sulfate content is determined by the Inductively Coupled Plasma Atomic Emission Spectroscopy (!CP-AES) method. The total oxidisable sulfur (TOS) content is calculated as the total sulfur less the sulfate sulfur content. The TOS is then used to calculate the Maximum Potential Acidity (MPA), which is based on the assumption that only the TOS content is present as reactive pyrite.

Maximum Potential Acidity

The MPA that can be generated by a sample is determined from the sample sulphur content. The total sulphur content of a sample is determined by the Leco high temperature combustion method. The calculation assumes that all the sulphur measured in the sample occurs as pyrite (FeS_2) and that the pyrite reacts under oxidising conditions to generate acid according to the reaction:

$$FeS_2 + 15/4\ O_2 + 7/2H_2O \Rightarrow Fe(OH)_3 + 2H_2SO_4$$

According to this reaction, the MPA of a sample containing 1% S as pyrite would be 30.6 kilograms of H_2SO_4 per tonne of material (i.e. kg H_2SO_4/t). Hence the MPA of a sample is calculated from the total sulphur content using the following formula:

$$\text{MPA (kg } H_2SO_4\text{/t)} = \text{(Total \%S)} \times 30.6$$

The use of the total sulphur assay to estimate the MPA is a conservative approach because some sulphur may occur in forms other than pyrite. Sulphate-sulphur and native sulphur, for example, are non-acid generating sulphur forms. Also, some sulphur may occur as other metal sulphides (e.g. covellite,

chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating.

Acid Neutralising Capacity

The acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid buffering is quantified in terms of the ANC.

The ANC is commonly determined by the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA, that is kg H_2SO_4/t.

Net Acid Producing Potential

This is a theoretical calculation commonly used to indicate if a material has potential to produce acidic drainage. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H_2SO_4/t and is calculated as follows:

$$NAPP = MPA - ANC$$

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

Net Acid Generation (NAG) Test

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. Therefore, the end result represents a direct measurement of the net amount of acid generated by the sample. This value is commonly referred to as the NAG capacity and is expressed in the same units as NAPP, that is kg H_2SO_4/t.

Single Addition NAG Test

The single addition NAG test involves the addition of 250 mL of 15% hydrogen peroxide to 2.5 gm of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulphides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the pH and acidity of the NAG liquor are measured.

The acidity of the liquor is then used to estimate the net amount of acidity produced per unit weight of sample. An indication of the form of the acidity is provided by initially titrating the NAG liquor to pH 4.5, then continuing the titration up to pH 7. The titration value at pH 4.5 includes acidity due to free acid (i.e. H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides at pH between 4.5 and 7.

Sample Classification

Due to the limitations of the NAG test, as discussed above the Total Oxidisable Sulfur (TOS) and NAPP data have been used to classify the acid forming nature of overburden and reject materials at the Codrilla site according to **Table 21** below.

Table 21 – Sample Classification of Acid producing potential

Total Oxidisable Sulfur (TOS) (%)	NAPP (kg H_2SO_4 /t)	Sample Classification
< 0.1	-	Non-Acid Forming (NAF)
0.1 ≤ *TOS* ≤ 0.2	≤ -20	
0.1 ≤ *TOS* ≤ 0.2	-20 < *NAPP* ≤ 0	Uncertain - Non-Acid Forming (UC-NAF)
0.1 ≤ *TOS* ≤ 0.2	> 0	Uncertain (UC)
>0.20	≤ 0	
0.2 < *TOS* ≤ 1.0	0 > *NAPP* ≤ 20	Uncertain - Potentially Acid Forming (UC-PAF)
> 1.0	> 20	Potentially Acid Forming (PAF)

5.1.5 Metal Scans

In mineralised areas it is common to find a suite of enriched elements that have resulted from natural geological processes. Metal scans are carried out to identify any elements that are present in a material at concentrations that may be of environmental concern with respect to surface water quality and revegetation. In addition to the exchangeable cations assessed as discussed above the Codrilla samples were analysed for the following elements:

- Sulfur – S
- Arsenic – As
- Boron – B
- Cadmium – Cd
- Cobolt – Co
- Chromium – Cr
- Copper – Cu
- Mercury – Hg
- Nickel – Ni
- Lead – Pb
- Selenium – Se
- Zinc – Zn

Whilst there are no guidelines or regulatory criteria specifically related to total metal concentrations in overburden and coal reject materials, the metal scan results were assessed against QLD-EPA (1998) environmental investigation levels (contaminated soils) and NEPC (1999a) health-based investigation levels (HILs) for parks and recreation (open spaces). The QLD-EPA (1998) guidelines are primarily aimed at contaminated land investigations and, in this context, provide a suitable guideline for an industrial facility, such as a mine. The NEPC (1999a) guidelines for 'open spaces' are less stringent than the QLD-EPA guidelines, however their applicability stems from the likely final land use of the mine following closure (*i.e.* a return to livestock grazing).

Metals do not necessarily pose an environmental risk if identified as enriched, and furthermore, metals of low concentration may cause environmental concerns in varying circumstances. The important issue for the Codrilla mine is the potential for overburden and potential reject material to leach soluble metals at concentrations that may impact the environment or human health.

Water extracts were used to determine the immediate element solubilities under the existing pH conditions of the sample. Element concentrations are generally compared with those recommended in relevant surface water (ANZECC, 2000) and groundwater (NEPM, 1999a) guidelines in order to determine their environmental significance.

5.2 Geochemical Characterisation Results of Overburden Material

The full suite of test results for overburden samples is attached in **Appendix 3**. Overburden and interburden are considered and reported together for this report and are hereby referred to as Overburden.

5.2.1 pH

The test results for current pH of the 14 overburden samples from the 2009 testing range from 6.3 through to 8.5 and average 7.48. The pH test results from the 12 overburden samples from the 2008 testing range from 7.2 to 8.9 and average 8.2. Therefore the pH of leachate from overburden material at the Codrilla site is likely to range from very slightly acidic to moderately alkaline, however the majority of material is likely to be neutral.

5.2.2 EC

The test results for EC of the 14 overburden samples range from 1,090 to 3,930uS/cm and average 2,595 uS/cm the preferred standard for measurement is in dS/m and therefore the range is 1.09 to 3.93 dS/m and average of 2.59 dS/m.

5.2.3 Cation Exchange Capacity and Sodicity

The Cation Exchange Capacity of the overburden samples ranges from 12.5 to 35.4 meq/100g with an average value of 21.2 meq/100g. These values indicate the overburden material is within the Moderate to High ranges for CEC and should therefore provide a reasonable growth medium for vegetation roots.

Table 22: Ratings for Cation Exchange Capacity

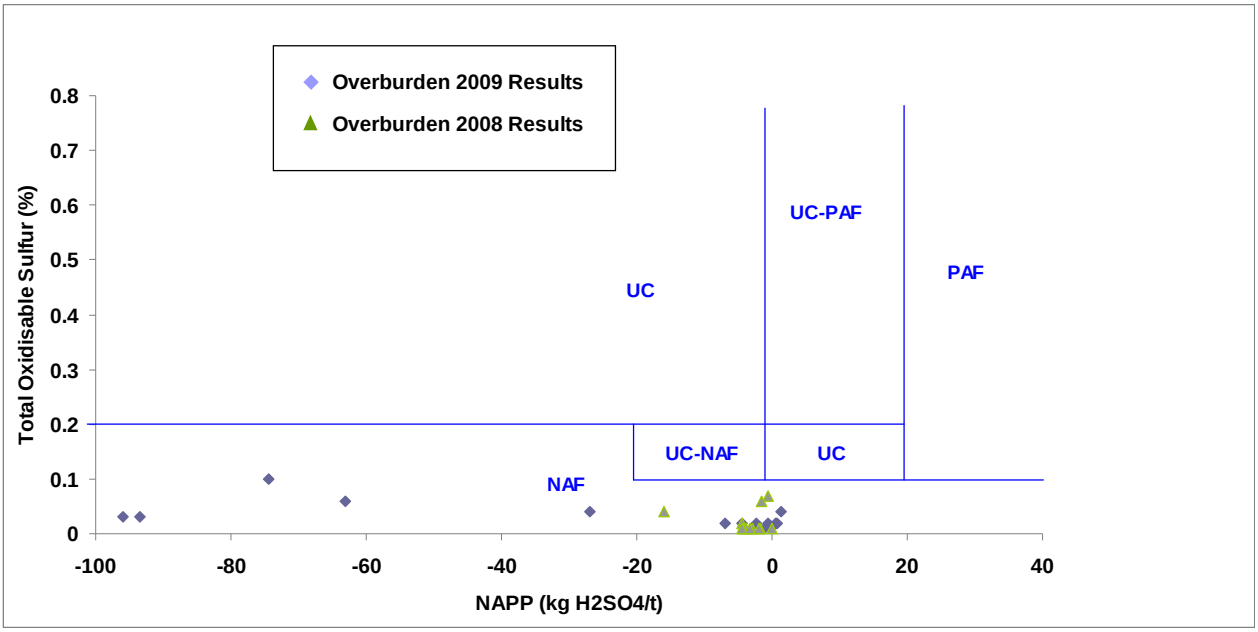
CEC Rating	CEC meq/100g
very low	<6
low	6-12
moderate	12-25
high	25-40
very high	>40

All of the tested overburden samples had very high ESP values ranging from 17.8% to 60.6% with the average being 47.5%. Given soils with ESP values of greater than 14% are considered strongly sodic, the overburden material at the Codrilla site may be considered extremely sodic. These materials are expected to be highly susceptible to severe erosion and tunnelling within the overburden dumps. The disturbance and exposure of this material to water may result in erosion and sedimentation of waterways and dams. The general practice with extremely sodic materials is to bury within the overburden dump where exposure to rain and runoff water is minimised, however given all the overburden samples tested were extremely sodic, the practice of minimising surface exposure to rainfall is the only practical solution.

5.2.4 Acid Base (NAPP) Results

The Acid Base test results for the 14 overburden (2009) samples, and 12 overburden (2008) samples are summarised in **Figure 9** below. On the basis of these results, all 26 overburden samples from 2008 and 2009 are classified as Non Acid Forming (NAF). The total sulfur content of all overburden samples was below 0.1% and considered inert for rehabilitation purposes.

Figure 9: Correlation between Overburden and interburden TOS and NAPP values



5.2.5 Metal Scans

The results of the overburden samples assessed for metals are provided in **Table 23** below and allows comparison of any enriched metal concentrations with those described in QLD-EPA (1998) environmental investigation guidelines for contaminated sites and NEPC (1999a) health-based guidelines for soils in 'open spaces'.

It is important to note that there are no specific regulatory criteria for metal concentrations in overburden and coal reject materials, nor in leachate derived from such materials on mine sites. It was determined that the most suitable tests to be undertaken for metal analysis was solids testing, as comparison to guidelines was clear and the overburden material was considered to be relatively dry within the emplacements due to a free draining landform. The metal concentrations in overburden from these materials, has been compared with the above guidelines to provide some context for the discussion of test results.

Table 23: Codrilla Overburden Metal Scan Results

Metal	No of samples analysed	Results range (mg/kg)	Average (mg/kg)	Health Investigation Levels (HIL's) (exposure setting E - NEPC 1999) (mg/kg)	Environmental Investigation Levels (EILs (EPA 1998) (mg/kg)
Arsenic	26	<5 to 14	*	200	20
Barium	12	<10 - 110	*	N/A	N/A
Beryllium	12	<1 - 3	*	40	N/A
Boron	26	<50 to <50	*	6,000	N/A
Cadmium	26	<1 to <1	*	40	3
Chromium	26	4 to 35	15	200	50
Cobalt	26	2 to 62	13	200	N/A
Copper	26	<5 to 95	*	2,000	60
Lead	26	<5 to 23	*	600	300
Manganese	12	<5 - 440	*	3,000	500
Mercury	26	<0.1 to <0.1	*	30	1
Molybdenum	12	<2 - <2	*	N/A	N/A
Nickel	26	2 to 126	29	600	60
Selenium	26	<5 to <5	*	N/A	N/A
Silver	12	<2 - <2	*	N/A	N/A
Strontium	12	20 - 256	73.2	N/A	N/A
Tin	12	<5 - <5	*	N/A	50
Zinc	26	5 to 148	50	14,000	200
Vanadium	12	13 - 75	30.7	N/A	N/A

* average not provided due to results less than laboratory limit of reporting

The results in **Table 23** indicate that several overburden materials tested have Copper and Nickel concentrations in solids greater than QLD-EPA (1998) environmental investigation levels (EIL), but well below NEPC (1999a) health-based investigation levels (HIL) for soils. Hence, multi-element results indicate that the concentration of metals in overburden solids and runoff/seepage is unlikely to present any environmental issues associated with revegetation and rehabilitation of any out-of-pit overburden storage facilities and on-site or downstream water quality.

5.3 Chemical Characterisation of Tailings & Reject Material

When coal is mined, some non-coal material from above and below the seams is usually extracted as well – this is termed “dilution”. A main objective of CHPP processes is to exclude from the product coal as much dilution, and as little coal, as possible. In simple terms, the ROM coal is first crushed to break it down to a nominated size and then screened to exclude the fragments larger than that size, on the principal that what did not break down was stronger than coal and was therefore dilution. This excluded material comprises the coarse reject. The crushed material is crushed further then added to a fluid medium then separated using various techniques that utilise differences in physical properties between coal and non-coal. The resultant waste is a mixture of water, process additives and ground and saturated rock particles, referred to as fine reject, or tailings.

Inevitably, neither coarse nor fine separation processes are completely effective, and a proportion of coal is captured in both waste streams. The actual amounts depend on the efficiency of both mining and coal preparation but coarse reject typically includes 20-30% coal; for tailings a representative range is 40-70% coal. Physically, coarse reject is predominantly gravel-sized fragments >20mm, while tailings depends heavily on strata close to the coal seam (roof and floor) but is a mixture of sand, silt and clay sized particles.

Because of the uncertain composition of actual reject, it was decided to analyse the component materials separately. Two samples of each roof and floor were composited from single boreholes and were sent with one coal sample for laboratory analyses. In addition to solids analyses, 1:2 leachates were prepared by mechanical agitation to represent potential runoff/leachate from coarse reject and supernatant from tailings. Analytes included normal soil water characteristics and parameters listed in Table 3 of the November 2009 Draft of the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (DERM). The results are summarised in Table 23 and Table 24.

Table 24: Codrilla Reject Solids Chemistry

Metal	No of samples analysed	Roof, coal and floor results range (mg/kg)	Health Investigation Levels (HILs) (exposure setting E - NEPC 1999) (mg/kg)	Environmental Investigation Levels (EILs) (EPA 1998) (mg/kg)	Hazardous dam Solids - (EPA 2002) (mg/kg)
Arsenic	17	<5 – 39	200	20	500
Boron	17	<50 - <50	6,000	N/A	15,000
Cadmium	17	<1 - <1	40	3	100
Chromium	12	<2 – 14	200	50	-
Cobalt	17	<2 – 31	200	N/A	500
Copper	17	<5 – 11	2,000	60	5,000
Lead	17	<5 – 79	600	300	1,500
Nickel	17	<2 – 128	600	60	3,000
Selenium	17	<5 - <5	N/A	N/A	-
Zinc	17	<5 – 904	14,000	200	35,000
Mercury	17	<0.1 – 0.3	30	1	75

Note: no average provided due to all results having some parameters less than laboratory limit of reporting.

Table 25: Codrilla Reject Leachate Chemistry

Metal	No of samples analysed	Roof, coal and floor results range (mg/L)	RCTIL (DERM, 2010) (mg/L)	OWSCL (DERM, 2010) (mg/L)	Hazardous dam liquor (mg/L) - (EPA 2002)
Aluminium	17	<0.1 – 2.3	0.1	5	-
Arsenic	17	<0.01 - <0.1	0.013	0.5	1
Boron	17	<0.1 – 1.3	0.37	-	5
Cadmium	17	<0.005 - <0.05	0.0002	0,01	10
Chromium	17	<0.01 - <0.1	0.001	-	-
Cobalt	17	<0.01 – 0.8	0.09	-	1
Copper	17	<0.01 – 1	0.002	1	1
Iron	17	<0.05 - 8	0.3	-	-
Lead	17	<0.01 – <0.1	0.01	0.1	0.5
Nickel	17	<0.01 – 3.1	0.011	1	1
Selenium	17	<0.01 – 0.8	0.01	-	-
Zinc	17	0.02 – 12.6	0.008	20	20
Mercury	17	<0.0001 - <0.001	-	-	2

Note: no average provided due to all results having some parameters less than laboratory limit of reporting.

With regard to potential for acid production, based on the classification in Table 20 all samples tested were either Uncertain or Uncertain – Potentially Acid Forming. This was due to all samples having >0.2% sulphur, although two samples so had high Acid Neutralising Capacity.

None of the results exceeded the limits in the DERM draft dams manual, which indicates that dams containing tailings or reject-contacted water would not automatically be considered regulated dams based on contaminant concentrations. However, an aboveground tailings storage facility would normally be assessed as Significant Hazard Category, and therefore a regulated dam, based on the physical consequences of discharge.

The concentrations of most analytes exceeded model EA conditions release water investigation trigger levels in one or more samples. Hence it is likely that water that has been in contact with CHPP reject will not be of suitable quality for uncontrolled release to receiving waters, and will need to be captured within the mine water management system. This is the usual situation for coal mines in central Queensland.

5.4 Conclusions and Management of Overburden & Reject Material

5.4.1 Overburden

The results from the Acid Base testing indicates that the overburden material will initially generate neutral to slightly alkaline runoff and seepage due to the current pH of the material. All overburden samples had very low sulphur content of <0.1% and are considered inert. The ANC generally exceeded the MPA for overburden samples indicating that the material has sufficient buffering capacity to neutralise the small amount of acidity that may be generated from sulphide oxidation. All overburden samples were classified as NAF with majority of NAPP values being negative, whilst only 3 samples were slightly positive being 0.6, 0.7 and 1.3 kg H_2SO_4/t.

The salinity levels of the runoff and seepage water is expected to be moderate. This may cause some vegetation species to be slower growing once the roots penetrate the moderately saline overburden material. Over time it is expected that salinity levels near the surface layers of overburden will lower due to leaching further into the dump profile. Water management structures such as dams should be monitored for salinity levels and appropriate management and release actions should be followed.

The presence of extremely sodic material throughout the overburden profiles gives rise to the need for implementing appropriate erosion and sediment controls on site prior to and during the development of the overburden emplacements. This sodic material is prone to severe surface crusting, gully erosion and tunnelling. The sodic overburden material should be covered with an inert topdressing sourced from the sites topsoil. The addition of gypsum over the surface may provide an effective reduction of surface crusting and dispersion, however the availability in central Queensland can be low. The addition of organic matter as an ameliorant into the soil should also reduce the effects of sodicity. The best suited final landuse for the overburden emplacements at Codrilla include nature conservation and a mosaic of grassland and bushland as is proposed. The final slope of the overburden emplacement should not exceed 10 degrees, and graded banks should be constructed at 1.2 to 1.5 % grade to minimise the chances of ponding and resultant tunnelling. As a general recommendation, the construction of dams or ponds on the rehabilitated overburden dumps should be minimised, to reduced the chances of tunnelling, however any water storage structures located on the dumps should be clay lined, again to minimise the chances of tunnelling through the dispersive material.

The range of analyses included in the water quality monitoring program for runoff/seepage from any constructed overburden or reject storage facility should focus on pH, EC and Total Dissolved Solids (TDS). Periodic sampling and testing of the full suite of dissolved metals described in this report (say every two years) should be included in the water quality monitoring program developed for the project.

5.4.2 Reject Material

CHPP reject is to be stored in the main in a co-disposal facility, that is, the coarse and fine reject streams will be combined at the CHPP and pumped as slurry to the disposal area. The excess water that drains from the matrix of reject solids will be recovered and returned to the process water circuit. There may be localized low pH seepage but based on the NAPP results ranging from 6.4 to -78.2 kg H_2SO_4/t, the return water is not expected to be generally acidic. However, as noted in Section 5.3 water associated with the co-disposal facility, including runoff, will not be of suitable quality for uncontrolled release from site and will be captured in the mine water system.

In the context of rehabilitation, the CHPP reject appears to be not particularly saline but poor fertility and combustion risk (from the included coal) dictate that an inert cover will be necessary. The main characteristics required of this cover are low potential to draw moisture out of the co-disposed reject; favourable growth medium properties and erosion resistance appropriate to the landform design.

6.0 REFERENCES

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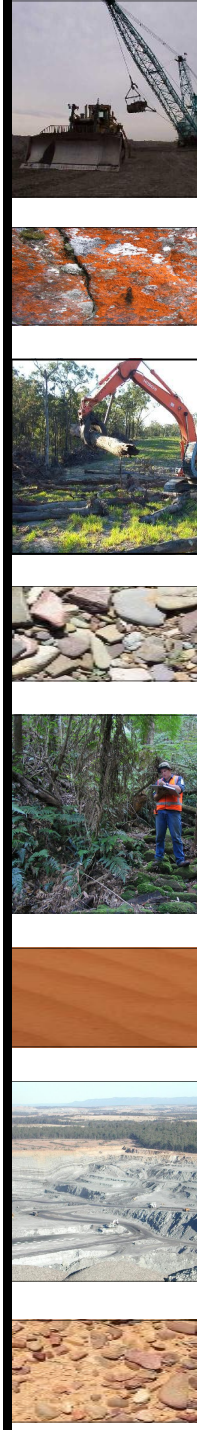
Field Assessment Procedure



APPENDIX 1

FIELD ASSESSMENT PROCEDURE

Elliott and Veness (1981) have described the basic procedure, adopted in this survey, for the recognition of suitable topdressing materials. In this procedure, the following soils factors are analysed. They are listed in decreasing order of importance.

Structure Grade

Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade (Charman, 1978) and depends on the proportion of coarse peds in the soil surface.

Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.

Consistence - Shearing Test

The shearing test is used as a measure of the ability of soils to maintain structure grade.

Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the extraction, transportation and spreading of topdressing material.

Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

Consistence - Disruptive Test

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

Mottling

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities; however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.

Macrostructure

Refers to the combination or arrangement of the larger aggregates or peds in the soil. Where these peds are larger than 10 cm (smaller dimension) in the subsoil, soils are likely to either slake or be hardsetting and prone to surface sealing. Such soils are undesirable as topdressing materials.

Texture

Sandy soils are poorly suited to plant growth because they are extremely erodible and have low water holding capacities. For these reasons soils with textures equal to or coarser than sandy loams are considered unsuitable as topdressing materials for climates of relatively unreliable rainfall, such as the Hunter Valley.

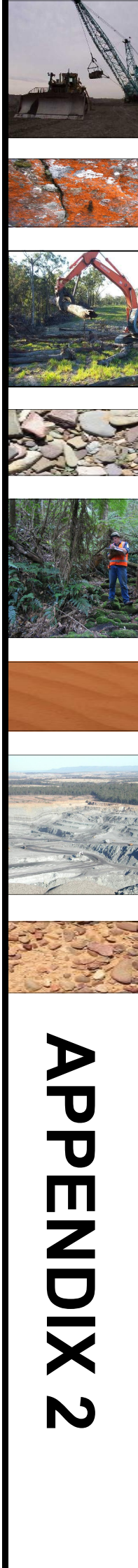
Root Density and Root Pattern

Root abundance and root branching is a reliable indicator of the capability for propagation and stockpiling.

Field Exposure Indicators

The extent of colonisation of vegetation on exposed materials as well as the surface behavior and condition after exposure is a reliable field indicator for suitability for topdressing purposes. These layers may alternate with other layers which are unsuitable. Unsuitable materials may be included in the topdressing mixture if they are less than 15cm thick and comprise less than 30 per cent of the total volume of soil material to be used for topdressing. Where unsuitable soil materials are more than 15 cm thick they should be selectively discarded.

Soil Information



APPENDIX 2

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

Particle size analysis measures the size of the soil particles in terms of grainsize fractions, and expresses the proportions of these fractions as a percentage of the sample. The grainsize fractions are:

clay	(<0.002 mm)
silt	(0.002 to 0.02 mm)
fine sand	(0.02 to 0.2 mm)
medium and coarse sand	(0.2 to 2 mm)

Particles greater than 2 mm, that is gravel and coarser material, are not included in the analysis.

Emerson Aggregate Test

Emerson aggregate test measures the susceptibility to dispersion of the soil in water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in water. The test indicates the credibility and structural stability of the soil and its susceptibility to surface sealing under irrigation and rainfall. Soils are divided into eight classes on the basis of the coherence of soil aggregates in water. The eight classes and their properties are:

Class 1	-	very dispersible soils with a high tunnel erosion susceptibility.
Class 2	-	moderately dispersible soils with some degree of tunnel erosion susceptibility.
Class 3	-	slightly or non-dispersible soils which are generally stable and suitable for soil conservation earthworks.
Class 4-6	-	more highly aggregated materials which are less likely to hold water. Special compactive efforts are required in the construction of earthworks.
Class 7-8	-	highly aggregated materials exhibiting low dispersion characteristics.

The following subdivisions within Emerson classes may be applied:

(1) slight milkiness, immediately adjacent to the aggregate
(2) obvious milkiness, less than 50% of the aggregate affected
(3) obvious milkiness, more than 50% of the aggregate affected
(4) total dispersion, leaving only sand grains.

Salinity

Salinity is measured as electrical conductivity on a 1:5 soil:water suspension to give EC (1:5). The effects of salinity levels expressed as EC at 25° (*d*S/cm), on plants are:

0 to 1	very low salinity, effects on plants mostly negligible.
1 to 2	low salinity, only yields of very sensitive crops are restricted.
greater than 2	saline soils, yields of many crops restricted.

pH

The pH is a measure of acidity and alkalinity. For 1:5 soil:water suspensions, soils having pH values less than 4.5 are regarded as strongly acid, 4.5 to 5.0 moderately acidic, and values greater than 7.0 are regarded as alkaline. Most plants grow best in slightly acidic soils.

LABORATORY TEST METHODS

Particle Size Analysis

Determination by sieving and hydrometer of percentage, by weight, of particle size classes: Gravel >2mm, Coarse Sand 0.2-2 mm, Fine Sand 0.02-0.2 mm, Silt 0.002-0.2 mm and Clay <0.002 mm SCS Standard method. Reference - Bond, R, Craze B, Rayment G, and Higginson (in press 1990) **Australia Soil and Land Survey Laboratory Handbook**, Inkata Press, Melbourne.

Emerson Aggregate Test

An eight class classification of soil aggregate coherence (slaking and dispersion) in water. SCS Standard Method closely related to Australian Standard AS1289. The degree of dispersion is included in brackets for class 2 and 3 aggregates. Reference - Bond R., Craze, B., Rayment, G., Higginson, F.R., (in press 1990). **Australian Soil and Land survey Laboratory Handbook**, Inkata Press, Melbourne.

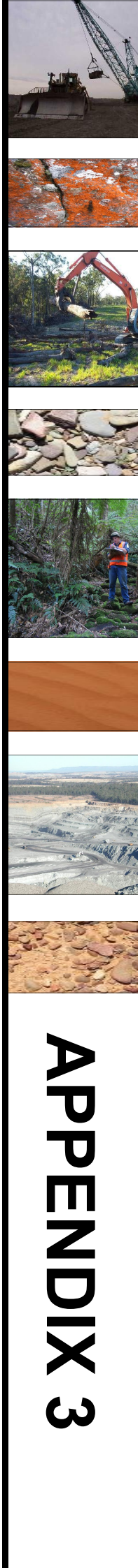
EC

Electrical Conductivity determined on a 1:5 soil:water suspension. Prepared from the fine earth fraction of the sample. Reference - Bond R, Craze B, Rayment G, Higginson FR (in press 1990) **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

pH

Determined on a 1:5 soil:water suspension. Soil refers to the fine earth fraction of the sample. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

Soil Test Results



APPENDIX 3

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB0918060**	Page	: 1 of 6
Client	: **GSS ENVIRONMENTAL**	Laboratory	: Environmental Division Brisbane
Contact	: MR CLAYTON RICHARDS	Contact	: Tim Kilmister
Address	: LEVEL 1, 241 DENISON ST BROADMEADOW NSW AUSTRALIA 2292	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: richards@gssenvironmental.com	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: 02 49203000	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: CODRILLA COAL MINE	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 16-NOV-2009
Sampler	: P.T, AGE GW consult	Issue Date	: 30-NOV-2009
Site	: ----		
		No. of samples received	: 19
Quote number	: BN/495/09	No. of samples analysed	: 5

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Inorganics
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Stafford Minerals - AY
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **ED045G (Chloride): LCS recovery falls outside Dynamic Control Limits. They are however within ALS Static Control Limits and hence deemed acceptable.**
- **EG005 (Total Metals): Sample EB0918060-015 (IC2 Roof) shows poor duplicate results due to sample heterogeneity. This was confirmed by visual inspection.**
- **EG005W (Water Leachable Metals): LCS recoveries for Cobalt fall outside Dynamic Control Limits. They are however within ALS Static Control Limits and hence deemed acceptable.**

Analytical Results

Sub-Matrix: **COAL**			Client sample ID	**3C8 COAL Composite**	----	----	----	----
			Client sampling date / time	16-NOV-2009 15:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB0918060-016**	**----**	**----**	**----**	**----**
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	**18.6**	----	----	----	----

Analytical Results

Sub-Matrix: COMPOSITE			Client sample ID	ICZ ROOF Composite	3C8 COAL Composite	9C10 FLOOR Composite	11C12 ROOF Composite	17C18 FLOOR Composite
			Client sampling date / time	16-NOV-2009 08:30	16-NOV-2009 08:30	16-NOV-2009 08:30	16-NOV-2009 08:30	16-NOV-2009 08:30
Compound	CAS Number	LOR	Unit	EB0918060-015	EB0918060-016	EB0918060-017	EB0918060-018	EB0918060-019
EA009: Nett Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	-9.4	6.4	1.7	-78.2	-54.8
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.9	3.6	5.7	8.7	8.7
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	3.7	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	0.2	20.2	2.3	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	16.5	8.5	5.4	99.2	70.1
^ ANC as CaCO3	----	0.1	% CaCO3	1.7	0.9	0.5	10.1	7.2
Fizz Rating	----	0	Fizz Unit	0	0	0	2	2
EG020T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.23	0.48	0.23	0.69	0.50
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	6	<5	<5	12	<5
Boron	7440-42-8	50	mg/kg	80	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Cobalt	7440-48-4	2	mg/kg	31	7	<2	2	4
Copper	7440-50-8	5	mg/kg	90	22	15	13	48
Lead	7439-92-1	5	mg/kg	17	<5	34	5	7
Nickel	7440-02-0	2	mg/kg	98	26	9	<2	<2
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Zinc	7440-66-6	5	mg/kg	104	27	10	19	50
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.2	<0.1	<0.1

Analytical Results

Sub-Matrix: DI WATER LEACHATE			Client sample ID	ICZ ROOF Composite	3C8 COAL Composite	9C10 FLOOR Composite	11C12 ROOF Composite	17C18 FLOOR Composite
			Client sampling date / time	19-NOV-2009 14:00	19-NOV-2009 14:00	19-NOV-2009 14:00	19-NOV-2009 14:00	19-NOV-2009 14:00
Compound	CAS Number	LOR	Unit	EB0918060-015	EB0918060-016	EB0918060-017	EB0918060-018	EB0918060-019
EA005: pH								
pH Value	----	0.01	pH Unit	6.74	7.67	8.10	8.48	8.53
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	603	2650	1250	1890	1040
ED040W: Water Leachable Sulfate by ICPAES								
Sulfate as SO4 2-	14808-79-8	1	mg/L	34	82	44	84	70
ED045G: Chloride Discrete Analyser								
Chloride	16887-00-6	1	mg/L	301	657	288	573	200
ED093W: Water Leachable Major Cations								
Calcium	7440-70-2	1	mg/L	<1	8	2	8	4
Magnesium	7439-95-4	1	mg/L	<1	16	1	9	4
Sodium	7440-23-5	1	mg/L	63	532	240	378	233
Potassium	7440-09-7	1	mg/L	2	4	2	4	4
EG005W: Water Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.10	mg/L	1.29	0.31	<0.10	0.41	0.27
Arsenic	7440-38-2	0.01	mg/L	<0.01	<0.01	0.03	<0.01	<0.01
Boron	7440-42-8	0.1	mg/L	0.2	0.3	0.4	0.3	0.3
Cadmium	7440-43-9	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	7440-47-3	0.01	mg/L	<0.01	<0.01	0.01	<0.01	<0.01
Cobalt	7440-48-4	0.01	mg/L	<0.01	0.02	<0.01	<0.01	<0.01
Copper	7440-50-8	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	7439-89-6	0.05	mg/L	0.10	0.50	<0.05	<0.05	<0.05
Lead	7439-92-1	0.01	mg/L	<0.01	<0.01	0.02	<0.01	<0.01
Nickel	7440-02-0	0.01	mg/L	<0.01	0.06	0.01	<0.01	<0.01
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.01	mg/L	0.07	0.08	0.02	0.02	0.02
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	1.1	0.7	0.7	0.5	0.5

Analytical Results

Sub-Matrix: SOIL			Client sample ID	ICZ ROOF Composite	9C10 FLOOR Composite	11C12 ROOF Composite	17C18 FLOOR Composite	----
			Client sampling date / time	16-NOV-2009 15:00	16-NOV-2009 15:00	16-NOV-2009 15:00	16-NOV-2009 15:00	----
Compound	CAS Number	LOR	Unit	EB0918060-015	EB0918060-017	EB0918060-018	EB0918060-019	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	8.4	23.8	14.6	18.9	----

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB0914861**	Page	: 1 of 8
Client	: **GSS ENVIRONMENTAL**	Laboratory	: Environmental Division Brisbane
Contact	: MR CLAYTON RICHARDS	Contact	: Tim Kilmister
Address	: LEVEL 1, 241 DENISON ST BROADMEADOW NSW AUSTRALIA 2292	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: richards@gssenvironmental.com	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: 02 49203000	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: CODRILLA COAL MINE	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: 568040	Date Samples Received	: 18-SEP-2009
Sampler	: PAUL TETT	Issue Date	: 01-OCT-2009
Site	: ----		
		No. of samples received	: 14
Quote number	: BN/495/09	No. of samples analysed	: 14

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dianne Blane		Newcastle
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Stafford Minerals - AY

General Comments

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **ANC Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong.**

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX1902-349061	CX1902-349067	CX1902-349082	CX1914-67286	CX1914-67290
			Client sampling date / time	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00
Compound	CAS Number	LOR	Unit	EB0914861-001	EB0914861-002	EB0914861-003	EB0914861-004	EB0914861-005
EA150: Particle Sizing								
+75µm	----	1	%	27	36	50	15	6
+150µm	----	1	%	6	22	48	8	4
+300µm	----	1	%	1	5	45	5	3
+425µm	----	1	%	1	2	44	4	2
+600µm	----	1	%	1	1	42	4	2
+1180µm	----	1	%	<1	<1	35	3	1
+2.36mm	----	1	%	<1	<1	20	1	1
+4.75mm	----	1	%	<1	<1	2	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA009: Net Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	-2.3	-63.0	-6.9	-1.2
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.8	7.4	8.7	8.8	7.0
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA015: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	0.5	2.8	64.7	7.4	1.5
^ ANC as CaCO3	----	0.1	% CaCO3	<0.1	0.3	6.6	0.8	0.2
Fizz Rating	----	0	Fizz Unit	0	0	3	0	0
EA037: pH (saturated paste)								
pH (Saturated Paste)	----	0.1	pH Unit	6.3	6.8	8.1	7.6	7.4
EA032: Electrical Conductivity (saturated paste)								
Electrical Conductivity (Saturated Paste)	----	1	µS/cm	2420	2950	2360	2460	2980
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	13.3	16.8	21.2	11.8	13.9
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	37	33	27	44	44
Silt (2-60 µm)	----	1	%	33	28	21	39	48
Sand (0.06-2.00 mm)	----	1	%	30	39	32	15	8
Gravel (>2mm)	----	1	%	<1	<1	20	2	<1
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EK007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	0.4	1.8	8.0	3.7	1.7

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX1902-349061	CX1902-349067	CX1902-349082	CX1914-67286	CX1914-67290
			Client sampling date / time	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00
Compound	CAS Number	LOR	Unit	EB0914861-001	EB0914861-002	EB0914861-003	EB0914861-004	EB0914861-005
ED007: Exchangeable Cations - Continued								
^ Exchangeable Magnesium	----	0.1	meq/100g	6.4	7.6	6.6	5.8	5.3
^ Exchangeable Potassium	----	0.1	meq/100g	0.8	0.7	0.6	0.5	0.9
^ Exchangeable Sodium	----	0.1	meq/100g	8.4	12.5	11.4	6.5	8.0
^ Cation Exchange Capacity	----	0.1	meq/100g	16.0	22.6	26.6	16.5	15.9
^ Exchangeable Sodium Percent	----	0.1	%	52.4	55.1	42.7	39.4	50.4
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.02	0.06	0.02	0.01
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	8	6	6	<5
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	11	19	26	18	17
Cobalt	7440-48-4	2	mg/kg	27	62	31	<2	7
Copper	7440-50-8	5	mg/kg	19	67	94	8	42
Lead	7439-92-1	5	mg/kg	9	11	9	<5	11
Nickel	7440-02-0	2	mg/kg	18	80	126	6	30
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Zinc	7440-66-6	5	mg/kg	31	141	118	9	148
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX1914-67299	CX1914-350413	CX1924-353327	CX1924-353335	CX1924-353341
			Client sampling date / time	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00
Compound	CAS Number	LOR	Unit	EB0914861-006	EB0914861-007	EB0914861-008	EB0914861-009	EB0914861-010
EA150: Particle Sizing								
+75µm	----	1	%	46	53	18	6	5
+150µm	----	1	%	40	45	4	4	11
+300µm	----	1	%	35	38	1	3	8
+425µm	----	1	%	32	35	<1	3	6
+600µm	----	1	%	28	32	<1	2	5
+1180µm	----	1	%	22	26	<1	2	3
+2.36mm	----	1	%	12	16	<1	1	1
+4.75mm	----	1	%	<1	<1	<1	<1	<1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA009: Net Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	-93.5	-74.4	0.6	0.7	-96.0
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	10.5	8.9	6.9	6.9	8.8
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA015: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	94.6	77.5	<0.5	<0.5	97.0
^ ANC as CaCO3	----	0.1	% CaCO3	9.6	7.9	<0.1	<0.1	9.9
Fizz Rating	----	0	Fizz Unit	3	3	0	0	3
EA037: pH (saturated paste)								
pH (Saturated Paste)	----	0.1	pH Unit	8.5	8.4	6.9	6.8	8.0
EA032: Electrical Conductivity (saturated paste)								
Electrical Conductivity (Saturated Paste)	----	1	µS/cm	1590	1660	1090	3250	3360
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	12.9	14.6	14.7	30.9	24.0
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	24	19	40	57	35
Silt (2-60 µm)	----	1	%	29	27	37	36	49
Sand (0.06-2.00 mm)	----	1	%	35	38	23	6	14
Gravel (>2mm)	----	1	%	12	16	<1	1	2
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
EK007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	23.2	9.6	1.2	1.1	7.1

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX1914-67299	CX1914-350413	CX1924-353327	CX1924-353335	CX1924-353341
			Client sampling date / time	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00
Compound	CAS Number	LOR	Unit	EB0914861-006	EB0914861-007	EB0914861-008	EB0914861-009	EB0914861-010
ED007: Exchangeable Cations - Continued								
^ Exchangeable Magnesium	----	0.1	meq/100g	4.8	7.0	6.3	5.4	12.5
^ Exchangeable Potassium	----	0.1	meq/100g	1.2	1.0	0.5	0.3	0.8
^ Exchangeable Sodium	----	0.1	meq/100g	6.3	9.1	7.4	8.5	12.4
^ Cation Exchange Capacity	----	0.1	meq/100g	35.4	26.7	15.3	15.3	32.9
^ Exchangeable Sodium Percent	----	0.1	%	17.8	34.0	48.0	55.4	37.8
EG042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.03	0.10	0.02	0.02	0.03
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	14	11	5	<5	6
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	16	23	14	10	22
Cobalt	7440-48-4	2	mg/kg	15	20	16	<2	29
Copper	7440-50-8	5	mg/kg	44	53	23	<5	95
Lead	7439-92-1	5	mg/kg	7	17	<5	<5	<5
Nickel	7440-02-0	2	mg/kg	29	60	23	2	95
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Zinc	7440-66-6	5	mg/kg	74	94	32	<5	87
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX1930-66306	CX1930-66310	CX1930-66314	CX1930-66323	----
			Client sampling date / time	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	----
Compound	CAS Number	LOR	Unit	EB0914861-011	EB0914861-012	EB0914861-013	EB0914861-014	----
EA150: Particle Sizing								
+75µm	----	1	%	15	39	23	31	----
+150µm	----	1	%	31	15	3	29	----
+300µm	----	1	%	16	4	2	28	----
+425µm	----	1	%	10	2	2	28	----
+600µm	----	1	%	8	1	2	27	----
+1180µm	----	1	%	6	<1	1	22	----
+2.36mm	----	1	%	4	<1	1	10	----
+4.75mm	----	1	%	<1	<1	<1	2	----
+9.5mm	----	1	%	<1	<1	<1	<1	----
+19.0mm	----	1	%	<1	<1	<1	<1	----
+37.5mm	----	1	%	<1	<1	<1	<1	----
+75.0mm	----	1	%	<1	<1	<1	<1	----
EA009: Net Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	1.3	-0.5	-4.5	-27.0	----
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.3	7.2	8.0	8.7	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	----
EA015: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	<0.5	1.0	5.1	28.2	----
^ ANC as CaCO3	----	0.1	% CaCO3	<0.1	0.1	0.5	2.9	----
Fizz Rating	----	0	Fizz Unit	0	0	0	0	----
EA037: pH (saturated paste)								
pH (Saturated Paste)	----	0.1	pH Unit	7.0	7.5	7.5	7.9	----
EA032: Electrical Conductivity (saturated paste)								
Electrical Conductivity (Saturated Paste)	----	1	µS/cm	2610	3930	3540	2130	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	15.1	20.2	24.6	22.2	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	33	36	35	35	----
Silt (2-60 µm)	----	1	%	27	38	56	29	----
Sand (0.06-2.00 mm)	----	1	%	36	26	9	26	----
Gravel (>2mm)	----	1	%	4	<1	<1	10	----
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	----
EK007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	1.0	2.6	3.3	8.3	----

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX1930-66306	CX1930-66310	CX1930-66314	CX1930-66323	----
			Client sampling date / time	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	15-SEP-2009 15:00	----
Compound	CAS Number	LOR	Unit	EB0914861-011	EB0914861-012	EB0914861-013	EB0914861-014	----
ED007: Exchangeable Cations - Continued								
^ Exchangeable Magnesium	----	0.1	meq/100g	5.3	8.2	6.6	8.0	----
^ Exchangeable Potassium	----	0.1	meq/100g	0.6	1.0	1.2	1.2	----
^ Exchangeable Sodium	----	0.1	meq/100g	10.6	15.3	14.0	12.8	----
^ Cation Exchange Capacity	----	0.1	meq/100g	17.4	27.2	25.0	30.4	----
^ Exchangeable Sodium Percent	----	0.1	%	60.6	56.4	56.0	42.2	----
EG020T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.02	0.02	0.04	----
EG005T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	11	12	7	6	----
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	----
Chromium	7440-47-3	2	mg/kg	34	12	7	21	----
Cobalt	7440-48-4	2	mg/kg	<2	15	15	28	----
Copper	7440-50-8	5	mg/kg	9	63	32	91	----
Lead	7439-92-1	5	mg/kg	<5	9	8	10	----
Nickel	7440-02-0	2	mg/kg	6	42	34	71	----
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	----
Zinc	7440-66-6	5	mg/kg	16	96	89	90	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB0815504**	Page	: 1 of 12
Amendment	: **1**		
Client	: **BOWEN BASIN JOINT VENTURE**	Laboratory	: Environmental Division Brisbane
Contact	: MR NGAIRE TRANTER	Contact	: Tim Kilmister
Address	: C/- McCOLLUM ENVIRONMENTAL MANAGEMENT SERVICES PTY LTD PO BOX 8120 MOUNT PLEASANT QLD, AUSTRALIA 4740	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: cash.sale@alsenviro.com	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 7 4953 2700	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: CODRILLA	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 07-NOV-2008
Sampler	: ----	Issue Date	: 29-JAN-2009
Site	: ----		
		No. of samples received	: 12
Quote number	: ----	No. of samples analysed	: 12

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA
WORLD RECOGNISED ACCREDITATION

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Cass Sealby	Senior Chemist - Acid Sulphate Soils	Inorganics
Kim McCabe	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Inorganics
Stephen Hislop	Senior Inorganic Chemist	Stafford Minerals - AY

Environmental Division Brisbane
Part of the **ALS Laboratory Group**
32 Shand Street Stafford QLD Australia 4053
Tel. +61-7-3243 7222 Fax. +61-7-3243 7218 **www.alsglobal.com**
A Campbell Brothers Limited Company

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **ANC Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong.**
- **ED040S (Soluble Major Anions): Sample EB0815504-011 (CX0714FC ENV1/A) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.**
- **EG005T (Total metals) Sample EB0815504-001 (CX0417FC ENV1) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection.**
- **EG005T (Total metals) Sample EB0815504-002 (CX0417FC ENV2) shows poor matrix spike recovery due to matrix interference. Confirmed by visual inspection.**
- **EG005T (Total metals) Sample EB0815504-011 (CX0714FC ENV1/A) shows poor duplicate results due to sample heterogeneity. Confirmed by visual inspection..**
- **Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.**
- **Retained Acidity not required because pH KCl greater than or equal to 4.5**
- **This report has been amended and re-released to allow the change of client details.**

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX0417FC ENV1 9.24 To 9.38 wea obn	CX0417FC ENV2 21.08 To 21.24 wea obn	CX0417FC ENV3 68.55 To 68.75 obn	CX0701FC ENV2 21.56 To 21.6 wea obn	CX0701FC ENV1 2.85 To 3 wea obn
			Client sampling date / time	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]
Compound	CAS Number	LOR	Unit	EB0815504-001	EB0815504-002	EB0815504-003	EB0815504-004	EB0815504-005
EA002: pH (Soils)								
pH Value	----	0.1	pH Unit	7.2	8.5	8.9	7.4	8.2
EA005: Net Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	-4.4	-3.8	-16.0	-1.7	-2.8
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.4	7.5	8.5	5.9	6.0
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	2.4	<0.1	<0.1	4.8	8.7
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equ	5.0	3.8	17.2	2.0	2.8
^ ANC as CaCO3	----	0.1	% CaCO3	0.5	0.4	1.8	0.2	0.3
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	6.0	7.3	8.2	5.0	6.4
pH OX (23B)	----	0.1	pH Unit	7.2	9.0	8.8	6.3	6.9
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	2	<2	<2	12	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	<2	<2	2	7
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	<2	<2	<2	7
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.02	% S	0.02	<0.02	<0.02	<0.02	<0.02
Peroxide Sulfur (23De)	----	0.02	% S	<0.02	<0.02	0.03	<0.02	<0.02
Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	<0.02	<0.02	0.03	<0.02	<0.02
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<10	<10	18	<10	<10
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.02	% Ca	<0.02	0.05	0.12	0.03	0.04
Peroxide Calcium (23Wh)	----	0.02	% Ca	<0.02	0.07	0.42	<0.02	<0.02
Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.02	<0.02	0.30	<0.02	<0.02
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<10	<10	152	<10	<10
sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.02	<0.02	0.24	<0.02	<0.02

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX0417FC ENV1 9.24 To 9.38 wea obn	CX0417FC ENV2 21.08 To 21.24 wea obn	CX0417FC ENV3 68.55 To 68.75 obn	CX0701FC ENV2 21.56 To 21.6 wea obn	CX0701FC ENV1 2.85 To 3 wea obn
			Client sampling date / time	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]
Compound	CAS Number	LOR	Unit	EB0815504-001	EB0815504-002	EB0815504-003	EB0815504-004	EB0815504-005
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	0.10	0.11	0.10	0.12	0.14
Peroxide Magnesium (23Tm)	----	0.02	% Mg	0.10	0.11	0.17	0.10	0.12
Acid Reacted Magnesium (23U)	----	0.02	% Mg	<0.02	<0.02	0.07	<0.02	<0.02
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<10	<10	55	<10	<10
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	<0.02	<0.02	0.09	<0.02	<0.02
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	<0.02	0.39	0.44	----	<0.02
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	<10	78	88	----	<10
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	<0.02	0.12	0.14	----	<0.02
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	12	<10
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	<1	<1
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	11.2	11.0	8.0	10.4	10.9
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	0.3	1.5	4.0	1.1	1.4
^ Exchangeable Magnesium	----	0.1	meq/100g	6.9	7.0	6.8	8.0	9.9
^ Exchangeable Potassium	----	0.1	meq/100g	0.7	0.6	1.0	0.5	0.8
^ Exchangeable Sodium	----	0.1	meq/100g	8.6	8.0	8.1	7.7	10.3
^ Cation Exchange Capacity	----	0.1	meq/100g	16.5	17.1	19.9	17.3	22.4
^ Exchangeable Sodium Percent	----	0.1	%	52.0	46.6	40.5	44.4	46.1
ED045G: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	160	120	260	110	160
ED047: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	<0.01	0.04	0.01	<0.01
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	1130	1180	1020	880	890
ED093T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	5010	4700	7140	3630	5050
Antimony	7440-36-0	5	mg/kg	<5	<5	<5	<5	<5

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX0417FC ENV1 9.24 To 9.38 wea obn	CX0417FC ENV2 21.08 To 21.24 wea obn	CX0417FC ENV3 68.55 To 68.75 obn	CX0701FC ENV2 21.56 To 21.6 wea obn	CX0701FC ENV1 2.85 To 3 wea obn
			Client sampling date / time	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]
Compound	CAS Number	LOR	Unit	EB0815504-001	EB0815504-002	EB0815504-003	EB0815504-004	EB0815504-005
EC005T: Total Metals by ICP-AES - Continued								
Arsenic	7440-38-2	5	mg/kg	<5	<5	14	<5	<5
Barium	7440-39-3	10	mg/kg	20	60	<10	<10	<10
Beryllium	7440-41-7	1	mg/kg	3	<1	<1	<1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	15	8	15	12	6
Cobalt	7440-48-4	2	mg/kg	10	6	36	<2	<2
Copper	7440-50-8	5	mg/kg	16	18	65	12	9
Iron	7439-89-6	50	mg/kg	14000	16200	15000	13400	24500
Lead	7439-92-1	5	mg/kg	14	13	23	6	<5
Manganese	7439-96-5	5	mg/kg	238	393	351	6	7
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2
Nickel	7440-02-0	2	mg/kg	23	9	38	6	6
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	<2
Strontium	7440-24-6	2	mg/kg	20	38	66	32	44
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	38	46	20	58	17
Zinc	7440-66-6	5	mg/kg	22	19	101	8	13
Calcium	7440-70-2	50	mg/kg	60	450	5460	260	320
Magnesium	7439-95-4	50	mg/kg	1370	1360	5010	1380	2150
Sodium	7440-23-5	50	mg/kg	2300	2190	2240	2140	2600
Potassium	7440-09-7	50	mg/kg	610	500	610	270	260
^ Sulfur as S	----	50	mg/kg	80	<50	350	60	<50
Phosphorus	7723-14-0	50	mg/kg	80	110	800	<50	<50
Titanium	7440-32-6	10	mg/kg	10	10	20	<10	20
Thallium	7440-28-0	5	mg/kg	<5	<5	<5	<5	<5
EC035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	----	0.100	mg/kg	<0.100	0.321	<0.100	<0.100	<0.100
EK058G: Nitrate as N by Discrete Analyser								
^ Nitrate as N (Sol.)	----	0.100	mg/kg	<0.100	<0.100	<0.100	<0.100	<0.100
EK059G: NOx as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.100	mg/kg	<0.100	0.360	0.147	<0.100	0.146

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX0701FC ENV3 36.78 To 36.9 wea obn	CX0732FC ENV1/A 35 To 35.1 wea obn	CX0732FC ENV1/B 35.1 To 35.2 wea obn	CX0732FC ENV2/A 47.92 To 48.12 wea obn	CX0732FC ENV2/B 48.12 To 48.22 wea obn
			Client sampling date / time	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]
Compound	CAS Number	LOR	Unit	EB0815504-006	EB0815504-007	EB0815504-008	EB0815504-009	EB0815504-010
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.6	8.1	8.2	8.2	8.4
EA009 : Net Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	<0.5	-0.6	-4.2	-4.5	-3.2
EA011 : Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.2	6.1	6.5	6.0	6.0
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	4.9	6.8	2.8	7.5	6.2
EA015 : Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equ	<0.5	2.8	4.6	4.8	3.6
^ ANC as CaCO3	----	0.1	% CaCO3	<0.1	0.3	0.5	0.5	0.4
Fizz Rating	----	0	Fizz Unit	0	0	0	0	0
EA029-A : pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	6.9	6.8	6.8	7.0	7.0
pH OX (23B)	----	0.1	pH Unit	7.0	6.9	7.1	4.2	4.2
EA029-B : Acidity - Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	<2	<2	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	11	<2	77	72
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	11	<2	77	72
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	0.12	0.12
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	0.12	0.12
EA029-C : Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Peroxide Sulfur (23De)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<10	<10	<10	<10	<10
EA029-D : Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.02	% Ca	0.03	0.06	0.06	0.10	0.06
Peroxide Calcium (23Wh)	----	0.02	% Ca	<0.02	0.05	0.05	0.12	0.06
Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.02	<0.02	<0.02	0.02	<0.02
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<10	<10	<10	10	<10
sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX0701FC ENV3 36.78 To 36.9 wea obn	CX0732FC ENV1/A 35 To 35.1 wea obn	CX0732FC ENV1/B 35.1 To 35.2 wea obn	CX0732FC ENV2/A 47.92 To 48.12 wea obn	CX0732FC ENV2/B 48.12 To 48.22 wea obn
			Client sampling date / time	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]
Compound	CAS Number	LOR	Unit	EB0815504-006	EB0815504-007	EB0815504-008	EB0815504-009	EB0815504-010
EA029-E: Magnesium Values								
KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	0.07	0.13	0.13	0.15	0.12
Peroxide Magnesium (23Tm)	----	0.02	% Mg	0.06	0.12	0.12	0.14	0.11
Acid Reacted Magnesium (23U)	----	0.02	% Mg	<0.02	<0.02	<0.02	<0.02	<0.02
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	0.06	<0.02	0.08	----	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	12	<10	16	----	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	<0.02	<0.02	0.03	----	----
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	<0.02	0.08	0.08
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	<10	51	48
Liming Rate	----	1	kg CaCO3/t	<1	<1	<1	4	4
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	12.4	17.9	13.4	15.4	15.4
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	1.0	2.2	2.3	3.6	2.6
^ Exchangeable Magnesium	----	0.1	meq/100g	4.6	8.8	8.5	9.9	8.3
^ Exchangeable Potassium	----	0.1	meq/100g	0.4	0.7	0.8	0.5	0.6
^ Exchangeable Sodium	----	0.1	meq/100g	6.5	12.0	11.4	11.9	10.9
^ Cation Exchange Capacity	----	0.1	meq/100g	12.5	23.8	22.9	26.0	22.4
^ Exchangeable Sodium Percent	----	0.1	%	51.8	50.4	49.6	46.0	48.5
ED045G: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	160	160	110	170	190
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.07	0.01	0.01	0.01
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	1030	1880	1370	1910	1970
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	2150	1900	2920	1690	1770
Antimony	7440-36-0	5	mg/kg	<5	<5	<5	<5	<5

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX0701FC ENV3 36.78 To 36.9 wea obn	CX0732FC ENV1/A 35 To 35.1 wea obn	CX0732FC ENV1/B 35.1 To 35.2 wea obn	CX0732FC ENV2/A 47.92 To 48.12 wea obn	CX0732FC ENV2/B 48.12 To 48.22 wea obn
			Client sampling date / time	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]	[06-NOV-2008]
Compound	CAS Number	LOR	Unit	EB0815504-006	EB0815504-007	EB0815504-008	EB0815504-009	EB0815504-010
EG005T: Total Metals by ICP-AES - Continued								
Arsenic	7440-38-2	5	mg/kg	10	<5	<5	<5	<5
Barium	7440-39-3	10	mg/kg	<10	40	<10	40	80
Beryllium	7440-41-7	1	mg/kg	1	<1	1	1	<1
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	<50
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	4	7	35	7	7
Cobalt	7440-48-4	2	mg/kg	3	<2	2	<2	<2
Copper	7440-50-8	5	mg/kg	14	10	35	8	17
Iron	7439-89-6	50	mg/kg	17500	19200	85600	870	4770
Lead	7439-92-1	5	mg/kg	<5	<5	<5	12	6
Manganese	7439-96-5	5	mg/kg	43	7	44	<5	105
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	<2
Nickel	7440-02-0	2	mg/kg	7	3	14	2	3
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	<5
Silver	7440-22-4	2	mg/kg	<2	<2	<2	<2	<2
Strontium	7440-24-6	2	mg/kg	28	256	98	123	130
Tin	7440-31-5	5	mg/kg	<5	<5	<5	<5	<5
Vanadium	7440-62-2	5	mg/kg	34	20	75	14	16
Zinc	7440-66-6	5	mg/kg	12	<5	16	<5	11
Calcium	7440-70-2	50	mg/kg	380	500	640	640	590
Magnesium	7439-95-4	50	mg/kg	930	1090	1310	1140	1060
Sodium	7440-23-5	50	mg/kg	1600	2480	2360	2390	2280
Potassium	7440-09-7	50	mg/kg	130	210	190	430	410
^ Sulfur as S	----	50	mg/kg	<50	50	<50	<50	<50
Phosphorus	7723-14-0	50	mg/kg	160	340	780	100	140
Titanium	7440-32-6	10	mg/kg	30	<10	40	<10	<10
Thallium	7440-28-0	5	mg/kg	<5	<5	<5	<5	<5
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	----	0.100	mg/kg	<0.100	<0.100	<0.100	<0.100	<0.100
EK058G: Nitrate as N by Discrete Analyser								
^ Nitrate as N (Sol.)	----	0.100	mg/kg	<0.100	<0.100	<0.100	<0.100	<0.100
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.100	mg/kg	<0.100	<0.100	0.133	0.124	<0.100

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX0714FC ENV1/A 19.4 To 19.5 wea obn	CX0714FC ENV2/B 19.5 To 19.6 wea obn	----	----	----
			Client sampling date / time	[06-NOV-2008]	[06-NOV-2008]	----	----	----
Compound	CAS Number	LOR	Unit	EB0815504-011	EB0815504-012	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	8.2	8.0	----	----	----
EA009 : Net Acid Production Potential								
^ Net Acid Production Potential	----	0.5	kg H2SO4/t	-2.0	-1.5	----	----	----
EA011 : Net Acid Generation								
pH (OX)	----	0.1	pH Unit	6.0	6.0	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	5.9	5.9	----	----	----
EA013 : Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equ	2.0	3.3	----	----	----
^ ANC as CaCO3	----	0.1	% CaCO3	0.2	0.3	----	----	----
Fizz Rating	----	0	Fizz Unit	0	0	----	----	----
EA029-A: pH Measurements								
pH KCl (23A)	----	0.1	pH Unit	6.0	6.4	----	----	----
pH OX (23B)	----	0.1	pH Unit	7.8	7.2	----	----	----
EA029-B: Acidity Trail								
Titratable Actual Acidity (23F)	----	2	mole H+ / t	<2	<2	----	----	----
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t	<2	10	----	----	----
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t	<2	10	----	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	----	----	----
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S	<0.02	<0.02	----	----	----
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S	<0.02	<0.02	----	----	----
EA029-C: Sulfur Trail								
KCl Extractable Sulfur (23Ce)	----	0.02	% S	<0.02	0.02	----	----	----
Peroxide Sulfur (23De)	----	0.02	% S	<0.02	0.02	----	----	----
Peroxide Oxidisable Sulfur (23E)	----	0.02	% S	<0.02	<0.02	----	----	----
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t	<10	<10	----	----	----
EA029-D: Calcium Values								
KCl Extractable Calcium (23Vh)	----	0.02	% Ca	<0.02	<0.02	----	----	----
Peroxide Calcium (23Wh)	----	0.02	% Ca	<0.02	<0.02	----	----	----
Acid Reacted Calcium (23X)	----	0.02	% Ca	<0.02	<0.02	----	----	----
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t	<10	<10	----	----	----
sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S	<0.02	<0.02	----	----	----
EA029-E: Magnesium Values								

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX0714FC ENV1/A 19.4 To 19.5 wea obn	CX0714FC ENV2/B 19.5 To 19.6 wea obn	----	----	----
			Client sampling date / time	[06-NOV-2008]	[06-NOV-2008]	----	----	----
Compound	CAS Number	LOR	Unit	EB0815504-011	EB0815504-012	----	----	----
EA029-E: Magnesium Values - Continued								
KCl Extractable Magnesium (23Sm)	----	0.02	% Mg	0.08	0.08	----	----	----
Peroxide Magnesium (23Tm)	----	0.02	% Mg	0.07	0.06	----	----	----
Acid Reacted Magnesium (23U)	----	0.02	% Mg	<0.02	<0.02	----	----	----
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t	<10	<10	----	----	----
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S	<0.02	<0.02	----	----	----
EA029-F: Excess Acid Neutralising Capacity								
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3	0.08	<0.02	----	----	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t	16	<10	----	----	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S	0.03	<0.02	----	----	----
EA029-H: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	----	----	----
Net Acidity (sulfur units)	----	0.02	% S	<0.02	<0.02	----	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	<10	<10	----	----	----
Liming Rate	----	1	kg CaCO3/t	<1	<1	----	----	----
EA055: Moisture Content								
^ Moisture Content (dried @ 103°C)	----	1.0	%	16.0	12.4	----	----	----
ED007: Exchangeable Cations								
^ Exchangeable Calcium	----	0.1	meq/100g	0.6	0.6	----	----	----
^ Exchangeable Magnesium	----	0.1	meq/100g	5.2	5.2	----	----	----
^ Exchangeable Potassium	----	0.1	meq/100g	0.4	0.4	----	----	----
^ Exchangeable Sodium	----	0.1	meq/100g	7.7	7.8	----	----	----
^ Cation Exchange Capacity	----	0.1	meq/100g	13.9	14.0	----	----	----
^ Exchangeable Sodium Percent	----	0.1	%	55.2	55.7	----	----	----
ED045G: Soluble Major Anions								
Sulfate as SO4 2-	14808-79-8	10	mg/kg	490	330	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	0.06	----	----	----
ED045: Chloride								
Chloride	16887-00-6	10	mg/kg	1380	1300	----	----	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	3440	3160	----	----	----
Antimony	7440-36-0	5	mg/kg	<5	<5	----	----	----
Arsenic	7440-38-2	5	mg/kg	<5	<5	----	----	----

Analytical Results

Sub-Matrix: SOIL			Client sample ID	CX0714FC ENV1/A 19.4 To 19.5 wea obn	CX0714FC ENV2/B 19.5 To 19.6 wea obn	----	----	----
			Client sampling date / time	[06-NOV-2008]	[06-NOV-2008]	----	----	----
Compound	CAS Number	LOR	Unit	EB0815504-011	EB0815504-012	----	----	----
EG005T: Total Metals by ICP-AES - Continued								
Barium	7440-39-3	10	mg/kg	<10	110	----	----	----
Beryllium	7440-41-7	1	mg/kg	<1	<1	----	----	----
Boron	7440-42-8	50	mg/kg	<50	<50	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	----	----	----
Chromium	7440-47-3	2	mg/kg	8	7	----	----	----
Cobalt	7440-48-4	2	mg/kg	<2	5	----	----	----
Copper	7440-50-8	5	mg/kg	8	10	----	----	----
Iron	7439-89-6	50	mg/kg	7500	7870	----	----	----
Lead	7439-92-1	5	mg/kg	<5	<5	----	----	----
Manganese	7439-96-5	5	mg/kg	36	440	----	----	----
Molybdenum	7439-98-7	2	mg/kg	<2	<2	----	----	----
Nickel	7440-02-0	2	mg/kg	7	7	----	----	----
Selenium	7782-49-2	5	mg/kg	<5	<5	----	----	----
Silver	7440-22-4	2	mg/kg	<2	<2	----	----	----
Strontium	7440-24-6	2	mg/kg	21	22	----	----	----
Tin	7440-31-5	5	mg/kg	<5	<5	----	----	----
Vanadium	7440-62-2	5	mg/kg	13	17	----	----	----
Zinc	7440-66-6	5	mg/kg	35	16	----	----	----
Calcium	7440-70-2	50	mg/kg	140	130	----	----	----
Magnesium	7439-95-4	50	mg/kg	1220	1100	----	----	----
Sodium	7440-23-5	50	mg/kg	2210	2040	----	----	----
Potassium	7440-09-7	50	mg/kg	430	400	----	----	----
^ Sulfur as S	----	50	mg/kg	60	60	----	----	----
Phosphorus	7723-14-0	50	mg/kg	<50	<50	----	----	----
Titanium	7440-32-6	10	mg/kg	10	20	----	----	----
Thallium	7440-28-0	5	mg/kg	<5	<5	----	----	----
EG435T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N (Sol.)	----	0.100	mg/kg	<0.100	<0.100	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
^ Nitrate as N (Sol.)	----	0.100	mg/kg	<0.100	<0.100	----	----	----
EK059G: NOx as N by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.100	mg/kg	<0.100	<0.100	----	----	----

Land and Property Management Authority

Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO09/294R1
REPORT TO:	Clayton Richards GSS Environmental PO Box 907 Hamilton NSW 2303
REPORT ON:	Thirty seven soil samples Codrilla MEM06-002
PRELIMINARY RESULTS ISSUED:	Not issued
REPORT STATUS:	Final
DATE REPORTED:	13 November 2009
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED

THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

SR Young

SR Young
(Laboratory Manager)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666, Fax: 02 6545 2520

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO09/294R1
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C5A/3 CEC & ex cation (me/100g)			P18B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	MC 15 bar (%)	Dry	Moist
1	Codrilla 1/1	10	14	70	6	<1	3(1)	0.02	6.2	4.8	<0.1	<2	3.3	10YR6/3	10YR4/3
2	Codrilla 1/2	26	17	53	4	0	3(2)	0.01	6.7	10.3	0.4	4	8.4	7.5YR6/4	7.5YR4/4
3	Codrilla 1/3	33	12	52	3	0	2(1)	0.02	7.1	13.3	0.9	7	11.1	7.5YR6/6	7.5YR5/6
4	Codrilla 2/1	16	19	49	16	<1	3(2)	0.02	7.2	7.7	0.4	5	5.1	10YR6/2	10YR4/2
5	Codrilla 2/2	16	18	49	16	1	2(2)	0.03	7.8	7.7	0.7	9	4.9	10YR7/2	10YR4/2
6	Codrilla 2/3	48	12	29	10	1	2(3)	0.62	9.2	23.2	5.4	23	14.6	10YR6/4	10YR4/4
7	Codrilla 3/1	34	8	47	11	<1	3(2)	0.10	8.5	20.8	2.0	10	11.0	10YR6/2	10YR4/2
8	Codrilla 3/2	36	8	43	12	1	2(1)	0.24	9.2	23.1	2.9	13	11.6	10YR6/2	10YR5/3
9	Codrilla 5/1	10	10	55	25	<1	3(1)	0.02	7.0	4.7	0.3	6	2.9	10YR6/2	10YR4/2
10	Codrilla 5/2	34	6	36	18	6	1	0.21	7.6	13.2	3.9	30	12.2	10YR6/3	10YR5/4
11	Codrilla 6/1	25	14	49	12	<1	8/3(1)	0.03	6.6	11.8	0.4	3	7.9	10YR5/3	10YR3/2
12	Codrilla 6/2	44	6	39	11	<1	2(3)	0.60	8.7	21.8	5.6	26	13.5	10YR6/3	10YR5/2

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO09/294R1
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GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C5A/3 CEC & ex cation (me/100g)			P18B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	MC 15 bar (%)	Dry	Moist
13	Codrilla 7/1	23	12	43	21	1	3(1)	0.01	6.8	8.2	0.4	5	6.2	10YR6/3	10YR4/4
14	Codrilla 7/2	50	10	29	11	<1	2(3)	0.14	8.0	20.1	3.3	16	15.4	10YR6/3	10YR5/4
15	Codrilla 8/1	14	2	59	25	<1	3(1)	<0.01	6.7	3.9	0.2	5	3.4	10YR6/3	10YR4/4
16	Codrilla 8/2	19	4	51	21	5	3(2)	0.01	7.3	3.6	0.8	22	4.6	10YR7/6	10YR5/6
17	Codrilla 9/1	23	13	49	15	<1	3(1)	0.02	6.4	11.1	0.6	5	7.1	10YR6/3	10YR4/3
18	Codrilla 9/2	50	11	29	9	1	2(1)	0.30	9.0	27.2	3.7	14	14.5	10YR6/3	10YR5/3
19	Codrilla 9/3	41	10	37	11	1	2(3)	0.95	9.3	23.8	6.8	29	13.5	10YR6/3	10YR5/4
20	Codrilla 10/1	38	15	34	13	<1	2(3)	0.12	8.4	16.1	2.9	18	11.2	10YR6/3	10YR4/3
21	Codrilla 10/2	35	15	36	12	2	2(3)	0.79	9.2	17.7	6.1	34	11.9	10YR6/3	10YR5/4
22	Codrilla 12/1	7	11	51	29	2	8/3(1)	<0.01	7.7	2.4	0.2	8	2.1	7.5YR7/2	7.5YR5/3
23	Codrilla 12/2	21	8	38	21	12	3(2)	0.01	7.5	4.8	0.5	10	6.3	10YR7/3	10YR5/4
24	Codrilla 13/1	30	11	31	26	2	3(3)	0.01	7.1	9.7	0.4	4	8.1	10YR6/4	10YR4/4
25	Codrilla 13/2	45	10	23	20	2	2(3)	0.04	7.6	15.5	1.8	12	13.0	10YR6/3	10YR5/4

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO09/294R1
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C5A/3 CEC & ex cation (me/100g)			P18B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	MC 15 bar (%)	Dry	Moist
26	Codrilla 14/1	8	6	52	29	5	3(1)	<0.01	6.0	2.1	0.2	10	1.9	10YR7/2	10YR5/4
27	Codrilla 14/2	27	7	27	21	18	2(3)	0.08	8.6	12.8	2.9	23	11.4	10YR6/4	10YR5/4
28	Codrilla 15/1	17	23	46	14	<1	3(3)	0.02	6.6	5.8	0.5	9	4.8	10YR6/3	10YR4/3
29	Codrilla 15/2	33	14	36	16	1	2(3)	0.53	8.2	12.0	4.8	40	10.6	10YR6/4	10YR4/6
30	Codrilla 16/1	20	13	46	19	2	2(1)	0.03	7.4	6.4	1.2	19	6.1	10YR6/3	10YR4/4
31	Codrilla 16/2	37	11	36	15	1	2(3)	0.54	9.1	15.9	7.2	45	12.5	10YR6/6	10YR4/6
32	Codrilla 17/1	10	9	49	27	5	8/3(1)	0.01	7.5	4.7	0.6	13	3.2	10YR7/2	10YR5/4
33	Codrilla 17/2	27	11	42	20	<1	2(3)	0.56	9.0	15.4	5.4	35	10.4	10YR6/4	10YR4/6
34	Codrilla 18/1	13	16	39	26	6	8/3(2)	0.01	8.0	5.4	0.6	11	3.5	10YR6/3	10YR4/4
35	Codrilla 18/2	33	13	31	22	1	1	0.15	9.1	14.0	3.5	25	10.2	10YR6/4	10YR4/6
36	Codrilla 19/1	13	8	52	26	1	8/3(2)	<0.01	7.5	5.2	0.4	8	3.4	10YR6/3	10YR4/4
37	Codrilla 19/2	30	5	42	20	3	3(3)	0.01	7.6	7.4	0.5	7	7.6	10YR7/6	10YR5/6

END OF TEST REPORT

Land and Property Management Authority

Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO09/293R1
REPORT TO:	Clayton Richards GSS Environmental PO Box 907 Hamilton NSW 2303
REPORT ON:	Twenty three soil samples Codrilla Haul Road MEM06-002
PRELIMINARY RESULTS ISSUED:	Not issued
REPORT STATUS:	Final
DATE REPORTED:	6 November 2009
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED

THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

SR Young

SR Young
(Laboratory Manager)

Scone Research Centre, PO Box 283 Scone 2337, 709 Gundy Road Scone 2337
Ph: 02 6545 1666, Fax: 02 6545 2520

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO09/293R1
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C5A/3 CEC & ex cation (me/100g)			P18B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	MC 15 bar (%)	Dry	Moist
1	Codrilla HR 5/1	9	5	44	14	28	3(1)	<0.01	5.7	5.7	0.5	9	3.7	10YR5/4	10YR4/4
2	Codrilla HR 5/2	24	2	35	14	25	3(3)	0.01	6.4	10.2	1.1	11	8.5	10YR5/4	10YR4/4
3	Codrilla HR 5/3	42	5	34	19	<1	1	0.07	7.9	17.2	3.2	19	14.3	10YR4/6	10YR4/4
4	Codrilla HR 6/1	11	6	64	18	1	8/3(1)	0.02	6.2	8.6	0.4	5	4.0	10YR5/3	10YR3/3
5	Codrilla HR 6/2	11	6	62	21	<1	3(1)	<0.01	6.5	8.9	0.4	4	3.8	10YR5/3	10YR4/3
6	Codrilla HR 6/3	33	4	47	16	<1	2(3)	0.19	8.9	18.9	3.1	16	11.1	7.5YR5/6	7.5YR4/4
7	Codrilla HR 7/1	8	6	71	15	<1	8/3(1)	0.03	5.9	8.7	0.4	5	3.4	10YR5/4	10YR4/4
8	Codrilla HR 7/2	8	9	70	13	<1	3(1)	<0.01	5.7	5.0	0.4	8	2.2	10YR6/4	10YR4/4
9	Codrilla HR 7/3	33	7	51	9	0	2(3)	0.03	7.2	12.1	0.7	6	10.0	5YR5/4	5YR4/4
10	Codrilla HR 8/1	11	10	54	16	9	8/3(1)	0.02	6.3	13.3	0.2	2	5.1	10YR5/2	10YR4/2
11	Codrilla HR 8/2	27	7	34	10	22	2(3)	0.14	8.4	26.8	4.4	16	13.5	7.5YR4/2	7.5YR3/2
12	Codrilla HR 8/3	38	15	39	8	<1	1	0.91	6.0	27.2	10.5	39	14.5	7.5YR6/4	7.5YR5/4

SR Young

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO09/293R1
Client Reference: Clayton Richards
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C5A/3 CEC & ex cation (me/100g)			P18B/2	Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	MC 15 bar (%)	Dry	Moist
13	Codrilla HR 11/1	6	11	63	19	1	8/3(1)	0.01	5.9	4.4	0.2	5	2.9	10YR5/2	10YR4/2
14	Codrilla HR 11/2	11	4	63	21	1	3(1)	<0.01	5.9	3.8	<0.1	<3	2.6	10YR5/4	10YR4/4
15	Codrilla HR 11/3	37	5	29	13	16	2(1)	0.03	7.0	8.9	0.5	6	11.5	10YR5/6	10YR4/6
16	Codrilla HR 12/1	9	6	62	23	<1	8/3(1)	0.03	7.0	7.5	0.1	1	3.0	10YR5/2	10YR4/2
17	Codrilla HR 12/2	4	10	61	24	1	3(1)	<0.01	6.8	3.3	<0.1	<3	1.1	7.5YR6/2	7.5YR4/2
18	Codrilla HR 12/3	27	12	42	19	<1	3(1)	0.29	9.2	19.8	1.8	9	10.1	10YR6/4	10YR5/4
19	Codrilla HR 13/1	4	8	59	29	<1	8/3(1)	0.02	6.5	4.2	<0.1	<2	2.3	10YR5/4	10YR4/4
20	Codrilla HR 13/2	8	8	56	28	<1	3(1)	<0.01	5.9	4.5	<0.1	<2	2.7	10YR6/4	10YR4/6
21	Codrilla HR 13/3	32	2	41	24	1	2(3)	0.06	7.3	8.9	2.0	22	10.3	10YR6/4	10YR5/4
22	Codrilla HR 14/1	18	16	50	16	<1	3(1)	0.05	7.4	16.4	0.1	1	7.0	10YR5/2	10YR4/2
23	Codrilla HR 14/2	48	14	28	10	<1	1	0.36	9.3	27.1	6.0	22	15.1	10YR6/3	10YR5/3

SR Young

END OF TEST REPORT

Appendix Fs

Codrilla Groundwater Assessment – Addendum Report

Australasian Groundwater & Environmental Consultants Pty Ltd

ADDENDUM REPORT on

REVISED MINE PLAN AND NUMERICAL MODELLING RERUN

CODRILLA COAL PROJECT

prepared for
BOWEN BASIN COAL JOINT VENTURE

Project No. G1471/A
April 2011

ABN:64 080 238 642

Australasian
Groundwater & Environmental
Consultants Pty Ltd

ADDENDUM REPORT on

REVISED MINE PLAN AND NUMERICAL MODELLING RERUN

CODRILLA COAL PROJECT

prepared for
BOWEN BASIN COAL JOINT VENTURE

Project No. G1471/A
April 2011

36 Jeays Street
Bowen Hills Qld 4006
Ph (+617) 3257 2055
Fax (+617) 3257 2088
Email: brisbane@ageconsultants.com.au
Web: www.ageconsultants.com.au

A.B.N 64 080 238 642

TABLE OF CONTENTS

Page No.

1.0 INTRODUCTION 1

2.0 AMENDMENT TO THE CODRILLA PROJECT MINE PLAN 1

3.0 REVISED NUMERICAL GROUNDWATER MODEL 1

3.1 Modelling Objectives 2

3.2 Model Code Selection 2

3.3 Modelling Strategy 2

3.3.1 Model Geometry and Boundary Conditions 3

3.3.2 Hydraulic Parameters 4

3.3.3 Recharge and Discharge 5

3.4 Steady State Calibration 5

4.0 PREDICTIVE SIMULATIONS 5

4.1 Transient Modelling – Mining Phase 5

4.2 Piezometric Surface/Water Table Levels 6

4.3 Impact on Groundwater Users 8

4.4 Inflow to Mined Void 8

4.5 Transient Model Budget Summary 10

4.6 Leakage from Alluvial Aquifers 11

4.7 Transient Modelling – Groundwater Recovery 11

4.8 Model Uncertainty and Limitations 15

5.0 POTENTIAL IMPACT OF PROJECT ON GROUNDWATER REGIME AND MITIGATION OPTIONS 15

5.1 Groundwater Inflow to Mine and Control Strategies 15

5.2 Groundwater Levels and Regional Impact 16

5.3 Impact on Existing Farm Bores 16

5.4 Impact on Environmental Values 16

5.5 Groundwater Contamination 17

5.6 Fitzroy Water Resource Plan and Regulations 18

Attachments:

Drawing No. 6A – Modflow Model Grid

Drawing No. 7A – Simulated vs Observed Pre-Mining Water Levels

Drawing No. 8A – Mine Development Plan

Drawing No. 9A – Groundwater Level Contours – 2026 End of Mining

Drawing No. 10A – Predicted Drawdown – 2026 End of Mining

ADDENDUM REPORT ON

REVISED MINE PLAN AND NUMERICAL MODELLING RERUN

CODRILLA COAL PROJECT

1.0 INTRODUCTION

This follow-up report is an Addendum to the report prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) for the Codrilla Coal Project Environmental Impact Assessment titled:

- *"Codrilla Coal Project – Groundwater Impact Assessment"*, Project No. G1471, dated July 2010.

This Addendum addresses the following modification to the proposed mine plan:

- The mine schedule has been reversed to run from east to west as against that previously assessed from west to east over a similar time period and life of mine.

This Addendum should be read in conjunction with the above mentioned report.

2.0 AMENDMENT TO THE CODRILLA PROJECT MINE PLAN

The revised mining plan proposes for mining commencing at the eastern end of the East Pit in 2013, with a generally westerly direction progression to the floor of the Upper Vermont Seam. The project is scheduled for completion after 14 years, in 2026. The revised mine plan and timing used in this addendum assessment provides for mining:

- commencing at the eastern end of East Pit and progressing westwards over a 11-year period between 2013 and 2023; and
- then restarting at the western end of West Pit and progressing eastwards over a five-year period between 2022 and 2026.

3.0 REVISED NUMERICAL GROUNDWATER MODEL

The revised mine plan has required a revision of the numerical model to incorporate the change in mining progression with the aim being to compare the predicted impact on groundwater levels both adjacent to the mine area and regionally as a result of the two mine progression options.

3.1 Modelling Objectives

The overall objective of the numerical modelling was to simulate the impact of the revised Codrilla Mine open cut operations on the hydrogeological regime of the area and in particular to undertake predictive modelling in order to:

- assess the potential groundwater inflow volumes to the open cut pits over the life of the mine;
- predict the zone of influence of dewatering and the level and rate of drawdown at specific locations as a result of the inflows to the mine;
- identify areas of potential risk where groundwater impact mitigation/control measures may be necessary; and
- the rate of groundwater recovery and long term impacts occurring on cessation of mining.

3.2 Model Code Selection

The numerical simulation of groundwater flow in the aquifers was undertaken using the MODFLOW SURFACT code (Hydrogeologic, 1997[1] – hereafter referred to as SURFACT), which is a commercial derivative of the standard MODFLOW code.

3.3 Modelling Strategy

This revised numerical model has utilised the original numerical modelling that was developed by:

- creating the model structure that resembles the regional geological structure incorporating the mine area and surrounds by simulating this geometry as separate model layers and applying appropriate hydraulic (aquifer) parameters and boundary conditions representative of the real environment; and
- calibrating the model to steady state conditions, that is to currently observed groundwater conditions that are known to exist within the project area.

Whilst this revision of the numerical model has been based on the original calibrated steady state model, the predictive transient modelling was undertaken to assess:

- impact of operation of the mine for a period of 14 years from 2013 to 2026 in accordance with the revised mine plan; and
- long-term recovery of the water levels in the final mine voids for the East and West Pit voids.

The extent of the model is shown in Drawing No. 6A.

[1] Hydrogeologic, (1997), MODFLOW SURFACT (Version 3.0), Software Code Documentation, Herndon, Virginia, USA, Hydrogeologic Inc.

3.3.1 Model Geometry and Boundary Conditions

The model geometry remains unchanged with 7 layers and surface elevations as was used previously. The three-dimensional view of the model domain and layers shown in Figure 1 below illustrates the geological layers in the model.

Boundary conditions also remain unchanged with details for each described below.

An active "flow" boundary as:

- a constant head boundary applied across the south-eastern edge of the model.

Three inactive or "no flow" boundaries along the:

- south-western boundary coincident with the concealed fault alignment;
- coal seam sub-crop alignments that mark the northern and eastern boundaries;
- north-west corner of the model that is considered beyond the influence of the proposed Codrilla Mine open pits; and
- the base of Layer 7 in the model.

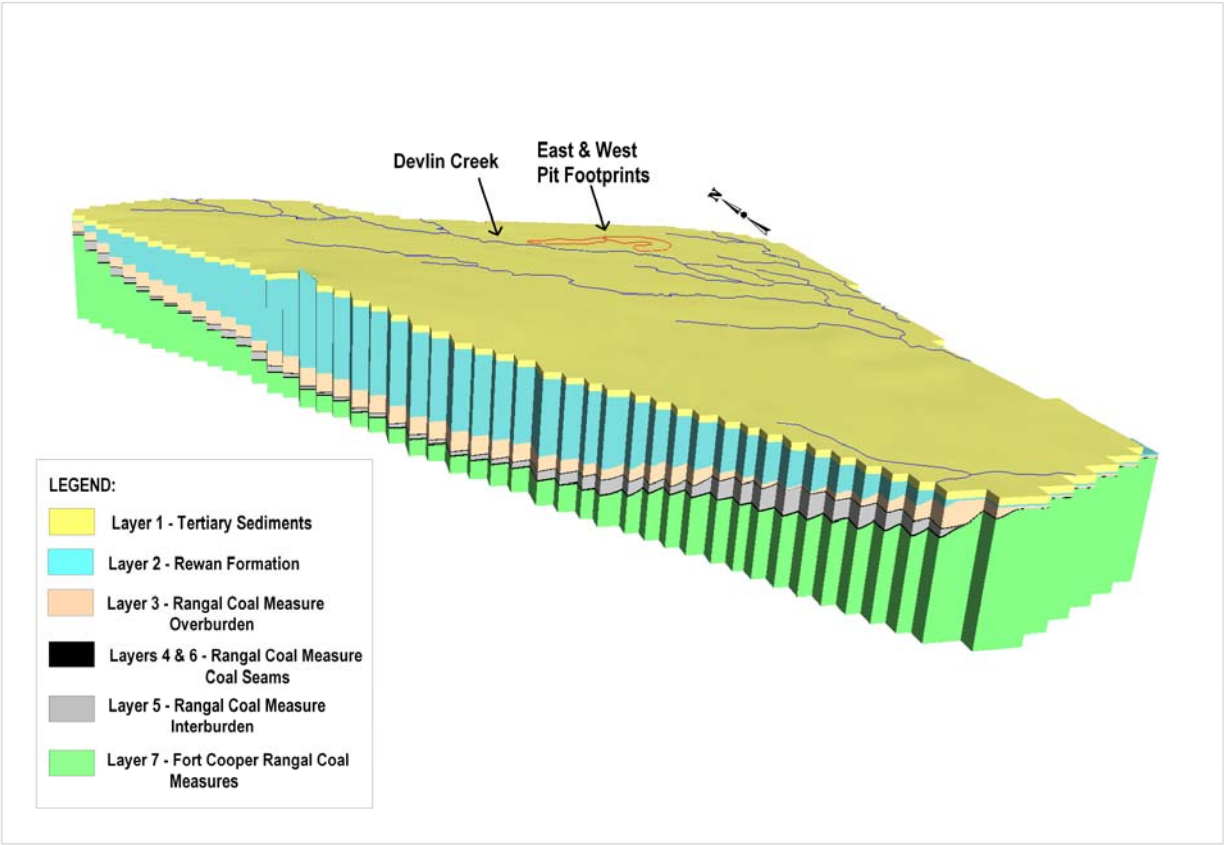

Figure 1: 3D Representation of Model Domain looking from South-west to North-east

3.3.2 Hydraulic Parameters

The values for all hydraulic parameters used in the current model remain unchanged from the original model and are presented below in Table 1.

Table 1: HYDRAULIC PARAMETERS

Layer	Parameter	Value
Layer 1 (Tertiary Sediments)	Horizontal Hydraulic Conductivity [kh]	Tertiary zone 0.05 m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	Tertiary zone 0.05
	Specific Storage [S_s]	soil zone 5×10^{-4}
Layer 2 (Triassic Rewan Formation)	Horizontal Hydraulic Conductivity [kh] based on Transmissivity relationship	Transmissivity 0.5m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	1×10^{-3}
	Specific Storage [S_s]	1×10^{-5}
Layer 3 (Permian Rangal Coal Measures overburden above the upper most coal seam)	Horizontal Hydraulic Conductivity [kh] based on Transmissivity relationship	Transmissivity 0.5m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	1×10^{-3}
	Specific Storage [S_s]	1×10^{-5}
Layer 4 (Lower Leichhardt 2 Coal Seam – upper most coal seam)	Horizontal Hydraulic Conductivity [kh]	0.05m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	5×10^{-3}
	Specific Storage [S_s]	1×10^{-4}
Layer 5 (Permian Rangal Coal Measures interburden between the upper and lower most coal seams	Horizontal Hydraulic Conductivity [kh] based on Transmissivity relationship	Transmissivity 0.2m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	1×10^{-3}
	Specific Storage [S_s]	1×10^{-5}
Layer 6 (Upper Vermont Coal Seam – lower most coal seam)	Horizontal Hydraulic Conductivity [kh]	0.05m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	5×10^{-3}
	Specific Storage [S_s]	1×10^{-4}
Layers 7 (Fort Cooper Coal Measures, base of model)	Horizontal Hydraulic Conductivity [kh]	0.001m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	1×10^{-4}
	Specific Storage [S_s]	1×10^{-6}

3.3.3 Recharge and Discharge

Rainfall sourced recharge was applied to the topographic surface of the uppermost layer (Layer 1) in the model. The recharge was applied at a constant rate, with no adjustment for seasonality. Bureau of Meteorology data collected at the Moranbah Water Treatment Plant over the 37-year period 1972 to 2009 shows:

- an average annual rainfall of 587.9mm/yr, or 1.61mm/day; and
- a mean daily evaporation of 6.4mm/day (0.0064m/day).

Discharge was modelled using the SURFACT Drain (DRN) package by assigning drain cells in Layer 1 only coincident with the creek alignments, and in Layers 1 to 6 to represent water abstraction from the East and West Pits during mining.

3.4 Steady State Calibration

Steady state calibration of the groundwater flow model to observed steady state water levels was undertaken in the previous model for Codrilla with the two parameters required for calibration being were hydraulic conductivity and recharge. A model wide recharge rate of 2.011×10^{-7} m/day (equivalent to 0.0125% of the average annual rainfall) was used to represent the pattern of groundwater contours and direction of groundwater flow under steady state conditions that generally matched those measured in the monitoring bores. This recharge rate was only applied to Layer 1. The steady state simulated pre-mining groundwater levels are shown in Drawing No. 7A.

4.0 PREDICTIVE SIMULATIONS

4.1 Transient Modelling – Mining Phase

The revised mining plan proposes for mining commencing at the eastern end of the East Pit in 2013, with a generally westerly direction progression to the floor of the Upper Vermont Seam. The project is scheduled for completion after 14 years, in 2026. The mine plan and timing used in the impact assessment is presented on Drawing No. 8A.

Conversion of the calibrated steady state model to transient flow conditions for the predictive mining scenario required the transient model to be set up with 56 stress periods, each of 91.3 days duration representing quarterly development of the mine over the 14 years life of mine period. The simulated steady state heads from model calibration were used as initial conditions representing groundwater levels at the start of the transient predictive simulation.

Dewatering of the open cut mining areas to represent the transient simulation of mine progression was undertaken using SURFACT drain cells set to the floor of the seam being mined. The simulation of the mining operations required the following simplified assumptions for each pit:

- Drain cells (DRN package) located coincident with the base of the East and West Pit footprints were placed to the floor of the Upper Vermont Seam (Layer 6) to allow for water to be removed from the model domain, thereby representing mine dewatering.

- The amount of water removed was determined by the drain conductance which was specified nominally high at 10,000m^2/day to ensure groundwater levels were reduced to the floor of the pit.
- In the pit spoil area disposal was not represented during the transient analysis thereby making the dewatering assumptions conservative – that is the amount of water being removed from the pit being greater than will be the case in reality.

To account for the progressive development of mining starting with East Pit and then moving westwards to the West Pit, the modelling strategy included a stop-start approach which incorporated the mining of each pit as two separate stages. This provided for simulation of the resultant mine dewatering of each pit as two separate stages as per the revised mine plan.

- the first stage being the simulation of mining at East Pit carried out over 44 stress periods (and representing 11 years between 2013 and 2023); and
- the second stage being mining at West Pit over 12 stress periods (representing 3 years between 2023 and 2026).

The simulation was stopped at end of the 44th stress period and spoil placed within the East Pit footprint with the exception of the final void to represent in-pit backfilling of the pit using spoil material. The transient model was then re-started to simulate mining of West Pit. The aquifer conditions at the end of Stage 1 were used to start the Stage 2 simulation. During the Stage 2 simulation, dewatering of the West Pit was undertaken while water levels within East Pit were allowed to begin recovering.

The following parameters were used to represent the spoil material and water body within the final void in both the East and West Pits:

- The hydraulic conductivity value in the mined pit area was adjusted to 0.1m/day for the spoil material and 10,000m/day in the final void.
- The specific yield of the mined pit area was adjusted to 0.01 for the spoil material and 1 in the final void.
- The storage coefficient of the mined pit area was adjusted to 0.0001 for the spoil material and 1 in the final void.
- Recharge to the mined pit area was adjusted to 10% of annual rainfall over the spoil material and 100% of annual rainfall over the final void.
- The evapo-transpiration package was made active in the mining area with an evaporation rate of 0.0064m/day over the spoil material and 0.0048m/day for the final void (i.e., adjusted evaporation rate using a pan factor of 0.25 for the water body within the pit).

4.2 Piezometric Surface/Water Table Levels

Model simulated water levels at the end of mining in 2026 in Layers 1 and 6, which represent the Tertiary sediment aquifer and Vermont Coal Seam respectively, are presented in Drawing No. 9A. The zone of depressurisation around the East and West Pits is clearly evident as observed by the steeply declining contours around the mined area.

The drawdown within the Tertiary sediment aquifer and Vermont Coal Seam attributable to the proposed mine development is presented in Drawing No. 10A. This shows a generally steep

drawdown curve within each layer, with the resultant cone of depression proximal to the East and West Pits mined areas. The extent of drawdown in Layer 1 as depicted by the 1m contour is generally contained to within a 2.5km radius of the northern, southern, eastern and western extents of the mined area. A similar drawdown response as depicted by the 1m contour is observed in Layer 6 extending up to around 4km north, south, east and west from the mine area. It is evident that commencement of mining from East Pit does not result in the greater overall drawdown extent observed with the previous mine plan. That is the aquifer drawdown extent does not extend as far the regional aquifer boundaries west and south-west of the mine area (as simulated by the model boundaries).

Simulated water levels at locations representing the centre of each pit and the final voids are shown in Figure 2. As for the previous mine plan, the modelling indicates a relatively steep drawdown response within the highwall sequences whilst mining progresses through that section of the open pit. This will likely give rise to saturated conditions resulting in seepage fronts along highwall batters during mining. Once mining ceases in the East Pit, the modelling predicts water levels rising within spoil material placed within the pit, whilst water levels within the final void recover more slowly, remaining near the base of the void. The modelling then shows a more pronounced drawdown response to water levels within the West Pit to that initially observed in the East Pit but with no obvious recovery observed before the end of mining in 2026. It should be noted that the simulation does not consider progressive placement of spoil within the West Pit, which potentially over-estimates the overall impact from the mine dewatering. However given the uncertainties and assumptions made with respect to the model parameters and setup, the predicted drawdown responses are considered acceptable.

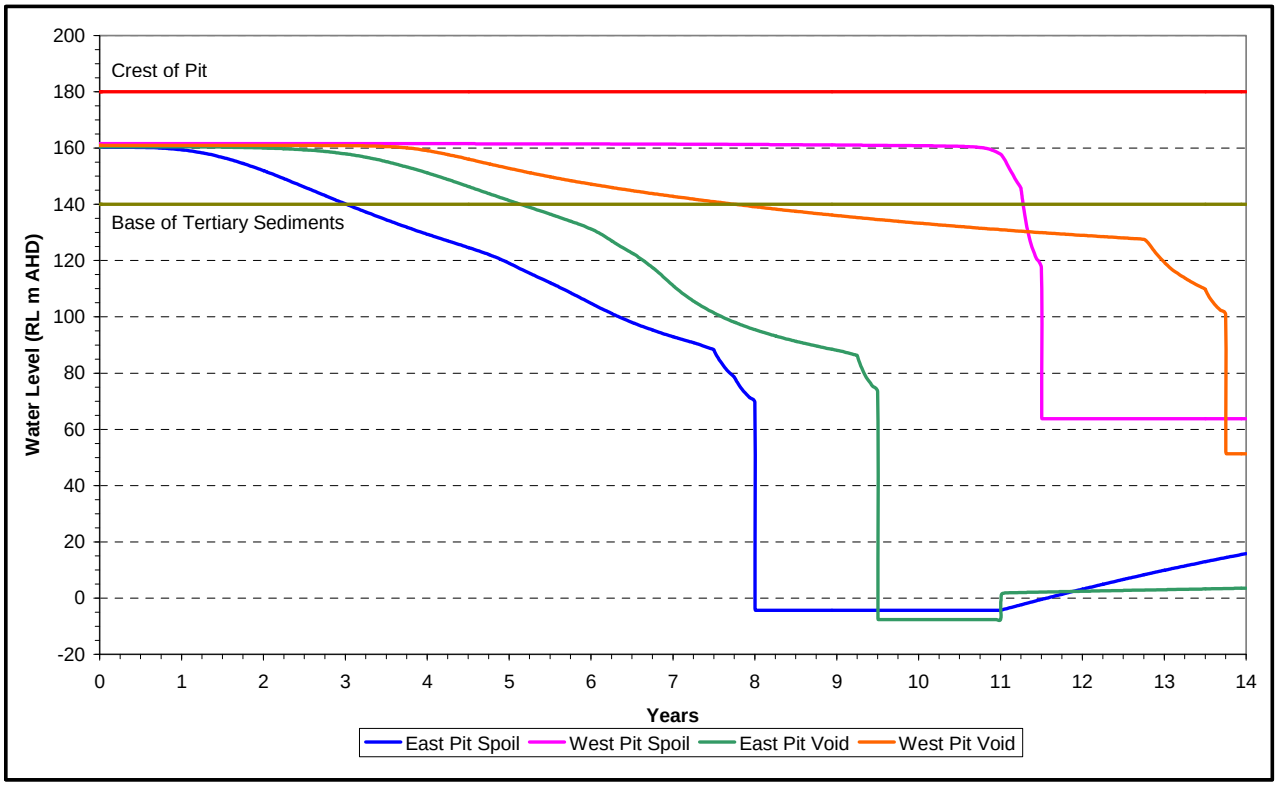

Figure 2: Simulated Drawdown within East and West Pits during Mining

4.3 Impact on Groundwater Users

As discussed in Section 4.2 the depressurised zone in the Tertiary sediments and underlying bedrock sequences extends up to 4km north, east and south of the mine. The only bore intersected by this drawdown is registered monitoring bore RN13040287 located about 3.5km north of the mine. The drawdown does not intersect any other of the 13 registered bores or the single unregistered bore identified as part of this study.

The closest registered and unregistered water supply bores to the proposed mine development are:

- RN85164 which is located approximately 10km north of the mine beyond the model boundary and hence within geology not hydraulically connected to that within the model area;
- RN111879 which is located approximately 11km south-east of the mine and within the model boundary; and
- The Devlin Creek property bore (DC Bore) located approximately 11km north-west of the proposed mining lease boundary.

As stated above, all bores are located beyond the extent of impact simulated in the transient analysis and hence would not be influenced by the mine development and resultant impact from aquifer dewatering.

4.4 Inflow to Mined Void

The model predicted heads and cell by cell flows were extracted for each stress period to assess the rate of groundwater inflow to the mine pits for the revised mine plan. The model simulated inflow rates to the proposed East and West Pits are shown in Figure 3 below. Detail of predicted inflows to each pit is discussed below.

<u>East Pit</u>

The predicted flows into East Pit range from 3.1ML/day at the end of the first stress period (representing the first quarter of the first year of mining) to maximum values between 5.5ML/day and 5.6 ML/day from mid 2015 to the end of 2016 (Year 4) when the outside northern and southern sections of East Pit are mined.

From 2016 the predicted inflows decrease steadily down to around 2.6ML/day over the next five years to mid 2022 (Year 10) as mining progresses through the inner sections of East Pit. This is due to these sections of the mine being mostly dewatered as a result of earlier mining of the outer northern and southern sections.

The increase in the predicted inflows from 2.6ML/day mid 2022 to 5.3ML/day at the end of 2023 (Year 11 and the end of mining in East Pit) are a response to the commencement of mining in West Pit at the start of the second quarter in 2022.

Overall, higher inflows are predicted for this revised mine plan (up to 5.6ML/day) compared to that previously simulated (up to 4.7ML/day) which is to be expected considering the increased size of the revised East Pit mine plan.

West Pit

As mentioned above, simulation of mining in West Pit starts with the second quarter in 2022 and continues until the end of 2026 (Year 14). The sharp decline in predicted inflows from 5.3ML/day to 1.2ML/day at the end of 2023 (Year11), represent cessation of active dewatering and placement of spoil backfill within East Pit (excluding the final void area). Progression of mining is thereafter limited to West Pit only, with inflows increasing from 1.2ML/day to a maximum of 3.3ML/day at the end of 2025 (Year 13). The final year of mining in 2026 (Year 14) indicates predicted inflows declining marginally to around 2.5ML/day.

The initially higher inflows predicted after the mining commences in the West Pit at the end of 2023 (5.3ML/day) are a combination of inflows to both the East Pit and West Pit. Hence it is possible the actual inflows to the West Pit would be similar to those predicted previously since the mine plan for West Pit is not significantly different from that previously simulated.

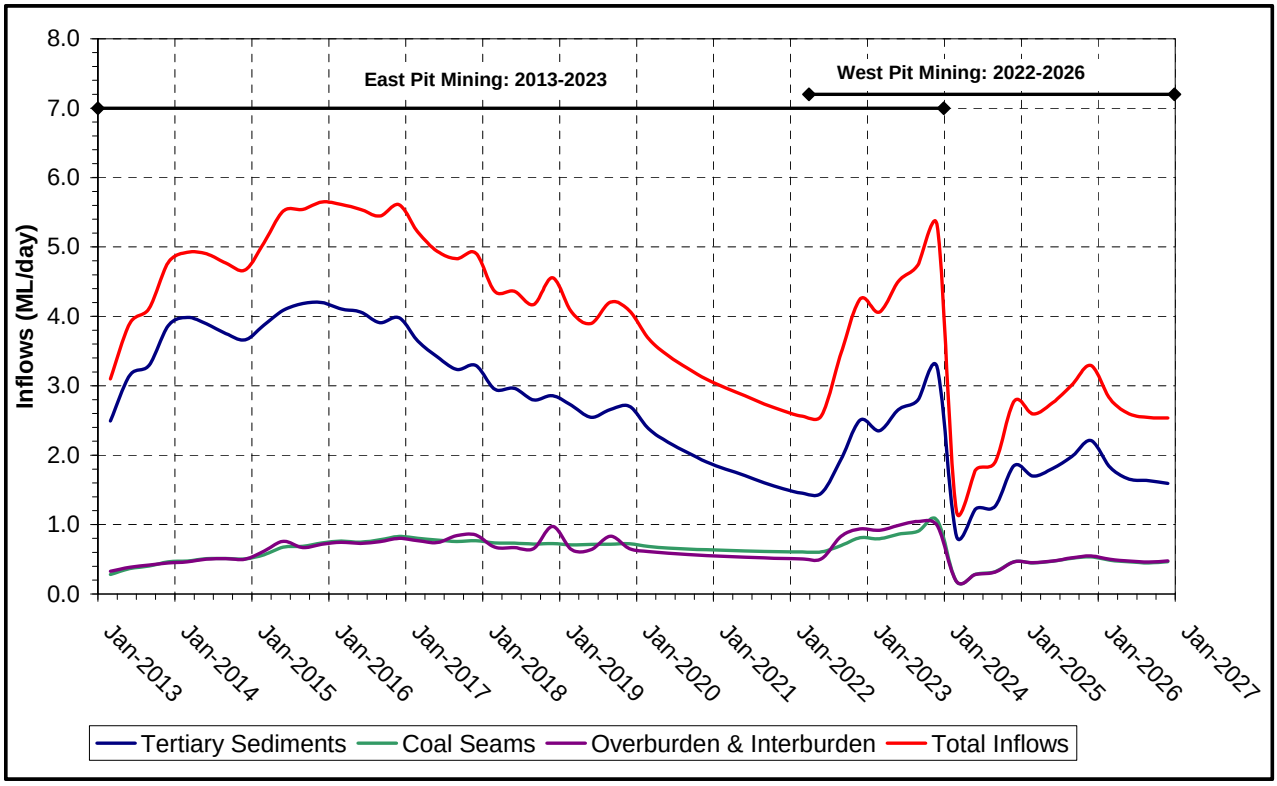

Figure 3: Simulated Seepage within East and West Open Pits

As for the previous simulation of predicted inflows to the East and West Pits, it is important to note that whilst a large proportion of the groundwater inflow will be lost from the aquifer, not all of this water report to dewatering pumps in the mine. This is because the model does not account for loss of water through evaporation from the coal face and water that is removed with the coal as moisture.

No details on the mined volumes of overburden/interburden and coal have been provided for this revised mine plan. However, based on the previously adopted assumptions for mining the coal seams, the potential groundwater loss via evaporation and moisture in the coal and waste rock could account for as much 40% of the total inflows predicted into East and West Pits.

Therefore when the loss from evaporation and coal moisture is considered, the actual volumes reporting to the in pit sumps are expected to be low.

It should also be noted that the simulated inflows are potentially a conservative overestimate for the following reasons:

- The model does not include the minor faults in the area and simulates a continuous aquifer system – assuming these faults act as barriers to groundwater flow, inflows to the model will be lower than predicted by the laterally continuous aquifers in the model; and
- The model assumes the entire pits remain dewatered when the pits are active.

4.5 Transient Model Budget Summary

The model water balance for the East Pit and West Pit transient analyses are presented in Table 2 and Table 3. These show the percent discrepancy was 0.85% in East Pit and 0.03% in West Pit, which indicate good accuracy for the numerical simulations and overall stability of the two models.

Table 2: TRANSIENT MODEL WATER BALANCE (EAST PIT – 2013 TO 2023)

Component	Cumulative Volume (ML)
IN	
CONSTANT HEAD =	0
DRAINS =	0
RECHARGE =	426.7
TOTAL IN =	27,085.5
OUT	
CONSTANT HEAD =	207.3
DRAINS =	26,879.6
RECHARGE =	0
TOTAL OUT =	27,315.6
IN - OUT =	230.1
PERCENT DISCREPANCY =	0.85

Table 3: TRANSIENT MODEL WATER BALANCE (WEST PIT – 2022 to 2026)

Component	Cumulative Volume (ML)
IN	
CONSTANT HEAD =	0
DRAINS =	0
RECHARGE =	1,099.9
TOTAL IN =	17,084.5
OUT	
CONSTANT HEAD =	56.5
DRAINS =	3,987.1
RECHARGE =	0
TOTAL OUT =	17,089.9
IN - OUT =	5.4
PERCENT DISCREPANCY =	0.03

Cumulative recharge increased from 426.7ML for East Pit to 1,099.9ML for West Pit with overall cumulative water losses as outflow from drain cells decreasing from 26,879.6ML (East Pit) to 3,987.1ML (West Pit). The losses from drain cells include dewatering from East and West Pits as well as discharge into the creeks within the model domain.

4.6 Leakage from Alluvial Aquifers

As discussed in the previous predictive modelling, the open pits are in close proximity to alluvium associated with Devlin Creek, in which a shallow groundwater aquifer exists as a perched aquifer. Groundwater levels in the shallow alluvial aquifer (where present) occur well above any groundwater associated with the underlying Tertiary sediments, indicating these aquifers are not hydraulically interconnected. This being the case and providing mining does not intersect the Devlin Creek alluvium, it is unlikely that mine dewatering and resultant depressurisation of the underlying Tertiary and Permian aquifers will impact on groundwater associated with the alluvium (alluvial aquifer).

4.7 Transient Modelling – Groundwater Recovery

Once mining operations cease within the East Pit at the end of 2023, dewatering of the East Pit open void also ceases and a slow recovery in groundwater levels in the area commences. As discussed in Section 4.1, recovery within the East Pit commenced after 2023 (Year 11) when mining ceased in that pit. Although the mine plan over the 14-year period shows progressive backfilling of each open pit with spoil from the section being mined, the model applies this spoil backfill in two stages, at the end of East Pit mining (in 2023), and on completion of mining in the West Pit at the end of 2026. Hence, at the end of mining in 2026 the configurations of the two final voids are as follows:

- The void at the western end of the East Pit footprint with an area of approximately 71ha. The lowest point in the final void will be RL-5m, a depth of about 180m below the spill level of the void (approximately RL174m).
- The void at the eastern end of the West Pit footprint with an area of approximately 57ha. The lowest point in this final void will be RL29m, a depth of about 151m below the spill level of the void (approximately RL180m).

The locations and extents of the final voids are shown below in Figure 4.

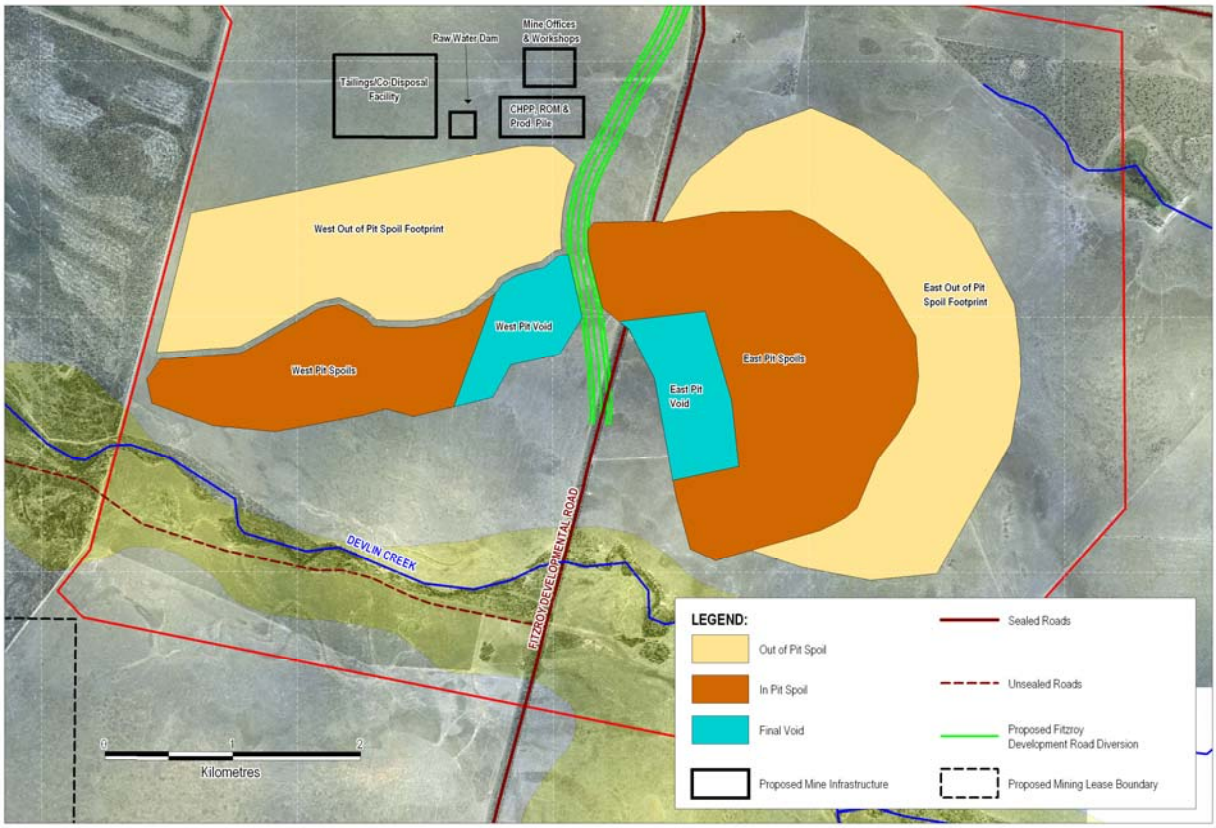

Figure 4: Locations and Extents of Final Voids and Spoil

At the cessation of mining, there will be a relatively high groundwater gradient between the open voids and the coal seam aquifers which will result in relatively rapid inflows; however, as the lakes begin to form in the voids, the gradient is reduced and the rate of groundwater inflow will decrease. Direct rainfall at the site will also add to the void and eventually a state of 'quasi' equilibrium will occur which will be influenced by the balance of inflows from groundwater and rainfall, and losses from evaporation.

The rate of recovery of groundwater levels in the aquifers will be dependent on rainfall, with below average rainfall years likely to extend the recovery period and wet years to reduce the time for stabilisation. Groundwater levels will likely recover below pre-mining levels as average daily evaporation is around four times the average daily rainfall in the area.

The closest monitoring bore to the proposed final void in the western pit is MB8B, located about 650m to the north-east which recorded a pre-mining groundwater level of RL159.2m. The closest registered bore to this void is RN13040287, located about 3500m to the north-northeast which recorded a pre-mining groundwater level of RL157.7m.

The water level in the final voids was estimated by running the transient groundwater recovery model with modifications incorporated for model parameters for areas of spoil backfill and final voids.

The hydraulic properties adopted for both the East and West Pits spoil backfilled areas and final voids are summarised in Table 4.

Table 4: SPOIL AND VOID HYDRAULIC PARAMETERS		
Layer	**Parameter**	**Value**
East and West Pits Spoil	Horizontal Hydraulic Conductivity [kh]	0.1 m/day
	Vertical Hydraulic Conductivity [kv]	10% of kh (above)
	Specific Yield [S_y]	0.01
	Specific Storage [S_s]	1×10^{-4}
	Recharge	1.609×10^{-4}m/day (10% of annual rainfall)
	Evapo-Transpiration	0.0064m/day
East and West Pits Voids	Horizontal Hydraulic Conductivity [kh]	10,000m/day
	Vertical Hydraulic Conductivity [kv]	10,000m/day
	Specific Yield [S_y]	1
	Specific Storage [S_s]	1
	Recharge	1.609×10^{-3}m/day (100% of annual rainfall)
	Evaporation	0.0048m/day

For both the East and West Pits spoil areas the evapo-transpiration rate was set with a constant extinction depth of 2m applied, whereas for the East and West Pits final void areas a cell-by-cell extinction depth was determined by calculating the total depth from the original ground surface to the bottom of the mined coal seam. The maximum evaporation rate in the final voids was set at the average evaporation rate multiplied by a pan factor of 0.75 to represent evaporation from an open water body.

The estimated recovery in water levels in the final voids and spoils is shown in Figure 5.

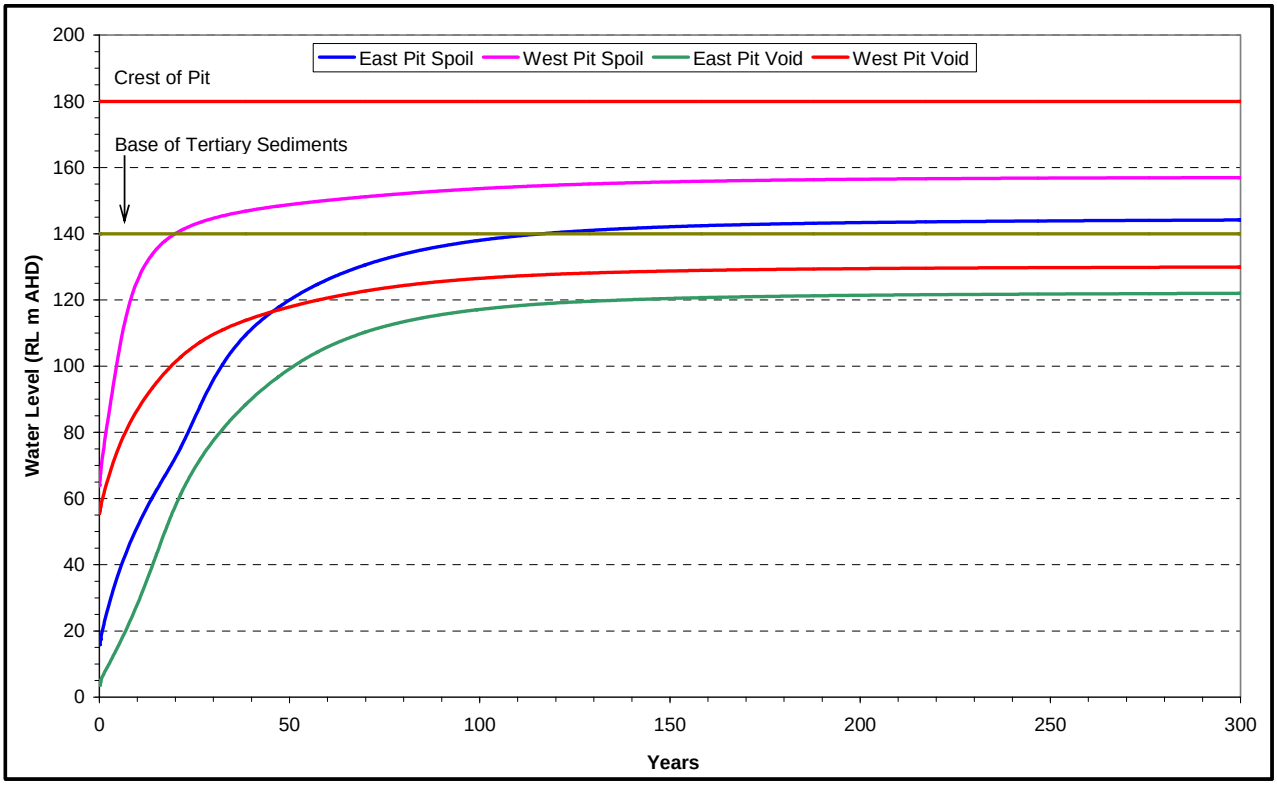

Figure 5: Simulated Water Level in East and West Pits Final Voids and Spoil

The assessment indicates groundwater levels in both the East and West Pit voids show a slow recovery rate with water levels rising to a pseudo-equilibrium level around RL120m in East Pit and RL128m in West Pit after 120 years post mining. Thereafter the water levels still continue to recover but at a very slow rate only reaching RL122m and RL130m in East and West Pit voids respectively after 300 years post mining. Similarly the water levels within the spoil in each pit initially recover relatively quickly to a pseudo-equilibrium level of around RL120m in East Pit spoil and RL149m in West Pit spoil after 50 years post mining. Thereafter the water levels in East Pit spoil rise very slowly to around RL157m and in West Pit to RL144m after 300 years post mining, generally levelling out after around 100 years.

The evaporative pumping effect in conjunction with the slow rainfall recharge potential for this area will result in the final equilibrium recovered void water levels being somewhere between that predicted for West Pit void and spoil water levels, which will probably be close to the base of the Tertiary Sediments. Hence the voids will most likely act as a local sink for groundwater and result in a gradual increase in the salinity of the void water over time. The quality of the water will be controlled by the groundwater seepage quality, leaching of salts from the spoil piles and evaporative concentration of rainfall inputs. The salinity of the water would be expected to be brackish, becoming saline over time. The void will act as a sink for the local groundwater and therefore attract water from the surrounding coal measures, with the hydraulic gradients preventing any migration of pit water back into the coal measures.

4.8 Model Uncertainty and Limitations

This model has been constructed based on limited available data and the use of the model predictions should be treated as such. The uncertainty in the model results can be reduced through the collection of inflow data after mining commences. If significant divergence is observed between the measured and model predicted inflows, revisiting the model and specifically re-calibration of the model parameters against the measured inflow data will reduce uncertainty and provide better predictions for the future. Similarly, a better understanding of the recharge potential from rainfall into the aquifer hosted in the Tertiary sediments would provide for a more accurate correlation between the predicted water levels for the steady state analysis with those measured.

Development, calibration and the results of predictive simulations from any groundwater model are based on available data characterizing the groundwater system under investigation. It is not possible to collect all the data characterizing the whole aquifer system in detail and therefore various assumptions have to be made during development of a groundwater model. A number of assumptions were made during development of the groundwater model described in this report and these assumptions together with their impact on the simulation results are discussed below.

- The model assumed that the hydraulic properties of the Tertiary and coal seam aquifers were uniform across the entire model domain. In reality the permeability of these aquifers would be variable which would result in a less uniform zone of depressurization than that predicted by the numerical model.
- In contrast the model has used variable hydraulic properties for the Rewan and Permian overburden and interburden sequences determined from a constant transmissivity value divided by the overall depth of these sequences within the model. This means the shallower sequences nearer the mine site have a higher permeability value than those located further to the south-west where these sediments are deeper and hence thicker. In reality such variability in hydraulic properties is more likely to be a function of depth below ground level where the extent and number of secondary permeability features such as faults and joints decline with depth as the rock becomes more competent.
- The lack of historical groundwater level and baseflow records for the water courses in the area meant only a steady state calibration could be undertaken.

5.0 POTENTIAL IMPACT OF PROJECT ON GROUNDWATER REGIME AND MITIGATION OPTIONS

Based on this revised mine plan, the project development will only intersect groundwater within the Codrilla A MLA, and not along the haul road alignment Options 1 to 3 within the Codrilla B MLA. This being the case, the haul road alignment is not considered to have any impact on groundwater and hence discussion hereafter on potential impacts on the groundwater regime from the project is limited to that within the Codrilla A MLA.

5.1 Groundwater Inflow to Mine and Control Strategies

The numerical modelling indicates inflows to the East Pit will initially be around 35L/s (3.1ML/day) and will increase up to about 65L/s (5.6ML/day). Similarly, predicted inflows to the West Pit will initially be around 14L/s (1.2ML/day) and will increase up to about 38L/s (3.3ML/day). However, the actual volumes of water pumped from each section of the mine will likely be less than these

volumes predicted as some water will be removed as moisture with the coal and some will be lost by evaporation from the open working face. These losses may represent up to about 40%. This being the case, inflows would only be expected to become an issue once they exceed those potential losses (through evaporation and overburden, interburden and coal moisture content) after the second year of mining for each pit.

Groundwater inflow to the open working highwall sections of the mine should be controlled by strategically located sumps and pumped to surface storages. The water will be of poor quality as discussed, but consideration could be given to using it in the CHPP and for dust suppression.

5.2 Groundwater Levels and Regional Impact

The mine development and operation will depressurise the Tertiary, deeper Triassic/ Permian and coal seam aquifers by groundwater inflows into the East and West Pits which will lower the elevation of the piezometric surface of these aquifers and create a cone of depression around the mine. The model simulated extent of the cone of depression in the overburden at the end of mining is shown on Drawing No. 9A. The drawdown due to mining is shown in Drawing No. 10A.

The drawings indicate that the zone of significant drawdown at the end of mining (i.e., greater than 5m) is limited to the area immediately surrounding the East and West Pits. That is, a generally steep drawdown curve develops a cone of depression up to approximately 4km radius of the northern, southern, eastern and western extents of the mined area. Based on these simulated drawdown levels, the extent of impact on groundwater levels is more prevalent on a local scale immediately adjacent to the mine site, but less so on a regional scale. As there are no other mines within the regional extents of the study area, there will be no cumulative drawdown impacts on the regional aquifer.

It is possible the extent of the simulated drawdown could be less than that predicted, as the numerical model does not include faulting on a local scale which could act as additional hydraulic barriers and limit the effects of aquifer drawdown.

5.3 Impact on Existing Farm Bores

As discussed in Section 4.3, there are no operational domestic or stock bores within or adjacent to the proposed mining lease area. Therefore no water supply bores will be affected by the lowering of water levels predicted.

5.4 Impact on Environmental Values

The Groundwater Impact Assessment for this project has identified that there are no groundwater dependent ecosystems that are likely to be impacted by the Codrilla Coal Project. Any vegetation that extracts groundwater is likely to intersect the alluvial aquifer associated with Devlin Creek. The groundwater level in the alluvial aquifer is around 15m higher (more elevated) than the deeper Tertiary, Triassic/Permian and coal seam aquifers and there is no direct hydraulic interconnection between these aquifers. On the basis that the alluvial aquifer is perched and shows no signs of hydraulic interconnection with the underlying saline aquifers, and will not be intersected by the mine operation open pits, it is unlikely that the alluvial aquifer will be affected by the mining operation.

The only environmental value for the groundwater that could be suitable for the proposed Codrilla Coal Project operation would be that for industrial use. Impact on the saline aquifers will not affect this environmental value as there are no other nearby users of this saline groundwater. The Groundwater Impact Assessment for this project has identified that no other obvious environmental values for groundwater were identified in the project area, due to the poor water quality and low bore yields.

5.5 Groundwater Contamination

The potential for groundwater contamination may occur from the following sources:

- rejects disposal, workshops, waste disposal – Tertiary, Triassic/Permian and coal seam aquifers;
- mining – coal seam aquifer.

There is potential for spills and contamination by metals and hydrocarbons from mine workshop, waste disposal and fuel storage areas; however adequate bunding and immediate clean-up of spills which is standard practice or a legislated requirement at mine sites, should prevent contamination of shallow groundwater system. Any spills from these areas are typically very localised and not regionally significant.

In assessing the potential impact, reference is made to the geochemical assessment report prepared by GSS Environmental (2010). GSS Environmental has geochemically characterised overburden, interburden and potential coal reject material from the proposed mine project and concluded that:

5.4.1 Overburden

The results from the Acid Base testing indicates that *the overburden material will initially generate neutral to slightly alkaline runoff and seepage due to the current pH of the material. All overburden samples had very low sulphur content and are considered inert. The acid neutralising capacity generally exceeded the maximum potential acidity for overburden samples indicating that the material has sufficient buffering capacity to neutralise the small amount of acidity that may be generated from sulphide oxidation. All overburden samples were classified as non acid forming.*

The salinity levels of the runoff and seepage water is expected to be moderate. This may cause some vegetation species to be slower growing once the roots penetrate the moderately saline overburden material. Over time it is expected that salinity levels near the surface layers of overburden will lower due to leaching further into the dump profile. Water management structures such as dams should be monitored for salinity levels and appropriate management and release actions should be followed.

The presence of extremely sodic material throughout the overburden profiles gives rise to the need for implementing appropriate erosion and sediment controls on site prior to and during the development of the overburden emplacements. This sodic material is prone to severe surface crusting, gully erosion and tunnelling.

5.4.2 Reject Material

CHPP reject is to be stored in the main in a co-disposal facility, that is, the coarse and fine reject streams will be combined at the CHPP and pumped as slurry to the disposal area. The excess water that drains from the matrix of reject solids will be recovered and returned to the process water circuit. There may be localized low pH seepage but based on the NAPP results the return water is not expected to be generally acidic.

In the context of rehabilitation, the CHPP reject appears to be not particularly saline but poor fertility and combustion risk (from the included coal) dictate that an inert cover will be necessary.

Considering the conclusion reached by GSS Environmental (2010), it is considered unlikely that leachate generated from these materials will adversely impact groundwater quality. As discussed the groundwater quality in the overburden and coal seam aquifers is poor (saline) and would only be suitable for limited industrial use. Based on the results of this geochemical characterisation, interaction between in pit disposal of overburden, interburden and potential coal rejects material with recovering (rising) groundwater levels and surface water (rainfall) runoff is not considered likely to result in poorer quality water in the Tertiary and Permian sediment aquifer systems following cessation of mining.

5.6 Fitzroy Water Resource Plan and Regulations

The project area falls in the Water Resource (Fitzroy Basin) Plan 1999, which applies to waters in watercourses and lakes, water in springs and overland flow water and does not apply to groundwater resources. However, the project is located in the Highlands Sub-artesian Area which is a declared sub-artesian area where any development works:

- that take or interfere with sub-artesian water, other than for domestic purposes or for stock watering, require a water entitlement, water permit or seasonal water assignment notice;
- are assessable development under the Sustainable Planning Act 2009 for taking sub-artesian water other than domestic purposes or for stock watering.

Similarly, the Queensland Government Water Regulation 2000 Moratorium Notice which regulates the Isaac River and Connors River Catchment in relation to the Highland Declared Area states that new applications to take sub-artesian water will not be accepted, except for applications to take sub-artesian water for mine dewatering purposes, or for a significant project as declared under Section 26 of the State Development and Public Works Organization Act 1979.

This being the case, the project will require both a water licence and a development permit to take or interfere with groundwater associated with the Tertiary and Permian sediments.

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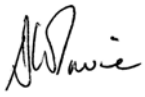
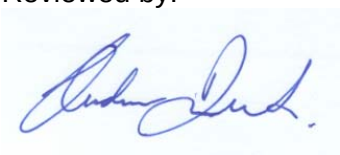
Reviewed by:





DUNCAN W. IRVINE
Senior Hydrogeologist

ANDREW M. DURICK
Principal Modeller/Senior Hydrologist

LIMITATIONS OF REPORT

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has prepared this report for the use of Bowen Basin Coal Joint Venture in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 8 March 2011.

The methodology adopted and sources of information used by AGE are outlined in this report. AGE has made no independent verification of this information beyond the agreed scope of works and AGE assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to AGE was false.

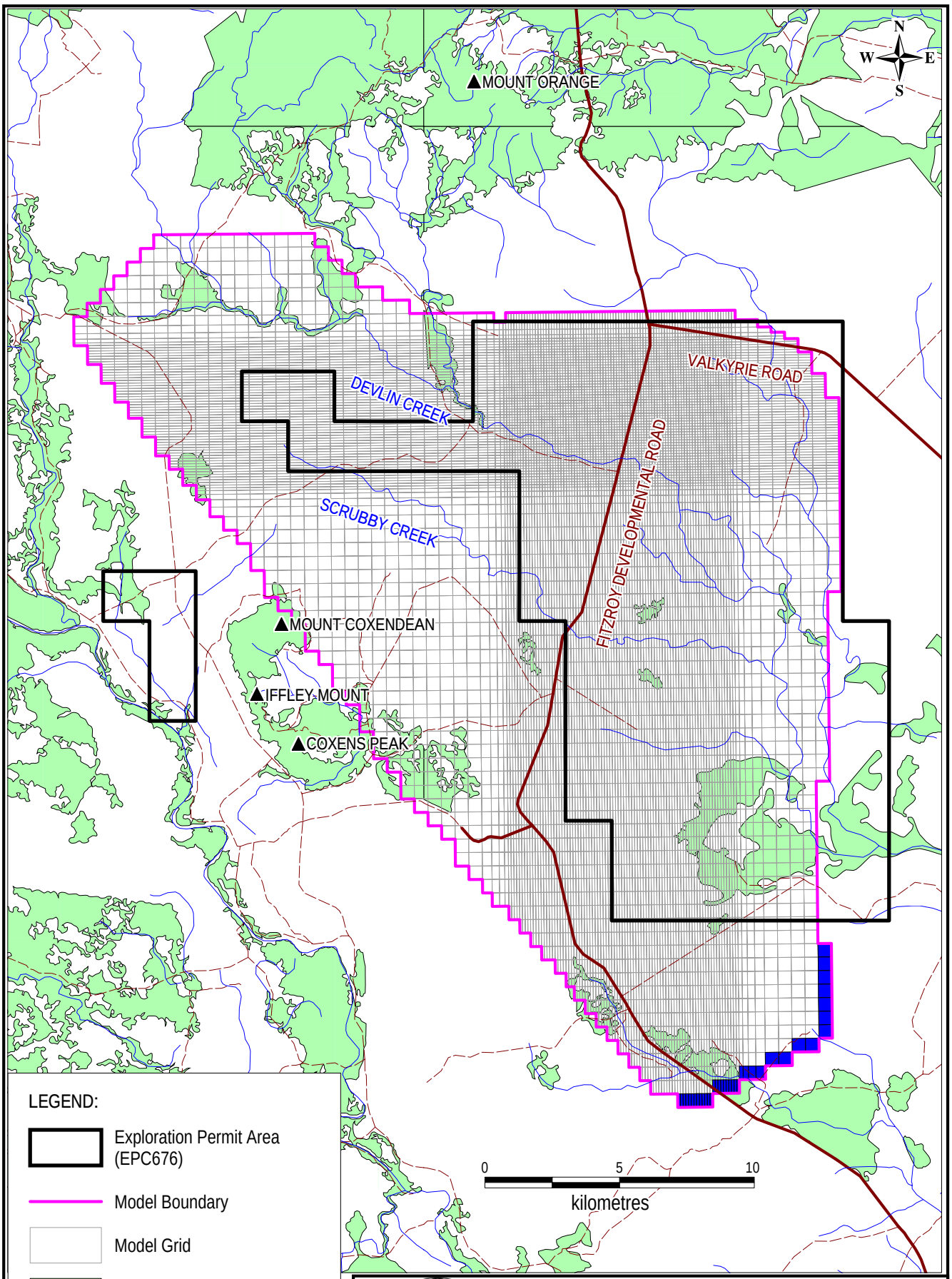
This study was undertaken between 11 February 2011 and 29 April 2011 and is based on the conditions encountered and the information available at the time of preparation of the report. AGE disclaims responsibility for any changes that may occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. It may not contain sufficient information for the purposes of other parties or other users. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing and other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment. Where borehole logs are provided they indicate the inferred ground conditions only at the specific locations tested. The precision with which conditions are indicated depends largely on the frequency and method of sampling, and the uniformity of the site, as constrained by the project budget limitations. The behaviour of groundwater is complex. Our conclusions are based upon the analytical data presented in this report and our experience.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, AGE must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge, information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.



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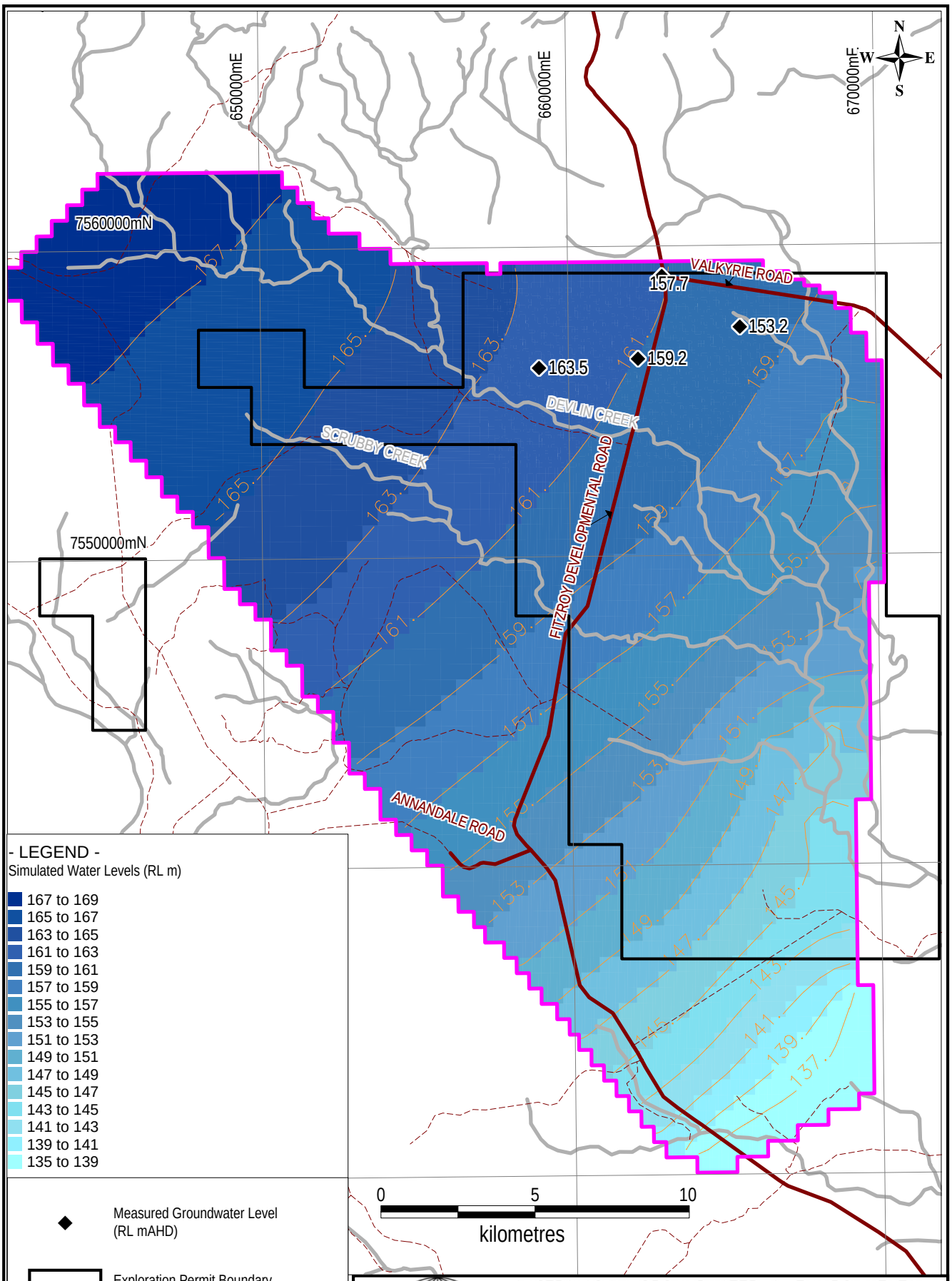
TITLE: CODRILLA COAL PROJECT ADDENDUM REPORT
REVISED MINE PLAN AND NUMERICAL MODELLING RERUN
MODFLOW MODEL GRID

CLIENT: Bowen Basin Coal Joint Venture			OFFICE: Brisbane
DRAWN BY: VER	SCALE: 1 : 200,000 (A4)	PROJECT No: G1471A	DRAWING No: 6A
APPROVED BY:		DATE: April 2011	



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SIMULATED VS OBSERVED PRE-MINING WATER LEVELS

CLIENT: Bowen Basin Coal Joint Venture			OFFICE: Brisbane
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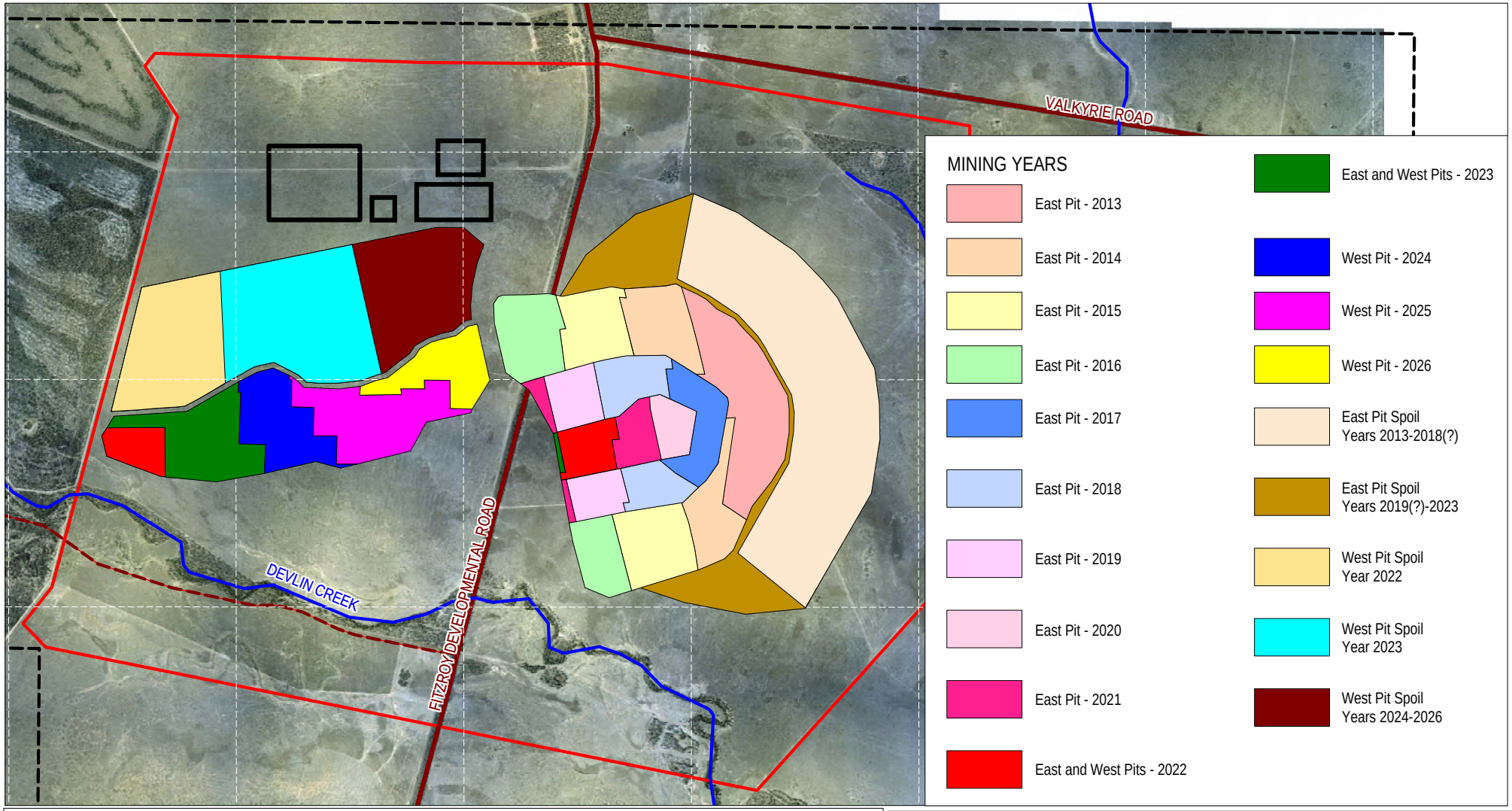

LEGEND:

- Quaternary Alluvium
- Exploration Permit Boundary (EPC676)
- Mine Infrastructure
- Proposed Mining Lease Area
- Sealed Roads
- Unsealed Roads/Tracks
- Fitzroy Development Road Realignment

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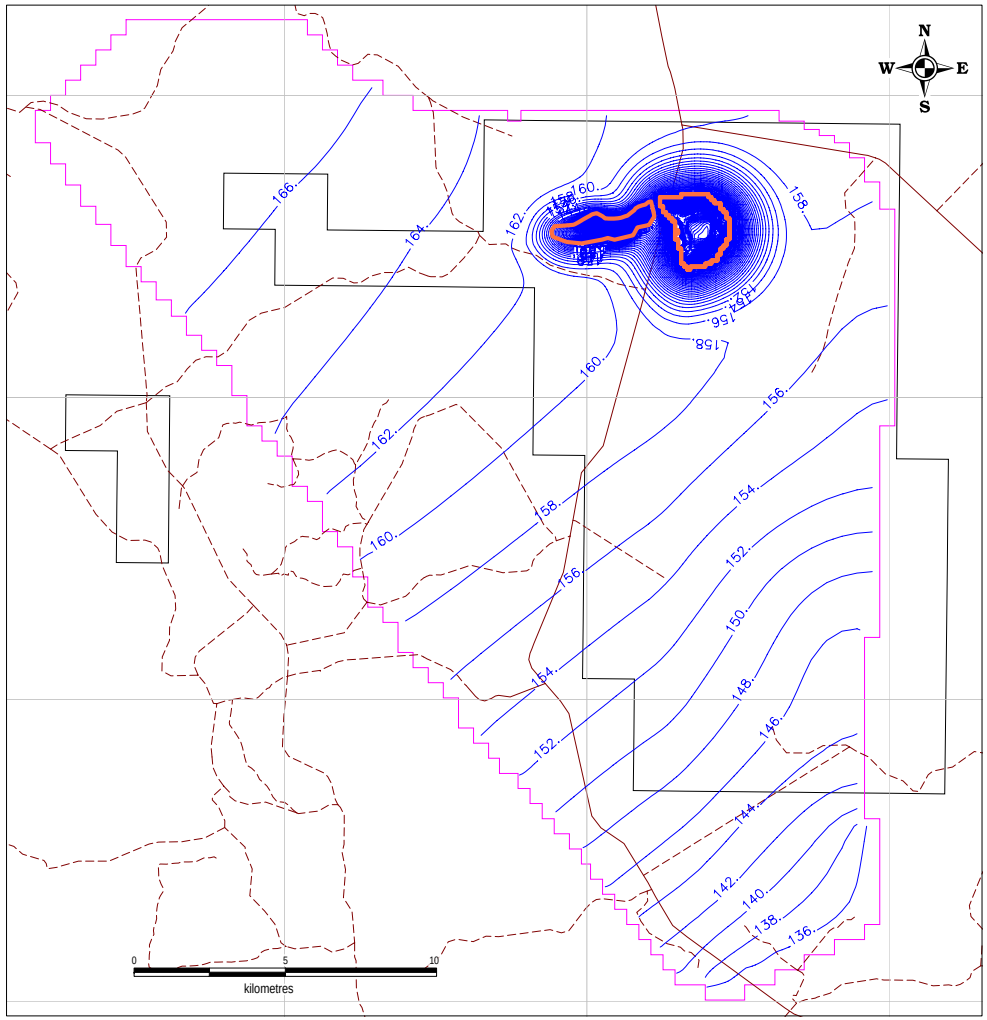
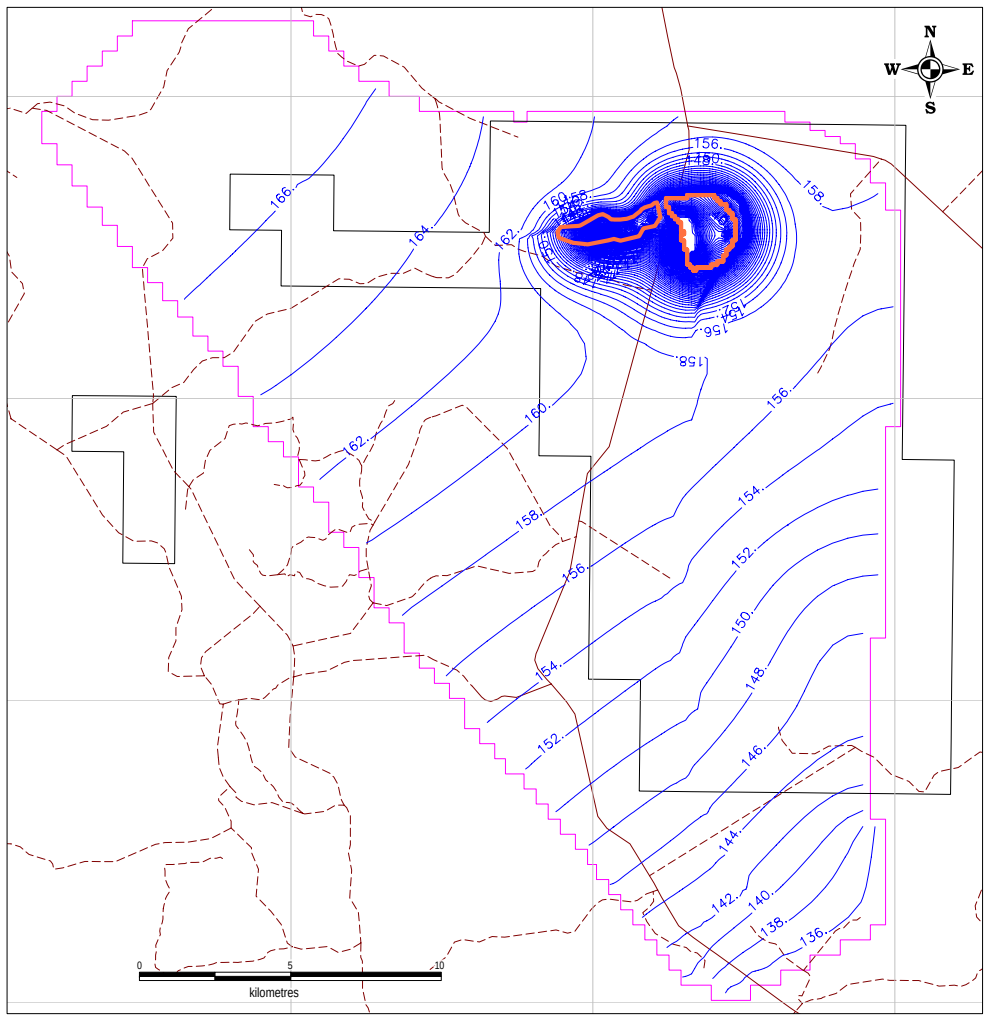
TITLE: CODRILLA COAL PROJECT ADDENDUM REPORT
REVISED MINE PLAN AND NUMERICAL MODELLING RERUN
MINE DEVELOPMENT PLAN

CLIENT: Bowen Basin Coal Joint Venture			OFFICE: Brisbane
DRAWN BY: DWI	SCALE: 1:50,000 (A4)	PROJECT No: G1471A	DRAWING No: 8A
APPROVED BY:		DATE: April 2011	

GROUNDWATER CONTOURS AT THE END OF MINING YEAR 2026 - TERTIARY SEDIMENTS



GROUNDWATER CONTOURS AT THE END OF MINING YEAR 2026 - VERMONT COAL SEAM



- LEGEND -

Exploration Permit Boundary (EPC676)

Model Boundary

Groundwater Contours

Sealed Roads

Unsealed Roads

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REVISED MINE PLAN AND NUMERICAL MODELLING RERUN
GROUNDWATER LEVEL CONTOURS - 2026 END OF MINING

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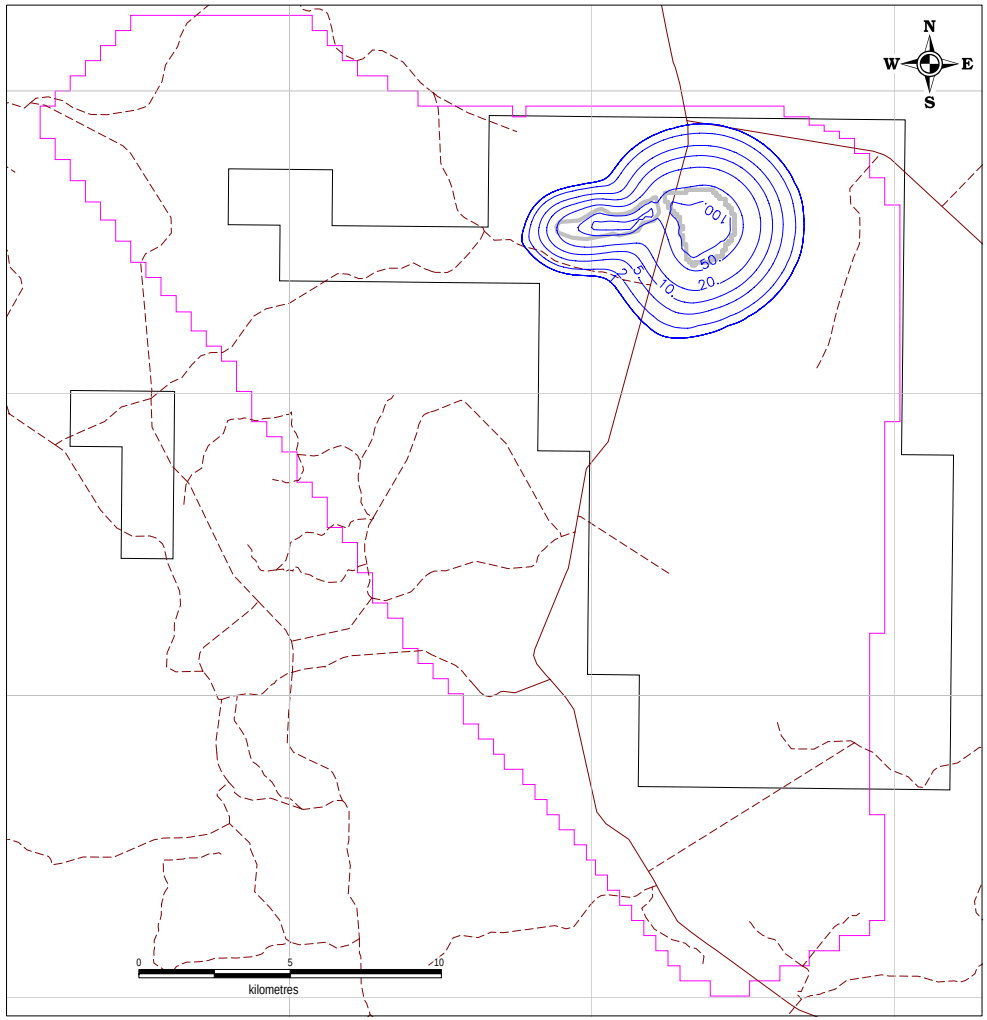
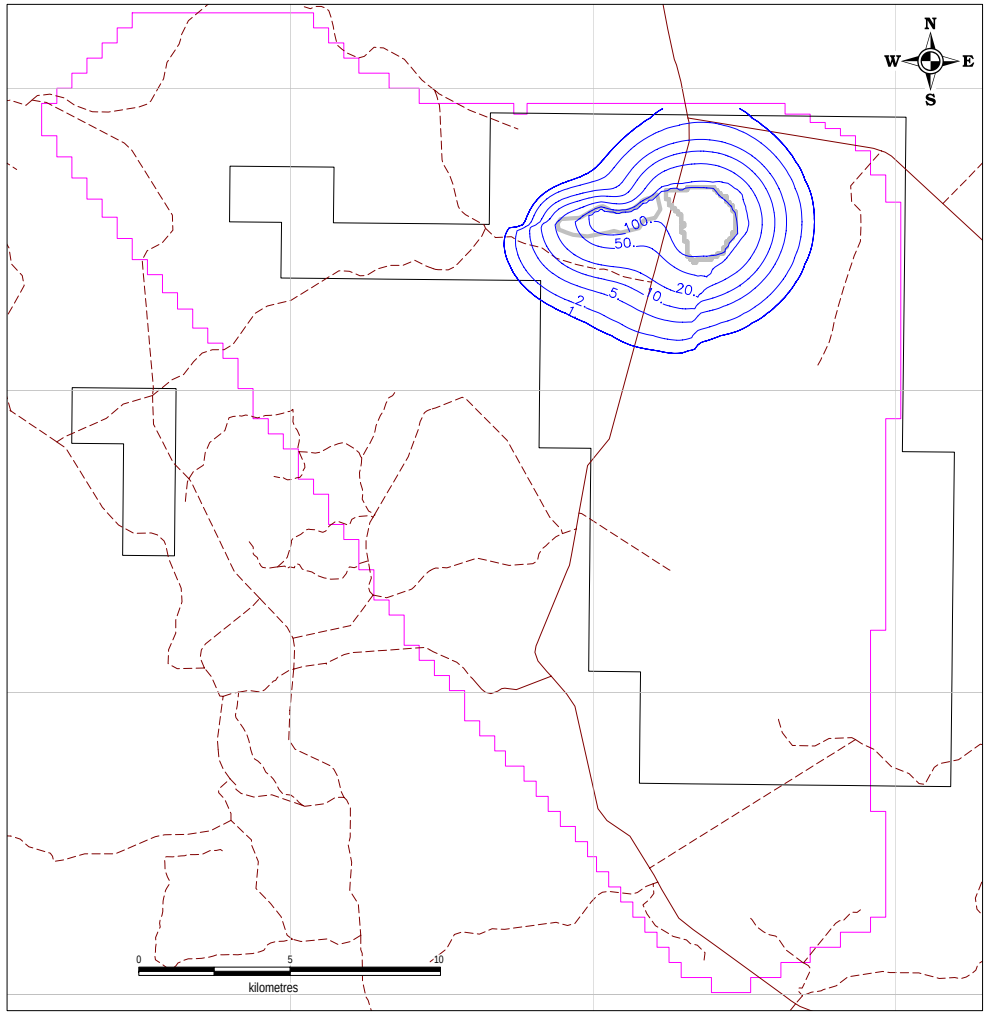
PREDICTED DRAWDOWN AT THE END OF MINING YEAR 2026 - TERTIARY SEDIMENTS



PREDICTED DRAWDOWN AT THE END OF MINING YEAR 2026 - VERMONT COAL SEAM



- LEGEND -

Exploration Permit Area (EPC676)

Model Boundary

Drawdown Contours

Sealed Roads

Unsealed Roads

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REVISED MINE PLAN AND NUMERICAL MODELLING RERUN
PREDICTED DRAWDOWN - 2026 END OF MINING

CLIENT: Bowen Basin Coal Joint Venture			OFFICE: Brisbane
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APPROVED BY:		DATE: April 2011	

Appendix Es

Codrilla Surface Water Assessment – Revised Report

CODRILLA COAL MINE SURFACE WATER IMPACT ASSESSMENT

BOWEN BASIN JOINT VENTURE

June 2011

www.wrmwater.com.au

WRM Water & Environment Pty Ltd
ABN: 96 107 404 544 ACN: 107 404 544
Level 5, Paddington Central,
107 Latrobe Terrace, PO Box 809,
Paddington Qld 4064 Australia
tel +61 7 3367 1279 fax +61 7 3367 1679
www.wrmwater.com.au

REPORT TITLE: Codrilla Coal Mine, Surface Water Impact Assessment
CLIENT: Bowen Basin Joint Venture
REPORT NUMBER: 0577-01-B [Rev 6]

Revision Number	Report Date	Description	Report Author	Reviewer
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0	25 June 2010		SMc	DN/GR
1	2 July 2010		SMc	DN/GR
2	9 September 2010		SMc/MB	DN/GR
3	13 September 2010	Final for EIS	SMc/MB	DN/GR
4	30 May 2011	Updated with revised mine plan & rainfall data for 2010	SMc/MB	DN/GR
5	1 June 2011	Minor revisions	SMc/MB	DN/GR
6	10 June 2011	Updates to downstream flow impacts	SMc/MB	DN/GR

For and on behalf of
WRM Water & Environment Pty Ltd

David Newton
Director

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EXECUTIVE SUMMARY

Introduction

McCollum Environmental Management Services is preparing an Environmental Impact Statement (EIS) for the Codrilla Project; a proposed coal mine located about 125km south-west of Mackay. As part of the EIS, WRM Water & Environment was requested to undertake a flood study and water balance to determine the impact of the proposed mining operations on flooding behaviour and streamflow in Devlin Creek, and its tributaries draining the project area.

Drainage Characteristics

The proposed Codrilla mining operations are located on flat land on the northern side of the Devlin Creek main channel. Devlin Creek is a tributary of the Isaac River. In the area of interest, Devlin Creek has an incised channel and a wide floodplain. The proposed mining operations are also located near Swampy Creek, which is a tributary of Devlin Creek. The Swampy Creek floodplain in the vicinity of the proposed mining operations has a flow capacity in excess of the Probable Maximum Flood discharge for Devlin Creek and will not impact on the proposed mine operations.

Water Quality

Most water quality parameter levels in Devlin Creek (both upstream and downstream of the mining lease) are lower than in the Isaac River. Median pH at all sample locations in the vicinity of the project is within the range of the Regional Guideline Values, but median pH in Swampy Creek is lower than Devlin Creek and the Isaac River. Median turbidity and TSS in Swampy Creek are higher than Devlin Creek. Median Total Nitrogen and Total Phosphorus concentrations at all sites are well in excess of the Regional Guideline Values. 95th percentile concentrations for the majority of metals in Devlin Creek are below the Release Contaminant Trigger Levels. Metals with levels in Devlin Creek naturally above the Release Contaminant Trigger levels include aluminium, uranium, zinc and iron.

Flood Impacts of the Proposed Mine

Hydrologic and hydraulic modelling of the Devlin Creek catchment was undertaken to determine the impact of the proposed Codrilla Project on Devlin Creek flood levels and velocities. The estimated design flood discharges for the Devlin Creek catchment at the proposed site are as follows:

- The 2 year Average Recurrence Interval (ARI) flood event: 70m^3/s;
- The 10 year ARI flood event: 204m^3/s;
- The 100 year ARI flood event: 525m^3/s;
- The 2,000 year ARI flood event: 1078m^3/s; and
- The Probable Maximum Flood (PMF) event: 3483m^3/s.

The results of the hydraulic modelling showed the following:

- The 2 year ARI design flood event is mostly contained within the Devlin Creek main channel and does not impact on the proposed mine footprint.
- The 10 year, 100 year and 2,000 year ARI design flood events will not impact on the eastern pit and overburden dump footprints of the proposed mine. However, the

proposed mine infrastructure area on the eastern side of Fitzroy Developmental Road is subject to partial backwater flooding during all events of 100 year ARI and larger.

- The western end of the open cut pit footprint is subject to partial backwater flooding during all events of 10 year ARI and larger. For the 100 year ARI flood event the maximum inundation depth within the pit footprint is approximately 1.4m.
- Flood plain velocities in the vicinity of the western pit and overburden dump range from approximately 0.1m/s to 0.9m/s for the 2 year to 2,000 year ARI flood events. Channel velocities in an unnamed tributary of Devlin Creek in the vicinity of the western pit and overburden dump range from approximately 0.5m/s to 1.1m/s for the 2 year to 2,000 year ARI flood events.
- Devlin Creek channel velocities range from approximately 0.8m/s to 2.5m/s upstream of Fitzroy Developmental Road and approximately 0.9m/s to 2.0m/s downstream of Fitzroy Developmental Road for the 2 year to 2,000 year ARI flood events.
- The PMF levels range from approximately 0.5m to a maximum of 1.5m higher than the 2,000 year ARI flood event. The PMF will inundate part of the western and eastern pit footprints as well as part of the eastern mine infrastructure area.

Two levees will be constructed to prevent flooding of the western pit footprint and the eastern mine infrastructure. The levee crest elevations will be set at the 2,000 year ARI flood level plus 0.5m (for the western levee this is between 180.1m AHD and 182.3m AHD, and for the eastern levee this is between 174.1m AHD and 175.7m AHD).

The proposed levee was included in the hydraulic model and the results showed the following impacts:

- The proposed levees prevent the inundation of the western pit and overburden dump and proposed mine infrastructure.
- The 2 year ARI design flood does not impact on the proposed mine. Therefore there is no change in flood depths resulting form the construction of the levees.
- There are no significant changes to flood depths for the 10 year ARI design flood resulting from the construction of the proposed levees. Any increases in flood level are limited to 0.1m.
- There are minor increases in flood depths for the 100 year ARI design flood resulting from the construction of the proposed levees. The flood depths have increased by a maximum of 0.2m and are concentrated near the upstream side of the western levee.
- There are localised increases in flood depth for the 2,000 year ARI design flood resulting from the construction of the proposed levees. The majority of the increases are less than 0.4m however, there is a small area immediately upstream of the proposed western levee where flood depths have increased by more than 0.4m.
- There is no significant change in flood velocities in Devlin Creek for the 2 year, 10 year, 100 year and 2,000 year ARI design floods as a result of the proposed levee. There are some increases in flood velocities (up to 0.5m/s for the 2,000 year ARI flood event) adjacent to the proposed levees.

<u>Site Water Management System and Site Water Balance</u>

The proposed mine operations will significantly change the drainage characteristics of the minor gullies crossing the mining area. Runoff from undisturbed areas will generally be diverted around the operational areas where possible. Runoff from disturbed areas will be captured in the site water management system.

Runoff collected in the pits will be pumped to one of three environmental dams for later reuse for dust suppression or in the Coal Handling and Preparation Plant (CHPP). During mining of the East Pit, additional pit water storage capacity is to be provided in a temporary pit water storage to be constructed by excavating ahead of mining within the proposed West Pit mining area. The temporary dam will be decommissioned before the West Pit advances to within close proximity. During mining of the West Pit, excess pit water would be stored in the East Pit void.

The environmental dams have been sized using a water balance model to ensure that under historical conditions it would be possible to contain all pit and plant runoff without discharge. Under the high runoff scenario, the temporary pit water storage volume required to achieve this is 2600ML.

If water quality and receiving water conditions allow, excess water could potentially be released from the site via controlled discharges from water storages. However historical simulation water balance modelling indicates that this should not be necessary if the water management system is implemented as proposed. When operated in this way, the risk of discharge from sediment dams over the project life is low. This approach is consistent with the intent of current drafts of DERM's Model Environmental Authority Conditions for Coal Mines in the Fitzroy Basin and the Manual for Assessing Hazard Categories of Dams. During dry periods, when the yield from the site water management system is low, water will need to be imported to meet supply shortfalls.

Impacts of the Proposed Project on Local Drainage Characteristics

The proposed water management system will have a significant impact on flows in the very small tributaries leaving the site. However, the impact on flows in the watercourses further downstream will be much smaller. In Devlin Creek, just downstream of the Swampy Creek confluence, the modelled median annual flow is predicted to be reduced by 7.0% in 2015 and by 10.8% when the mine footprint is largest.

Surface Water Monitoring

A surface water monitoring program will be implemented for the Codrilla Project to demonstrate the effectiveness of site water management in ensuring that mining operations do not have an adverse impact on the environmental values of receiving waters. The surface water monitoring program will include monitoring of flows in Devlin Creek, as well as water quality upstream and downstream of the mine along Devlin Creek and Swampy Creek.

TABLE OF CONTENTS

Page

1 INTRODUCTION 1

2 DRAINAGE NETWORK 3

2.1 EXISTING DRAINAGE NETWORK 3
2.1.1 Catchment Characteristics 3
2.1.2 Devlin Creek Channel and Floodplain Characteristics 5
2.1.3 Swampy Creek Channel and Floodplain Characteristics 5
2.1.4 Site Drainage Characteristics 6
2.2 IMPACTS OF MINING OPERATIONS 8

3 CLIMATIC CONDITIONS 9

3.1 RAINFALL & EVAPORATION 9
3.2 2010/11 WET SEASON RAINFALLS 10
3.3 STREAMFLOW 11

4 SURFACE WATER QUALITY 12

4.1 ENVIRONMENTAL VALUES & WATER QUALITY OBJECTIVES 12
4.2 WATER QUALITY DATA 12

5 EXISTING WATER USE ENTITLEMENTS 17

6 ESTIMATION OF DEVLIN CREEK DESIGN DISCHARGES 18

6.1 OVERVIEW 18
6.2 MODEL DESCRIPTION 18
6.3 MODEL CONFIGURATION 18
6.4 DESIGN RAINFALL DEPTHS & PROBABLE MAXIMUM PRECIPITATION 19
6.5 AREAL REDUCTION FACTORS 19
6.6 MODEL CALIBRATION 21
6.6.1 Methodology 21
6.6.2 Rational Method Discharge 21
6.6.3 Flood Frequency Analysis 22
6.6.4 URBS Model Parameters 23
6.7 ADOPTED DESIGN DISCHARGES 24

7 ASSESSMENT OF DEVLIN CREEK FLOOD IMPACTS 25

7.1 MODELLING OVERVIEW 25
7.2 TUFLOW MODEL CONFIGURATION 25
7.2.1 Existing Conditions Configuration 25
7.2.2 Adopted Manning's 'n' Values 26
7.2.3 Inflow and Outflow Boundaries 27

7.2.4 Existing Hydraulic Structures 27
7.3 EXISTING FLOOD LEVELS 28
7.4 FLOOD IMPACTS OF THE PROPOSED MINE 33
7.5 PROBABLE MAXIMUM FLOOD 39

8 SITE WATER BALANCE 41

8.1 OVERVIEW 41
8.2 MODELLED STAGING OF MINE PLAN 42
8.3 CATCHMENT AREAS 49
8.4 CLIMATE DATA AND RAINFALL-RUNOFF MODEL 50
8.5 PIT GROUNDWATER INFLOWS 52
8.6 ENVIRONMENTAL DAM AND SEDIMENT DAM SIZES 54
8.7 OPERATING RULES 54
8.7.1 Pit Water System 54
8.7.2 Sediment Dam Collection System 55
8.8 SITE WATER DEMANDS 56
8.9 MODEL RESULTS 58
8.9.1 Pit Water Management System Performance 58
8.9.1 Sediment Dam Collection System Performance 60
8.9.2 Overall Site Water Balance 63
8.9.3 Impacts on Flows In Local Catchments 64
8.10 PROVISION FOR EMERGENCY RELEASES 64

9 SURFACE WATER MONITORING PLAN 66

9.1 OVERVIEW 66
9.2 WATER QUALITY MONITORING LOCATIONS 66
9.3 WATER QUALITY MONITORING SCHEDULE 68

10 SUMMARY OF FINDINGS 69

11 REFERENCES 71

APPENDIX A WATER QUALITY SAMPLING RESULTS 73

APPENDIX B FLOOD VELOCITY MAPS 78

LIST OF TABLES

		Page
Table 2.1	Local (Pre Mine) Catchment Characteristics	3
Table 3.1	Details of Rainfall Stations in the Area of Interest	9
Table 3.2	Mean Monthly Rainfall and Evaporation in the Area of Interest	10
Table 3.3	Annual Rainfall and Runoff Volumes for Devlin Creek Catchment	11
Table 4.1	Recorded Water Quality Data, Swampy Creek, Devlin Creek & Isaac River	16
Table 6.1	Devlin Creek URBS Model Sub-Catchment Areas	18
Table 6.2	Devlin Creek Catchment Rainfall Depths	19
Table 6.3	Devlin Creek Catchment Areal Reduction Factors	19
Table 6.4	Devlin Creek Rational Method Parameters	21
Table 6.5	Recorded Peak Flood Discharges, Devlin Creek at Bombandy	22
Table 6.6	Flood Frequency Analysis, Devlin Creek at Bombandy	22
Table 6.7	Adopted URBS Model Global Parameters	23
Table 6.8	Adopted URBS Model Losses	23
Table 6.9	Adopted Devlin Creek Design Discharges at Downstream Lease Boundary	24
Table 7.1	Adopted Manning's 'n' values	27
Table 7.2	Adopted Design Discharges at Inflow Boundaries	27
Table 7.3	Fitzroy Developmental Road Culvert Data	27
Table 7.4	Change in Flood Depth, Various Locations around the Proposed Levees	34
Table 8.1	Site Catchment Areas and Types (Stage 5)	49
Table 8.2	Total Catchment Areas	49
Table 8.3	AWBM Model Calibration Results – Devlin Creek at Bombandy	50
Table 8.4	Adopted AWBM Model Parameters – Low Runoff	50
Table 8.5	Adopted AWBM Model Parameters – High Runoff	51
Table 8.6	Dam Capacities	54
Table 8.7	Pit Water Management System Operating Volumes (ML)	54
Table 8.8	Sediment Water Management System Operating Volumes (ML)	55
Table 8.9	Demand Summary	56
Table 8.10	Areas adopted for dust suppression demand estimates	57
Table 8.11	Pit Water Management System Performance	58
Table 8.12	Total Site Water Balance – Mean of all 14 year sequences - High runoff case	63
Table 8.13	Total Site Water Balance – Mean of all 14 year sequences- Low runoff case	63
Table 8.14	Reduction in flows in local catchments	64
Table 8.15	Estimated 20th Percentile Trigger Flows (from DERM streamflow records)	65
Table 9.1	Existing & Recommended Water Quality Monitoring Sites	66
Table 9.2	Release Event Water Quality Monitoring Schedule	68
Table 9.3	Storage Monitoring Schedule	68

LIST OF FIGURES

		Page
Figure 1.1	Codrilla Coal Mine Project Locality	2
Figure 2.1	Local Drainage Network	4
Figure 2.2	Devlin Creek Channel in the Vicinity of the Fitzroy Developmental Road Crossing	5
Figure 2.3	Cross Section of Swampy Creek Channel & Floodplain in the vicinity of the Eastern Overburden Dump	7
Figure 3.1	Distribution of Monthly Rainfall (Nebo Shire Council) and Evaporation (Moranbah Water Treatment Plant)	10
Figure 4.1	Location of Water Quality Sampling Sites	14
Figure 4.2	Variation in Electrical Conductivity with Discharge	15
Figure 6.1	Devlin Creek URBS Model Configuration	20
Figure 6.2	Flood Frequency Distribution, Devlin Creek at Bombandy	23
Figure 7.1	TUFLOW Model Configuration	26
Figure 7.2	2 Year ARI Flood Depths, Devlin Creek	29
Figure 7.3	10 Year ARI Flood Depths, Devlin Creek	30
Figure 7.4	100 Year ARI Flood Depths, Devlin Creek	31
Figure 7.5	2,000 Year ARI Flood Depths, Devlin Creek	32
Figure 7.6	Change in Flood Depth, 2 Year ARI, Devlin Creek	35
Figure 7.7	Change in Flood Depth, 10 Year ARI, Devlin Creek	36
Figure 7.8	Change in Flood Depth, 100 Year ARI, Devlin Creek	37
Figure 7.9	Change in Flood Depth, 2,000 Year ARI, Devlin Creek	38
Figure 7.10	Probable Maximum Flood Depths, Devlin Creek	40
Figure 8.1	Codrilla Coal Project, Stage 1 (2013 to 2014)	43
Figure 8.2	Codrilla Coal Project, Stage 2 (2015 to 2020)	44
Figure 8.3	Codrilla Coal Project, Stage 3 (2021 to 2022)	45
Figure 8.4	Codrilla Coal Project, Stage 4 (2023)	46
Figure 8.5	Codrilla Coal Project, Stage 5 (2024 to 2027)	47
Figure 8.6	WMS Schematic Diagram	48
Figure 8.7	Simulated Groundwater Seepage (after AGE, 2010)	52
Figure 8.8	Net Pit Groundwater Inflow	53
Figure 8.9	ED1 Behaviour – Project Commencing 1982 (High Runoff)	58
Figure 8.10	Environmental Dam Storage Volume – Probability of exceedance (High Runoff)	59
Figure 8.11	In-pit stored water volume	59
Figure 8.12	Sediment Dam SD4 Behaviour – Project Commencing 1982 (High Runoff)	60
Figure 8.13	Sediment Dams – Number of Discharge Days over 13 Years – High Runoff	61
Figure 8.14	Sediment Dams – Number of Discharge Days over 13 Years – Low Runoff	61

Figure 8.15 Sediment Dam Total Discharge Volume over 13 years – High Runoff 62

Figure 8.16 Sediment Dam Total Discharge Volume over 13 years – Low Runoff 62

Figure 8.17 Recorded Frequency Curves for 20th Percentile Trigger Flows (mm/d - no-flow days excluded) 65

Figure 9.1 Locations of Water Quality Monitoring Stations 67

1 INTRODUCTION

McCollum Environmental Management Services is preparing an Environmental Impact Statement (EIS) for the Codrilla Project, a proposed coal mine located about 125km south-west of Mackay. As part of the EIS, WRM Water & Environment was requested to undertake a flood study and water balance to determine the impact of the proposed mining operations on flooding behaviour in Devlin Creek and its tributaries, that drain the area of interest. Figure 1.1 shows the location of the proposed Codrilla Project.

To undertake the flood study, a TUFLOW two dimensional hydraulic model was developed of Devlin Creek and its floodplain for existing conditions and with the proposed mine infrastructure in place. This report presents the methodology and results of the flood study and water balance, provides an overview of surface water resources in the vicinity of the project and defines potential surface water impacts of the Codrilla Project. This report supersedes the previous version of the report (Revision 3, 13 September 2010) which was originally submitted with the EIS. This revision incorporates updated water balance modelling to include recent climate data, as well as changes to the mine plan.

This report is structured as follows.

- Section 2 describes the characteristics of the Devlin Creek catchment and the local drainage characteristics of the channel and floodplain in the vicinity of the proposed mining operations as well as potential impacts of the mining operations.
- Section 3 describes the climatic conditions of the Devlin Creek catchment, including rainfall and evaporation patterns and available streamflow data.
- Section 4 describes the surface water quality of the Devlin Creek catchment, upstream and downstream of the proposed mining lease boundary.
- Section 5 discusses the existing water use entitlements in the Devlin Creek catchment.
- Section 6 presents the methodology and results of the hydrological modelling undertaken to determine design flood discharges for the Devlin Creek catchment.
- Section 7 presents the methodology and results of the hydraulic modelling undertaken to determine design flood levels, flood extents and flood velocities for existing and proposed mine conditions.
- Section 8 presents the methodology and results of the water balance modelling undertaken to assess the performance of the proposed water management system in controlling runoff from disturbed areas.
- Section 9 outlines a surface water monitoring plan.
- Section 10 summarises the findings of the study.
- Section 11 is a list of references.
- Appendix A provides surface water quality sampling results.
- Appendix B provides maps that show the existing conditions and changes in velocities at the study area for the range of flood events investigated.

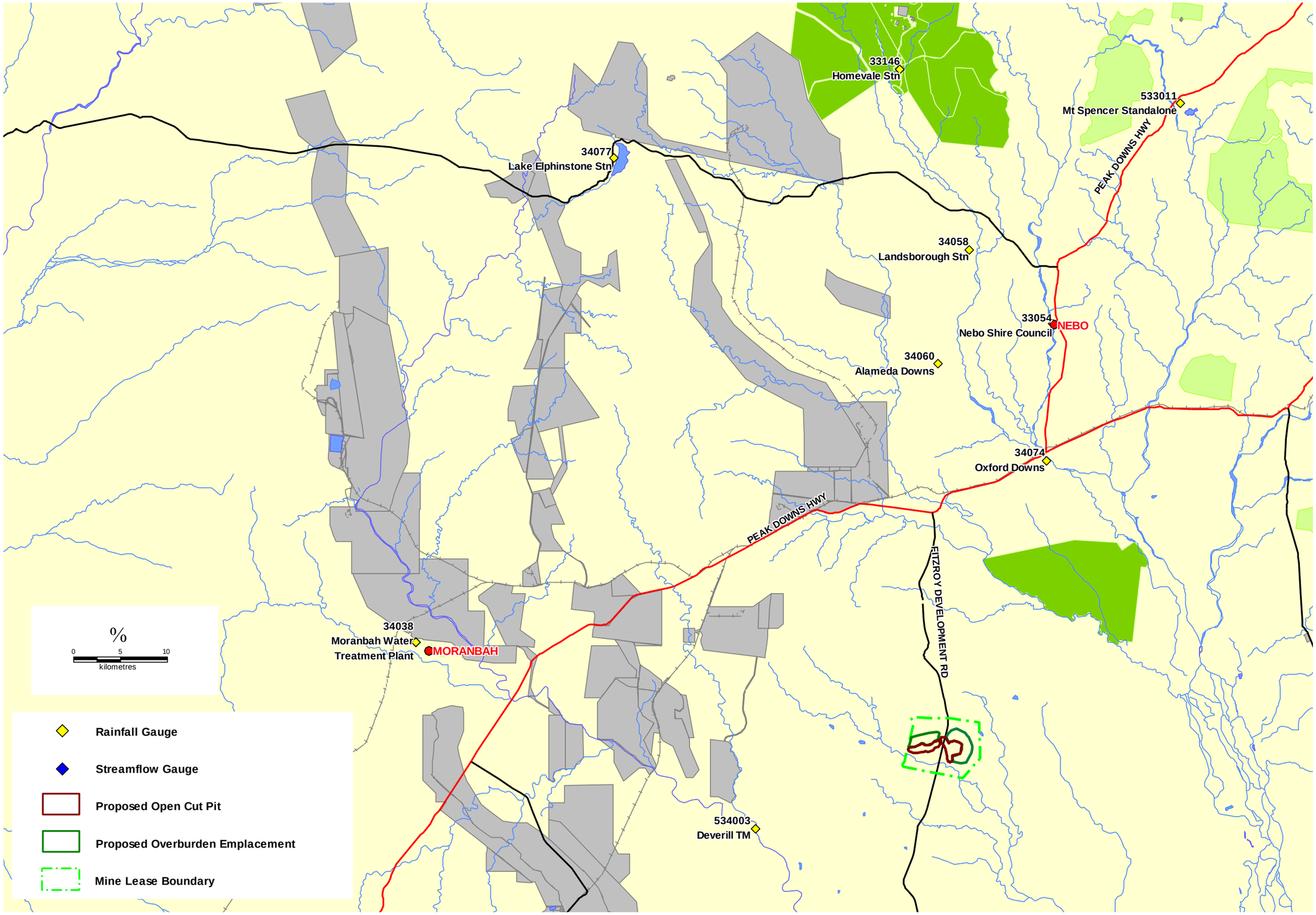

Figure 1.1 Codrilla Coal Mine Project Locality

2 DRAINAGE NETWORK

2.1 EXISTING DRAINAGE NETWORK

2.1.1 Catchment Characteristics

Figure 2.1 shows the proposed location of Codrilla Project mining operations. The site is located on flat land on the northern side of Devlin Creek, to the west of its south-flowing tributary Swampy Creek. Devlin Creek flows in a south-easterly direction adjacent to the proposed mine and discharges to the Isaac River approximately 38km to the south-east. Devlin Creek has a total catchment area of over 1,200km^2 of which, approximately 260km^2 is upstream of the Codrilla Project's eastern mining tenement boundary.

The Devlin Creek catchment incorporates a number of tributaries, including Swampy Creek, Bundarra Creek, Birdies Gully, Duck Creek, Scrubby Creek, and South Creek. A significant proportion of the catchment has been cleared for grazing, with some areas of remnant vegetation remaining in the upper catchment. The Moorvale Mine is located in the upper headwaters of Devlin Creek.

The flow characteristics of the catchments shown in Figure 2.1 are summarised in Table 2.1 below. The median annual flow has been estimated based on the results of a catchment modelling using the Australian Water Balance Model (AWBM) (Boughton, 2003). The model was calibrated to streamflow observations at the Devlin Creek @ Bombandy streamflow gauge operated by DERM between 1971 and 1988 (see Figure 1.1). The catchment area to this gauge is 1,026km^2. The median annual runoff over the modelled period is approximately 23.6mm/a, or 4.2% of median annual rainfall (mean annual runoff is 5.6% of mean annual rainfall).

Table 2.1 Local (Pre Mine) Catchment Characteristics

Reporting Point	Description of Location	Catchment Area (km^2)	Median Annual Flow (ML/a)
A	Devlin Creek @ Lease Boundary	261.2	6,173
B	Trib of Swampy Creek @ Lease Boundary	22.4	528
C	Trib of Swampy Creek @ Lease Boundary	5.8	137
D	Trib of Swampy Creek @ Lease Boundary	5.42	128
E	Swampy Creek D/S of minor Trib (B, C, D)	145.1	3,430
F	Devlin Creek D/S of Swampy Creek	437.9	10,350

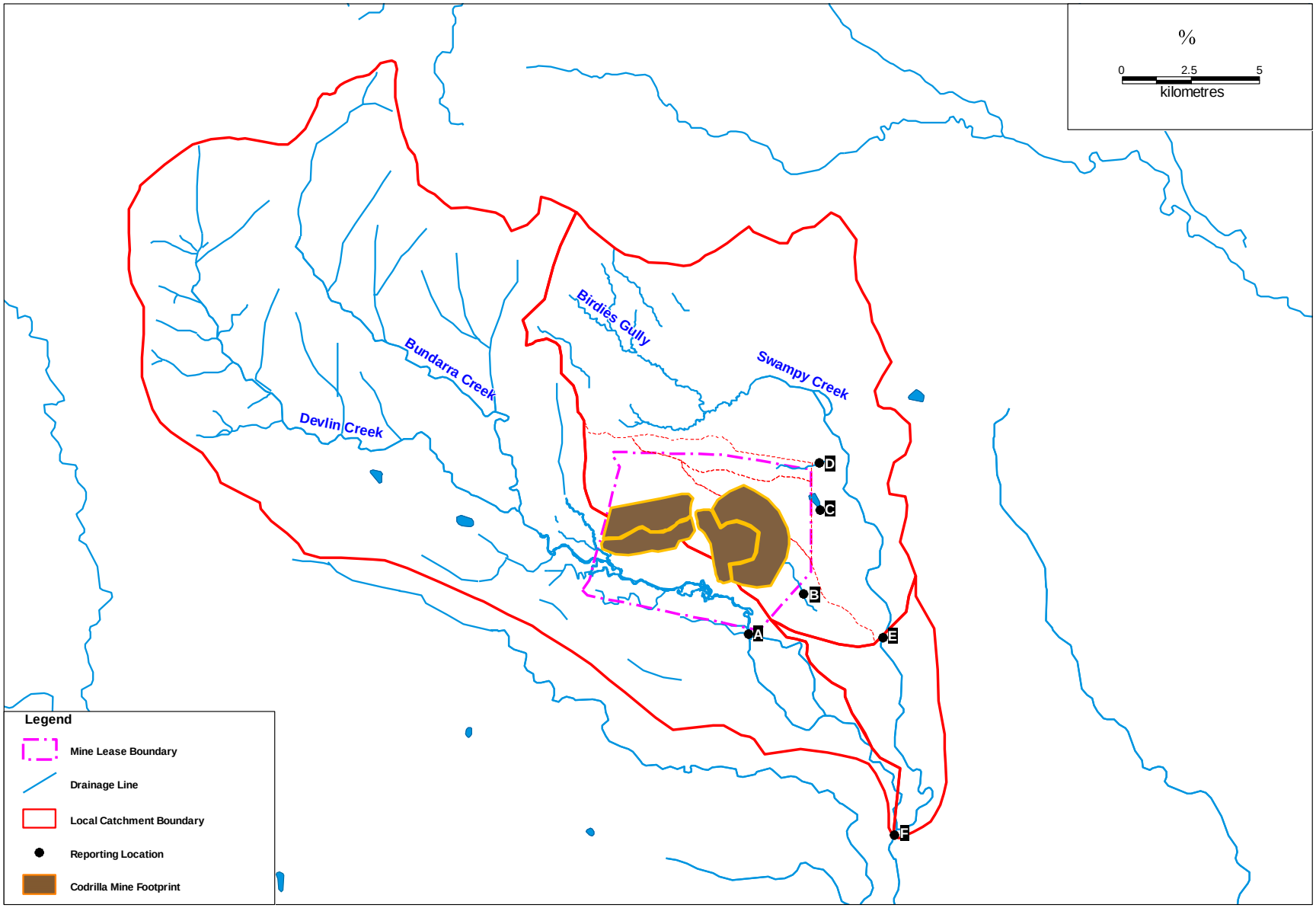

Figure 2.1 Local Drainage Network

2.1.2 Devlin Creek Channel and Floodplain Characteristics

Devlin Creek in the area of interest consists of an incised main channel across a very wide, flat floodplain. Numerous old meander bends which have been cut off from the current channel alignment are evident at various locations along the creek. The Devlin Creek channel has a base width of about 5 to 10m and is about 3 to 5m deep. The banks of the creek are quite steep ranging from approximately 1V:2H to 1V:3H. The banks are vegetated with a mixture of large mature eucalypts and grasses. In some locations along Devlin Creek, erosion of the banks is evident as is large woody debris. Figure 2.2 shows a photograph of the Devlin Creek channel in the vicinity of the Fitzroy Developmental Road crossing (close to the proposed mining operations) taken in May 2009.

Figure 2.2 Devlin Creek Channel in the Vicinity of the Fitzroy Developmental Road Crossing

2.1.3 Swampy Creek Channel and Floodplain Characteristics

Swampy Creek is a tributary of Devlin Creek that joins Devlin Creek some 9km south-east of the Codrilla Mine Lease. Swampy Creek has a catchment area of approximately 100km^2 adjacent to the proposed mine. It drains in a southerly direction approximately 3km to the north-east of the proposed eastern overburden dump. Swampy Creek discharges into Devlin Creek approximately 9km to the south-east of the proposed mining operations. The location of Swampy Creek relative to the proposed mine is shown in Figures 1.1 and 2.1.

Figure 2.3 shows a cross section of Swampy Creek taken from the edge of the eastern overburden dump to the mining lease boundary. The location of the cross section is shown in Figure 2.1. The cross section of Swampy Creek in this location has an area of approximately 12,500m^2 to the ground level at the eastern boundary of the proposed overburden dump (171.7m AHD). Using Manning's equation, with an adopted bed slope of 0.1% and an 'n' value of 0.05, the Swampy Creek channel and floodplain in this location has a flow capacity of

approximately 16,800 m^3/s. This is significantly higher than the calculated Devlin Creek Probable Maximum Flood discharge, which is about 3,500m^3/s. Swampy Creek has a smaller catchment than Devlin Creek in the vicinity of the mine, hence flooding from Swampy Creek will not impact on the proposed mine workings.

2.1.4 Site Drainage Characteristics

Due to the very flat topography of the Devlin Creek floodplain, flow paths for local stormwater drainage are poorly defined. The approximate boundaries of local catchments draining the area of proposed mining operations are shown in Figure 2.1. However, there are no well defined watercourses across the floodplain. The flood and drainage behaviour of site runoff will be controlled by the design of proposed stormwater flow paths to be undertaken as part of infrastructure design.

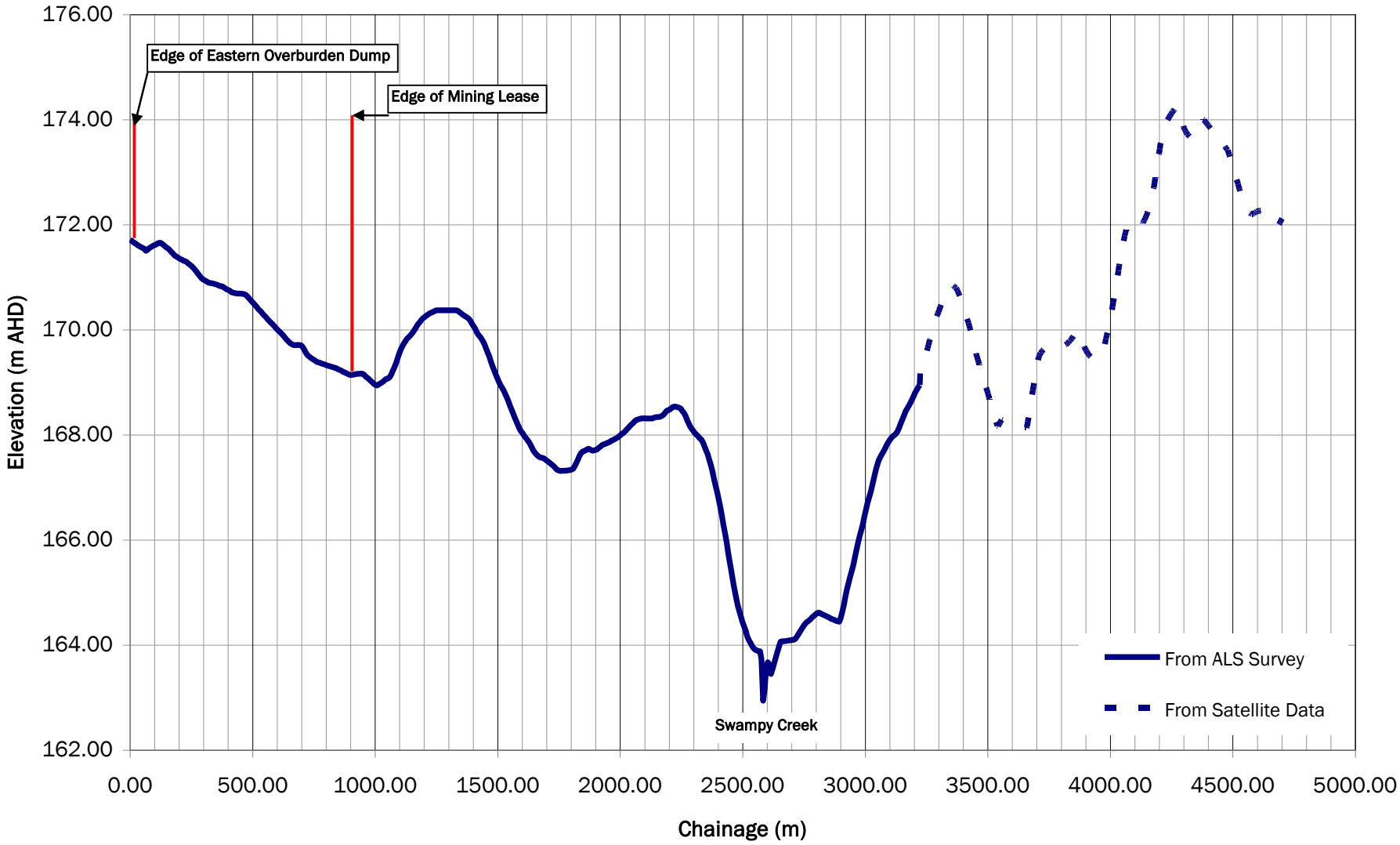

Figure 2.3 Cross Section of Swampy Creek Channel & Floodplain in the vicinity of the Eastern Overburden Dump

2.2 IMPACTS OF MINING OPERATIONS

The proposed locations of the open cut pits and overburden emplacements for the Codrilla Project are outside the banks of the Devlin Creek and Swampy Creek main channels. Hence, the proposed mine operations will not affect the geomorphology or frequent flow behaviour of Devlin Creek or Swampy Creek. Mine infrastructure is located above the Swampy Creek floodplain at an elevation significantly higher than the elevation of the main channel and therefore will not affect flood depths and flow velocities during rare flood events. However, mine infrastructure will be located on the Devlin Creek floodplain and will potentially affect flood depths and flow velocities during flood events where flows exceed the main channel capacity. Details of the hydrologic and hydraulic modelling that assess the impacts of the proposed development on flood behaviour along Devlin Creek are presented in subsequent sections of this report.

Proposed haul road crossings of waterways will include culverts capable of passing the 2 year ARI flood event and will be designed to ensure minimal impact on larger flood events. These haul road crossings will have small local upstream impacts and detailed flood modelling has not been undertaken as part of this impact assessment.

The proposed development may obstruct flow paths for local stormwater runoff, which are poorly defined due to the very flat topography of the Devlin Creek floodplain. Potential impacts on local runoff will be addressed in the design of stormwater management infrastructure on the site.

It is proposed to return the open cut pits to natural surface level (apart from the small final void areas) at the cessation of mining activities.

3 CLIMATIC CONDITIONS

3.1 RAINFALL & EVAPORATION

Table 3.1 shows summary details of rainfall recording stations in the vicinity of the Devlin Creek catchment. Note that none of these stations are located within the Devlin Creek catchment. The locations of the various stations are shown in Figure 1.1.

Table 3.1 Details of Rainfall Stations in the Area of Interest

Station No.	Station Name	Type	Elevation (m)	Lat. (°S)	Long. (°E)	Distance from Site (km)	Opened	Closed	Owner
33054	Nebo Shire Council	Daily	195	-21.6889	148.6881	45km NE	30-03-1870		BOM
33146	Homevale Stn	Daily	280	-21.4447	148.5306	72km N	30/08/1970	29/06/1998	BOM
33146	Homevale Stn	Pluvio	280	-21.4447	148.5306	72km N	24/10/1970	29/06/1998	BOM
34038	Moranbah Water Treatment Plant	Daily	240	-21.9947	148.0308	58km NW	30/03/1972		BOM
34058	Landsborough Stn	Daily	300	-21.6181	148.6019	53km N	1/01/1966		BOM
34060	Alameda Downs	Daily	250	-21.7278	148.5697	41km N	30/08/1972		BOM
34074	Oxford Downs	Daily	180	-21.8208	148.6825	32km NE	1/01/1895		BOM
34077	Lake Elphinstone Stn	Daily	350	-21.5297	148.2353	72km NW	1/01/1973		BOM
533011	Mt Spencer Standalone	Pluvio		-21.4778	148.8206	73km NE	3/04/1985		NRW
534003	Deverill TM	Pluvio	200	-22.1742	148.3811	22km SW	1/08/1995		BOM

Table 3.2 shows mean monthly rainfalls for the two rainfall stations with the longest period of record, Nebo Shire Council (Station No. 33054) and Oxford Downs (Station No. 34074). Results are shown for a “water year”, commencing in October. The mean annual rainfall recorded at Nebo over a period of 139 years is about 750 mm. The mean annual rainfall at Oxford Downs, 32 km from the mine site is about 640 mm. Note that Oxford Downs has significant periods of missing data.

The closest meteorological station recording evaporation is located at the Moranbah Water Treatment Plant (Station No. 34074), located some 58 km to the north-west of the proposed mine site. Mean monthly evaporation (based on a Class A evaporation pan) is also shown in Table 3.2. Mean annual evaporation is 2346 mm, which is substantially higher than rainfall.

Figure 3.1 shows the annual distribution of monthly rainfall and evaporation in the vicinity of the mine site. Mean evaporation exceeds mean rainfall in every month of the year.

Table 3.2 Mean Monthly Rainfall and Evaporation in the Area of Interest

Month	Mean Monthly Rainfall (mm)		Mean Monthly Evaporation (mm)
	Nebo Shire Council (33054) [139 years data]	Oxford Downs (34074) [64 years data]	Moranbah WWTP (34038) [24 years data]
October	31.2	32.7	251.1
November	55.0	57.6	258.0
December	96.9	97.3	269.7
January	139.0	113.9	254.2
February	135.9	102.3	210.0
March	106.8	76.3	217.0
April	47.3	38.9	174.0
May	34.8	32.3	133.3
June	39.5	33.9	108.0
July	27.8	20.2	117.8
August	17.9	19.3	151.9
September	19.8	16.5	201.0
Total	**751.9**	**641.2**	**2346.0**

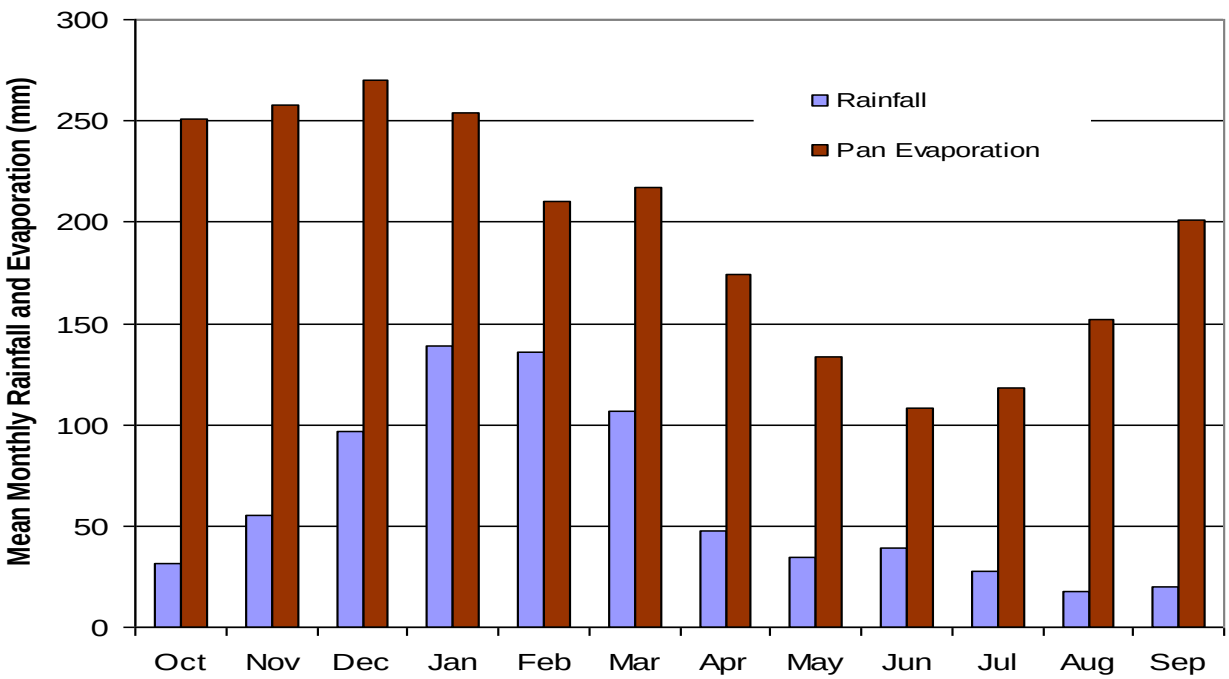

Figure 3.1 Distribution of Monthly Rainfall (Nebo Shire Council) and Evaporation (Moranbah Water Treatment Plant)

3.2 2010/11 WET SEASON RAINFALLS

The 2010/11 wet season resulted in significant rainfall over the area of interest. Review of recorded daily rainfalls at Oxford Downs indicates that:

- Calendar 2010 was the wettest year on record (49 years of complete data available) with a total annual rainfall of 1,324 mm.

- The 2010/2011 wet season (Dec/Jan/Feb) had a total rainfall of 853 mm, which was the third-wettest on record (1,214mm was recorded in 1990/91 and 1,044 mm in 1917/18).
- December 2010 was the wettest December on record, with a total rainfall of 529 mm. The second-wettest December occurred in 1990 with 458 mm of rainfall.

3.3 STREAMFLOW

Figure 1.1 shows the location of the stream flow gauge on Devlin Creek. The Bombandy gauging station (Station No. 130412A) is located approximately 27km south-east (downstream) of the proposed mining operations and was operated by the QLD Department of Environment and Resource Management between 1971 and 1988. Currently, there are no operating stream flow gauges within the Devlin Creek catchment. The catchment area of Devlin Creek to Bombandy is approximately 1023km^2.

Table 3.3 shows the annual recorded runoff volume at the Bombandy streamflow gauge for the period of record, as well as total annual rainfall taken as the mean of recorded annual rainfalls at the four closest stations to the Devlin Creek catchment:

- Nebo Shire Council (No. 33054),
- Landsborough Station (No. 34058),
- Alameda Downs (No. 34060), and
- Oxford Downs (No. 34074).

Table 3.3 Annual Rainfall and Runoff Volumes for Devlin Creek Catchment

Year Commencing	Annual Rainfall (mm)	Annual Runoff Volume at Bombandy	
		(ML)	(mm)
Oct-71	913	21246	17.7
Oct-72	592	17216	14.3
Oct-73	1349	171397	142.5
Oct-74	1065	29185	24.3
Oct-75	1289	68130	56.6
Oct-76	1190	27221	22.6
Oct-77	1071	50666	42.1
Oct-78	1130	65253	54.2
Oct-79	753	2358	2.0
Oct-80	929	17695	14.7
Oct-81	784	1210	1.0
Oct-82	952	78063	64.9
Oct-83	1085	1305	1.1
Oct-84	906	3144	2.6
Oct-85	857	10136	8.4
Oct-86	607	730	0.6
Oct-87	1321	19179	15.9
Mean	**988**	**34361**	**29**

[a] Mean of annual rainfall at Station No.s 33054, 34058, 34060 and 34074.
* Data missing from some stations

4 SURFACE WATER QUALITY

4.1 ENVIRONMENTAL VALUES & WATER QUALITY OBJECTIVES

The downstream receiving waters do not include potable or irrigation water supply systems, or National Parks within 100km of the site. Existing downstream water use is restricted to domestic and agricultural use for stock watering.

The waterways located within and downstream of the Codrilla Project Mining Lease are not included in Schedule 1 of the Environmental Protection (Water) Policy 2009 (EPP Water). The environmental values listed in Part 3 Section 6 of the EPP Water that are to be protected are therefore the:

- biological integrity of an aquatic ecosystem that is adversely affected by human activity to a relatively small but measurable degree;
- suitability of the water for agricultural and recreational use; and
- cultural and spiritual values of the water.

The indicators and water quality guidelines relevant to the above environmental values are listed in the Queensland Water Quality (QWQ) Guidelines and ANZECC (2000). The conditions of waterways located in the vicinity of the Codrilla Project mining lease are classified as Level 2; slightly to moderately disturbed ecosystems under the QWQ Guidelines (DERM, 2009a).

4.2 WATER QUALITY DATA

There is limited information currently available on surface water quality in the area of interest. Table 4.1 shows water quality data recorded at 4 locations (shown in Figure 4.1):

- Swampy Creek at Valkyrie Road (located about 5.5km north-east of the mining lease);
- Devlin Creek at Fitzroy Developmental Road (within the mining lease);
- Devlin Creek at Bombandy (DERM Stn. No. 130412A) (located about 27km south-east (downstream) of the mining lease); and
- Isaac River at Fitzroy-Developmental Road (located about 38km south-south-east of the mining lease).

Although based on a limited number of samples, this data provides an indication of typical water quality parameters for Devlin Creek, both upstream and downstream of the mining lease. The data has also been compared with Regional Guideline Values (DERM, 2009a) and Release Contaminant Trigger Levels (DERM, 2009b). Appendix A shows the full water quality sampling results for all four locations. The following is of note:

- Generally, parameter levels in Devlin Creek (both upstream and downstream of the mining lease) are lower than in the Isaac River, with the exception of dissolved oxygen, total nitrogen, boron, copper, zinc and iron.
- Median pH at all locations is within the range of the Regional Guideline Values.

- Median pH in Swampy Creek is lower than Devlin Creek and the Isaac River.
- Median turbidity and TSS in Swampy Creek are higher than Devlin Creek.
- Median Total Nitrogen and Total Phosphorus concentrations at all sites are well in excess of the Regional Guideline Values.
- 95th percentile concentrations for the majority of metals in Devlin Creek are below the Release Contaminant Trigger Levels. Metals with levels in Devlin Creek naturally above the Release Contaminant Trigger levels include aluminium, uranium, zinc and iron.

Figure 4.2 shows the relationship between Electrical Conductivity (EC) and a qualitative assessment of stream discharge in Devlin and Swampy Creeks and the Isaac River. In Devlin Creek, EC can be significantly elevated during low-flow periods but drops below 200 µS/cm at medium and higher flows. Swampy Creek EC values display a similar pattern, although the EC values at low flows are much lower than in Devlin Creek. The variation of EC with flow in the Isaac River is less pronounced, although no low flow samples were available at the monitoring site.

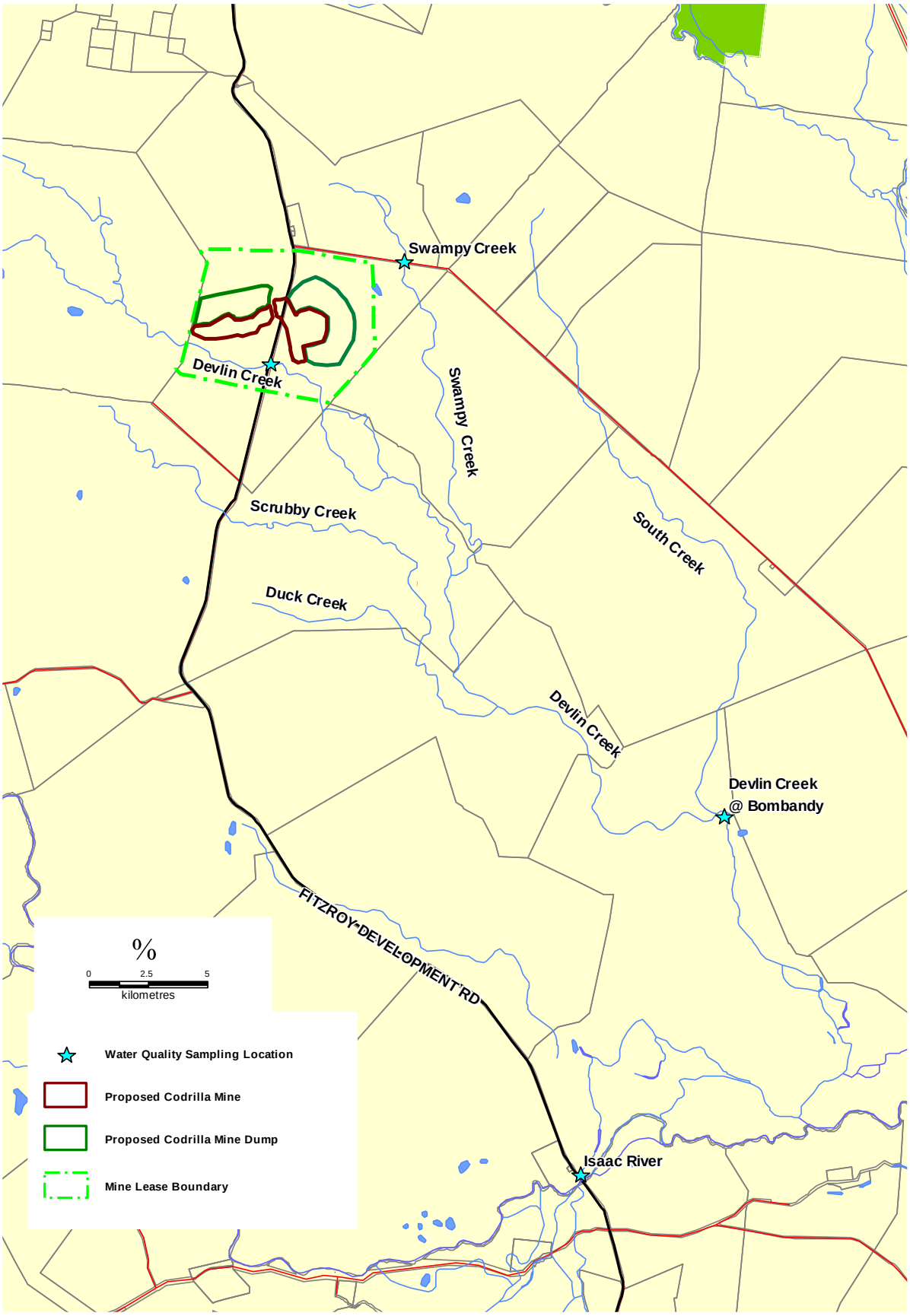

Figure 4.1 Location of Water Quality Sampling Sites

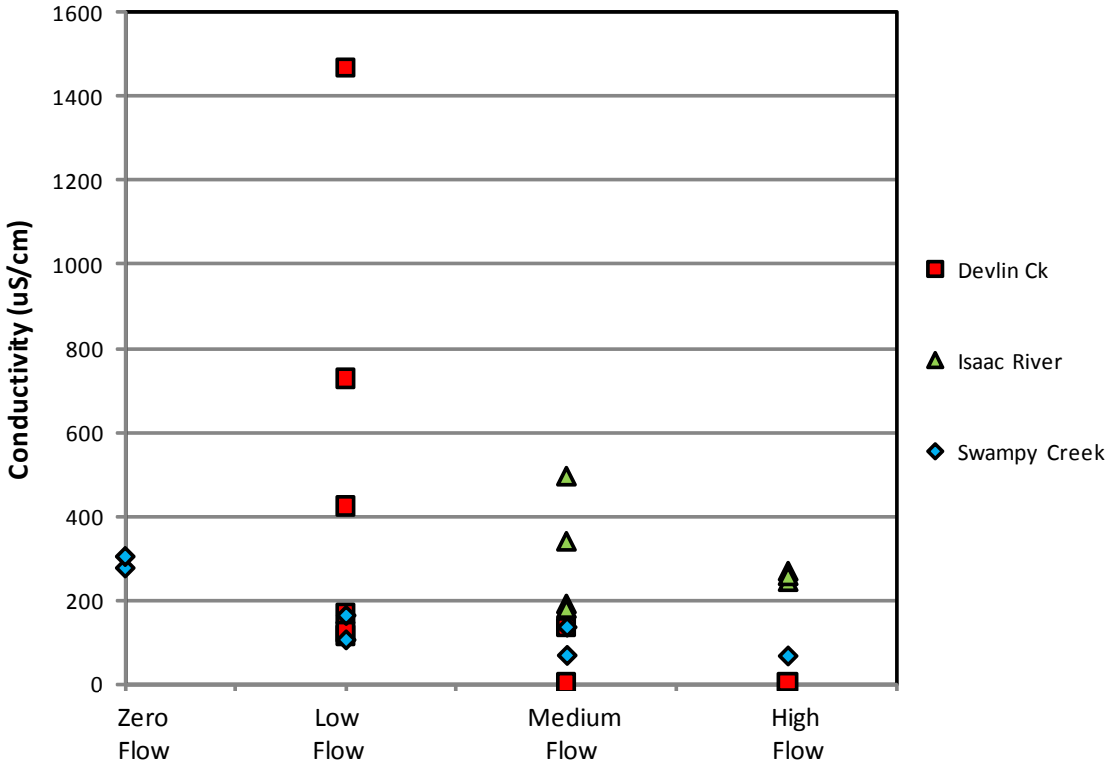

Figure 4.2 Variation in Electrical Conductivity with Discharge

Table 4.1 Recorded Water Quality Data, Swampy Creek, Devlin Creek & Isaac River

Parameter	Units	Median Water Quality								Regional Guideline Values[3]
		Swampy Creek (at Valkyrie Road)[1]		Devlin Creek (at Fitzroy Development Road)[1]		Devlin Creek (at Bombandy)[2]		Issac River[1]		
pH	pH Units	6.7	(7)	7.4	(9)	7.2	(21)	7.5	(7)	6.5-7.5
Temperature	° C	26.6	(4)	26.1	(4)	24.5	(16)	27.0	(3)	-
Conductivity	µS/cm	136	(7)	136	(9)	155.0	(21)	258	(7)	720
Turbidity	NTU	493	(7)	106	(9)	85.0	(4)[6]	>1000	(7)	25
Dissolved Oxygen	mg/L	5.1	(7)	5.0	(9)	NA	-	4.8	(7)	90-110 (%)
Hardness	mg/L	37	(7)	39	(9)	47.0	(18)	63	(7)	-
Total Suspended Solids	mg/L	172	(7)	70	(9)	64.0	(14)	400	(7)	-
Total Nitrogen	mg/L	1.35	(7)	1.45	(9)	NA	-	1.23	(7)	0.25
Total Phosphorus	mg/L	0.1	(7)	0.1	(8)	NA	-	0.21	(6)	0.03
Sulphate	mg/L	<2.0	(7)	3.0	(9)	3.9	(8)[6]	8.0	(7)	-
Fluoride	mg/L	<2.0	(7)	<0.1	(9)	0.1	(14)	0.1	(7)	-
		95th Percentile Water Quality								Release Contaminant Trigger Levels[4]
Aluminium [5]	µg/L	1947	(7)	841	(9)	NA	-	850	(7)	100.0
Antimony [5]	µg/L	<5	(7)	<5	(9)	NA	-	<5	(7)	-
Arsenic [5]	µg/L	5	(7)	3	(9)	NA	-	<4	(7)	13.0
Beryllium [5]	µg/L	<5	(7)	<5	(9)	NA	-	<1	(7)	-
Boron [5]	µg/L	191	(7)	118	(9)	60	(4)[7]	110	(7)	370.0
Cadmium [5]	µg/L	<5	(7)	<5	(9)	NA	-	<0.2	(7)	0.2
Chromium [5]	µg/L	<5	(7)	<5	(9)	NA	-	<2	(7)	1.0
Cobalt [5]	µg/L	<5	(7)	<5	(9)	NA	-	<7	(7)	90.0
Copper [5]	µg/L	5	(4)	7.5	(7)	NA	-	6.6	(5)	-
Lead [5]	µg/L	<5	(7)	<5	(9)	NA	-	<5	(7)	10.0
Manganese [5]	µg/L	81	(7)	70	(9)	NA	-	261	(7)	1900.0
Molybdenum [5]	µg/L	<5	(7)	<5	(9)	NA	-	<5	(7)	34.0
Nickel [5]	µg/L	3.8	(7)	<5	(9)	NA	-	8.7	(7)	11.0
Selenium [5]	µg/L	<5	(7)	<5	(9)	NA	-	<5	(7)	10.0
Uranium [5]	µg/L	5.5	(7)	<6	(9)	NA	-	14	(7)	1.0
Vanadium [5]	µg/L	<5	(7)	<6	(9)	NA	-	<13	(7)	10.0
Zinc [5]	µg/L	37	(7)	75	(9)	NA	-	29	(7)	8.0
Iron [5]	µg/L	915	(7)	588	(9)	3900	(5)[7]	948	(7)	300.0
Mercury [5]	µg/L	0.2	(7)	0.2	(9)	NA	-	<0.1	(7)	0.2

1. Samples from 2010/2011
2. Historical Samples 1971- 1988
3. Taken from DERM Queensland Water Quality Guidelines (2009)
4. Taken from DERM Final Model Water Conditions for Coal Mines in the Fitzroy Basin
5. Dissolved
6. Mean Value
7. Maximum Value

(#) – Number of Samples

5 EXISTING WATER USE ENTITLEMENTS

Advice from the Queensland Government Department of Environment and Resource Management (DERM) indicates that there are no current water licences and/or development permits on Devlin Creek. This indicates that there are currently no formal water use entitlements along Devlin Creek. However, DERM provided advice that the owners of Lot 9 on KL119 (located about 23km south-east of the proposed mining lease) hold a permit to source water from Devlin Creek for stock and domestic supply. It is also possible that other landholders and livestock may access small volumes of water from Devlin Creek on an informal basis.

The proposed open cut pit extent will not affect in-bank flows along Devlin Creek. The total pit catchment area is approximately 6.5km^2 which is less that 3% of the catchment area of Devlin Creek to Fitzroy Developmental Road. Hence, the proposed development will have no measurable impact on the quantity of water available to downstream users.

6 ESTIMATION OF DEVLIN CREEK DESIGN DISCHARGES

6.1 OVERVIEW

Devlin Creek flood discharges were estimated for a range of design storm events including the 2 year, 10 year, 100 year and 2,000 year Average Recurrence Interval (ARI) events using the URBS runoff-routing model. Discharges were also estimated for the Probable Maximum Flood (PMF). Recorded streamflow data for Devlin Creek is available at Bombandy. However, the catchment at this location is more than 5 times larger than the Devlin Creek catchment adjacent to the proposed mine infrastructure and hence this data is not well suited to model calibration at the mine site. The results of the URBS model were checked against design flood discharges obtained using the Rational Method, as well as the results of a flood frequency analysis at Bombandy. Details of the hydrologic modelling methodology and results are provided in the following sections.

6.2 MODEL DESCRIPTION

URBS is a networked (i.e. sub-catchment based) runoff-routing model that estimates flood hydrographs by routing rainfall excess through a module representing the catchment storage. In URBS, the storages are arranged to represent the drainage network of the catchment. The distributed nature of storage within the catchment is represented by a separate series of concentrated storages for the main stream and for major tributaries to provide a degree of physical realism. Full details of the URBS model and its features are given in the URBS User Manual (Carroll, 2007).

URBS is widely used in Australia for flood hydrograph estimation and is the preferred hydrologic model for flood forecasting adopted by the Bureau of Meteorology.

6.3 MODEL CONFIGURATION

Figure 6.1 shows the adopted configuration of the Devlin Creek URBS model. The model covers the Devlin Creek catchment to the downstream mining lease boundary (231km^2). It consists of 15 sub-catchments. Table 6.1 shows the areas for each sub-catchment used in the model.

Table 6.1 Devlin Creek URBS Model Sub-Catchment Areas

Sub-Catchment No	Area (km^2)	Sub-Catchment No	Area (km^2)
1	20.1	9	2.7
2	32.1	10	3.1
3	27.7	11	9.6
4	21.5	12	7.9
5	25.5	13	6.3
6	16.0	14	4.8
7	32.5	15	17.1
8	4.3		

6.4 DESIGN RAINFALL DEPTHS & PROBABLE MAXIMUM PRECIPITATION

The URBS model uses design rainfall intensity-frequency duration data from Australian Rainfall and Runoff (ARR) (IEAust, 1998) for the 2, 10 and 100 year ARI design events. Rainfall depths for the 2,000 year ARI event were estimated using the CRC-Forge method (Hargraves, c2004). Probable Maximum Precipitation depths were estimated using the Generalised Short Duration Method (GSDM) for storm durations up to 6 hours (BoM, 2003a) and the Generalised Tropical Storm Method Revised (GTSMR) for storm durations between 12 hours and 72 hours (BoM, 2003b). The adopted rainfall depths for the Devlin Creek catchment are shown in Table 6.2.

Table 6.2 Devlin Creek Catchment Rainfall Depths

Storm Duration (hrs)	Rainfall Depths (mm)				
	2 Year	10 Year	100 Year	2,000 Year	PMP
3	52.1	73.2	109.4	200.5	490.0
6	62.2	90.5	139.9	245.4	630.0
9	67.9	101.1	158.6	273.2	705.0
12	73.7	111.9	177.8	301.1	780.0
18	81.6	126.1	203.9	349.0	900.0
24	89.6	140.4	230.3	386.6	1020.0
36	97.9	156.2	260.6	435.5	1230.0
48	106.2	171.9	290.9	484.3	1430.0
72	111.5	185.4	321.5	561.0	1790.0

The ARR temporal patterns were applied for the 2, 10 and 100 year ARI design events and the BoM GSDM and GTSMR temporal patterns were applied for the 2,000 year ARI and PMP events.

6.5 AREAL REDUCTION FACTORS

Areal Reduction Factors (ARFs) obtained from the Queensland Extreme Rainfall Estimation Project (EREP) (Hargraves c.2004) were applied to the 2, 10 and 100 year ARI rainfall depths. ARFs were not applied to the 2,000 year ARI or PMP rainfall depths as an ARF is included in the rainfall estimation process. The adopted ARFs are shown in Table 6.3.

Table 6.3 Devlin Creek Catchment Areal Reduction Factors

Storm Duration (hrs)	ARF
3	0.900
6	0.925
9	0.931
12	0.938
18	0.944
24	0.950
36	0.950
48	0.950
72	0.950

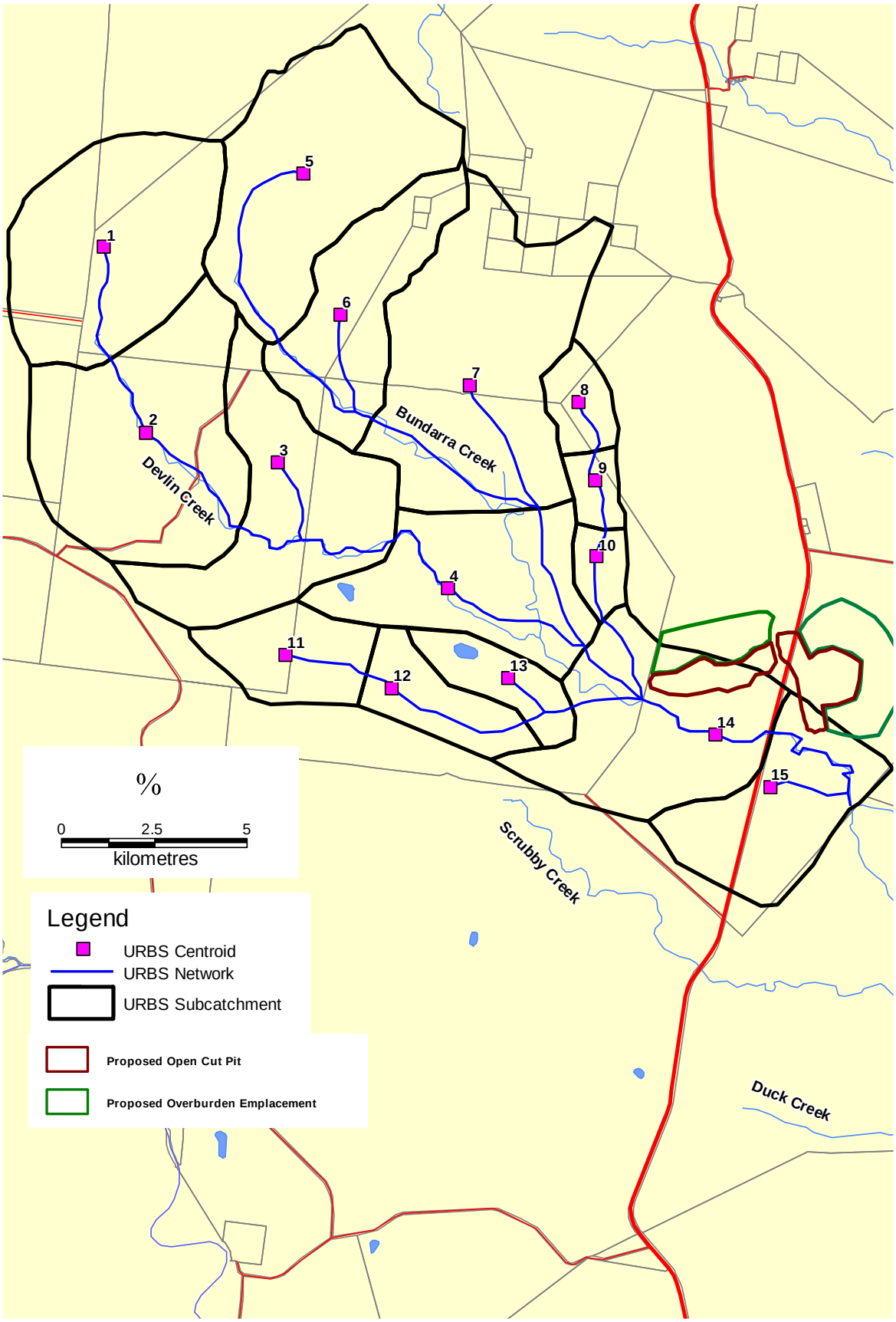

Figure 6.1 Devlin Creek URBS Model Configuration

6.6 MODEL CALIBRATION

6.6.1 Methodology

No suitable rainfall or streamflow data was available for the calibration of the URBS model in the vicinity of the Codrilla Project.

URBS model parameters were initially selected based on a similar previous study undertaken by WRM for the Bee Creek catchment, located between 16 and 20km to the north of the Codrilla site. The Bee Creek model was calibrated to 4 historical flood events. The estimates of design discharges obtained for Devlin Creek using the Bee Creek model parameters were then checked against independent design discharge estimates obtained from the Rational Method and from flood frequency analysis of recorded streamflow data at Bombandy.

Details of the Rational Method and flood frequency analyses, as well as the adopted URBS model parameters and estimated design discharges are provided below.

6.6.2 Rational Method Discharge

The 100 year ARI design discharge for the Devlin Creek catchment to the downstream lease boundary was estimated using the Main Roads Department Rational Method as recommended in Australian Rainfall and Runoff (IEAust, 1987).

Table 6.4 shows the adopted Rational Method parameters to calculate the 100 year ARI discharge for the Devlin Creek catchment at the location of interest.

Table 6.4 Devlin Creek Rational Method Parameters

Rational Method Parameters	
Catchment Area (km^2)	231
Hydraulic Radius (m)	1.47
Average Manning's n	0.05
Stream Length (km)	32
Slope (%)	0.1
Time of Concentration (hours)	19.2
100 Yr ARI Rainfall Intensity at t_c (mm/hr)	12.4
100 Yr ARI Runoff Coefficient (C)	0.66
100 Yr ARI Discharge (m^3/s)	**524**

6.6.3 Flood Frequency Analysis

The methodology recommended in Australian Rainfall and Runoff (IEAust, 1987) was used to fit a Log-Pearson Type III distribution to an annual series of recorded peak flood discharges for Devlin Creek at Bombandy (130412A). Table 6.5 shows recorded peak annual flood discharges at Bombandy. The flood frequency analysis (FFA) results, including the 5% and 95% confidence limits for a range of design discharges are given in Table 6.6. Figure 6.2 shows the plot of the historical peak flows together with the adopted flood frequency distribution. The following is of note with regards to the flood frequency analysis:

- The annual data is for water years (October – September).
- No recorded annual peak series data was available for Bombandy prior to 1971 or after 1988. Hence the flood frequency distribution is based on 17 years of data. As such, the uncertainty in the estimates for large events, such as the 100 year is high.

The estimated 100 year ARI discharge at Bombandy is 552m³/s, which is similar to the Rational Method estimate of 524m³/s at the downstream Codrilla lease boundary, even though the catchment area to Bombandy is about 5 times larger. This apparent inconsistency may reflect the high level of uncertainty in the FFA results due to the short period of recorded data, or the characteristics of the catchment were overbank storage volumes are very large, which significantly reduce peak discharges during large flood events.

Table 6.5 Recorded Peak Flood Discharges, Devlin Creek at Bombandy

Water Year	Peak Discharge (m³/s)
1971/72	57
1972/73	59
1973/74	230
1974/75	99
1975/76	111
1976/77	80
1977/78	196
1978/79	214
1979/80	16
1980/81	55
1981/82	13
1982/83	151
1983/84	16
1984/85	28
1985/86	44
1986/87	6
1987/88	270

Table 6.6 Flood Frequency Analysis, Devlin Creek at Bombandy

ARI Years	Estimated Peak Discharge (m³/s)		
	95% Confidence Limit	Estimated Value	5% Confidence Limit
2	40	65	107
10	145	237	388
100	209	552	1458

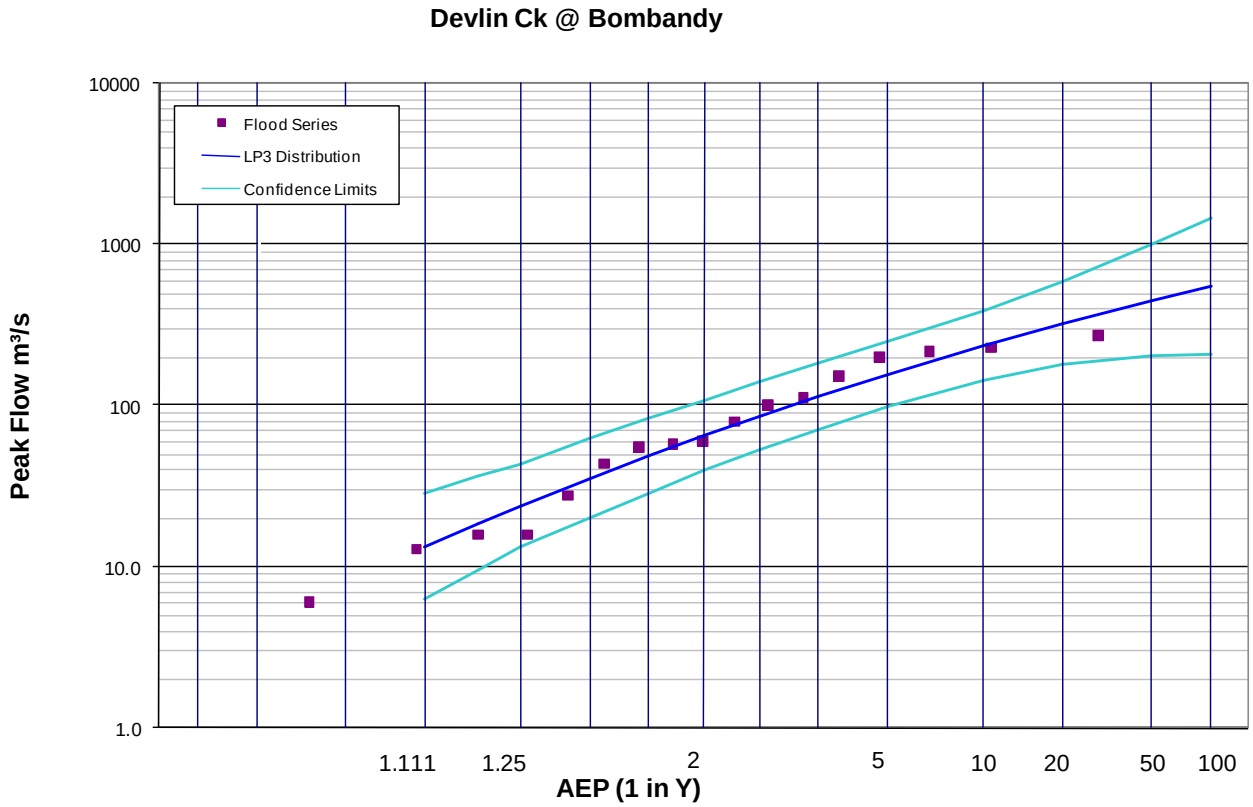

Figure 6.2 Flood Frequency Distribution, Devlin Creek at Bombandy

6.6.4 URBS Model Parameters

The adopted URBS parameters are shown in Table 6.7.

Table 6.7 Adopted URBS Model Global Parameters

Parameters	Value
Channel Lag Parameter – α	0.35
Catchment Lag Parameter – β	3.0
Catchment Non-Linearity Factor – m	0.8

The adopted initial and continuing losses for the various events, shown in Table 6.8, were selected to approximately match the URBS model discharges to the Rational Method discharge estimate and the FFA results.

Table 6.8 Adopted URBS Model Losses

Design Event (ARI Years)	Initial Loss (mm)	Continuing Loss (mm/hr)
2	60	2.5
10	40	2.5
100	20	2.5
2,000	20	2.5
PMP	0	0.0

6.7 ADOPTED DESIGN DISCHARGES

Table 6.9 shows the estimated peak design discharges at the downstream lease boundary. Matching the URBS model discharges to the FFA results for the larger catchment to Bombandy should provide a conservative estimation of design discharges at the Codrilla Project Site.

Table 6.9 Adopted Devlin Creek Design Discharges at Downstream Lease Boundary

Design Event (ARI Years)	Design Discharge (m^3/s)	Critical Duration (hours)
2	70	36
10	204	18
100	525	12
2,000	1078	18
PMP	3483	12

7 ASSESSMENT OF DEVLIN CREEK FLOOD IMPACTS

7.1 MODELLING OVERVIEW

A significant proportion of flood discharges along Devlin Creek flow across the floodplain and not within the main channel. To effectively simulate the movement of water across the floodplain, a TUFLOW two dimensional hydrodynamic model (WBM, 2008) of the Devlin Creek floodplain was developed. The model was used to estimate the 2 year, 10 year, 100 year and the 2,000 year ARI design flood levels, flood extents and flood velocities along Devlin Creek in vicinity of the proposed mining lease for both existing and developed conditions. The TUFLOW model was also used to assess the flood behaviour of the Probable Maximum Flood.

TUFLOW estimates flood levels on a fixed grid pattern by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The model automatically calculates breakout points and flow directions within the study area. It is also capable of linking with a one-dimensional model (ESTRY) to ensure accurate simulation of both in-bank and overbank flows. For this study, all structures and channels were modelled within the 2D domain.

No calibration data was available for the model. During a site visit in May 2009, anecdotal evidence was obtained relating to a water level over Fitzroy Developmental Road for an event that occurred in January or February 2008. There is no subdaily rainfall data available for the events in January and February 2008 and therefore it was not possible to estimate discharges or flood levels to compare against the anecdotal information.

7.2 TUFLOW MODEL CONFIGURATION

7.2.1 Existing Conditions Configuration

Figure 7.1 shows the spatial extent of the TUFLOW model for existing conditions for Devlin Creek in the vicinity of the proposed mining lease. The modelled study area covers approximately 2,800 ha and includes the Devlin Creek channel and overbank areas both upstream and downstream of the proposed disturbed areas. A 5m grid size and a 2 second time step were adopted for the two dimensional model area.

Ground level data was obtained from Airborne Laser Survey (ALS), due to the large area of the floodplain model. The ALS data was used to create a digital terrain model of the area. The ALS data was also used to define the Devlin Creek bed geometry, which was integrated into the TUFLOW model to ensure that the channel characteristics were properly defined and channel conveyance was maintained.

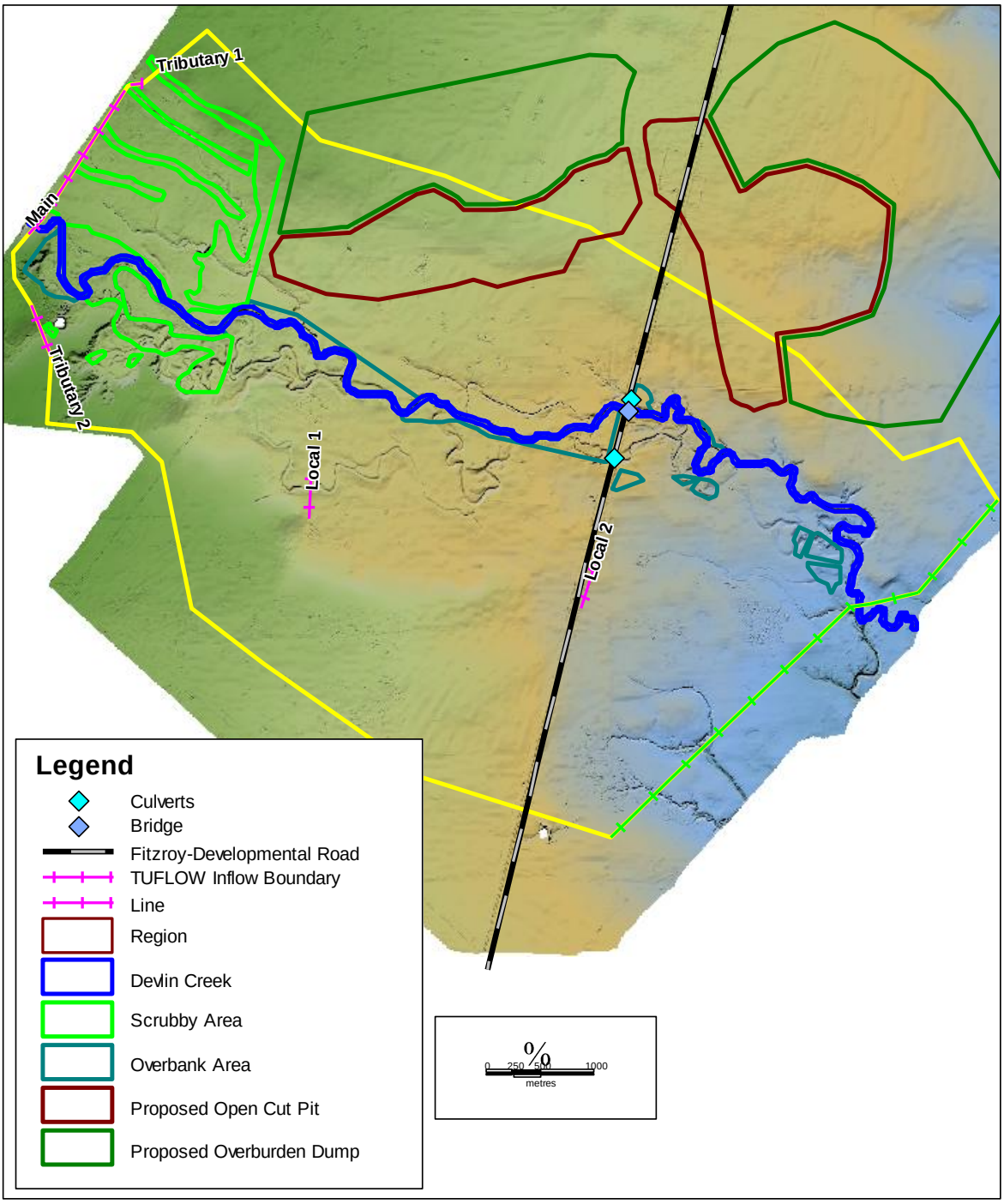

Figure 7.1 TUFLOW Model Configuration

7.2.2 Adopted Manning's 'n' Values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness). In the absence of calibration data for the hydraulic model, Manning's 'n' values were selected based on typical published values (for example, those of Chow, 1959). The adopted Manning's n values are given in Table 7.1 and their extents are shown in Figure 7.1.

Table 7.1 Adopted Manning's 'n' values

Location	Adopted Manning's 'n'
Floodplain Area	0.040
River Channel	0.050
Overbank Area	0.045
Scrubby Area	0.070

7.2.3 Inflow and Outflow Boundaries

Figure 7.1 shows the locations of the inflow and outflow boundaries used in the TUFLOW model. Four inflow boundaries and one outflow boundary were used to convey water through the model. Table 7.2 shows the adopted peak design discharges at each of the inflow boundaries. The flood hydrographs (flow versus time relationship) were taken from the URBS model output.

A "TUFLOW" generated rating curve was adopted for the downstream boundary. An adopted hydraulic gradient of 0.1% (1m/1000m) was applied to the boundary based on the slope of the channel at the downstream end.

Table 7.2 Adopted Design Discharges at Inflow Boundaries

ARI (Years)	Discharge (m^3/s)				
	Main	Tributary 1	Tributary 2	Local 1	Local 2
2	54	6	11	10	8
10	157	15	30	31	23
100	320	28	58	61	45
2,000	810	67	140	141	104
PMF	2744	232	479	497	366

7.2.4 Existing Hydraulic Structures

Three hydraulic structures were included in the base model; the Fitzroy Developmental Road Bridge over Devlin Creek and two sets of existing drainage culverts underneath Fitzroy Developmental Road to the north and south of the bridge as shown in Figure 7.1. The Fitzroy Developmental Road Bridge was included as a 2D layered flow constriction within the 2D domain. This allowed for the different flow constrictions as flow passed the bridge that would be experienced as water levels changed over the course of an event. The culverts were included as 1D structures within the 2D domain. Table 7.3 shows the adopted configuration of these culverts.

Table 7.3 Fitzroy Developmental Road Culvert Data

Culvert Properties	Northern Culverts	Southern Culverts
U/S Invert Level	173.22m AHD	173.4m AHD
D/S Invert Level	173.12m AHD	173.4m AHD
Culvert Size	2.1m x 1.5m	1.20m x 0.90m
Number of Barrels	5	5

7.3 EXISTING FLOOD LEVELS

Figure 7.2, Figure 7.3, Figure 7.4 and Figure 7.5 show the 2 year, 10 year, 100 year and 2,000 year ARI design flood extents and depths for Devlin Creek in the vicinity of the proposed mine under existing conditions. The location of the proposed mine footprint and associated mine infrastructure is shown in Figure 2.1, Section 2. Figures B1 to B4 in Appendix B show the 2 year, 10 year, 100 year and 2,000 ARI design velocities in Devlin Creek, respectively. The following is of note.

- The 2 year ARI design flood is mostly contained within the Devlin Creek main channel and does not impact on the proposed mine footprint.
- The 10 year, 100 year and 2,000 year ARI design floods do not impact on the eastern pit and overburden dump of the proposed mine. However, proposed mine infrastructure on the eastern side of Fitzroy Developmental Road is subject to partial backwater flooding during all events of 100 year ARI and larger.
- The western end of the open cut pit is subject to partial backwater flooding during all events of 10 year ARI and larger. For the 100 year ARI flood event the maximum inundation depth within the pit footprint is approximately 1.4m.
- Flood plain velocities in the vicinity of the western pit and overburden dump range from approximately 0.1m/s to 0.9m/s for the 2 year to 2,000 year ARI flood events. Channel velocities in an unnamed tributary of Devlin Creek in the vicinity of the western pit and overburden dump range from approximately 0.5m/s to 1.1m/s for the 2 year to 2,000 year ARI flood events.
- Devlin Creek channel velocities range from approximately 0.8m/s to 2.5m/s upstream of Fitzroy Developmental Road and approximately 0.9m/s to 2.0m/s downstream of Fitzroy Developmental Road for the 2 year to 2,000 year ARI flood events.

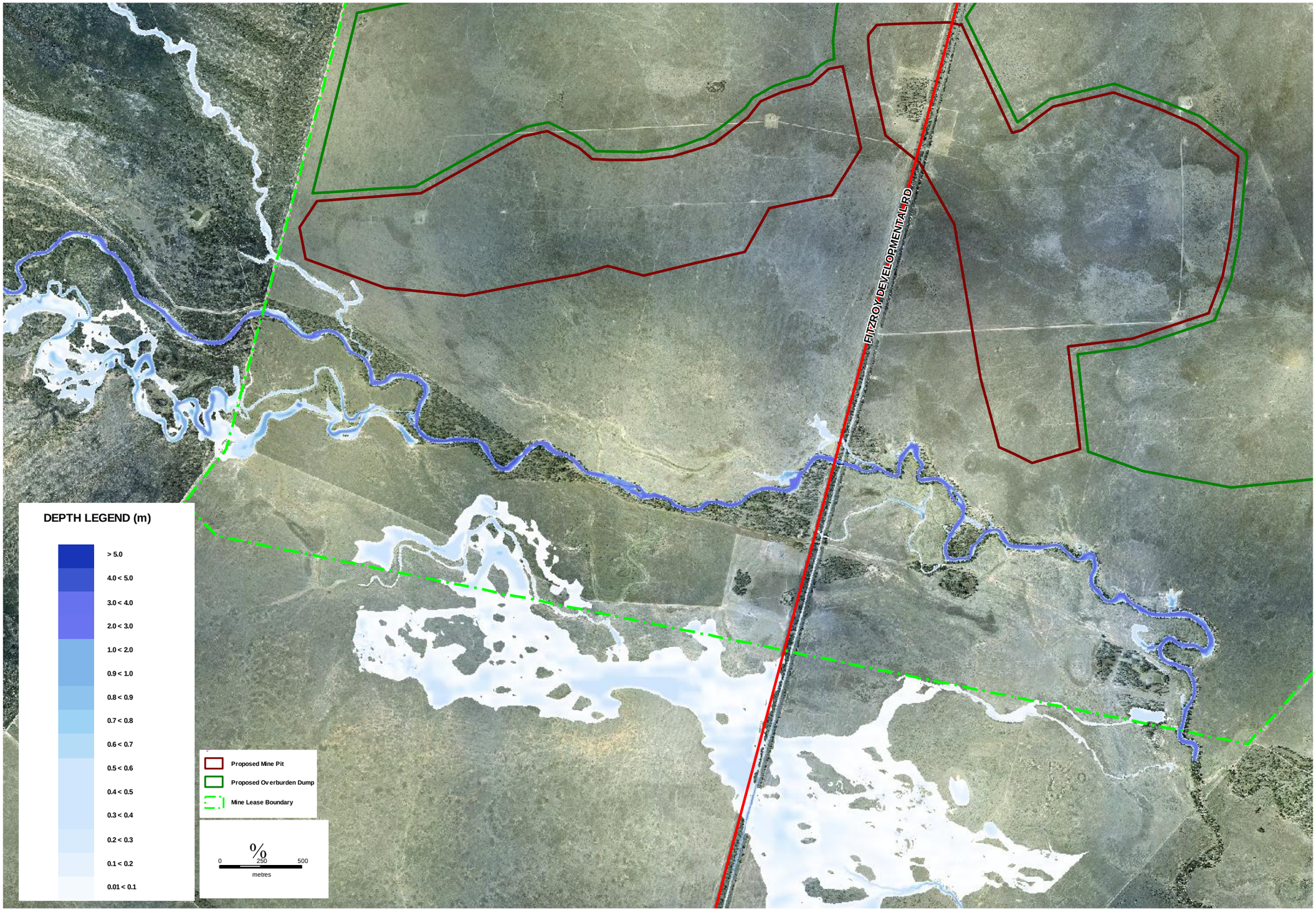

Figure 7.2 2 Year ARI Flood Depths, Devlin Creek

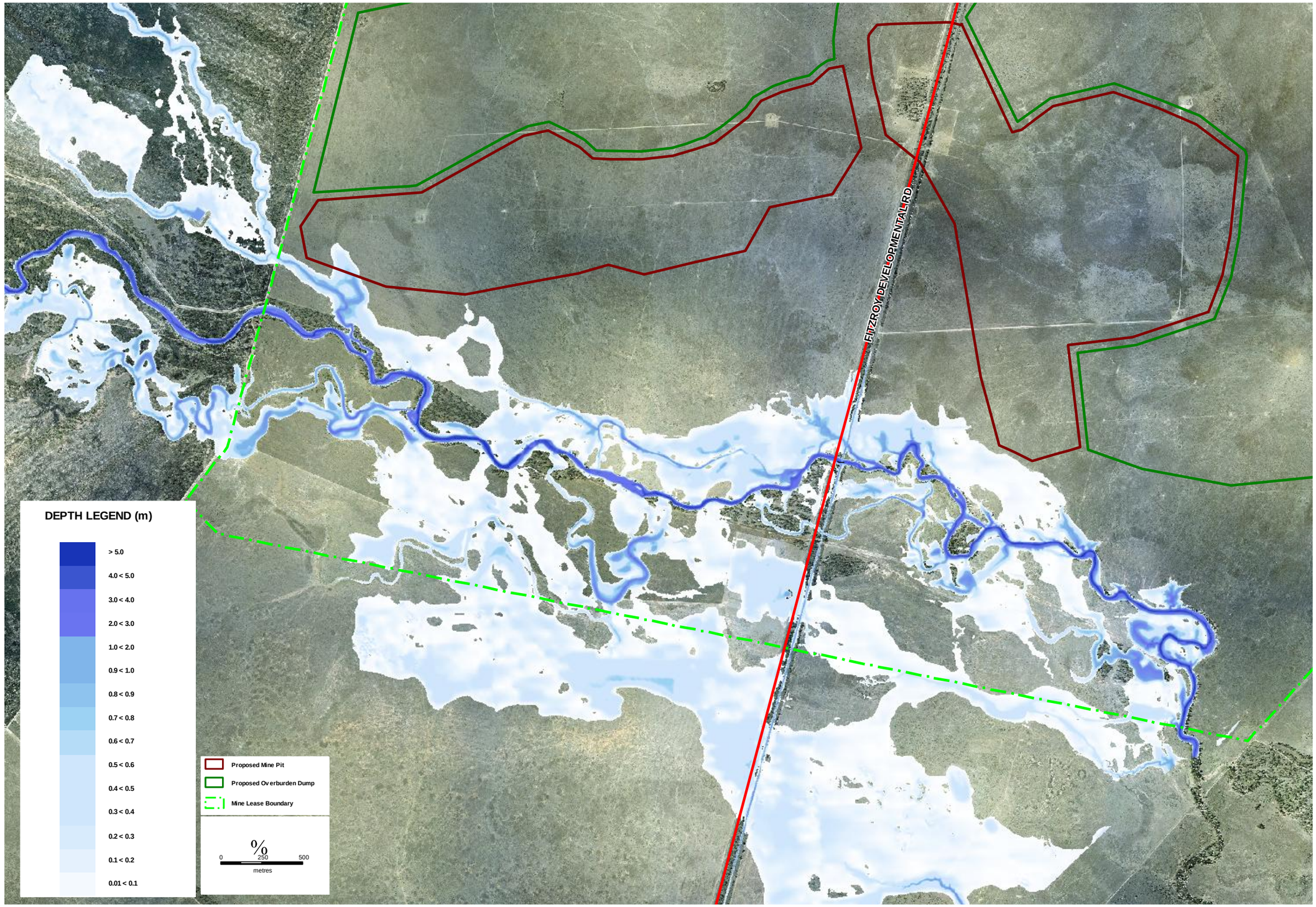

Figure 7.3 10 Year ARI Flood Depths, Devlin Creek

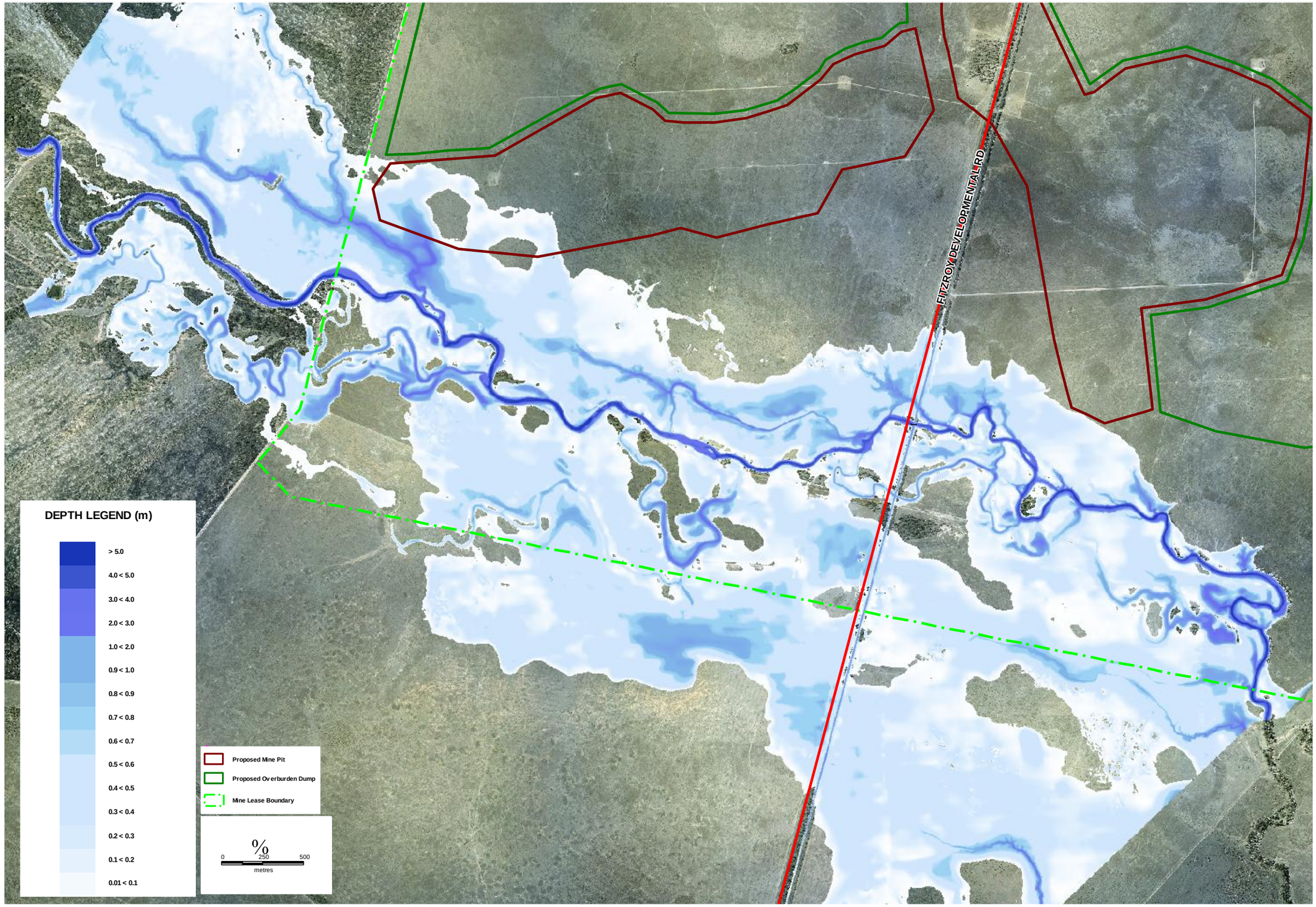

Figure 7.4 100 Year ARI Flood Depths, Devlin Creek

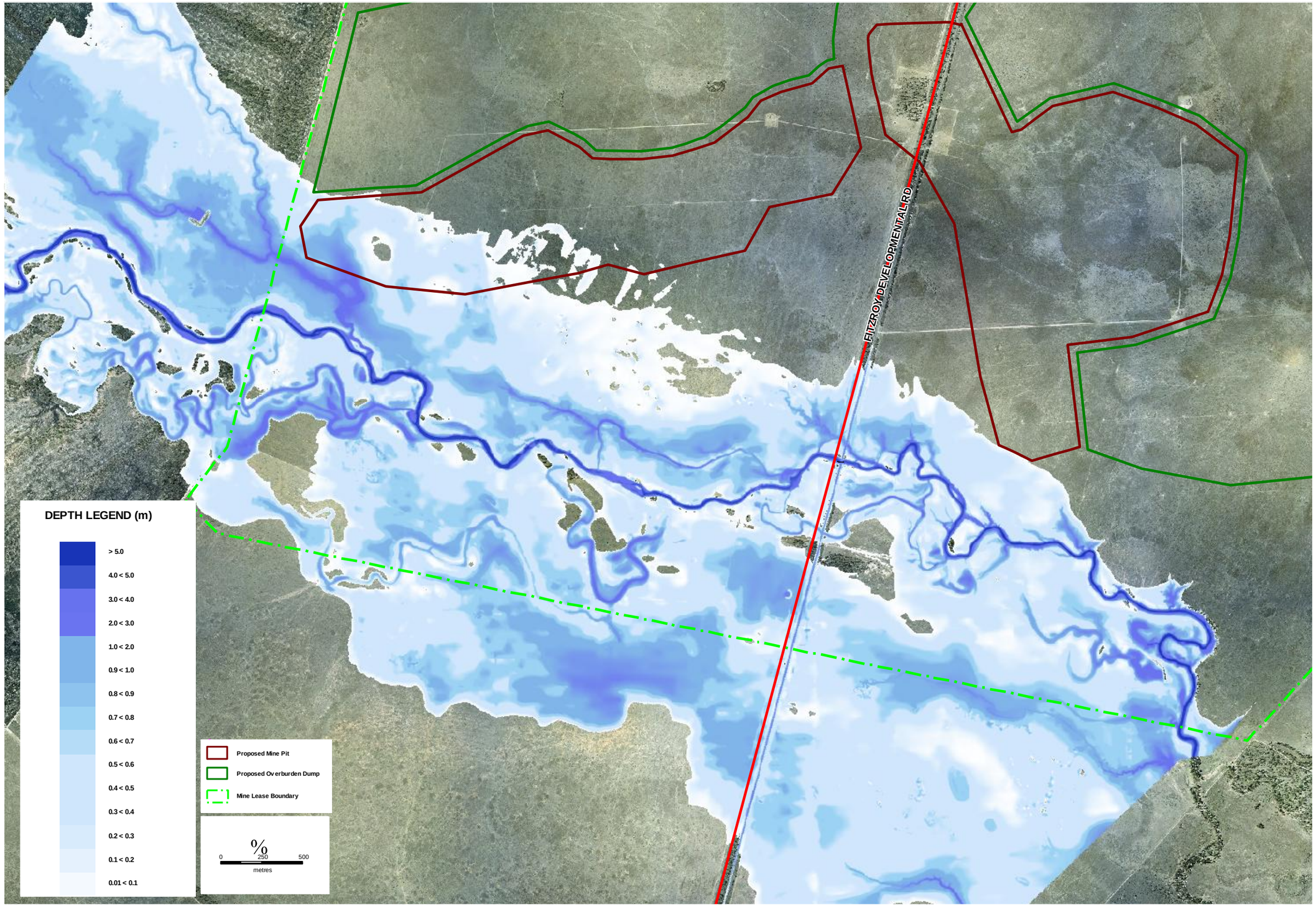

Figure 7.5 2,000 Year ARI Flood Depths, Devlin Creek

7.4 FLOOD IMPACTS OF THE PROPOSED MINE

Due to the very flat topography of the Devlin Creek floodplain, flow paths for local stormwater drainage are poorly defined. The flood and drainage behaviour of site runoff will be controlled by the design of proposed stormwater flow paths to be undertaken as part of infrastructure design.

Flood modelling results for Devlin Creek under existing conditions show that part of the western pit and some eastern mine infrastructure may be subject to some flood inundation for larger and extreme flood events.

A levee will be constructed to prevent flooding of the western pit and overburden dump and the eastern mine infrastructure. The levees were included in the TUFLOW model as Z-shape lines. The location of the levees is shown in Figures 7.6 to 7.9. The required elevation of the levee crests will be the 2,000 year ARI flood level plus 0.5m (about 180.1m AHD to 182.3m AHD for the western levee and 174.1m AHD to 175.7m AHD).The height of the levee crests above ground level is generally of the order of 0.7m, with a maximum height of about 7m in a topographical depression near the western levee.

Figure 7.6, Figure 7.7, Figure 7.8 and Figure 7.9 show the change in the 2 year, 10 year, 100 year and 2,000 year ARI design flood depths for Devlin Creek under proposed mining conditions, including the construction of a levee to protect the proposed mine infrastructure. Table 7.5 shows the change in flood depths at various locations in the vicinity of the proposed levees. Figures B5 – B8 in Appendix B show the change in flood velocities for the 2 year, 10 year, 100 year and 2,000 year ARI design floods in Devlin Creek, respectively. The following is of note:

- The proposed levees prevent the inundation of the western pit and overburden dump and proposed mine infrastructure.
- The 2 year ARI design flood does not impact on the proposed mine. Therefore there is no change in flood depths resulting form the construction of the levees.
- There are no significant changes to flood depths for the 10 year ARI design flood resulting from the construction of the proposed levee. Any increases in flood level are limited to 0.1m.
- There are minor increases in flood depths for the 100 year ARI design flood resulting from the construction of the proposed levees. The flood depths have increased by a maximum of 0.2m and are concentrated near the upstream side of the western levee.
- There are localised increases in flood depth for the 2,000 year ARI design flood resulting from the construction of the proposed levees. The majority of the increases are less than 0.4m however, there is a small area immediately upstream of the proposed western levee where flood depths have increased by over 0.4m.
- There is no significant change in flood velocities in Devlin Creek for the 2 year, 10 year, 100 year and 2,000 year ARI design floods as a result of the proposed levee. There are some increases in flood velocities (up to 0.5m/s for the 2,000 year ARI flood event) in the area surrounding the proposed levees.
- The flood impacts of the proposed mine are isolated to the area immediately adjacent to the proposed open cut pits. The development will have no impact on regional flooding in waterways downstream of the mining lease.

Table 7.4 Change in Flood Depth, Various Locations around the Proposed Levees

Location	Ground Elevation (m AHD)	Event											
		2 Year ARI			10 Year ARI			100 Year ARI			2,000 Year ARI		
		Existing Flood Depth (m)	Developed Flood Depth (m)	Difference (m)	Existing Flood Depth (m)	Developed Flood Depth (m)	Difference (m)	Existing Flood Depth (m)	Developed Flood Depth (m)	Difference (m)	Existing Flood Depth (m)	Developed Flood Depth (m)	Difference (m)
A	178.97	0.45	0.45	0.00	1.00	1.01	0.01	1.99	2.11	0.12	2.38	2.60	0.22
B	178.64	0.16	0.16	0.00	1.21	1.22	0.01	2.03	2.05	0.02	2.34	2.37	0.03
C	176.42	-	-	-	0.74	0.74	0.00	1.48	1.48	0.00	1.74	1.74	0.00
D	172.14	3.11	3.11	0.00	3.95	3.95	0.00	4.06	4.06	0.00	4.15	4.15	0.00
E	174.86	-	-	-	-	-	-	0.16	0.16	0.00	0.29	0.29	0.00
F	170.30	2.92	2.92	0.00	4.00	4.00	0.00	4.30	4.30	0.00	4.41	4.41	0.00
G	173.58	-	-	-	0.10	0.11	0.01	0.25	0.25	0.00	0.32	0.32	0.00

- Not inundated

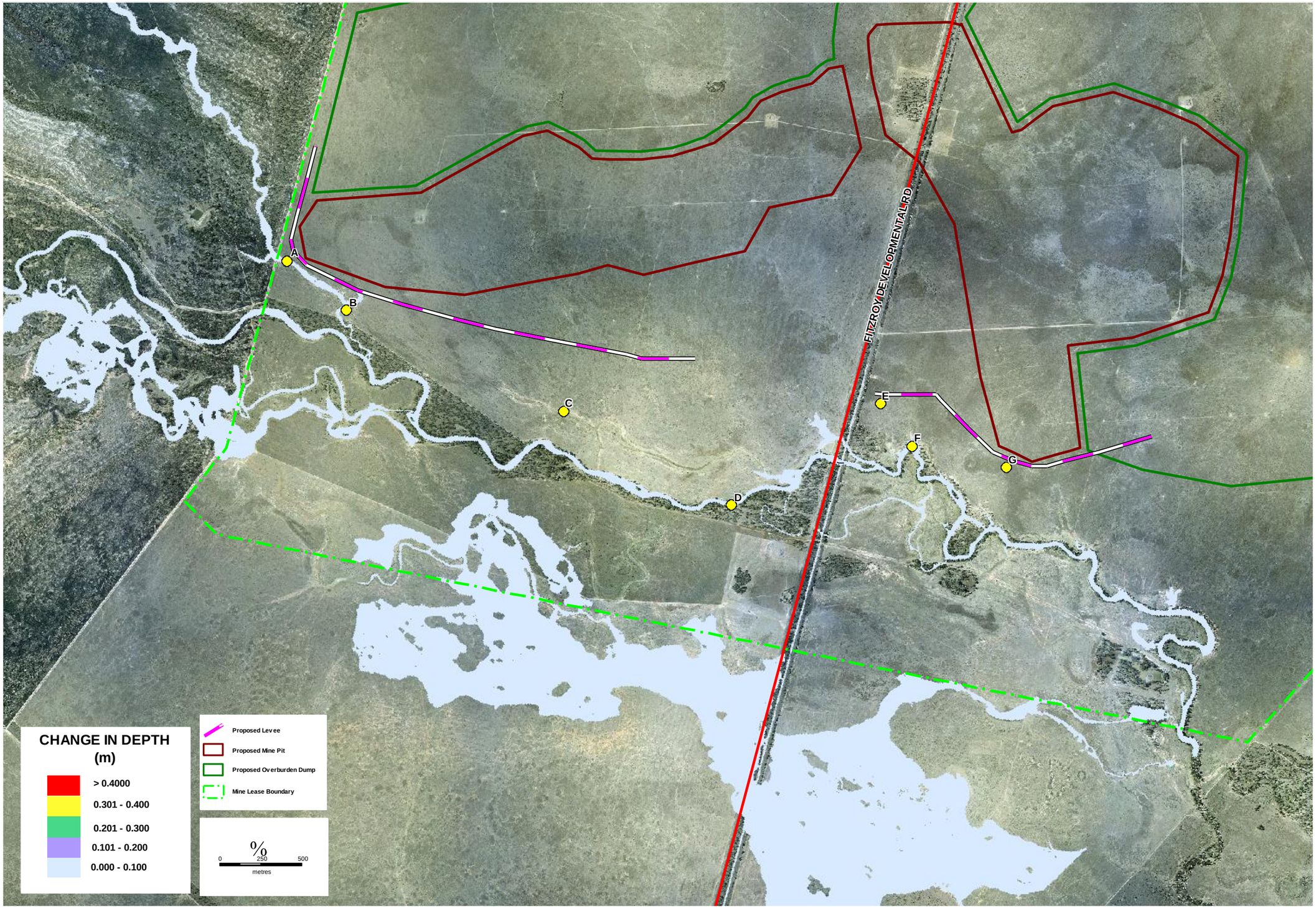

Figure 7.6 Change in Flood Depth, 2 Year ARI, Devlin Creek

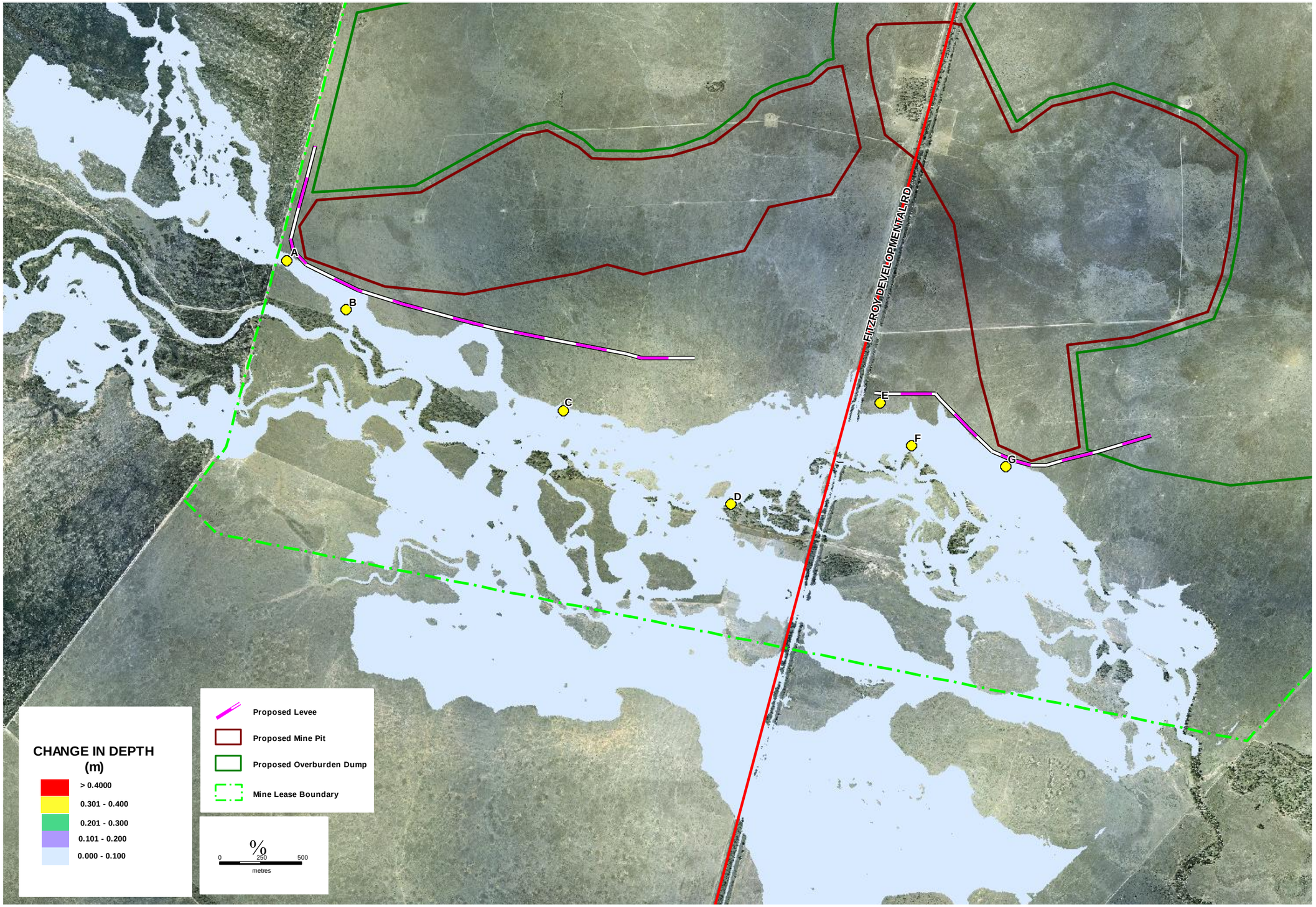

Figure 7.7 Change in Flood Depth, 10 Year ARI, Devlin Creek

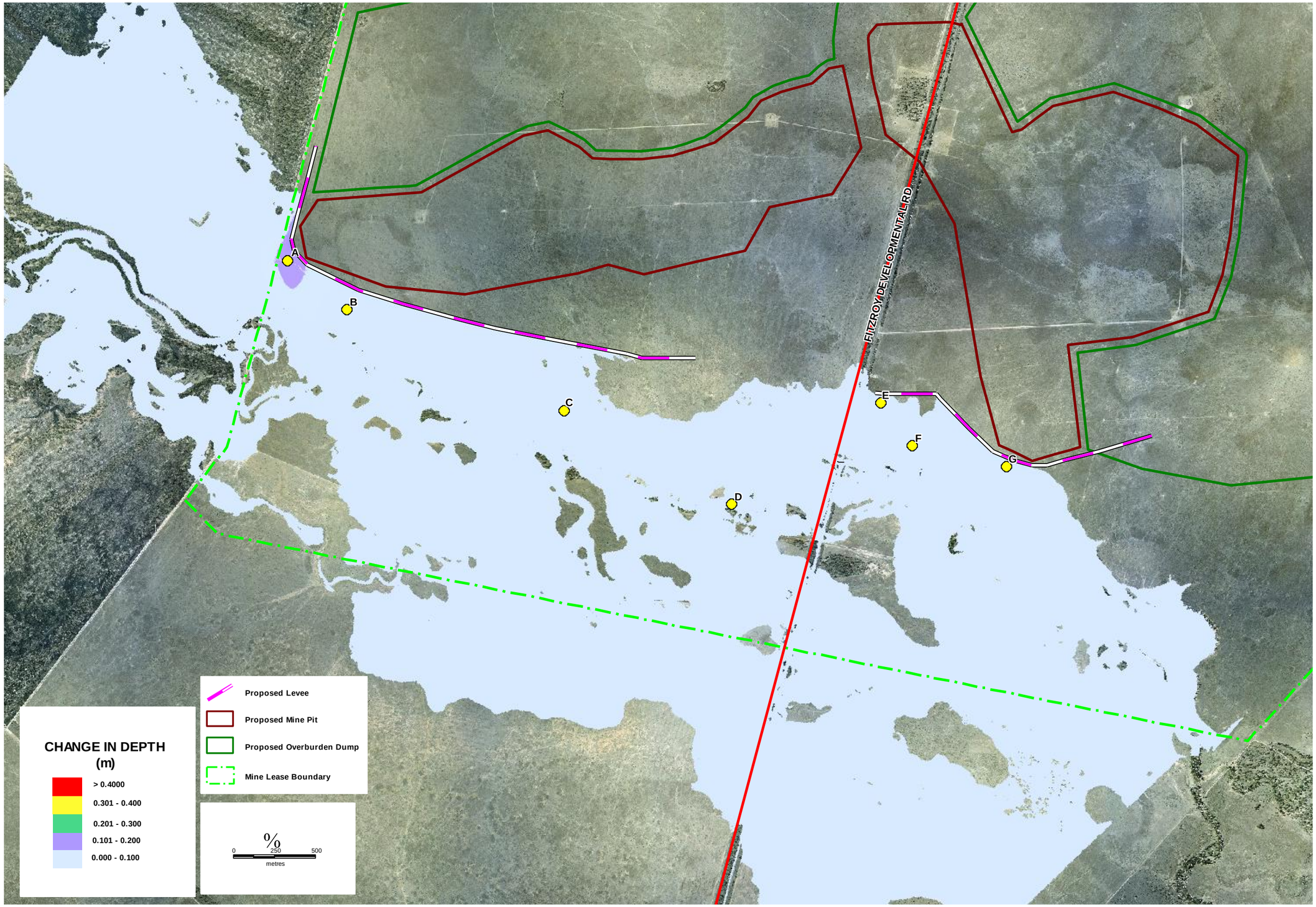

Figure 7.8 Change in Flood Depth, 100 Year ARI, Devlin Creek

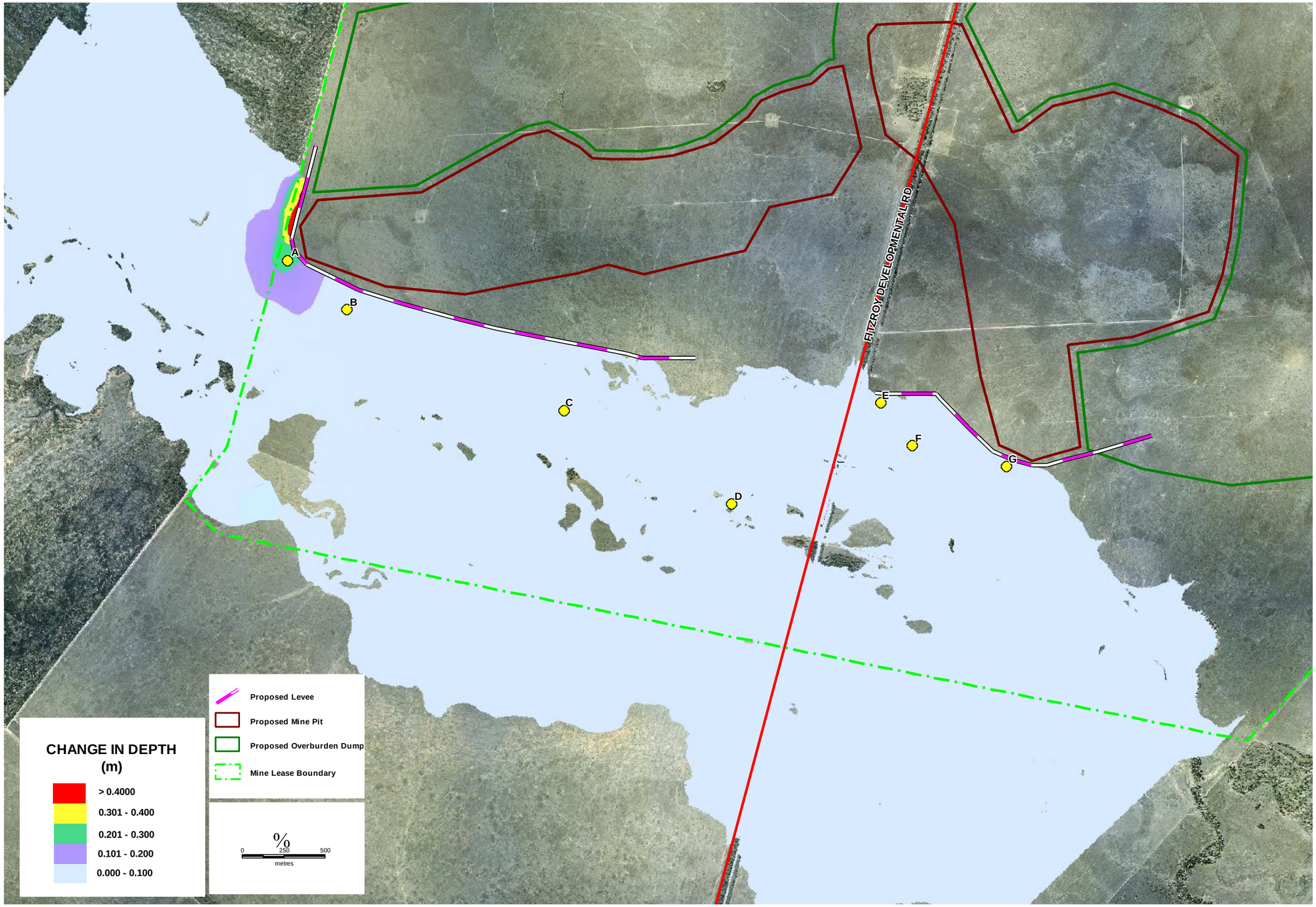

Figure 7.9 Change in Flood Depth, 2,000 Year ARI, Devlin Creek

7.5 PROBABLE MAXIMUM FLOOD

Figure7.10 shows the Probable Maximum Flood (PMF) levels along Devlin Creek adjacent to the proposed mine. PMF levels range from approximately 0.5m higher than the 2,000 year ARI flood levels to a maximum of 1.5m higher than the 2,000 year ARI flood levels.

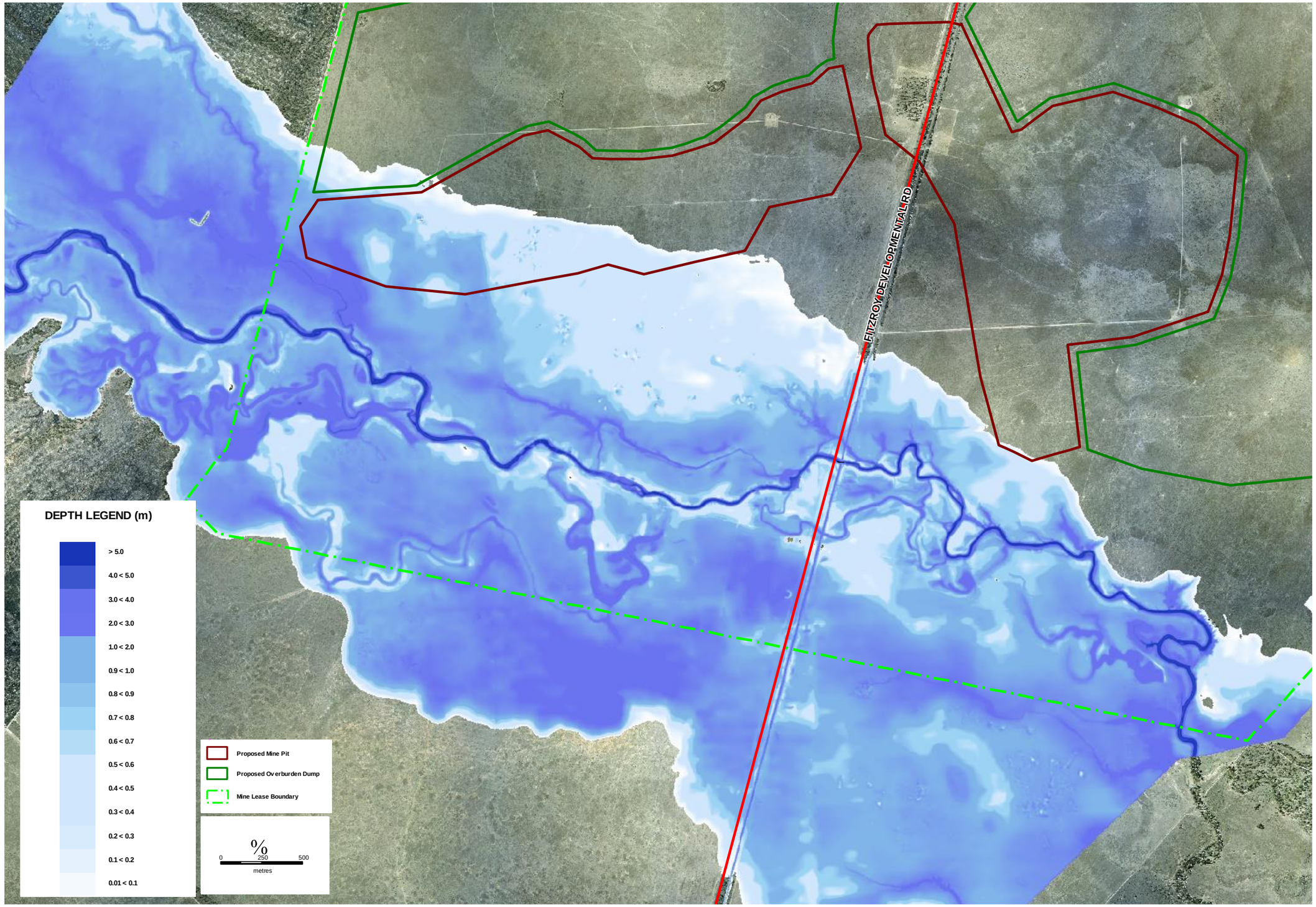

Figure 7.10 Probable Maximum Flood Depths, Devlin Creek

8 SITE WATER BALANCE

8.1 OVERVIEW

The proposed operations will significantly change the characteristics of the minor drainage paths crossing the mining area. A water management system has been devised for the project to separate clean water runoff from surface water that is affected by mining operations. A site water balance modelling study has been undertaken to confirm the effectiveness of the system in limiting off site discharge, and to quantify the impacts on drainage behaviour. A daily timestep GoldSIM model of the site catchments and water management system was developed to make this assessment on the basis of historical climate data.

It is important to understand how the system will perform under the wettest and driest sequences of historical climate record. The model was run for 98 fourteen-year sequences spanning the period 1900 to 2010 (the first being 1900-1913, and the last being 1997-2010). Each sequence represented the mining operation, notionally operating from Jan 2013 to December 2026.

Due to the potential uncertainties in the catchment runoff characteristics, two model cases were used in the assessment:

- High runoff (runoff parameters were selected such that they tend to overestimate catchment runoff). These parameters were used to demonstrate the water management system can reliably contain site runoff even when conservative assumptions are adopted.
- Low runoff (runoff parameters were selected such that they represent the “best estimate” of catchment runoff). These parameters were used to quantify the impact of the project on downstream flows, and for investigating the potential for site water yield to supplement water supplies.

8.2 MODELLED STAGING OF MINE PLAN

The Project has been modelled in five stages, which represent the evolution of the mine layout over time:

- Stage 1 2013 to 2014 (Eastern Pit only) – Macarthur Coal Stage 2 (Year 2)
- Stage 2 2015 to 2020 (Eastern Pit only) – Macarthur Coal Stage 4 (Years 5-6)
- Stage 3 2021 to 2022 (Eastern Pit only) – Macarthur Coal Stage 6 (Years 9-10)
- Stage 4 2023 (Western Pit only) – Macarthur Coal Stage 7 (Year 11)
- Stage 5 2024 to 2027 (Western Pit only) – Macarthur Coal Stage 8 (Years 12-14)

The conceptual water management system layouts at each stage of the project are shown in Figure 8.1 to Figure 8.5. The system is also shown schematically in the diagram in Figure 8.6.

The WMS comprises 2 discrete systems:

1. A pit water system – which captures pit water and runoff from other areas where there is a risk of relatively poor quality runoff. Water is pumped to the environmental dams and then to the Process Water Dam for reuse. Water captured in the Pit Water system is used in preference to the other water sources to reduce the risk of discharge.
2. A sediment dam water system – water captured in the sediment dams is returned to a separate Process Water Dam for reuse.

The following is of note:

- The model does not specifically model the co-disposal system. The CHPP demand is the make-up requirement net of co-disposal return water
- Runoff from undisturbed areas will generally be diverted around the operational areas where possible. Runoff from disturbed areas will be captured in the site water management system.
- If storage water quality and receiving water conditions allow, excess water could potentially be discharged from the site in a controlled manner (but this is has not been modelled).
- During exceptionally wet periods later in the mine life, excess water can be temporarily stored in the Eastern Pit Void.
- Early in the mine life, a temporary pit water dam (ED4) will be provided in the future Western Pit mining area. The dam will receive excess pit water from the Eastern Pit, which is relatively large. The dam will be located to ensure that the Western Pit can be safely mined while the dam is being operated and decommissioned.

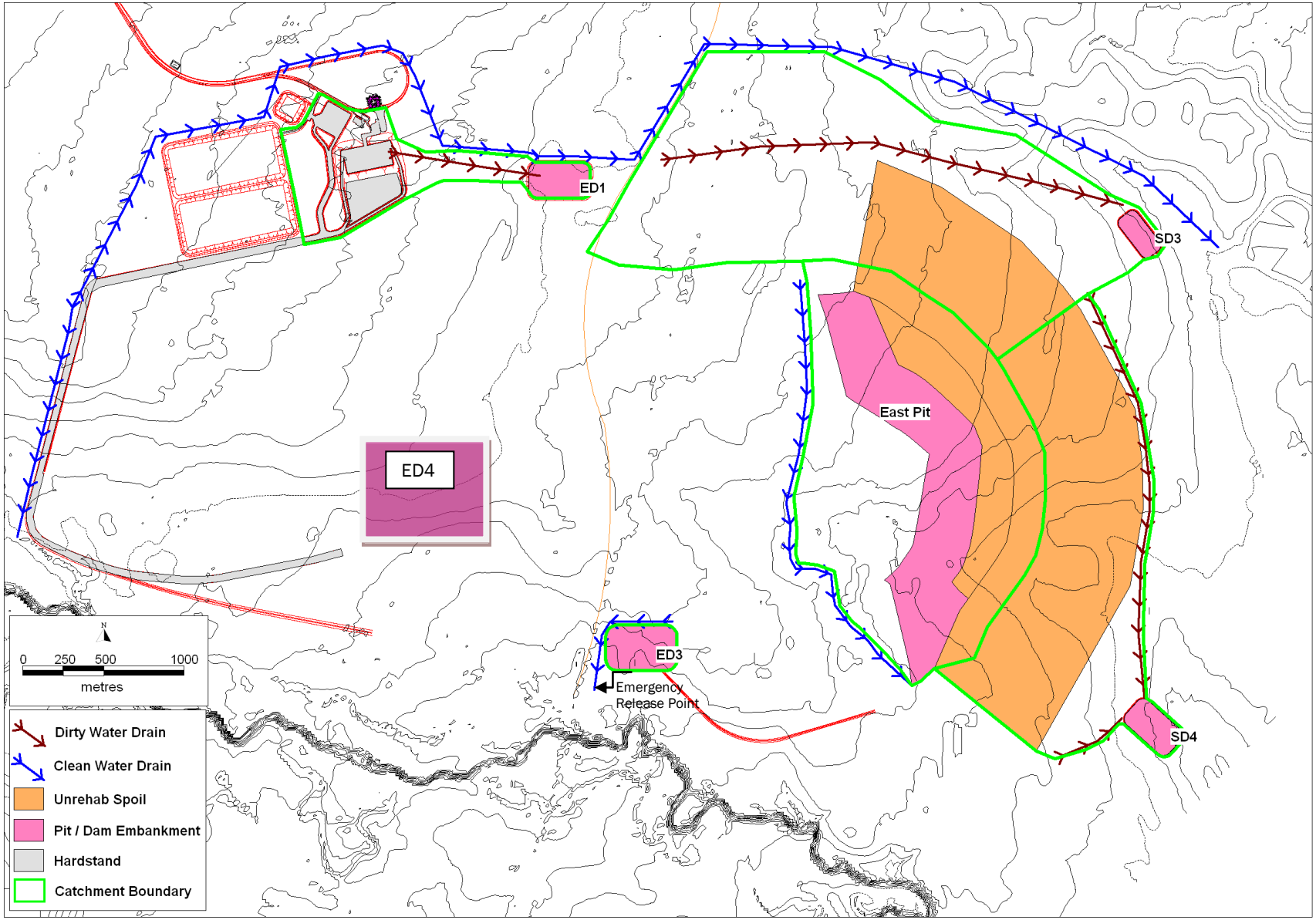

Figure 8.1 Codrilla Coal Project, Stage 1 (2013 to 2014)

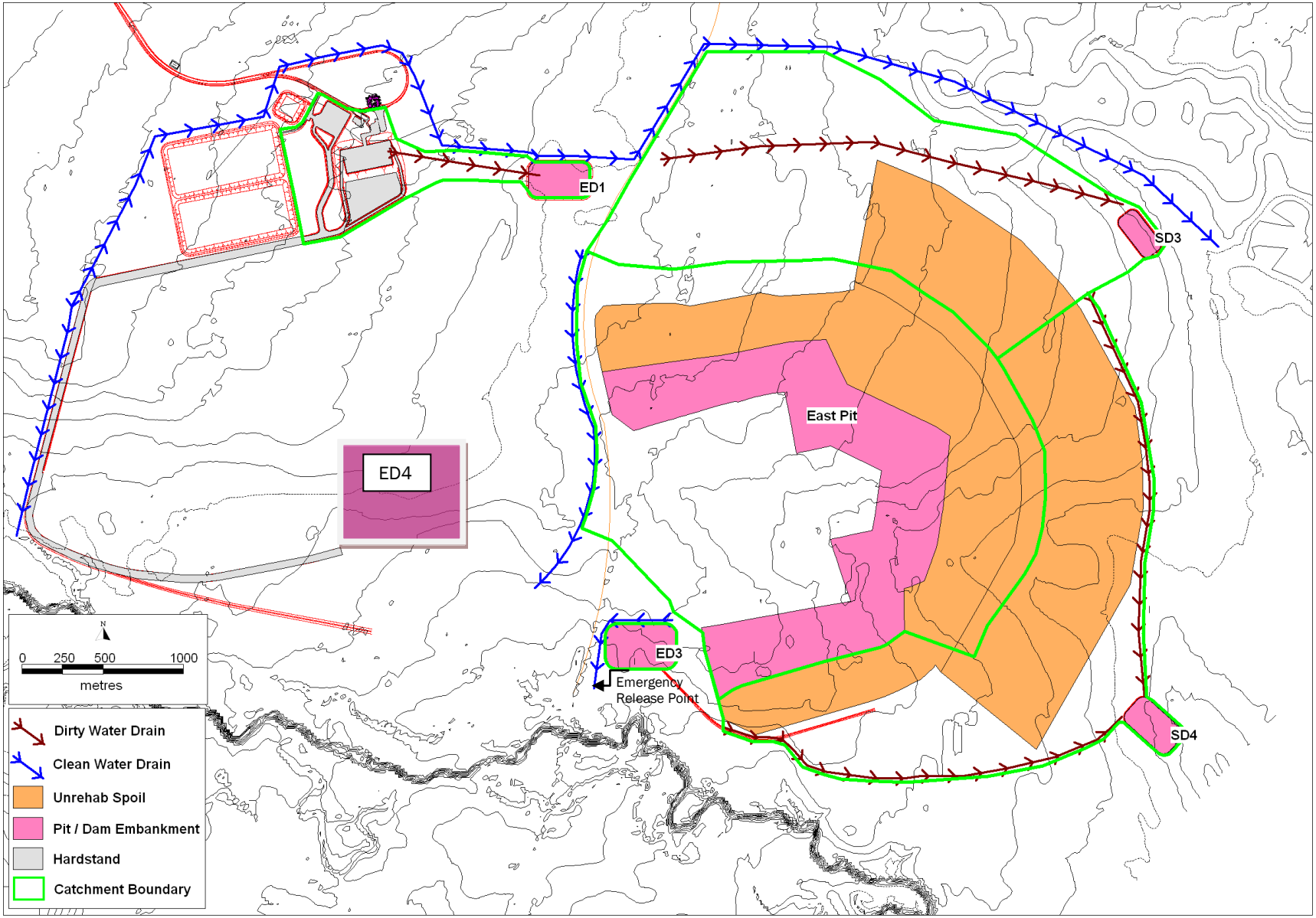

Figure 8.2 Codrilla Coal Project, Stage 2 (2015 to 2020)

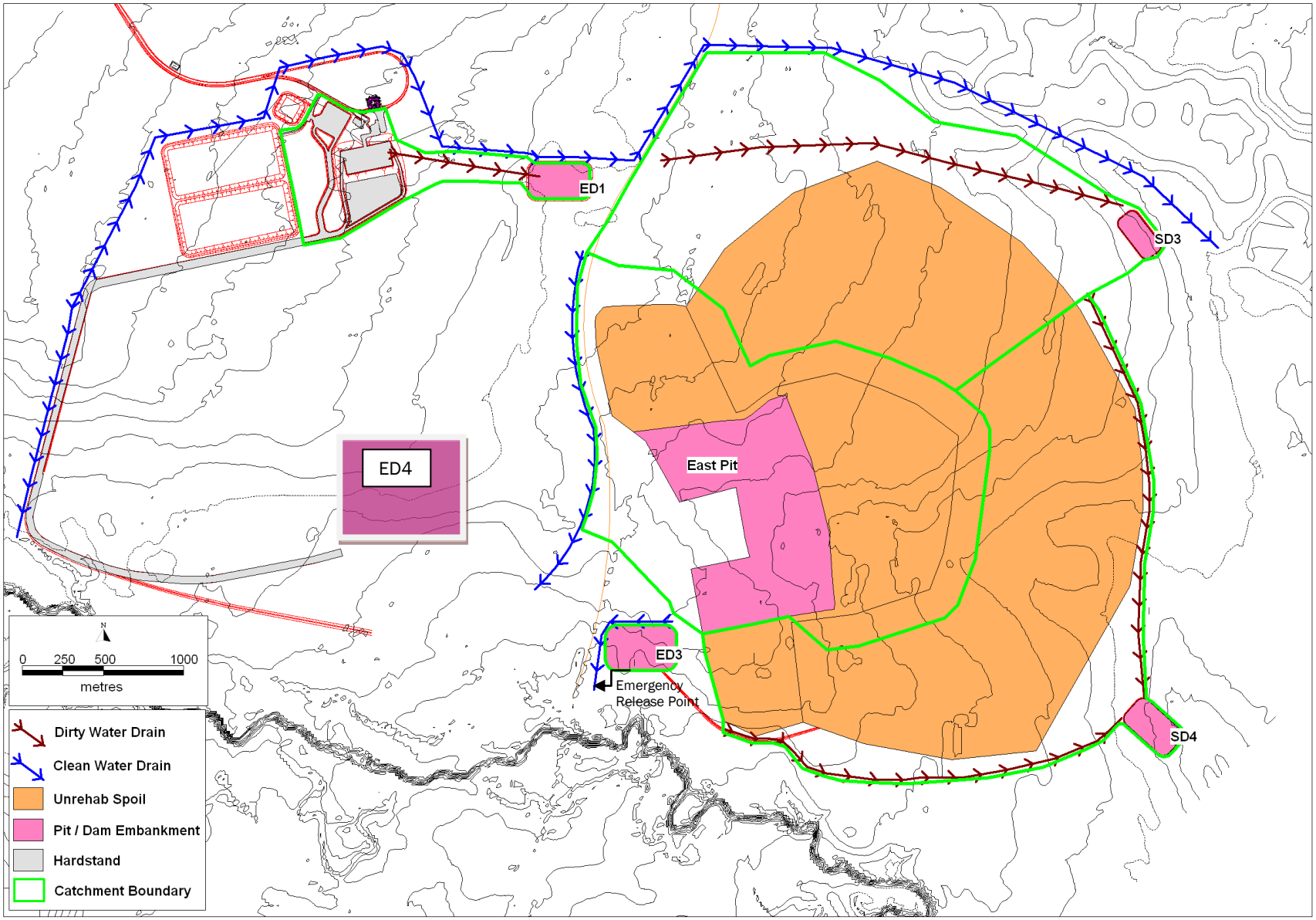

Figure 8.3 Codrilla Coal Project, Stage 3 (2021 to 2022)

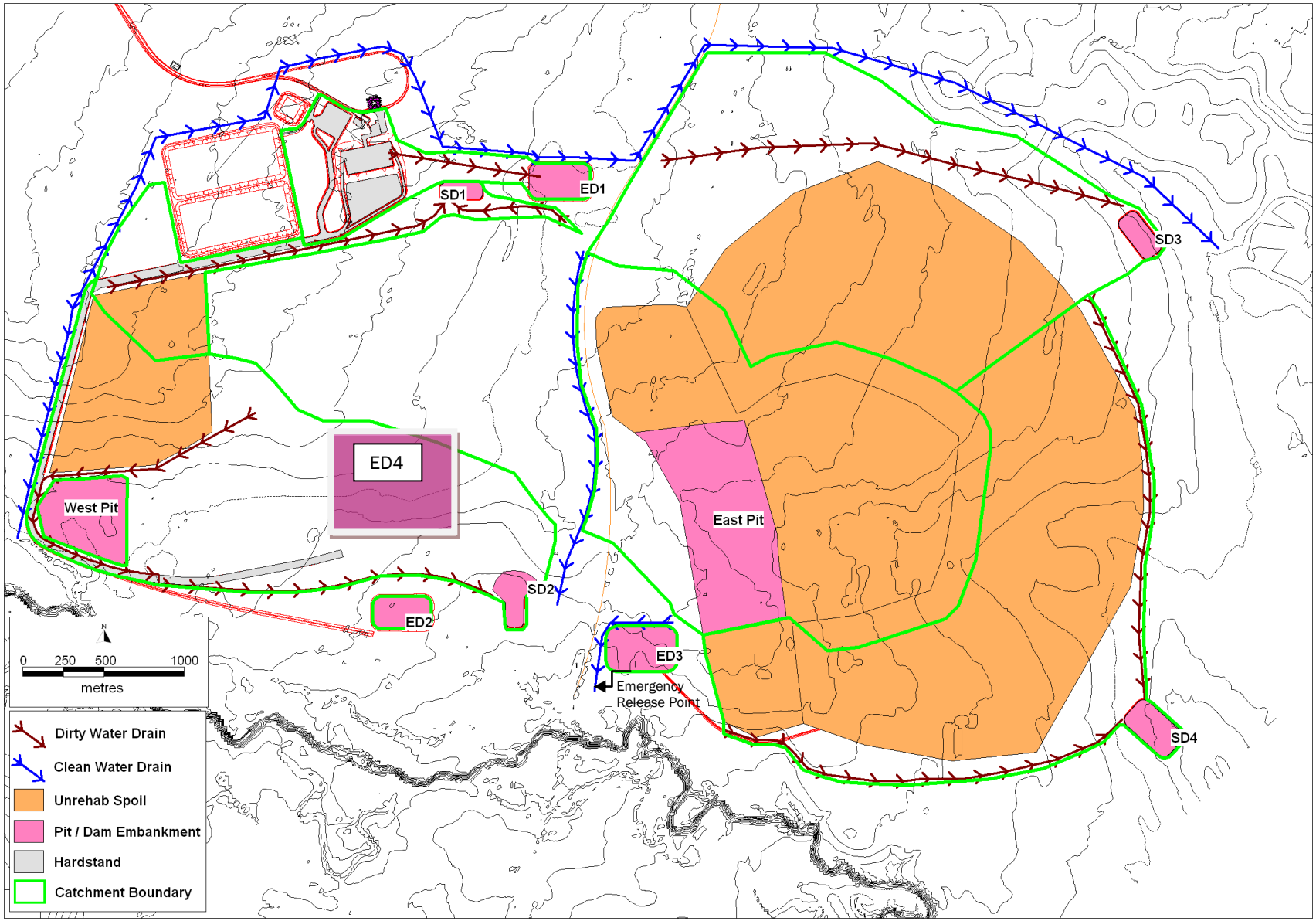

Figure 8.4 Codrilla Coal Project, Stage 4 (2023)

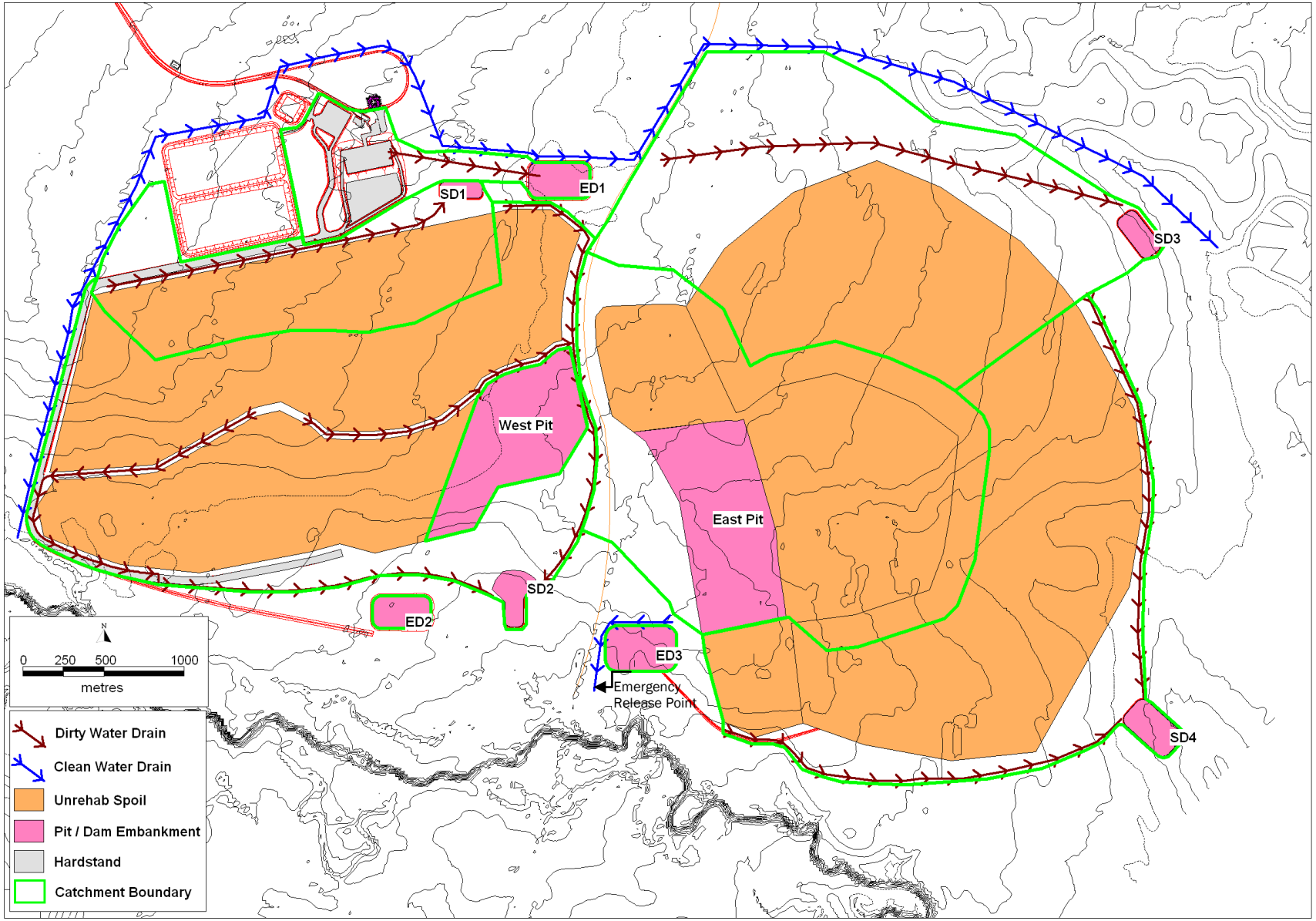

Figure 8.5 Codrilla Coal Project, Stage 5 (2024 to 2027)

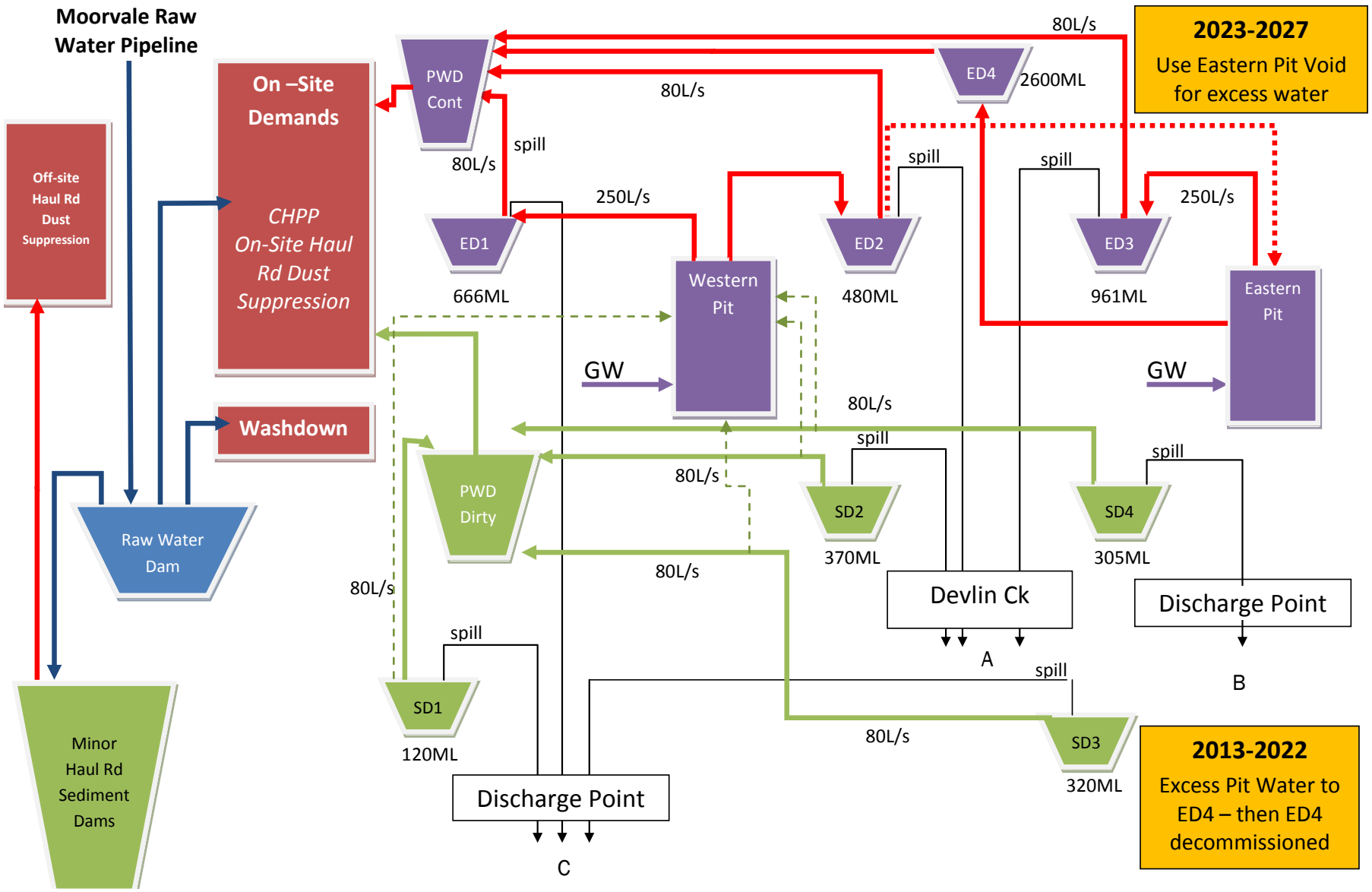

Figure 8.6 WMS Schematic Diagram

8.3 CATCHMENT AREAS

Each dam captures runoff from various catchment types. Catchments across the site were characterised into the following types:

- Undisturbed;
- Unrehabilitated spoil;
- Pit Floor;
- Hardstand Areas.

The areas reporting to each of the dams will change as the site develops. The breakup of catchment types at the end of the project life (Stage 5) are summarised in Table 8.1. The total catchment areas for each stage of mine production are given in Table 8.2.

Table 8.1 Site Catchment Areas and Types (Stage 5)

Storage	Catchment Area (ha)				
	Undisturbed	Unrehabilitated Spoil	Pit Floor	Hardstand	TOTAL
SD1	38.2	115.9	2.5	6.6	163.2
SD2	123.5	362.4	5.5	15.8	507.2
SD3	237.5	196.6	4.1	0.0	438.2
SD4	80.1	328	7.0	0.0	415.1
ED1	44.6	0.0	8.2	20.7	73.5
ED2	0.0	0.0	7.0	0.0	7.0
ED3	0.0	0.0	11.9	0.0	11.9
ED4	0.0	0.0	7.0	0.0	7.0
East Pit	72.7	284.3	71.3	0.0	428.3
West Pit	0.0	0.0	57.6	0.0	57.6
Sediment Return Water Dam	0.0	0.0	7.0	0.0	7.0
Pit Return Water Dam	0.0	0.0	7.0	0.0	7.0

Table 8.2 Total Catchment Areas

Storage	Total Catchment Area (ha)				
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
SD1	0.0	0.0	0.0	78.6	163.3
SD2	0.0	0.0	0.0	337.1	507.2
SD3	353.5	353.5	438.2	438.2	438.2
SD4	216.1	329.5	415.1	415.1	415.1
ED1	73.5	73.5	73.5	73.5	73.5
ED2	0.0	0.0	0.0	7.0	7.0
ED3	11.9	11.9	11.9	11.9	11.9
ED4	7.0	7.0	7.0	7.0	0.0
East Pit	287.6	598.8	428.4	428.3	428.3
West Pit	0.0	0.0	0.0	23.7	57.6
Sediment Return Water Dam	7.0	7.0	7.0	7.0	7.0
Pit Return Water Dam	7.0	7.0	7.0	7.0	7.0

8.4 CLIMATE DATA AND RAINFALL-RUNOFF MODEL

In the absence of long-term records for the project area - site-specific climate data (daily rainfall, Morton's lake evaporation and Potential Evapotranspiration calculated using the FAO Penman-Monteith formula) for the model was obtained from DERM's Data Drill service.

> The Data Drill *"accesses grids of data derived by interpolating the Bureau of Meteorology's station records. Interpolations are calculated by splining and kriging techniques. The data in the Data Drill are all synthetic; there are no original meteorological station data left in the calculated grid fields. However, the Data Drill does have the advantage of being available for any set of coordinates in Australia" (Jeffrey et al., 2001).*

Catchment runoff was modelled using the AWBM rainfall-runoff model (Boughton, 2003). For undisturbed areas, the AWBM was calibrated to streamflow observations at the Devlin Creek at Bombandy streamflow gauge operated by DERM between 1971 and 1988 downstream of the site (see Figure 4.1). The catchment area to this gauge is 1,026km^2. The median annual runoff over the modelled period is approximately 23.6mm/a, or 4.2% of median annual rainfall (mean annual runoff is 5.6% of mean annual rainfall).

AWBM parameters for other catchment types were derived from previous modelling experience, and were generally selected to be consistent with the parameters adopted in the latest update of the Moorvale and Coppabella Mine water balance models.

Table 8.3 AWBM Model Calibration Results – Devlin Creek at Bombandy

Description	Recorded 1971-88	Calculated 1971-88
Total Number of Days	6,336	6,336
Number of Flow Days	981	994
Mean Annual Runoff Co-efficient (%)	5.6	5.7

Table 8.4 Adopted AWBM Model Parameters – Low Runoff

Model Parameter	Undisturbed	Unrehabilitated Spoil	Pit Floor	Hardstand
A1	0.02	0.02	0.1	0.1
A2	0.195	0.195	0.9	0.9
BFI	0.00	0.00	0	0.9
C1	10.0	10.0	12	8
C2	40	40	38	13.5
C3	420	420	0	0
K_{base}	0.00	0.00	1	0
K_{surf}	0.16	0.16	0	0.1
Median Annual Runoff (mm/a)	24	24	68	151
Mean Annual Runoff ((mm/a)	55	55	119	199

Table 8.5 Adopted AWBM Model Parameters – High Runoff

Model Parameter	Undisturbed	Unrehabilitated Spoil	Pit Floor	Hardstand
A1	0.02	0.1	0.1	0.1
A2	0.195	0.9	0.9	0.9
BFI	0.00	0.9	0	0.9
C1	5	12	12	8
C2	20	21	38	13.5
C3	210	0	0	0
K_{base}	0.00	0.7	1	0
K_{surf}	0.16	0.16	0	0.1
Median Annual Runoff (mm/a)	39	114	68	151
Mean Annual Runoff (mm/a)	83	163	119	199

8.5 PIT GROUNDWATER INFLOWS

Pit groundwater inflow estimates were obtained from the AGE groundwater report addendum (AGE, 2011, P10.) The report presents simulated pit seepage derived from numerical groundwater modelling of the intersected aquifers. The report notes that these are likely to be conservative overestimates of groundwater seepage rates. The results are presented in Figure 8.7 below.

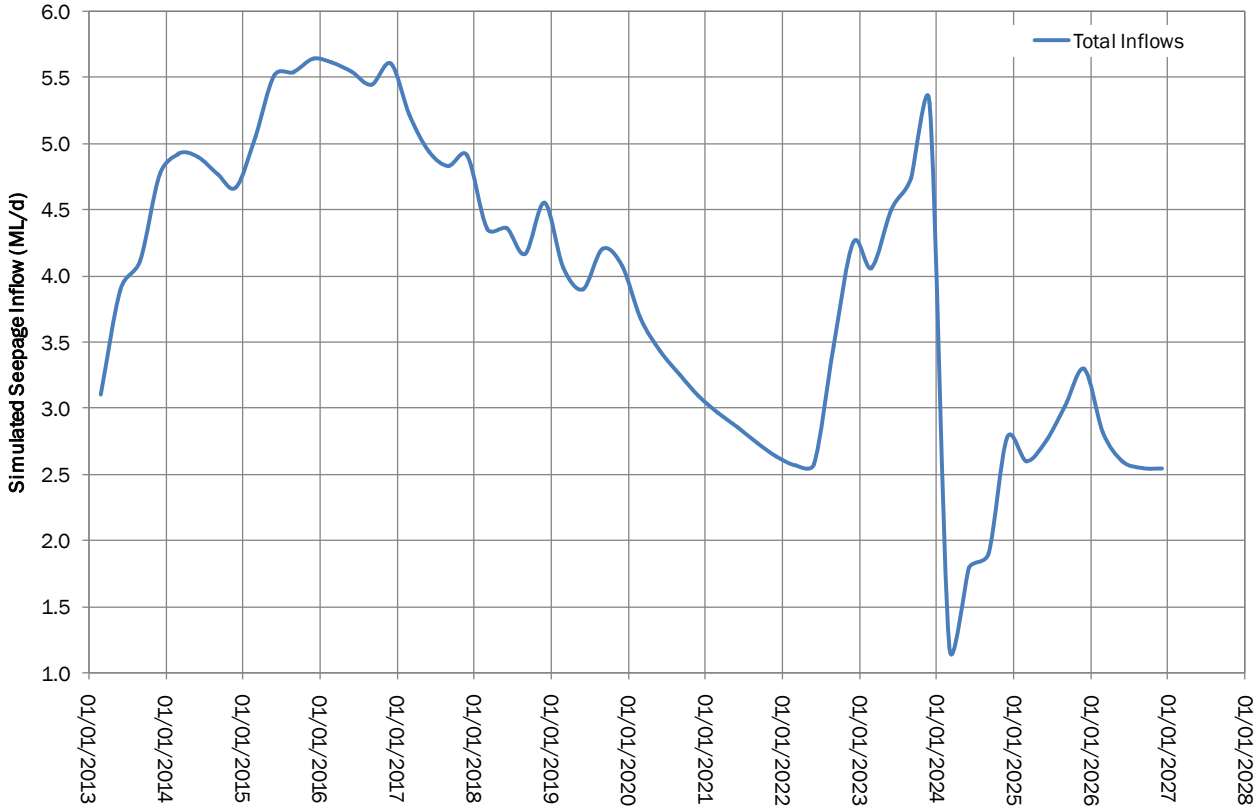

Figure 8.7 Simulated Groundwater Seepage (after AGE, 2010)

The AGE report (AGE, 2010) noted that in-pit groundwater inflows will be smaller due to losses from evaporation and coal extraction on the basis of the following conceptual model:

Inflow = Simulated Seepage
- Evaporation Rate (mm/d)*(500m length of face * 14m height of face)
- entrained loses to mining (1.61ML/d))

This model was incorporated into the GoldSim Model – as shown In Figure 8.8 below. Despite losses to evaporation and coal extraction, this results in some significant groundwater inflows when seepage rates are highest.

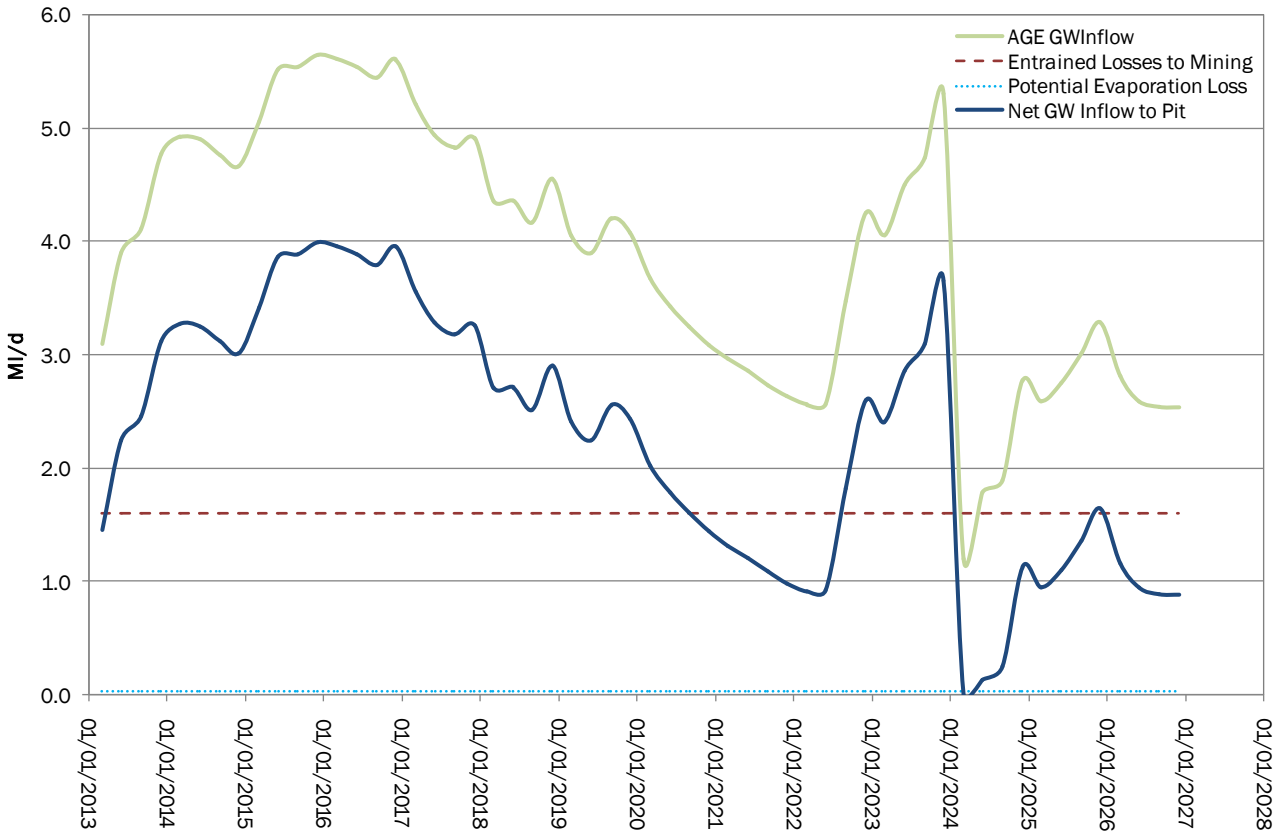

Figure 8.8 Net Pit Groundwater Inflow

8.6 ENVIRONMENTAL DAM AND SEDIMENT DAM SIZES

The capacities of the site water management dams are summarised in the table below. Sediment Dams have been sized to contain runoff from a 10 year ARI 24 hour rainfall event (with a volumetric runoff coefficient of 0.5).

Table 8.6 Dam Capacities

Sediment Dam	Capacity (ML)	Environmental Dam	Capacity (ML)
SD1	120	ED1	666
SD2	370	ED2	480
SD3	320	ED3	961
SD4	305	ED4	2600

With the exception of ED1, all environmental dams will have minimal external catchment.

8.7 OPERATING RULES

8.7.1 Pit Water System

Each of the environmental dams is to be operated such that a minimum operating freeboard is maintained under normal operating conditions. A conservative operational freeboard allowance (the runoff from the 100 year ARI 3 month wet season rainfall with a runoff coefficient of 1) was adopted for operation of the dams. The freeboard allowances are summarised in Table 8.7.

Table 8.7 Pit Water Management System Operating Volumes (ML)

Volume Component	ED1	ED2	ED3	ED4	Pit Return Water Dam
Total Capacity	666	480	961	2600	150
Operational Freeboard Allowance	412	61	103	61	91
Max Operational Volume (MOV)	254	419	858	2539	59

The following operating rules were applied to the pit dewatering system:

- Any water accumulating in the pits is immediately pumped to an environmental dam.

West Pit

- If the ED1 MOV is not exceeded - pump to ED1 until the MOV is reached;
- If the ED1 MOV is exceeded – pump to ED2;
- If the ED2 MOV is exceeded – cease pumping.

Pit dewatering capacity has been assumed to be 200L/s for each pump (i.e. a total of 400L/s).

East Pit

- If the ED1 MOV is not exceeded - pump to ED1 until the MOV is reached;
- If the ED4 MOV is not exceeded - pump to ED4 until the MOV is reached;
- If the ED1 MOV is exceeded – pump to ED3;
- If the ED3 MOV is exceeded – cease pumping.

Pit dewatering capacity has been assumed to be 200L/s for each pump (i.e. a total of 600L/s). All other pumps have been modelled as having a capacity of 80L/s. The incoming raw water pipeline from Moorvale was assumed to have a capacity of 76L/s.

8.7.2 Sediment Dam Collection System

Discharge water quality from sediment dams at other similar nearby operations can usually be expected to be within the licensed water quality discharge limits. However, Macarthur Coal wishes to limit the risk of discharge occurring without significant receiving water flows. To achieve this, excess sediment dam water will be pumped to the plant area for reuse or to the Eastern Pit void (once mining there ceases at the end of Stage 3).

The following operating rules were applied to the Sediment Dam collection system:

- Each sediment dam is to be operated such that as soon as water accumulates in them it is returned to the plant area for reuse;
- If the Sediment Return Water Dam MOV is not exceeded - pump to Sediment Return Water Dam until the MOV is reached;
- If the Sediment Return Water Dam MOV is exceeded – cease pumping. If East Pit void is available, pump to East Pit void.

All pumps have been modelled as having a capacity of 80L/s (except pumps to PWD from SD2 and SD4 which have a capacity of 120L/s).

The operational water volumes for the sediment water collection system are summarised below.

Table 8.8 Sediment Water Management System Operating Volumes (ML)

Volume Component	SD1	SD2	SD3	SD4	Sediment Return Water Dam
Catchment Area (ha)	163.3	507.2	438.2	415.1	
Total Capacity	120	370	320	305	60
Operational Freeboard Allowance	0	0	0	0	35

8.8 SITE WATER DEMANDS

Most water demands can use water captured in either the pit water management system or sediment dam water. Dust suppression water demands will vary over the mine life due to the disturbed area increasing and climatic variability. The basis of the demand estimates is summarised in Table 8.9 below, note that:

- The dust suppression demand is averaged over the 13 year simulation.
- The total average demand of 2,187ML/a (based on a total of 28,431ML over the project life) is less than the final demand of approximately 2,296 ML/a near project end.

Table 8.9 Demand Summary

Item	Average Demand (ML/a)	Basis of Estimate
Vehicle washdown	90 (constant)	Drawn from raw water supplies only.
CHPP	896 (constant)	Based on 128m³/h in DRA report 7,000 h/a (assumes 60% co-disposal recovery). Note this estimate includes ROM dust suppression requirements.
Out of Pit Overburden Dust Suppression	333 (varies)	Nil if rainfall >5mm/d, Otherwise Area X 4mm/d Dust modelling indicates that additional suppression may be required on the out of pit overburden dumps. However, dust suppression requirements are not well understood. For the purpose of the water balance model, an application rate of 2mm/d was applied to the last 500mx1000m of overburden dump.
Haul Road Dust Suppression	958 (varies)	In mine haul roads will be approximately 30m wide.
Internal Haul Roads		
Out-of-Pit Haul Roads	233 (varies)	Nil if rainfall >5mm/d, Otherwise Area X 4mm/d We have assumed out-of-pit haul roads will be 5km long for each pit.
In-Pit Haul Roads	44 (varies)	Nil if rainfall >5mm/d, Otherwise Area X 2mm/d, Adopt We have assumed in-pit haul roads will be 3km long each.
External Haul Road		
To Moorvale (varies)	682	Nil if rainfall >5mm/d, Otherwise Area X 4mm/d, Adopt Area extracted from the Lambert and Rehbein Drawings * 80%.

The areas adopted for the application of dust suppression water at each stage of mining is summarised in the table below.

Table 8.10 Areas adopted for dust suppression demand estimates

		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
External Haul Road	Area (m^2)	511,000	511,000	511,000	511,000	511,000
Out of Pit Haul Road	Length (km)	10	10	10	5	5
	Area (m^2)	110,000	110,000	189,200	220,000	220,000
In Pit Haul Road	Length (km)	3	3	3	3	3
	Area (m^2)	66,000	66,000	66,000	66,000	66,000
Out of Pit Overburden	Area (m^2)	500,000	500,000	500,000	500,000	500,000

8.9 MODEL RESULTS

8.9.1 Pit Water Management System Performance

An example of the behaviour of the system is shown in Figure 8.9, which shows ED1 during the critical wet period commencing in 1982 under the high runoff scenario.

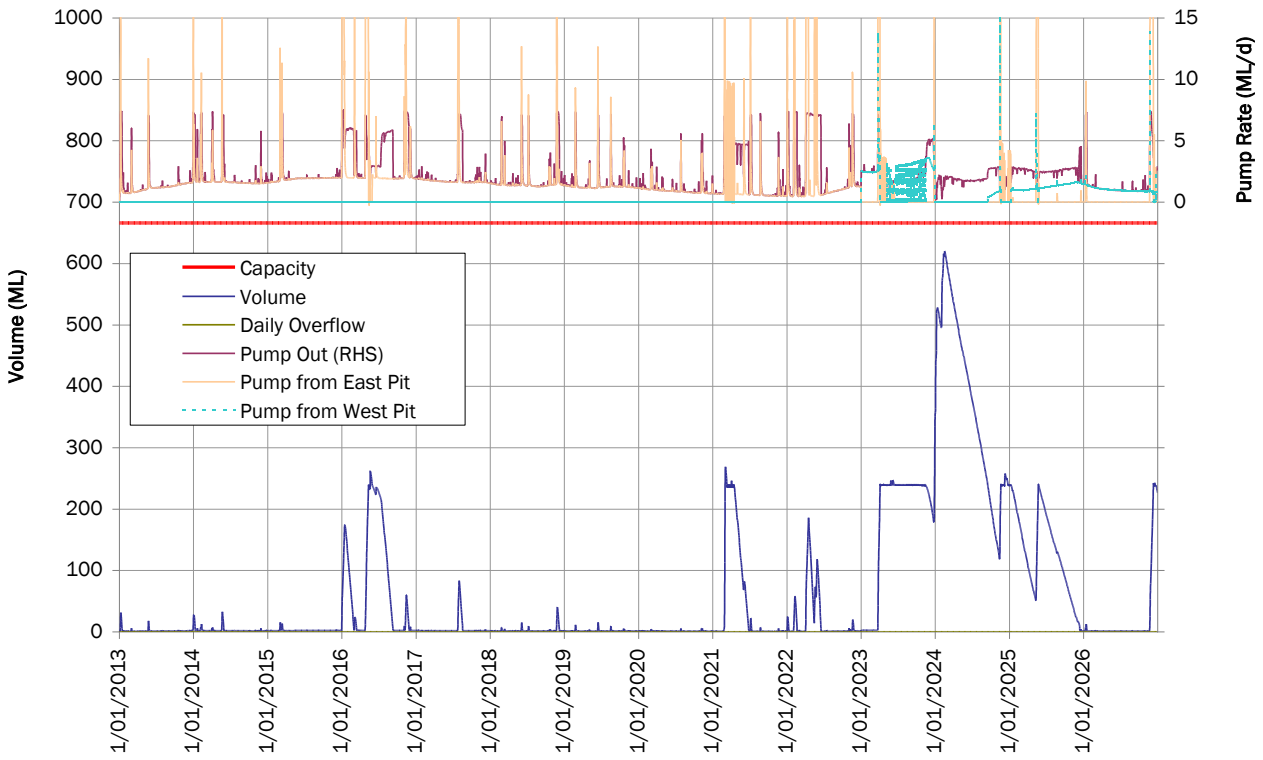

Figure 8.9 ED1 Behaviour – Project Commencing 1982 (High Runoff)

The results show that under the modelled historical conditions, the proposed pit water management system would not have discharged. The maximum stored water volumes are well within the total dam capacities. This is illustrated in Figure 8.10, below, which shows the probability of exceedance for the stored volume in each of the Environmental Dams, and Table 8.11, which compares the maximum modelled volumes to the storage capacities.

Table 8.11 Pit Water Management System Performance

	ED1	ED2	ED3	ED4	Pit Return Water Dam
Maximum Storage Volume (ML)	620	405	878	2,540	67
Design Capacity (ML)	666	480	961	2,600	150

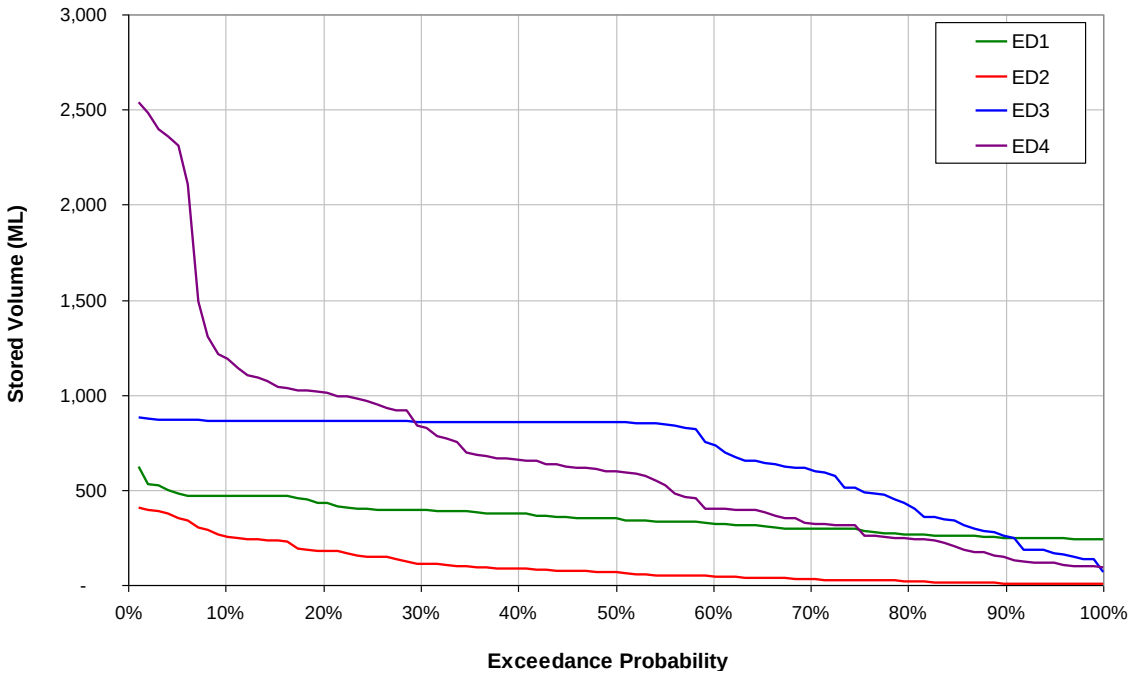

Figure 8.10 Environmental Dam Storage Volume – Probability of exceedance (High Runoff)

Figure 8.11 shows the probability of various stored water volumes occurring in the mine pits. The analysis is based on a simulation from 1900 to 2010. For the East Pit, Stage 2 was modelled, and for the West Pit, Stage 5 was modelled (as these are the critical periods for pit availability – when the pit catchment areas are greatest). The results show that the modelled water management system does not allow large volumes of water to accumulate in West Pit. In East Pit, large volumes of are unavoidable, due to the large pit catchment. However, the high pit dewatering capacity (600L/s) allows the frequency and duration of large stored water volumes to be maintained at manageable levels.

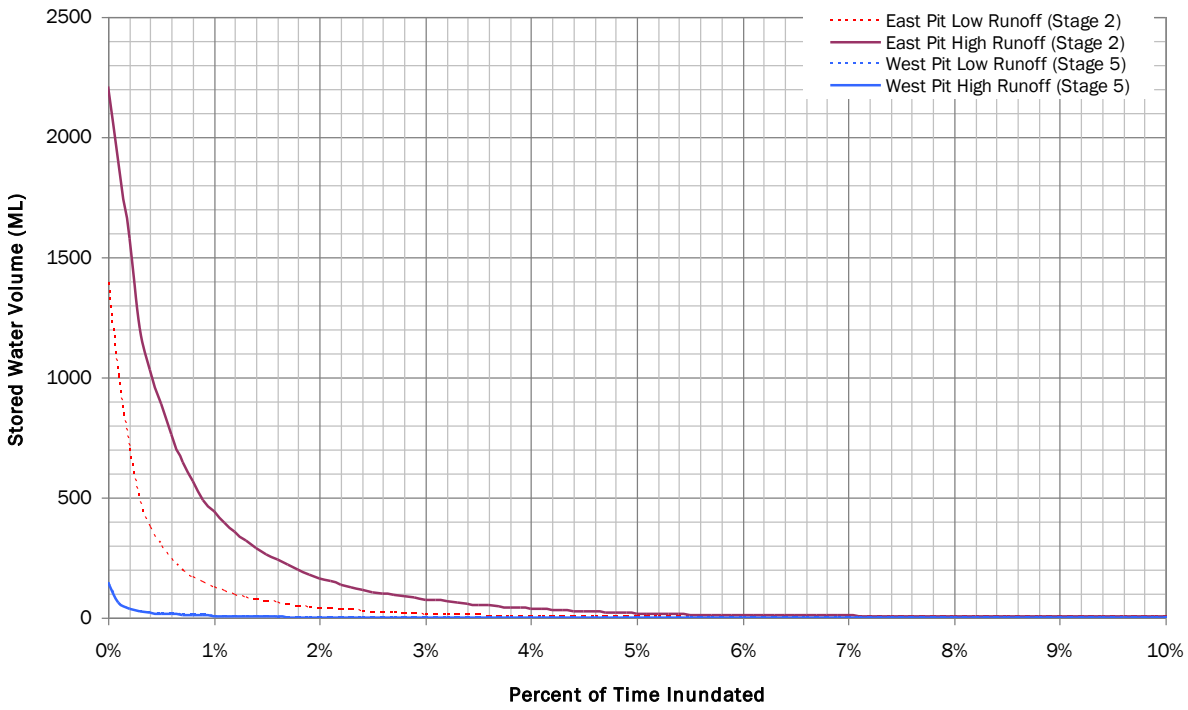

Figure 8.11 In-pit stored water volume

8.9.1 Sediment Dam Collection System Performance

Figure 8.12 shows an example of the behaviour of SD4 during the critical wet period commencing in 1982. The results show that except for periods immediately following rain, the dam is held close to empty.

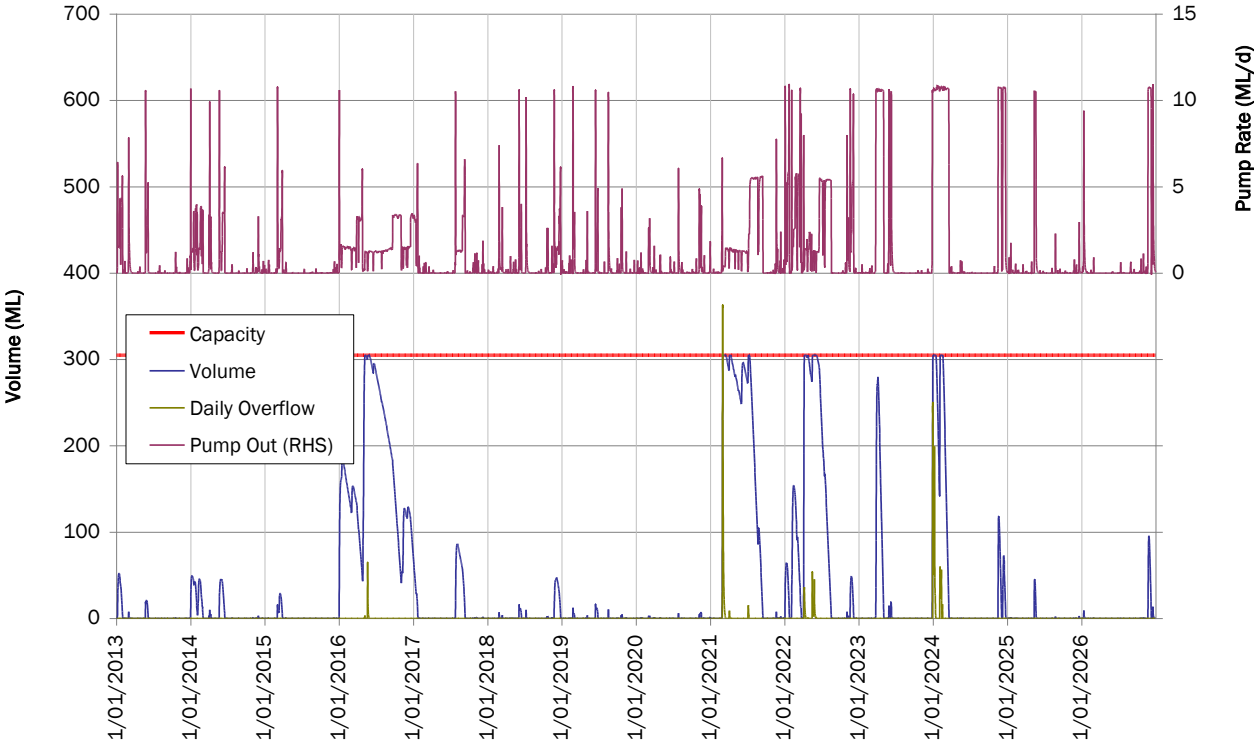

Figure 8.12 Sediment Dam SD4 Behaviour – Project Commencing 1982 (High Runoff)

Figure 8.13 to Figure 8.16 show the frequency of modelled sediment dam spillway discharges over the mine life. Under the low runoff scenario, this occurs less than 3 days per year on average. Under the high runoff scenario, this occurs more often, however, most of the flow days occur in a small number of large events. The median number of discharges per stage is one, and the maximum number of discharges per stage is 5.

Significant volumes of water could accumulate in the Eastern Pit if unused water in excess of site demands is captured (up to 3,400 ML in the worst case 14 year sequence). The Eastern Pit has a maximum capacity of 74,000ML if required. During their operational periods, stored pit water volumes will be kept to minimal through the proposed pit dewatering system. The proposed system should be sufficient to prevent significant interruptions to mining due to pit inundation.

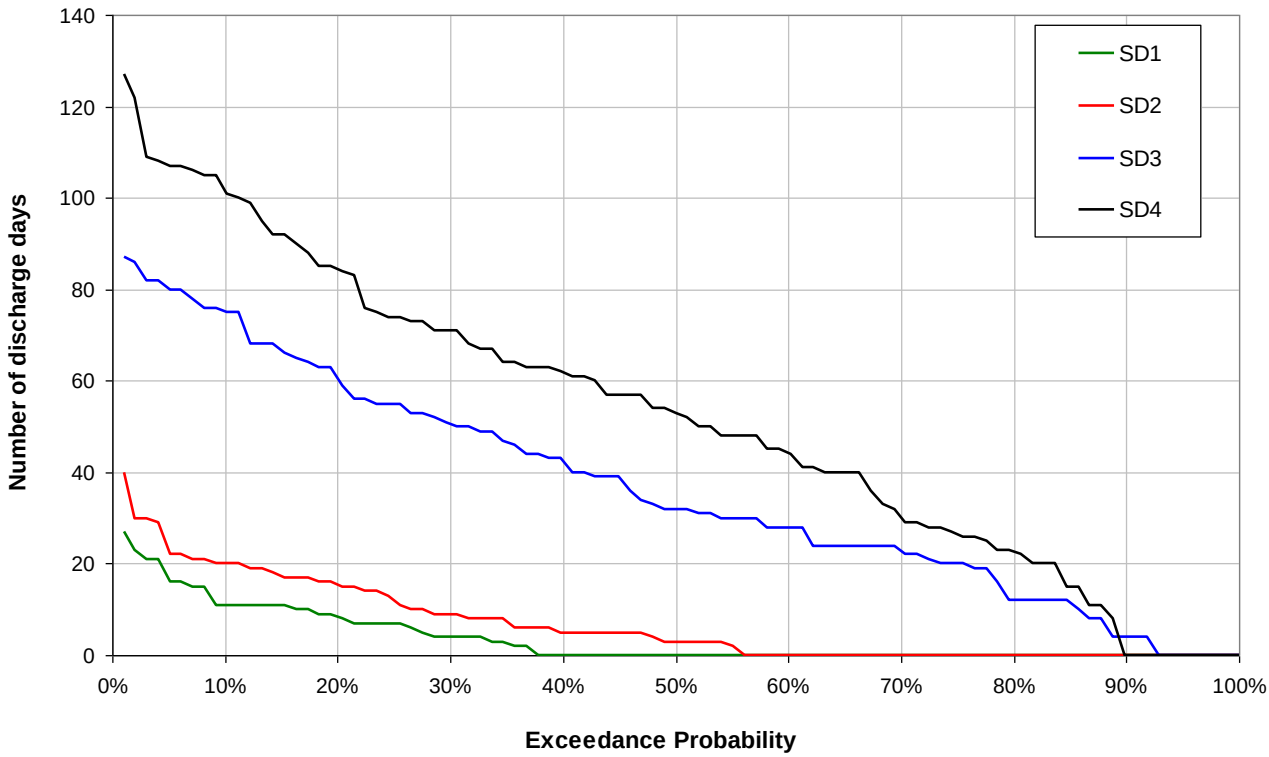

Figure 8.13 Sediment Dams – Number of Discharge Days over 13 Years – High Runoff

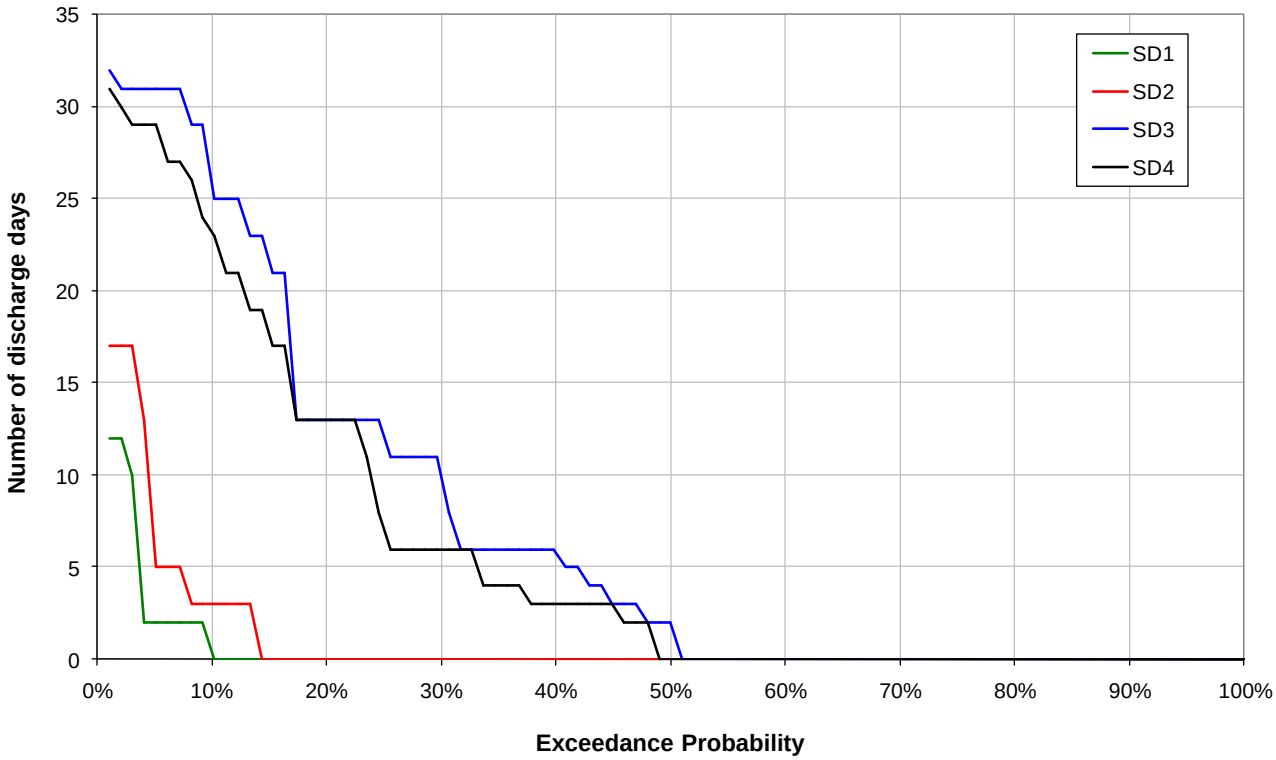

Figure 8.14 Sediment Dams – Number of Discharge Days over 13 Years – Low Runoff

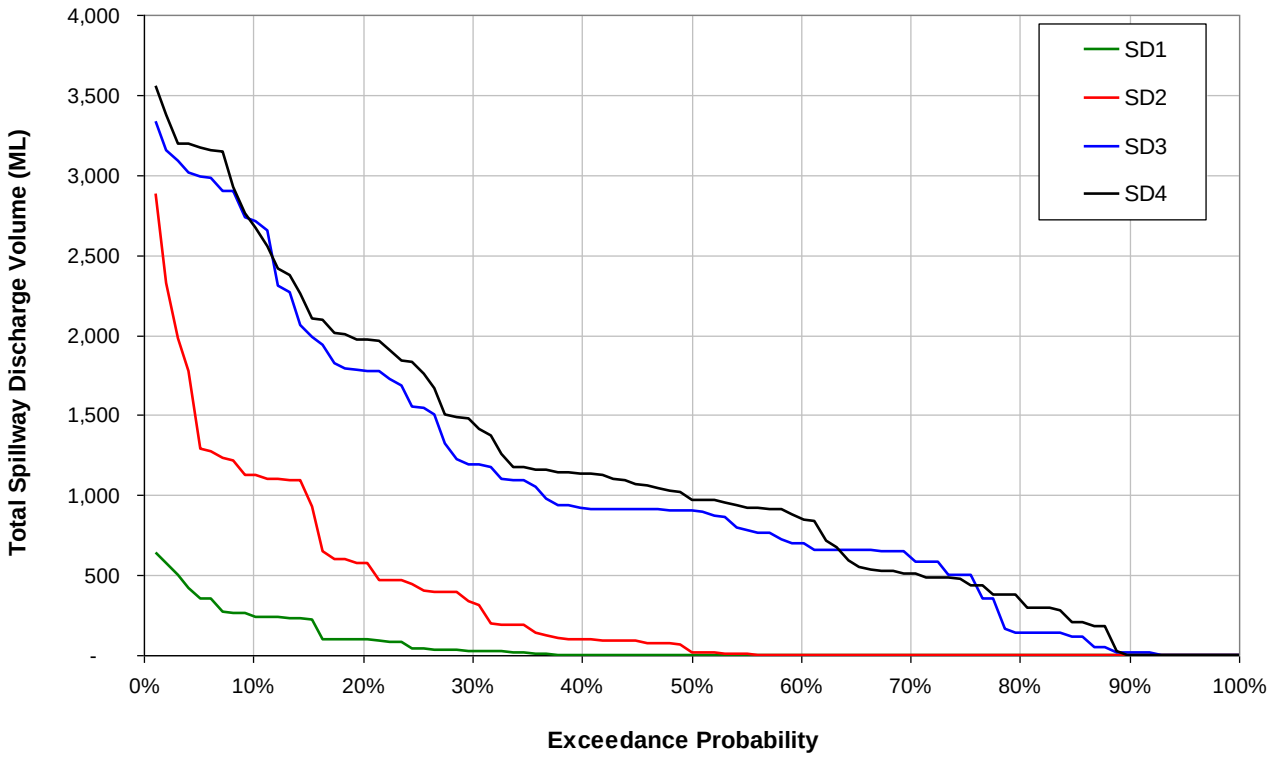

Figure 8.15 Sediment Dam Total Discharge Volume over 13 years – High Runoff

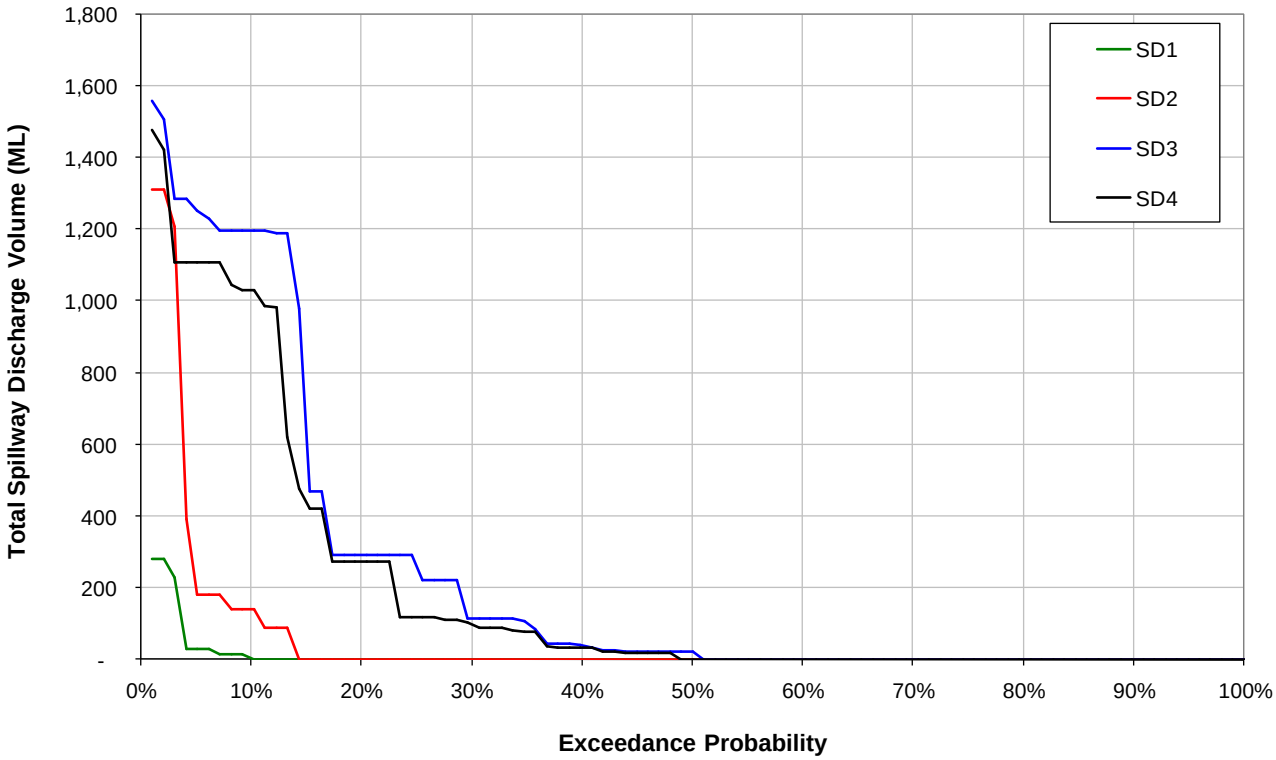

Figure 8.16 Sediment Dam Total Discharge Volume over 13 years – Low Runoff

8.9.2 Overall Site Water Balance

The overall site water balance for the life of the project is summarised in the tables below.

Table 8.12 Total Site Water Balance – Mean of all 14 year sequences - High runoff case

Flow Component	West Pit	East Pit	Environmental Dams	Sediment Dams	Total
	ML	ML	ML	ML	ML
Groundwater Inflow	2,056	9,501	0	0	**11,556**
Catchment Runoff	194	7,339	1,124	13,586	**22,243**
Direct Rainfall	3.6	67.9	1,568	951	**2,590**
Total Inflow	**2,253**	**16,907**	**2,692**	**14,537**	**36,390**
Evaporation	5	80.8	2,341	1058.3	**3,485**
Overflows	0	0	0.0	2,564	**2,564**
Demands	0	0	12,476	5,840	**18,317**
Total Outflow	**5**	**81**	**14,817**	**9,463**	**24,366**
Change in Volume	3	49.8	213	91.6	**357**

Table 8.13 Total Site Water Balance – Mean of all 14 year sequences- Low runoff case

Flow Component	West Pit	East Pit	Environmental Dams	Sediment Dams	Total
	ML	ML	ML	ML	ML
Groundwater Inflow	2,056	9,501	0	0	**11,556**
Catchment Runoff	194	3,422	963	4,721	**9,300**
Direct Rainfall	3.5	40.8	1,465	912	**2,421**
Total Inflow	**2,253**	**12,964**	**2,428**	**5,633**	**23,277**
Evaporation	5	32.8	1,865	601	**2,504**
Overflows	0	0	0.0	489	**489**
Demands	0	0	9,864	2,846	**12,710**
Total Outflow	**5**	**33**	**11,729**	**3,936**	**15,703**
Change in Volume	3	12.2	58	27.6	**101**

8.9.3 Impacts on Flows In Local Catchments

The proposed mine water management system has been sized to contain runoff from disturbed areas for later reuse, with a very low risk of discharge. This is consistent with the intent of current drafts of DERM's Model Environmental Authority Conditions for Coal Mines in the Fitzroy Basin and the Manual for Assessing Hazard Categories of Dams. As a consequence, the Codrilla Project will have a significant impact on flows in the small tributaries that flow through the site. However, the impact on flows in the watercourses just downstream will be much smaller. This is illustrated in Table 8.14, which summarised the impacts of the project at the locations shown in Figure 2.1. At Devlin Creek, just downstream of the Swampy Creek confluence, the modelled median annual flow is predicted to be reduced by 7.0% in 2015 and by 10.8% when the mine footprint is largest. At Reporting Point C, flows will be increased, due to the diversion of undisturbed catchments around the disturbed areas.

Table 8.14 Reduction in flows in local catchments

Reporting Point	Catchment Area (km^2)	Reduction in Median Annual Flow		Description
		2015	2024	
A	261.2	-1.5%	1.7%	Devlin Creek @ Lease Boundary
B	22.4	91.1%	91.1%	Trib of Swampy Creek @ Lease Boundary
C	5.8	-56.9%	-56.9%	Trib of Swampy Creek @ Lease Boundary
D	5.42	9.6%	9.6%	Trib of Swampy Creek @ Lease Boundary
E	145.1	9.5%	15.1%	Swampy Creek D/S of minor Trib (B, C, D)
F	437.9	7.0%	10.8%	Devlin Creek D/S of Swampy Creek

*Flows increase due to clean catchment diversions

8.10 PROVISION FOR EMERGENCY RELEASES

The proposed water management strategy for the Codrilla project is based on no release of water from the mine water management system. However, it is possible that emergency releases may be required under an extreme climate scenario beyond the range of modelled climatic conditions, or if key assumptions or estimates in the water balance modelling, such as the rate of groundwater inflows, are substantially incorrect. Emergency releases, if required, will be undertaken to minimise impacts on receiving water quality by ensuring that discharges occur above the 20th percentile flow in Devlin Creek and that mine water discharges are diluted by a factor of at least 4 to 1.

Figure 8.17 shows the flow frequency curves estimated from recorded streamflow data at 9 gauges in the area of interest, with no-flow days excluded. Table 8.15 below shows the 20th percentile flows (in mm/d) derived from the information shown in Figure 8.17.

The results show that the 20th percentile flow in Devlin Creek is about 0.0014 mm/d, which is the lowest of all streams in the area. Based on the Devlin Creek catchment area to Fitzroy Developmental Road of about 250 km^2, the 20th percentile flow is approximately 4 L/s. In practice, it unlikely that emergency discharges would be less than about 100 L/s. Hence, a minimum stream discharge of 400 L/s would be required to achieve a dilution ratio of 4 to 1.

Water quality will be monitored downstream of the release point to ensure that regional water quality guideline values are not exceeded. Emergency discharges would be immediately ceased if electrical conductivity (a measure of salinity) exceeds the regional guideline value.

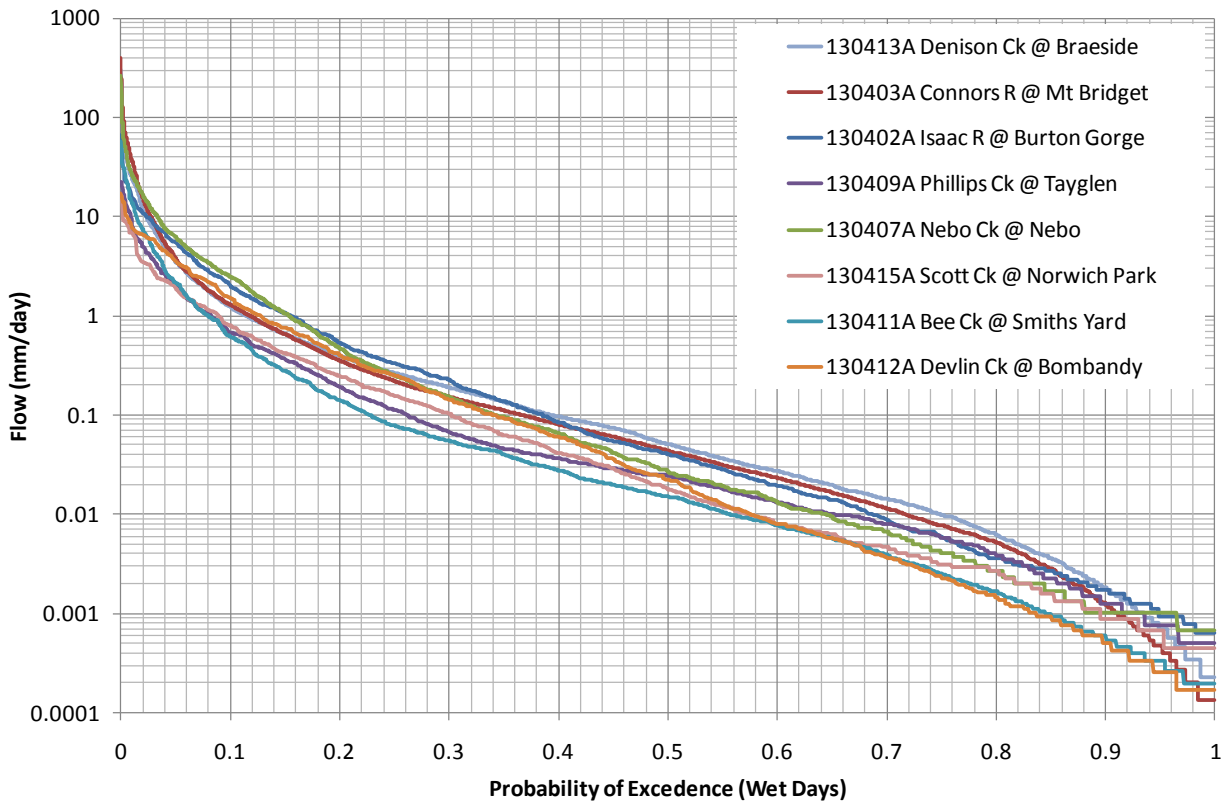

Figure 8.17 Recorded Frequency Curves for 20th Percentile Trigger Flows (mm/d - no-flow days excluded)

Table 8.15 Estimated 20th Percentile Trigger Flows (from DERM streamflow records)

Gauge No.	Gauge Name	Stream	20th percentile flow (ML/d)	20th percentile flow (mm/d)
130411A	Smiths Yard	Bee Ck	2.2	0.0017
130407A	Nebo	Nebo Ck	0.7	0.0027
130410A	Deverill	Isaac	5.9	0.0015
130413A	Braeside	Denison Ck	4.8	0.0063
130402A	Burton Gorge	Isaac	2.0	0.0036
130412A	Bombandy	Devlin Ck	1.5	0.0014
130409A	Tayglen	Phillips Ck	1.3	0.0038
130403A	Mt Bridget	Connors	6.7	0.0052
130415A	Norwich Park	Scott Ck	1.0	0.0027

9 SURFACE WATER MONITORING PLAN

9.1 OVERVIEW

The objective of the surface water monitoring plan for the Codrilla Project is to demonstrate the effectiveness of site water management in ensuring that mining operations do not have an adverse impact on the environmental values of receiving waters. The surface water monitoring program consists of the following components:

- Sampling at fixed locations (using automatic samplers such as pumping or rising stage samplers);
- Additional sampling of receiving waters during and after mine water discharge events (if any); and
- Sampling of onsite mine storages.

9.2 WATER QUALITY MONITORING LOCATIONS

Figure 9.1 shows the existing water quality sampling locations already established for the Codrilla Project. The water quality monitoring program has been designed to provide upstream, source and downstream monitoring in the Devlin Creek catchment as well as onsite storage monitoring. The Devlin Creek catchment is currently monitored at one upstream (Swampy Creek) and one downstream (Devlin Creek at Fitzroy Developmental Road) locations.

The water quality monitoring program will be expanded to include a location upstream of mining disturbance on Devlin Creek, downstream of mining disturbance on Devlin Creek and downstream of the mining lease on Swampy Creek as shown in Figure 9.1. The sampling site at Fitzroy Developmental Road will be moved downstream of the mine water emergency release point. A stream flow monitoring station will be installed at the monitoring site upstream of the mine on Devlin Creek.

Table 9.1 provides a description of the existing and recommended water quality monitoring sites.

Table 9.1 Existing & Recommended Water Quality Monitoring Sites

Monitoring Point	Location
USSC	Swampy Creek, Upstream of Mining Lease
DCFDR	Devlin Creek downstream of Fitzroy Developmental Rd
USDC	Devlin Creek, Upstream of Mining Lease
DSSC	Swampy Creek, Downstream of Mining Lease
DSDC	Devlin Creek, Downstream of Mining Lease

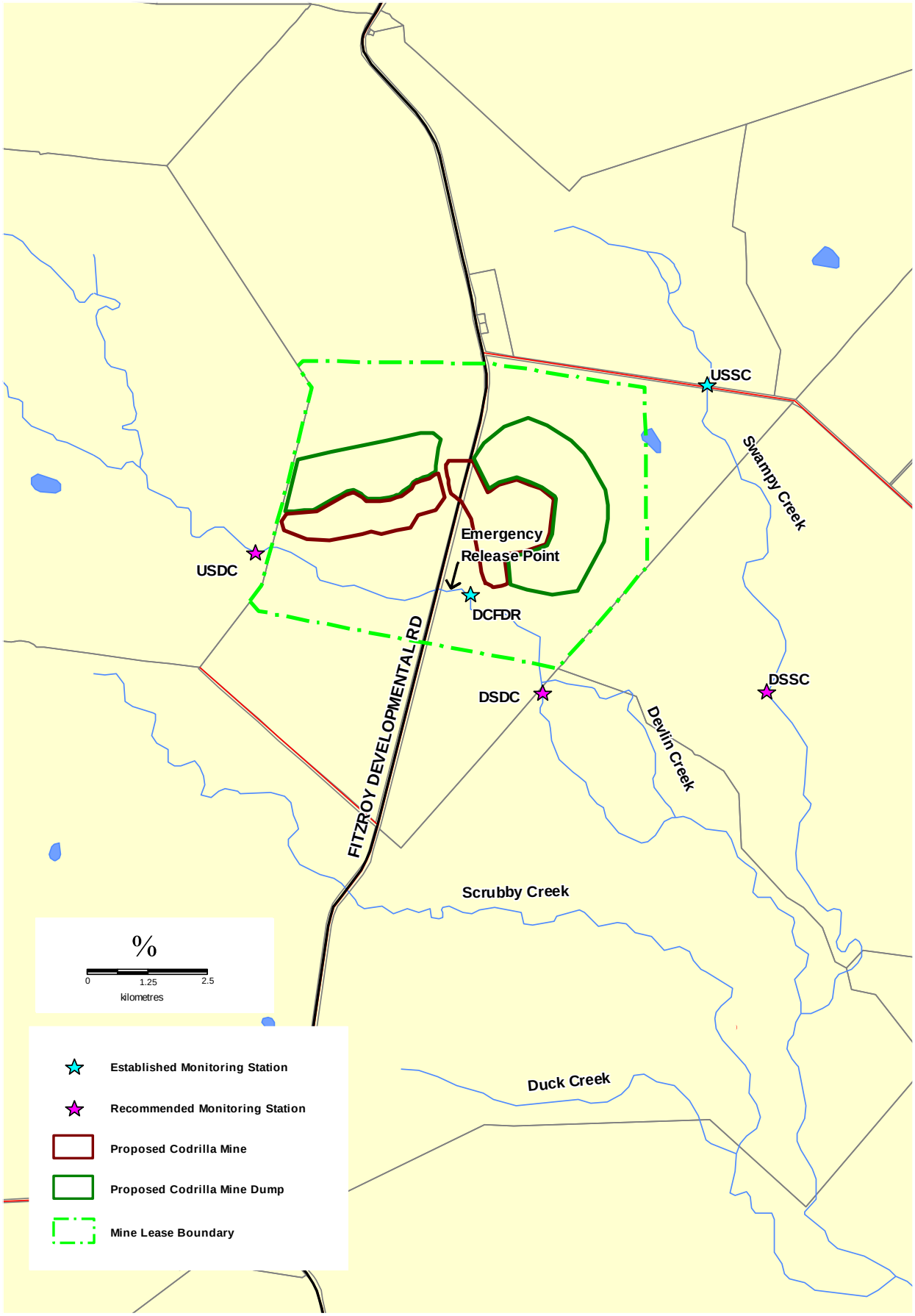

Figure 9.1 Locations of Water Quality Monitoring Stations

9.3 WATER QUALITY MONITORING SCHEDULE

Table 9.2 defines the frequency and parameters to be sampled at each location. Management of water on the mine site will aim to ensure no release of pit water from the site. However, should an event occur where water discharge from the site is required, additional sampling will be undertaken throughout the period when such emergency releases are occurring.

Table 9.3 defines the frequency and parameters to be sampled in the water storages across the mine site. The water quality monitoring program complies with the requirements for a Receiving Environment Monitoring Program (REMP) (DERM, 2009b) and provides regular monitoring of mine site water storages.

Table 9.2 Release Event Water Quality Monitoring Schedule

Location	Parameter	Monitoring Frequency
USSC & USDC	- Water Level - Electrical Conductivity - pH - Turbidity - Suspended Solids - Sulphate - And others listed in Table 3 of DERM 2009b	Continuous (Water level). Automatic sampling during flow events. Additional grab samples daily during release.
All DS Locations	- Electrical Conductivity - pH - Turbidity - Suspended Solids - Sulphate - And other listed in Table 3 of DERM 2009b	Automatic sampling during flow events. Additional grab samples daily during release (the first sample must be taken within 2 hours of commencement of release).

Table 9.3 Storage Monitoring Schedule

Location	Parameter	Monitoring Frequency
All onsite storages	- Water Level - EC - pH - turbidity - TSS	Monthly. Following rainfall events >30mm in 24 hours

Gauge boards (as a minimum) will be used to monitor mine site storage water levels and enable inflows and outflows to be derived. This data will substantially improve the characterisation of catchment runoff and the performance of the minesite water management system. It is recommended that automatic monitoring equipment be installed on key storages.

The event-based sampling will enable quantification of any pollutant loads from the site and their corresponding impact on the water quality of receiving waters. On-site monthly sampling from the water storages allows for any potential problem areas with respect to pollutant generation on-site to be identified in advance ensuring appropriate remedial action can be taken.

10 SUMMARY OF FINDINGS

WRM Water & Environment Pty Ltd was requested to undertake a flood study and water balance study to determine the impact of the proposed Codrilla coal mining operations on flooding and drainage behaviour in Devlin Creek and its tributaries.

Flood Study

To undertake the flood study, a TUFLOW two dimensional hydraulic model was developed of Devlin Creek and its floodplain for existing conditions and with the proposed mine infrastructure in place.

The results of the study are as follows:

- Generally surface water quality in the Devlin Creek catchment is consistent upstream and downstream of the mining lease. Prior to mining, some monitored parameters, such as total suspended solids, total nitrogen, total phosphorus and metals, exceed the Regional Guideline Values for the Central Coast Regions and the Release Contaminant Trigger Levels for Coal Mines in the Fitzroy Basin.
- There are no formal water use entitlements on Devlin Creek, but water from Devlin Creek may be accessed informally for stock and domestic use. Given that the total pit catchment area is approximately 6.5km^2 (or is less that 3% of the catchment area of Devlin Creek to Fitzroy Developmental Road), the proposed development will have no measurable impact on the quantity of water available to downstream users.
- The proposed locations of the open cut pits and overburden emplacements for the Codrilla Project are outside the banks of the Devlin Creek main channel. Hence, the proposed mine will not affect the geomorphology or frequent flow behaviour of Devlin Creek.
- Mine infrastructure will be located on the Devlin Creek floodplain and will potentially affect flood depths and flow velocities during flood events where flows exceed the main Devlin Creek channel capacity.
- The 2 year ARI design flood does not impact on the proposed mine.
- The 10 year, 100 year and 2,000 year ARI design floods do not impact on the eastern pit and overburden dump of the proposed mine. However, proposed eastern mine infrastructure is subject to flooding during all events of 100 year ARI and larger.
- The western end of the open cut pit is subject to partial backwater flooding during all events of 10 year ARI and larger. For the 100 year ARI flood event the maximum inundation depth within the pit footprint is approximately 1.4m
- A levee is required to protect the open cut pit and overburden dump and mine infrastructure from flooding during all events of 10 year ARI and larger.
- The levees will not impact significantly on flood depths for the 10 year and 100 year ARI flood events. Increases in flood level resulting from the construction of the levees for these events are limited to under 0.2m
- The levees will cause localised increases in flood depth for the 2,000 year ARI. Immediately upstream of the levees, flood depths will be increased by over 0.4m.

- The levees will not significantly impact in flood velocities in Devlin Creek for the 2 year, 10 year, 100 year and 2,000 year ARI design floods.
- Probable Maximum Flood levels in Devlin Creek range from approximately 0.5m higher than the 2,000 year ARI flood levels to a maximum of 1.5m higher than the 2,000 year ARI flood levels. As it is proposed that the mine pits will be rehabilitated to natural surface level following cessation of mining activities, hence levee bank protection for the rehabilitated mine pits will not be required.

Site Water Management System and Site Water Balance

The proposed operations will significantly change the characteristics of the minor gullies crossing the mining area. A water management system has been devised for the project, with the following key features:

- Runoff from undisturbed areas will generally be diverted around the operational areas where possible. Runoff from disturbed areas will be captured in the site water management system.
- Runoff entering the pits will be pumped to one of three environmental dams for later reuse for dust suppression or in the Coal Handling and Preparation Plant (CHPP).
- During mining of the East Pit, additional pit water storage capacity is to be provided in a temporary pit water storage to be constructed by excavating ahead of mining within the proposed West Pit mining area. The temporary dam will be decommissioned before the West Pit advances to within close proximity.
- Runoff from out of pit spoil dumps will be captured in one of four sediment dams, and the captured water would be returned to the plant area for reuse.
- If water quality and receiving water conditions allow, excess water could potentially be discharged from the site.

The purpose of the water balance study was to confirm the effectiveness of the system in limiting off site discharge, and to quantify the impacts on the drainage behaviour. A GoldSIM model of the site catchments and water management system was developed to make this assessment on the basis of historical climate data. The AWBM rainfall/runoff model was used to generate a daily time series of catchment runoff.

The results of the study are as follows:

- Under historical conditions it would be possible to contain all pit and plant runoff without discharge if a large enough temporary pit water storage. Under the high runoff scenario, the required storage volume is 2,500ML .
- The risk of discharge from sediment dams is low.
- During mining of the Western Pit, significant volumes of water could accumulate in the Eastern Pit (up to 3,400 ML in the worst case 14 year sequence). The Eastern Pit could potentially store up to 74,000ML of water, if required.
- During dry periods, when the yield from the site water management system is low, water will need to be imported to meet supply shortfalls.
- The proposed water management system will have a significant impact on flows in the very small tributaries leaving the site. However, the impact on flows in the watercourses further downstream will be much smaller. In Devlin Creek, just downstream of the Swampy Creek confluence, the modelled median annual flow is predicted to be reduced by 7.0% in 2015 and by 10.8% when the mine footprint is largest. The impact on flows in the Isaac River downstream would be negligible.

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APPENDIX A

WATER QUALITY SAMPLING RESULTS

Table A1 Historical Water Sampling Results, Devlin Creek at Bombandy

Variable		Count	Minimum	10 Percent	Median	90 Percent	Maximum	Mean	Std Dev	SDate	End Date
100	Stream Water Level	21	-0.74	0.09	0.53	0.99	1.67	0.42	0.55	25/08/1971	13/04/1988
140	Stream Discharge	21	0	0	0	0.068	3.721	0.20	0.81	25/08/1971	13/04/1988
630	Distance below Water Surface	21	0.1	0.1	0.1	0.1	0.1	0.10	0.00	25/08/1971	13/04/1988
2010	Electrical Conductivity @ 25C	21	57	72	155	235	270	152.05	57.02	25/08/1971	13/04/1988
2010.5	Electrical Conductivity @ 25C (Field)	3	55	-	-	-	152	90.67	53.35	5/12/1985	13/04/1988
2030	Turbidity	4	40	-	-	-	100	85.00	30.00	11/06/1983	13/04/1988
2051	Colour - True	1	10	-	-	-	10	10.00	0.00	11/06/1983	11/06/1983
2080.5	Water Temperature (Field)	16	14	16	24.5	28.5	31	23.44	5.03	6/07/1972	13/04/1988
2100	pH	21	6.4	6.9	7.2	7.9	9.2	7.40	0.59	25/08/1971	13/04/1988
2113	Total Alkalinity as CaCO3	17	21	41.6	57	77.2	80	57.00	15.34	25/08/1971	13/04/1988
2123	Alkalinity Hydroxide as OH	9	0	-	-	-	0	0.00	0.00	8/12/1971	4/08/1976
2124	Alkalinity Carbonate as CO3	11	0	0	0.2	0.9	3.9	0.55	1.14	12/12/1973	11/06/1983
2125	Alkalinity Bicarbonate as HCO3	19	25.5	39.6	65	93.6	96	65.71	20.77	25/08/1971	13/04/1988
2132	Hardness as CaCO3 (calculated)	18	13	31.1	47	61.6	66	44.56	13.14	25/08/1971	13/04/1988
2141	Hydrogen as H	11	0	0	0	0	0	0.00	0.00	25/08/1971	29/10/1976
2169	Total Dissolved Solids (calc)	18	34	72.8	97	139.3	140	97.39	27.11	25/08/1971	13/04/1988
2170	Total Dissolved Ions	18	47.3	85.1	129.15	161.69	175.4	122.88	32.85	25/08/1971	13/04/1988
2172	Total Suspended Solids	14	9	16.8	64	249	690	125.50	178.47	26/09/1973	13/04/1988
2302	Calcium as Ca - soluble	19	2	6.4	10	15.2	17	10.17	3.90	25/08/1971	13/04/1988
2311	Chloride as Cl	19	5	7.4	15	29.2	40	16.53	9.15	25/08/1971	13/04/1988
2322	Magnesium as Mg - soluble	19	2	2.56	4.4	6.06	8	4.33	1.47	25/08/1971	13/04/1988
2331	Nitrate as NO3	9	0.2	-	-	-	10	2.58	2.97	8/12/1971	13/04/1988
2381	Potassium as K	13	3.1	4.02	4.7	5.7	6.5	4.65	0.86	26/09/1973	13/04/1988
2391	Sodium as Na	19	5	7.52	14	23	24	14.98	6.33	25/08/1971	13/04/1988
2401	Sulphate as SO4	8	0	-	-	-	7.5	3.91	2.33	8/12/1971	13/04/1988
2551	Boron as B	4	0.03	-	-	-	0.06	0.04	0.02	11/06/1983	13/04/1988
2641	Fluoride as F	14	0.05	0.05	0.1	0.27	0.34	0.14	0.09	25/08/1971	11/06/1983
2682	Iron as Fe - soluble	5	0.1	-	-	-	3.9	1.62	1.51	11/10/1972	13/04/1988
2762	Silica as SiO2 - soluble	15	6	6.4	13	20.2	42	14.40	9.01	26/09/1973	13/04/1988

Table A2 Water Quality Sampling Results, Swampy Creek at Valkyrie Road

CODRILLA PROJECT EIS								
Sample Number		M10R1	M10R4	M10R7	M10R10	M10R12	M10R13	M10R15
Flow		High	Medium	Low	Low	Zero	Zero	Medium
Date Sampled		31/01/2010	5/02/2010	20/02/2010	25/03/2010	18/11/2010	23/11/2010	1/12/2010
Time Sampled		14:41	9:45	7:20	10:00	11:00	11:55	13:53
Sample Identification		SWAMPY CREEK						
PARAMETERS	UNITS							
pH	pH Units	7.29	6.39	6.67	6.54	6.65	8.23	7.9
Temperature**	°C	26.9	26.8	25.4	26.3			
Conductivity	µS/cm	67.80	135.60	163.10	105.70	275	302	69
Turbidity	NTU	>1000	136.0	59.7	93.6	804	>1000	493
Dissolved Oxygen	mg/L	6.83	3.33	3.19	6.79	4.90	5.13	5.81
Total Suspended Solids[1]	mg/L	262	64	48	30	172	635	246
Biological Oxygen Demand[1]	mg/L	2	<2	<2	<4	17	3	2
Sulphate[1]	mg/L	<2	<2	<2	<0.5	3	3	<2
Fluoride[1]	mg/L	<0.1	<0.1	<0.1	<0.5	0.2	0.2	<0.1
Ortho Phosphate (P)[1]	mg/L	0.119	0.035	0.013	<0.5	<0.005	0.011	0.045
Total Phosphorus (P)[1]	mg/L	0.14	0.11	0.07	<0.1	0.14	0.06	0.09
Nitrate (as N)[1]	mg/L	0.07	<0.01	0.01	<0.5	0.1	0.16	0.01
NOx (as N)[1]	mg/L	0.08	<0.01	0.01	<0.5	0.14	0.16	0.01
Ammonia (as N)[1]	mg/L	0.14	<0.01	0.05	<1	0.02	<0.01	0.01
Total Nitrogen (as N)[1]	mg/L	0.9	1.2	1.1	<2	1.5	2.2	3.4
Hardness (HCO3)[1]	mg/L	9	55	37	20	84	80	13
Petroleum Hydrocarbon (C6-C9)[1]	µg/L	<50	<50	<50	<20			
Petroleum Hydrocarbon (C10-C14)[1]	µg/L	<50	<50	<50	<40			
Petroleum Hydrocarbon (C15-C28)[1]	µg/L	<200	<200	<200	<100			
Petroleum Hydrocarbon (C29-C36)[1]	µg/L	<50	<50	<50	<100			
Sum of TPH C10-C36[1]	µg/L	--	--	--	--			
PARAMETERS TOTAL	UNITS							
Aluminium[1]	µg/L	10200	900	1740	1000	10700	15000	6200
Antimony[1]	µg/L	<5	<5	<5	<5	<5	<5	<5
Arsenic[1]	µg/L	<5	<5	<5	<5	<5	<5	<5
Beryllium[1]	µg/L	1.0	<1	<1	<5	<1	<1	<1
Boron[1]	µg/L	30	40	40	50	90	160	40
Cadmium[1]	µg/L	<0.5	<0.5	<0.5	<5	<0.5	<0.5	<0.5
Chromium[1]	µg/L	16	<5	<5	<5	11	15	7
Cobalt[1]	µg/L	10	<5	<5	<5	10	10	<5
Copper[1]	µg/L	15	<5	<5	<5			
Lead[1]	µg/L	8	<5	<5	7.4	6	7	<5
Manganese[1]	µg/L	526	17	127	40	937	734	180
Molybdenum[1]	µg/L	<5	<5	<5	<5	<5	<5	<5
Nickel[1]	µg/L	13	<5	<5	<5	14	14	6
Selenium[1]	µg/L	<5	<5	<5	<5	<5	<5	<5
Uranium[1]	µg/L	0.5	<0.5	<0.5	<5	0.7	0.8	<0.5
Vanadium[1]	µg/L	30	<10	<10	<5	30	60	20
Zinc[1]	µg/L	30	12	10	23	19	18	10
Iron[1]	µg/L	9340	770	1800	1600	10000	9290	3580
Mercury[1]	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PARAMETERS FILTERED	UNITS							
Aluminium[1]	µg/L	190	2310	200	89	<10	1100	1000
Antimony[1]	µg/L	<5	<5	<5	<5	<5	<5	<5
Arsenic[1]	µg/L	<1	5	2	<5	1	<1	<1
Beryllium[1]	µg/L	<1	<1	<1	<5	<1	<1	<1
Boron[1]	µg/L	20	40	50	44	200	140	170
Cadmium[1]	µg/L	<0.1	<0.1	<0.1	<5	<0.1	<0.1	<0.1
Chromium[1]	µg/L	<1	<1	<1	<5	<1	<1	2
Cobalt[1]	µg/L	<1	<1	<1	<5	<1	<1	<1
Copper[1]	µg/L	3	1	5	<5			
Lead[1]	µg/L	<1	<1	<1	<5	<1	<1	<1
Manganese[1]	µg/L	21	13	102	8.9	32	<1	10
Molybdenum[1]	µg/L	<1	<1	<1	<5	2	2	1
Nickel[1]	µg/L	1	3	4	<5	3	3	2
Selenium[1]	µg/L	<5	<5	<5	<5	<5	<5	<5
Uranium[1]	µg/L	<5	<5	6	<5	0.4	0.6	<0.1
Vanadium[1]	µg/L	<0.1	<0.1	<0.1	<5	<5	<5	5
Zinc[1]	µg/L	6	10	22	26	30	30	40
Iron[1]	µg/L	100	1050	260	490	<50	<50	600
Mercury[1]	µg/L	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1

FIELD NOTES

SWAMPY CK 18/11/2010: Creek not flowing, sample taking from large pool of water. Approximately 1.5m below road.
SWAMPY CK 23/11/2010: Creek not flowing, still at same level as 18/11/2010 (1.5m below road). Sample taking from same large pool of water.
SWAMPY CK 01/12/2010: Sample taken from flowing water. Moderate flow approximately 40cm over the road.
SWAMPY CK 21/12/2010: Road closed sign in place. Rang Nebo Police and still weren't able to gain access.
SWAMPY CK 07/01/2011: Road closed sign in place. Rang Nebo Police and still weren't able to gain access.
SWAMPY CK 05/02/2011: Road closed sign in place. Rang Nebo Police and still weren't able to gain access.

SWAMPY CK 31/01/2010: Substantial flow approximately 1m above road.
SWAMPY CK 05/02/2010: Moderate flow approximately 40cm above road.
SWAMPY CK 20/02/2010: Low flow approximately 10cm above road.
SWAMPY CK 25/03/2010: Low flow approximately 5cm above road.

Table A3 Water Quality Sampling Results, Devlin Creek at Fitzroy Developmental Road

CODRILLA PROJECT EIS										
Sample Number		M10R2	M10R5	M10R8	M10R11	M10R16	M10R17	M11R1	M11R3	M11R5
Flow		High	Medium	Low	Low	Low	Medium	Low	Low	Low
Date Sampled		31/01/2010	5/02/2010	20/02/2010	25/03/2010	1/12/2010	21/12/2010	7/01/2011	5/02/2011	17/03/2011
Time Sampled		15:10	10:18	7:48	10:38	14:20	9:57	8:20	10:17	6:45
Sample Identification		DEVLIN CREEK								
PARAMETERS	UNITS									
pH	pH Units	7.14	6.78	6.96	7.42	7.89	7.67	7.55	7.25	7.95
Temperature**	°C	25.6	27.3	25.6	26.5					
Conductivity	µS/cm	6.1	135.7	424.0	728.0	116	3.1	1470	168.1	124.3
Turbidity	NTU	>1000	529	105	106	620	85	39	39.8	128
Dissolved Oxygen	mg/L	5.02	4.45	4.16	7.71	6.03	5.00	2.94	7.98	7.03
Total Suspended Solids[1]	mg/L	480	70	46	50	177	74	29	22	110
Biological Oxygen Demand[1]	mg/L	5	<2	<2	<4	2		<2	2.4	<2
Sulphate[1]	mg/L	<2	3	6	15	<2	7	5.1	<2	<2
Fluoride[1]	mg/L	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	0.1	<0.1	<0.1
Ortho Phosphate (P)[1]	mg/L	0.111	0.018	0.069	<0.5	0.048	0.006	0.014	0.020	0.011
Total Phosphorus (P)[1]	mg/L	0.22	0.09	0.12	0.14	0.09	0.08		0.11	0.08
Nitrate (as N)[1]	mg/L	0.28	<0.01	0.09	0.6	0.02	0.05	0.14	0.03	<0.02
NOx (as N)[1]	mg/L	0.29	0.26	0.09	<0.5	0.02		0.15	<0.05	<0.05
Ammonia (as N)[1]	mg/L	0.02	0.05	0.05	<1	0.01	<0.01	0.04	0.03	0.01
Total Nitrogen (as N)[1]	mg/L	1.4	1.5	1.2	<2	2.1	5.8	0.7	1.53	0.8
Hardness (HCO3)[1]	mg/L	16	36	52	57	34	39	85	89	35.6
Petroleum Hydrocarbon (C6-C9)[1]	µg/L	<50	<50	<50	<20		<50	<50	<50	<50
Petroleum Hydrocarbon (C10-C14)[1]	µg/L	<50	<50	<50	<40		<50	<50	<50	<50
Petroleum Hydrocarbon (C15-C28)[1]	µg/L	<200	<200	<200	<100		<200	<200	<200	<200
Petroleum Hydrocarbon (C29-C36)[1]	µg/L	<50	<50	<50	<100		<50	90	50	<50
Sum of TPH C10-C36[1]	µg/L	--	--	--	--		-	90	<200	<200
PARAMETERS TOTAL	UNITS									
Aluminium[1]	µg/L	6140	5760	2070	1300	7200	3870	200	1600	4800
Antimony[1]	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5
Arsenic[1]	µg/L	8	<5	<5	<5	<5	<5	2	1	<5
Beryllium[1]	µg/L	2.0	<1	<1	<5	<1	<1	<1	<1	<1
Boron[1]	µg/L	40	50	40	79	40	40	70	70	40
Cadmium[1]	µg/L	<0.5	<0.5	<0.5	<5	<0.5	<0.5	<0.2	<0.2	<0.5
Chromium[1]	µg/L	7	5	<5	<5	7	<5	<1	2	<5
Cobalt[1]	µg/L	16	5	<5	<5	7	<5	<1	<1	1
Copper[1]	µg/L	64	17	6	5.4		14		8	<5
Lead[1]	µg/L	5	<5	<5	5.3	8	<5	<1	<1	<5
Manganese[1]	µg/L	341	148	63	95	376	123	92	34	87
Molybdenum[1]	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5
Nickel[1]	µg/L	20	7	<5	<5	10	<5	3	4	<5
Selenium[1]	µg/L	<5	<5	<5	<5	101	<5	2	5	<5
Uranium[1]	µg/L	<0.5	<0.5	<0.5	<5	<0.5	<0.5	<5	0.1	<0.5
Vanadium[1]	µg/L	20	20	<10	6.7	30	<10	<5	<5	<10
Zinc[1]	µg/L	39	35	30	26	18	9	31	49	<5
Iron[1]	µg/L	4840	5710	2380	1200	6840	2810	840	1400	3200
Mercury[1]	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PARAMETERS FILTERED	UNITS									
Aluminium[1]	µg/L	350	750	890	88	560	180	<50	380	290
Antimony[1]	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5
Arsenic[1]	µg/L	<1	4	1	<5	1	1	1	1	1
Beryllium[1]	µg/L	<1	<1	<1	<5	<1	<1	<1	<1	<1
Boron[1]	µg/L	20	50	60	76	130	90	100	70	50
Cadmium[1]	µg/L	<0.1	<0.1	<0.1	<5	<0.1	<0.1	<0.1	<0.2	<0.1
Chromium[1]	µg/L	<1	<1	1	<5	1	<1	<1	<1	<1
Cobalt[1]	µg/L	<1	<1	<1	<5	<1	<1	<1	<1	1
Copper[1]	µg/L	8	4	4	<5		3		4	6
Lead[1]	µg/L	<1	<1	<1	<5	<1	<1	<1	<1	<1
Manganese[1]	µg/L	6	6	8	17	4	12	47	9	85
Molybdenum[1]	µg/L	<1	<1	<1	<5	<1	1	2	<5	<1
Nickel[1]	µg/L	2	<1	3	<5	2	1	2	2	2
Selenium[1]	µg/L	<5	<5	<5	<5	<5	<5	<5	<1	<5
Uranium[1]	µg/L	<5	<5	6	<5	<0.1	0.1	<5	<0.1	<0.1
Vanadium[1]	µg/L	<0.1	<0.1	0.2	<5	6	<5	<5	<5	<5
Zinc[1]	µg/L	15	11	38	31	100	20	29	24	6
Iron[1]	µg/L	140	250	540	290	620	170	210	230	370
Mercury[1]	µg/L	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

FIELD NOTES

DEVLIN CK 18/11/2010: Creek not flowing, no water, no sample taken.
DEVLIN CK 23/11/2010: Creek not flowing, no water, no sample taken.
DEVLIN CK 01/12/2010: Sample taken from flowing water. Low flow approximately 25cm deep.
DEVLIN CK 21/12/2010: Sample taken from flowing water. Moderate flow approximately 80cm deep.
DEVLIN CK 07/01/2011: Sample taken from flowing water. Low flow approximately 20cm deep.
DEVLIN CK 05/02/2011: Sample taken from flowing water. Low flow approximately 30cm deep.
DEVLIN CK 17/03/2011: Sample taken from flowing water. Low flow approximately 30cm deep.

DEVLIN CK 31/01/2010: High Flow approximately 1.5m deep.
DEVLIN CK 05/02/2010: Moderate Flow approximately 50cm deep.
DEVLIN CK 20/02/2010: Low Flow approximately 25cm deep.
DEVLIN CK 25/03/2010: Low Flow approximately 20cm deep.

Table A4 Water Quality Sampling Results, Isaac River at Fitzroy Developmental Road

CODRILLA PROJECT EIS								
Sample Number		M10R3	M10R6	M10R9	M10R14	M11R2	M11R4	M11R6
Flow		High	High	Medium	Medium	Medium	High	Medium
Date Sampled		31/01/2010	5/02/2010	20/02/2010	23/11/2010	7/01/2011	5/02/2011	17/03/2011
Time Sampled		16:02	11:19	8:35	13:07	9:00	11:09	7:30
Sample Identification		ISAAC RIVER						
PARAMETERS	UNITS							
pH	pH Units	7.28	6.87	6.98	7.9	7.56	7.46	7.76
Temperature**	ºC	27.3	27	25.7				
Conductivity	µS/cm	269.00	244.00	191.10	180	340	258	495
Turbidity	NTU	>1000	>1000	>1000	>1000	549	678	>1000
Dissolved Oxygen	mg/L	4.95	0.74	4.72	4.84	4.70	6.68	7.37
Total Suspended Solids[1]	mg/L	160	109	230	474	400	400	1100
Biological Oxygen Demand[1]	mg/L	3	<2	<2	<2	<2	2.6	2.7
Sulphate[1]	mg/L	3	8	8	10	3.4	3.2	20
Fluoride[1]	mg/L	0.2	0.2	<0.1	0.1	<0.1	0.1	0.2
Ortho Phosphate (P)[1]	mg/L	0.141	0.043	0.056	0.044	0.049	0.035	0.015
Total Phosphorus (P)[1]	mg/L	0.32	0.19	0.16	0.09		0.23	0.26
Nitrate (as N)[1]	mg/L	<0.01	<0.01	0.21	0.05	0.08	0.03	0.25
NOx (as N)[1]	mg/L	<0.01	0.15	0.21	0.05	0.1	<0.05	0.25
Ammonia (as N)[1]	mg/L	<0.01	0.12	0.05	0.01	0.06	<0.01	0.01
Total Nitrogen (as N)[1]	mg/L	0.8	1.8	1.2	0.1	1.4	1.23	2
Hardness (HCO3)[1]	mg/L	100	63	40	39	58	150	111.7
Petroleum Hydrocarbon (C6-C9)[1]	µg/L	<50	<50	<50		<50	<50	<50
Petroleum Hydrocarbon (C10-C14)[1]	µg/L	<50	<50	<50		<50	<50	<50
Petroleum Hydrocarbon (C15-C28)[1]	µg/L	<200	<200	<200		<200	<200	<200
Petroleum Hydrocarbon (C29-C36)[1]	µg/L	<50	<50	<50		50	<50	<50
Sum of TPH C10-C36[1]	µg/L	--	--	--		50	<200	<200
PARAMETERS TOTAL	UNITS							
Aluminium[1]	µg/L	10400	16400	10400	22000	2000	11000	14000
Antimony[1]	µg/L	<5	<5	<5	<5	<5	<5	<5
Arsenic[1]	µg/L	6	<5	<5	<5	1	<1	<5
Beryllium[1]	µg/L	<1	<1	<1	1	<1	<1	<1
Boron[1]	µg/L	60	<10	40	90	<50	110	70
Cadmium[1]	µg/L	<0.5	<0.5	<0.5	<0.5	<0.2	<0.2	<0.5
Chromium[1]	µg/L	29	<5	18	28	4	13	17
Cobalt[1]	µg/L	13	<5	9	19	6	6	9
Copper[1]	µg/L	17	10	11			8	12
Lead[1]	µg/L	<5	<5	6	12	5	7	6
Manganese[1]	µg/L	217	<5	291	769	270	220	350
Molybdenum[1]	µg/L	<5	<5	<5	<5	<5	<5	<5
Nickel[1]	µg/L	39	<5	20	34	9	16	21
Selenium[1]	µg/L	<5	<5	<5	<5	<1	5	2
Uranium[1]	µg/L	<0.5	<0.5	0.5	0.9	<5	0.5	<0.5
Vanadium[1]	µg/L	30	<10	30	80	12	22	30
Zinc[1]	µg/L	54	<5	76	53	25	27	37
Iron[1]	µg/L	12100	21600	13500	21000	2900	14000	16000
Mercury[1]	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PARAMETERS FILTERED	UNITS							
Aluminium[1]	µg/L	90	410	200	500	<50	<50	1000
Antimony[1]	µg/L	<5	<5	<5	<5	<5	<5	<5
Arsenic[1]	µg/L	<1	4	<1	<1	<1	<1	<1
Beryllium[1]	µg/L	<1	<1	<1	<1	<1	<1	<1
Boron[1]	µg/L	50	60	50	110	50	110	60
Cadmium[1]	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1
Chromium[1]	µg/L	2	<1	<1	<1	<1	<1	1
Cobalt[1]	µg/L	<1	<1	<1	<1	<1	<1	7
Copper[1]	µg/L	5	<1	3			1	7
Lead[1]	µg/L	<1	<1	<1	<1	<1	<1	5
Manganese[1]	µg/L	4	3	5	<1	<1	<5	370
Molybdenum[1]	µg/L	<1	<1	<1	<1	<1	<5	<1
Nickel[1]	µg/L	9	1	4	2	3	2	8
Selenium[1]	µg/L	<5	<5	<5	<5	<5	<1	<5
Uranium[1]	µg/L	16	<5	9	<0.1	<5	0.1	0.4
Vanadium[1]	µg/L	<0.1	<0.1	<0.1	<5	<5	<5	13
Zinc[1]	µg/L	17	24	12	30	<5	4	16
Iron[1]	µg/L	100	150	190	80	140	<50	1200
Mercury[1]	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

FIELD NOTES

ISAAC RIVER 18/11/2010: Water over road, unable to access.
ISAAC RIVER 23/11/2010: Sample taken from flowing water. Moderate flow approximately 5m below bridge.
ISAAC RIVER 01/12/2010: Water over road, unable to sample.
ISAAC RIVER 21/12/2010: Water over road, unable to sample.
ISAAC RIVER 07/01/2011: Sample taken from flowing water. Moderate flow approximately 5m below bridge.
ISAAC RIVER 05/02/2011: Sample taken from flowing water. High flow apporximately 2 to 2.5m below bridge.
ISAAC RIVER 17/03/2011: Sample taken from flowing water. Moderate flow approximately 5m below bridge.

ISAAC RIVER 31/01/2010: High flow apporximately 2.5m below bridge.
ISAAC RIVER 05/02/2010: High flow apporximately 3m below bridge.
ISAAC RIVER 20/02/2010: Moderate flow apporximately 5m below bridge.
ISAAC RIVER 25/03/2010: Not required to be sampled.

APPENDIX B

FLOOD VELOCITY MAPS

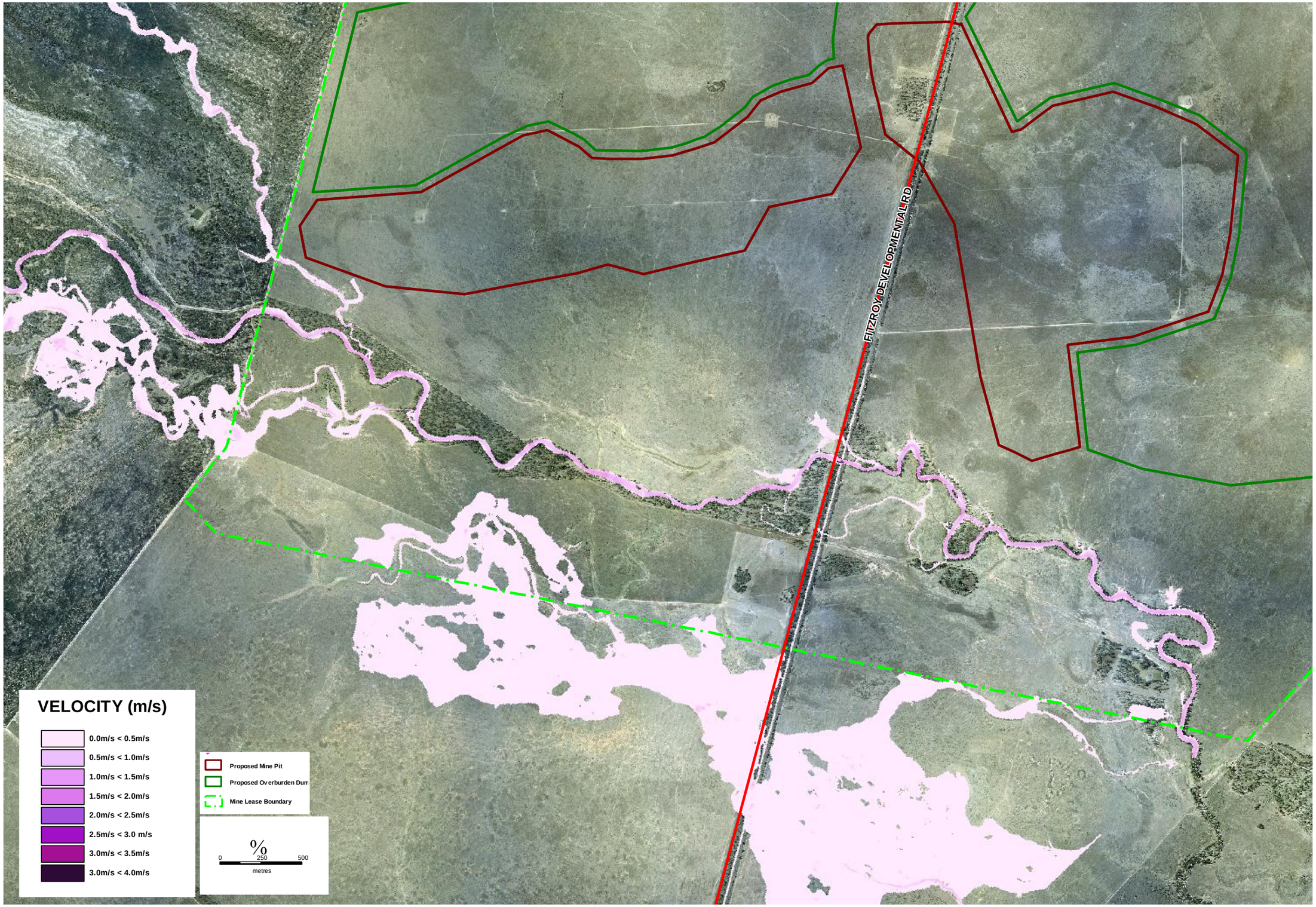


Figure B1 Existing Conditions, 2 Year ARI Flood Velocities, Devlin Creek

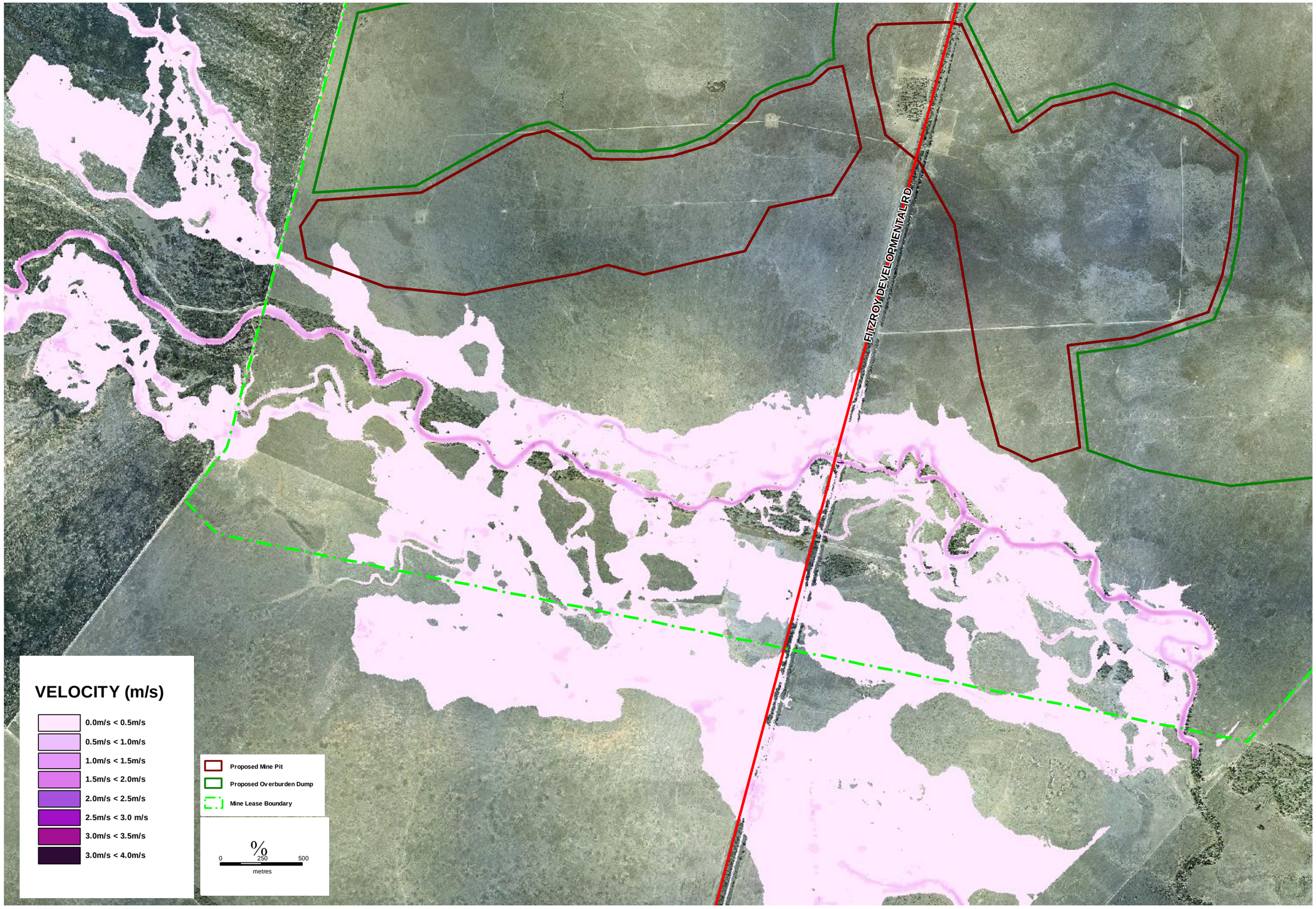


Figure B2 Existing Conditions, 10 Year ARI Flood Velocities, Devlin Creek

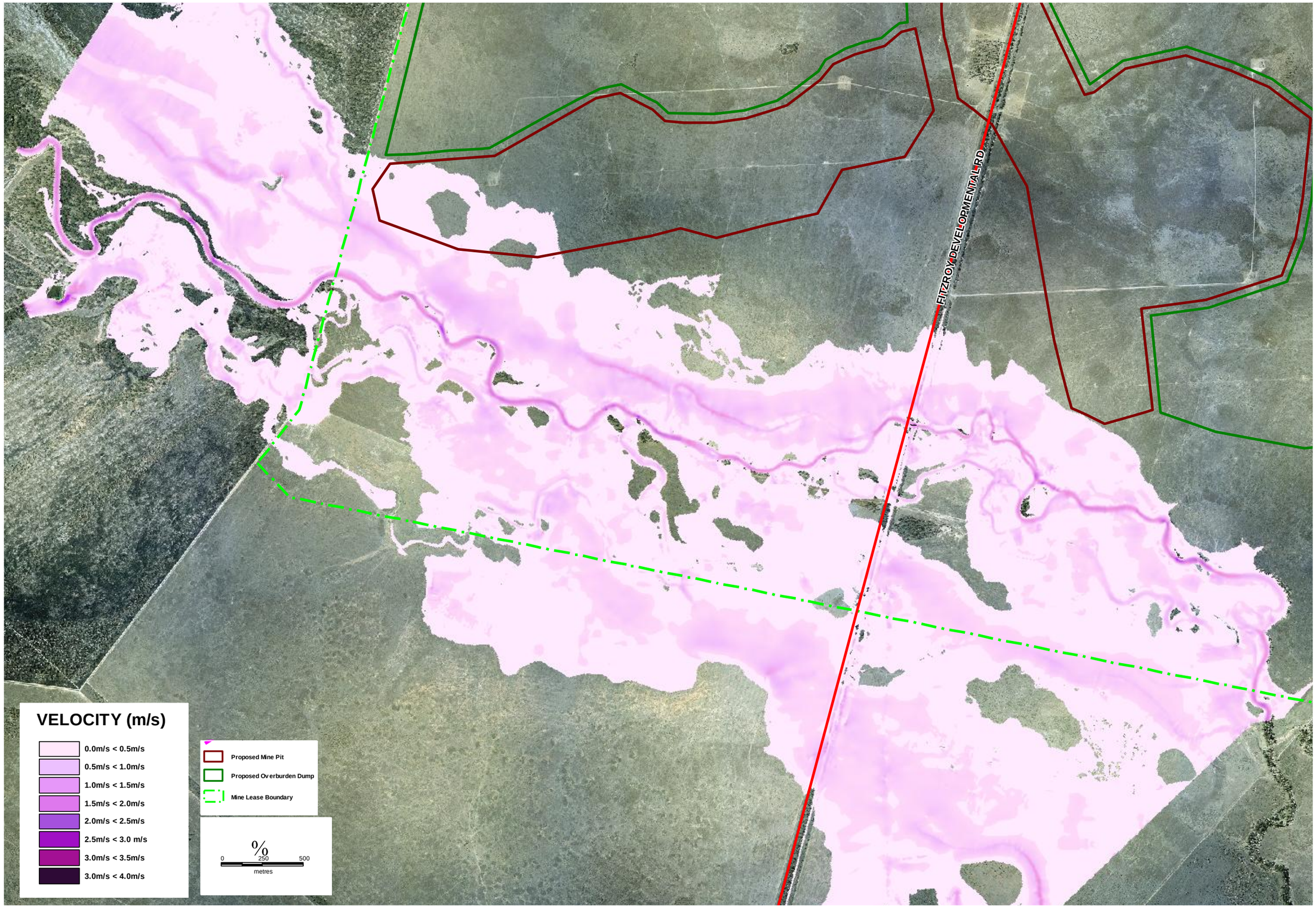


Figure B3 Existing Conditions, 100 year ARI Flood Velocities, Devlin Creek

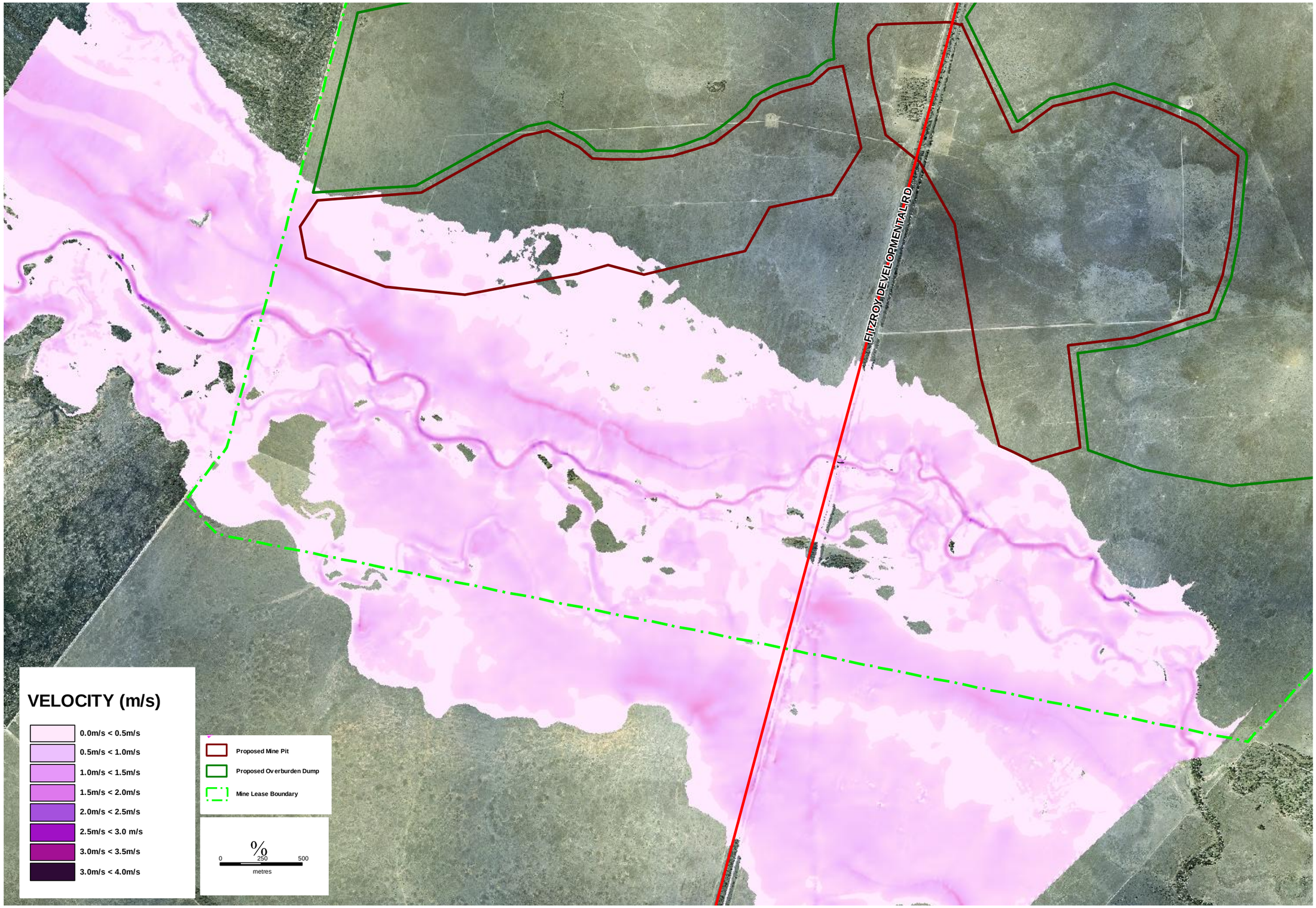


Figure B4 Existing Conditions, 2,000 Year Flood Velocities, Devlin Creek

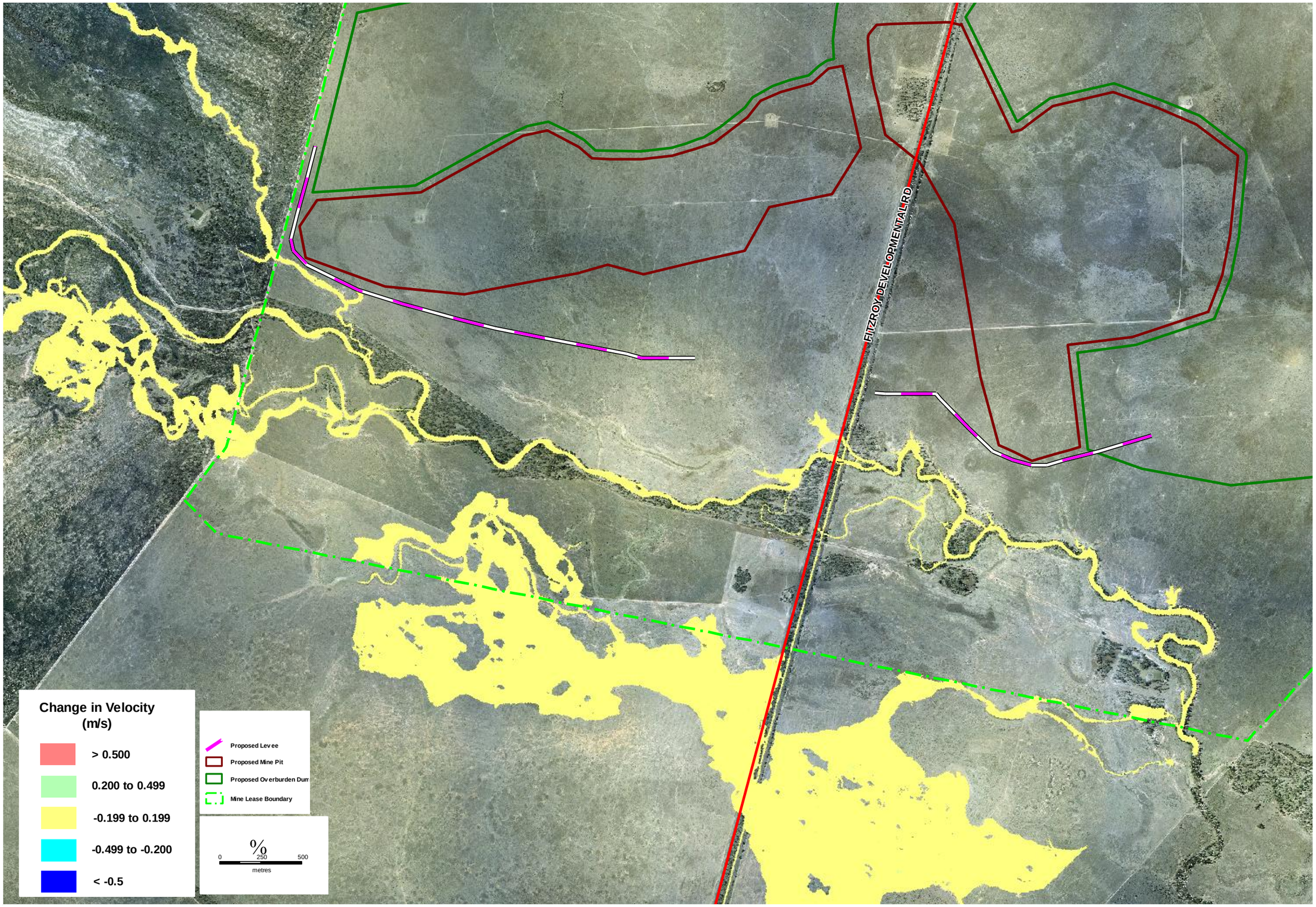


Figure B5 Change in Flood Velocities, 2 year ARI, Devlin Creek

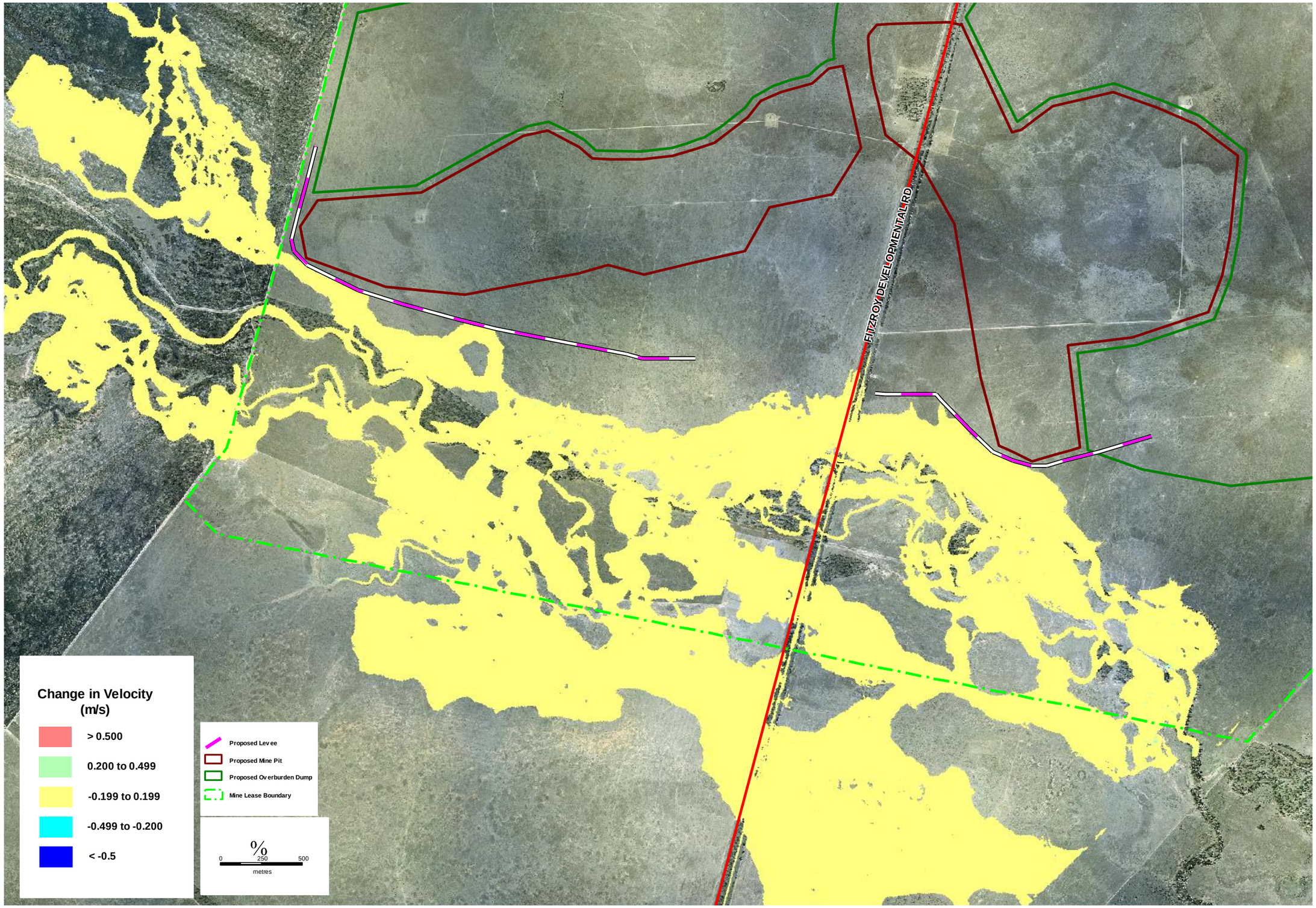


Figure B6 Change in Flood Velocities, 10 year ARI, Devlin Creek

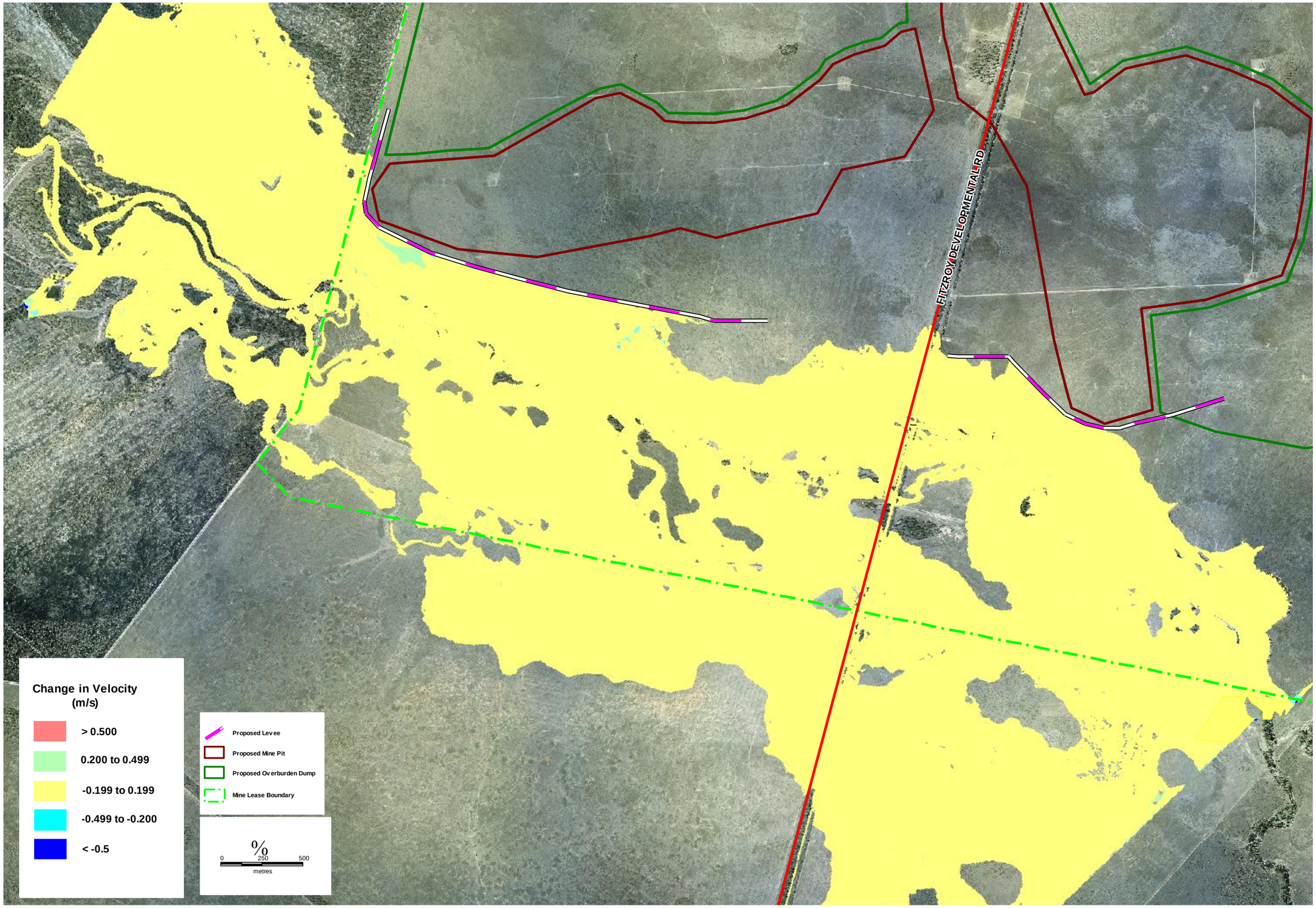


Figure B7 Change in Flood Velocities, 100 year ARI, Devlin Creek

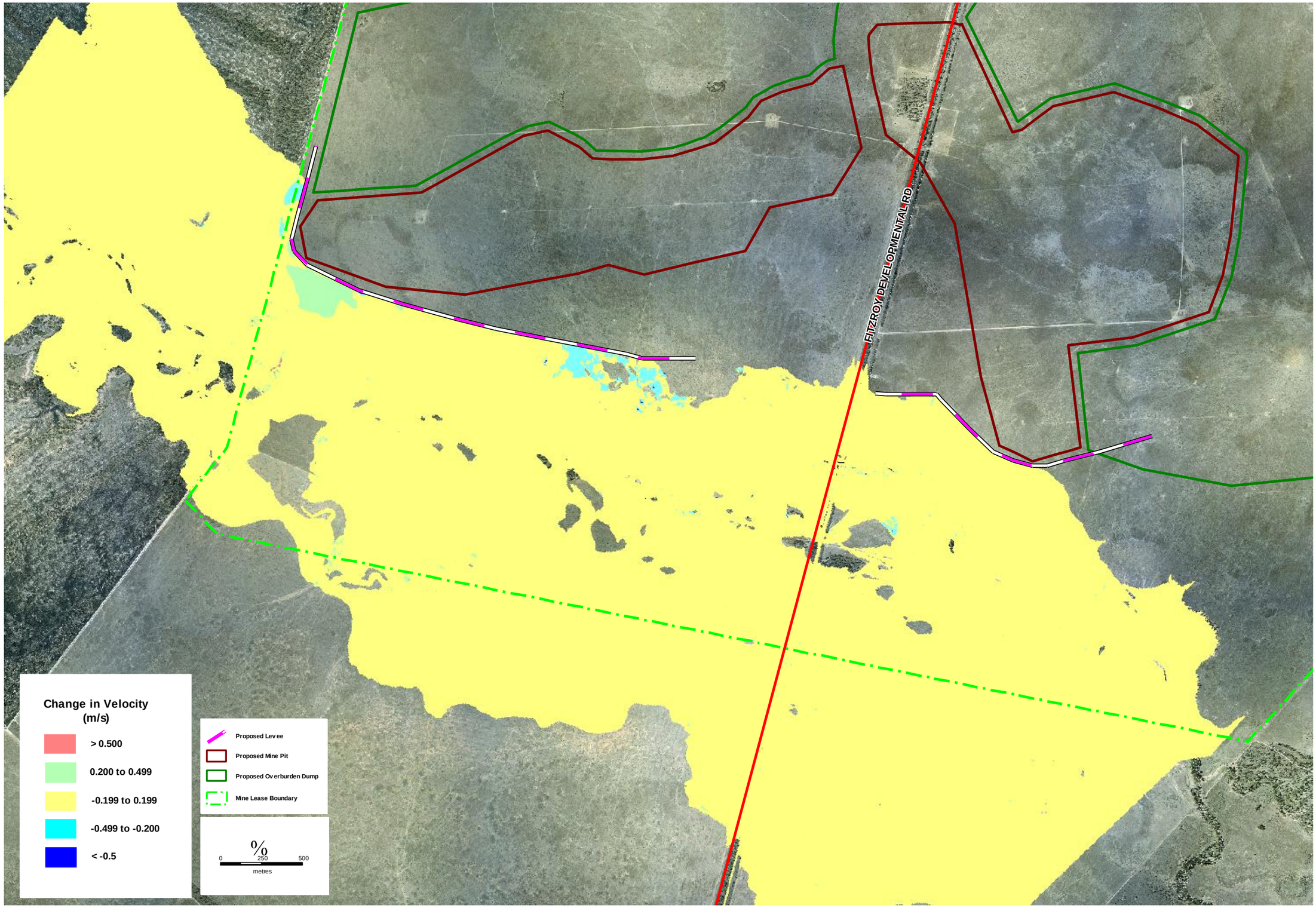


Figure B8 Change in Flood Velocities, 2,000 year ARI, Devlin Creek

REPORT TO

Peabody Energy Ltd

on the

Updated Feasibility Level Geotechnical Study for Codrilla

Date: 23rd March, 2012
Project No: 001047
Report No: IMC1397

Prepared by: Ty Grantham, Barry Ward and Marcel Croon

IMC Mining Group Pty Ltd
Level 40, Riverside Centre
123 Eagle Street
GPO Box 2579
BRISBANE QLD 4000

Tel. +61 7 3226 9100
Fax. +61 7 3226 9101

ISO 9001
BUREAU VERITAS
Certification

TABLE OF CONTENTS

1 INTRODUCTION 6

1.1 FEASIBILITY STUDY ASSESSMENT 6
1.2 SCOPE OF WORK 6

2 LOCATION OF SITE 7

3 DRILLING PROGRAM 9

4 LABORATORY PROGRAM 11

4.1 LABORATORY RESULTS 11
4.1.1 Soft Overburden Units 11
4.1.2 Roof and Floor 12
4.1.3 Spoil Cover Assessment Results 12

5 GEOLOGY INTERPRETATION 19

5.1 DEPOSIT GEOLOGY 19
5.2 GEOLOGICAL STRUCTURE AND SEAM DIP 20
5.2.1 Faults 20
5.2.2 Intrusions 22

6 OVERBURDEN, INTERBURDEN AND FLOOR CONDITIONS 30

6.1 OVERBURDEN 30
6.2 INTERBURDEN 40
6.3 FLOOR CONDITIONS 41

7 HYDROGEOLOGY 46

8 ACOUSTIC SCANNER INTERPRETATION (ATV) AND PROCESS 47

8.1 ATV INTERPRETATION PROCESS 47
8.2 SITE OVERVIEW 48
8.3 LIMITATIONS 48
8.4 CLASSIFICATION OF DISCONTINUITIES 50
8.5 CONSIDERATIONS FOR MINE PLANNING 51
8.5.1 In-situ Stress Orientation 52
8.5.2 Pole Projection Diagrams 52
8.5.3 Rose Diagrams 53
8.5.4 Dip-Azimuth Rose Diagrams 54
8.6 ANALYSIS OF JOINTS 55
8.7 INTERPRETED JOINTS – BOREHOLE ANALYSIS 59
8.7.1 CX0711C – Joints 59
8.7.2 CX3106FC – Joints 60
8.7.3 CX3108C – Joints 61
8.7.4 CX3109C – Joints 63
8.7.5 CX3115FC – Joints 64
8.8 ANALYSIS OF BEDDING 65
8.9 INTERPRETED BEDDING – ALL BOREHOLES 68
8.9.1 CX0711C – Bedding 68

8.9.2 CX3106FC – Bedding ... 69
8.9.3 CX3108C – Bedding ... 70
8.9.4 CX3109C – Bedding ... 71
8.9.5 CX3115C – Bedding ... 72

9 PRELIMINARY KINEMATIC ANALYSIS ... 73

9.1 ASSUMPTIONS ... 77
9.2 INDICATIVE PLANAR FAILURE MECHANISMS ... 77
9.2.1 Final and Interim Highwall ... 77
9.2.2 Endwall North and South ... 78
9.2.3 Low wall East ... 80
9.2.4 Low wall North-East and South-East ... 81
9.3 INDICATIVE WEDGE FAILURE MECHANISMS ... 82
9.3.1 Final and Interim Highwall ... 82
9.3.2 Endwall North and South ... 83
9.3.3 Low wall East ... 85
9.3.4 Low wall North-East and South-East ... 85
9.4 KINEMATIC ANALYSIS DISCUSSION AND SUMMARY ... 86

10 CUT SLOPE STABILITY ... 90

10.1 MATERIAL PROPERTIES ... 90
10.2 GENERIC DESIGN CRITERIA ... 91
10.3 GENERIC SLOPE DESIGN ... 91
10.4 GENERIC DESIGN RESULTS AND DISCUSSION ... 92
10.5 SUMMARY OF PREVIOUS NUMERICAL MODELLING ... 96
10.6 BOX CUT – LOW WALL STABILITY ANALYSIS ... 101
10.7 MODELLING CASES ... 103
10.8 BOXCUT – LOWWALL STABILITY ANALYSIS RESULTS ... 105
10.9 FAULT/STRUCTURAL INTERACTIONS ON PIT WALLS – PRINCIPAL HAZARDS AND CONTROLS ... 110
10.9.1 Bench Scale Hazards ... 110
10.9.2 Large Scale Hazards ... 110
10.9.3 Monitoring and Stability Controls ... 111

11 SPOIL STABILITY ... 115

11.1 EX-PIT SPOIL DUMPS ... 115
11.2 IN-PIT SPOIL DUMPS ... 115

12 MINING CONDITIONS ... 118

12.1 EXCAVATABILITY ... 118
12.2 TRAFFICKABILITY ... 119
12.3 GROUNDWATER ... 119

13 SPOIL COVER SUITABILITY – ENVIRONMENTAL CONSIDERATIONS ... 121

13.1 ACID GENERATING POTENTIAL ... 121
13.2 DISPERSION POTENTIAL AND SALINITY (DISPERSIVITY) ... 121
13.3 EROSION POTENTIAL ... 122
13.4 ROCK COVER SUITABILITY – VU SANDSTONE ... 122

14 REFERENCES ... 123

TABLE

Table 4-1: Soil Classification Tests 13
Table 4-2: Shear Strength Test Results 14
Table 4-3: Strength and Durability Tests 15
Table 4-4: Emerson Class Results 18
Table 5-1: Anomalous Borehole Structure 22
Table 6-1 : Summary of Overburden Units 31
Table 6-2: Estimated Interburden Strength 41
Table 6-3 : Estimated Floor Unit Strength 42
Table 8-1 : Depth Intervals for Interpretation Based On Available Boreholes 48
Table 8-2: Recorded Joint Dip Angles 55
Table 8-3: Mean Joint Set Orientation - Codrilla Site 57
Table 8-4: Mean Joint Set Orientation – CX0711C 59
Table 8-5: Mean Joint Set Orientations – CX3106FC 60
Table 8-6: Mean Joint Set Orientation – CX3108C 62
Table 8-7: Mean Joint Set Orientation – CX3109C 63
Table 8-8: Mean Joint Set Orientation – CX3115FC 64
Table 8-9: Recorded Bedding Dip Angles 66
Table 9-1: Pit Slope Azimuth Cases 75
Table 9-2: Potential Failure Mechanisms for Pit Slope Cases 89
Table 10-1 : Shear Strength Values for Analysis 90
Table 10-2: Generic Design Criteria 91
Table 10-3 : Factors of Stability for Circular Slip Failure 92
Table 10-4 : Rock Mass Properties for Numerical Modelling 96
Table 10-5 : Joint Material Properties 97
Table 10-6: Low Wall Stability Zones 101
Table 10-7: West and East Pit Lowwall Stability Zones for Analysis 103
Table 10-8: Factors of Stability for Circular Slip Failure 105
Table 11-1 : Factors of Stability - In-Pit Spoil Failure 116
Table 12-1 : Estimated Interburden Blast Parameters 118

FIGURES

Figure 2-1: Site Location Plan 8
Figure 3-1: Fully Geotechnical Borehole Plan 10
Figure 5-1: Generalised Stratigraphic Section 23
Figure 5-2: Geology Cross Section – Western Limb 24
Figure 5-3: Geology Cross Section – Southern Limb 25
Figure 5-4: VU Seam Thickness 26
Figure 5-5: VU Seam Structure 27
Figure 5-6: VU Depth of Cover 28
Figure 5-7: Geological Structure – Borehole Intercepts 29
Figure 6-1 : Synopsis of Overburden from Fully Cored Boreholes 36
Figure 6-2: Depth to Base of Tertiary 37
Figure 6-3: Depth to Base of Weathering 38
Figure 6-4: Tertiary to Base of Weathering 39

Figure 6-5: Representative Interburden Sections 44
Figure 6-6: VU Floor Conditions 45
Figure 8-1: IMC Structure Dictionary 47
Figure 8-2: ATV Borehole Location Plan 49
Figure 8-3 : Example of Bedding and Lithological Contact 51
Figure 8-4 : Example of Possible Caved Zone, Shear Zone and Joints 51
Figure 8-5: Example IMC Interpreted Pole Contours for Joints 53
Figure 8-6: Example IMC Interpreted Strike Rose Diagram for Joints 54
Figure 8-7: Example IMC Dip-Azimuth Rose Diagram for Bedding 55
Figure 8-8: Joint Dip Angle Frequency – Codrilla Site 56
Figure 8-9: Pole Contours for Interpreted Joints – Codrilla Site 56
Figure 8-10: Rose Diagram for Interpreted Joints – Codrilla Site 57
Figure 8-11: Interpreted Joint Sets – Stereonet Layout Plan 58
Figure 8-12: Pole Contours for Interpreted Joints – CX0711C 59
Figure 8-13: Rose Diagram for Interpreted Joints – CX0711C 60
Figure 8-14: Pole Contours for Interpreted Joints – CX3106FCR 61
Figure 8-15: Rose Diagram for Interpreted Joints – CX3106FCR 61
Figure 8-16: Pole Contours for Interpreted Joints – CX3108C 62
Figure 8-17: Rose Diagram for Interpreted Joints – CX3108C 62
Figure 8-18: Pole Contours for Interpreted Joints – CX3109C 63
Figure 8-19: Rose Diagram for Interpreted Joints – CX3109C 64
Figure 8-20: Pole Contours for Interpreted Joints – CX3115FC 65
Figure 8-21: Rose Diagram for Interpreted Joints – CX3115FC 65
Figure 8-22: Bedding Angle Frequency Distribution – Codrilla Site 66
Figure 8-23: Pole Contours for Interpreted Bedding – Codrilla Site 67
Figure 8-24: Rose Diagram for Interpreted Bedding – Codrilla Site 67
Figure 8-25: Bedding Dip Azimuth Rose Diagram – CX0711C 68
Figure 8-26: Bedding Dip Azimuth Rose Diagram – CX3106FC 69
Figure 8-27: Bedding Dip Azimuth Rose Diagram – CX3108FC 70
Figure 8-28: Bedding Dip Azimuth Rose Diagram – CX3109FC 71
Figure 8-29: Bedding Dip Azimuth Rose Diagram – CX3115FC 72
Figure 9-1: Pit Locations for Kinematic Scenarios 74
Figure 9-2: Planar Failure Kinematic Scenario Example 76
Figure 9-3: Wedge Failure Kinematic Scenario Example 76
Figure 9-4: Planar Kinematic Scenario – Final Highwall 78
Figure 9-5: Planar Kinematic Scenario – Interim Highwall 78
Figure 9-6: Planar Kinematic Scenario – Endwall North 79
Figure 9-7: Planar Kinematic Scenario – Endwall South 80
Figure 9-8: Planar Kinematic Scenario – Low wall East 80
Figure 9-9: Planar Kinematic Scenario – Low wall North-East 81
Figure 9-10: Planar Kinematic Scenario – Low wall South-East 82
Figure 9-11: Wedge Kinematic Scenario – Final Highwall 83
Figure 9-12: Wedge Kinematic Scenario – Interim Highwall 83
Figure 9-13: Wedge Kinematic Scenario – Endwall North 84
Figure 9-14: Wedge Kinematic Scenario – Endwall South 84
Figure 9-15: Wedge Kinematic Scenario – Low wall East 85
Figure 9-16: Wedge Kinematic Scenario – Low wall North-East 86
Figure 9-17: Wedge Kinematic Scenario – Low wall South-East 86
Figure 9-18: Wedge Failure Mechanism Geometry 87

Figure 9-19: Planar Failure Mechanism Geometry 88
Figure 10-1: Generic Slope Design 94
Figure 10-2: Generic Slope Stability Analysis 95
Figure 10-3: Slope Configuration for Numerical Modelling 98
Figure 10-4: Stress Distribution 99
Figure 10-5: Strength Factor 100
Figure 10-6: Lowwall Stability Zones – West and East Pit 102
Figure 10-7: Lowwall Slope Stability Analysis 104
Figure 10-8: Boxcut Design Option – Dummy Boxcut 108
Figure 10-9: Boxcut Design Option – Spoil Buttress 109
Figure 10-10: Approximate 2D Seismic Line - East Pit 112
Figure 10-11: 2D Seismic Section – East Pit 113
Figure 10-12: Block Slippage Failure Geometry 114
Figure 11-1: Spoil Dump Failure Modes 117

1 INTRODUCTION

At the request Macarthur Coal (MCC), IMC Mining Group Pty Ltd (IMC) completed the analytical geotechnical work that was considered necessary prior to implementation of mining. A significant focus of geotechnical assessment was on the boxut - low wall areas. A kinematic analysis was completed to assess structural patterns across the site and an examination was made of the principal geotechnical hazards as they relate to mining.

1.1 Feasibility Study Assessment

The previous assessment presented a feasibility level geotechnical evaluation of the for the Codrilla site, in terms of the geotechnical data analysed, which characterised overburden and interburden conditions, and presented the details of generic slope stability analysis (Ref 2). However the assessment was not based around a finalised mine plan. In this case, the design recommendations presented were generic in nature and required review and validation against the proposed mine layout, particularly in relation to low wall and boxcut locations.

1.2 Scope of Work

The proposed scope of works was completed as follows:

1. Field program to investigate potential box cut locations, including geotechnical log development in WellCAD and field data reductions;
2. Refinement and confirmation of slope designs based on the current mine plan and geology model;
3. Interpretation of the structural model in relation to the box cut and low wall location;
4. Completion of acoustic scanner interpretation and kinematic analysis, including the development of a geological structure database;
5. Refinement of recommendations on ex-pit and in-pit dumping, potential risks to proposed mining method, and trafficability; and
6. Assessment of ex-pit spoil material for rehabilitation purposes. This involved evaluating the sandstone unit below the VU seam as a potential cover material for the spoil dump and also the dispersive nature of the spoil.

2 LOCATION OF SITE

The Codrilla Prospect is situated in the northern part of EPC 676, which is located astride the Fitzroy Developmental Road (Beef Road) about 25km south of the intersection with the Peak Downs Highway. Figure 2-1 shows the location of the Codrilla Prospect with respect to nearby coal mines and tenements.

The topography is essentially flat, with an elevation between RL180 in the north-west and RL160 in the south, averaging approximately RL170. The only watercourse traversing the Codrilla area is the ephemeral Devlin Creek.

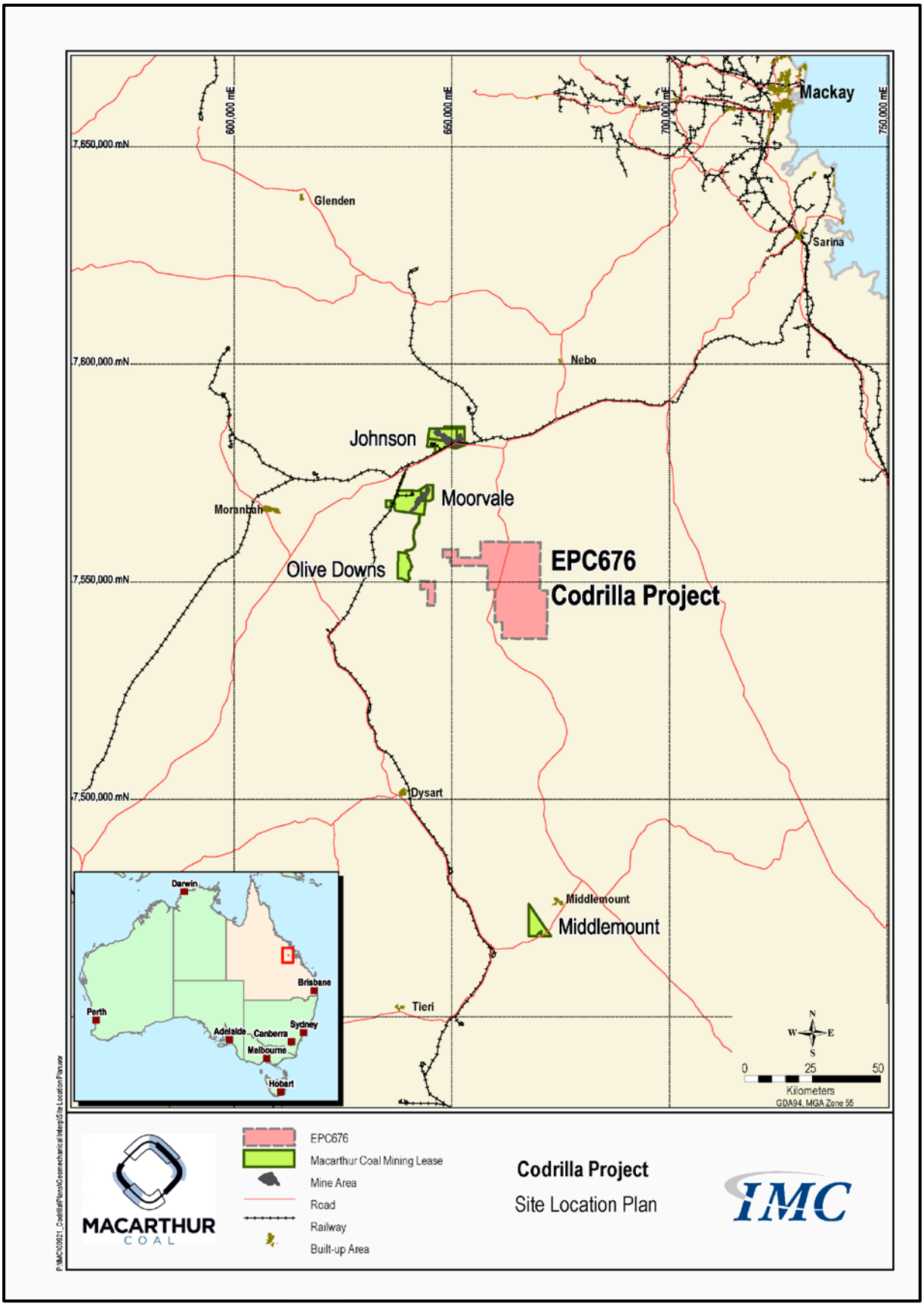


Figure 2-1: Site Location Plan

3 DRILLING PROGRAM

A programme of four fully cored geotechnical boreholes was carried out during August and September, 2011 under the supervision of MCC, with oversight from IMC. The locations of these holes, CX3106FC, CX3115FC, CX3122FC and CX3127FC are shown in Figure 3-1. These holes were cored from close to ground level, to enable engineering geological logs to be compiled for the soft overburden strata and coal seams, and to provide samples for geomechanical testing. The locations were determined to provide further coverage of the proposed low wall areas, following on from the 2009 study.

Coring was HQ giving nominally 63mm diameter core. Engineering logs for these holes are provided in Appendix A.

The acoustic televiewer was also completed on several holes as part of the routine geophysical program.

A significant drilling program was completed by MCC during 2011; however some of the data was not available at the time of report completion for incorporation into the report. It was also noted that the 2011 drilling program focused on coverage of the central portion and LOX areas for each pit.

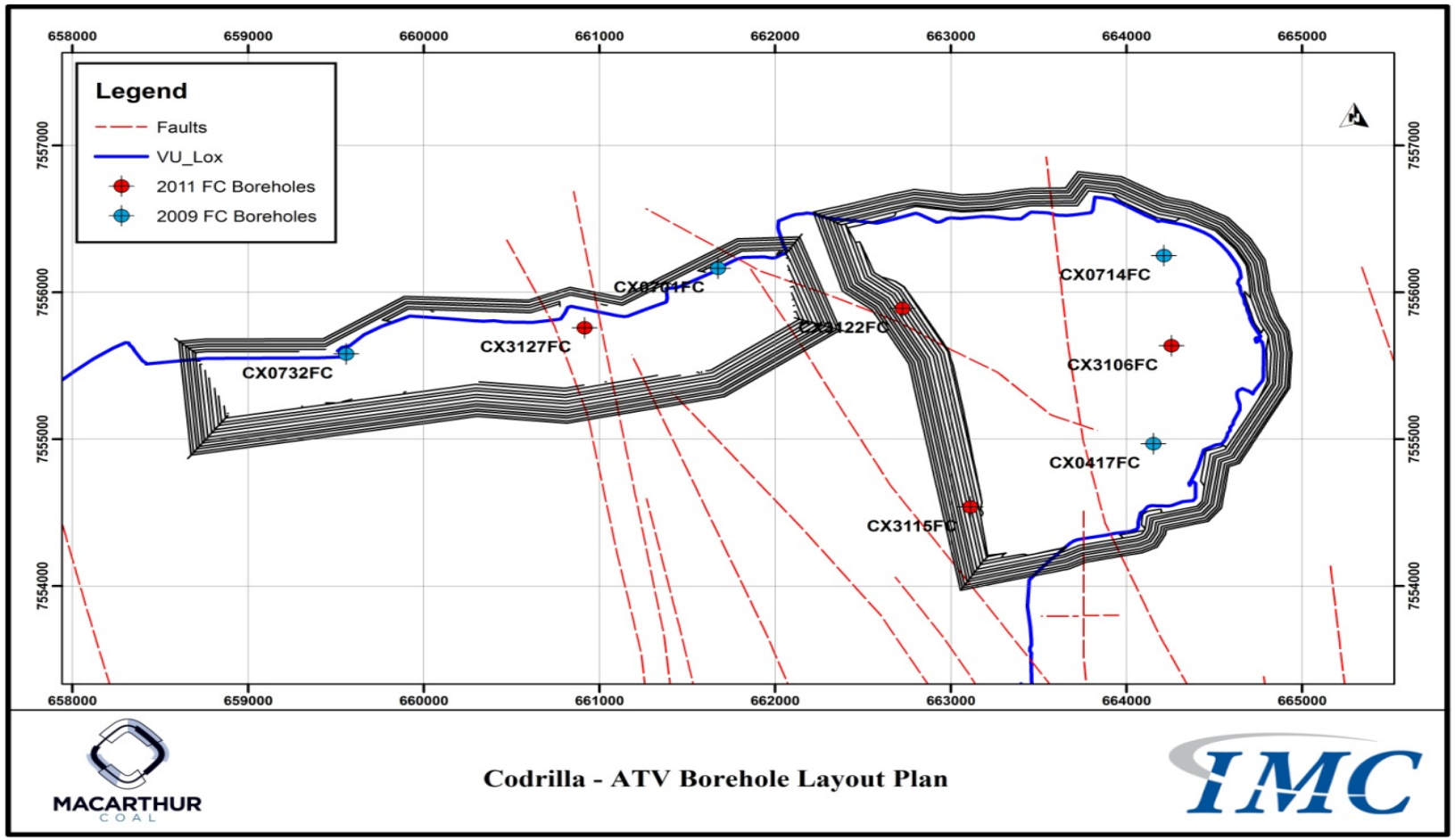


Figure 3-1: Fully Geotechnical Borehole Plan

4 LABORATORY PROGRAM

For this study, the laboratory program focused on improving the reliability of material properties used for slope stability modeling, as part of the previous phase of work. This was achieved by targeting specific soft overburden units (Tertiary and weathered Permian) for sampling and testing.

In addition to this, a separate program of testing was conducted on samples recovered from the soft overburden units and the sandstone unit below the VU seam, which was aimed at assessing the dispersive characteristics of the soft overburden and sandstone as a potential spoil cover material. The results of the testing are presented separately in Section 13.

Similar to the previous study, disturbed and undisturbed samples were taken from the four fully cored boreholes for geomechanical testing. All samples were preserved and dispatched to the laboratory in accordance with nominated procedures.

Routine soil classification (Atterberg limits), shrinkage, slake durability, unconfined compressive strength (UCS) were conducted on overburden, roof and floor samples by Cardno (Ullman & Nolan Technical Services Pty Ltd) at their Mackay laboratory. Triaxial testing was carried out by Trilab Pty Ltd in Brisbane. Young's modulus and Poisson's ration testing was not conducted as part of this laboratory program. Recommendations for roof and floor testing were not included as part of IMC's mandate.

4.1 Laboratory Results

4.1.1 Soft Overburden Units

Soil classification testing indicated the soft overburden to comprise primarily silty or sandy clay or clayey silt of low to intermediate plasticity, with minor occurrences of high plasticity clay. The results are summarised in Table 4-1.

Triaxial testing was conducted on selected samples of soft overburden and one sample of the Yarrabee Tuff to determine shear strength values. These comprised back-saturated, consolidated multistage tests with pore water pressure measurement. A further sample of the Yarrabee Tuff was tested by direct shear. Shear strength parameters derived from these tests indicate significant variability in the shear strength of material at the site. These are also dependent on the nature of the material tested. In this case, soft clayey materials and more competent, highly weathered rock would show variability in shear strength. The results are presented in Table 4-2.

Direct shear testing was carried out on comminuted core to provide an indication of run-of-mine spoil strength during the Feasibility Study. Core from CX0701FC was sent to Australian Soil Testing Pty Ltd where a 1m section from 15.5m to 16.5m was selected as being reasonably representative of the soft overburden. This was broken up manually to pass 6.7mm, and placed in a 100mm shear box under light compaction. Tests were made on a dry (as received) basis and after saturation.

The dry test results were not uniform, showing a drop-off of shear strength above 300 kPa with strength picking up again around 500 kPa. Examination of the test material suggested that below 300 kPa the material remained intact, but from 300 to 500 kPa the particle shape became flattened and lenticular, facilitating shearing.

Above 500 kPa the material became compressed into a more solid mass with much less void space. All the test curves showed a progressive increase in shear strength rather than a more traditional peak value. The 'failure' value was accordingly taken as approximately 10% strain, which tended to correspond to a leveling off in vertical compression (that is, zero volume change). These results are also summarised in Table 4-3.

Results of individual laboratory tests are presented in Appendix B.

4.1.2 Roof and Floor

Unconfined Compressive Strength (UCS) tests were conducted on rock samples from target coal seam roof and floor with slake durability tests on the latter. This mainly focused on the Leichardt and Vermont Upper seams.

Uniaxial compressive strength (UCS) testing indicated the roof units for all seams to be low strength, averaging approximately 10MPa. The predominant roof material was laminite.

Similarly, UCS testing indicated the floor units to be low strength, averaging approximately 8MPa. Floor units generally comprised mudstone, laminite and siltstone, with the occasional occurrence of sandstone.

The UCS and slake durability results are summarised in Table 4-3.

Results of individual laboratory tests are presented in Appendix B.

4.1.3 Spoil Cover Assessment Results

Specific testing requirements completed for the spoil cover assessment included:

- Emerson Class - conducted to assess the dispersive nature of the material, essentially with respect to rehabilitation of spoil and where the overburden (particularly the Tertiary clay) contained slake susceptible clay or mudstone;
- Atterberg Limits - determines the liquid and plastic limits of clayey materials, which is useful indicator of reactivity. An example of a reactive soil would be volcanically derived clay;
- Slake Durability - indicates of rock degradability, which measures changes in rock properties due to chemical and mechanical breakdown; and
- UCS - the unconfined compressive strength of the material.

A discussion of the results of the testing is presented in Section 13.

The results of the Emerson Class testing are summarised in Table 4-4 below, with the UCS, slake durability and Atterberg Limits testing included in Table 4-1 and Table 4-3.

Table 4-1: Soil Classification Tests

Borehole	Depth From (m)	Depth To (m)	Unit	Description	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Linear Shrinkage (%)	Class
CX0417FC	12.33		2	cream to orange with black slightly sandy clay	43	25	18	11.0	CI
CX0417FC	16.20		2	cream to orange with black slightly sandy clay	38	12	26	13.0	CI
CX0417FC	26.50		3	yellow grey & red-brown silty clay with f-c sand	38	15	23		CI
CX0701FC	9.48		2	orange buff slightly sandy clay	50	31	20	8.5	MI
CX0701FC	20.70		2	grey red-brown silty clay	44	12	28		CI
CX0701FC	38.55		3	grey orange very sandy clay	32	22	10	9.0	CL
CX0714FC	16.00		2	orange grey sandy clay (m-c sand)	45	24	21	14.0	CI
CX0714FC	24.00		3	orange grey sandy clay (m-c sand)	32	18	14	9.0	CL
CX0714FC	34.92		3	grey red-brown silty clay with f-c sand	35	13	22		CL/CI
CX0714FC	42.80		4	grey red clay	51	26	25	13.5	CH
CX0714FC	50.13		4	cream red clay	48	30	18	11.0	MI
CX0714FC	64.00		5	grey orange laminated clay	54	35	20	13.5	MH
CX0714FC	111.88		YT	yellow to cream tuff	43	19	24	8.0	CI
CX0732FC	20.19		3	grey yellow-brown silty clay with f-m sand	26	15	11		CL
CX0732FC	31.53		3	grey red-brown silty clay	62	17	45		CH
CX0732FC	56.75		YT	brown tuff	47	23	24		CI
CX3106FC	9.24	9.48	2	Silty sand - f-m grained	33	15	18	11.0	SC
CX3106FC	14.00	14.20	2	Sandy clay, reddish grey	43	20	23	12.5	
CX3106FC	57.95	58.25	3	HW claystone, reddish grey	35	20	15	6.5	
CX3115FC	10.00	10.30	2	XW claystone, sandy, reddish grey	44	14	30	15	CI
CX3115FC	15.48	15.68	3	XW claystone, sandy, grey	46	15	31	15.5	CI
CX3115FC	55.00	55.20	3	HW claystone, reddish grey	44	19	25	12.0	CI
CX3115FC	69.19	69.39	4	HW clayey sandstone, yellow brown	39	22	17	8.5	SC
CX3122FC	10.00	10.20	2	XW claystone, reddish grey	26	18	8	2.5	SC
CX3122FC	24.24	24.44	3	XW claystone, grey brown	37	19	18	8.5	CI
CX3127FC	10.30	10.50	2	XW claystone, sandy, reddish grey	44	13	31	14.5	CI
CX3127FC	36.04	36.24	3	XW claystone, sandy, reddish brown	56	24	32	14.0	
CX3127FC	44.63	44.85	4	HW siltstone, clayey, grey brown	65	28	37	19.0	CH

orange highlighted cells indicate 2011 test results

Table 4-2: Shear Strength Test Results

Borehole	Depth From (m)	Depth To (m)	Horizon	Lithology	Test Type	Moisture (%)	Density (t/m^3)	Cohesion (kPa)	Friction (ϕ)
CX0417FC	26.50		Unit 3	silty clay with f-c sand	triaxial	17.2	2.28	24	29.0
CX0417FC2	125.54		YT	tuff	direct shear			11	38.5
CX0701FC	20.70		Unit 2	silty clay	triaxial	16.2	2.20	70	13.0
CX0714FC	34.92		Unit 3	clay with f-c sand	triaxial	12.4	2.26	65	33.0
CX0732FC	20.19		Unit 3	silty clay with f-m sand	triaxial	14.9	2.23	58	29.0
CX0732FC	56.75		YT	tuff	triaxial	18.3	2.15	70	29.5
CX0701FC	15.5	16.5	Unit 2	reconstituted (spoil)	direct shear dry	15.6	1.47 (bulk)	0	40.0
CX0701FC	15.5	16.5	Unit 2	reconstituted (spoil)	direct shear saturated	15.6	1.47 (bulk)	0	29.0
CX3106FC	9.48	9.78	Unit 2	silty sand	triaxial	13.8	2.19	35.5	30.8
CX3106FC	62.33	62.61	Unit 4	MW siltstone	triaxial	13.3	2.00	**262.1****	29.9
CX3115FC	11.44	11.77	Unit 2	XW claystone	triaxial	15.4	2.18	32.6	30.7
CX3115FC	74.89	75.19	Unit 4	HW sandstone	triaxial	6.8	2.56	Specimen failed Stage 1	
CX3122FC	5.12	5.45	Unit 1b	XW claystone	triaxial	15.6	2.13	37.0	22.5
CX3127FC	8.77	9.05	Unit 2	XW claystone	triaxial	12.3	2.25	**120.0****	22.5
CX3127FC	41.60	41.90	Unit 4	HW siltstone	triaxial	21.1	2.09	71.5	18.0

orange highlighted cells indicates 2011 test results;
** indicates low reliability value

Table 4-3: Strength and Durability Tests

Borehole	Depth From (m)	Depth To (m)	Horizon	Lithology	UCS (MPa)	Moisture (%)	Density (t/m^3)	Slake (%)	Modulus (GPa)	Poisson's Ratio
CX0417FC	78.39		Unit 5	siltstone	9.5	5.6	2.44			
CX0417FC2	104.32		LL3-VU interburden	sandstone	25.4	3.5	2.73		6.22	0.23
CX0417FC2	108.97		LL3-VU interburden	carb siltstone	8.3	5.6	2.42			
CX0417FC2	126.18		VU floor FL1	siltstone				85.6		
CX0417FC2	126.32		VU floor FL1	siltstone	9.0	3.9	2.50			
CX0701FC	58.10		VU sub-floor FL2	mudstone (sw)				21.1		
CX0701FC	58.74		VU sub-floor FL2	mudstone (mw)	2.0	14.2	2.21			
CX0701FC	61.62		VU sub-floor FL3	sandstone (mw)	2.7	9.6	2.34			
CX0714FC	78.88		Unit 5 (LL2 floor)	mudstone				17.1		
CX0714FC	111.99		VU floor FL1	siltstone				96.3		
CX0732FC	58.95		VU floor FL1	mudstone				29.4		
CX0732FC	61.73		VU sub-floor FL3	sandstone (mw)	2.3	9.5	2.32			
CX3106FC*	**189.37**	**189.60**						**95.6**		
CX3106FC*	**191.70**	**192.01**		**Sandstone**	**20.2**	**1.1**	**2.72**			
CX3115FC	82.76	83.06		Sandstone	9.3	3.7	2.52			
CX3115FC	84.37	84.66		Sandstone	4.1	8.2	2.42	3.1		
CX3115FC	116.03	116.23	LL2 Roof	Siltstone	11.6	4.2	2.46			
CX3115FC	119.6	119.86	LL2 Floor	Siltstone	1.5	2.4	2.55	96.5		
CX3115FC	153.21	153.48	VU Roof	Siltstone	45.5	2.3	2.54			
CX3115FC	161.94	162.26	VU Floor	Siltstone	4.3	2.9	2.36	91.3		
CX3115FC*	**169.5**	**169.72**		**Sandstone**	**65.7**	**1.6**	**2.59**	**96.8**		
CX3118CR	113.54	113.81	LL2 Roof	XM	8.0	6.6	2.36			
CX3118CR	117.15	117.47	LL2 Floor	XM-Sandstone	5.2	6.1	2.53	14.9		
CX3118C	143.85	144.06	VUS Roof	XM	12.0	3.9	2.523			
CX3118C	155.51	155.79	VU Floor	Mudstone	13.9	5.0	2.436	71.8		
CX3119C	139.76	140.07	Interburden	Mudstone	23.8	2.0	2.731			
CX3119C	140.66	140.93	Interburden	XM	5.1	5.5	2.388	16.6		

orange highlighted cells indicates 2011 test results; *** indicates spoil suitability assessment**

Table 4-3: Strength and Durability Tests - Continued

Borehole	Depth From (m)	Depth To (m)	Horizon	Lithology	UCS (MPa)	Moisture (%)	Density (t/m^3)	Slake (%)	Modulus (GPa)	Poisson's Ratio
CX3119C	141.03	141.31	LL2 Roof	XM	6.2	5.0	2.400			
CX3119C	143.88	144.14	LL2 Floor	Siltstone				44.5		
CX3119C	173.77	174.07	VU Roof	Sandstone	34.1	2.4	2.644			
CX3119C	182.03	182.3	VU Floor	Siltstone/Mudstone	16.8	3.5	2.505	69.6		
CX3122FC	78.04	78.84	LU Roof	Siltstone	1.1	10.2	2.352			
CX3122FC	80.69	80.99	LU Floor	Siltstone	1.7	13.1	2.206	3.5		
CX3122FC	99.13	99.4	LL1 Roof	Sandstone	13.0	3.6	2.545			
CX3122FC	101.57	101.87	LL1 Floor	Sandstone	6.4	4.0	2.502	92.5		
CX3122FC	136.87	137.18	LL2 Roof	Siltstone/Mudstone	9.9	3.3	2.515			
CX3122FC	142.59	142.85	LL2 Floor	Siltstone	2.9	6.1	2.377	44.7		
CX3122FC	165.73	165.96	VU Roof	Siltstone	14.4	2.6	2.528			
CX3122FC*	**175.00**	**175.27**	**VU Floor**	**Siltstone**	**16.5**	**3.9**	**2.481**	**86.1**		
CX3123C	147.61	147.91	VU Floor	XM/Mudstone	9.3	4.1	2.49			
CX3123C	156.36	156.66	VU Floor	XM	12.1	4.1	2.447	70.1		
CX3124C	155.20	155.47	VUF Roof	XM						
CX3124C	166.24	166.50	VUF Floor	Mudstone	11.3	4.7	2.403	74.5		
CX3124C	167.42	167.68	LL3 Roof	XM						
CX3124C	171.5	171.80	LL3 Floor	XM	1.9	3.6	2.427	65.3		
CX3124C	194.45	194.73	VUF (2) Roof	XM	7.8	3.7	2.483			
CX3124C	197.79	198.07	VUF (2)Floor	XM				82.3		
CX3124C	198.35	198.60	VU Roof	XM	8.2	3.9	2.523			
CX3124C	207.77	208.09	VU Floor	YTB (TU)	4.9	6.4	2.398	31.0		
CX3127FC	72.64	72.98	VU Roof	XL	2.2	9.8	2.319			
CX3127FC	82.42	82.71	VU Floor	XM	2.2	10.8	2.275	11.2		
CX3127FC	84.93	85.15		Sandstone	18.9	3.0	2.51			

orange highlighted cells indicates 2011 test results; *** indicates spoil suitability assessment**

Table 4-3: Strength and Durability Tests - Continued

Borehole	Depth From (m)	Depth To (m)	Horizon	Lithology	UCS (MPa)	Moisture (%)	Density (t/m^3)	Slake (%)	Modulus (GPa)	Poisson's Ratio
CX3127FC*	**99.00**	**99.21**		**Sandstone**	**22.7**	**1.8**	**2.53**	**95.4**		
CX3129C	63.51	63.73	VU Roof	XL						
CX3129C	73.29	73.59	VL Floor	Mudstone	4.0	10.1	2.306	41.5		
CX3132C	85.63	85.93		XM	0.7	8.5	2.276			
CX3132C	88.90	89.20		XM	0.2	11.3	2.168	30.1		
CX3132C	110.23	110.46		Siltstone	12.3	3.8	2.546			
CX3132C	122.25	122.5		Siltstone	2	5.8	2.409	50.8		

orange highlighted cells indicates 2011 test results; *** indicates spoil suitability assessment**

Table 4-4: Emerson Class Results

Borehole No.	Depth From	Depth To	Sample No.	Emerson No.	Comment
CX3106FC	14.00	14.20	165753	5	Unlikely to be sodic
CX3106FC	55.00	55.20	165765	6	Not sodic
CX3122FC	21.00	21.24	6224	4	May be sodic
CX3122FC	69.04	69.24	6239	7	No Dispersion

orange highlighted cells indicates 2011 test results

5 GEOLOGY INTERPRETATION

5.1 Deposit Geology

Figure 5-1 shows the stratigraphical succession. The main target seam is the Vermont Upper (VU) at the base of the Permian Rangal Coal Measures. This has a typical thickness of about 7.5m over the main part of the site however this reduces to about 4.5m in the south.

Other seams within the Rangal Coal Measures with mining potential include the various splits of the Leichardt Seam, the LU, LL1 and LL2 seams. Another minor seam, the LL3 occurs in places below the LL2 Seam, and may represent a split off the VU Seam. This is typically present in the southern area where the VU Seam has a reduced thickness. The Leichardt Seams are generally between 1m to 2m thick, but can be over 3m thick in places. A feature of the Codrilla deposit is the wide variation in thickness of the upper seams and of the interburden distance between them.

The Rangal Coal Measures (RCM) is approximately 110m thick and comprises fine lithic sandstone, siltstone and mudstone. The base of the RCM is marked by the Yarrabee Tuff, which is a widespread and easily recognised marker band. The underlying Fort Cooper Coal Measures strata are predominantly sandstone with banded coal seams. The VL1 Seam is a thin stony seam immediately below the Yarrabee Tuff; the VL2 is thicker, from 2.5m to 4.0m on average but is also stony. Neither of these seams is currently included in the mine plan.

The Rangal Coal Measures are overlain by the barren Rewan Group which comprises sandstone, siltstone and mudstone with a characteristic greenish-grey colour. These would only be present in the overburden where the depth of mining exceeds the present 100m or so.

The top of the Permian strata are deeply weathered, with the base of weathering between 50m and 100m below ground surface. The Permian weathering thickness is interpreted to be between 20m and 50m thick, which is greater than usual, and includes a major proportion of highly to completely weathered material in the form of sandy claystone. The overlying Tertiary is for the most part sandy or silty clay of similar characteristics to the weathered Permian, and is interpreted to be 40m thick on average with range between 25m and 65m. The thick Tertiary and deep weathering appears to be a unique feature of the Codrilla Deposit.

Typical cross sections showing the disposition of the seams for the western and southern parts of the mining area are presented in Figure 5-2 and Figure 5-3.

Isopachs of VU Seam thickness is presented in Figure 5-4. The VU Seam has an average thickness of approximately 6.30m across the site, with a median thickness of approximately 7.0m. Thickness ranges from 1.0m in borehole CX1110, to 10.1m in borehole CX0729.

5.2 Geological Structure and Seam Dip

The Codrilla Prospect is located on the eastern flank of the Coxendean Sub-basin, a separate eastern extension of the Bowen Basin. The coal measures strata have a regional north-south strike with a dip to the west, however just north of the Codrilla Prospect the strike has been disrupted by deformation around the dome of the Bundara Intrusive Complex, causing a sharp swing to a westerly strike direction.

As a consequence the strata at Codrilla form a syncline with a south-west axis with seam dips of the order of 10° around the nose of the syncline, flattening out at depth. South of the nose the strike is south with dips up to 15°, whilst on the north side the strike is due west with dips increasing towards the west and reaching up to 20°.

Figure 5-5 shows structure contours on the base of the VU Seam, which represents the mining floor.

The contours in Figure 5-5 are based on the borehole intersections and are thus limited in confidence by the number of available boreholes. It is apparent that they can only give a general indication of the disposition of the VU Seam, particularly on the limbs of the syncline where the contours are typically based on only two in-line values. Seam dips as recorded from cored boreholes vary from 20° to 30°, sometimes with variations within the borehole.

Seam dips recorded from cored boreholes are noted in Table 5-1. In general terms these fit with the structure contours from the geological model, with dips up to 25° along the western limb and dips from 20° to 10° around the nose. However, there are divergences such dips of 30° or 40° on the western limb where the contours indicate an average of 19°, and cases of significant variation within single boreholes. It is thus apparent that seam dip can be more variable at a local level than indicated by the contours.

Depth of cover varies along the lox line from 60m to 65m along the western limb and 75m along the southern limb, but increases to 90m plus around the nose of the syncline. The depth of cover contours for the VU Seam is shown in Figure 5-6, together with the interpreted subcrop (LOX) line.

5.2.1 Faults

The current fault interpretation is shown in Figure 5-6. This is based on interpretation of the structure contours and the 2D seismic survey. It shows a series of north to north-northwest striking normal faults forming a horst and graben complex across the nose of the syncline. The original interpretation of the 2D seismic traverse (676-02-03) suggests the faults are steep reverse faults with displacements in the order of 8m to 12m. Interpretation of recently procured 2D seismic data indicated a wide structurally disturbed zone in the east pit. A discussion of this is presented in Section 10.9.

In addition to the fault interpretation discussed above, there are a number of anomalous structural features apparent in individual boreholes, such as missing seams, or seam repeats and over thrusting in the VU Seam. Anomalous geological structure identified from borehole interpretation is presented in Table 5-1. This was only completed for the 2009 data at this stage. The location of these boreholes is shown in Figure 5-7.

Missing seams generally indicate the presence of normal faults. Four instances of missing minor seams were noted, in CX0739, CX0418, CX0749 and 1910, none of which lie on interpreted fault lines. However, the thickness variation in the minor seams between boreholes is significant and the level of confidence in the correlation is therefore not high. This may be due to insufficient boreholes to confirm the natural variation or it may indicate that the deposit is more structurally disturbed than the model indicates. The top of the VU Seam appears to have been faulted out in CX0419.

Seam repeats or anomalous increases in thickness are usually indicative of thrusting or reverse faulting arising from compression during the latest tectonic phase of the Bowen Basin. Thrusts are generally of low to moderate angle and of relatively small vertical displacement, and as such, they are virtually impossible to detect from structural interpretation or seismic survey. They are normally only detected from borehole interceptions where coal seams are affected.

Seam repeats were noted in CX0419 (VU), CX0700 (LL1), CX0720 (LL2), CX0735 (VU), CX0742 (YT) and CX1917 (VU) and a thrust was noted within the VU Seam in CX0729. The over thrust VU Seam in CX0735 was not replicated in the re-drill CX0735C4.

Given the incidence of thrusting note above, it can be concluded that thrusting and local perturbation in the VU Seam could be widespread, particularly if there is interaction with the postulated normal faults causing reverse displacement and buckling against them.

Table 5-1: Anomalous Borehole Structure

Borehole	Feature	Horizon	Dip
CX0417C		LL2 boc	2^0
CX0417C		LL3 toc	20^0
CX0417C		LL3 boc	5^0
CX0417FC		LL1	4^0
CX0417FC		LL2	5^0 - 30^0
CX0417FC2		VU	5^0 - 10^0
CX0418	VU fault zone (thrust)		
CX0418	VL2 missing		
CX0419	top VU faulted out		
CX0700	LL1 fault repeat		
CX0700	LL2 overthrust		
CX0700	fault zone 130.5m		
CX0700	VU top repeat?		
CX0701C4		VU	10^0, 20^0, 25^0
CX0701C4		VL1 boc	15^0
CX0701FC		VU	20^0
CX0703C4		LU	10^0
CX0703C4		VL1 subfloor	8^0
CX0707C4		LL2	10^0
CX0707C4		VU toc	3^0
CX0708C4		LL2	3^0
CX0708C4		VU toc	2^0
CX0708C4		VL1 boc	4^0
CX0714C4		LL2	13^0
CX0714C4		VU	5^0 - 10^0
CX0720	LL2 repeat		
CX0720C	LL2 thrust repeat	LL2	4^0
CX0721	GI reduced thickness		
CX0727C4		LL2 toc	4^0
CX0729	fault zone in VU 92.0-94.0		
CX0729C4	VU sheared, faulted	VU toc	10^0
CX0732FC		VU	25^0
CX0735	VU fault repeat		
CX0739	LL2 missing		
CX0742	YT repeat?		
CX0743		LL2 boc	10^0
CX0749	LL3 missing		

5.2.2 Intrusions

From the available data, there was no direct evidence from borehole intersections of igneous intrusion at Codrilla, with the only suggestion of intrusive activity being a reference to coked coal in the LL3 Seam. However, given the presence of a major intrusive body to the north, some dykes emanating from this could be expected to transect the deposit.

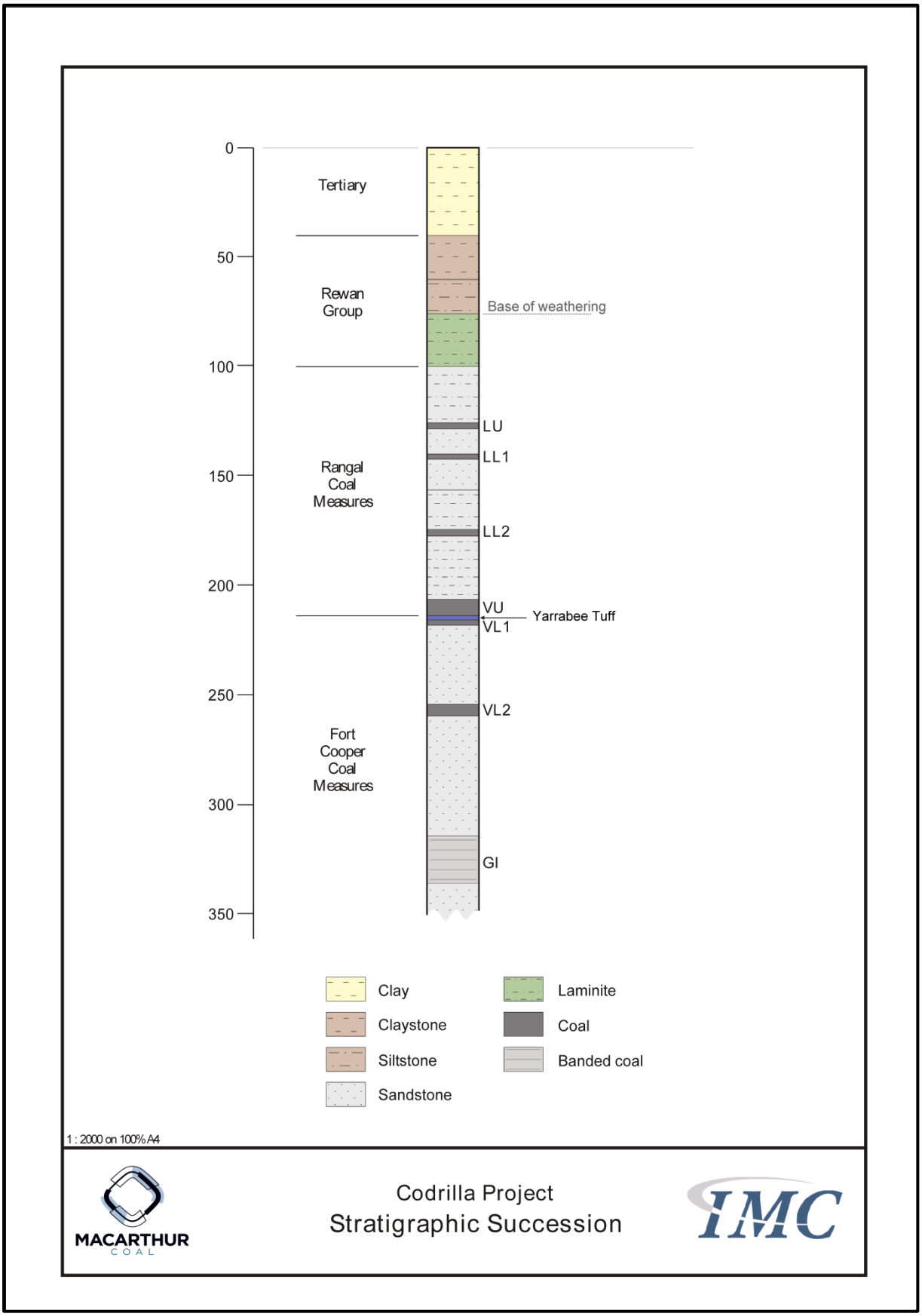


Figure 5-1: Generalised Stratigraphic Section

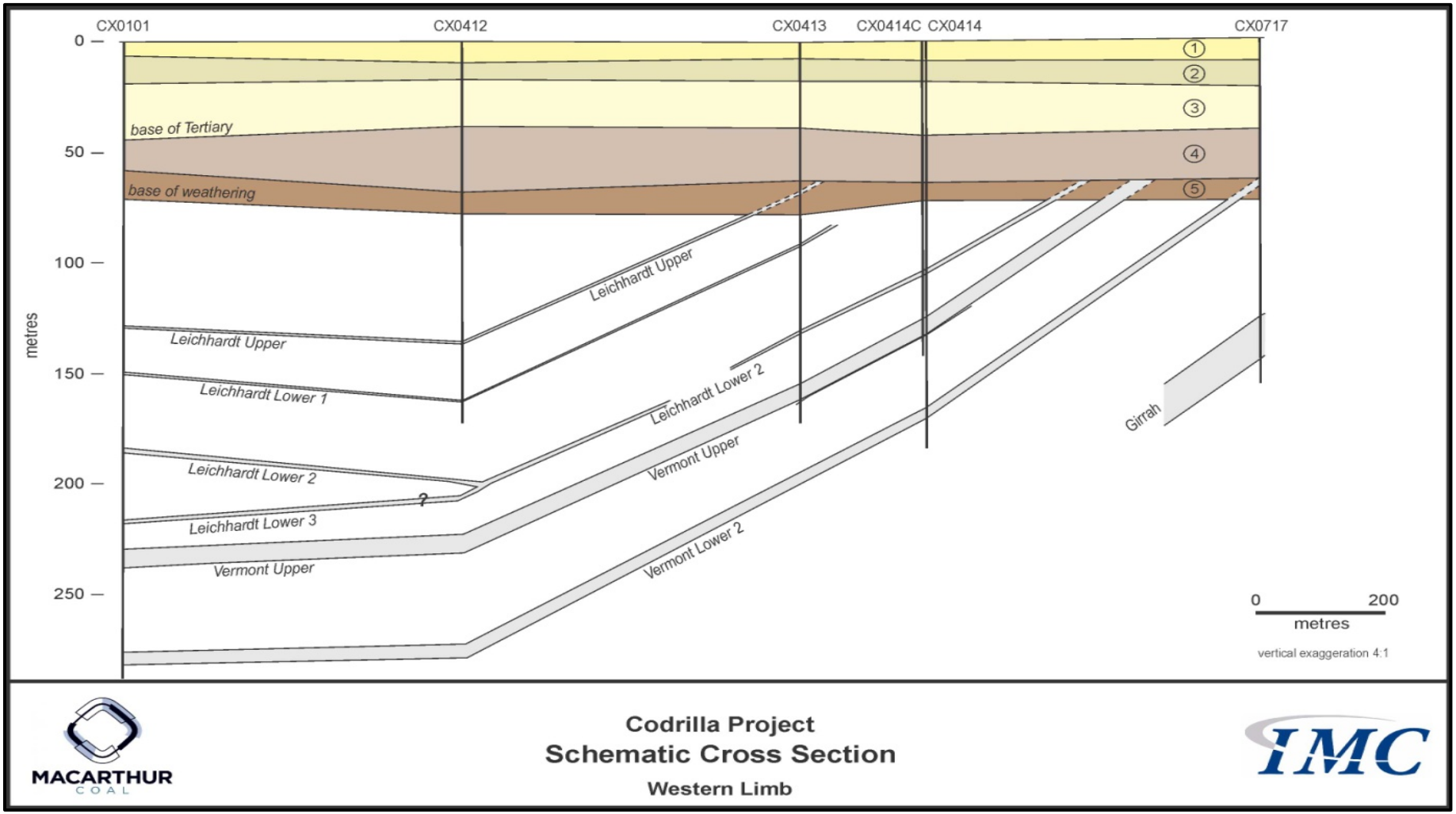


Figure 5-2: Geology Cross Section – Western Limb

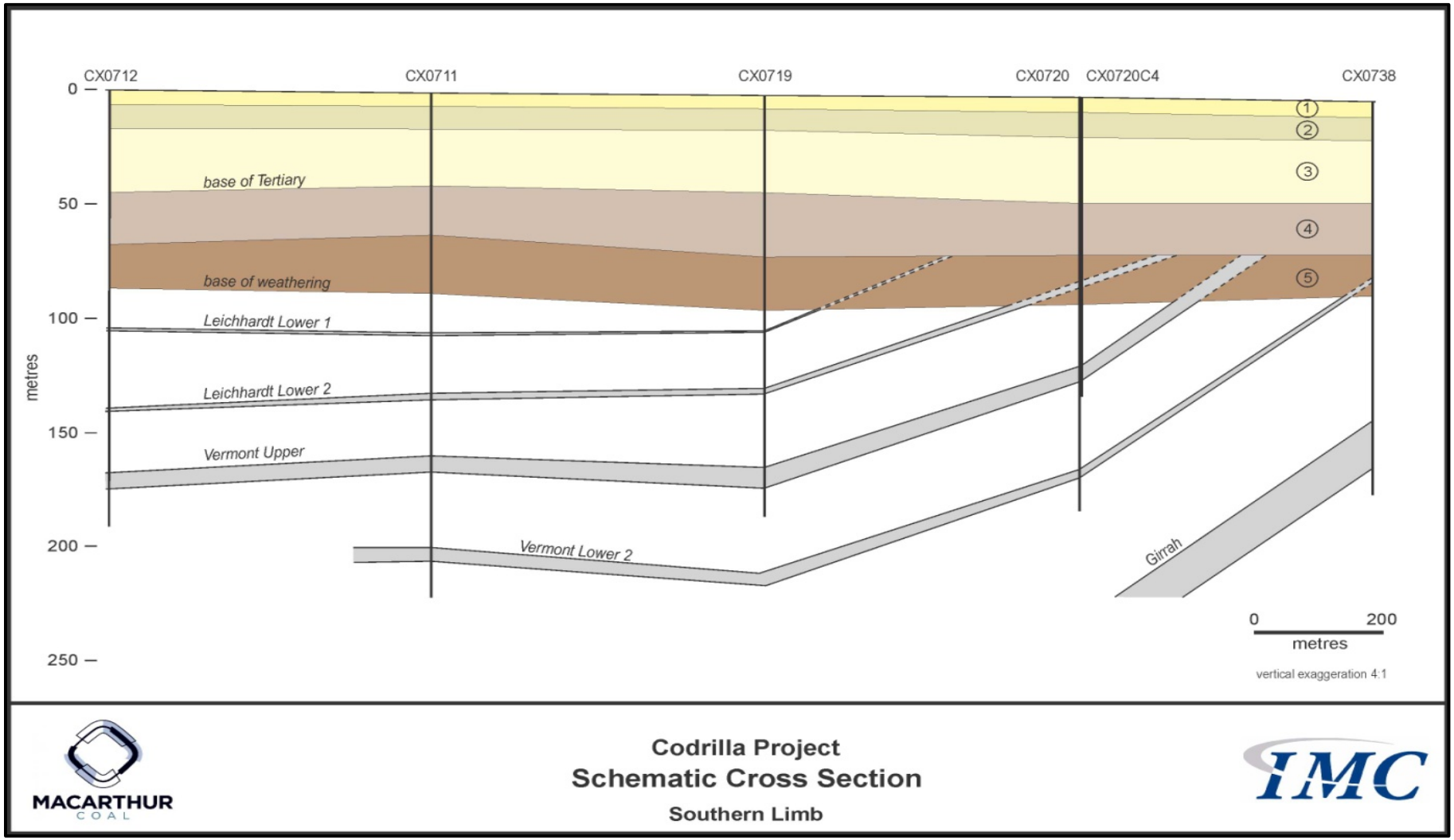


Figure 5-3: Geology Cross Section – Southern Limb

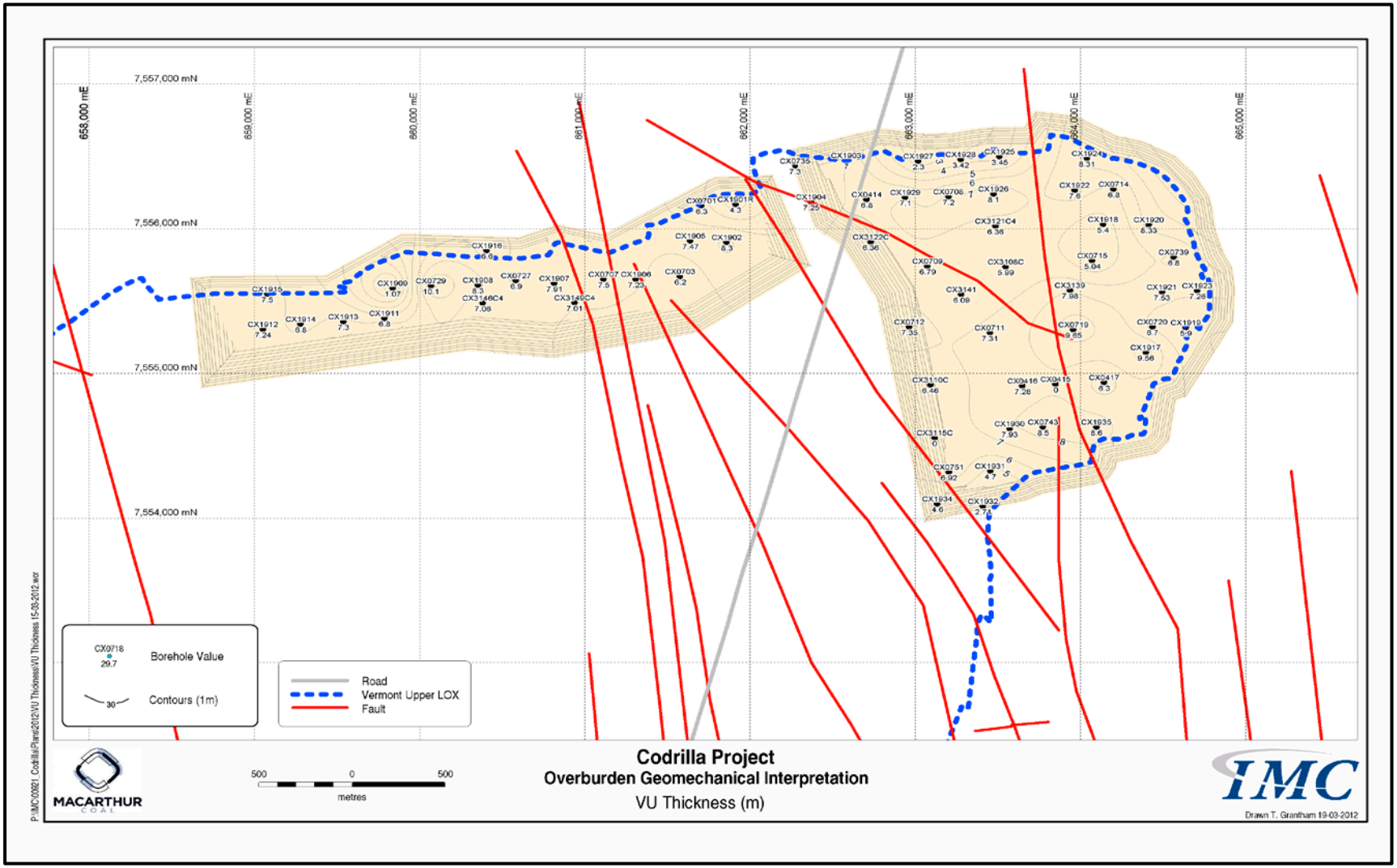


Figure 5-4: VU Seam Thickness

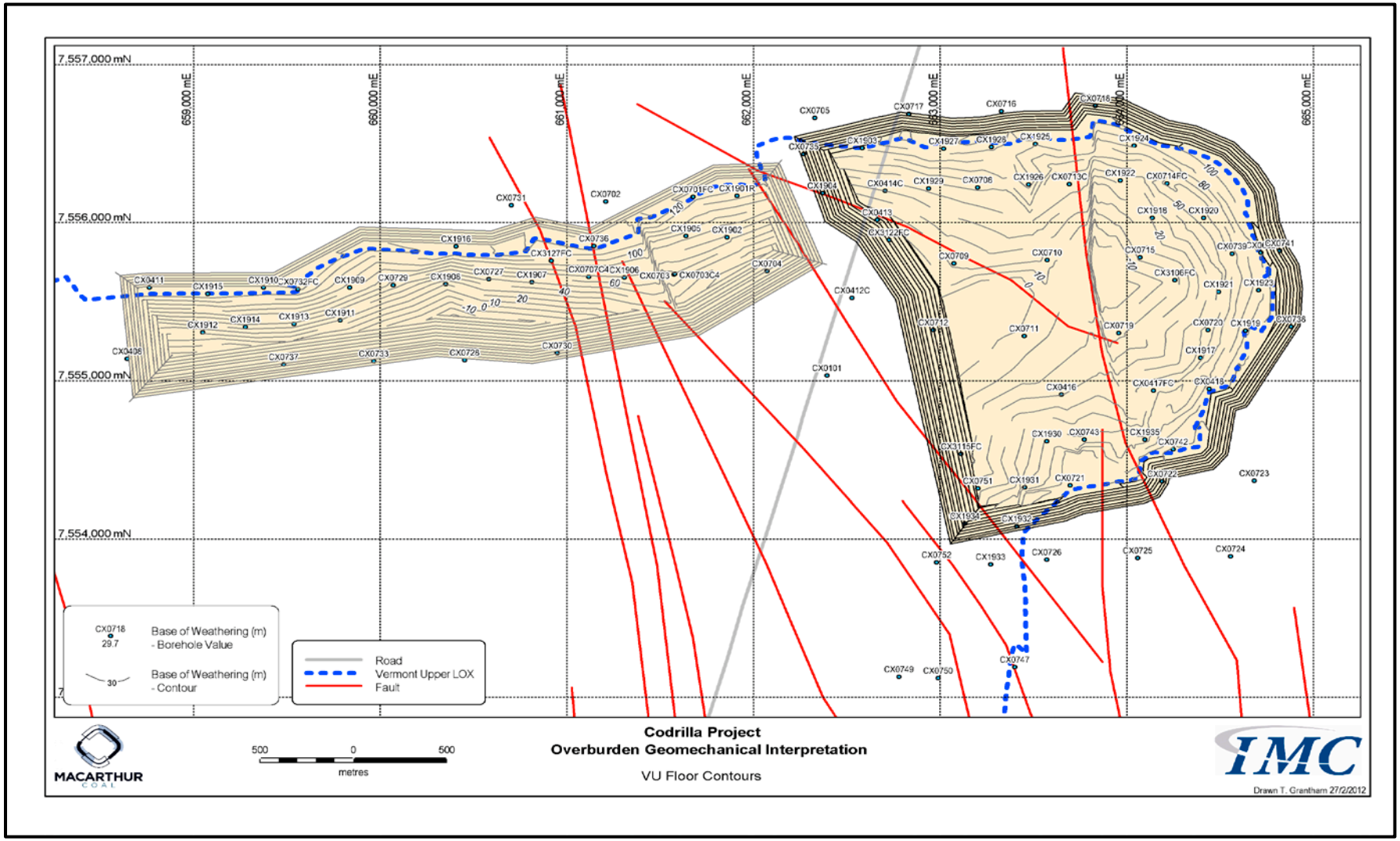


Figure 5-5: VU Seam Structure

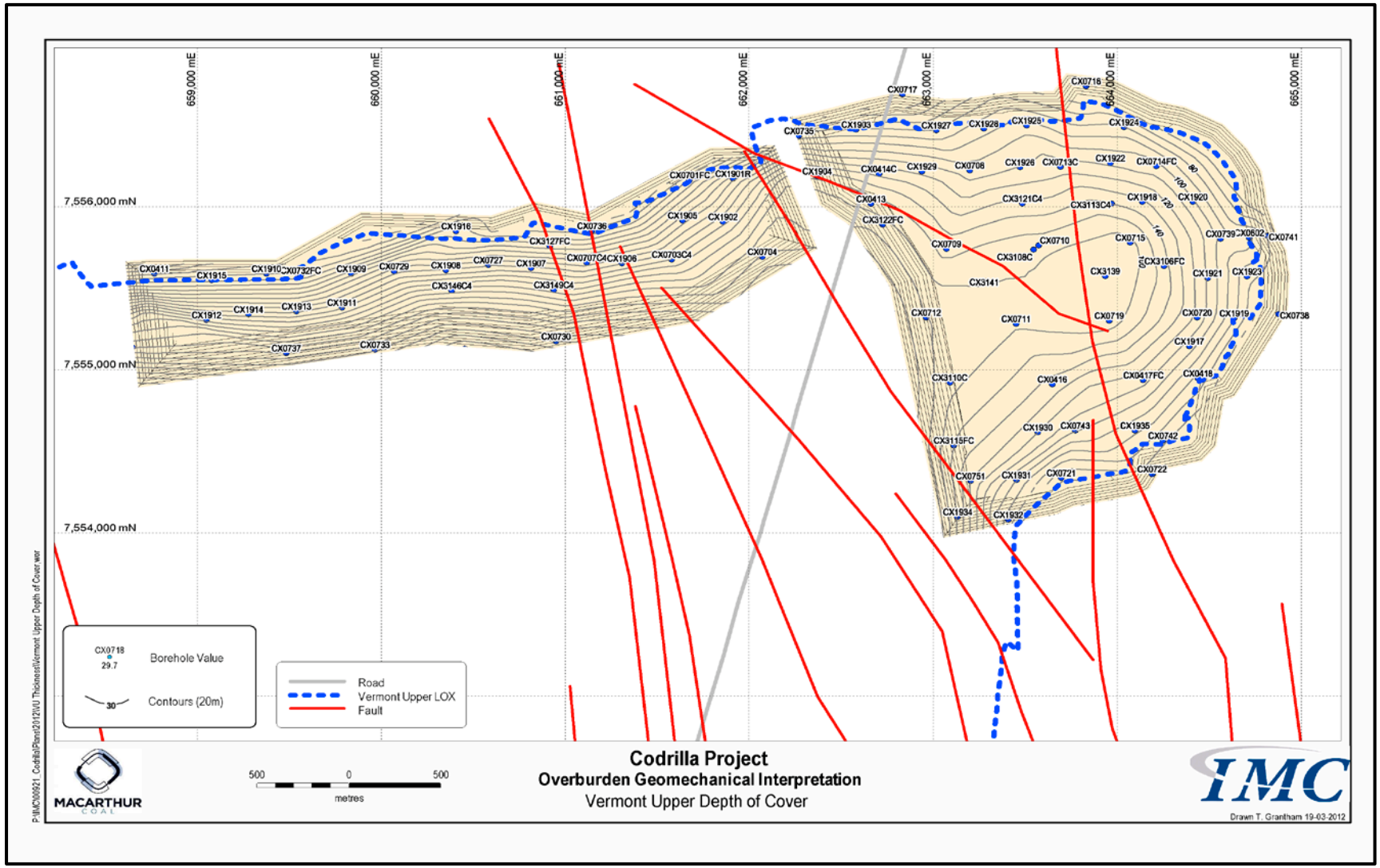


Figure 5-6: VU Depth of Cover

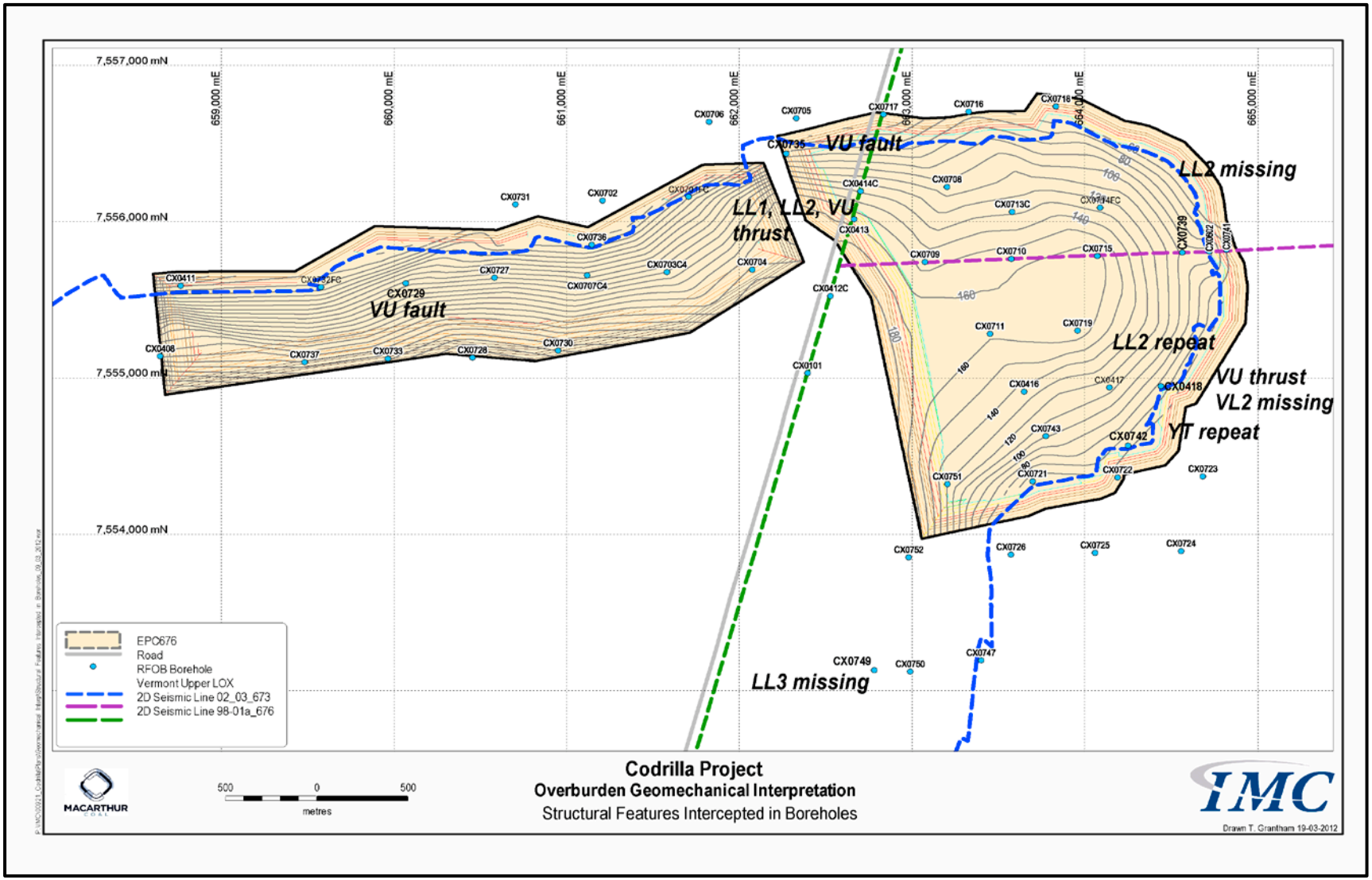


Figure 5-7: Geological Structure – Borehole Intercepts

6 OVERBURDEN, INTERBURDEN AND FLOOR CONDITIONS

6.1 Overburden

The four fully cored geotechnical boreholes during the 2011 field program were drilled to provide a detailed engineering description of the overburden material, as well as provide samples for testing. The results were incorporated with the 2009 drilling program, in which four fully cored boreholes were completed.

Overburden, in the context of this section, refers to material down to the VU Seam at subcrop, and hence is restricted to the Tertiary and weathered Permian layers. These are essentially horizontally disposed as indicated on the cross sections presented in Section 5 (Figure 5-2 and Figure 5-3).

A synopsis of the eight fully cored boreholes (2009 and 2011 fully cored programs) is presented in Figure 6-1. This shows a summary of the main litho types down to the base of weathering. This shows the overburden sequence interpreted into five geomechanical units.

The main component of the overburden is silty or sandy clay or claystone, orange grey in the upper part and pale grey with red or red-brown mottling in the lower part. Also included in the latter are weathered ironstone bands and in some places dark brown to black clay horizons. Gravel layers were recorded in several boreholes, generally at the Tertiary/Permian contact.

Also marked on Figure 6-1 is the depth at which joints are first apparent and bedding becomes discernable. There is no indication of bedding or joints above these levels.

The overburden sequence was interpreted into five geomechanical units, which are indicated in Figure 6-1 and are summarised below in Table 6-1.

Table 6-1 : Summary of Overburden Units

Unit	Horizon	Gamma Count Av.	Min Thickness (m)	Max Thickness (m)	Average Thickness (m)	Material	Nature	Condition	Age
1	Superficials	60	4.2	10.2	7	Clayey sand	Unconsolidated	Loose	Quaternary
2	Laterised Zone	80	6.7		11	Orange-grey sandy clay	Completely weathered	Stiff	Tertiary
3	Tertiary Clay	60	8.5	39.2	22	Pale grey, orange-grey, red-grey sandy clay	Completely weathered	Very Stiff	Tertiary
4	Weathered Permian Claystone	75	7	30	18	Orange-brown, orange-grey sandy claystone	Highly to Completely weathered	Very Weak	Permian
5	Weathered Permian Rock	80	7.2	33.3	17	Siltstone with sandstone etc	Moderately to Slightly weathered	Weak	Permian

These units were essentially based on interpretation of the geophysical logs as it was not possible to define or correlate horizons between boreholes from lithological descriptions alone. In this case, only the 2009 data was used for interpretation as the results from the recent drilling campaign were not available at the time of report completion. The interpretation from the 2009 program was considered to provide adequate coverage across the site to allow reasonable interpretation.

The interpreted units were discernable, but not readily definable, from the core logs and even less definable from chip logs. Geophysical logs from the cored holes and all available chip holes were accordingly examined and interpreted, primarily using the gamma log.

Interpreting Tertiary or weathered Permian from gamma logs alone is notoriously difficult and generally unreliable, however, it was noted that the logs showed responses that could be reasonably well correlated between boreholes, and these were used to identify and define the overburden units described above in conjunction with chip descriptions.

Table 6-1 above shows the average gamma response for each unit; however the range of values tends to be extensive and overlapping. Although the average values can be used for a general guide, the main point of correlation is the contrast between the units which is typically quite sharp.

The base of weathering was determined systematically from the density log as the depth at which the density reached a value of 2.5. This did not necessarily coincide with the geological description but in the majority of cases was a fairly close match.

The overburden units were intended to represent distinct geomechanical horizons. Horizon names were ascribed to the overburden units as shown in Table 6-1 for ease of use without necessarily being definitive in the stratigraphic sense.

This approach was adopted partly because the interpretation of the Tertiary at Codrilla is contentious. The previous view was that the Tertiary was relatively thin and that the Permian weathering was particularly deep – the deep weathering was considered to be a characteristic unique to Codrilla.

There is reason to question this – weathering, being a product of atmospheric exposure, is a broad regional scale feature unlikely to show significant variation in depth locally in similar rock types. At Codrilla the variation is considerable, ranging from 50m to 100m in a distance of 3km. It is difficult to justify how this could occur almost entirely within Permian strata of a similar nature.

Elsewhere in the Bowen Basin the Permian weathering layer beneath the Tertiary is typically about 20m thick, increasing to 40m in places. Total depth of weathering is thus typically 20m plus the Tertiary, which itself can be quite thick depending on the pre-Tertiary topography. The latter is known to be rugged in places with thick Tertiary infilling of valleys. The expectation for Codrilla would thus be 50m to 60m of Tertiary with 20m to 30m of Permian weathering.

The material cored in Unit 3 is at first glance typical of Tertiary clay in coloration, which is pale grey with red mottling and weathered ironstone bands and staining, although it differs in being sandier and of lower plasticity than the usual Tertiary clay. It was also devoid of bedding, which is another typical diagnostic for differentiating between Tertiary and Permian; jointing was also almost nonexistent.

Gravel, or gravelly clay, was noted in Unit 3 in a number of boreholes in a zone along the northern flank of the deposit from CX0408 to CX0739. The gravel horizon typically occurs within Unit 3 at a depth of between 25m and 30m. In some cases it deeper, around 37m and at the eastern limit it is between 53m and 59m. These deeper levels appear to coincide with the base of Unit 3.

Gravel layers up to 2m thick were intersected in CX0714FC, CX0417FC and CX3106FC, as indicated in Figure 5-1, at a depth of between approximately 48m and 58m. Sample recovered from the gravel layers showed medium to coarse gravel comprising a mixture of sub-angular to sub-rounded dark coloured fine grained igneous rock and angular fragments of vein quartz in a clayey matrix. The angularity indicates a local source; that is a non transported deposit, atypical of Permian clastic material. Also included was a fragment of petrified wood, which means the gravel deposit has to be post Permian lithification. The unavoidable conclusion is that this horizon represents a basal Tertiary deposit in this borehole.

Sand and gravel was noted in Unit 4 in boreholes CX0602, CX0738 and CX0741, which are the easternmost boreholes around the nose of the syncline. As sandstone is the predominant lithology in the strata below the VU and as these holes are located east of the VU subcrop, it is considered that in these cases, the loose sand and fine gravel most likely represents the residual effects of leaching out the matrix from Permian sandstones in the weathering zone.

Unit 1 – Superficials: This represents the layer of unconsolidated surface deposits. Descriptions of this material are variable, from clay to sand, but it would appear that sand or clayey sand is the predominant material. The base of the unit is frequently well defined lithologically, with a contrast between sand and clay.

Unit 1 is essentially unconsolidated, loose and non plastic. It has an average thickness of 7m with variation between 4m and 10m.

Unit 2 – Laterised Zone: This is a clay layer that is consistently identifiable on the gamma log with a higher average count than the underlying Unit 3 material. It is not readily discernable as a separate unit in the lithological logs and the base is not apparent visually in the fully cored boreholes, although there is a persistent contrast on the gamma logs which has been taken to mark the base of the unit. It is believed that Unit 2 represents near-surface oxidation or laterisation and weathering of the Tertiary clay.

A number of boreholes along the northern flank recorded a 1m to 4m thickness of dark brown to black claystone, sometimes carbonaceous within Unit 2, generally at a depth of between 6m and 14m. In two of the fully cored holes this horizon was described as orange grey or cream sandy clay interbedded with black coal, the latter being completely weathered to clay. A discrete horizon of dark coloured carbonaceous-looking clay at a particular level is not untypical of the Tertiary, and probably represents a former pond deposit. A point of note is that this horizon has been erroneously correlated with one or other of the Rangal coal seams in the database, which could lead to potential distortion in the seam structure contours.

The material comprising Unit 2 is generally described as orange grey, brown grey or yellow grey sandy clay. In engineering terms it is categorised as stiff clay of intermediate plasticity. Test results were consistent giving an average liquid limit of 44% and an average plasticity index of 23%. Only one triaxial test was made on Unit 2 material and this indicated cohesion of 70 kPa with a 13° friction angle.

There are no records of caprock in Unit 2 but there is indication of some ferruginous material in places.

The thickness of Unit 2 is quite consistent with an average of 11m and a range from 7m to 15m.

Unit 3 – Tertiary Clay: This horizon has a fairly uniform gamma response with an overall average count of 80, although in more detail up to three different layers can be differentiated and correlated. Descriptions of this horizon are variable but predominantly record pale grey to cream with orange, red or red-brown mottling, which is typical colouring for Tertiary clay, however the composition is given as sandy claystone, siltstone or clayey sandstone rather than the pure claystone of the Tertiary from elsewhere. The high sand content is thus unusual and seems to be a characteristic of the Codrilla area.

Weathered ironstone bands or nodules are also present in the unit, together with gravel horizons as described above. In some cases the gravel can be taken as marking the base of the unit, but elsewhere the demarcation of the base is less obvious and more subjective to interpret. Identification of the Tertiary/Permian boundary is difficult at the best of times, particularly where there is Tertiary clay overlying fine grained Permian rock that has been completely weathered to clay. Even in fully cored boreholes the boundary cannot be resolved in these cases to within +2m.

This is also the case with the fully cored holes at Codrilla. Borehole CX0714FC and CX3106FC both recorded basal gravel layers, and CX0417FC showed a colour change from the diagnostic mottled red and grey to orange and grey close to the interpreted level, but CX0701FC, CX0732FC, CX3115FC, CX3122FC and CX3127FC showed no differentiation. Given the subjective nature of the interpretation and the possible variations, it is suggested that the base of Unit 3 can be taken as a first estimate only for the base of Tertiary.

Unit 3 can be summarised as a very stiff sandy clay or very weak sandy claystone, of low to intermediate plasticity. Test results were reasonably consistent for the most part, giving an average liquid limit of 33% and an average plasticity index of 16%. One sample gave values of 62% and 45% respectively for liquid limit and plasticity index, more indicative of the high plasticity that normally typifies the Tertiary clay. Triaxial tests indicated an average cohesion of 49 kPa with a 300 friction angle.

The thickness of Unit 3 is not uniform but varies between 8.5m to 39.8m, the thickness presumably being governed by variations in the pre Tertiary topography. Figure 6-2 shows the depth to the base of Unit 3, that is the presumed base of Tertiary. This shows the Tertiary to be generally between 30m and 40m thick with a 60m deep channel running south-southeast across the nose of the syncline.

Unit 4 – Weathered Permian Clay: This represents the highly to completely weathered upper section of the Permian weathering zone. The thickness of the unit was picked from a uniform gamma log –indicative of clay – and the chip descriptions, but the base of the unit is subjective. The material is very weak sandy claystone or clayey sandstone for the most part, weathered to the consistency of very stiff to hard clay.

The colours are generally orange grey to orange brown without the red or weathered ironstone of Unit 3. In some cases coal seams have been identified within the unit.

One traditional diagnostic for differentiating between the Tertiary and the weathered Permian is the lack of any bedding in the former. In the lack of other evidence, the onset of discernable bedding is normally taken the start of the Permian. As can be seen in Figure 6-1, the onset of bedding observed in the cored boreholes occurs at or within Unit 4.

Tests on Unit 4 samples were consistent showing borderline intermediate to high plasticity, with an average liquid limit of 51% and an average plasticity index of 21%.

Unit 4 has an average thickness of 17.7m with a range from 7.0m to 30.0m. There appears to be a trend in the thickness with thinner values, between 10m and 15m, along the western limb and values between 20m and 25m elsewhere, however there are individual variations.

Unit 5 – Weathered Permian Rock: This unit represents the lower part of the weathering zone down to the base of weathering but for the most part comprises with rock in the highly to moderately weathered category. A main feature of this unit is that the bedding is well developed together with any intraformational shear planes. The base of Unit 5, as mentioned above was picked systematically from the density log but is in close agreement with the estimate from chip and core logging.

Unit 5 has a variable thickness, from 7.2m to 33.3m with an overall average of 17.2m. In general there is a similar trend to Unit 4 with thinner values along the western limb and thicker values in the nose of the syncline. Individual variations are possibly due to the difficulty in picking the base of Unit 4 or 5.

Figure 6-3 shows the depth to the base of Unit 5, which is effectively the base of weathering. This shows a similar pattern to the Tertiary thickness contour plot (Figure 6-2) with a deep channel running south-southeast across the nose of the syncline reaching a maximum depth of 98.2m. Away from the channel the depth of weathering is generally between 60m and 75m.

Isopachs of the difference between the base of Unit 3 and the base of Unit 5, which represents the depth of the Permian weathering zone are presented in Figure 6-4. This shows a thickness of between 25m and 35m on the western limb and 35m to 45m elsewhere. The overall average for the Permian weathering values is 35m; the maximum was 52.7m in CX0719 located in the channel area. CX0652 had an anomalously low value at 18.8m as indicated from the lithology and density logs but the caliper suggests that consistently stronger strata is not recorded until 66.8m, which would give a weathering thickness of 31.6m.

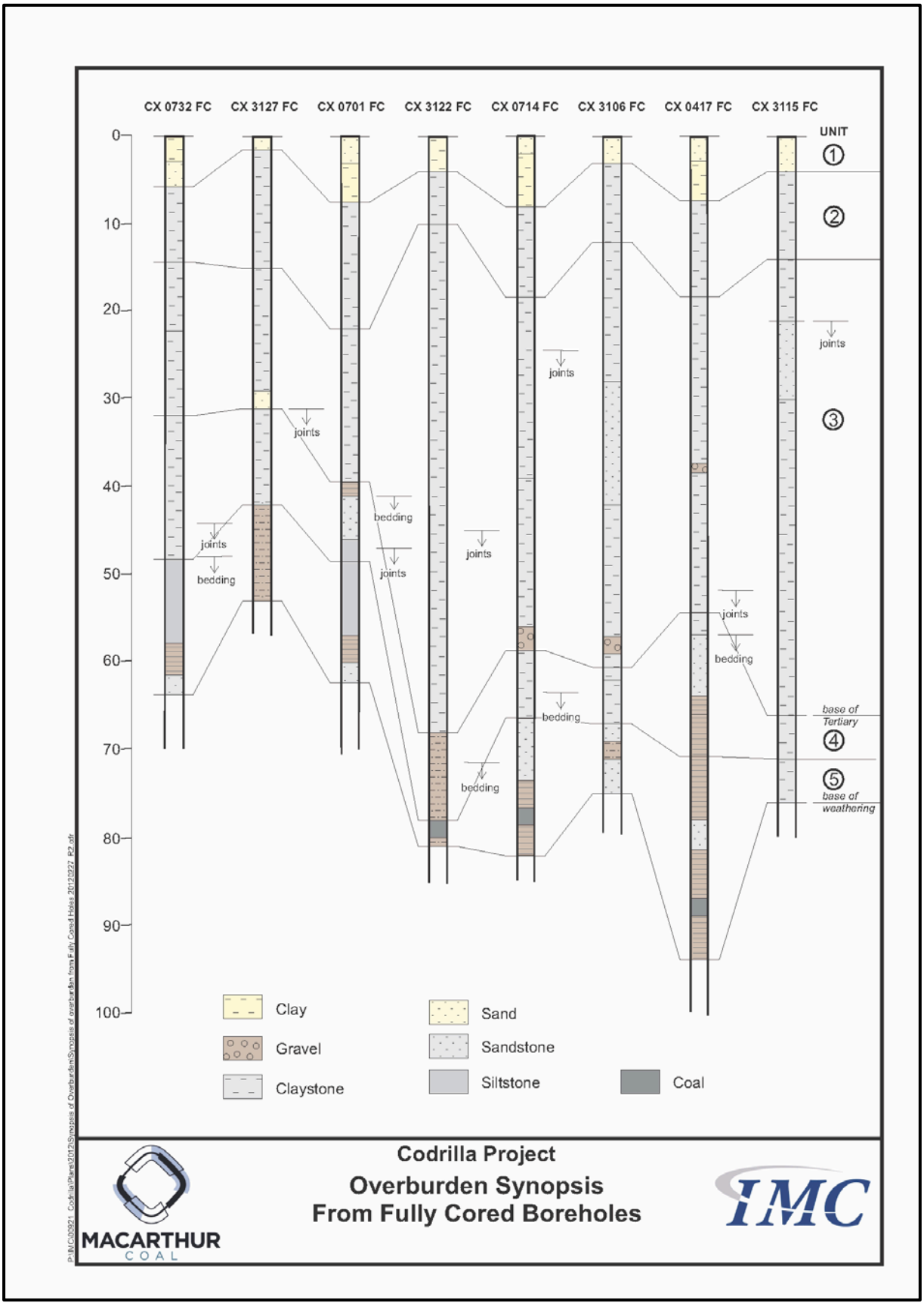


Figure 6-1 : Synopsis of Overburden from Fully Cored Boreholes

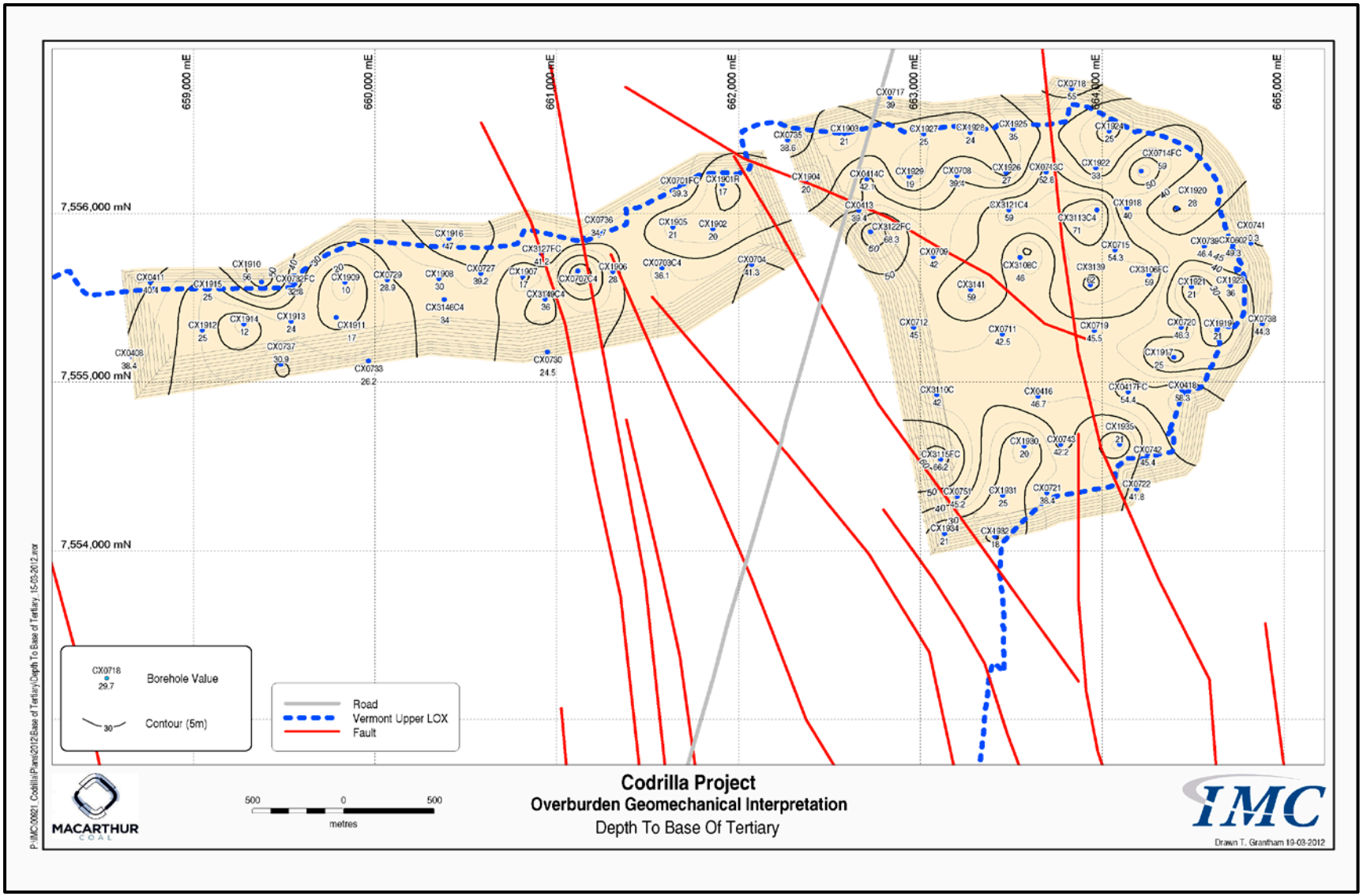


Figure 6-2: Depth to Base of Tertiary

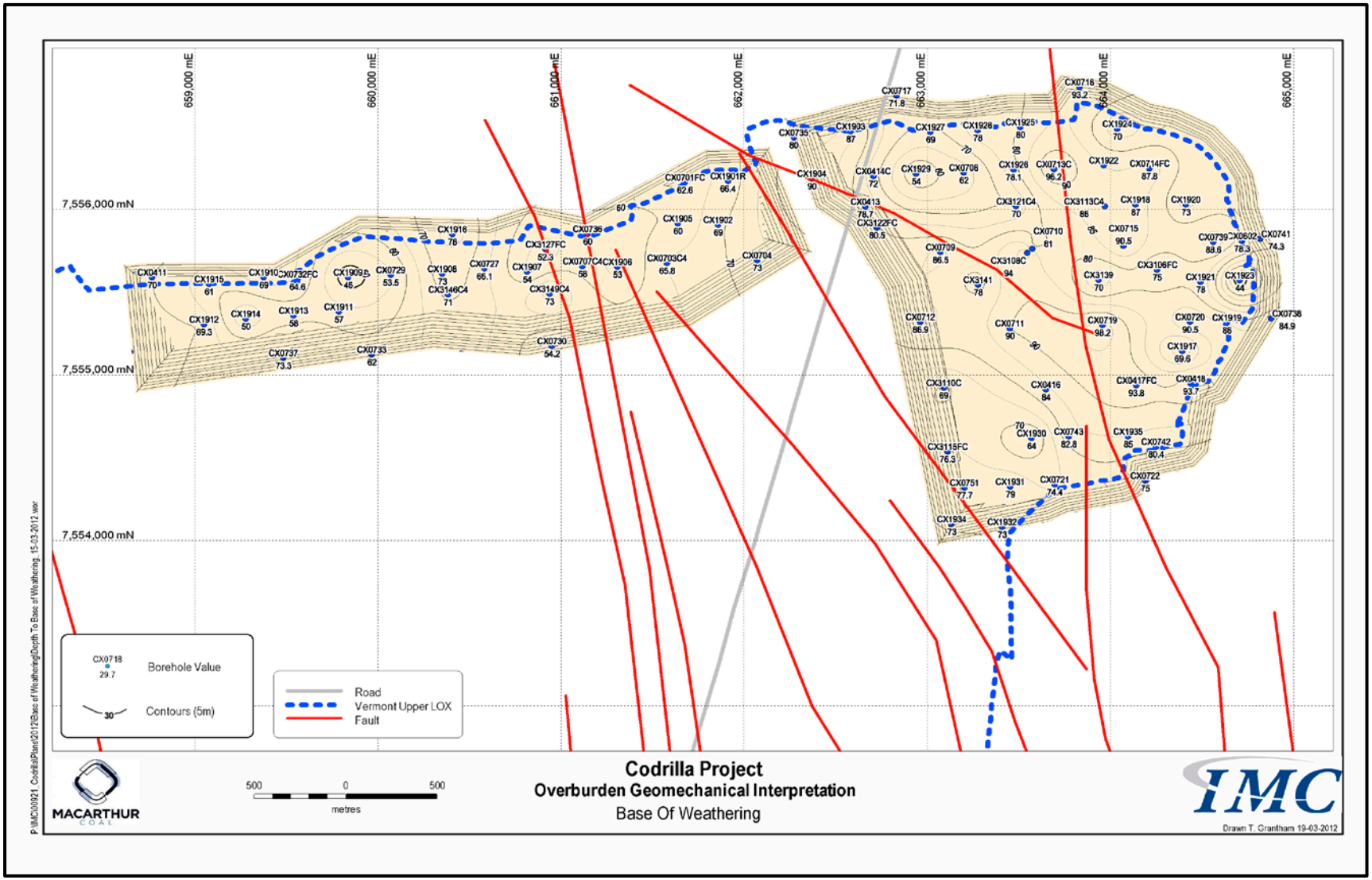


Figure 6-3: Depth to Base of Weathering

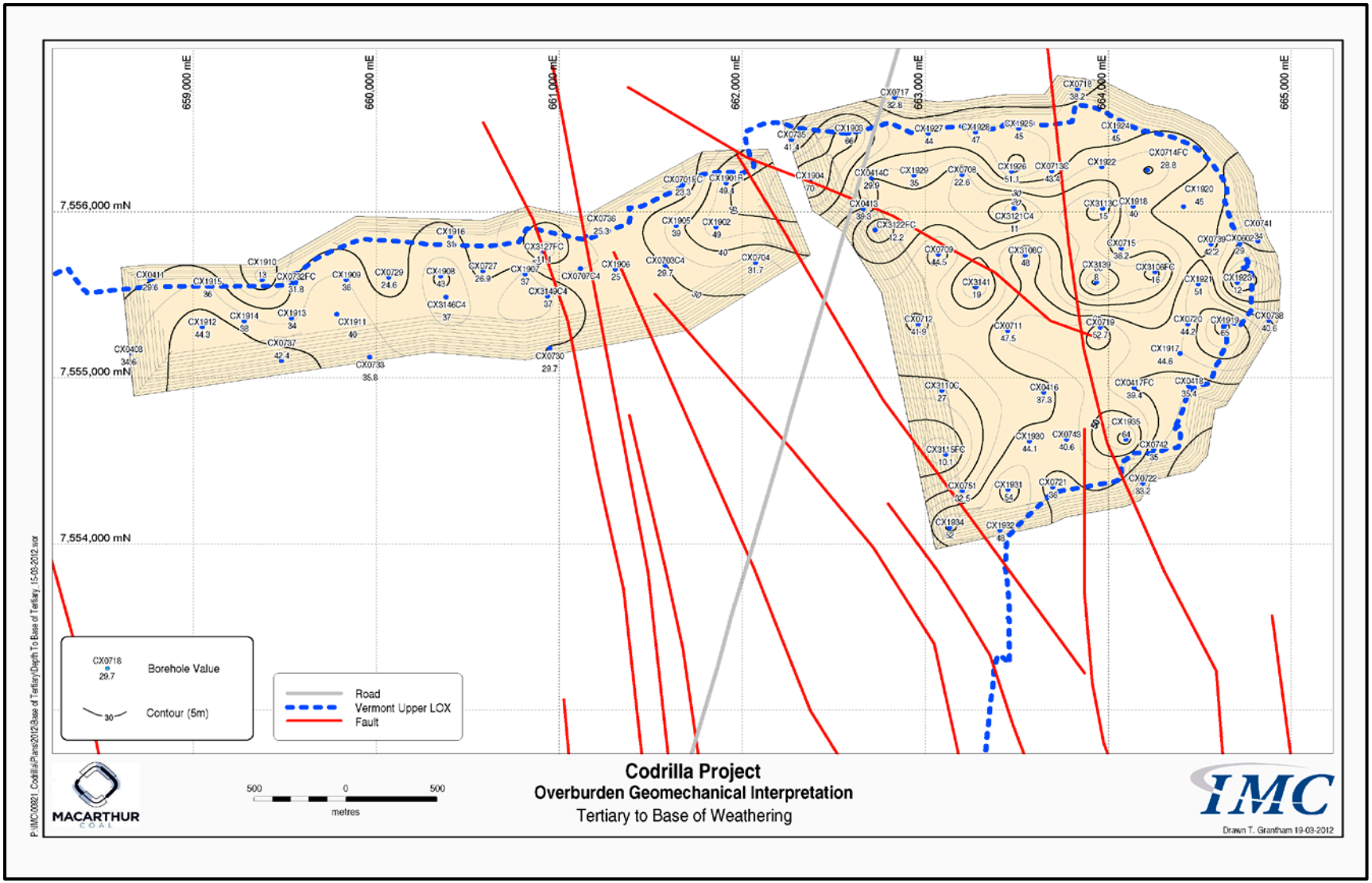


Figure 6-4: Tertiary to Base of Weathering

6.2 Interburden

Interburden in this section refers to all rock material below the base of weathering, even though it is still technically overburden, in order to differentiate it from the soft overburden described in the preceding section. As can be seen in Figure 5-2 and Figure 5-3 from Section 5, the rock interburden is dipping hence the stratigraphic content varies with depth, as opposed to the soft overburden which is essentially horizontally disposed.

The interburden strata above the VU Seam are mostly fine grained, either siltstone or laminite (thinly interbedded fine sandstone and siltstone), except for the upper part of the LL1 to LL2 Seam interval, where fine to medium laminated sandstone are present. Below the VU the strata are predominantly laminated fine to medium sandstone. No bodies of massive sandstone have been identified in the interburden sequence.

Representative interburden sections showing the coal seams and the intervals between are presented in Figure 6-1.

The LU and LL1 Seam are quite consistent with an average thickness of 1.1m each, with a range from 0.55m to 1.60m. The interval between them is 14.5m on average with a range generally between 7m and 20m, with one extreme value of 29.8m. The interburden is mostly laminite with fine to medium sandstone predominating where the interval is thicker. Being the highest seam in the sequence, the LU was only intercepted in the deeper holes so that data points are more limited (24% of boreholes).

The LL2 Seam is more variable, with a thickness generally between 1.0m and 2.5m, with a maximum thickness of 5.84m in CX0700, which is clearly anomalous and may be due to tectonic rather than geological thickening. The LL1 Seam to LL2 Seam interval is 36m on average with a range from 25.1m to 53.4m. Descriptions of the interburden include siltstone, laminite, fine sandstone and fine to medium sandstone. From the logs, there is a general indication that the upper part is sandstone and the lower part finer grained, possibly sandstone or laminite.

The LL2 Seam to VU Seam interval is fairly consistent with an average thickness of 27m. Lithological descriptions of this interval range from siltstone, through laminite to sandstone, but the majority would tend to favour laminite as the major component.

The LL3 Seam is generally not present within the mining area.

At the time of report completion, there was no systematic data on rock strength available, other than one full sonic log through the interburden in CX0101 and some sonic coverage in the fully cored boreholes. The sonic log can be used to provide an estimate of rock strength, which is normally based on a site specific UCS-sonic relationship. A specific formula has not been developed for Codrilla; however a first approximation can be derived from the downhole sonic velocity logs using the Capcoal standard formula for German Creek Mines, which is applicable to the Rangal Coal Measures:

$$UCS = 3330e^{-0.0499t}$$

where UCS is the unconfined compressive strength in MPa and t is the sonic transit time in µsec/ft.

This gives the following estimates from the CX0101 log as shown in Table 6-2.

Table 6-2: Estimated Interburden Strength

Interval	Lithology	Sonic Velocity (m/sec)	Transit Time (µsec/ft)	UCS (MPa)
above LU	siltstone	4000	76	74.3
LU - LL1	sandstone fm	3900	78	67.4
LL1 - LL2	sandstone fm	4000	76	74.3
	siltstone	3600	85	48.7
LL2 - LL3	siltstone	3100	98	24.6
	sandstone	3500	87	43.2
LL3 - VU	sandstone f	3300	92	33.2

Borehole CX101 is a deep hole so that all units are below the base of weathering, the value for the uppermost part starting at a depth of 105m. The table indicates that the upper overburden down to the LL2 Seam is strong with an average UCS of about 77 MPa, which is suspected to be an over-estimate. Below that the interburden strata, both sandstone and siltstone, are moderately strong, in the 25 to 50 MPa range.

Several tests were made on samples from the weathered zone (Unit 5) and these gave UCS values from 2.0 to 9.5 MPa. Two samples of unweathered rock from the deepest fully cored borehole, CX0417FC2, gave UCS values of 8.3 and 25.4 respectively for siltstone and sandstone.

6.3 Floor Conditions

The VU Seam is the principal target seam and will form the mining floor in the opencut pit. Consequently the VU Seam floor has been examined in some detail. The overlying lessser seams would be mined as transient parting operations and hence floor conditions for individual upper seams have not been addressed. The floor sequence for the VU Seam is illustrated in the representative section shown in Figure 6-6.

The Yarrabee Tuff (YT) forms the base of the VU Seam mining. The YT is a pale brown fine tuff, the upper part of which is usually re-worked with carbonaceous material. The upper part is frequently identified as a separate lithological unit in the borehole logs but in the context of this report the YT refers to the full or composite thickness of tuffaceous material. The YT section has an average thickness of 0.5m with a range from 0.2m to 0.8m.

The nature of the YT is normally quite variable, ranging from hard and brittle to soft and puggy, generally with a high slaking potential. It is also known to contain slickensided discontinuities or polished bedding partings. Soil classification tests indicated clay of intermediate plasticity.

The YT is underlain by the 0.5m thick VL1 Seam. This is a dirty coal with tuff bands and is not normally considered to be economic for mining. The VL1 Seam varies in thickness up to 1.0m and in some cases thins out altogether. It is usually associated with bedding plane shearing on the tuff bands.

A sequence of three geomechanical units of increasing strength and competence were interpreted in the stone floor below the VL1 Seam. These units have been termed FL1, FL2 and FL3 as indicated in Figure 6-6. The interpretation was based on the gamma log and lithological descriptions and all available logs were examined and interpreted.

Unit FL1 is the immediate floor and is typically a weak to moderately weak carbonaceous mudstone or siltstone, sometimes with coal bands. The top may be transitional from the stony coal of the VL1 Seam. It is relatively thin ranging from 0.2m to 1.0m.

Unit FL1 grades down into the laminated siltstone of Unit FL2, which has a highly variable thickness ranging from 0.7m to 6.2m. The indication from the sonic log in CX0101 is that the strength of this unit increases from top to base.

Below this is a more massive and consistent medium sandstone that constitutes Unit FL3. In fully penetrating boreholes this sandstone is some 25m to 40m and virtually makes up the entire VL1 Seam to VL2 Seam interval.

Interpretation of the sonic log for CX0101 gives the following estimate of strength for the floor units as shown in Table 6-3.

Table 6-3 : Estimated Floor Unit Strength

Interval	Lithology	Sonic Velocity (m/sec)	Transit Time (µsec/ft)	UCS (MPa)
FL1	carb siltstone	2900	105	17.6
FL2	siltstone	3200	95	28.7
FL3	sandstone fm	4200	73	89.1

These should be taken as top of the range strength estimates for unweathered rock. The sonic strengths from CX0714FC were 3.3 MPa for FL1, 7.6 MPa for FL2 and 28.7 MPa for FL3; CX0732FC gave a sonic strength of 33.2 MPa for FL3.

Laboratory testing on floor samples indicated a UCS value of 9.9 MPa for Unit FL1; with an average slake durability of 75.7%, ranging from 29.4% to 96.3%. Other tests were on weathered samples and these showed a reduction in strength to around 2.5 MPa for all three floor units, with a corresponding reduction in durability to 22.5% on average.

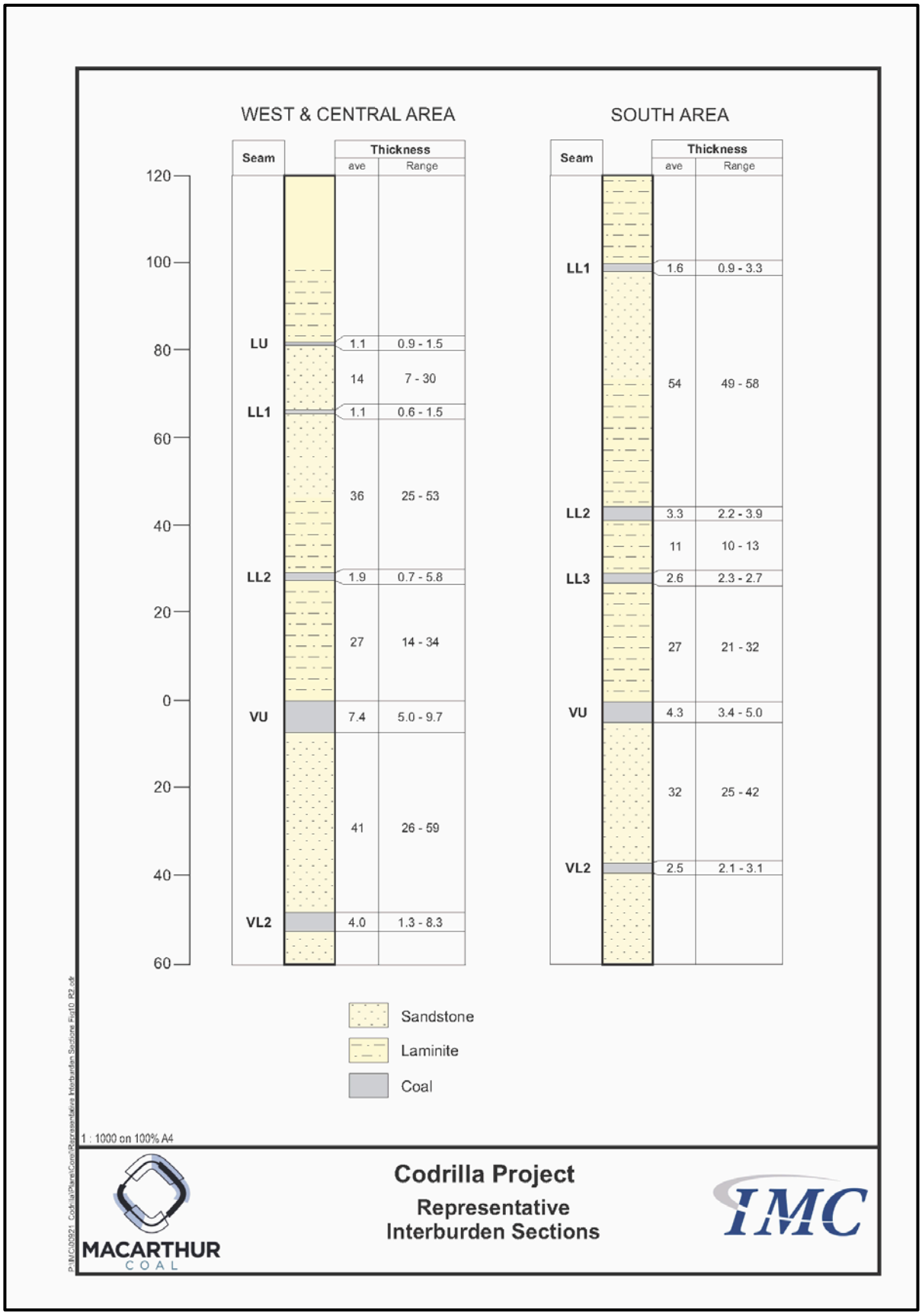


Figure 6-5: Representative Interburden Sections

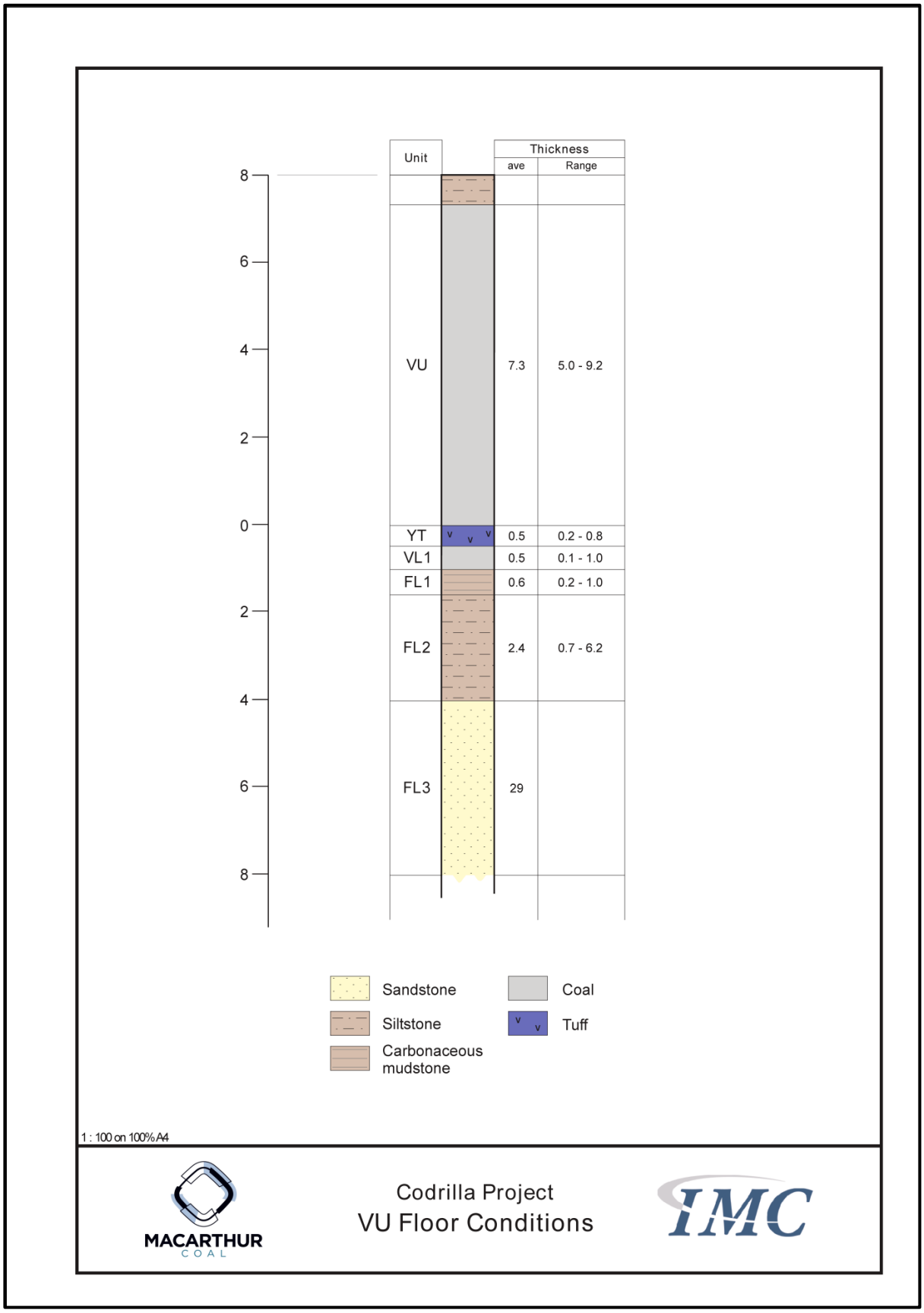


Figure 6-6: VU Floor Conditions

7 HYDROGEOLOGY

No further groundwater evaluation was made for the deeper formations as part of this assessment.

A pebble conglomerate layer was identified at the base of the Tertiary clay. This unit comprised an intermediate plasticity clayey gravel, with sub-rounded to rounded clasts. Whilst not continuous across the site, the material was identified in several boreholes. The unit may represent a high energy flowing paleo-channel, and may form a system of discontinuous confined aquifers or semi-confined aquifer lenses.

From a mining perspective, where this unit is encountered, the potential for groundwater emissions is possible and would require further assessment to evaluate the potential pit inflows, but also there is the potential for the material to undercut the lower benches should the material be partially saturated.

8 ACOUSTIC SCANNER INTERPRETATION (ATV) AND PROCESS

8.1 ATV Interpretation Process

WellCAD files were provided by Weatherford, and number of steps was required to interpret discontinuities within the borehole sidewall. These are summarised as follows:

1) Following the application of Quality Control processes and conversions, discontinuities were interpreted as "picks" through sinusoid positioning and shaping on structural projection logs using WellCAD software features. The categories used for interpretation are as defined by discrete allocated colours in WellCAD. It should be noted that these features are interpreted as they appear, in magnetic north and representing an apparent dip;

2) On completion of the interpretation for each relevant strata section, structure logs are converted from apparent to true dip, with a further stage involving conversion from magnetic to true north through rotation of the structure logs by +9°;

3) The structure legend shown in Figure 8-1 was used to identify discontinuity types as defined by colour and shape;

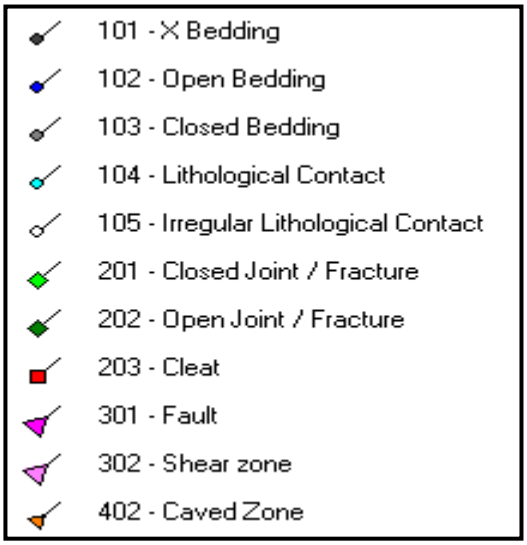


Figure 8-1: IMC Structure Dictionary

4) Borehole breakout is generally determined through assessment of both amplitude and travel time. The borehole image is presented in magnetic north and the borehole breakout interpretation (value) therefore requires rotation by +9° to obtain the breakout relative to True North. The Principal Major Horizontal Stress orientation (σ^{H1}) is interpreted in all cases at 90° to the borehole breakout; and

5) Compositing of interpreted structures into a database format and the production of stereonet plots, including pole projection diagrams and rose plots. This was particularly useful for bedding, joint and cleat orientations, and also the general analysis of discontinuity trends in the context of mining impacts.

8.2 Site Overview

The acoustic scanner (ATV) interpretation was completed to establish background structural patterns across the site, which would be an important component for the kinematic analysis. A total of five boreholes from the East Pit were available for ATV interpretation. A plan showing the ATV borehole locations are presented in Figure 8-2. No ATV information was available for the West Pit at this stage.

8.3 Limitations

The limitations of interpreting geological structures using the ATV method are that it provides no indication of the persistence of the structure/discontinuity. The only method that can be employed to fully understand structural persistence is by routine geotechnical mapping during operations and incorporation of this information into a database. This can then identify the structures which may have the potential to lead to slope instability. Similarly, information pertaining to the planarity of the discontinuities or groundwater interaction, which may increase the potential for geotechnical hazards, is not known either. During core logging, faults may be identified by surfaces with movement features such as slickensides, gouge infill or zones of brecciation. Cross referencing against core was not completed as part of this assessment.

On this basis, the information procured from the ATV interpretation should be used only for preliminary planning purposes and confirmed by core logging and routine bench scale face mapping and assessment during operations.

A number of boreholes had only partial ATV data for interpretation. The ATV sondes are only operational in a borehole fluid, usually water. Table 8-1 shows the depth interval for each borehole available for interpretation.

Table 8-1 : Depth Intervals for Interpretation Based On Available Boreholes

Borehole No.	From (m)	To (m)
CX0711C	83.4	164.3
CX3106FCR	80.0	180.2
CX3108C	95.2	161.0
CX3109C	73.8	115.3
CX3115FC	78.0	171.0

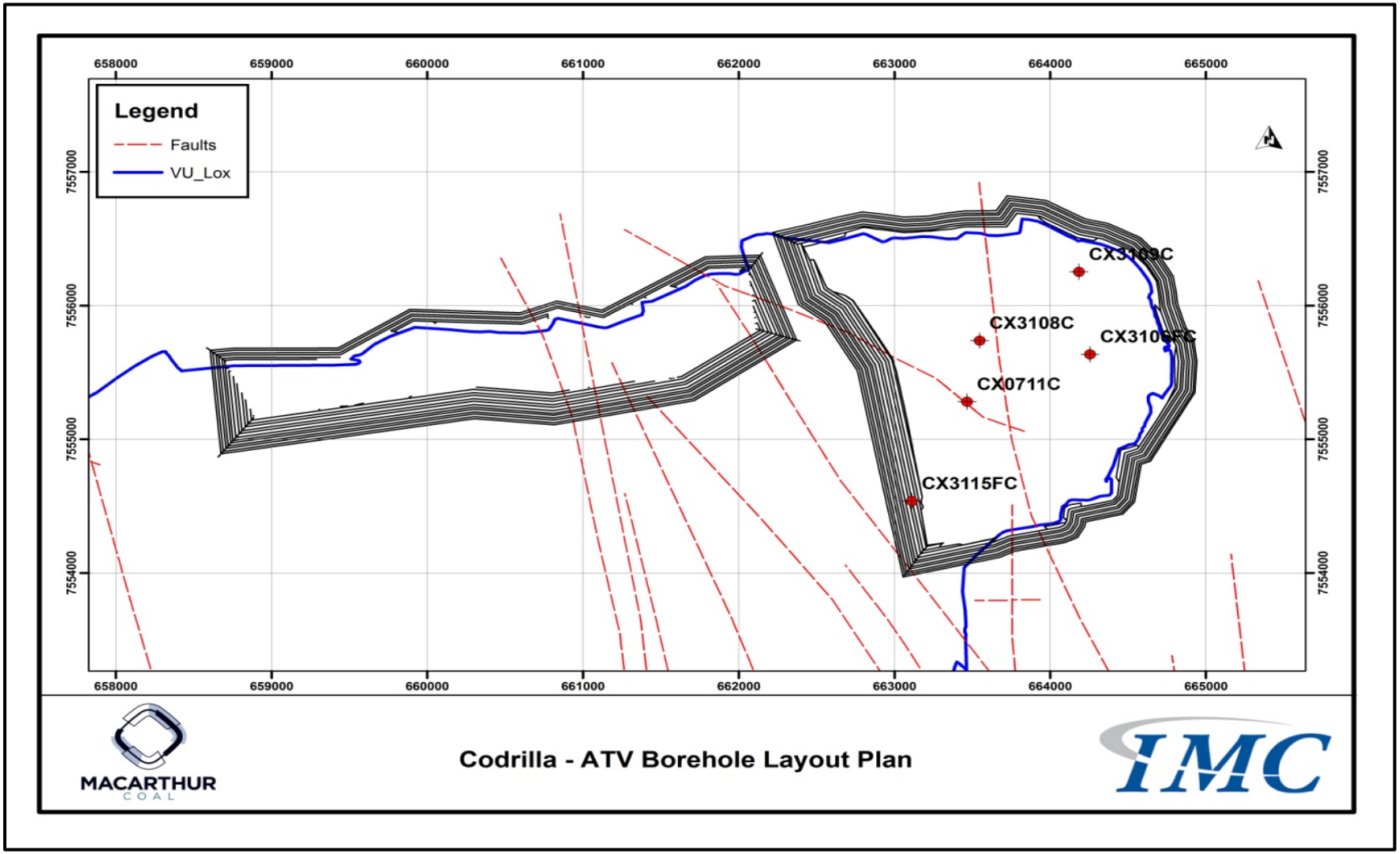


Figure 8-2: ATV Borehole Location Plan

8.4 Classification of Discontinuities

In the context of this assessment, it was considered sensible to limit interpretation to structures that were important from a geotechnical perspective and could be tied in, to some extent, with interpreted features from geotechnical logging.

For the interpretation the classification of discontinuities were simplified into 4 main categories:

- **Bedding**: Generally low angle 0° - 25° features representing either a closed bedding or open plane. These discontinuity picks are represented by solid grey or dark blue lines illustrated in Figure 8-3;
- **Lithological Contacts**: Distinct contact between two major lithology types usually representing a plane of weakness. These discontinuity picks are represented by solid cyan coloured lines as illustrated in Figure 8-3;
- **Joints:** Classified as discontinuities at increased angles relative to bedding partings which are presumed to be continuous across the hole, with no indication that the feature is open, but still represents a weakness plane. As mentioned in Section 8.3, it is difficult to differentiate between joints and tightly bound faults by ATV interpretation; therefore these definitions were grouped collectively as "joints". The joints can either be closed or open and are represented by solid light and dark green lines as illustrated in Figure 8-4; and
- **Fault/Shear Zones:** This is a general description which represents possible structural anomalies that can be interpreted by a caliper deflection, decrease in density and an increase in gamma response associated with possible clay infilling. This feature was often observed at coal/rock interfaces, and may also be associated with shearing/faulting along weaker coal/rock contacts or within weak strata. Interpreted shear/fault zones could also be identified where intervals of high joint/defect density (joint swarm) are observed (green sinusoids). These discontinuity picks are represented by hatched pink regions as illustrated in Figure 8-4.

Coal cleat was not examined as part of this investigation.

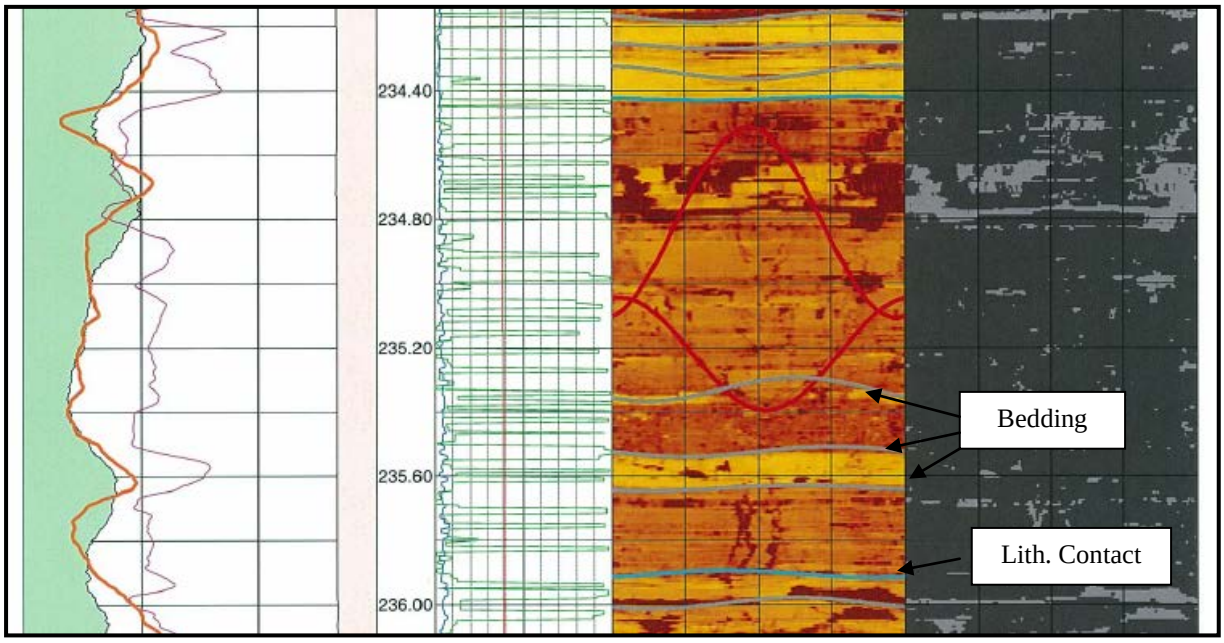


Figure 8-3 : Example of Bedding and Lithological Contact

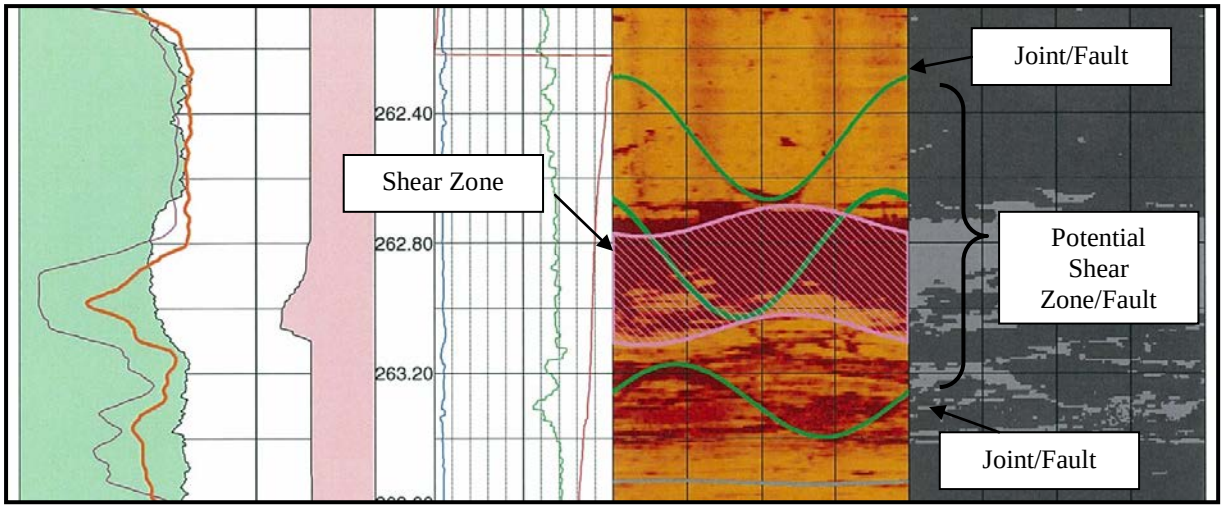


Figure 8-4 : Example of Possible Caved Zone, Shear Zone and Joints

8.5 Considerations for Mine Planning

The potential geotechnical impact of each discontinuity type during operations is controlled by its orientation relative to the pit face. In this context, IMC have broadly defined features based on the following dip categories:

- **Very low angle features** – 0 to 19^0, usually bedding and sheared lithological contacts or caved strata;
- **Low angle features** – 20^0 to 44^0, typically cross bedding structures, bedding influenced by proximal faulting or low angle joints, faults or shears;
- **Moderate angle features** – 45^0 to 69^0, typically joints, faults or shears; and
- **High angle features** – 70^0 to 90^0, typically joints, faults or shears.

The above structure types (Section 8.3) are presented as a series of pole projection diagrams, which allow preferred orientation "clusters" or "sets" to be established relative to true north. This method of presentation allows a mean vector to be applied, giving an average dip and dip direction for the set of structures. This is discussed further in Section 8.5.2.

Structure categories are presented as lower hemisphere equal angle circular plots where the orientation (dip and azimuth) of each feature is represented by a single point (or pole) on the diagram.

8.5.1 In-situ Stress Orientation

In this case, borehole breakout was not observed due to the shallow nature of the deposit; however the inferred principal in-situ stress direction from other Bowen Basin coal deposits in the vicinity of Middlemount/Dysart would be northeast - southwest.

8.5.2 Pole Projection Diagrams

Pole projection diagrams were used to identify the orientation (relative to true north) and dip magnitude (relative to horizontal) of interpreted discontinuities. An example of a pole contours illustrating joint orientation is shown in Figure 8-5.

An interpretation of the general orientations of interpreted sets of features, for each pole projection diagram, is provided for each ATV borehole across the Codrilla project area.

Where there are a high density of structure picks interpreted in a region of a pole projection plot, these are referred to as the "major" set. These can be identified when the contouring function is applied. Where there are additional clusters of interpreted structures, represented by a lower density of picks, these are referred to as "minor" sets or clusters. Each cluster set is determined by a set window which calculates the mean orientation for the set.

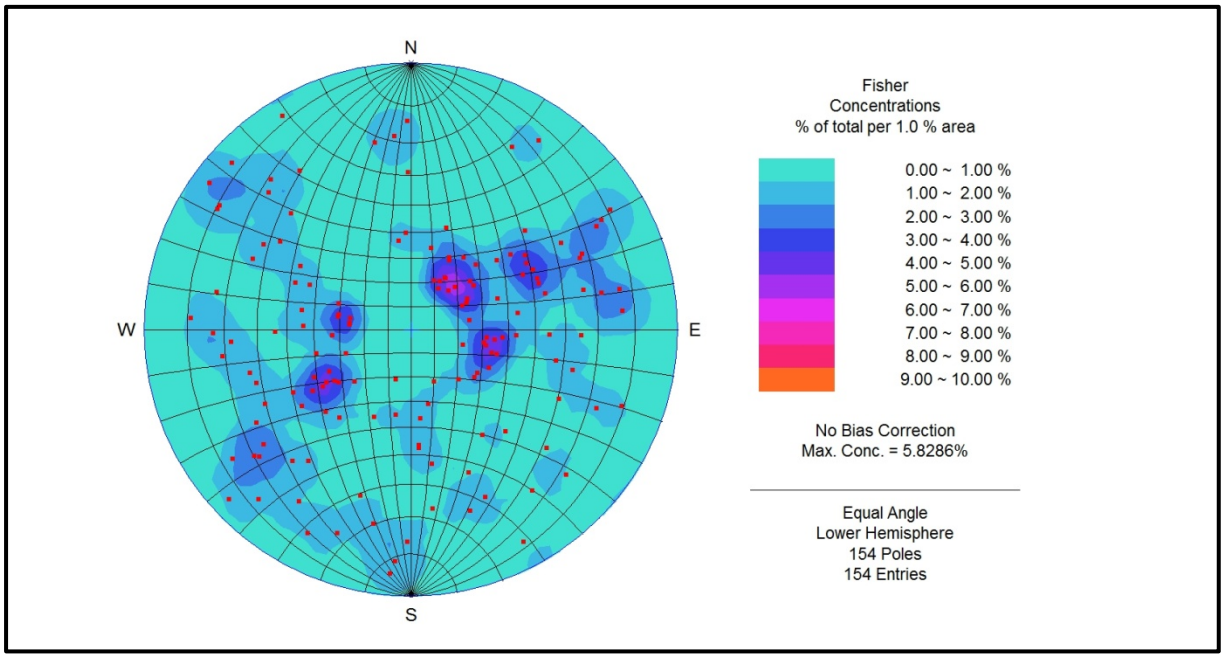


Figure 8-5: Example IMC Interpreted Pole Contours for Joints

8.5.3 Rose Diagrams

Rose diagrams are used to present a directional representation of structures and the frequency of each class in terms of "strike". An example of a rose plot is shown below in Figure 8-6. The rose diagrams allow sets or clusters of planes to be more sharply grouped and visually defined, and often allows for better determination of dominant structure sets, particularly when there is significant structural variability. Rose diagrams are often more intuitive as a means of presenting data, and are particularly suitable for vertical and sub-vertical data sets.

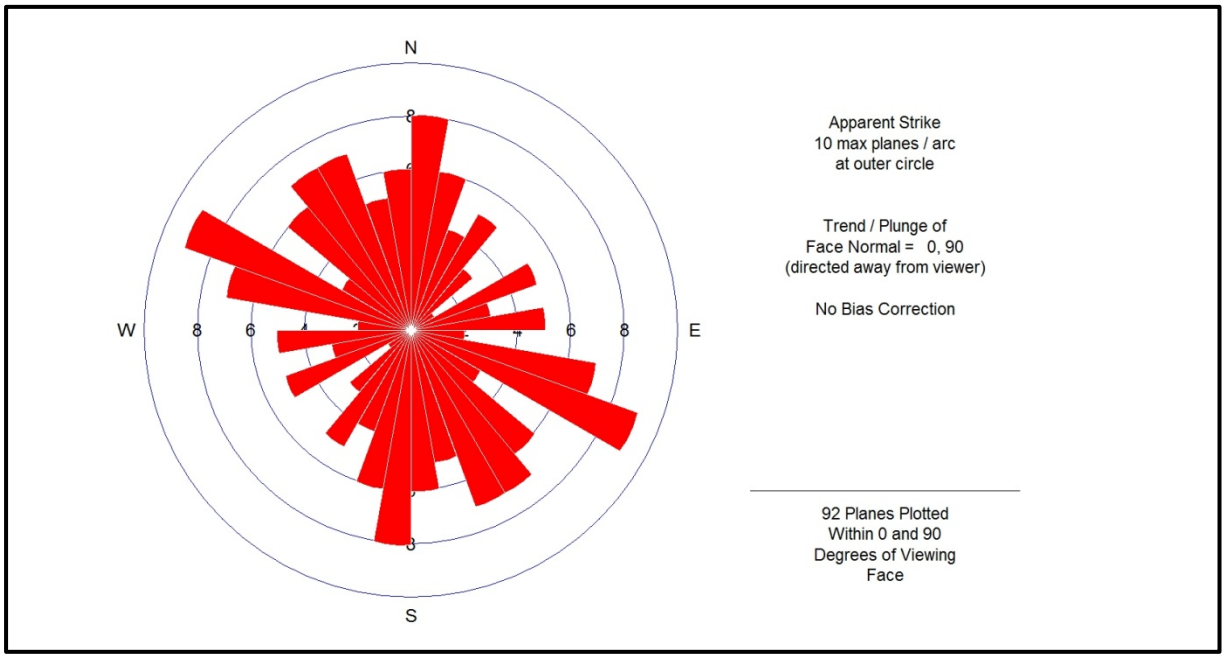


Figure 8-6: Example IMC Interpreted Strike Rose Diagram for Joints

8.5.4 Dip-Azimuth Rose Diagrams

Rose dip-azimuth plots are similar to strike rose plots; however, each "petal" corresponds to the count of planes having their azimuth fall within a particular interval. An example of a dip-azimuth rose diagram is show below in Figure 8-7. These plots are used in this report for bedding, as they give a more intuitive indication of the "downhill" direction for mine planning purposes.

Note that counts of bedding discontinuities for the defined intervals are represented by "open bedding" (category 102) and "closed bedding" (category 103).

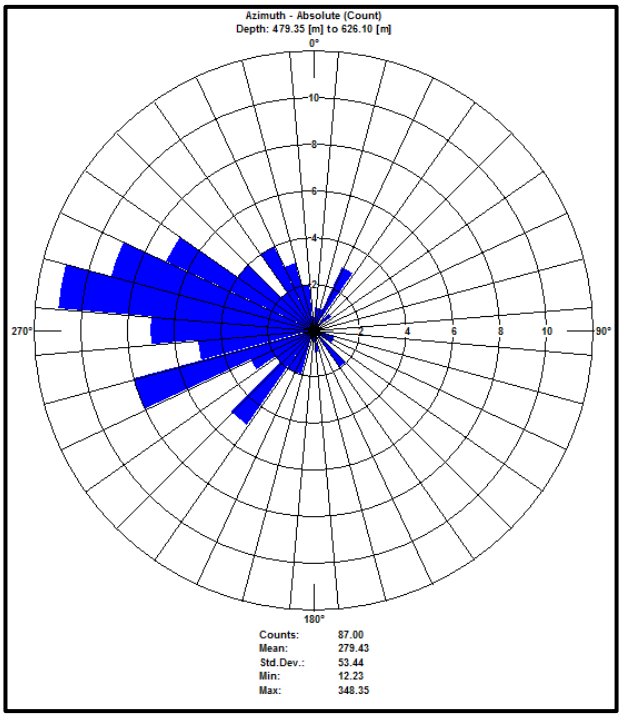


Figure 8-7: Example IMC Dip-Azimuth Rose Diagram for Bedding

8.6 Analysis of Joints

Joints were frequently observed throughout the rock mass, mainly in siltstone and interbedded units. Some of the sandstone units were observed to be massive therefore did not contain discontinuities or defects. At this stage there was no information collected which described the characteristics of the joints, such as planarity and roughness of the joint surfaces.

Table 8-2 presents an analysis of joint planes recorded from the ATV interpretation.

Table 8-2: Recorded Joint Dip Angles

Dip Angle Category (^{0})	Count	Percentage (%)
20 - 39	54	34
40 - 59	36	23
60 - 79	53	34
80 - 90	14	9
Total	157	100

The above table shows the predominant joint dips to be > 40^0, however a significant proportion of joints were recorded at < 40^0. The median dip angle for all joints recorded was approximately 54^0.

Figure 8-2 presents a joint angle frequency histogram, which shows two possible joint categories; one low angle and one moderate to high angle population.

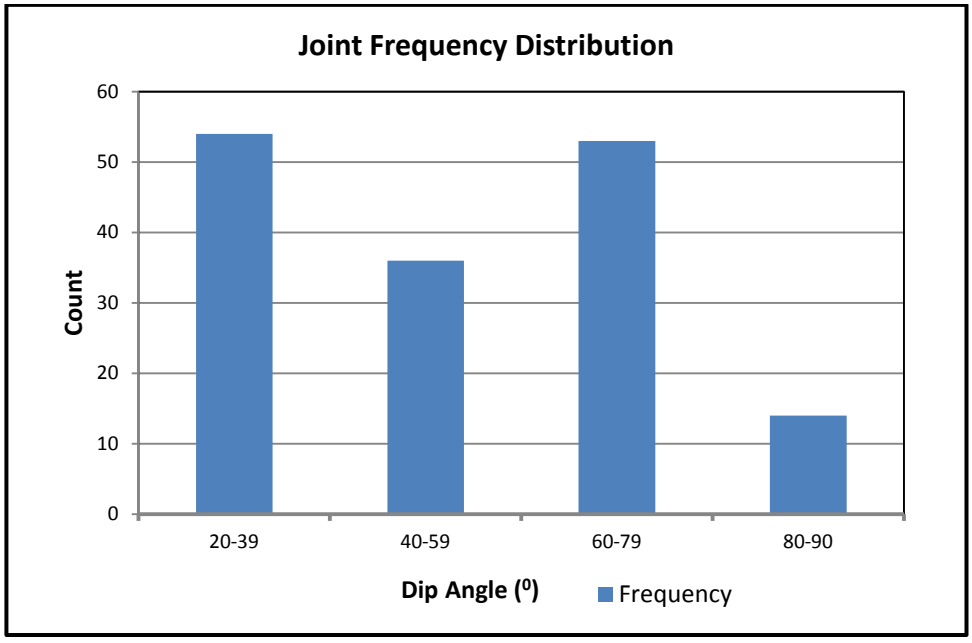


Figure 8-8: Joint Dip Angle Frequency – Codrilla Site

Figure 8-9 and Figure 8-10 shows the pole contours and rose diagram, respectively, for recorded joints across the Codrilla site, where five distinct joint sets were interpreted. The dip and azimuth for each joint set is summarised in Table 8-3.

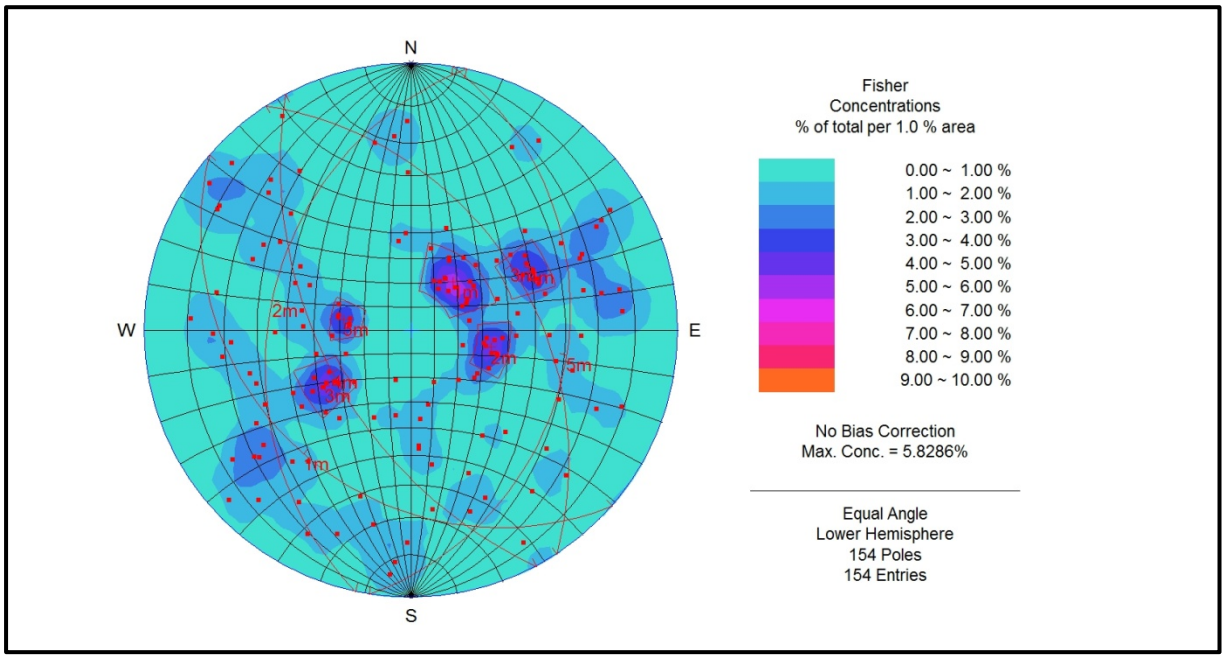


Figure 8-9: Pole Contours for Interpreted Joints – Codrilla Site

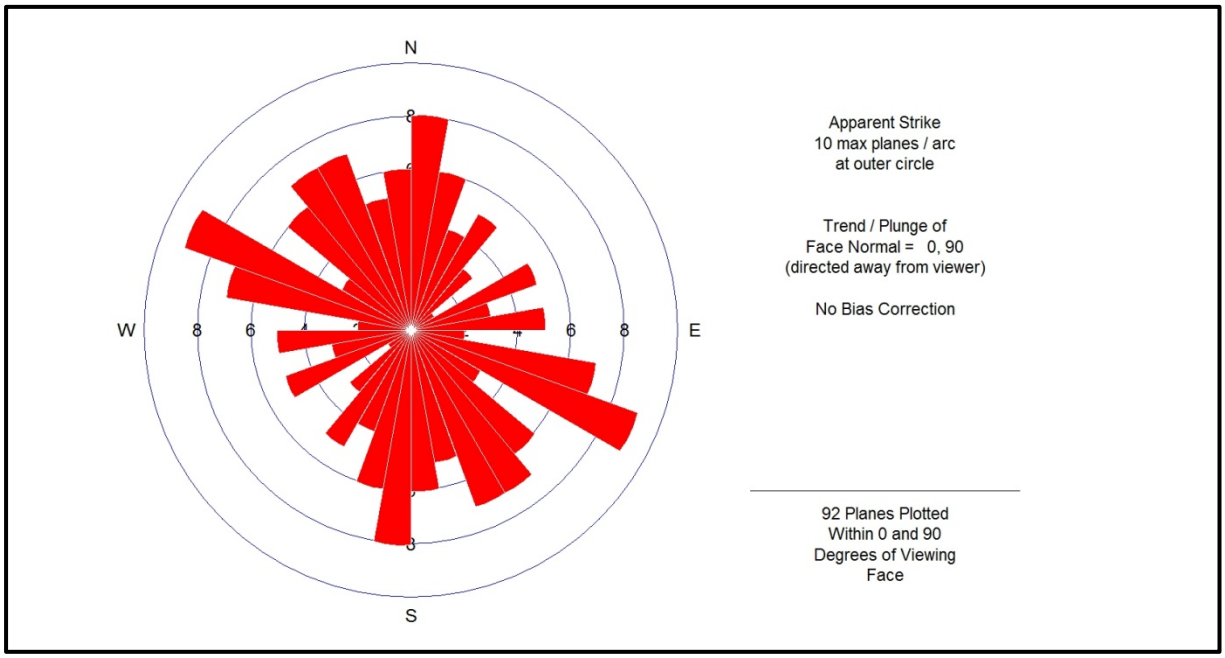


Figure 8-10: Rose Diagram for Interpreted Joints – Codrilla Site

Table 8-3: Mean Joint Set Orientation - Codrilla Site

Set	Mean Dip (^{0})	Mean Dip Direction
1	27	221
2	34	282
3	42	057
4	53	242
5	29	099

Figure 8-11 presents a site plan showing the stereonets of the major joint sets interpreted from each borehole. An analysis of joints for each borehole is presented in Section 8.7.

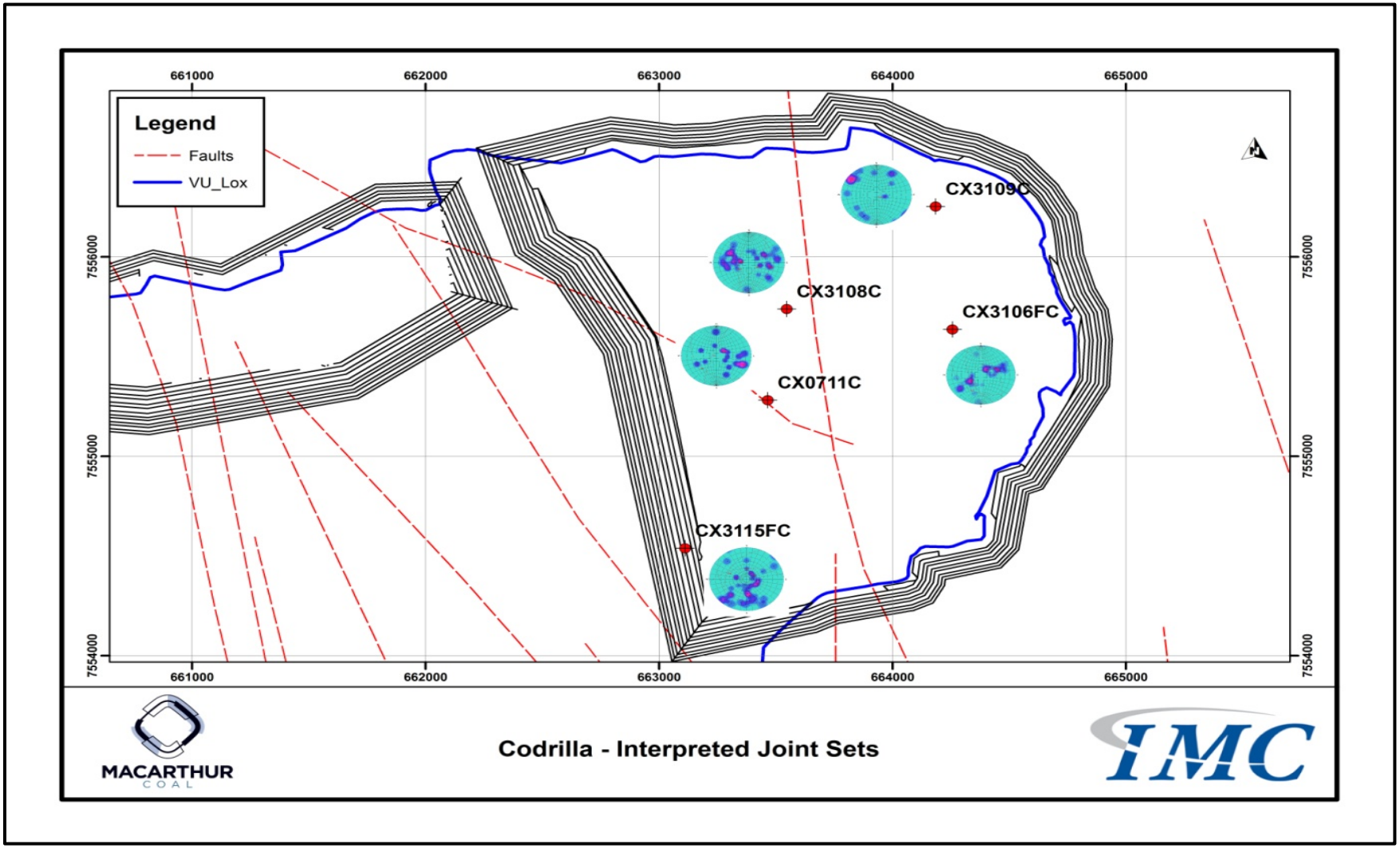


Figure 8-11: Interpreted Joint Sets – Stereonet Layout Plan

8.7 Interpreted Joints – Borehole Analysis

8.7.1 CX0711C – Joints

Borehole CX0711C showed two major joint/defect sets with azimuths toward the west-northwest and southwest, respectively. The southwest dipping set represents a low angle joint set, whilst the northwest dipping set represents a angle angle joint set.

Table 8-4 summarises the main joint set orientations. Figure 8-12 and Figure 8-13 present the pole contour and rose diagrams for borehole CX0711C joints.

Table 8-4: Mean Joint Set Orientation – CX0711C

Set	Dip (^{0})	Dip Direction
1	77	291
2	29	229

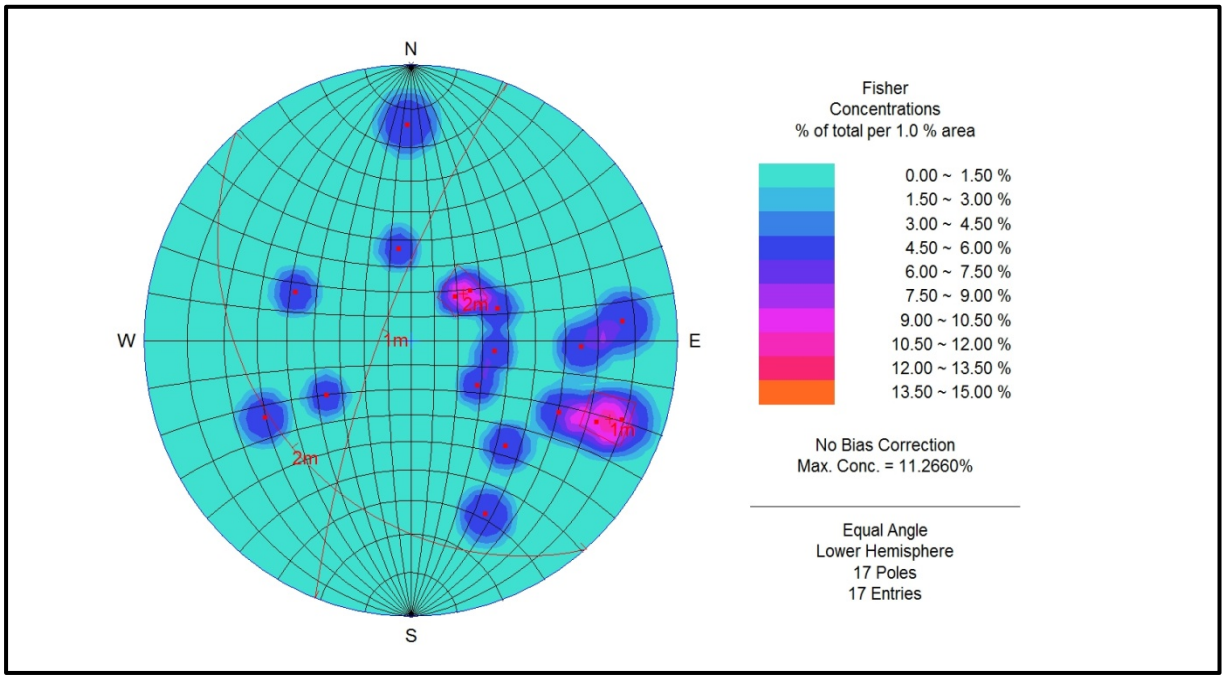


Figure 8-12: Pole Contours for Interpreted Joints – CX0711C

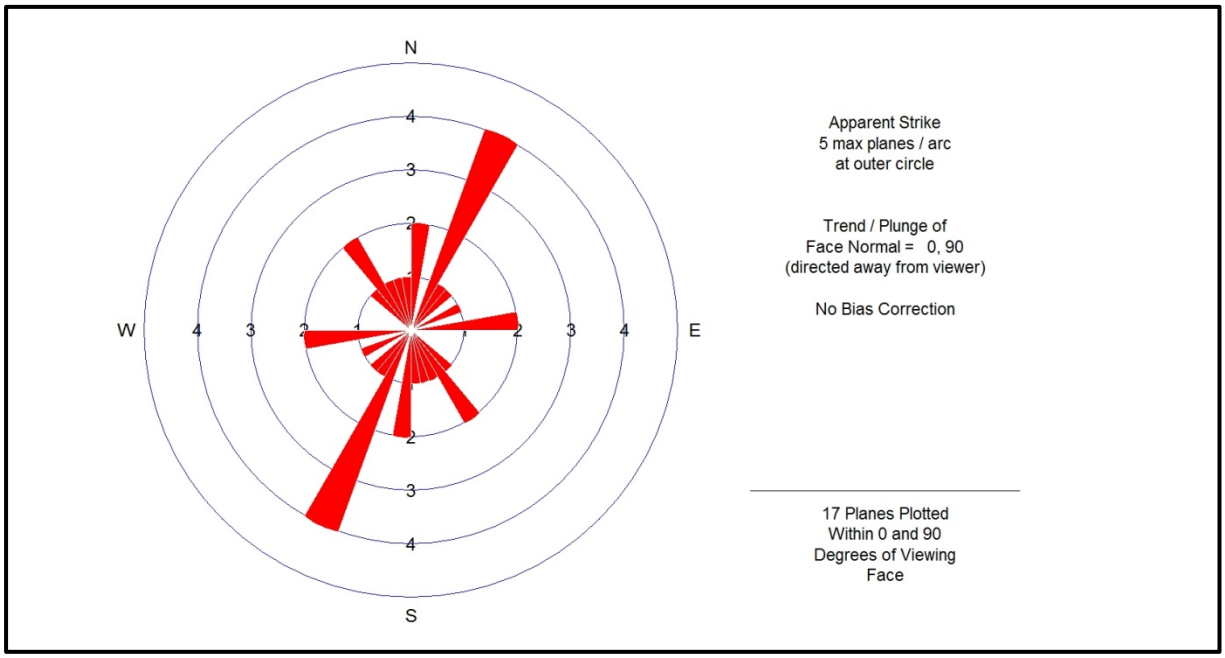


Figure 8-13: Rose Diagram for Interpreted Joints – CX0711C

8.7.2 CX3106FC – Joints

Borehole CX3106FC showed three major low to moderate angle joint sets with azimuths toward the south-southwest, northeast and southwest, respectively.

Table 8-5 summarises the main joint set orientations. Figure 8-14 and Figure 8-15 present the pole contour and rose diagrams for borehole CX3106FC joints.

Table 8-5: Mean Joint Set Orientations – CX3106FC

Set	Dip (^{0})	Dip Direction
1	29	212
2	41	055
3	53	248

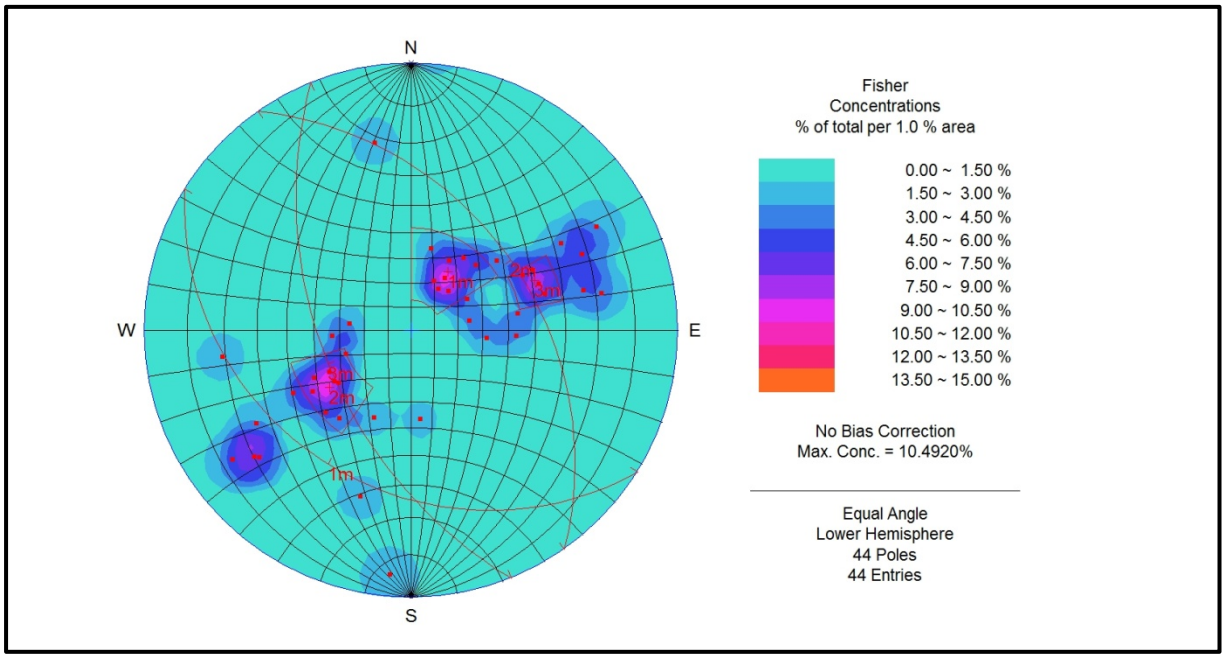


Figure 8-14: Pole Contours for Interpreted Joints – CX3106FCR

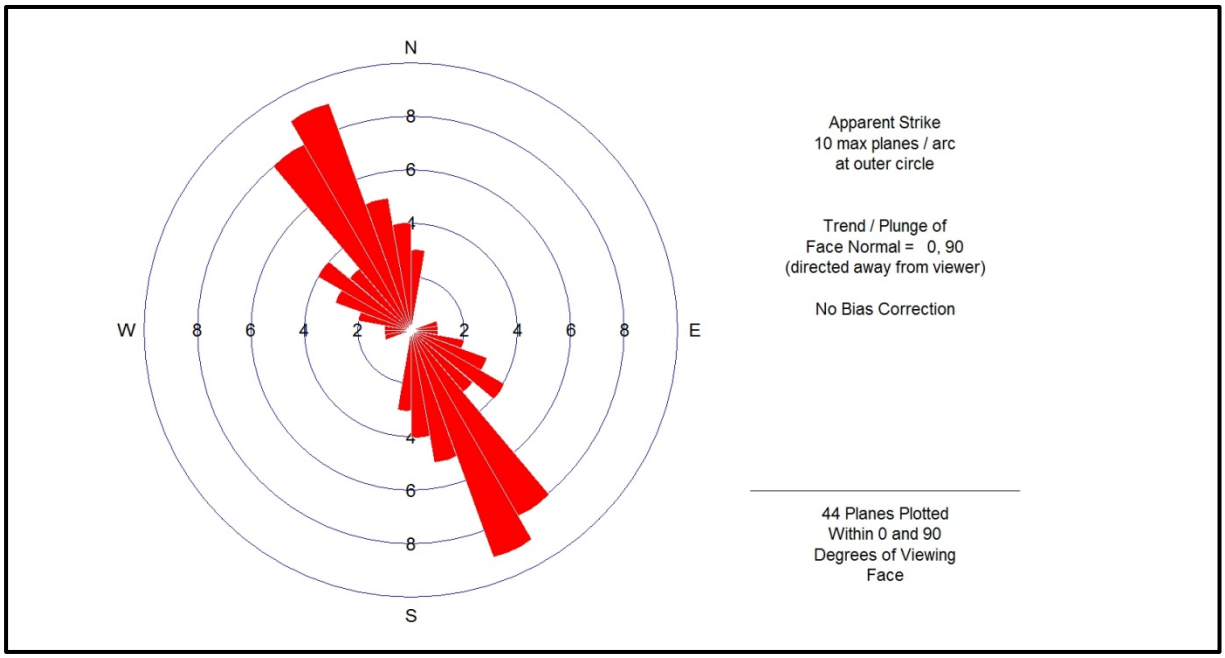


Figure 8-15: Rose Diagram for Interpreted Joints – CX3106FCR

8.7.3 CX3108C – Joints

Borehole CX3108C showed four low to moderate angle joint sets with azimuths toward the southwest, west-northwest, east-southeast and southeast, respectively.

Table 8-6 summarises the main joint set orientations. Figure 8-16 and Figure 8-17 presents the pole contour and rose diagrams for borehole CX3108C joints.

Table 8-6: Mean Joint Set Orientation – CX3108C

Set	Dip (^{0})	Dip Direction
1	52	239
2	59	280
3	28	103
4	64	119

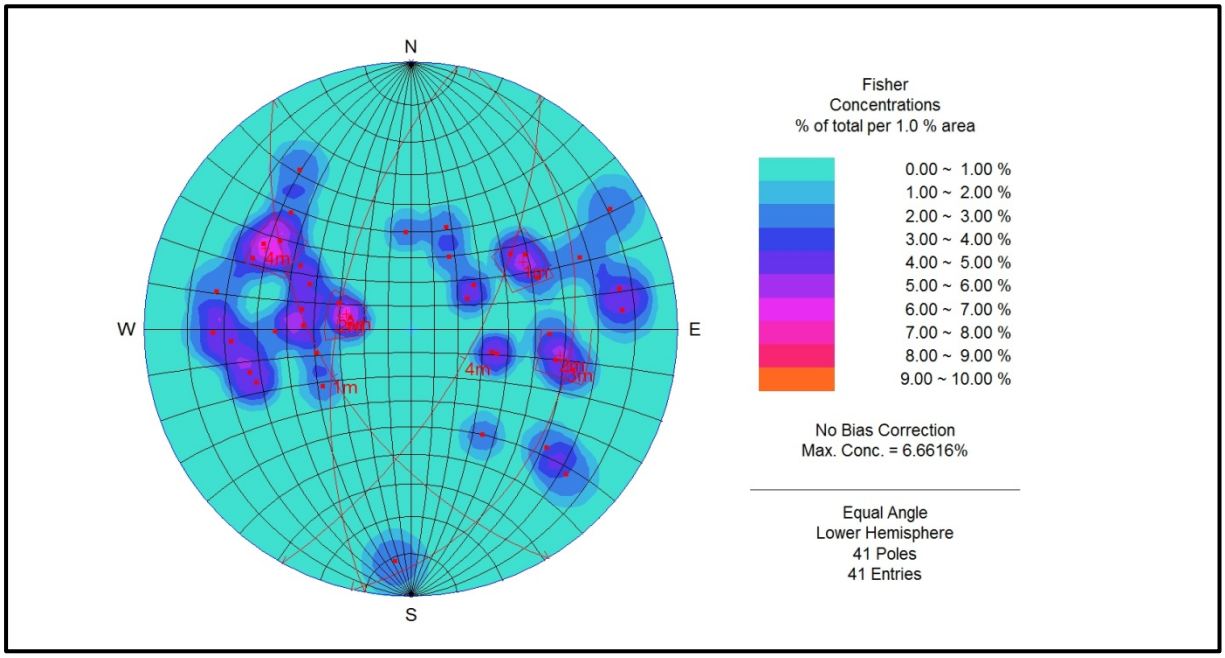


Figure 8-16: Pole Contours for Interpreted Joints – CX3108C

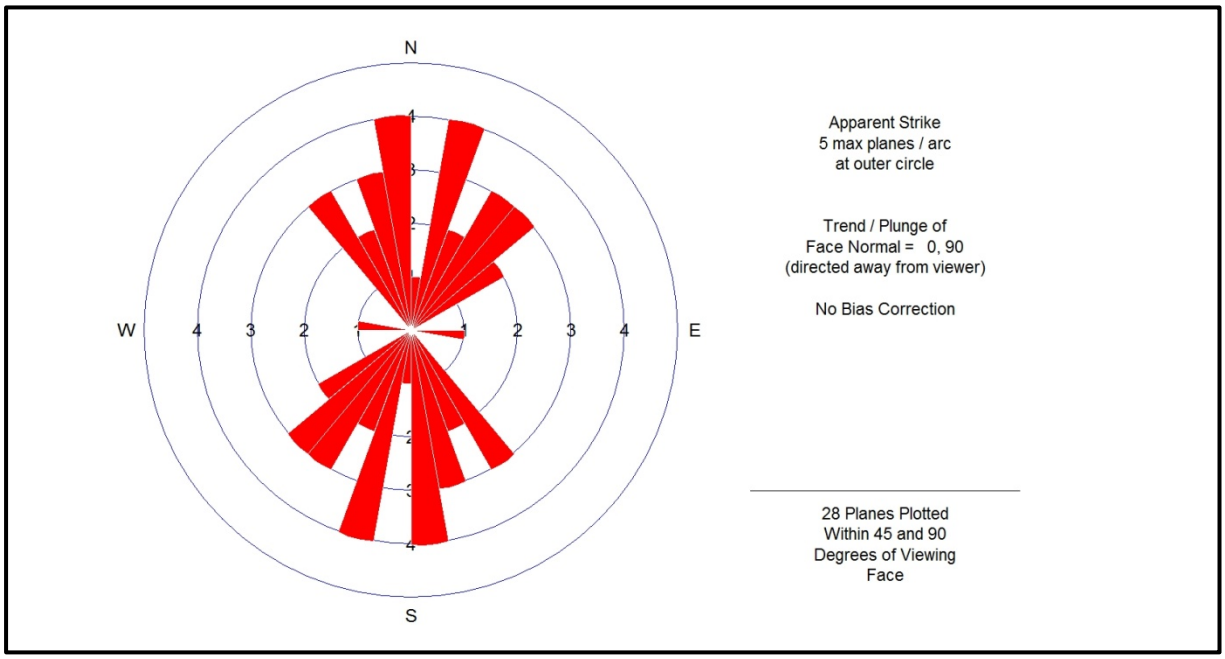


Figure 8-17: Rose Diagram for Interpreted Joints – CX3108C

8.7.4 CX3109C – Joints

Borehole CX3109C showed a high angle joint set with azimuths toward the southeast.

Table 8-7 summarises the main joint set orientations. Figure 8-18 and Figure 8-19 presents the pole contour and rose diagrams for borehole CX3109C joints.

Table 8-7: Mean Joint Set Orientation – CX3109C

Set	Dip (^{0})	Dip Direction
1	81	128

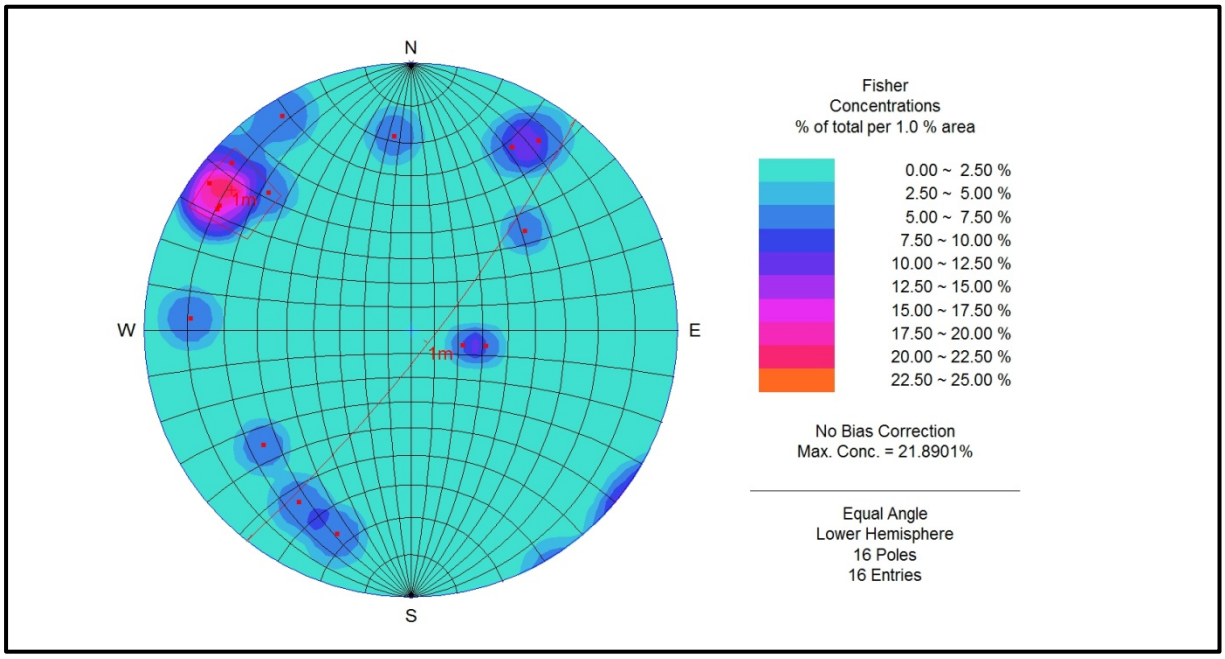


Figure 8-18: Pole Contours for Interpreted Joints – CX3109C

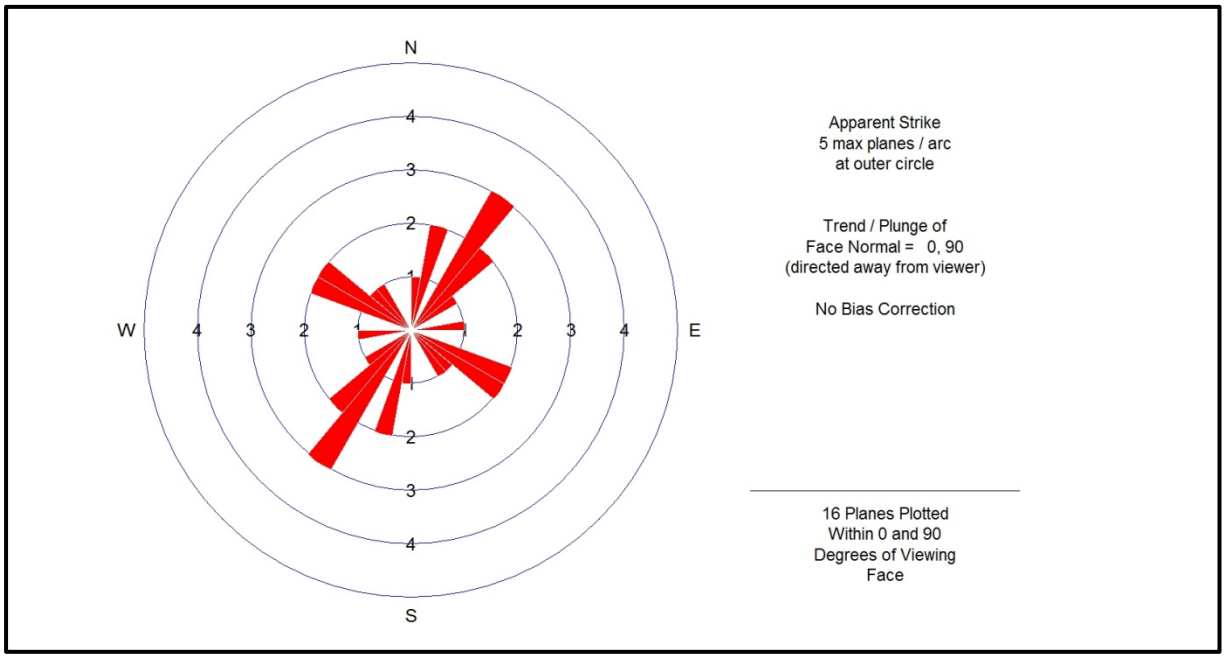


Figure 8-19: Rose Diagram for Interpreted Joints – CX3109C

8.7.5 CX3115FC – Joints

Borehole CX3115FC showed three moderate angle joint sets with azimuths towards the southwest, west-northwest and north, respectively.

Table 8-8 summarises the main joint set orientations. Figure 8-20 and Figure 8-21 presents the pole contour and rose diagrams for borehole CX3115FC joints.

Table 8-8: Mean Joint Set Orientation – CX3115FC

Set	Dip (^{0})	Dip Direction
1	24	229
2	34	289
3	50	354

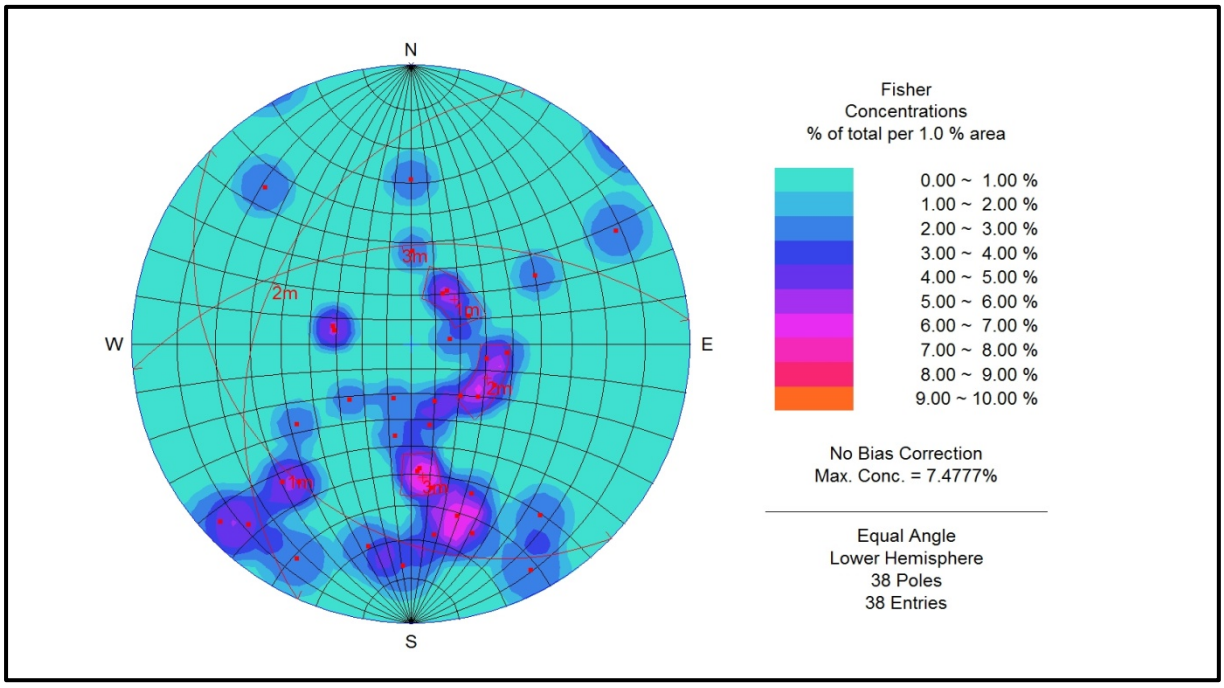


Figure 8-20: Pole Contours for Interpreted Joints – CX3115FC

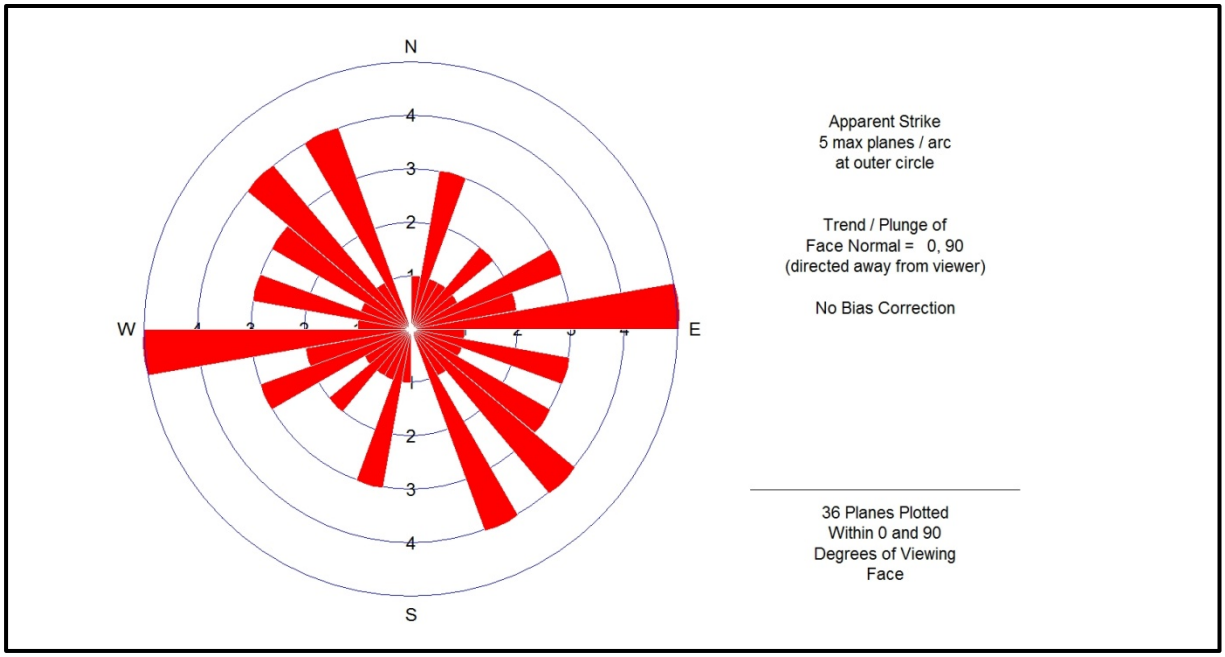


Figure 8-21: Rose Diagram for Interpreted Joints – CX3115FC

8.8 Analysis of Bedding

Interpreted bedding for all available boreholes showed some variability in azimuth. This observed variability may be a result of the influence of localised faults or shear zones, which tend to steepen the dip of the bedding planes. A more reliable method of obtaining the overall site bedding trends is to examine the target seam floor structure.

From the stereographic analysis, it was possible to ascertain a low confidence site wide azimuth trend. However, more localised trends were observed on a borehole by borehole basis, which is presented in Section 8.9.

Figure 8-22 presents an analysis of bedding dip angles recorded from the ATV interpretation. A total of 84% of the bedding surfaces interpreted dip at ≤ 19^0, with 56% dipping at ≤ 14^0. It must be noted that these dip angles are the site average and are not weighted with respect to geological structures or discretised according to interburden unit. The table below shows the majority of bedding dips to be < 19^0, with median dip angle for all interpreted bedding of approximately 12^0.

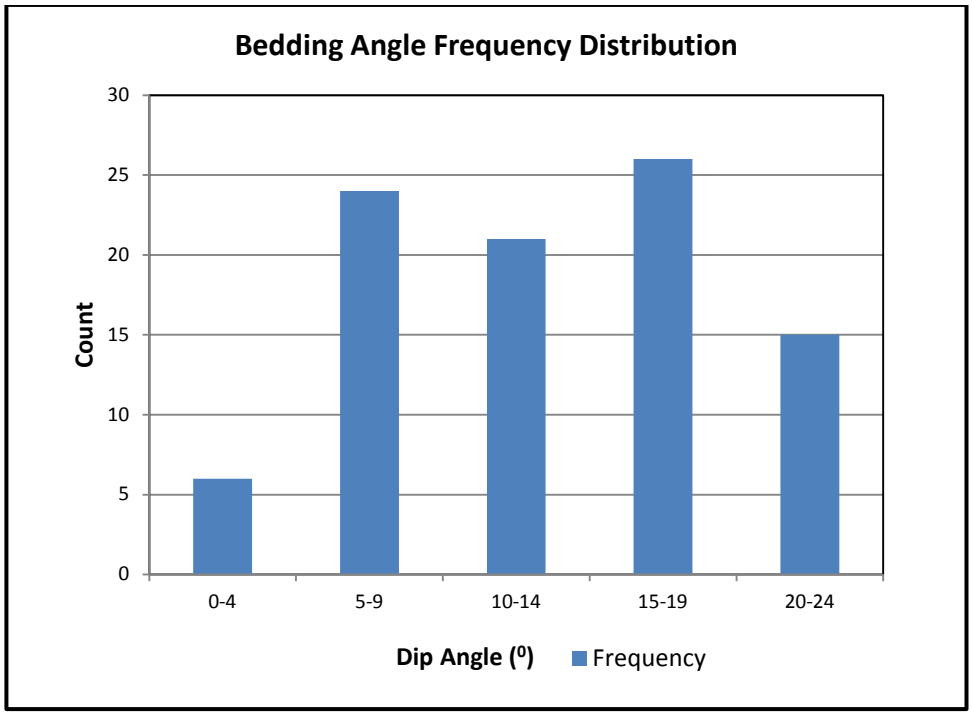


Figure 8-22: Bedding Angle Frequency Distribution – Codrilla Site

Table 8-9: Recorded Bedding Dip Angles

Dip Angle Category (^{0})	Count	Percentage (%)
0 - 4	6	7
5 - 9	24	26
10 -14	21	23
15 - 19	26	28
20 - 24	15	16
Total	92	100

Figure 8-23 and Figure 8-24 presents a pole contour plot and rose diagram for bedding structures across the Codrilla site.

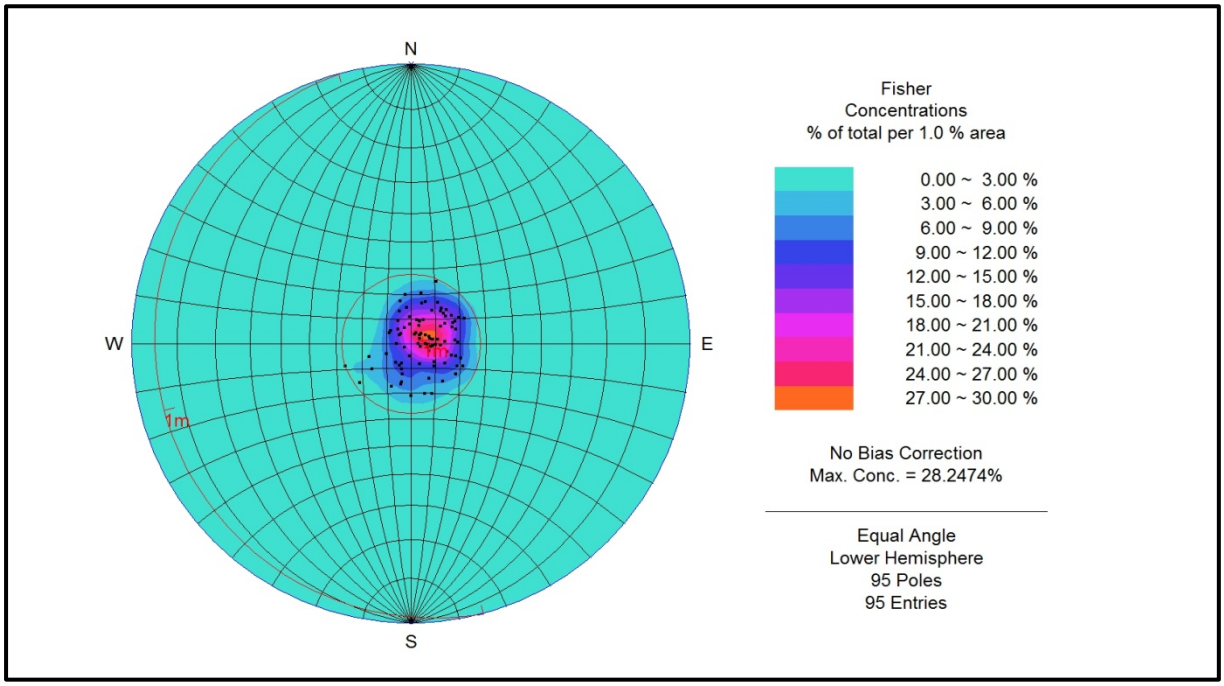


Figure 8-23: Pole Contours for Interpreted Bedding – Codrilla Site

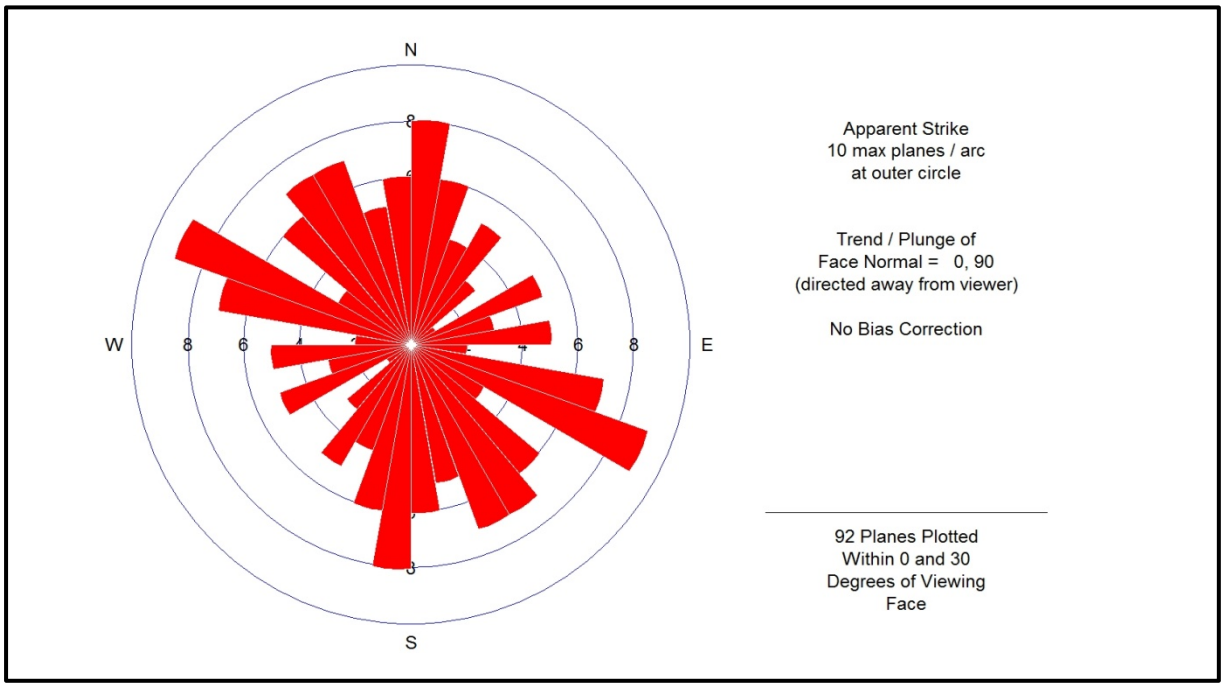


Figure 8-24: Rose Diagram for Interpreted Bedding – Codrilla Site

8.9 Interpreted Bedding – All Boreholes

8.9.1 CX0711C – Bedding

Figure 8-25 presents the bedding azimuth rose diagram for the CX0711C. The diagram shows an azimuth trend towards the west-northwest.

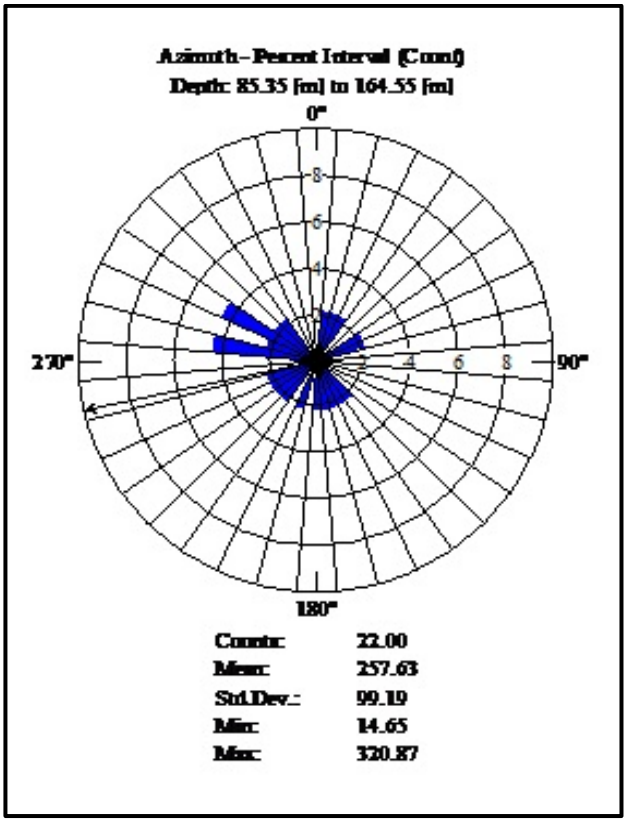


Figure 8-25: Bedding Dip Azimuth Rose Diagram – CX0711C

8.9.2 CX3106FC – Bedding

Figure 8-26 presents the bedding azimuth rose diagram for the CX3106FC. The diagram shows an azimuth trend towards the west-southwest.

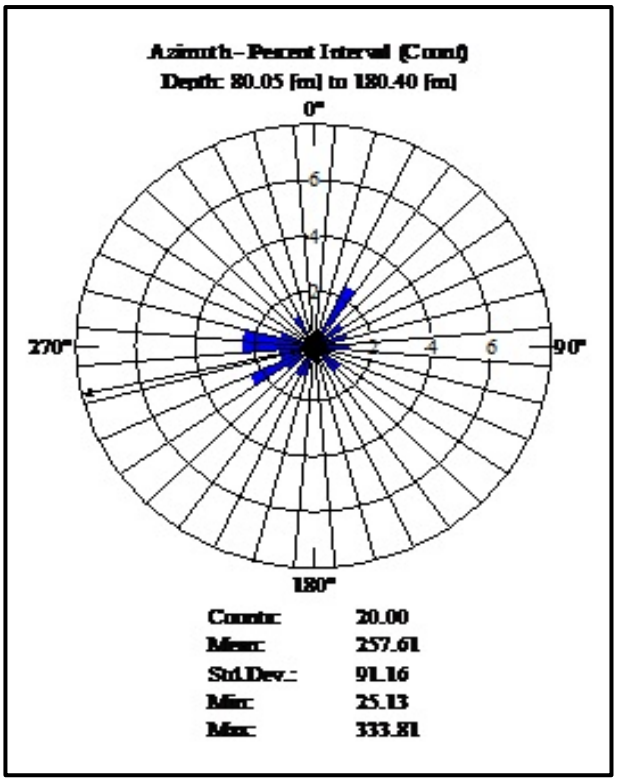


Figure 8-26: Bedding Dip Azimuth Rose Diagram – CX3106FC

8.9.3 CX3108C – Bedding

Figure 8-27 presents the bedding azimuth rose diagram for the CX3108FC. The diagram shows an azimuth trend towards the west.

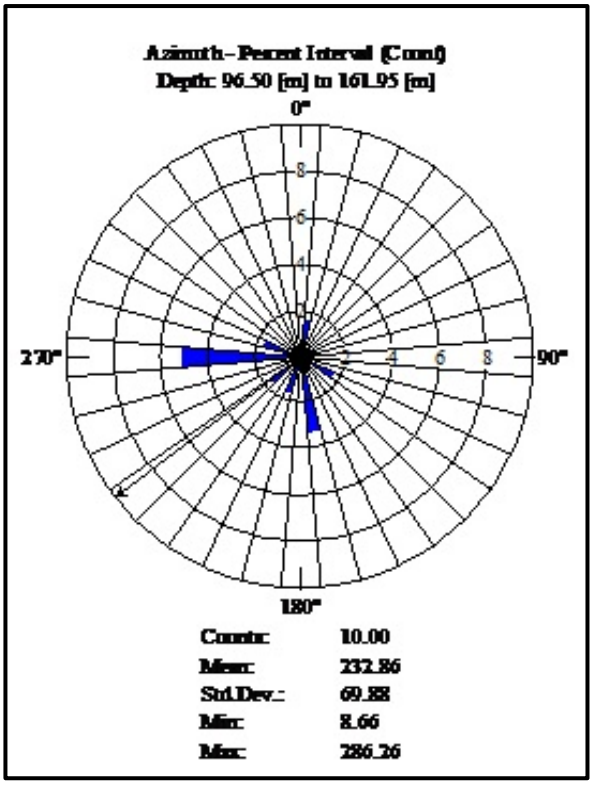


Figure 8-27: Bedding Dip Azimuth Rose Diagram – CX3108FC

8.9.4 CX3109C – Bedding

Figure 8-28 presents the bedding azimuth rose diagram for the CX3109FC. The diagram shows an azimuth trend towards the south southwest (SSW).

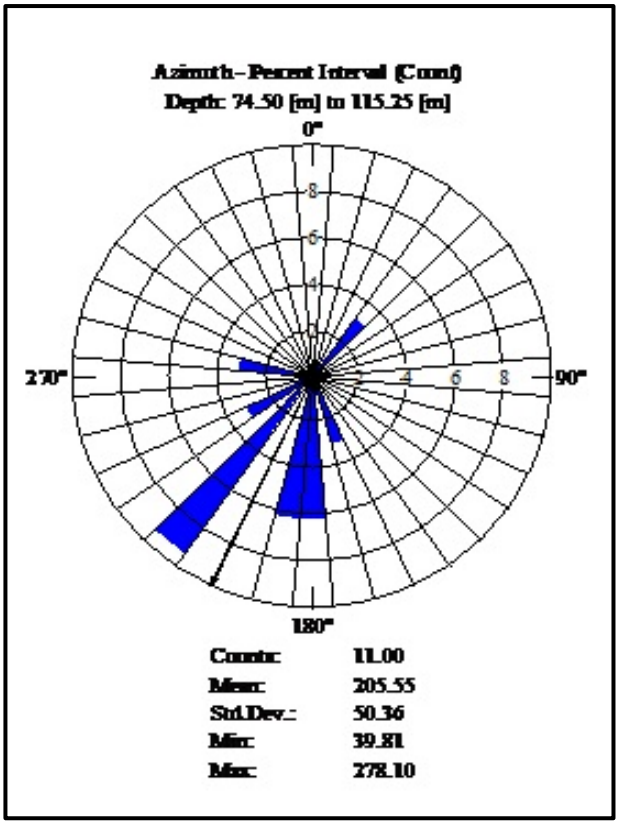


Figure 8-28: Bedding Dip Azimuth Rose Diagram – CX3109FC

8.9.5 CX3115C – Bedding

Figure 8-29 presents the bedding azimuth rose diagram for the CX3115FC. The diagram shows an azimuth trend towards the west southwest (WSW).

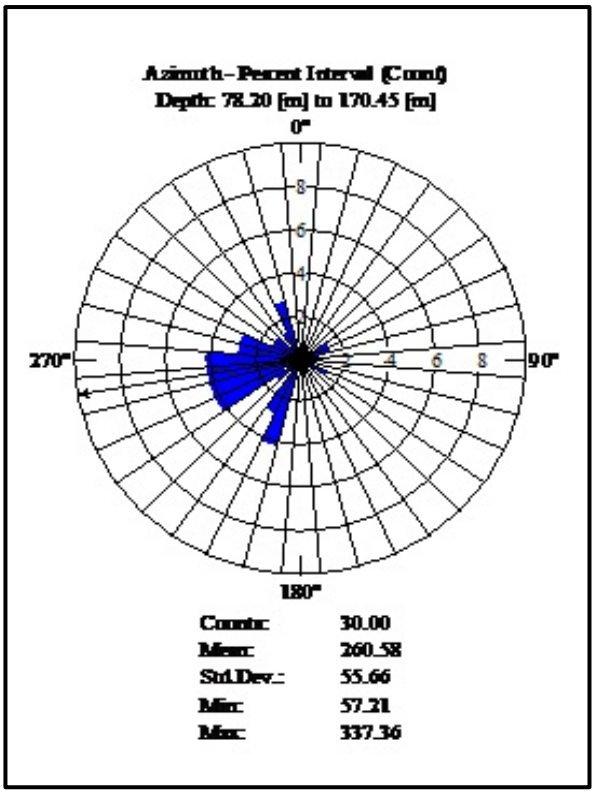


Figure 8-29: Bedding Dip Azimuth Rose Diagram – CX3115FC

9 PRELIMINARY KINEMATIC ANALYSIS

An evaluation of structural interactions for nominated interim and final highwall positions, northern and southern end walls and low wall positions was conducted to identify potential bench scale stability issues. This was achieved using the Rocscience DIPS V5.1 software to interpret the structural data obtained from the ATV interpretation.

The analysis presented was designed to test the applicability of the proposed pre-split bench angles, and to examine the potential failure mechanisms that may exist for fresh rock slopes designed at 65°. On this basis, the kinematic analysis was only conducted for fresh Permian materials, where failure would be controlled by adverse block configurations and geometries relative to the pit face.

The following failure mechanisms were examined as part of the kinematic analysis:

- Planar failures; and
- Wedge failures.

Toppling failure was not considered as part of the kinematic analysis due to it being a relatively uncommon occurrence in the Bowen Basin.

Based on the limited amount of acoustic scanner data, the kinematic analysis presented is considered only indicative at this stage, and is also limited to the East Pit, given that no ATV information was available for the West Pit. A further constraint was that most of the ATV boreholes were not located in proximity to the final pit slopes; therefore some undisclosed variations in the presented analysis could be expected.

It is important to note, that whilst the kinematic analysis produces a statistical likelihood of a “set” of joints or discontinuities contributing to potential instability, failure is the result of individual, or the interaction of individual discontinuities. Although the interpretation of discontinuity sets is considered to have a low reliability at this stage, joints sets that are shown to daylight on the pit face are likely to have a greater chance of failure, than random joints. It is recommended that additional ATV information be procured during more detailed phases of work to improve the reliability of joint/discontinuity set interpretations.

For the purposes of analysis, kinematic scenarios were evaluated for several positions along the low wall, endwalls and for an interim and final highwall position for the East Pit. These are presented in Figure 9-1.

Table 9-1 below presents seven pit slope azimuth cases, using available borehole data for the highwall, end wall and low wall.

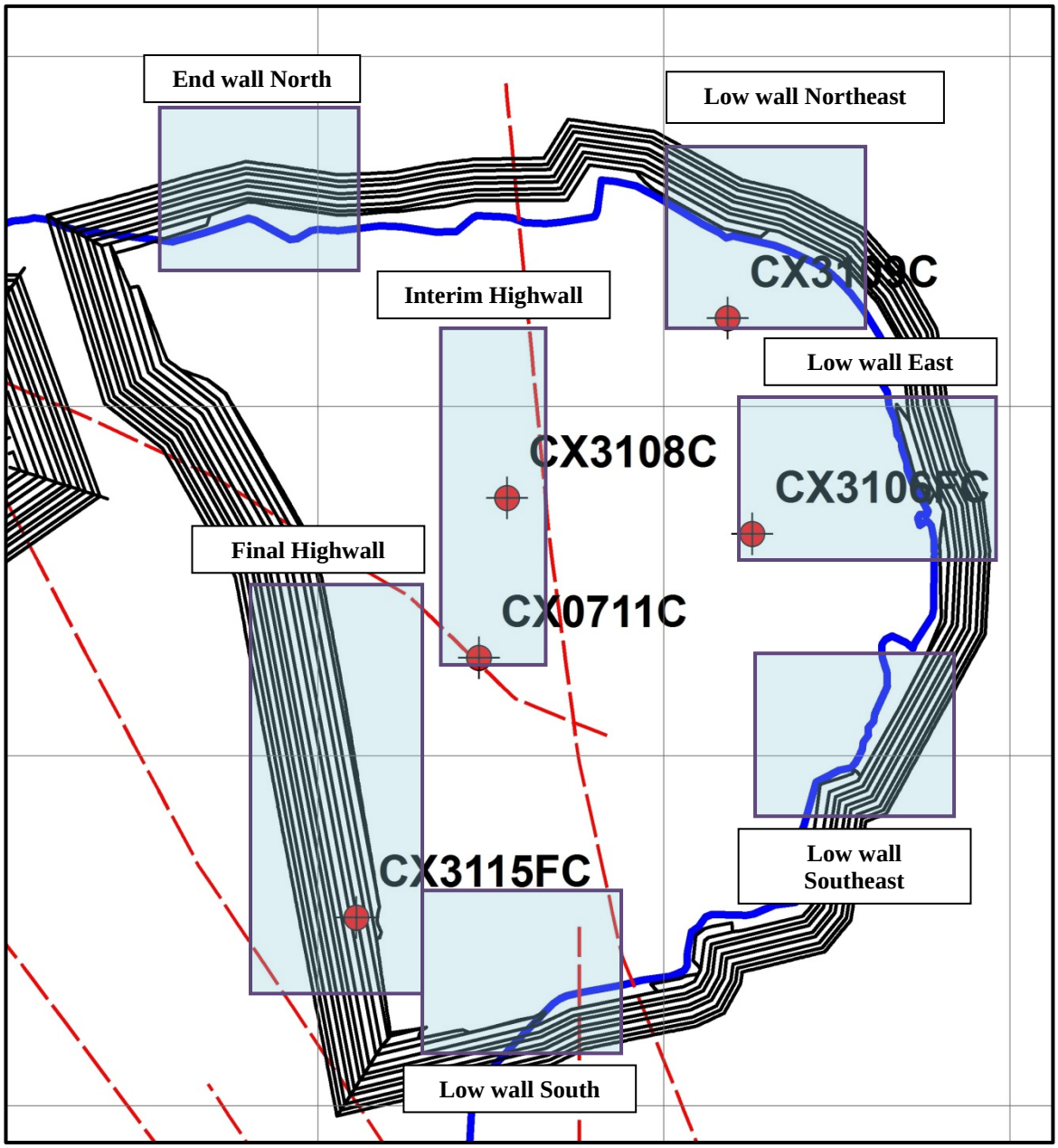


Figure 9-1: Pit Locations for Kinematic Scenarios

Table 9-1: Pit Slope Azimuth Cases

Case	Relevant Borehole	Approx. Bench Angle (^{o})	Approx. Wall Azimuth(^{o})
Final Highwall	CX3115C	65	080
Interim Highwall	CX3108C & CX0711C	65	080
Endwall - North	CX3108FC	65	165
Endwall - South	CX3115FC	65	345
Lowwall - East	CX3106FC	65	265
Low wall - Northeast	CX3109C	65	235
Low wall - Southeast	CX3106FC	65	315

These failure mechanisms were assessed by plotting the pit wall dip and azimuth on a stereonet, using those measurements presented in the above.

Pit wall daylight envelopes were also plotted, along with the friction cone which is essentially an assumed friction angle of the structure (joints, bedding etc) planes.

An example of planar, wedge and block slippage failure mechanisms from a stereographic analysis is presented in Figure 9-2 to Figure 9-3.

For planar failure analysis, structure poles that plot outside of the friction cone, but within the daylight envelope (orange highlighted region), are considered to be kinematically free to move. Structure poles that plot inside the friction cone generally indicate that planar failure would be unlikely due to frictional resistance.

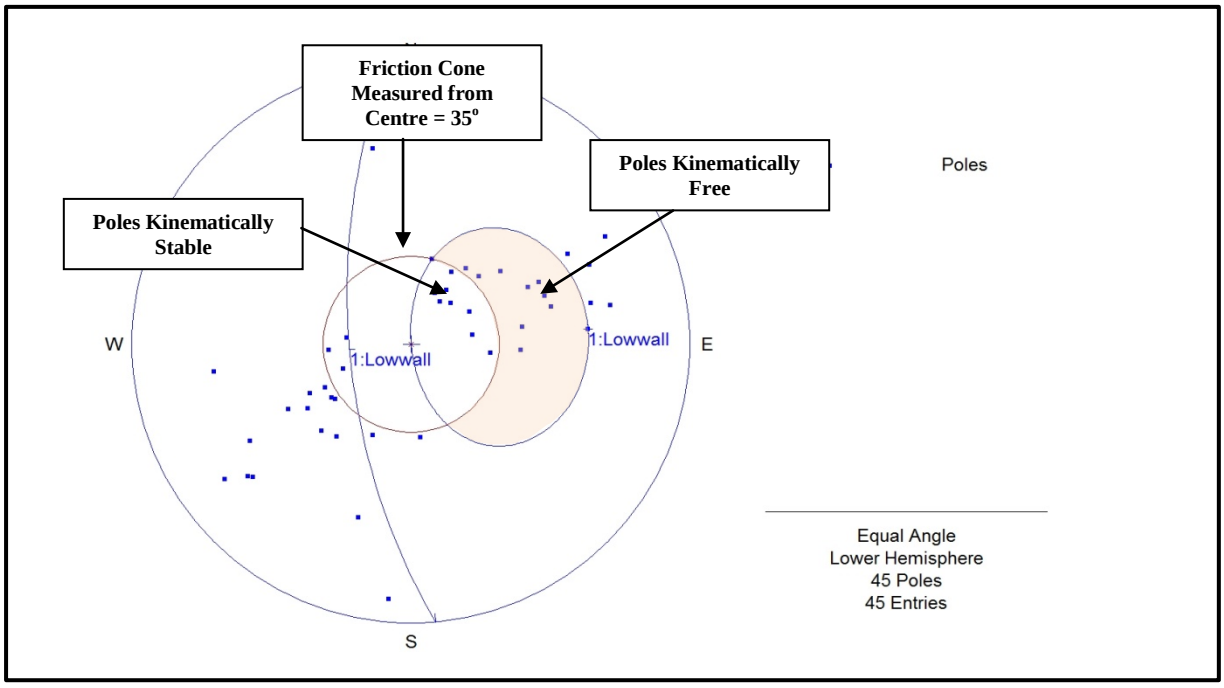


Figure 9-2: Planar Failure Kinematic Scenario Example

Similarly, for wedge failure analysis, the intersection of structure planes which daylight on the pit face, inside the friction cone, are kinematically free to move.

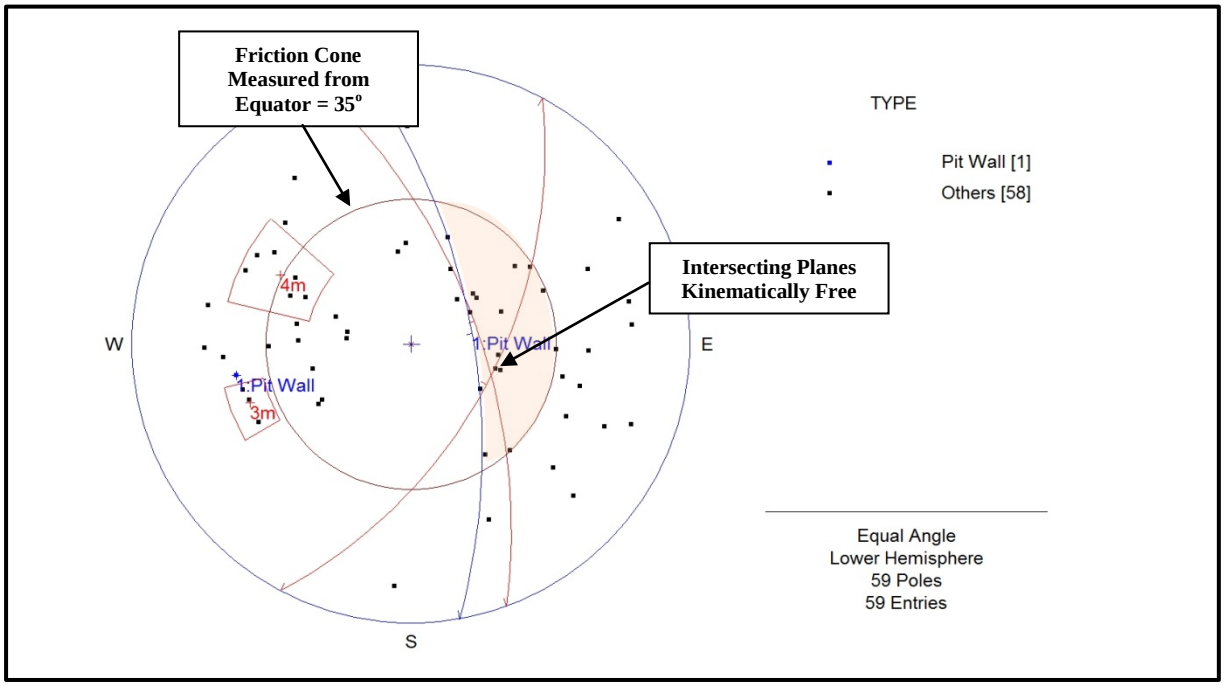


Figure 9-3: Wedge Failure Kinematic Scenario Example

9.1 Assumptions

The following assumptions were made for the analysis of discontinuities:

- Friction angle of joint planes assumed to be approximately 35°;
- Friction angle of Yarrabee Tuff (YT) assumed to be approximately 20^{0};
- Friction cone for wedge configurations measured from the equator of the stereonet; therefore 55° used for planes; and
- Joint planes are pervasive and continuous throughout the rock mass.

9.2 Indicative Planar Failure Mechanisms

9.2.1 Final and Interim Highwall

Figure 9-4 and Figure 9-5 show the stereographic analyses for the final and interim highwall positions, respectively. The analyses indicate the following joint sets for each case:

- Three main joints sets for the final highwall; and
- Four main joint sets for the interim highwall.

The final highwall case showed the joint sets were unlikely to form planar failure configurations, based on the available data; however the interim highwall case indicated that of the four main joint sets measured two could have the potential to form planar failure configurations.

For both cases, the analyses show the possibility for planar configurations from random joint orientations; however based on the limitations of the dataset, these are not considered to be statistically relevant at this stage.

In addition to this, potential wedge configurations were also identified for the interim highwall case, which will be discussed in Section 9.3.

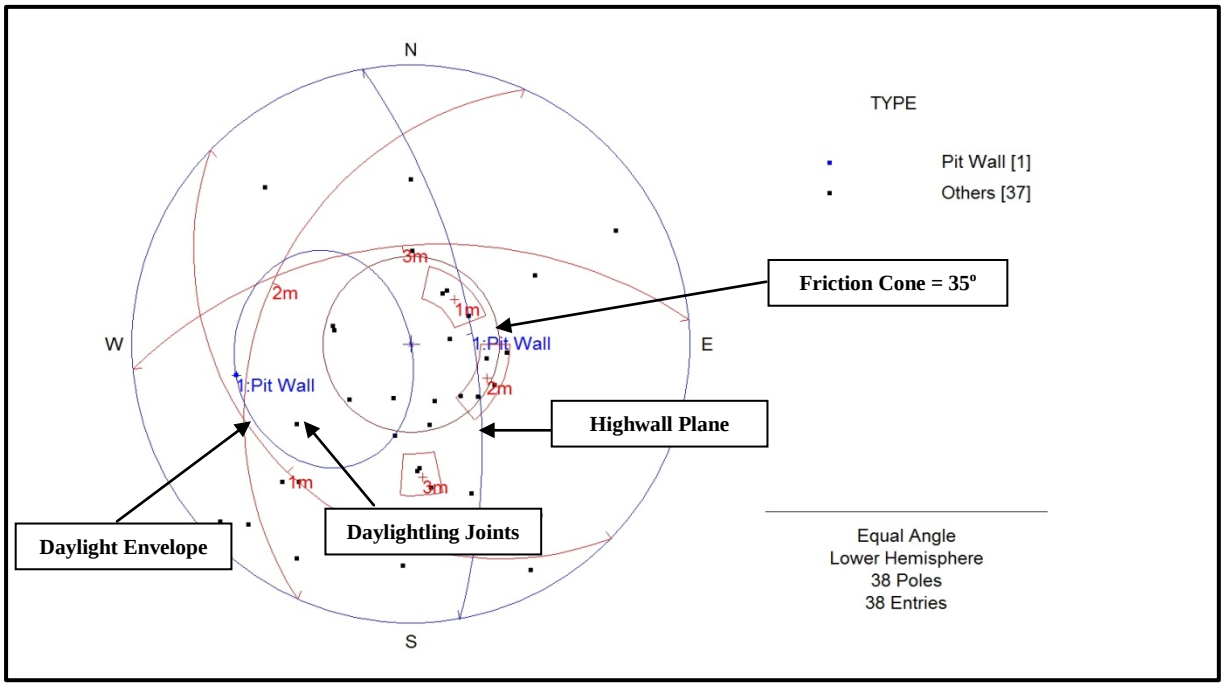


Figure 9-4: Planar Kinematic Scenario – Final Highwall

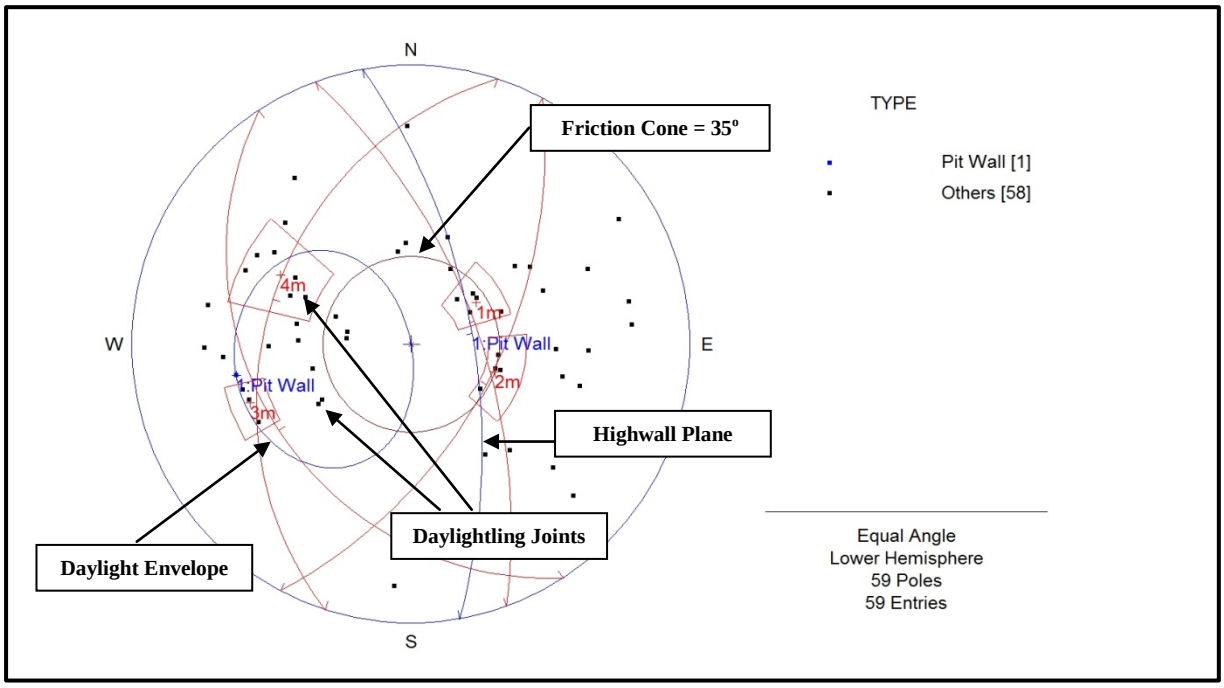


Figure 9-5: Planar Kinematic Scenario – Interim Highwall

9.2.2 Endwall North and South

Figure 9-6 and Figure 9-7 show the stereographic analyses for the endwall north and endwall south cases, respectively. The analyses indicated the following joints sets for each case:

- Four main joint sets for endwall north; and
- Three main joints sets for endwall south.

The endwall north case showed that joint sets were unlikely to form planar failure configurations, based on the available data; however the endwall south case indicated that one of the joint sets could have the potential to form planar failure configurations. The endwall south case also shows two joint sets located inside the friction cone. This indicates that the dip of the joints is lower than the frictional forces required for displacement under dry conditions, therefore would be kinematically stable.

Similar to the highwall cases, the analyses showed the possibility for planar configurations from random joint orientations; however based on the limitations of the dataset, these are not considered to be statistically relevant at this stage.

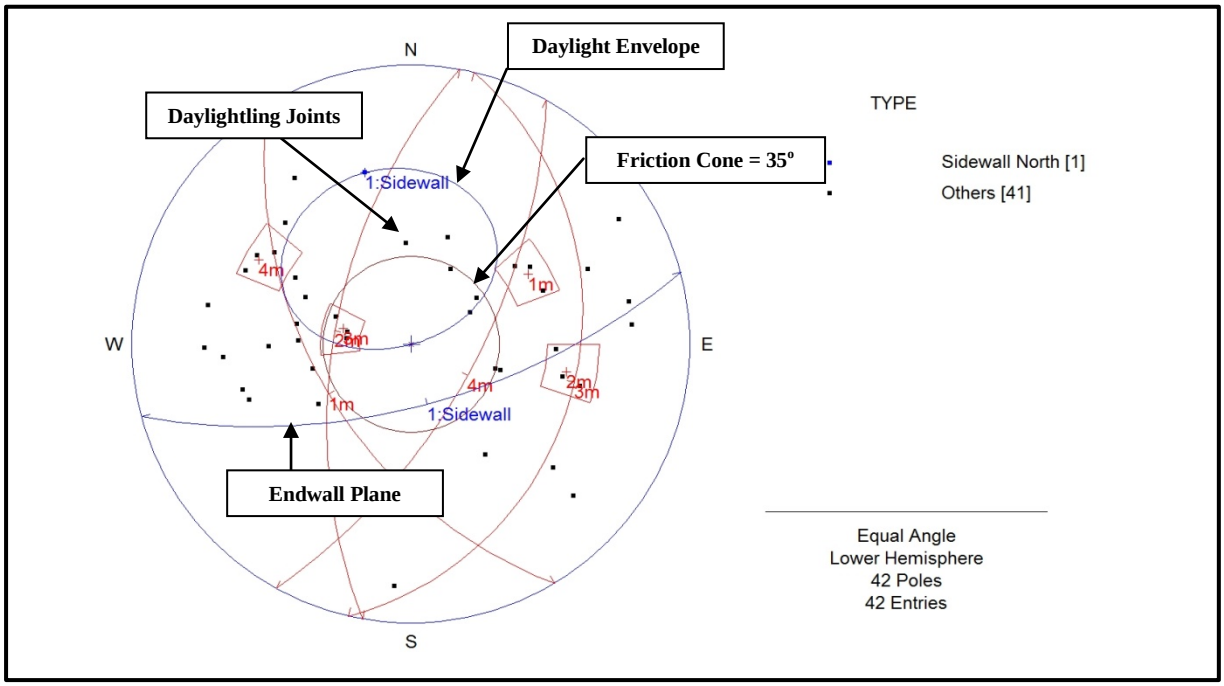


Figure 9-6: Planar Kinematic Scenario – Endwall North

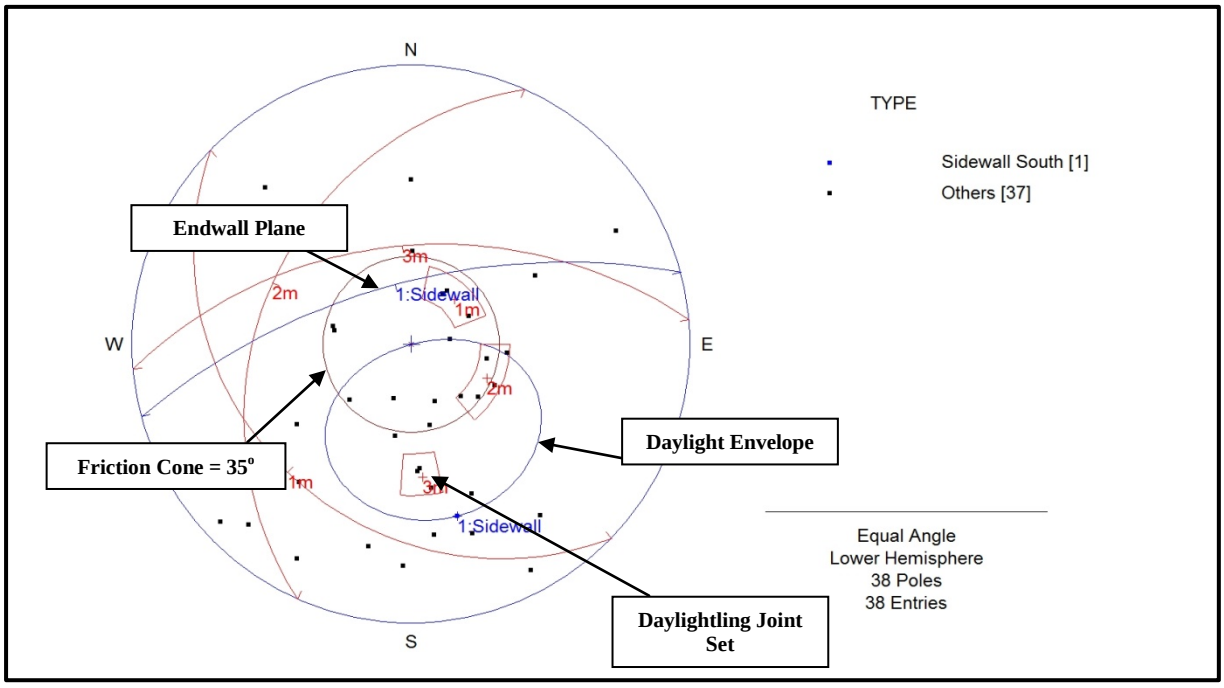


Figure 9-7: Planar Kinematic Scenario – Endwall South

9.2.3 Low wall East

Figure 9-8 shows the stereographic analyses for the low wall east case. The analyses indicated the following joints sets for each case:

- Three main joint sets for low wall east.

The low wall east case showed that one joint set could have the potential to form planar failure configurations, with also the possibility of random joint configurations.

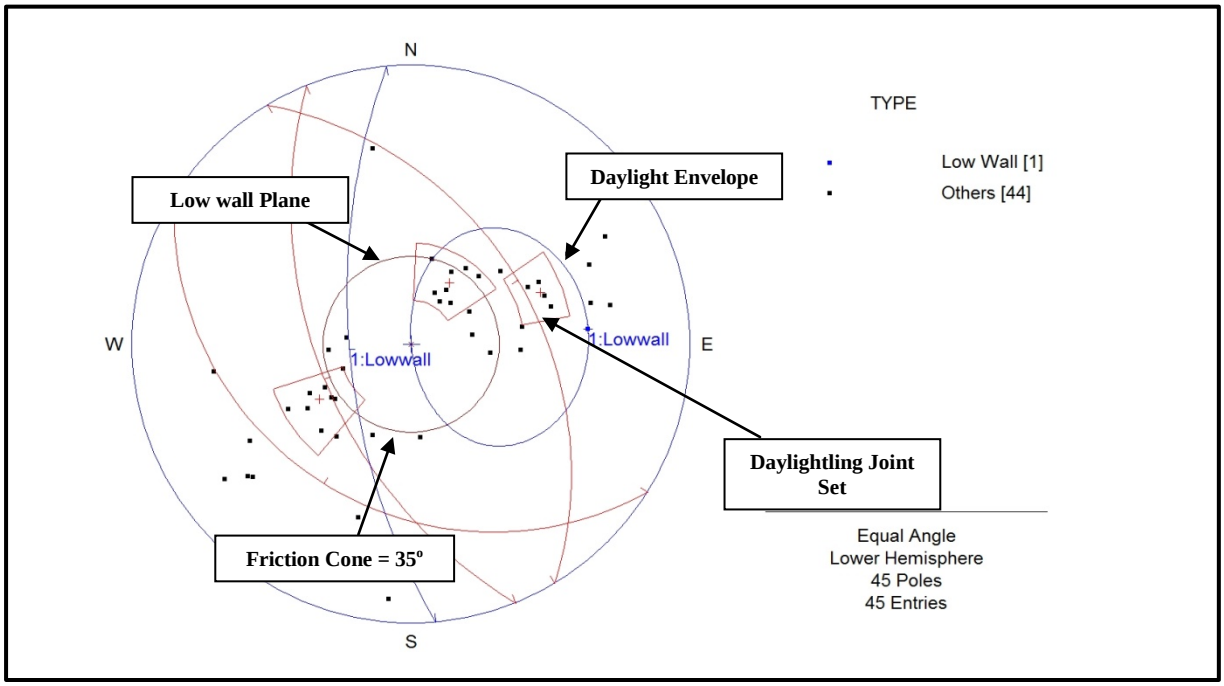


Figure 9-8: Planar Kinematic Scenario – Low wall East

9.2.4 Low wall North-East and South-East

Figure 9-9 and Figure 9-10 show the stereographic analyses for the low wall north-east and low wall south-east cases, respectively. The analyses indicated the following joints sets for each case:

- One main joint sets for low wall north-east; and
- Three main joints sets for low wall south-east.

Both cases showed that interpreted joint sets were unlikely to form planar failure configurations, based on the available data; however the analyses showed the possibility for planar configurations from random joint orientations for the low wall south-east case.

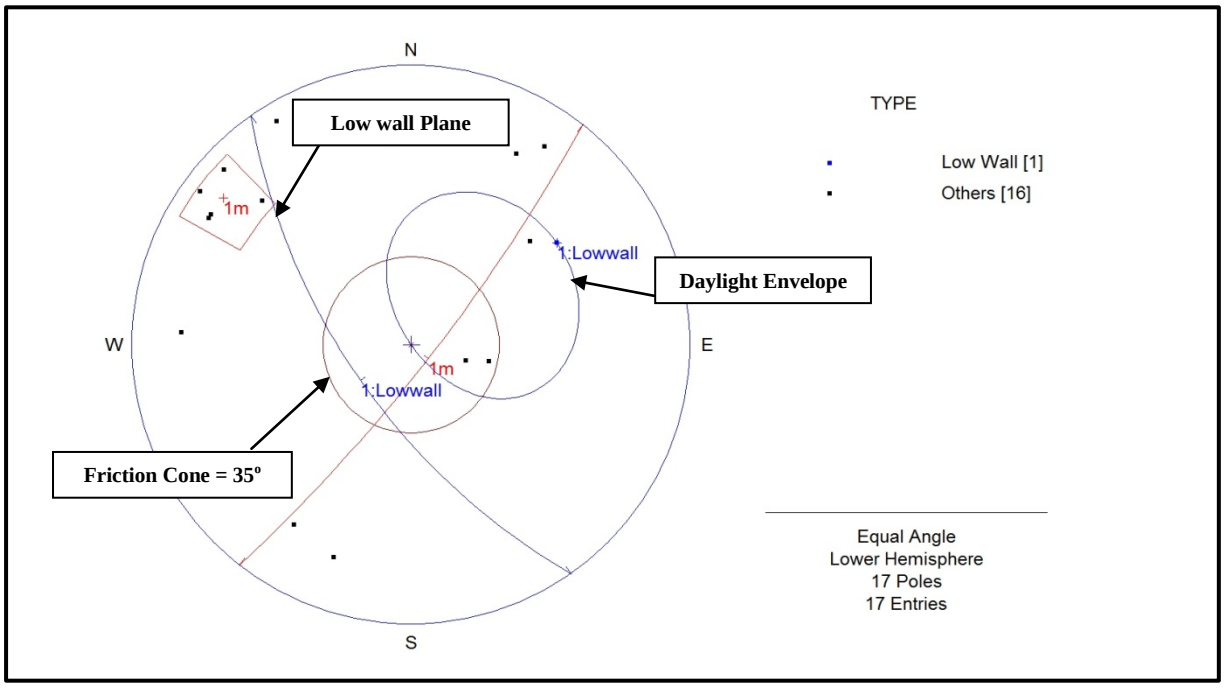


Figure 9-9: Planar Kinematic Scenario – Low wall North-East

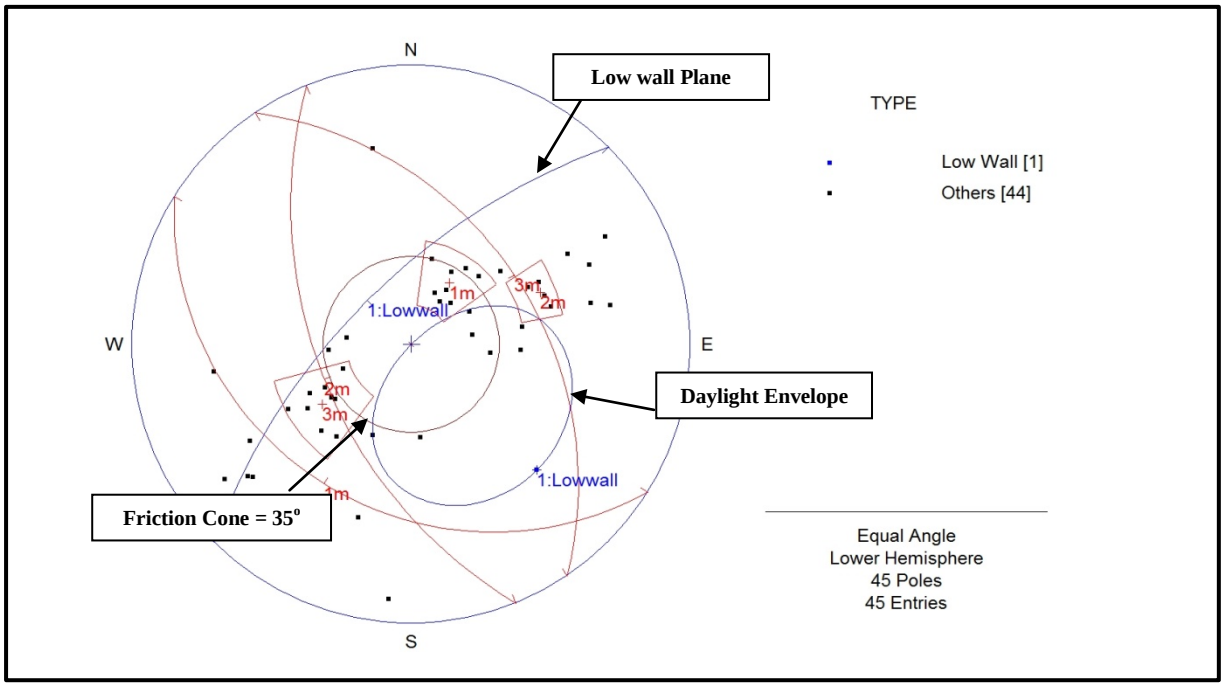


Figure 9-10: Planar Kinematic Scenario – Low wall South-East

9.3 Indicative Wedge Failure Mechanisms

9.3.1 Final and Interim Highwall

Figure 9-11 shows the final highwall case does not indicate the potential for significant wedge configurations at this stage, with only two random joint poles showing steep intersections.

The interim highwall case did however indicate the potential for wedge configurations for the interpreted joint sets, as shown in Figure 9-12.

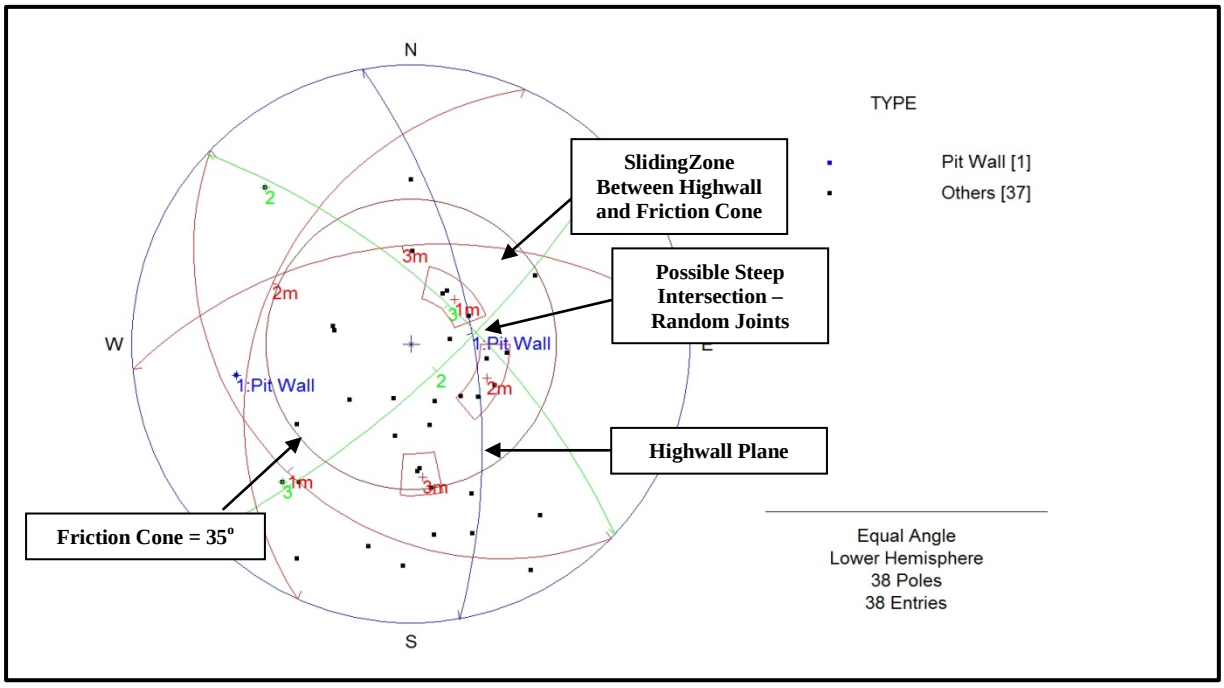


Figure 9-11: Wedge Kinematic Scenario – Final Highwall

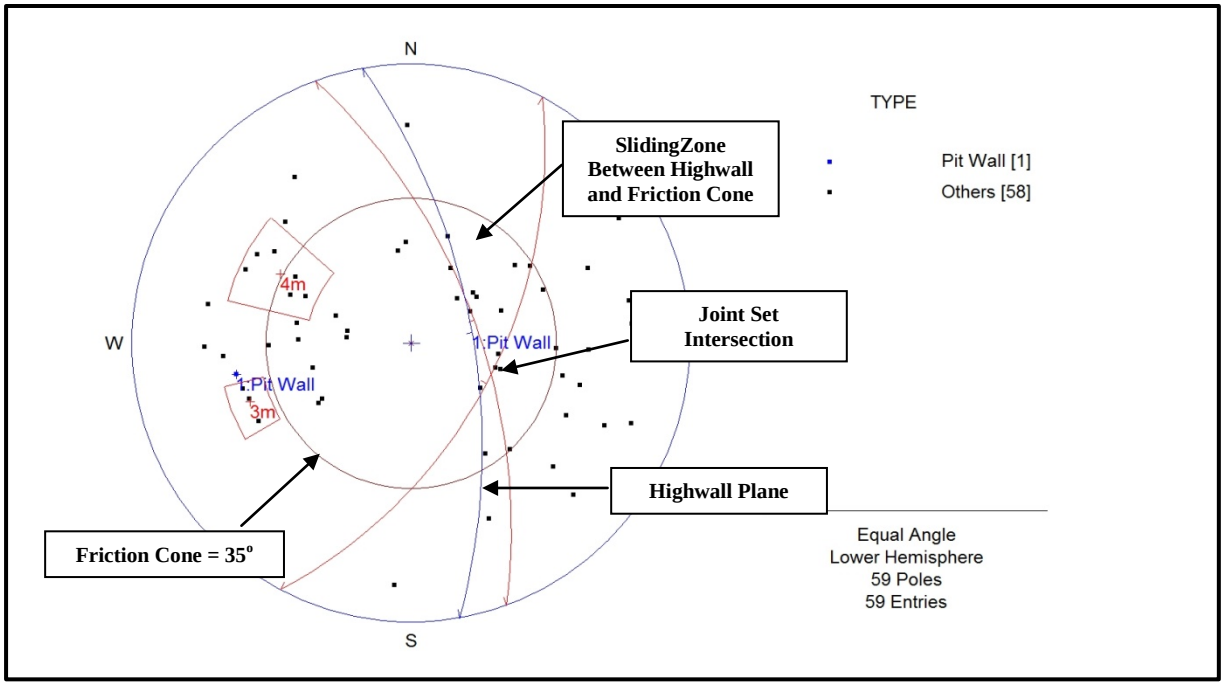


Figure 9-12: Wedge Kinematic Scenario – Interim Highwall

9.3.2 Endwall North and South

Figure 9-13 shows the endwall north case and indicates the potential for kinematically unstable wedge configurations; however the intersection plotted marginally close to the frictional limits. Wedge failure, in this case, may be dependent on the characteristics of the joint surfaces.

Similarly, the endwall south case also indicated the potential for wedge configurations; however these intersections were marginally outside of the friction cone, as shown in Figure 9-14.

Both cases would need to be evaluated further for this type of failure mechanism.

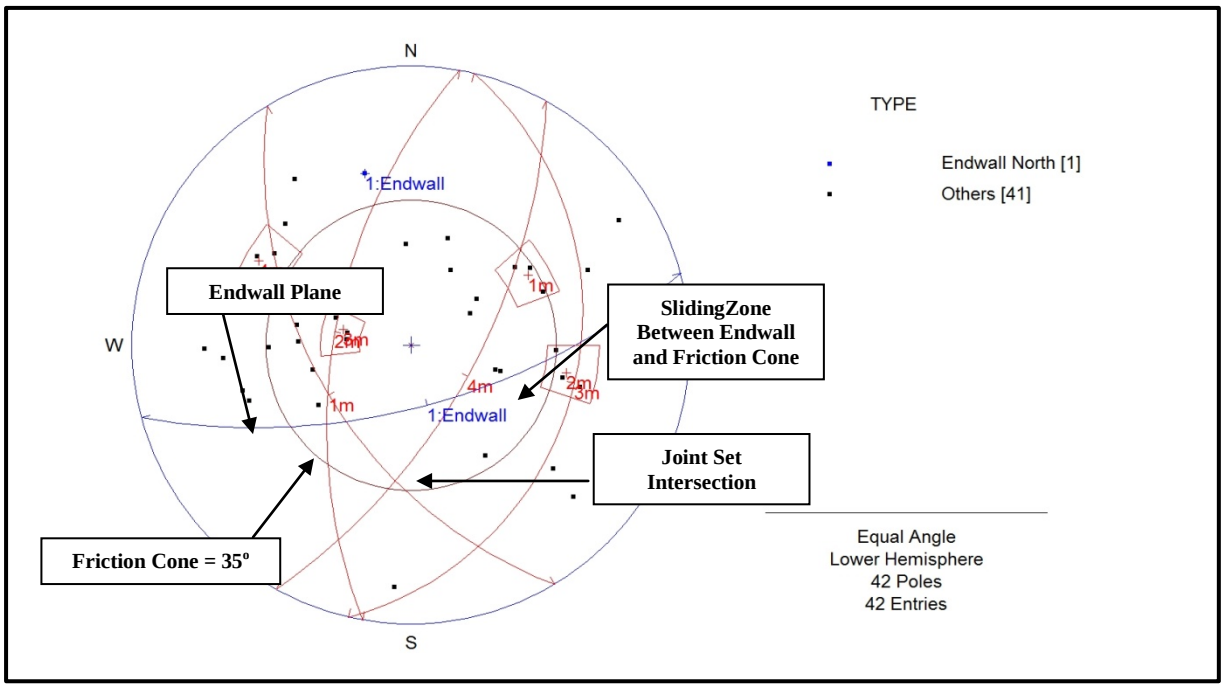


Figure 9-13: Wedge Kinematic Scenario – Endwall North

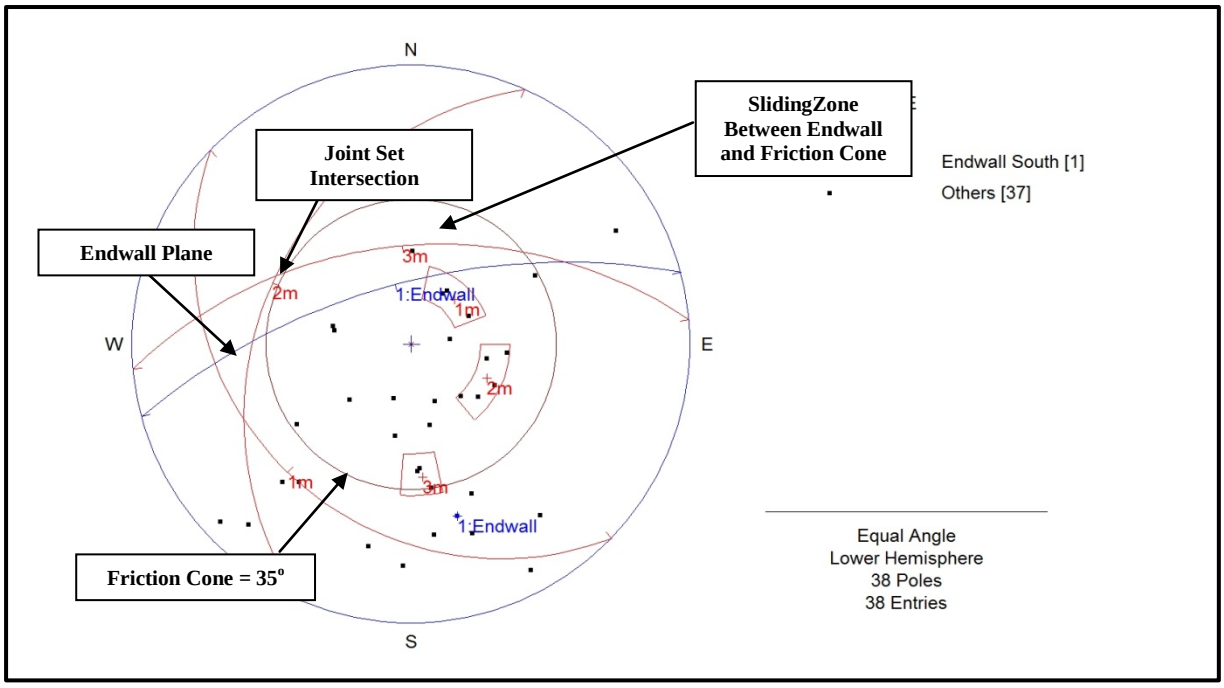


Figure 9-14: Wedge Kinematic Scenario – Endwall South

9.3.3 Low wall East

Figure 9-15 shows the low wall east case does not indicate the potential for wedge configurations. In this case, the interpreted joint set intersections do not daylight on the low wall face. An evaluation of random joint intersections did not indicate the likelihood of this occurring.

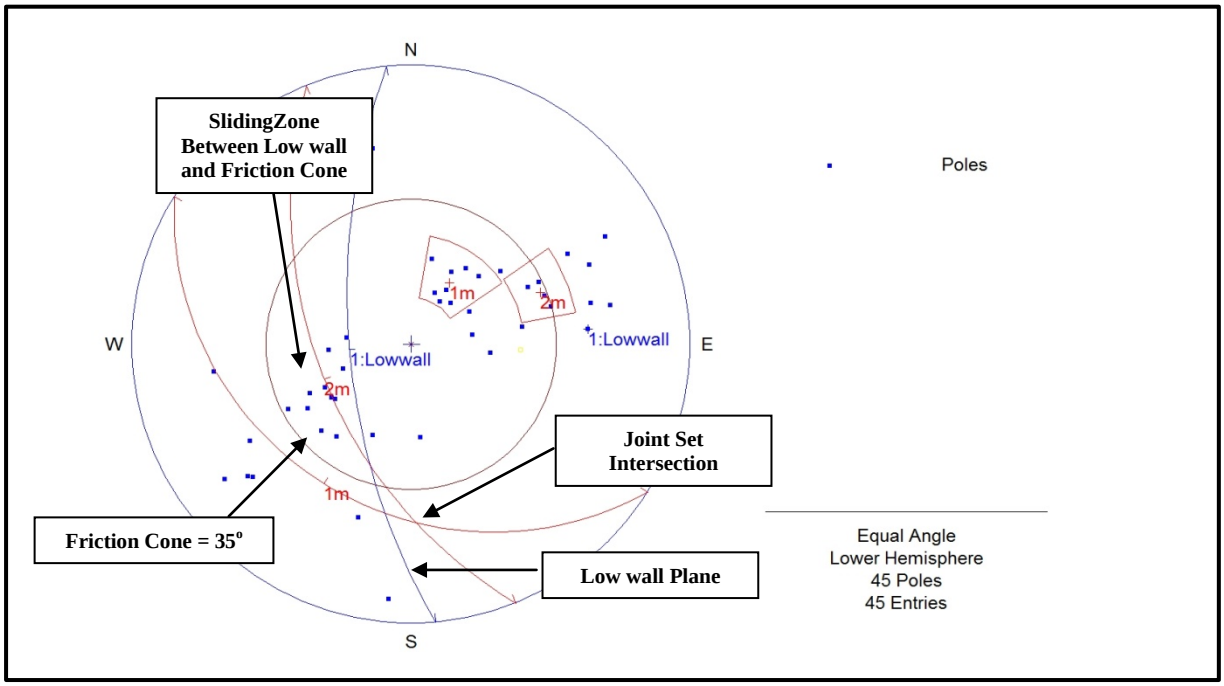


Figure 9-15: Wedge Kinematic Scenario – Low wall East

9.3.4 Low wall North-East and South-East

Figure 9-16 showed the low wall case did not indicate the potential for wedge configurations. In this case, the interpreted joint set intersections do not daylight on the low wall face. An evaluation of random joint intersections did not indicate the likelihood of this occurring.

The low wall southeast case showed comparatively few joint planes therefore the reliability of the dataset is very low. In this case, only one joint set was interpreted, therefore wedge configurations would be unlikely to form, as shown in Figure 9-17.

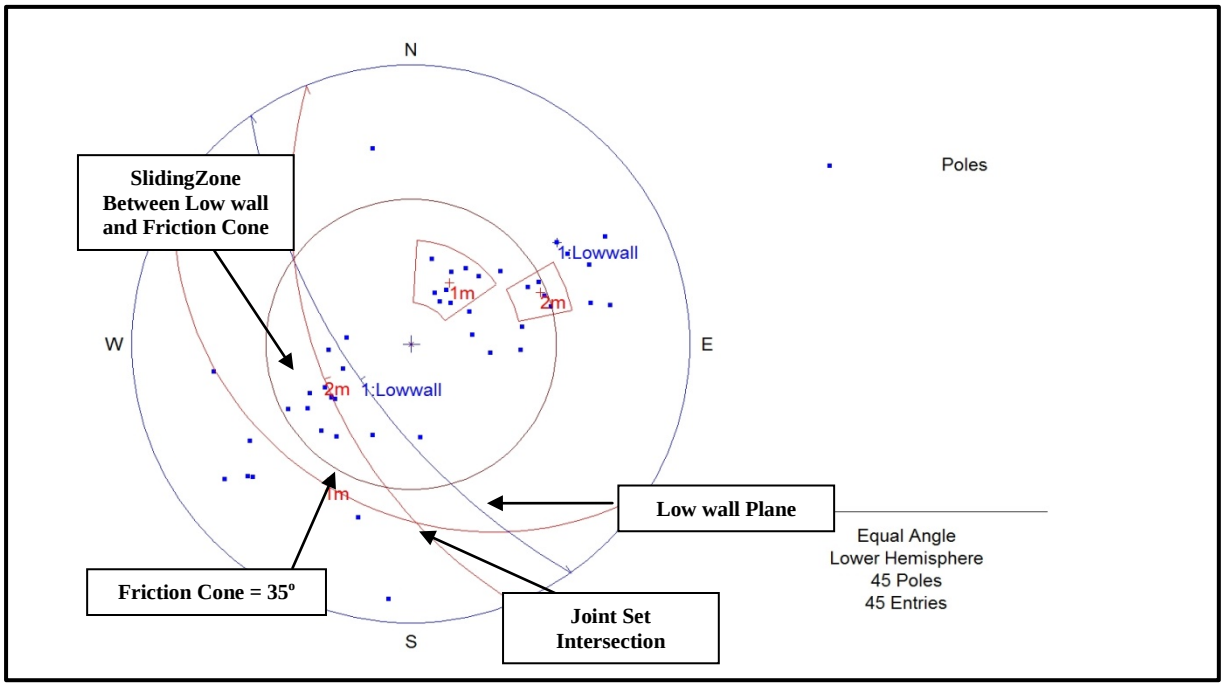


Figure 9-16: Wedge Kinematic Scenario – Low wall North-East

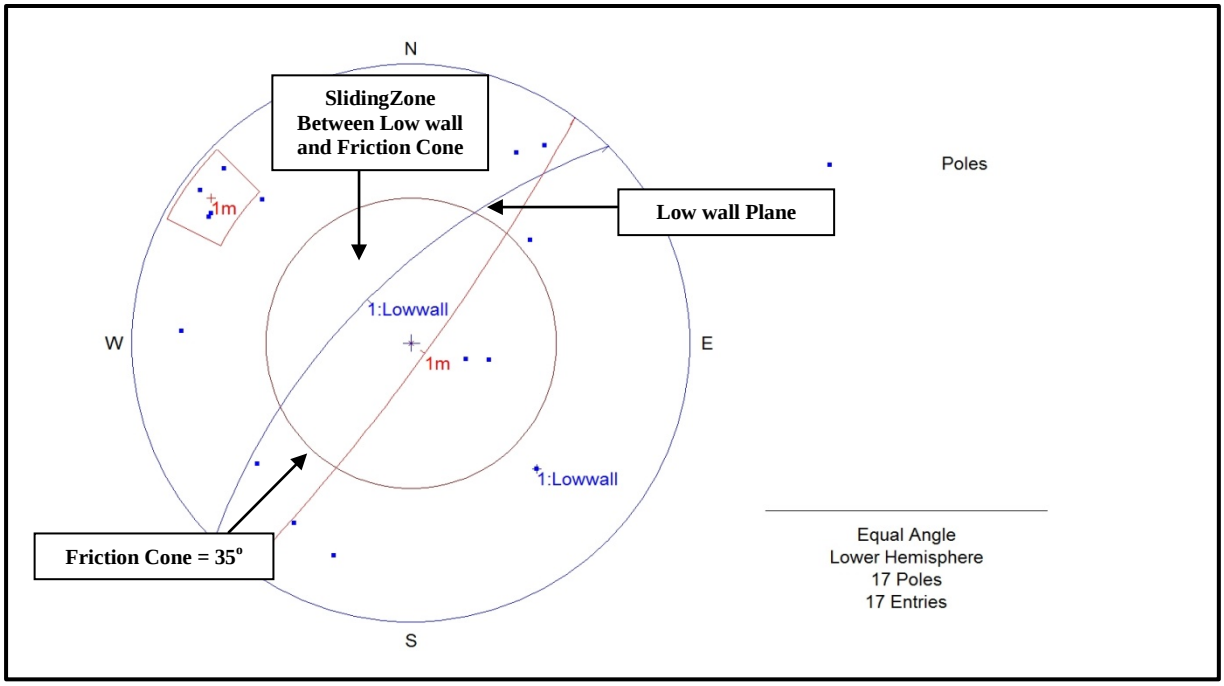


Figure 9-17: Wedge Kinematic Scenario – Low wall South-East

9.4 Kinematic Analysis Discussion and Summary

For the Codrilla deposit, the strength and quality of the rock fabric is too high to permit mass slope failure by shearing through the body of the material, hence failure is a function of the characteristics of discontinuities present in the rock mass. From

the kinematic analysis, it is evident that localised failure configurations can be created from combinations of joints or the disposition of the joint relative to the slope face, however assessing failure scale is difficult using kinematic techniques.

The scale of structural failures can be classified into main three categories:

- Small to medium scale failures from joint planar intersections; and
- Small to medium scale failures from adverse joint combinations or wedges.

Small scale rockfall configurations are common where joint planes are non pervasive and tend to be confined to discrete beds. These types of failures are an inevitable hazard in rock slopes and cannot be entirely eliminated.

Larger scale wedge configurations can develop when the joint planes are more pervasive and daylight in the slope face. Daylighting joints or joint intersections could create a potential for high angle rock failure conditions.

A more common occurrence would be where pervasive joint planes intersect the bench at a small oblique angle of less than approximately 20^0. This tends to create a potential asymmetric planar wedge condition. The wedge would fail if there were conjugate joints (not necessary pervasive) that would link up to form the second separation plane or, since the wedge would be cantilevering laterally, where tensile failure breaks the cantilever effect. The wedge failure mechanism geometry is illustrated in Figure 9-18.

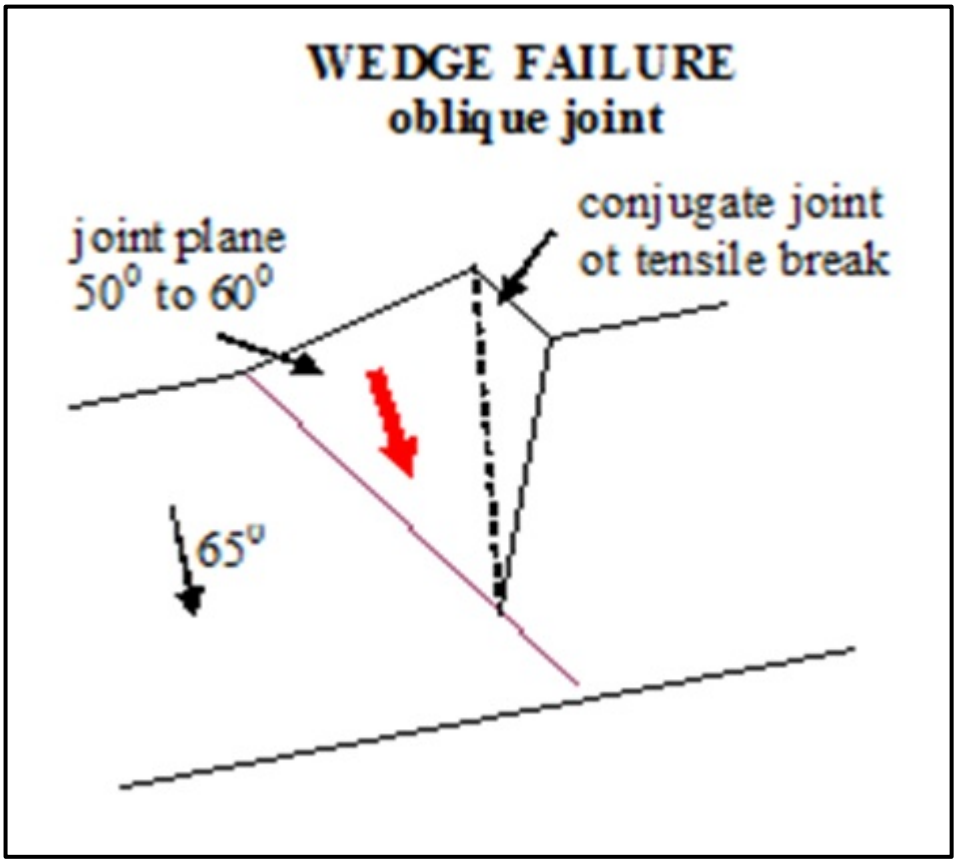


Figure 9-18: Wedge Failure Mechanism Geometry

The structural data analysed from the ATV outputs does not contain information on the pervasiveness of the joint planes throughout the rock mass. The interaction of joint planes that are persistent at the metre scale would have a higher probability of forming larger blocks, which would have a greater chance of movement under gravity. This characteristic is typically a key driver for slope instability. For the analysis presented, it was assumed that the joint planes were pervasive throughout the rock mass.

If the joint planes were oriented parallel to the slope, there would be a possibility of planar slip along the joint plane. In these conditions, the attitude of the wall would be governed by the joint angle, as the wall would fail back to the joint plane. This situation is more likely to occur where the highwall is approaching a major structure oriented parallel to the face, such as those identified in the 2D seismics. The planar failure mechanism geometry is illustrated in Figure 9-19.

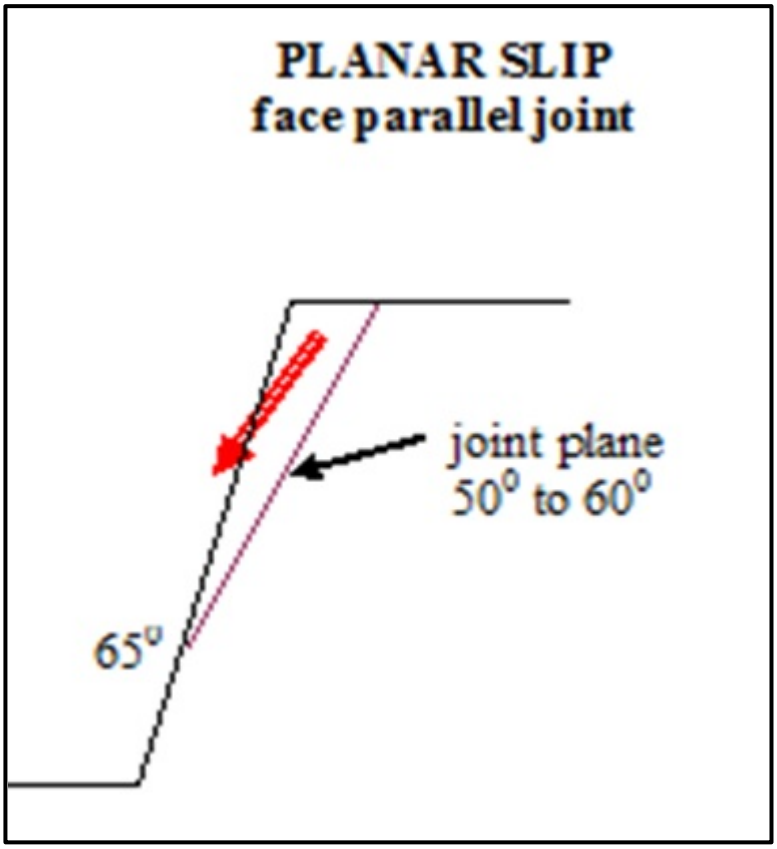


Figure 9-19: Planar Failure Mechanism Geometry

Generally, both failure mechanisms would not prejudice the overall stability of the slope, but could induce bench scale failure, as well as constituting a major hazard to mining operations beneath the wall. The likelihood of major rockfalls of this type would depend on the pervasiveness of the joints that would require joint planes in excess of approximately 10m in extent, as well as discontinuity orientations to within 20^0 of the wall.

Table 9-2 below presents a summary of failure mechanisms and the specific mode of failure for each pit wall case.

Table 9-2: Potential Failure Mechanisms for Pit Slope Cases

Case	Planar Configurations		Wedge Configurations	
	Joint Set	Random Joints	Joint Set	Random Joints
Final Highwall		√		√
Interim Highwall	√		√	
Endwall - North		√	√	
Endwall - South	√			√
Low wall - East	√	√		
Low wall – North-East		√		
Low wall – South-East		√		

This shows that there is a distinct likelihood that both planar, wedge and block slippage failure mechanisms could be mobilised from interpreted joint sets and random joint combinations on the slope faces for the East Pit. In this case, failure mechanisms mobilised from joint sets are more likely to occur than the random intersections.

In light of the findings presented, it is strongly recommended that further ATV work be conducted to improve the reliability of structural patterns across the site. In addition to this, monitoring of rock exposures is recommended to highlight those areas of the pit which may be susceptible to the different failure mechanisms.

10 CUT SLOPE STABILITY

10.1 Material Properties

Material properties were derived mainly from geotechnical testing, with the exception of the Yarrabee Tuff which was estimated from other projects and local experience. Table 10-1 summarises the strength parameters for each of the overburden geomechanical units identified.

Table 10-1 : Shear Strength Values for Analysis

Horizon	Density (kN/m^3)	Cohesion (kPa)	Friction Angle (ϕ)	Source
Unit 1	21.3	37	22.5^0	Single Measurement
Unit 2	22.1	46	23.4^0	Average of Measured
Unit 3	22.6	49	30.3^0	Average of Measured
Unit 4	23.1	72	24^0	Average of Measured
Unit 5	23.5	75	30^0	Estimate
YT - Low		15	15^0	Lake Lindsay Residual
YT - High		1	24.5^0	Middlemount Average
Spoil		30	34^0	Measured from Composite Cuttings
Base Spoil	Clay	0	29^0	Measured from Composite Cuttings
Base Spoil	Weak Rock	0	23^0	Capcoal Value for Fine Spoil

Triaxial shear testing on samples collected from Unit 2 to Unit 4 produced some variable results for cohesion and friction angle; therefore, average values were used for analysis. The selection criteria of appropriate strength parameter values for Unit 2 to Unit 4 are as follows:

- The elimination of unreliable data by selecting appropriate Mohr circle combinations from triaxial shear test results;
- The exclusion of outlier values and the use of engineering judgment for value selection – for example, the laboratory results indicated cohesion values for Unit 2 samples tested of 120 kPa. In this case, a 50% reduction was assumed to account for site variability; and
- Similarly, samples tested from Unit 4 samples indicated cohesion values > 260 kPa. In this case, a cohesion value of 75 kPa was assumed to account for site variability and also for applicability in limit equilibrium modeling.

Direct shear testing was conducted on two samples recovered from the Yarrabee Tuff (YT) and recorded friction angles of 38.5° and 29.5°, and cohesion values of 11 kPa and 70 kPa, respectively. These results were considered to be high in comparison to average shear strength values across the Bowen Basin.

The nature of the YT is known to be quite variable, from brittle to puggy, sometimes with slickensided partings, however the worst case for stability is where there has been bedding plane shearing, producing a pervasive smooth or slickensided planar surface, with a relatively low shear strength. In this case, the residual shear strength value taken from Lake Lindsay was used for analysis to represent the low strength case, and a high strength case recorded from Middlemount (Table 10-1).

10.2 Generic Design Criteria

The generic design criteria have not changed from the original proposed for the feasibility study. For the geotechnical conditions expected at Codrilla, the basic design criteria are presented below in Table 10-2.

Table 10-2: Generic Design Criteria

Material	Bench Height (m)	Slope Angle (°)	Berm Width (m)
Unit 1, 2, 3 & 4	20	45	10
Unit 5	Variable	55	15
Fresh Rock	40 - 45	65	15

The generally accepted minimum Factor of Stability (FOS) for mine slope design, is 1.2 (Ref 3), where the FOS in the context of limiting equilibrium slope stability analyses is defined as the ratio of resisting forces to disturbing forces for any given slope failure configuration.

10.3 Generic Slope Design

The Codrilla deposit is characterised by a thick cover of soft overburden comprising Tertiary and weathered Permian that is predominantly sandy clay or claystone. The nature of this material means that soft slope batters are required down to at least the base of Unit 4. The underlying fresh rock is generally moderately strong to strong, but is likely to contain structural discontinuities and associated defects and could be subject to significant in situ stresses from the deep excavation level.

Taking these factors into consideration, a generic slope design was adopted based on operating practice in other opencut mines in the Bowen Basin. This is illustrated in Figure 10-1.

Slopes through the clay layers down to the base of Unit 4 were designed at 45° batter angle with 20m high benches and 10m wide berms. The ground level is generally flat at approximately RL180; therefore benches are designed on levels RL160, RL140 and RL120. The batter angle for the bottom bench through the weathered Permian strata of Unit 5 is increased to 55°. The design is intended to give an overall slope angle of approximately 35° down to the BOW.

The height of the bottom bench through Unit 5 will vary according to the location of the BOW, but for analytical purposes the average Unit 5 thickness of 15m is used, with a 15m berm at rockhead. The 10m intermediate berms are designed to have sufficient width to catch any accumulation of material from slumping or partial collapse of the bench due to erosion or slumping of horizons of loose or water-bearing sand.

A conservative batter angle is advised for rock benches, at least for planning purposes, because of the high potential for defect driven instability, and the

possibility of stress-induced movement affecting the integrity of the rock mass. Rock batters in this case would be limited to 65°. Based on the current pit design, a 15m berm is allowed for at rockhead (base of Unit 5) to allow for any defect-driven instability, such as fault bounded wedge failures or planar failures that would otherwise undercut the soft overburden and potentially precipitate major slope failure.

Multiple pass mining of the intermediate seams will influence the height of benches in the rock slopes; therefore actual slope configurations will be variable, however, a maximum bench height of 40m is specified. This is also dependent on the proposed mining method. Generally, a maximum bench height of 40m is preferable for operations from a safety perspective however a 45m bench height would be more appropriate for dragline mining (refer Figure 10-1). At this stage MCC have not indicated a preferred mining method.

The generic design for the soft overburden was tested using the Galena code for circular slip failure. Multiple analyses were performed using the Bishop Simplified method to establish the least stable slip surface within the constraints. The shear strength parameters used for the analyses, where possible were updated from the Feasibility Study (Table 10-1). Dry conditions were presumed given the predominantly clay sequence and lack of aquifers. At this stage, the soft overburden units were modeled as horizontally disposed.

10.4 Generic Design Results and Discussion

The slip circle configurations are illustrated in Figure 10-2. The toe of the failure was taken at the toe of the bench and the most critical slip circle in each case had a backscarp 5m back from the crest (mid-berm).

The results of the slope stability analyses are summarised below in Table 10-3.

The results of individual analyses are presented in Appendix C.

Table 10-3 : Factors of Stability for Circular Slip Failure

Bench	Material	Factor of Stability (FOS)
Bench 1	Units 1, 2 & 3	1.47
Bench 2	Unit 3	1.67
Bench 3	Unit 4	1.92
Bench 1+2	Units 1, 2 & 3	1.54
Bench 2+3	Units 3 & 4	1.55
Bench 1+2+3	Units 1, 2, 3 & 4	1.34

Using parameters updated from the Feasibility Study, these were still considered to be conservative; however the results indicate that mass slope failure would be unlikely.

Based on the results of the slope stability modeling, it is concluded that the proposed bench configurations for the generic design provides an adequate degree of stability against mass failure of the Tertiary and weathered Permian clays. This part of the design, down to the base of Unit 5, is applicable to all slopes. The full generic design including the weathered Permian rock (Unit 5) and fresh Permian rock is applicable to all highwall and endwall slopes not subject to structural disturbance, and where there is not an adverse dip in the face (refer Figure 10-1). The design however is not applicable to boxcut - low walls.

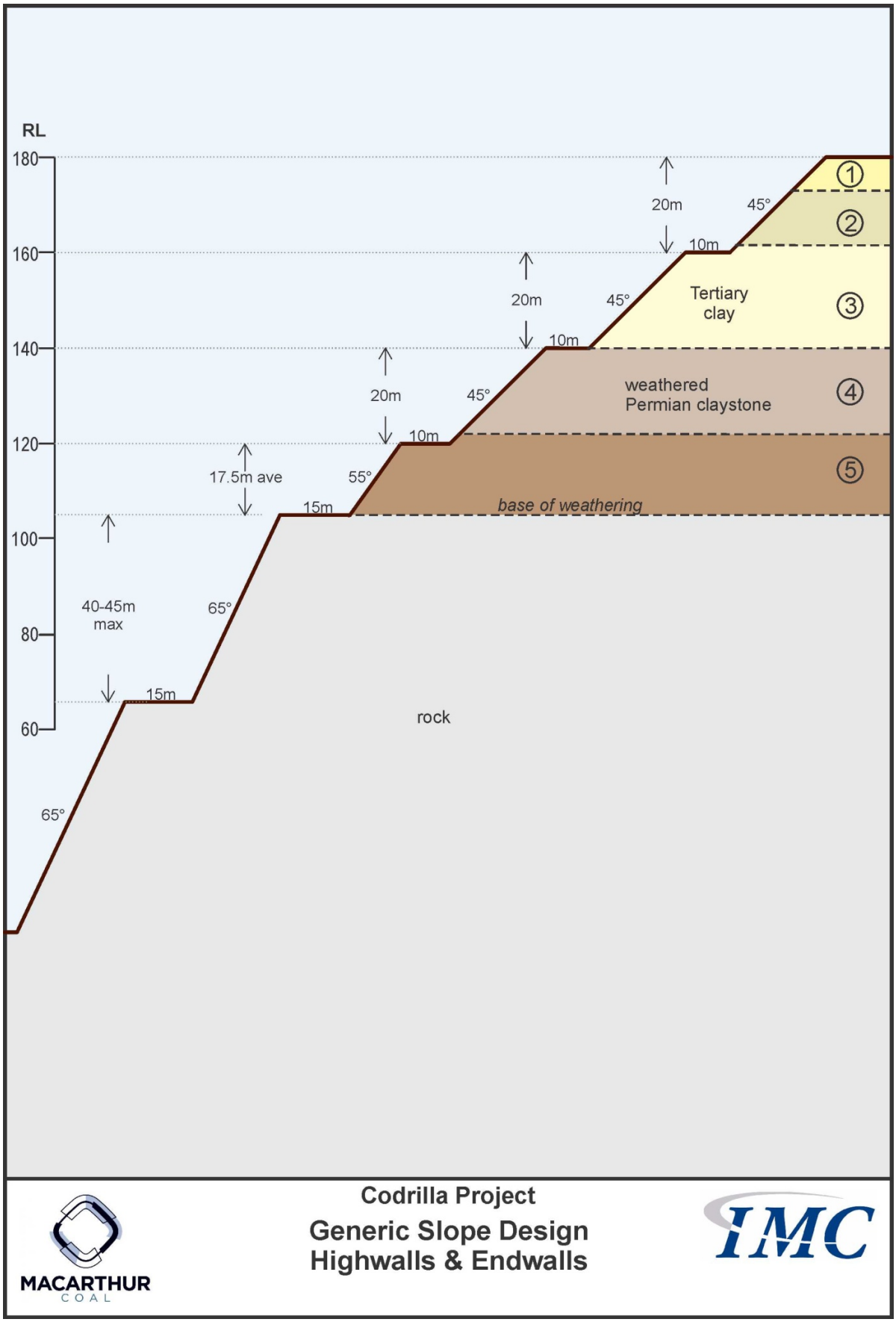


Figure 10-1: Generic Slope Design

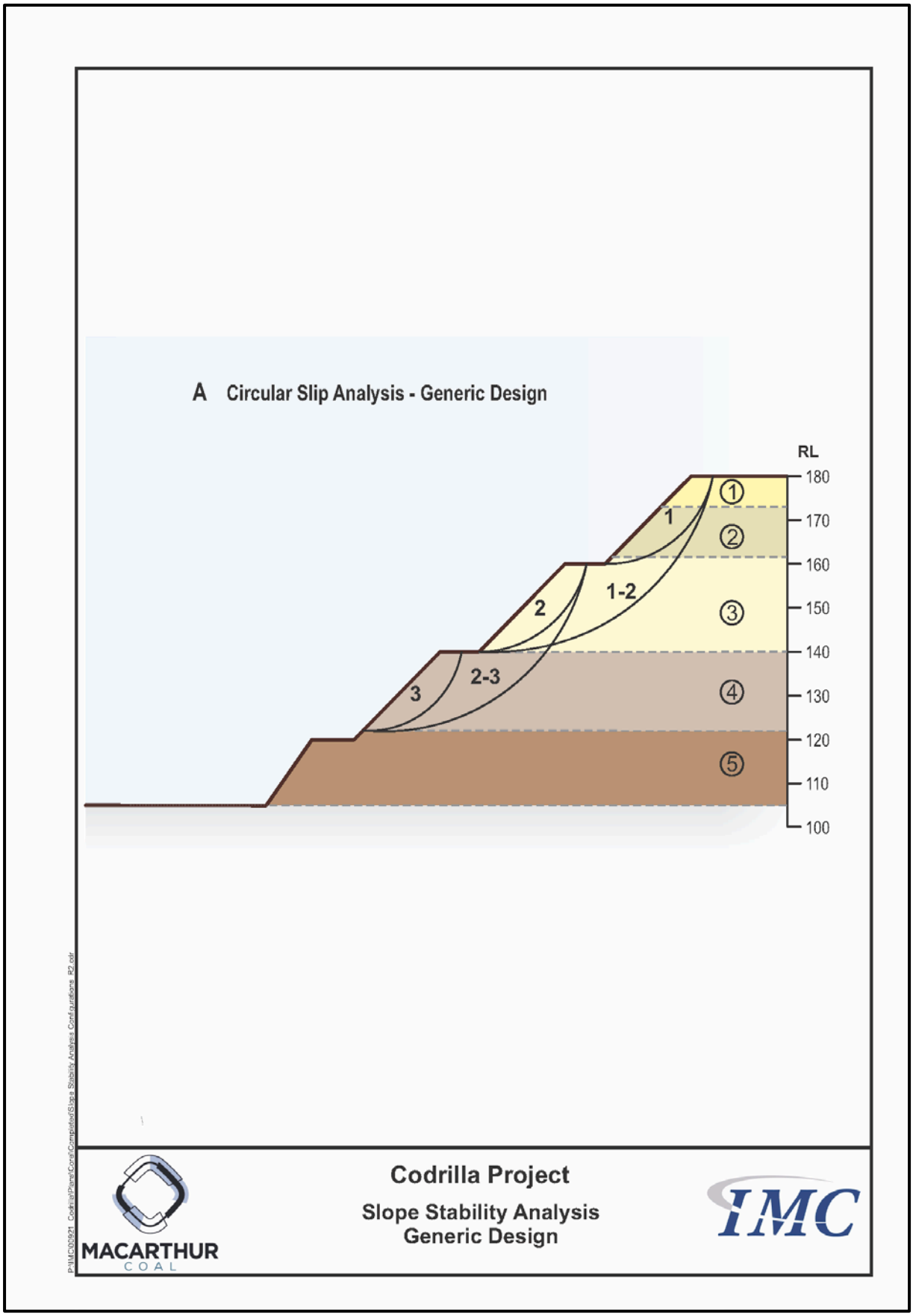


Figure 10-2: Generic Slope Stability Analysis

10.5 Summary of Previous Numerical Modelling

For the Feasibility Study, finite element analysis using Phase2 software was completed as part of a general analysis.

As the potential depth of mining could be up to 200m, insitu and mining induced stress could have an impact on the stability of the rock slopes. A finite element analysis, using the Phase2 code, was accordingly carried out to gauge the effect of stress on the wall design. The model used was as per the generic design (total wall height 165m) with the addition of horizontally disposed rock overburden units covering the VU Seam to LU Seam interval.

Figure 10-3 shows the slope model used for the numerical analysis; the overburden layers are horizontal, as the dip does not materially affect the stress distribution. Rock mass properties used in the model are summarised in Table 10-4.

Table 10-4 : Rock Mass Properties for Numerical Modelling

Unit	Lithology	Sonic Velocity (m/sec)	Density (t/m^3)	Intact UCS (MPa)	In situ UCS (MPa)	E (MPa)	ν	Φ (°)	C (kPa)	T (kPa)
1	Superficials		2.0		0	10	0.33	30	0	0
2	Laterised zone		2.2		0.08	16	0.33	25	25	0
3	Tertiary clay		2.25		0.17	34	0.33	30	50	0
4	Weathered Permian claystone		2.25		0.5	120	0.3	30	0.14	0.04
5	Weathered Permian rock		2.35		1	250	0.3	30	0.29	0.08
6	Siltstone 1	4000	2.5	30	17	5500	0.25	40	4	1.4
7	LU Seam		1.6	10	5.6	2240	0.3	40	1.3	0.45
8	Sandstone 1	3900	2.5	30	17	5500	0.25	40	4	1.4
9	LL1 Seam		1.6	10	5.6	2240	0.3	40	1.3	0.45
10	Sandstone 2	4000	2.5	30	17	5500	0.25	40	4	1.4
11	Siltstone 2	3600	2.5	25	14	4500	0.25	37	3.5	1.1
12	LL2 Seam		1.6	10	5.6	2240	0.3	40	1.3	0.45
13	Siltstone 3	3300	2.5	20	11	3500	0.25	35	2.9	0.9
14	VU Seam		1.6	10	5.6	2240	0.3	40	1.3	0.45
15	YT/VL1/FL1		2.0	6	3.4	1360	0.3	30	1	0.3
16	FL2 (siltstone)	3200	2.5	20	11	3500	0.25	35	2.9	0.9
17	FL3 (sandstone)	4200	2.5	30	17	5500	0.25	40	4	1.4

The upper coal seams have been modelled as interfaces (joints) but the VU Seam has been included as a discrete layer. The weak floor beneath the VU Seam has been modeled as a composite unit consisting of the Yarrabee Tuff, VL1 Seam and Unit FL1, with the top of the Yarrabee Tuff as an interface. Interface properties are listed in Table 10-5 below. The analysis is essentially elastic deformation but allowing the interfaces to fail. A hydrostatic stress field was assumed, in this case, as it represented the simplest modeling case, with the least variables.

Table 10-5 : Joint Material Properties

Interface	Normal stiffness (MPa/m)	Shear stiffness (MPa/m)	Joint cohesion (MPa)	Joint friction angle (°)	Joint Tensile strength (MPa)
Coal seam	15000	6000	0.8	30	0.2
Yarrabee Tuff	10000	4000	0.5	25	0.1

Figure 10-4 shows the stress distribution for the major principal mining induced stress. The stress reaches about 2 MPa towards the bottom of the slope, with a higher concentration up to 5 MPa in the immediate floor at the toe.

Figure 10-5 shows the strength factor, that is, the ratio of rock strength to stress. The modelling results indicated that there was no failure of the rock strata, but the strength factor was less than 1.25 at the toe, and the YT interface was failing.

In practical terms, for a jointed rock mass the strength factor plot would suggest that some degree of local failure could become manifest towards the base of the wall where the maximum wall height exceeds about 160m. This could result in blocks falling out and undercutting the wall but would not necessarily lead to mass instability. As the mining is a multi-seam operation, the pit will be terraced such that the full height would only apply to the final highwall and a small section of the endwalls.

The model shows that low strength bedding planes or intraformational shear planes (and no doubt any structural discontinuities such as thrust planes) would fail at 160m wall height. In the case of adversely dipping beds or structure, block movement out of the wall would probably occur, which could present a risk of larger scale failure.

The analysis presented did not incorporate the in-situ stress field, since the tectonic setting at Codrilla is known to be complex (as outlined in previous sections), therefore the typical Bowen Basin setting may not apply. Now that the final highwall locations are known, it may be appropriate to consider a more detailed numerical modeling approach based on actual geology, within which potential variations in the stress field could be tested, using specific kinematic scenarios.

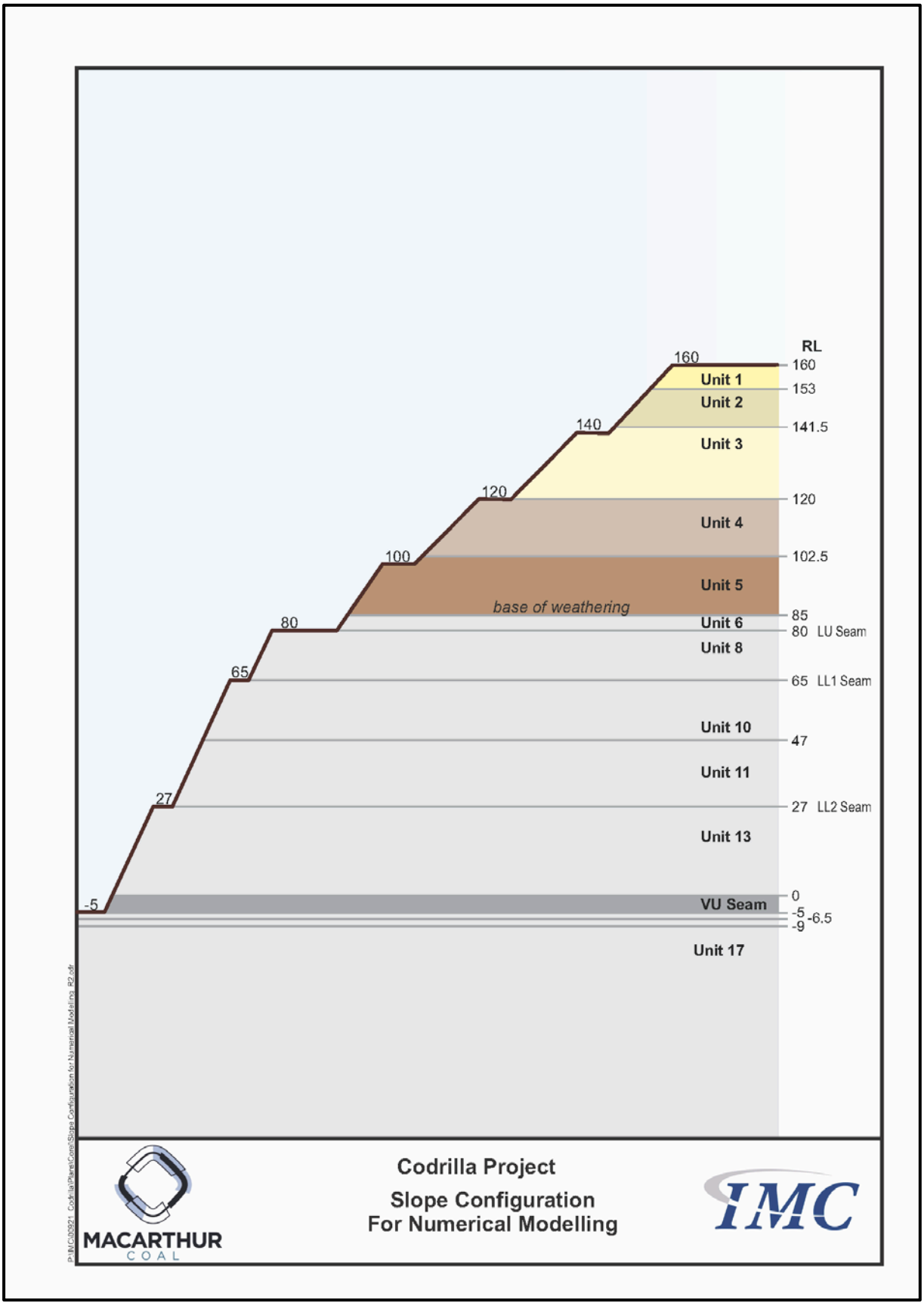


Figure 10-3: Slope Configuration for Numerical Modelling

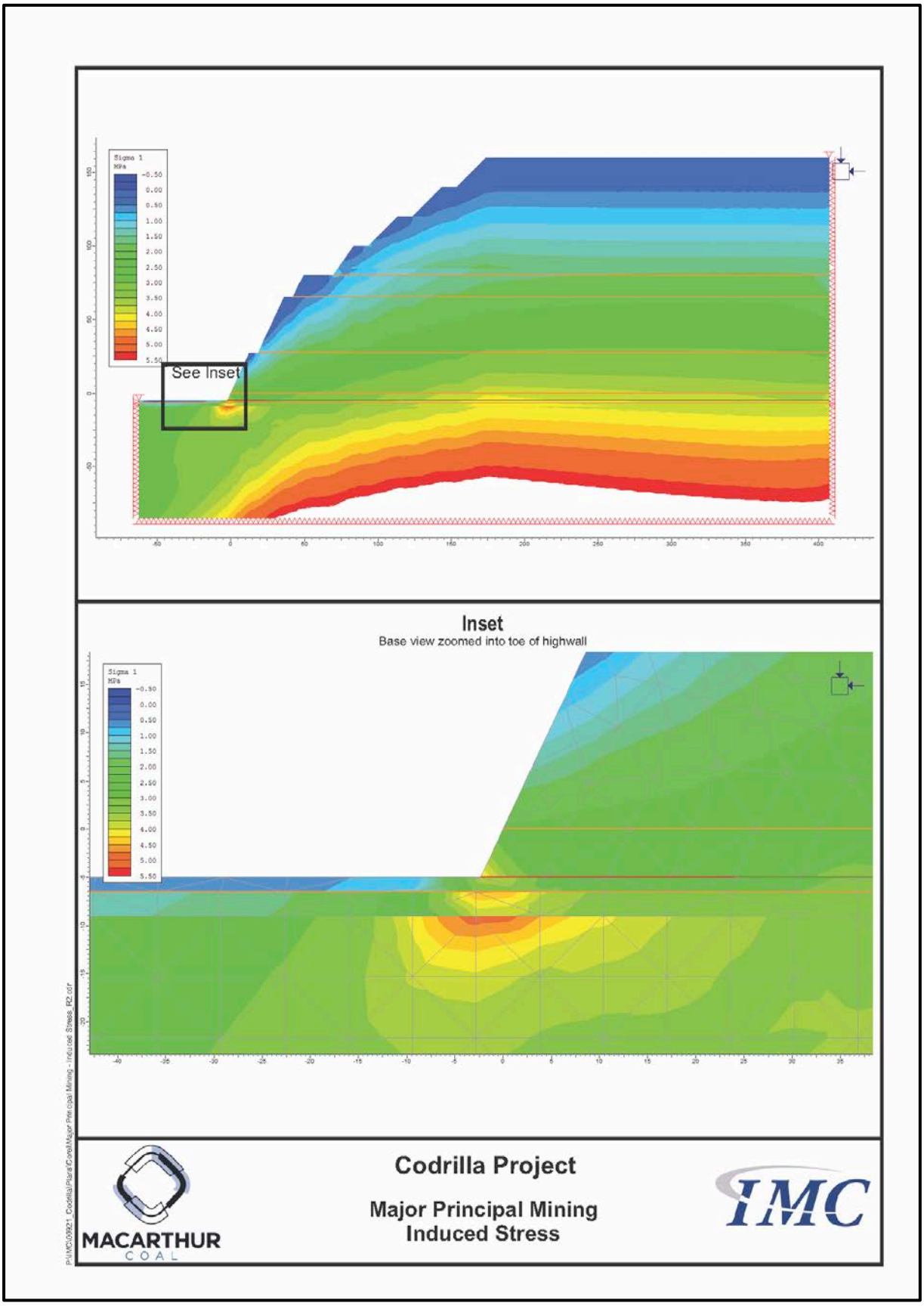


Figure 10-4: Stress Distribution

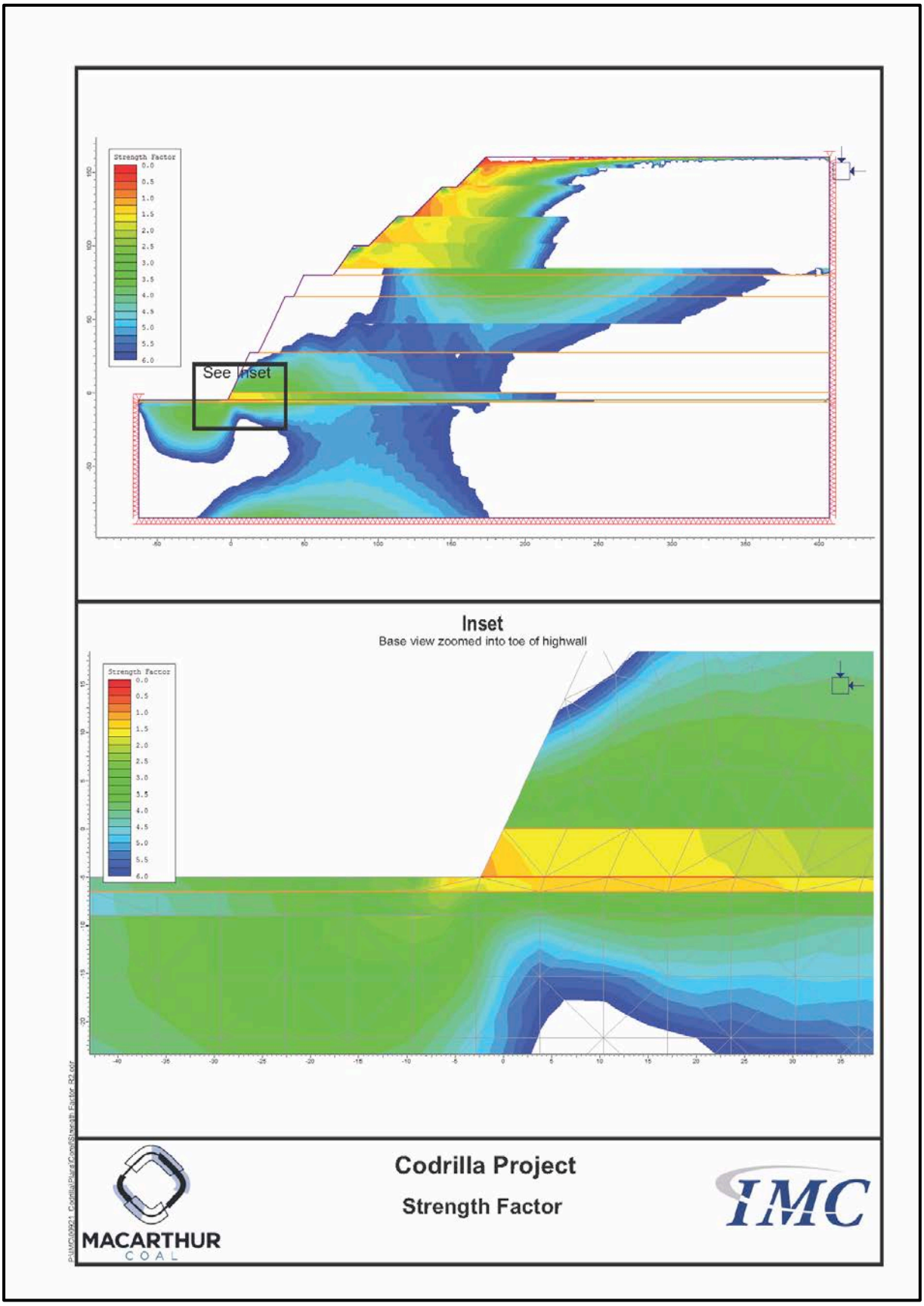


Figure 10-5: Strength Factor

10.6 Box Cut – Low Wall Stability Analysis

Boxcut - Low wall stability is a function of geometrical constraints resulting from a combination of the dip, the depth of the low wall, and the thickness of the Tertiary, as well as the material strength.

The LOX line (subcrop) for the VU Seam was divided into zones of similar geometry for analysis, from which slope designs have been generated. This should be satisfactory for general planning purposes, but it should be noted that there are variations within the zones, which could necessitate local adjustment to the design at a more detailed level of mine planning.

A total of 11 low wall zones were generated to represent the different stability zones around the pit. This included 4 sections from the West Pit and 7 sections from the East Pit. Figure 10-6 presents the low wall zone locations used for stability analysis.

The Tertiary clay (Unit 3) was identified as being a major driver of instability, due to the low shear strength. The thickness of Unit 3 Tertiary clay, depth to BOW and floor dips for each section are summarised in Table 10-6.

Sections which represented the best and worst case stability zone scenarios were selected from each pit from the low wall and endwall zones. In most cases there were similarities between stability zones, in terms of floor dip and overburden thickness, therefore a representative case was chosen for zones of similar characteristics in each case. The generic slope design was applied for all cases.

At this stage, a representative highwall case was not analysed as the possibility of block slippage was considered to be very low due back a back dip, however further discussion on highwall geotechnical hazards is presented in Section 10.9.

Analyses were carried out to examine the stability with respect to a full height failure configuration. In addition to this, lower height analyses were conducted where the failure surface for a full height failure was deemed to be unrealistic, due to the geometry of the VU floor. In this case, a failure surface through to a lower bench was examined.

Table 10-6: Low Wall Stability Zones

Section	Unit 3 Thickness (m)	Base of Weathering (m)	VU Seam Dip	Location
Zone A	40	70	14.0°	West Pit
Zone B	33	65	10.3°	
Zone C	31	53	17.6°	
Zone D	39	63	11.3°	
Zone E	39	72	12.6°	East Pit
Zone F	37	72	5.5°	
Zone G	57	90	16.2°	
Zone H	41	69	10.3°	
Zone I	44	78	11.3°	
Zone J	38	74	6.0°	
Zone K	45	78	10.3°	

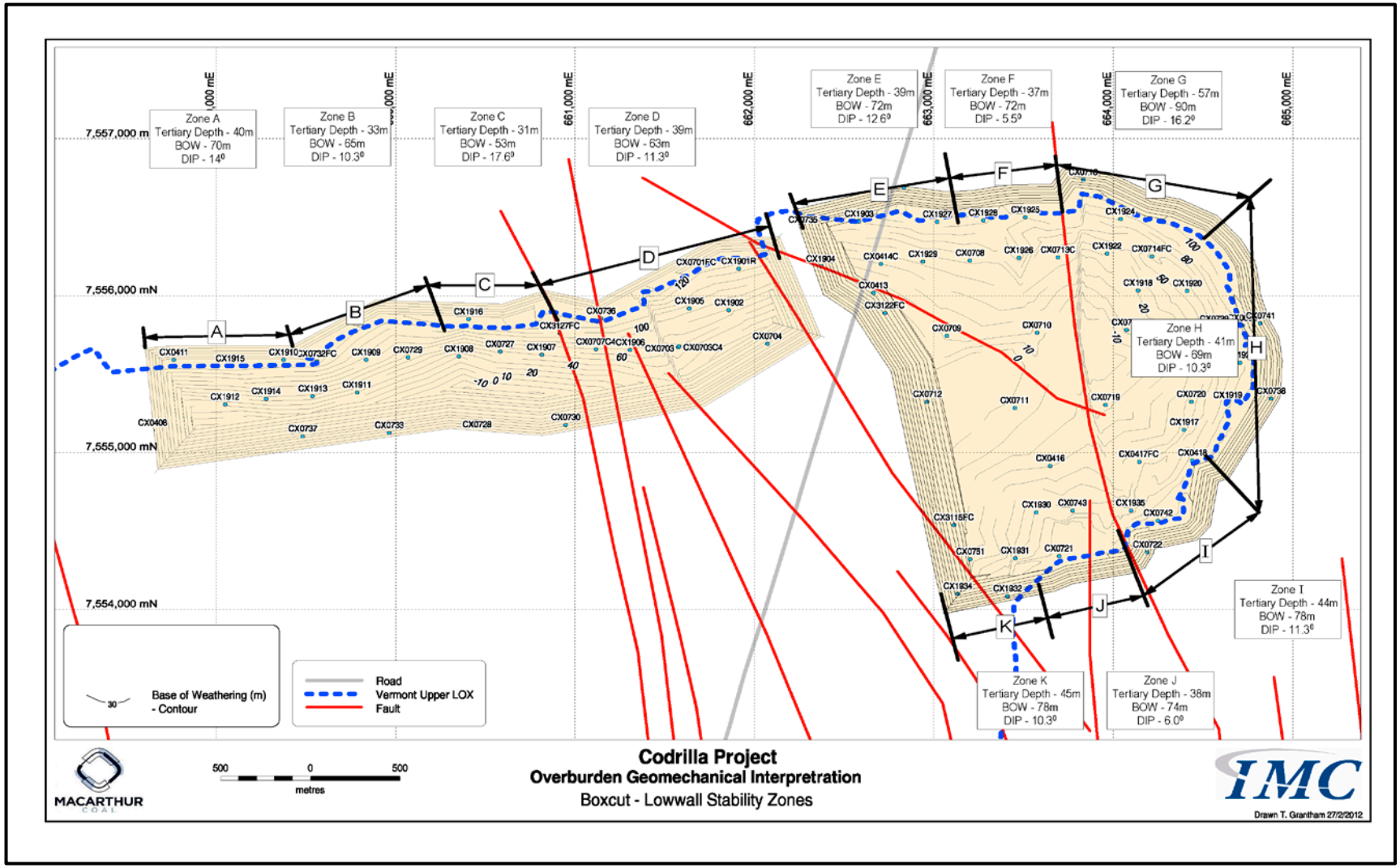


Figure 10-6: Lowwall Stability Zones – West and East Pit

10.7 Modelling Cases

Representative cross sections were compiled for each of the zones, based on the generic model, and a potential composite failure surface was estimated. This was based on a planar section from the toe to the intersection of the extrapolated YT with the base of Unit 4, and a quasi-circular section up to the crest at the point where a rising 60° line met the slope surface. Figure 10-7 shows the non-circular failure surfaces for used in the analysis for each case.

For this study, a total of 7 low wall stability cases were examined, as shown in Table 10-7. Each section was then analysed using the Galena code for Sarma's method for both high and low basal strength cases.

Table 10-7: West and East Pit Low wall Stability Zones for Analysis

Pit	Low wall Stability Zone
West Pit	Zone A
	Zone B
	Zone C
East Pit	Zone E
	Zone F
	Zone G
	Zone I

Zones A to C, and G and I represent low wall profiles in the West Pit and East Pit, respectively, whilst Section E and F represent the end wall profiles in the East Pit. The end wall location on the eastern end of the West Pit will be dictated by the major fault which at this stage has not been defined sufficiently to allow a representative geological section to be established. It is possible that the end wall profile will be formed in solid ground to the west of the fault. It should also be noted that there are variations within the zones, which could necessitate local adjustment to the design at a more detailed level of mine planning.

For all profiles, a high and low YT shear strength case was modeled, as shown in Table 10-1.

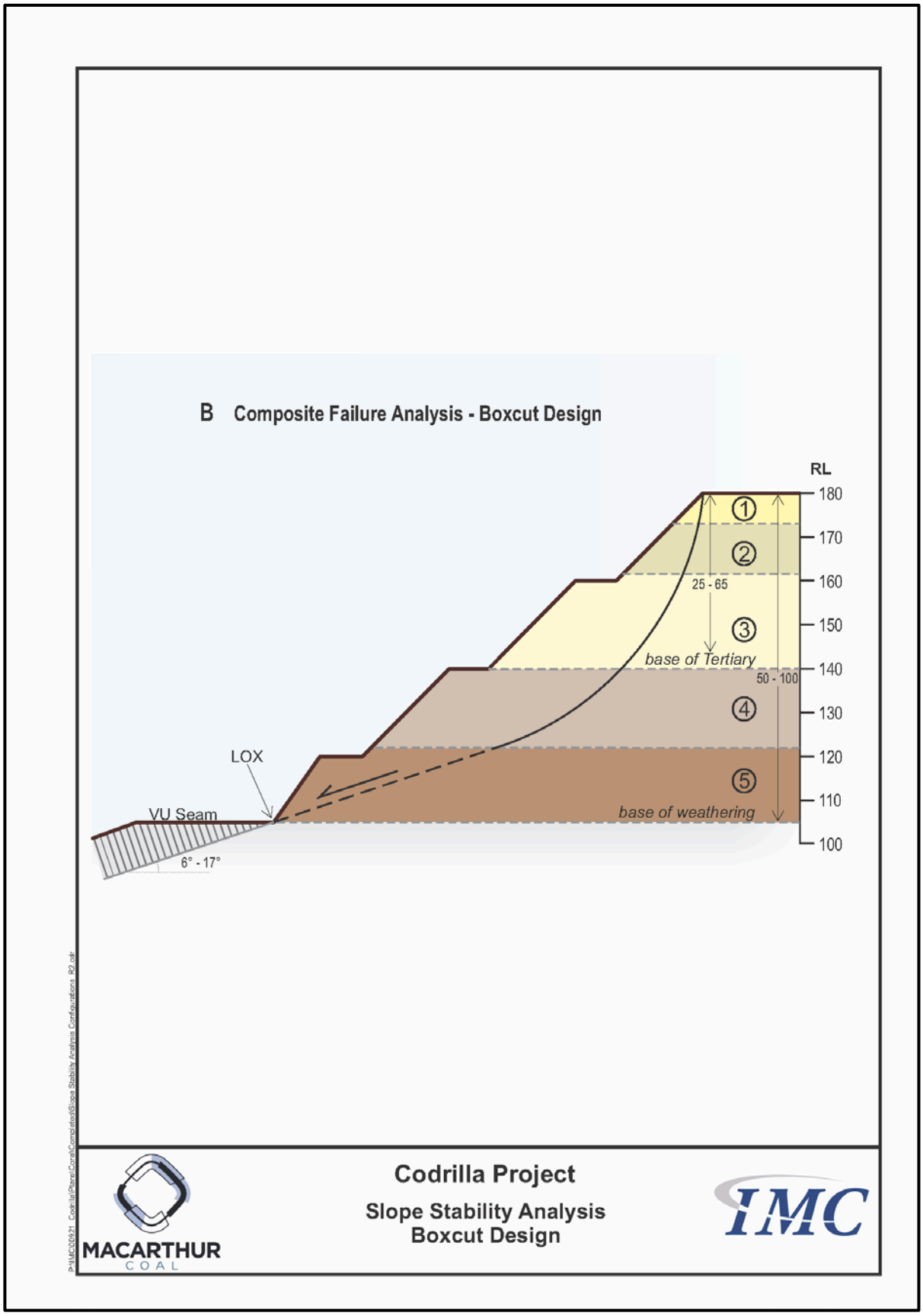


Figure 10-7: Low Wall Slope Stability Analysis

10.8 Boxcut – Low Wall Stability Analysis Results

Table 10-8 below summarises the results of the stability analysis.

Table 10-8: Factors of Stability for Circular Slip Failure

Stability Zone	Dip Angle (°)	FoS Upper Shear Strength	FoS Lower Shear Strength
Zone A – Full Height	14.0	**1.09**	**1.00**
Zone B – Full Height	10.3	1.26	**0.98**
Zone C – Full Height	17.6	**1.16**	**1.14**
Zone C – RL 150 Bench	17.6	**1.17**	**1.09**
Zone D – Full Height	11.3	1.21	**0.96**
Zone E – Full Height	12.6	**1.12**	**1.01**
Zone F – Full Height	5.5	2.22	1.57
Zone G – Full Height	16.2	**1.05**	**0.93**
Zone I – Full Height	11.3	1.19	**0.94**

orange highlight indicates FoS < 1.2

The results indicate that under a low strength scenario all zones would present an unstable configuration for the generic slope design, with FoS less than 1.2, except for Zone F in which the critical floor dip was not exceeded, thus presenting a stable configuration. For the high strength scenario the results indicate an acceptable FoS for the shallower dip Zones B, D, F and I, with FoS less than 1.2 for the remainder. Allowing for variation in shear strength and the probability that the low strength value would apply at least in part, it is clear that some design modification would be required to ensure there is an adequate level of stability.

There is a possibility that intermediate height failures would also show a less than adequate FoS but these have not been examined as it is the full height case that will ultimately be applicable.

The available options for mitigating the risk of systematic slope failure include:

- Setting back toe up-dip of lox line (dummy boxcut); and
- Excavating below Unit 4 in 60m bays and backfill (toe buttress).

In the first option, the potential for major failure can be designed out by geometric changes that remove the planar slip surface from beneath the main part of the slope. This can be achieved by shifting the low wall toe up-dip and creating a dummy boxcut up-dip of the LOX line, as indicated in Figure 10-8.

A 35m toe shift would eliminate the potential for a composite slip failure in Zone C. It would not eliminate the potential for failure but would restrict the potential failure

to the third bench (Unit 4 bench) in Zone A, which may be an acceptable risk. However, a 35m shift plus a 15m berm at the base of Unit 4 would eliminate the potential for a composite slip failure in Zone A. Zone F would not require any shift in the toe position.

The geometry for Zones B, D, E, G and I is such that a 50m - 65m wide dummy boxcut would be needed to restrict failure potential, which would most likely render it financially non viable.

The second option, which was evaluated as part of the Feasibility Study, is to minimise the instability risk by limiting the exposed width of the low wall. This could be achieved by excavating the low wall in bays of limited width, approximately 50m to 60m, backfilling each with overburden from the adjacent bay. In this case the overburden could be stripped down to the base of Unit 4, or thereabouts – strictly speaking to the first onset of bedding planes in the weathered Permian – with excavation in 60m wide bays down to the VU Seam.

This would leave a spoil buttress against the low wall to counteract any subsequent slippage on the residual section of bedding, as illustrated in Figure 10-9. There should be no need to excavate up-dip of the LOX line, so that although the method is not efficient in operation, it at least delivers coal unlike the dummy boxcut approach.

The efficacy of this option was tested as part of the Feasibility Study using a spreadsheet version of the modified Bishop method of slices. The slope geometry was as per the illustration in Figure 10-9, with a 60m wide buttress to the height of the bottom bench, with a 35° batter. The standard Capcoal shear strength value for fine spoil was used for the base of the buttress (see Table 10-1 showing shear strengths in Section 10.1), assuming Permian rock spoil would be used for this purpose. The analyses were for dry conditions with the same composite failure path as used before.

The results of modeling, for the low strength YT scenario, were FoS varying from 0.96 to 1.25. They indicate that although the buttress approach improved the level of stability for short term design; however the FoS values were less than acceptable for the medium term, which suggests that the buttress would not be satisfactory for a fully-opened length of low wall.

There is also a high probability of random instability from undetected structural disturbances or seam rolls. In general terms, the main fault direction is north-south and the seismic interpretation suggests associated thrusting or compression folding rising to the east. With this configuration, locally steep dip components would be perpendicular to the northern and southern low walls and thus would not constitute a stability hazard, however, on the east low wall the dip planes would be adversely oriented with respect to the low wall, and would thus present a significant stability hazard where they daylight out of the low wall.

Slope failure in these cases would take the form of block slippage down the thrust planes, which is likely to result in full slope failure. Even if the initial slippage is only partial height, it could result in undercutting the upper benches and lead to full scale slope failure.

Some local modification to highwall orientation may be required in faulted areas, to accommodate adverse combinations of fault and joint planes. This would typically involve rebating the highwall to sufficient depth to remove potentially unstable

masses. As the exact nature and disposition of the fault planes will not be known with sufficient certainty beforehand, design changes will probably have to be made as and when conditions are exposed during mining.

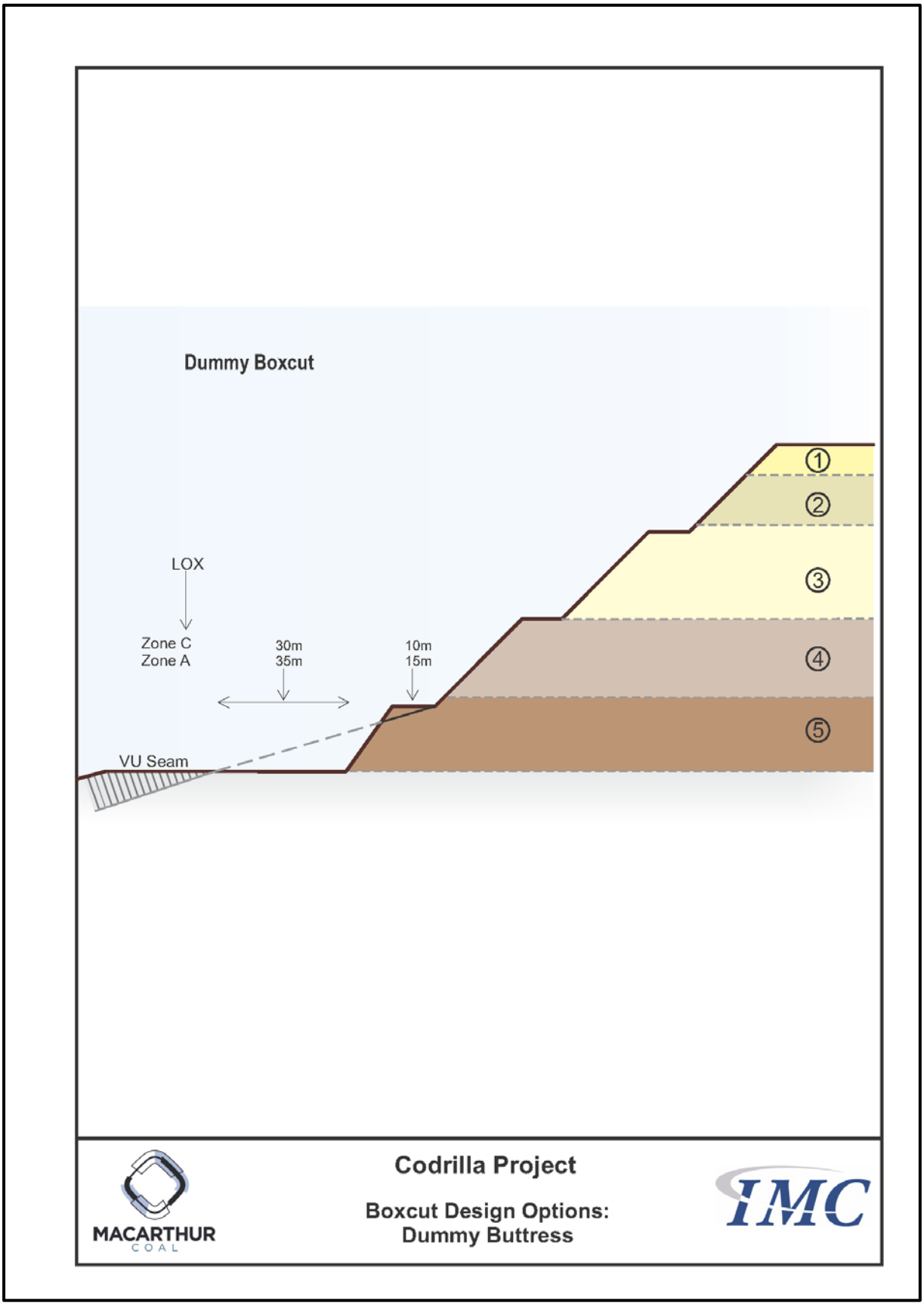


Figure 10-8: Boxcut Design Option – Dummy Boxcut

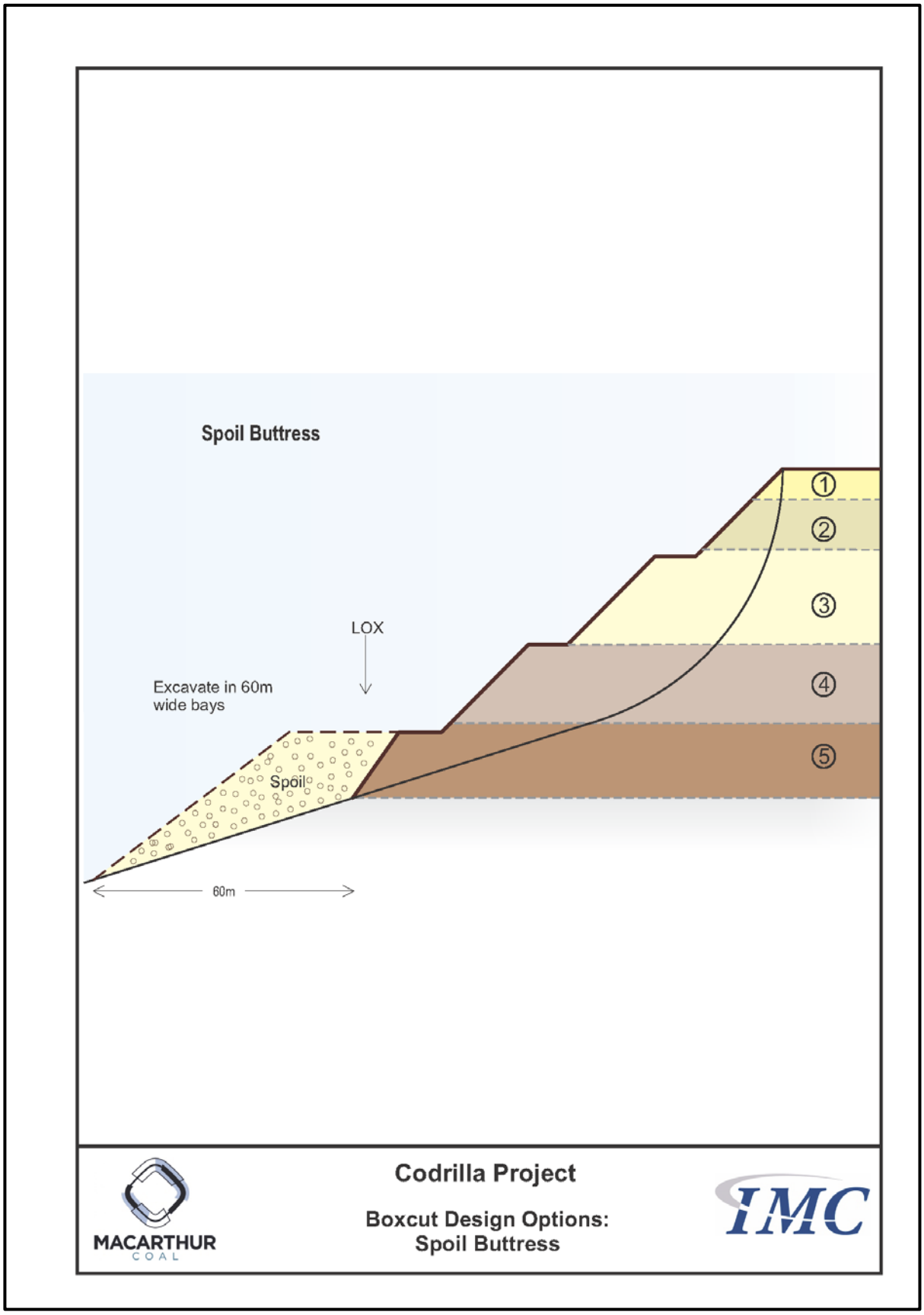


Figure 10-9: Boxcut Design Option – Spoil Buttress

10.9 Fault/Structural Interactions on Pit Walls – Principal Hazards and Controls

10.9.1 Bench Scale Hazards

The kinematic analysis showed the potential for planar and wedge configurations, which may lead to bench scale failures. As mentioned previously, these types of small to medium scale failures could be common occurrence during operations. Adequate controls would need to be implemented to sufficiently mitigate operational risks. These controls could include the following:

- Sufficient berm widths to contain gravity induced failures;
- Bench face scaling (where possible) to remove loose materials; and
- Pre-split blasting of the face to reduce back-break, which tends to reduce dilatancy of the discontinuities, and by imposing of a 10m exclusion zone at the foot of the wall. The recommended 65^0 bench angle through rock benches is typically the maximum lay-back for angled pre-split drilling.

10.9.2 Large Scale Hazards

The structural model supplied by MCC indicates there are several major faults identified at the Codrilla site (refer Figure 10-6). The north - south striking faults in the East Pit would have the potential to cause significant instability on interim highwall positions of the East Pit if the mining direction was from east to west.

Another oblique fault was observed to intersect the east pit final highwall, although the angle of intersection between the fault and highwall is greater than 20° and may be less likely to impact on stability.

There was a significant fault zone also observed in the West Pit; however the faults appear to intersect the highwall and low wall sub-perpendicular. The mining impacts of this would be relatively low, however regular monitoring is recommended.

It should be noted that there is some discrepancy between the information presented in the structural model compared to that from the 2D seismic. The 2D seismic supplied by MCC indicates a wide, structurally disturbed zone associated with the large scale faulting within the East Pit. From a geotechnical perspective, these fault zones have the potential to generate significant instability for the interim highwall positions. Figure 10-10 shows the 2D seismic section through the East Pit.

The 2D seismic also shows the faults to be variably oriented. In this case, mobilisation of several failure mechanisms could be possible, which would further increase the likelihood of instability. The 2D seismic output is presented in Figure 10-11. At this stage, there is limited information which systematically defines the characteristics of the large fault zone in the East Pit. The 2D seismic generally provides a good method to define the presence of structures and give an indication of overall displacement; however it usually contains insufficient detail for operational planning. It is recommended the 2D seismic information be incorporated into the current geological model.

Floor dip is not normally of major concern for typical highwalls; however given the identified disturbance zones it is possible for floor dip reversals in any of the walls. This may be evaluated by assessing the target seam floor structure. Adverse floor dips/floor dip reversals generally occur in the vicinity of major faults, where the

strata deform in response to the fault movement and increase in dip towards the fault. These can occur over very short distances (between boreholes) and may be undetected during ground investigations. In the event of adverse dip, there would be a need for further analysis to evaluate the impacts on wall stability. At this stage, no information was available in order to assess floor dip reversals.

An assessment of the VU floor contours indicated variable floor dips along the low wall sections of the East and West Pits. Generally, the risk of mass block slippage on the floor increases where the dip exceeds approximately 8°. In this case, floor generated instability for the pit wall is considered unlikely, except in the case of the south-west facing sidewall, where the dip rises to the fault.

In this case, larger scale block slippage mechanisms could be mobilised, which have the potential to impact significantly on the operations and the safety of personnel. This type of failure mechanism involves a combination of high angle joint planes and basal slippage on adversely dipping beds or intraformational shear planes that are at increasing dip beneath the slope, as illustrated in Figure 10-12. In this case, the Yarrabee Tuff is considered to be the slippage plane, which is characteristically low strength, and would daylight on the pit face. The LL2 seam floor also indicated evidence of intraformational shearing. Due to the steeper inclination, adverse gravitational forces would be generated which, in conjunction with the removal of confining forces associated with excavation, allows the bench to move forward, resulting in the opening up any face-parallel joints.

Surface run-off down the face can enter the joint and reduce the cohesion of the bedding plane, which may encourage block slippage out of the face, particularly from the lower part of the bench. The scale of this type of failure is typically small, from small rock falls to large blocks ($\geq 10m^3$).

In cases of major pervasive joints or fault planes behind the wall, storm run-off can enter and generate hydrostatic pressure. Pore pressure uplift could also be generated beneath the block, further reducing the resistance to sliding. These forces may be great enough to disrupt the whole bench (refer Figure 10-12).

10.9.3 Monitoring and Stability Controls

Monitoring of the highwall slope is generally recommended in order to provide adequate response to large scale instability. In this case, radar techniques are particularly useful and are employed widely.

Where a highwall stability problem develops, various stability controls can be implemented to manage the operational risks. These are presented as follows:

- Locate interim highwalls either behind face parallel major structure so that the fault is mined out;
- Use photogrammetry techniques to map joint sets, which can be used to develop highwall hazard plans;
- Establish a suitable standoff distance from the fault and leave a buttress of intact rock in front of the fault;
- Management of storm water run-off to avoid flows entering joint or fault planes, or mining induced cracks on benches;

- Change in mining method to enable better stability control and flexibility through the fault zones. This may include slope stabilisation using the soft wall method (cut wall to 45^0 through faulted zones), which has proved to be an effective control in managing highwall instability at other mines; and
- Change in mining sequence to approach the faulted area from more favourable directions.

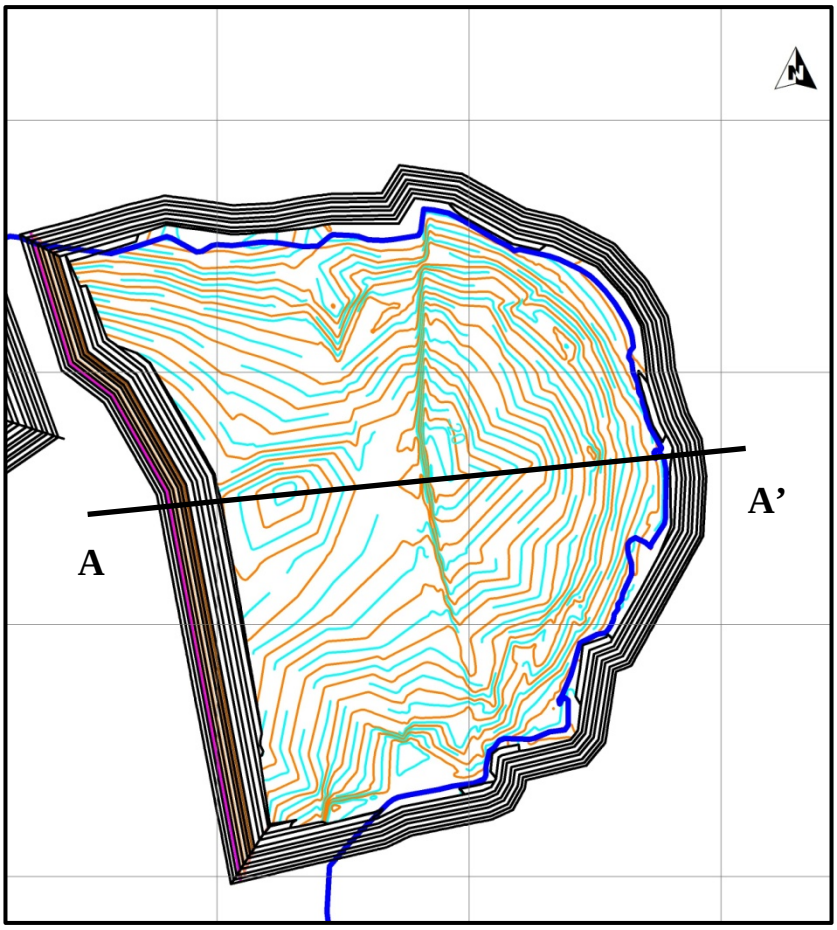


Figure 10-10: Approximate 2D Seismic Line - East Pit

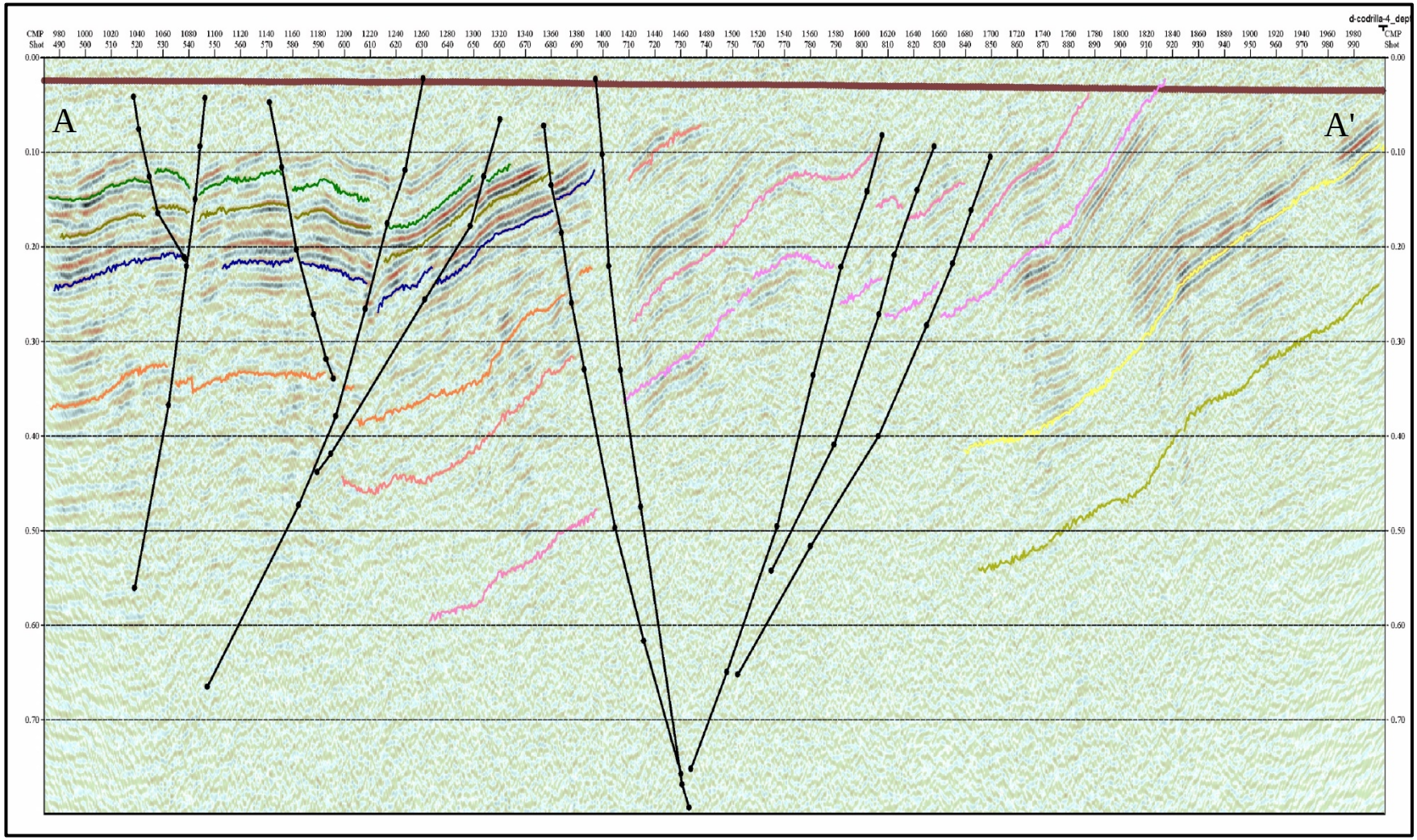


Figure 10-11: 2D Seismic Section – East Pit

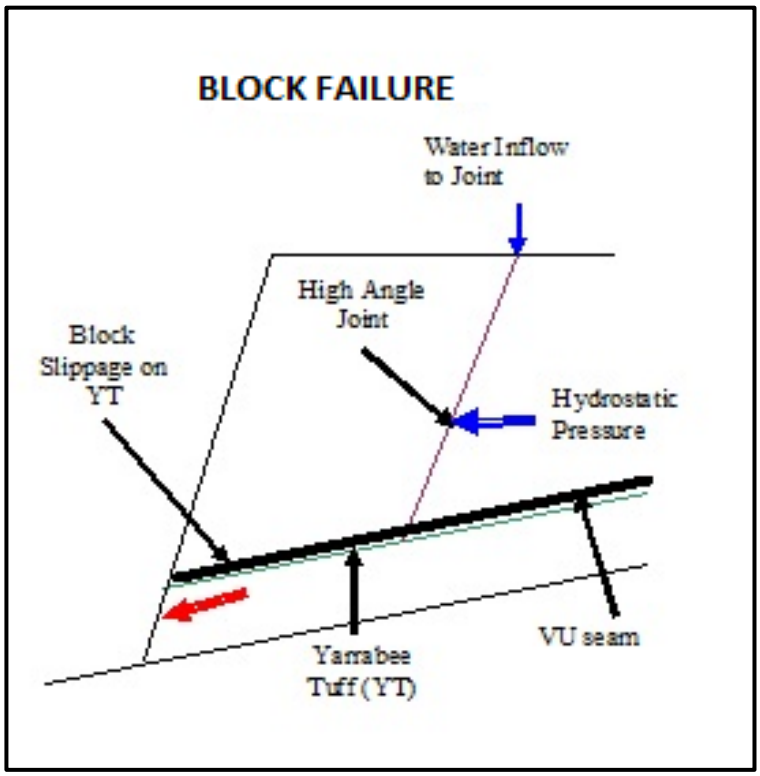


Figure 10-12: Block Slippage Failure Geometry

11 SPOIL STABILITY

11.1 Ex-Pit Spoil Dumps

Boxcut spoil will be dumped externally on flat natural ground, with batters formed by end-dumping at the angle of repose, which is presumed to be 35°. A dump height of 80m was adopted for analytical purposes, with 20m lifts and 8m berms, giving an overall slope angle of 30°.

Testing of a comminuted core sample of Unit 2 overburden indicated a peak dry shear strength of c = 0 kPa, ϕ = 40°. This friction angle is significantly higher than the standard spoil values derived by BMA and Capcoal for design purposes. Inspection of the test data showed that this value was a good fit to the data at lower normal loading, up to 300 kPa, whereas taking account of the higher test loading, up to 550 kPa, a better fit was given by c = 30 kPa, ϕ = 34°. As the dump height would give loadings in excess of 550 kPa, this value was adopted for analysis.

Slope stability analyses were made for circular slip failure using the Galena code for the Bishop simplified method for a full height failure, as illustrated in Figure 11-1A. The most critical slip surface ran from a location 10m back from the crest, and emerged 10m in front of the toe, passing through the natural ground (Unit 1 material). The analysis indicated a FoS = 1.61 for dry conditions, and a FoS = 1.42 for a phreatic surface up to 20m above natural ground within the dump. The latter is a very conservative condition as the bulk of the spoil is likely to be more or less impermeable clay. The Galena output is presented in Appendix D.

The results indicate that instability in benched external spoil dumps with angle of repose batters is not going to be an issue. Note that in consideration of ex pit dumps that there may be a need to establish a flatter final batter at say 1 in 3.5 grade for rehabilitation. A minimum 20m stand-off distance from the wall crest should be allowed for to avoid any undercutting of the spoil in the event of localised failures through the in-situ slope beneath. The stand-off would need to be increased to 50m for Low wall Zone K, where the slope geometry indicates a potential major failure path could occur approximately 42m back from the crest.

11.2 In-Pit Spoil Dumps

For conventional strike mining, with down-dip strips to an advancing highwall, dumping of spoil up-dip of the working area can create a risk of spoil failure through slippage on the floor of the dump. This risk typically becomes elevated where the dip exceeds approximately 8°.

In-pit spoil failure is typically bi-planar, as illustrated in Figure 11-1B, with translational slippage along the floor of the pit with a backscarp formed by shearing through the spoil at a steep angle. This configuration was analysed using the Galena code for Sarma's method. The backscarp was taken at 63°, which is fairly typical for spoil failures, emerging at the crest line. The as-measured strength of c = 30 kPa, ϕ = 34° was used for shearing through the body of the spoil. A benched dump profile was modeled, based on 20m lifts, 8m berms and a 35° angle of repose.

Basal slippage can occur along the base of spoil, where the material is typically subject to wetting and slaking or in the floor itself if there are weak or sheared horizons. The Capcoal residual value for fine spoil of c = 0 kPa, ϕ = 23° was used

for the basal spoil strength case and the standard Lake Lindsay value for the VL1 horizon of c = 10 kPa, ϕ = 20° was used for shearing through the floor. Analyses were made for dry conditions.

Analyses were made for a series of dip angles from 10° to 16°, for a dump height of 100m. The results are tabulated below in Table 11-1.

Results of individual analyses are presented in Appendix D.

Table 11-1 : Factors of Stability - In-Pit Spoil Failure

Dip	FoS spoil base	FoS weak floor	FoS YT low
10^0	1.37	1.27	**1.07**
12^0	1.33	1.24	**1.04**
14^0	1.22	**1.14**	**0.95**
16^0	**1.16**	**1.08**	**0.90**

orange highlight indicates FoS < 1.2

The results of the analyses indicate that up-dip spoil dumps would be acceptable on floor dips of up to about 14.5° for slippage on the base of spoil. The FoS are somewhat less for failure through the floor, suggesting an upper dip angle constraint of about 13° in general. This would effectively preclude the option for up-dip spoiling in low wall zones A, C and G.

The FoS values presented in Table 11-1 are only applicable if there is no weakness in the floor, such as a continuous sheared or slickensided horizon or intraformational shear plane. When the analyses were run for basal slippage on the YT using the low strength case of c = 15 kPa, ϕ = 15°, which is a typical value for bedding plane shear, the FoS were all less than acceptable. This means that floor treatment would be required in all cases to disrupt any potential shear planes, including the YT itself, the VL1 seam and associated thin tuff bands, and the immediate floor below the VL1 seam.

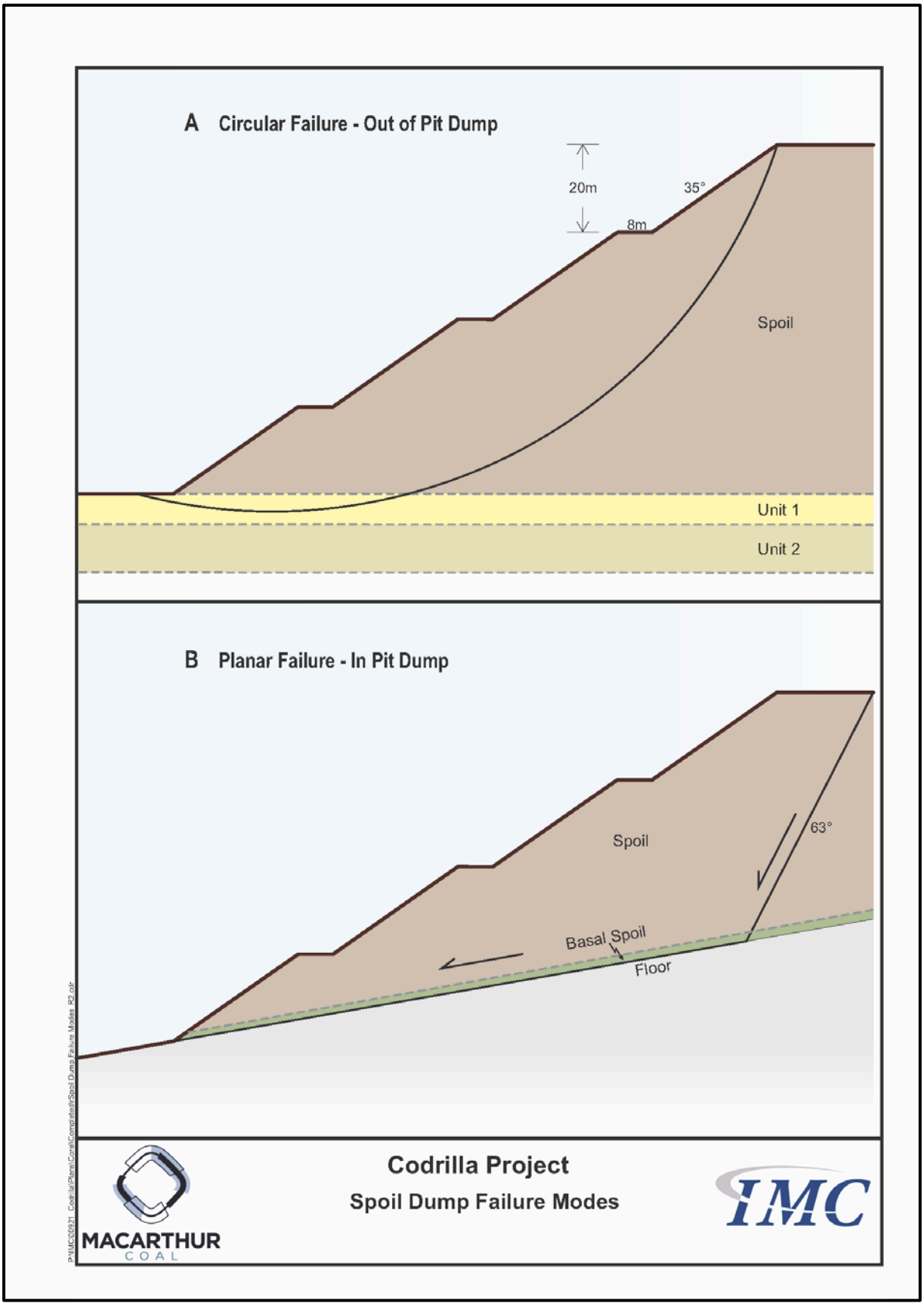


Figure 11-1: Spoil Dump Failure Modes

12 MINING CONDITIONS

12.1 Excavatability

The superficial surface layer, with an average thickness of 7m, is unconsolidated, and comprises mostly clayey sand or sand. This layer is clearly free dig. There are no references to caprock or other hard material, either at the surface or within the underlying clays; although there are cases of ferruginous material in the laterised zone (Unit 2) which may be somewhat harder than the clay.

The Tertiary, which is taken to extend to the base of Unit 3, is composed of stiff to very stiff sandy clay or clayey sand. It can be considered as free dig material for excavation, however due to the homogeneity and compactness of the material, some degree of light blasting may be advantageous to improve the efficiency of the excavators and to reduce equipment damage. However, Tertiary clay is not particularly amenable to blasting and 'belling' of blast holes is not uncommon.

Unit 4 in the overburden sequence, which is equated to completely weathered Permian, is similar to the Tertiary but more compact, being essentially a very weak sandy claystone or clayey sandstone. This, and the upper part of the underlying weathered Permian rock strata in Unit 5, would theoretically be free dig material for large hydraulic excavators, but in practice would normally require light blasting.

Apart from some loose sand at the surface, the soft overburden appears to be largely homogeneous clay of low to medium plasticity, so that blast hole instability should not be an issue. There were no reports of significant hole instability in the exploration drilling. Gravel layers were noted in a number of boreholes within or at the base of Unit 3 which are likely to be loose and could cause some caving in blast hole sides. Similarly at deeper levels within Unit 4 there are records of loose sand where the sandstone strata have been completely weathered and leached, and these horizons could also cause possible caving.

The rock below the weathered zone appears to be typical fine grained coal measure strata, moderately weak to moderately strong. No bodies of massive sandstone were identified in the interburden sequence above the VU Seam. There is very little measured data regarding the physical properties of the overburden rock material, as most boreholes were not cored and did not have sonic velocity logs for estimating rock strength. The following parameters as shown in Table 12-1 are based on the one full sonic log through the interburden in CX0101.

Table 12-1 : Estimated Interburden Blast Parameters

UCS (MPa)	10 -50
Modulus (GPa)	2.5 - 11.5
Poisson's ratio	0.2 - 0.3
Tensile strength (MPa)	1 - 5
Density (t/m^3)	2.4 - 2.6
Sonic velocity (m/sec)	2000 - 4000

The VU Seam would normally be blasted, particularly if mining is to be carried out using wheeled loaders, but the coal could probably be dug unblasted by hydraulic excavator.

12.2 Traffickability

Tertiary clay of any sort is likely to become untraffickable when wet, even though the clays at Codrilla are sandier and less plastic than typical Tertiary. This would impact on ramps down to rockhead as well as to the general overburden stripping fleet. The Permian clays in Unit 4 would be similar. A dark brown to black claystone has been noted in Unit 2 places, generally at a depth of between 6m and 14m. Horizons of black clay, representing pond deposition in the Tertiary, have been found to be soft and highly troublesome for trafficking at other mines.

Little information is available on the detailed nature of the floor for the upper seams, but the borehole data indicates variable conditions ranging from soft carbonaceous mudstone to hard sandstone. It would appear that conditions will be reasonable for trafficking except in those cases where the floor is mudstone and water is accumulating.

The mining floor for the VU Seam will be the Yarrabee Tuff. This is highly variable in nature, varying from brittle to puggy and is highly slake susceptible in places. It is generally considered to be unsuitable for trafficking, and is usually removed by bulldozing into rills. Note in this connection that it normally needs to be rilled in any case before dumping spoil to avoid leaving a potential basal slip horizon. The poor quality VL1 Seam is normally left to form the trafficking surface.

Floor treatment will be required for spoil dumped on the VU Seam floor where there is an outward dip of more than 5°, to disrupt potential shear planes or thin weak tuffaceous clay bands associated with the VL1 Seam and any weakness in immediate mudstone floor. The potential weak floor sequence below the YT is from 0.7m to 1.5m thick. It is suggested that the floor should be disrupted by blasting to a depth of approximately 4m prior to any up-dip spoil dumping.

12.3 Groundwater

There are no known major aquifers and the overburden is largely clay which is more or less impermeable; however there are occasional references to water make in exploration boreholes, none of which would indicate anything more than a minor aquifer.

The only likely emissions of groundwater in the upper soft overburden could be from the gravel layers or lenses, although there is no specific reference to this from the exploration drilling. Any exposed gravel layers are likely to be free-draining and of limited volume and in excavation would be drained to sumps. There is also a possibility of blast holes making water from the gravel. The other potential source of groundwater in the overburden is the sand or sandstone towards the bottom of the weathered zone.

The coal seams can typically constitute minor aquifers, particularly the thick VU Seam and would be expected to make some amount of water when exposed in the pit. Localised higher flows could be expected from the fault zones within the coal seams where the fracturing provides the flow path and storage.

The general conclusion is that the pit would be relatively dry with only nuisance water emissions from the aforementioned sources. The normal method of control

would be to drain surface water into sumps, in order to avoid accumulation in trafficked areas.

13 SPOIL COVER SUITABILITY – ENVIRONMENTAL CONSIDERATIONS

As part of MCC's environmental obligations, spoil dumps are required to be rehabilitated in accordance with relevant legislation.

The intent of rehabilitation is to effectively mitigate the physical and chemical degradation of the spoil dumps, but also to control any potential polluting sources.

Generally, there are several physical and chemical characteristics which are important to ascertain when rehabilitating mine spoil. These include:

- Acid generating potential;
- Dispersion potential and salinity; and
- Erosion potential.

An assessment was conducted to ascertain basic physical and chemical properties of the spoil material and the suitability of the competent sandstone unit as a spoil cover material.

Section 4 presented the laboratory results as part of the assessment to determine some basic physical and chemical characteristics of the Tertiary clay spoil and the suitability of a higher competency sandstone unit, below the VU Seam, as a spoil cover. For this study however, only limited chemical and physical index testing was conducted, which could be considered a screening process for evaluation during more detailed studies.

It is recommended that further studies be undertaken to understand the distribution of soils across the site that would require adequate management in order successfully rehabilitate.

13.1 Acid Generating Potential

The generation of acidic conditions is primarily a result of the oxidation of sulphide minerals within the either a soil lattice or rock matrix. The potential impacts of acid generation are often extensive; therefore materials of this nature would require management from the outset (Ref 4).

Strategies for managing the impacts of potential acid generation include:

- Minimising material oxidation via water and oxygen contact;
- Introducing neutralising agents, such as carbonates;
- Preventing discharge of acidic runoff from within the spoil dump; and
- Treatment of runoff and seepage water prior to discharge.

13.2 Dispersion Potential and Salinity (Dispersivity)

Soil dispersion is generally controlled by the exchangeable sodium content of the soil, where even small concentrations of exchangeable sodium can have a significant influence on dispersion potential (Ref 1). In this case, the dispersion mechanism only requires the presence of water, therefore the modification of the landform has limited affect on the success of the rehabilitation (Ref 4).

Often soils with a significant concentration of exchangeable sodium are also unsuitable for vegetation growth due high salinity. This is another critical factor in controlling soil dispersion.

Strategies for managing the impacts of dispersion and salinity include:

- Application of a cover material to prevent seepage contact and to provide a suitable growth medium for the establishment of vegetation; and
- Addition of reagents to displace sodium cations.

The results of the limited testing indicate some dispersive variability for the soft overburden samples tested, although the tests suggest that material dispersion is unlikely.

13.3 Erosion Potential

Where chemical stability is unlikely to be the key driver of spoil degradation, other physical properties, such as swelling potential, would still warrant the placement of a suitable covering.

In this case, clayey materials with high liquid limits tend to swell significantly upon exposure to moisture resulting in a reduction in cohesion and shear strength. These materials would be susceptible to further physical degradation and would require a protective rock cover to reduce this likelihood.

Strategies for managing erosion potential include:

- Reducing the slopes and catchment areas;
- Application of a cover material and the establishment of vegetation.

13.4 Rock Cover Suitability – VU Sandstone

The sandstone unit below the VU seam was evaluated as a potential soil cover material. Material strength testing indicated some variability in UCS, ranging from 16.5 MPa to 65.7 MPa. Inspection of the UCS test results in Section 4 (Table 4-3) indicated the low strength values were the result of failure along pre-defined surfaces, and therefore a representative UCS value are likely to be moderate to high strength.

Slake durability testing indicated the sandstone material to have a low slake potential, which also an important material property when selecting a suitable cover material.

The testing indicates the material to have suitable physical properties for use a spoil cover, however further test work would be required in order to evaluate the materials acid generating potential.

14 REFERENCES

1. Hazelton, P.A & Murphy, B.W (2007). **"Interpreting Soil Test Results: What Do All The Numbers Mean?"** New South Wales Department of Natural Resources.
2. Ward, B and Hanson C (2009). **"Codrilla Project Opencut Feasibility Study – Geotechnical Report"**, IMC Mining Solutions Pty Ltd.
3. Read, J and Stacey, P (2009). **"Guidelines for Open Pit Slope Design"**. CSIRO Publishing.
4. Henderson, S (Minserve) et al (2008). **"Specification of Overburden for Use as Cover Spoil"**. ACARP Project C14042

APPENDIX A – Geotechnical Logs

GEOTECHNICAL DRILLHOLE LOG

DRILLHOLE: CX3106FC

PROJECT: CODRILLA

E: 664257, N:7555636, RL:173.4

COMP DEPTH: 75.00m

Depth 1:50	Samples	Litho	Description	Weathering RS	XW	HW	MW	SW	FR
0.0			Clayey SAND (SC), medium dense, medium to coarse grained, brown (Quaternary).						
1.0			Clayey SAND (SC), medium dense, medium to coarse grained, grey (Tertiary).						
2.0									
3.0			CLAYSTONE (XW), extremely low strength, pinkish-red brown, mottled, weathered to silty clay (CH) in parts.						
4.0									
5.0									
6.0									
7.0									
8.0									
9.0									

Depth 1:50	Samples	Litho	Description	Weathering					
				RS	XW	HW	MW	SW	FR
10.0									
11.0									
12.0									
13.0									
14.0									
15.0									
16.0									
17.0									
18.0									
19.0									
20.0									
21.0									
22.0									
23.0									

Depth 1:50	Samples	Litho	Description	Weathering					
				RS	XW	HW	MW	SW	FR
24.0									
25.0									
26.0									
27.0									
28.0			SILTSTONE (HW), extremely low strength, grey-brown, fine grained, with fine grained SAND thoughout.						
29.0			SANDSTONE (HW), very low strength, fine grained, brown grey, with (CH) in matrix, Fe staining in places, minor fracturing observed.						
30.0									
31.0									
32.0									
33.0									
34.0									
35.0									
36.0									

Depth 1:50	Samples	Litho	Description	Weathering RS	XW	HW	MW	SW	FR
37.0									
38.0									
39.0									
40.0									
41.0									
42.0			CLAYSTONE (HW), very low strength, reddish grey, mottled, some fine grained sand lenses, weathered to silty to sandy clay (CH) in parts, minor microfractures observed.						
43.0									
44.0									
45.0									
46.0									
47.0									
48.0									
49.0			SANDSTONE (HW), very low strength, grey brown, fine grained, with (CH) in matrix.						

Depth 1:50	Samples	Litho	Description	Weathering RS	XW	HW	MW	SW	FR
50.0									
51.0			CLAYSTONE (HW), very low strength, reddish grey, mottled, some fine grained sand lenses, weathered to silty to sandy clay (CH) in parts, Fe staining.						
52.0									
53.0									
54.0									
55.0									
56.0									
57.0			PEBBLE CONGLOMERATE (HW), dense, pebbles with fine to coarse GRAVEL and SAND, white, with high plasticity CLAY matrix.						
58.0									
59.0									
60.0			CLAYSTONE (HW), very low strength, pinkish-red brown, mottled, some fine grained sand lenses, weathered to silty to sandy clay (CH) in parts, Fe staining thoughout (Permian), fractures.						
61.0									
62.0			SILTSTONE (MW), very low strength, grey-brown, fine grained, with fine grained SAND thoughout, fractures.						

Depth 1:50	Samples	Litho	Description	Weathering RS	XW	HW	MW	SW	FR
63.0									
64.0			SANDSTONE (MW), very low strength, orange-brown, fine grained, finely laminated, weakly cemented, fractures.						
65.0									
66.0									
67.0			SILTSTONE (MW), very low strength, grey-brown, fine grained, with fine grained SAND thoughout, fractures.						
68.0									
69.0			SANDSTONE (SW), low strength, orange-brown, fine grained, finely laminated, fractures.						
70.0									
71.0									
72.0			SILTSTONE (FR), low strength, grey-brown, fine grained, with fine grained SAND thoughout.						
73.0									
74.0									
75.0			EOH @ 75m - Base of Weathering						

GEOTECHNICAL DRILLHOLE LOG

DRILLHOLE: CX3115FC

PROJECT: CODRILLA

E: 663112, N:7554538, RL:174.9

COMP DEPTH: 76.30m

Depth 1:50	Samples	Litho	Description	Weathering RS	XW	HW	MW	SW	FR
0.0			Clayey SAND (SC), medium dense, loose, medium to coarse grained, brown (Quaternary) - Residual Soil.						
1.0									
2.0									
3.0									
4.0									
5.0			CLAYSTONE (XW), extremely low strength, pinkish-red grey, mottled, sandy, weathered to silty clay (CH) in parts.						
6.0									
7.0			SANDSTONE (HW), very low strength, very fine grained, red grey, with (CH) in matrix.						
8.0									
9.0									
			CLAYSTONE (HW), extremely low strength, grey brown, mottled, sandy, weathered to silty clay (CH) in parts.						

Depth 1:50	Samples	Litho	Description	Weathering RS	XW	HW	MW	SW	FR
10.0									
11.0									
12.0									
13.0									
14.0									
15.0									
16.0									
17.0									
18.0									
19.0									
20.0									
21.0									
22.0			SANDSTONE (HW), very low strength, very fine grained, red grey, with (CH) in matrix.						
23.0									

Depth 1:50	Samples	Litho	Description	Weathering RS	XW	HW	MW	SW	FR
24.0									
25.0									
26.0									
27.0									
28.0			CLAYSTONE (HW-MW), very low strength, red grey brown to yellow grey, mottled, sandy, weathered to silty clay and clayey sand (CH) & (SC) in parts.						
29.0									
30.0									
31.0									
32.0									
33.0									
34.0									
35.0									
36.0									

Depth 1:50	Samples	Litho	Description	Weathering					
				RS	XW	HW	MW	SW	FR
37.0									
38.0									
39.0									
40.0									
41.0									
42.0									
43.0									
44.0									
45.0									
46.0									
47.0									
48.0									
49.0									

Depth 1:50	Samples	Litho	Description	Weathering					
				RS	XW	HW	MW	SW	FR
50.0									
51.0									
52.0									
53.0									
54.0									
55.0									
56.0									
57.0									
58.0									
59.0									
60.0									
61.0									
62.0									

Depth 1:50	Samples	Litho	Description	Weathering RS	XW	HW	MW	SW	FR
63.0									
64.0									
65.0									
66.0									
67.0			SANDSTONE (HW), very low strength, very fine grained, light grey to brown grey, with (CH) in matrix, thin CLAYSTONE bands.						
68.0									
69.0									
70.0									
71.0									
72.0									
73.0									
74.0									
75.0									

Depth 1:50	Samples	Litho	Description	Weathering RS	XW	HW	MW	SW	FR
76.0									
			EOH @ 76.3m - BASE OF WEATHERING						
77.0									
78.0									
79.0									
80.0									
81.0									

GEOTECHNICAL DRILLHOLE LOG

DRILLHOLE: CX3122FC

PROJECT: CODRILLA

E: 662726, N:7555890, RL:175.6

COMP DEPTH: 80.47m

Depth 1:50	Sample	Lithology	Description	Weathering RS	XW	HW	MW	SW	FR
0.0			Clayey SAND (SC), medium dense, medium grained, brown to grey (Quaternary / Tertiary) - Aluvials.						
1.0									
2.0									
3.0									
4.0			CLAYSTONE (XW), extremely low strength, red grey, mottled, sandy, weathered to silty clay (CH) in parts, Fe staining in places.						
5.0									
6.0									
7.0									
8.0									
9.0									

Depth 1:50	Sample	Lithology	Description	Weathering RS	XW	HW	MW	SW	FR
10.0			SANDSTONE (HW), very low strength, fine grained, red grey, clayey, Fe staining in places.						
11.0									
12.0									
13.0									
			CLAYSTONE (HW-MW), very low strength, grey brown, mottled, sandy, Fe staining in places, fractures.						
14.0									
15.0									
16.0									
17.0									
18.0									
19.0									
20.0									
21.0									
22.0									

Depth 1:50	Sample	Lithology	Description	Weathering					
				RS	XW	HW	MW	SW	FR
23.0									
24.0									
25.0									
26.0									
27.0									
28.0									
29.0									
30.0									
31.0									
32.0									
33.0									
34.0									
35.0									

Depth 1:50	Sample	Lithology	Description	Weathering					
				RS	XW	HW	MW	SW	FR
36.0									
37.0									
38.0									
39.0									
40.0									
41.0									
42.0									
43.0									
44.0									
45.0									
46.0									
47.0									
48.0									

Depth 1:50	Sample	Lithology	Description	Weathering					
				RS	XW	HW	MW	SW	FR
49.0									
50.0									
51.0									
52.0									
53.0									
54.0									
55.0									
56.0									
57.0									
58.0									
59.0									
60.0									
61.0									

Depth 1:50	Sample	Lithology	Description	Weathering RS	XW	HW	MW	SW	FR
62.0									
63.0									
64.0									
65.0									
66.0									
67.0									
68.0									
			SILTSTONE / SANDSTONE (MW-SW), interbedded, very low strength, brown grey, clayey, fractures.						
69.0									
70.0									
71.0									
72.0									
73.0									
74.0									
75.0									

Depth 1:50	Sample	Lithology	Description	Weathering RS	XW	HW	MW	SW	FR
75.0									
76.0									
77.0									
78.0			WEATHERED COAL (SW), Leichardt Lower 1 Seam, very low strength, black.						
			SILTSTONE / SANDSTONE (SW), very low strength, grey, carbonaceous in places.						
79.0									
80.0									
			EOH @ 80.47m - Base of Weathering						
81.0									

GEOTECHNICAL DRILLHOLE LOG

DRILLHOLE: CX3127FC

PROJECT: CODRILLA

E: 660916, N:7555759, RL:180.3

COMP DEPTH: 52.89m

Depth 1:50	Sample	Lithology	Description	Weathering RS	XW	HW	MW	SW	FR
0.0			SAND (SC), medium dense, fine to medium grained, brown red (Quaternary / Tertiary) - Aluvials.						
1.0									
2.0			CLAYSTONE (XW), extremely low strength, grey red, mottled, sandy, weathered to silty clay (CH) in parts, Fe staining in places.						
3.0									
4.0									
5.0									
			CLAYSTONE (XW-HW), very low strength, grey red, mottled, sandy, weathered to silty clay (CH) in parts, Fe staining in places, fractures.						
6.0									
7.0									
8.0									
9.0									

Depth 1:50	Sample	Lithology	Description	Weathering RS	XW	HW	MW	SW	FR
10.0									
11.0									
12.0									
13.0									
14.0									
15.0									
16.0									
17.0									
18.0									
19.0									
20.0									
21.0									
22.0			CLAYSTONE / SANDSTONE (XW-HW), very low strength, grey brown, mottled, sandy, Fe staining in places.						

Depth 1:50	Sample	Lithology	Description	Weathering RS	XW	HW	MW	SW	FR
23.0									
24.0									
25.0									
26.0									
27.0									
28.0									
29.0									
30.0									
31.0			CLAYSTONE (HW), very low strength, white red, sandy in places, Fe staining in places, fractures.						
32.0									
33.0									
34.0									
35.0									

Depth 1:50	Sample	Lithology	Description	Weathering RS	XW	HW	MW	SW	FR
36.0									
37.0									
38.0									
39.0									
40.0									
41.0									
42.0			SILTSTONE (MW-SW), very low strength, brown grey, carbonaceous in places, fractures.						
43.0									
44.0									
45.0									
46.0									
47.0									
48.0									

Depth 1:50	Sample	Lithology	Description	Weathering RS	XW	HW	MW	SW	FR
49.0									
50.0									
51.0									
52.0									
53.0			EOH @ 52.89m - Base of Weathering						
54.0									
55.0									
56.0									
57.0									
58.0									
59.0									
60.0									
61.0									

APPENDIX B – Laboratory Test Results

Trilab
+61 7 3357 5535 www.trilab.com.au 10/104 Newmarket Rd, Windsor QLD 4030

TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client:	Macarthur Coal (C&M Management) Pty Ltd	**Report No.:**	11091158 - CU
Project:	"Codrilla Project" EPC676	**Test Date:**	2/11/2011
		Report Date:	9/11/2011
Client Id.:	CX3106FC / 165752	**Depth (m):**	9.48-9.78

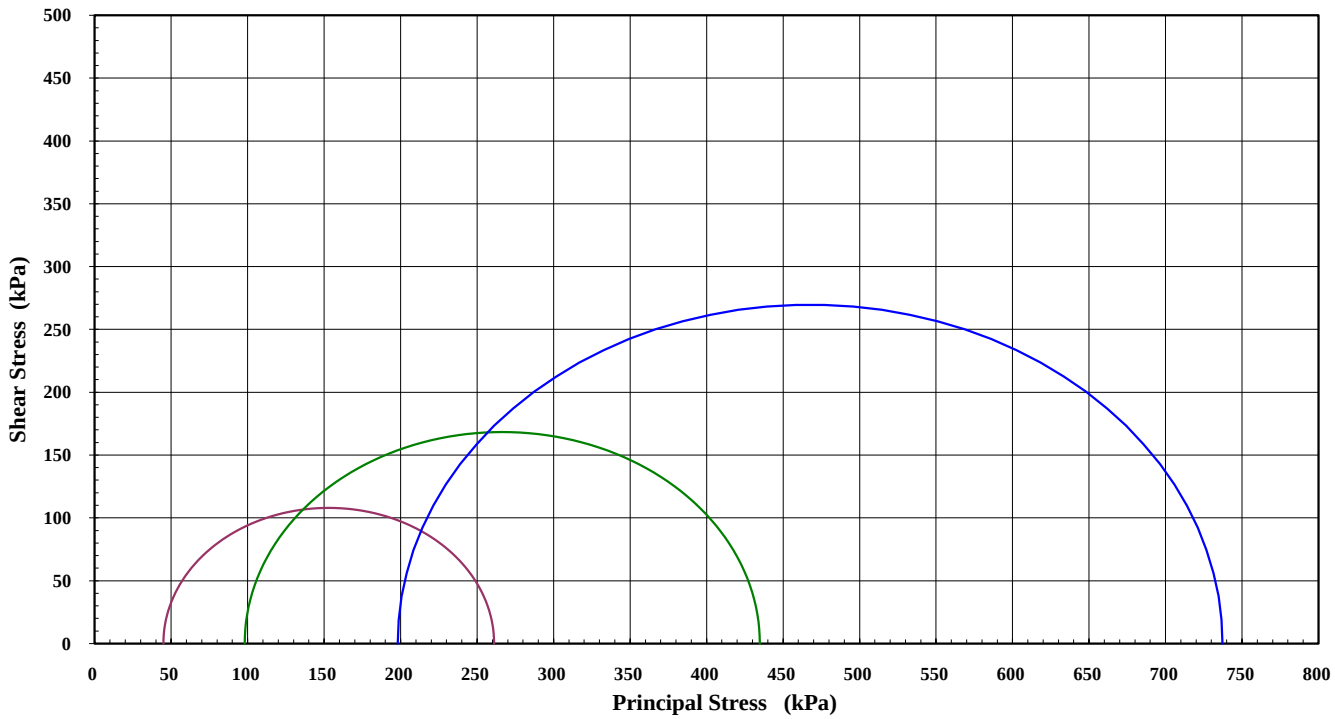
Description: SILTY SAND - grey & yellow

SAMPLE & TEST DETAILS

Initial Height:	127.7	mm	Initial Moisture Content:	12.3	%	Rate of Strain:	0.005	%/min
Initial Diameter:	60.2	mm	Final Moisture Content:	13.8	%	B Response:	97	%
L/D Ratio:	2.1 : 1		Wet Density:	2.19	t/m^3			
			Dry Density:	1.95	t/m^3			

Failure Criteria: Peak Principal Stress Ratio

Mohr Circle Diagram



	1 to 2	2 to 3	1 to 3
Interpretation between stages :			
Cohesion C' (kPa) :	31.3	39.8	35.5
Angle of Shear Resistance Φ' (Degrees) :	32.2	30.2	30.8

Sample Type:	Single Individual Undisturbed Specimen	Remarks:	Tested as Received
Sample/s supplied by the client		Note: Graph not to scale	

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Authorised Signatory
J. Russell

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TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

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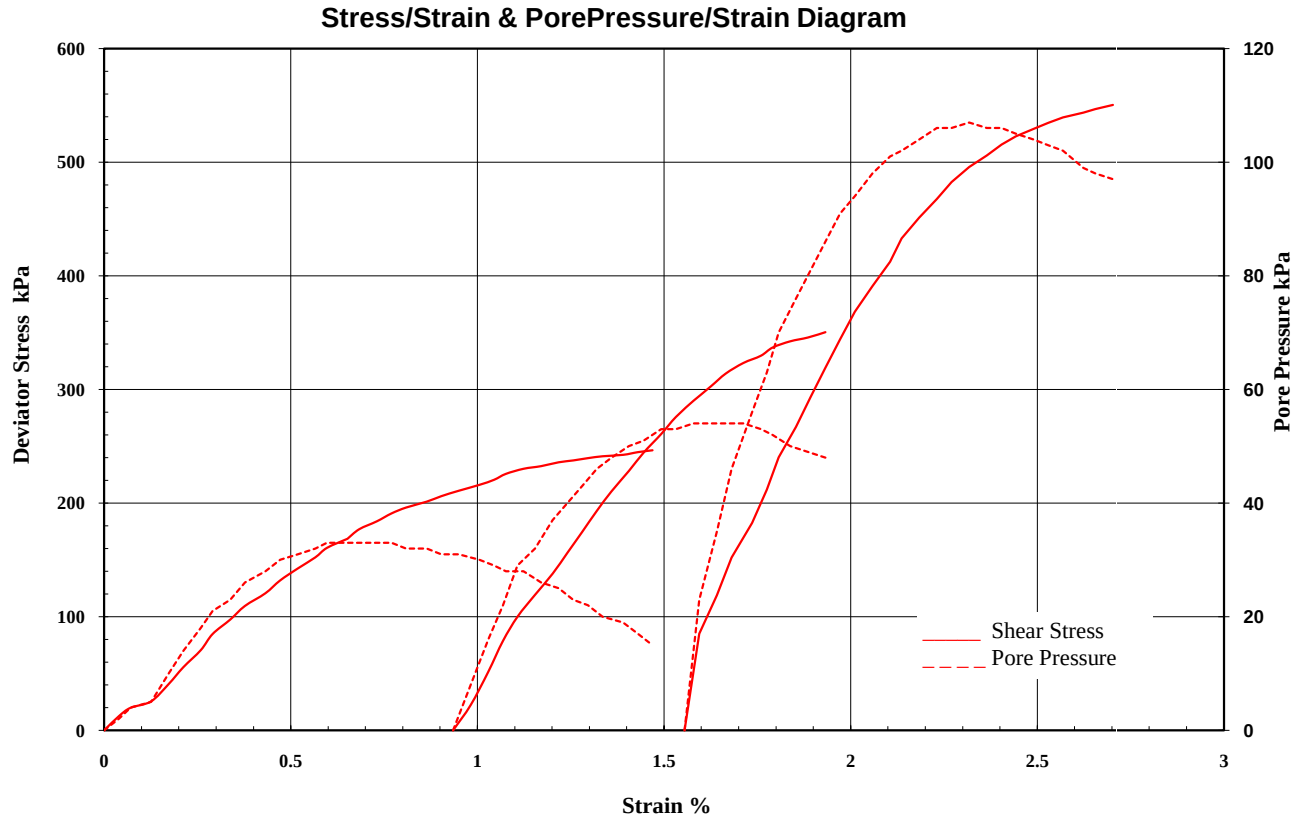
Project:	"Codrilla Project" EPC676	**Test Date:**	2/11/2011
		Report Date:	9/11/2011
Client Id.:	CX3106FC / 165752	**Depth (m):**	9.48-9.78

Description: SILTY SAND - grey & yellow



FAILURE DETAILS

Confining Pressure	Back Pressure	Initial Pore	Failure Pore	Principal Effective Stresses σ'_1	σ'_3	σ'_1 / σ'_3	Deviator Stress	Strain
582 kPa	507 kPa	507 kPa	535 kPa	261 kPa	45 kPa	5.800	216 kPa	1.01 %
656 kPa	506 kPa	506 kPa	558 kPa	435 kPa	98 kPa	4.437	337 kPa	1.79 %
807 kPa	507 kPa	507 kPa	609 kPa	737 kPa	198 kPa	3.724	539 kPa	2.57 %

Sample Type: Single Individual Undisturbed Specimen
Remarks: Tested as Received
Sample/s supplied by the client
Note: Graph not to scale

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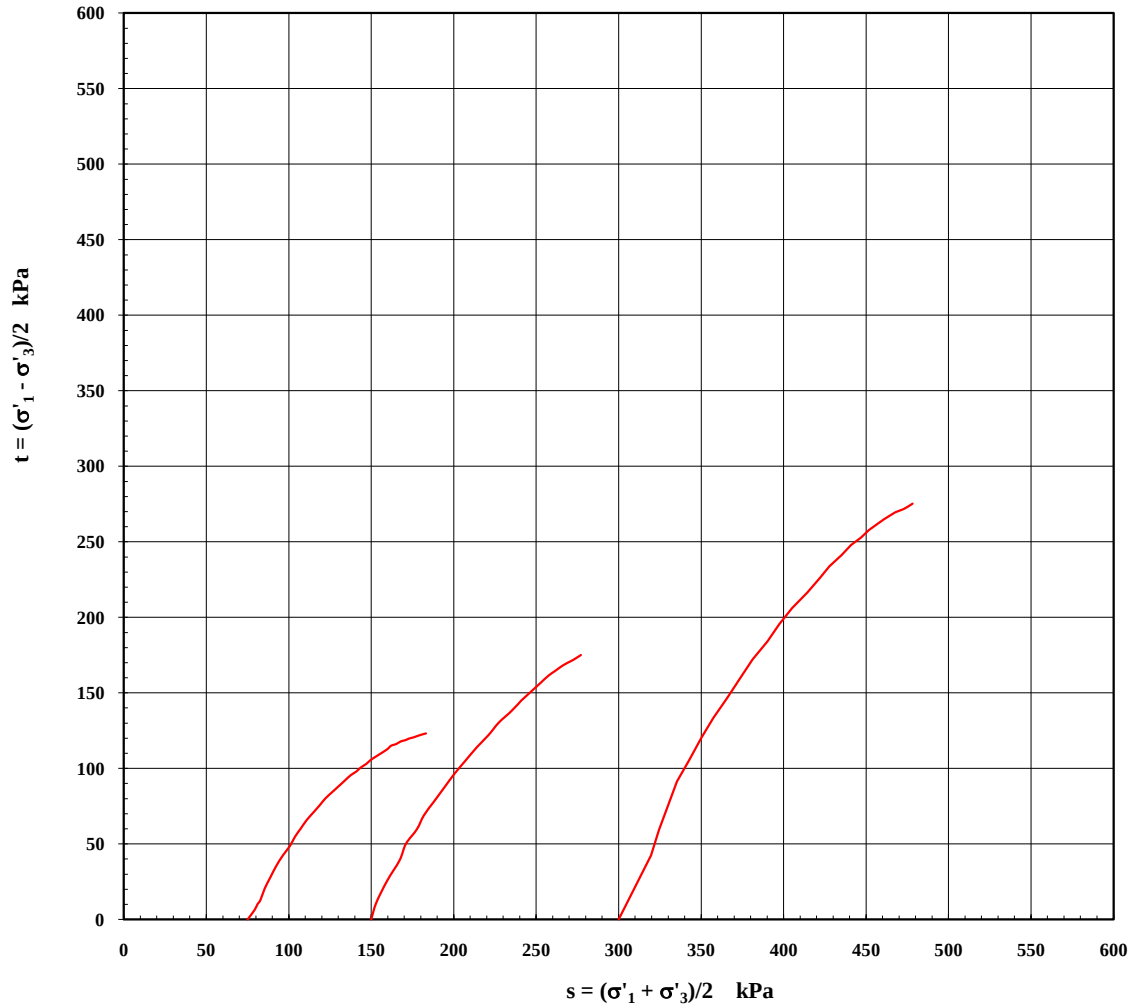
		Report Date:	9/11/2011
Client Id.:	CX3106FC / 165752	**Depth (m):**	9.48-9.78

Description: SILTY SAND - grey & yellow

MIT Method - Effective Stress Path



Sample Type:	Single Individual Undisturbed Specimen	Remarks:	Tested as Received
Sample/s supplied by the client		Note: Graph not to scale	

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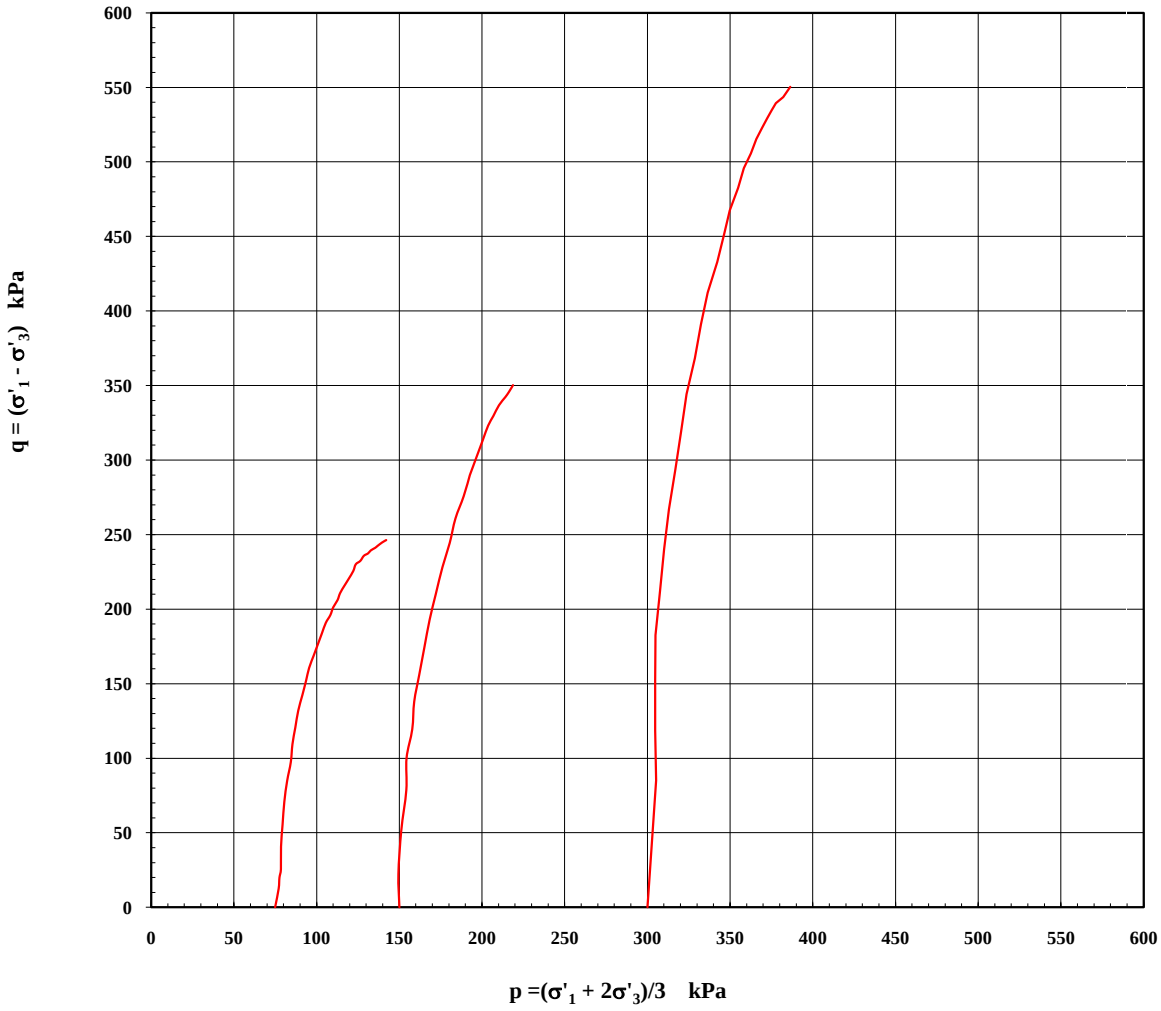
Project:	"Codrilla Project" EPC676	**Test Date:**	2/11/2011
		Report Date:	9/11/2011
Client Id.:	CX3106FC / 165752	**Depth (m):**	9.48-9.78

Description: SILTY SAND - grey & yellow

Cambridge Method - Effective Stress Path



Sample Type:	Single Individual Undisturbed Specimen	Remarks:	Tested as Received
Sample/s supplied by the client		Note: Graph not to scale	

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TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client:	Macarthur Coal (C&M Management) Pty Ltd	**Report No.:**	11091158 - CU
Project:	"Codrilla Project" EPC676	**Test Date:**	2/11/2011
		Report Date:	9/11/2011
Client Id.:	CX3106FC / 165752	**Depth (m):**	9.48-9.78
Description:	SILTY SAND - grey & yellow		

Sample Type:	Single Individual Undisturbed Specimen	Remarks:	Tested as Received
Sample/s supplied by the client		Note: Graph not to scale	

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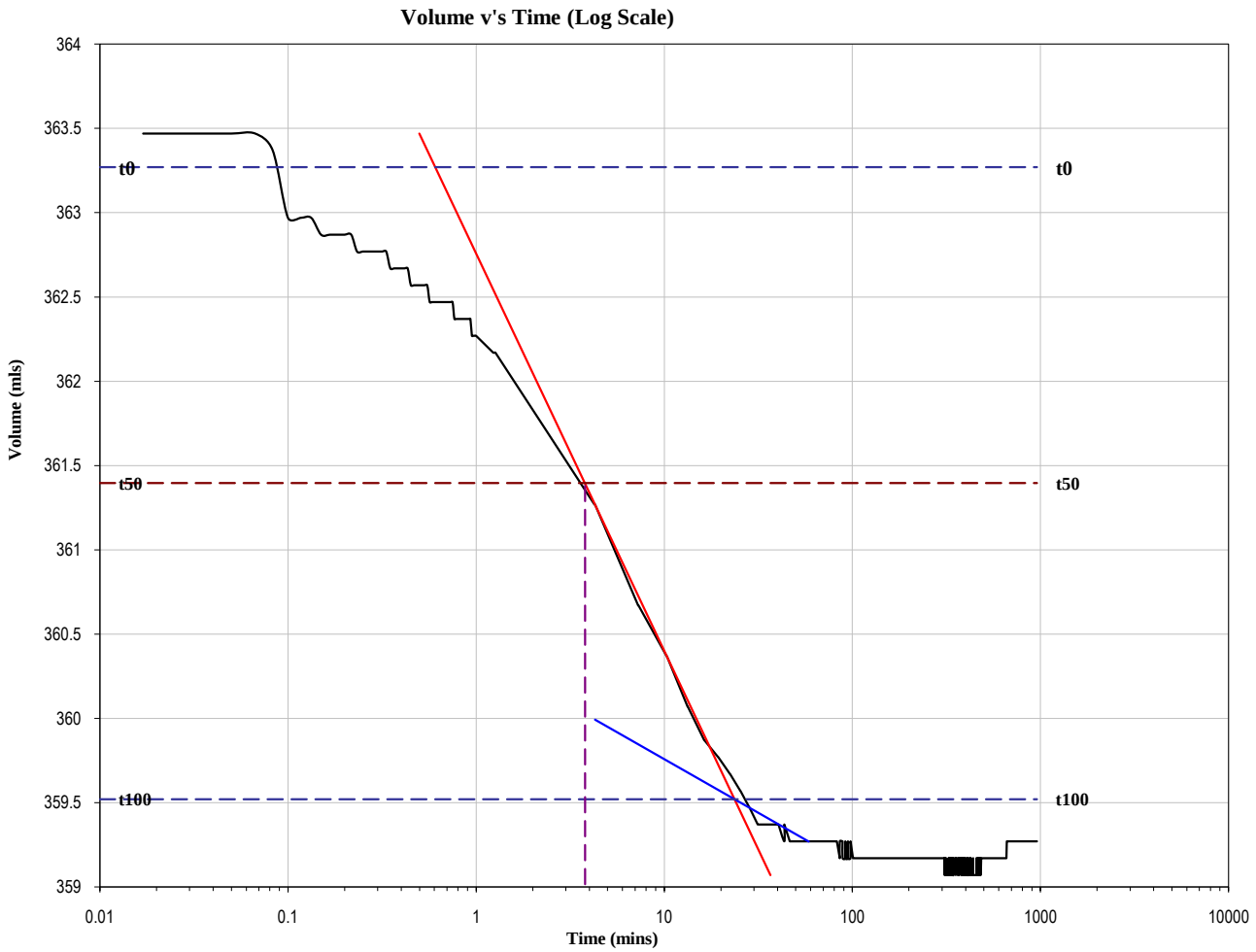

Cv:	**3.33**	**m^2/year**
Mv:	**0.145**	**m^2/MN**
k:	**1.50E-10**	**m/s**

Sample Type:	Single Individual Undisturbed Specimen	Remarks:	Tested as Received
Sample/s supplied by the client		Note: Graph not to scale	

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TRIAXIAL TEST REPORT

Test Method: AS1289.6.4.2

Client:	Macarthur Coal (C&M Management) Pty Ltd	**Report No.:**	11091159 - CU
Project:	"Codrilla Project" EPC676	**Test Date:**	3/11/2011
		Report Date:	9/11/2011
Client Id.:	CX3106FC / 165770	**Depth (m):**	62.33-62.61

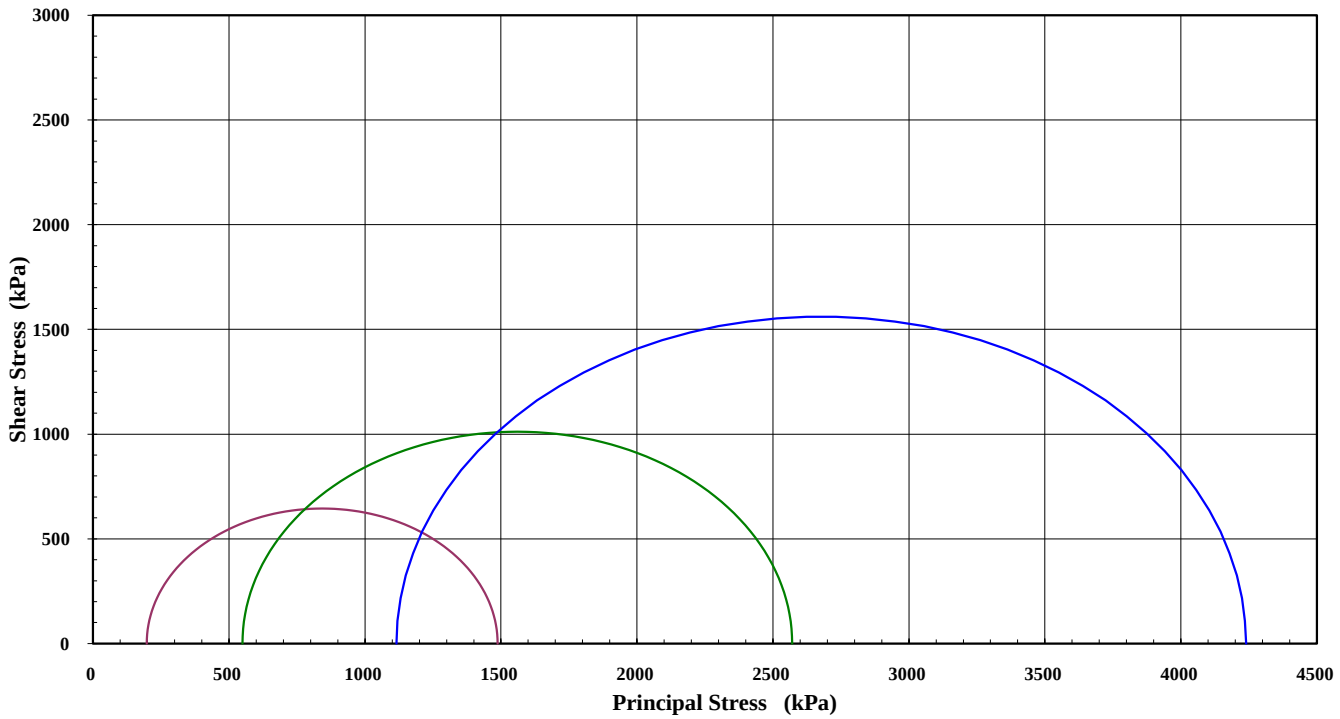
Description: SILTSTONE - yellow-brown

SAMPLE & TEST DETAILS

Initial Height:	135.0	mm	Initial Moisture Content:	13.2	%	Rate of Strain:	0.005	%/min
Initial Diameter:	60.0	mm	Final Moisture Content:	13.3	%	B Response:	97	%
L/D Ratio:	2.3 : 1		Wet Density:	2.27	t/m^3			
			Dry Density:	2.00	t/m^3			

Failure Criteria: Peak Principal Stress Ratio

Mohr Circle Diagram



	1 to 2	2 to 3	1 to 3
Interpretation between stages :			
Cohesion C' (kPa) :	249.1	278.6	262.1
Angle of Shear Resistance Φ' (Degrees) :	30.7	29.5	29.9

Sample Type:	Single Individual Undisturbed Specimen	Remarks:	Tested as Received
Sample/s supplied by the client		Note: Graph not to scale	

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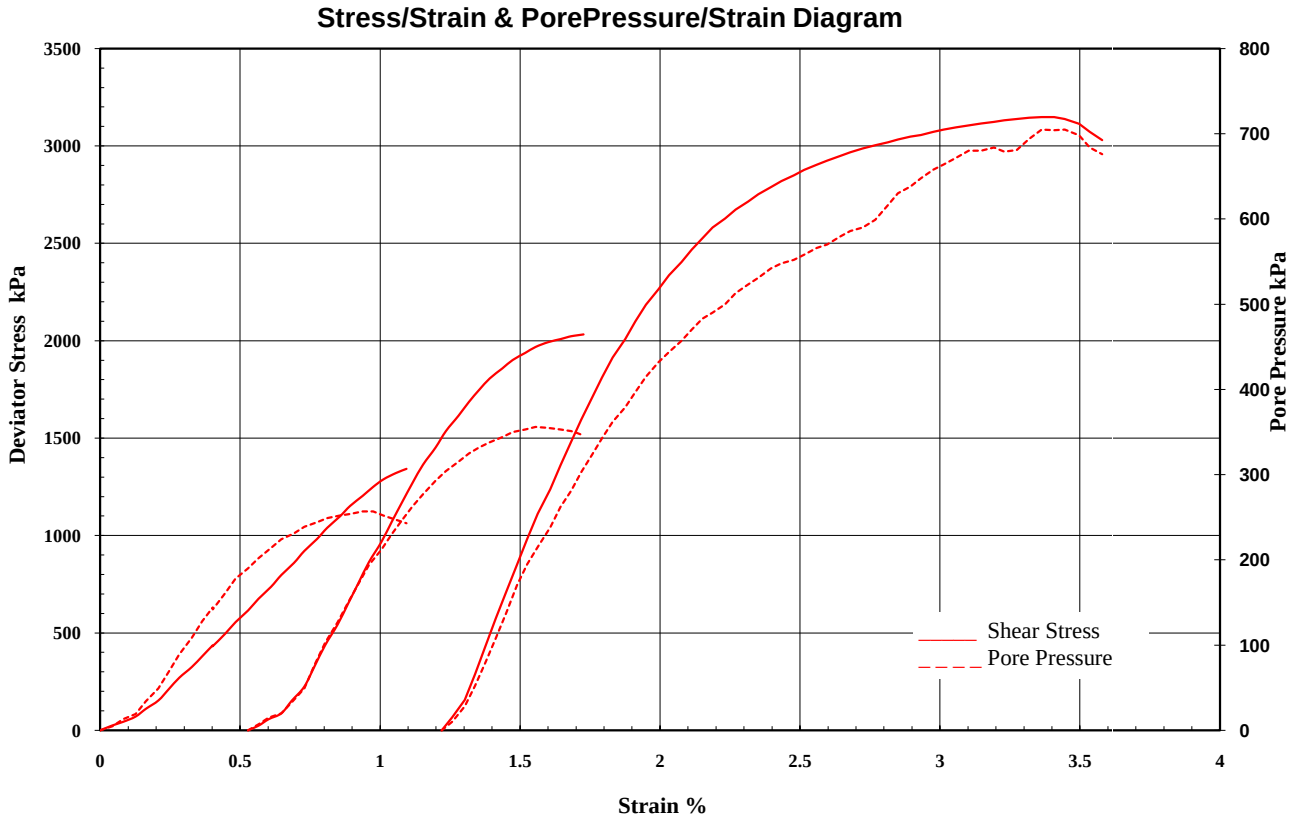
Client Id.:	CX3106FC / 165770	**Depth (m):**	62.33-62.61

Description: SILTSTONE - yellow-brown



FAILURE DETAILS

Confining Pressure	Back Pressure	Initial Pore	Failure Pore	Principal Effective Stresses σ'_1	σ'_3	σ'_1 / σ'_3	Deviator Stress	Strain
763 kPa	313 kPa	317 kPa	569 kPa	1487 kPa	198 kPa	7.511	1289 kPa	1.01 %
1213 kPa	313 kPa	317 kPa	668 kPa	2571 kPa	549 kPa	4.683	2022 kPa	1.68 %
2111 kPa	311 kPa	311 kPa	1016 kPa	4240 kPa	1116 kPa	3.799	3124 kPa	3.19 %

Sample Type: Single Individual Undisturbed Specimen Remarks: Tested as Received

Sample/s supplied by the client Note: Graph not to scale

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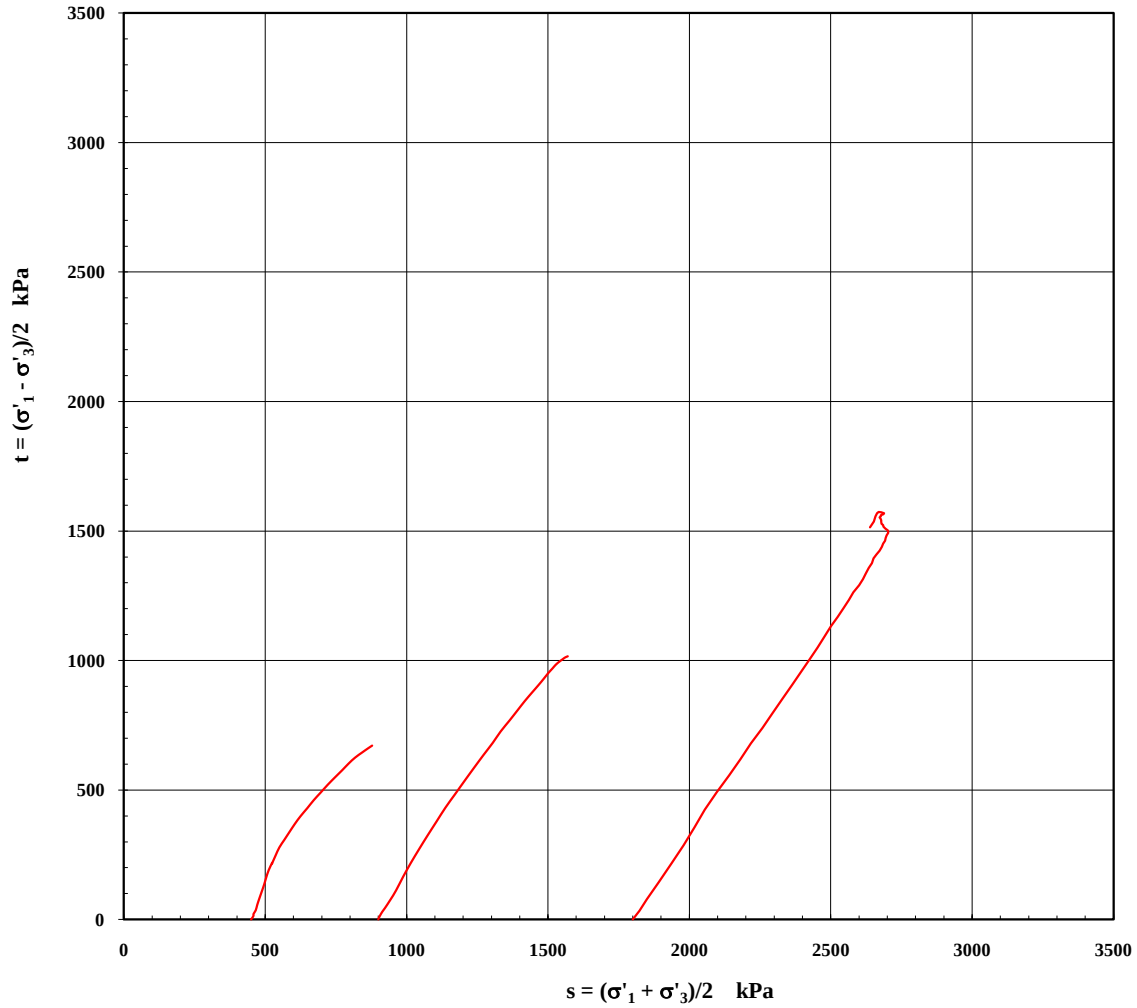
		Report Date:	9/11/2011
Client Id.:	CX3106FC / 165770	**Depth (m):**	62.33-62.61

Description: SILTSTONE - yellow-brown

MIT Method - Effective Stress Path



Sample Type:	Single Individual Undisturbed Specimen	Remarks:	Tested as Received
Sample/s supplied by the client		Note: Graph not to scale	

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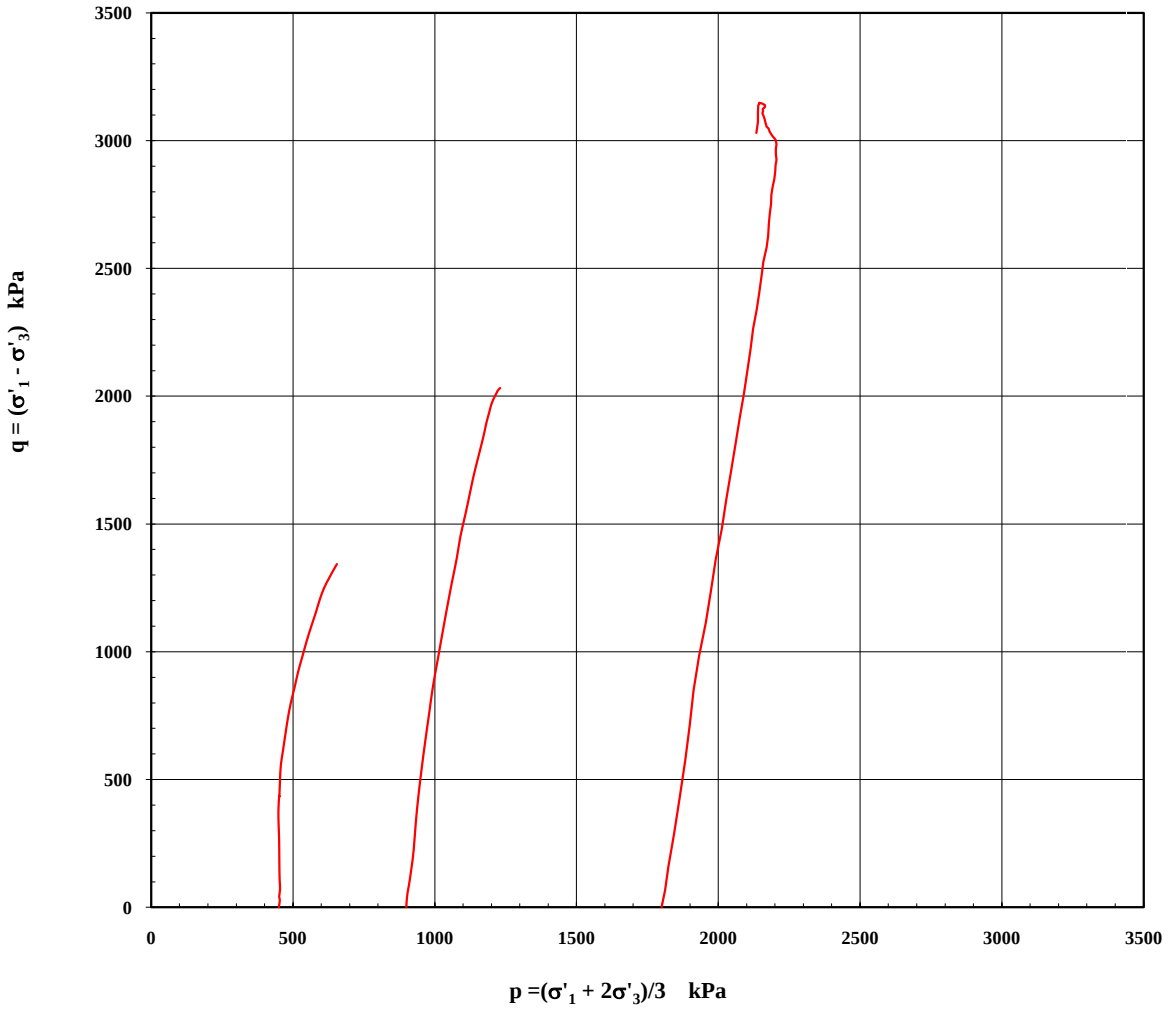
Cambridge Method - Effective Stress Path



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Sample/s supplied by the client		Note: Graph not to scale	

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		Report Date:	9/11/2011
Client Id.:	CX3106FC / 165770	**Depth (m):**	62.33-62.61
Description:	SILTSTONE - yellow-brown		

Sample Type:	Single Individual Undisturbed Specimen	Remarks:	Tested as Received
Sample/s supplied by the client		Note: Graph not to scale	

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Client Id.:	CX3106FC / 165770	**Depth (m):**	62.33-62.61

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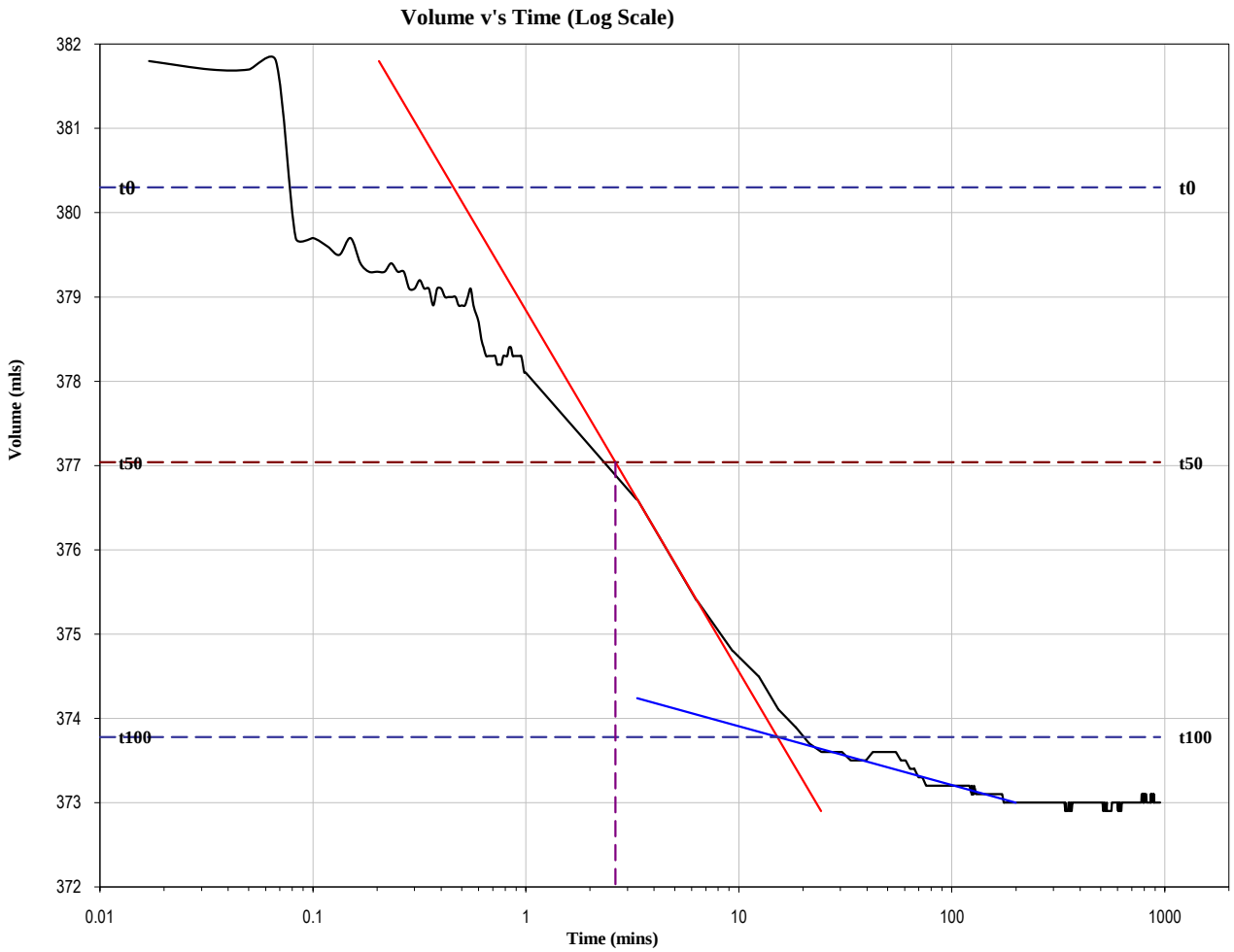

Cv:	**4.61**	**m^2/year**
Mv:	**0.046**	**m^2/MN**
k:	**6.60E-11**	**m/s**

Sample Type:	Single Individual Undisturbed Specimen	Remarks:	Tested as Received
Sample/s supplied by the client		Note: Graph not to scale	

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CARDNO ULLMAN & NOLAN

GEOTECHNIC PTY LTD

71 CONNORS ROAD MACKAY QLD

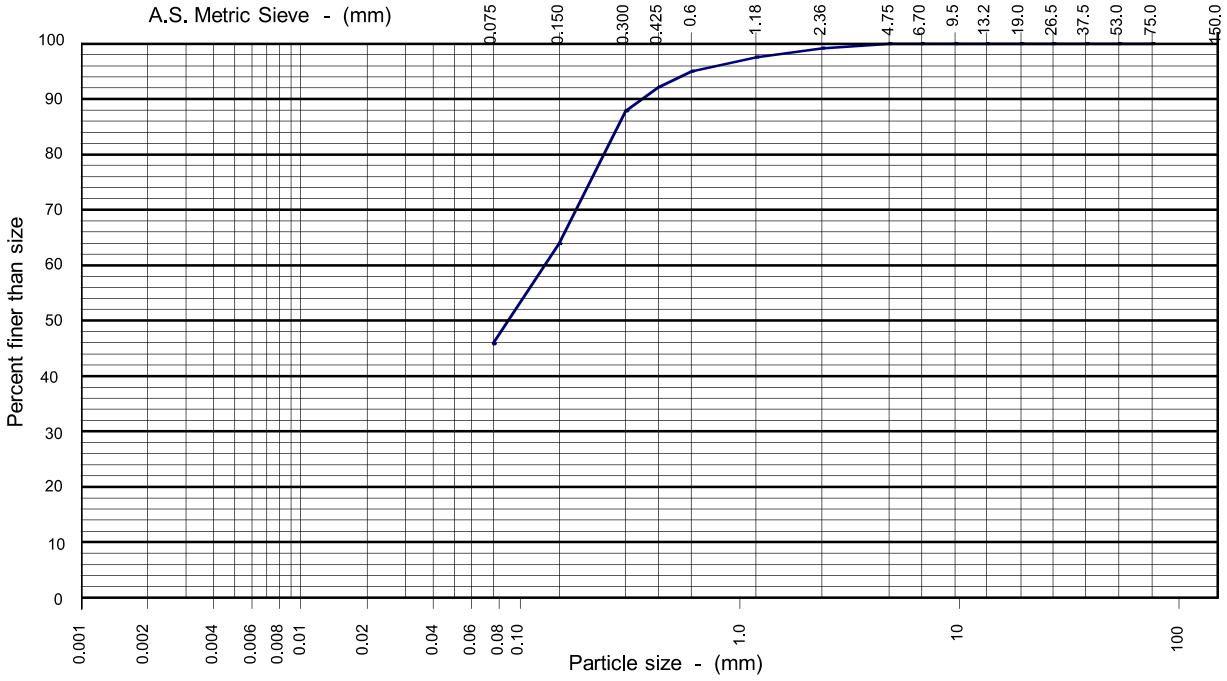
UNGR 1 G

(-/10/10)

REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-3979AB
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 9.24-9.48m(Uncorrected)	**TESTED BY:**	MW,LH	**DATE:**	5-6.10.11
MATERIAL:	Clayey Sand	**CHECKED BY:**	KR	**DATE:**	6.10.11
TEST PROCEDURES:	AS 1289.3.1.1, 3.2.1, 3.3.1, 3.4.1, 3.6.1	**CLIENT REF:**	CX3106FC-165751		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
46				28	21	4	1	0	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0	100		
9.5	100		
4.75	100		
2.36	99		
1.18	98		
0.600	95		
0.425	92		
0.300	88		
0.150	64		
0.075	46		

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
33	15	18	11.0	-

Classification: **Clayey Sand;** fine to coarse grained

(SC)

Sampled in Accordance with AS 1289.1.2.1 (6.5.3)

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

NATA

Accredited No. 910

Certificate No. 11-3979A

Date of Issue 6.10.11

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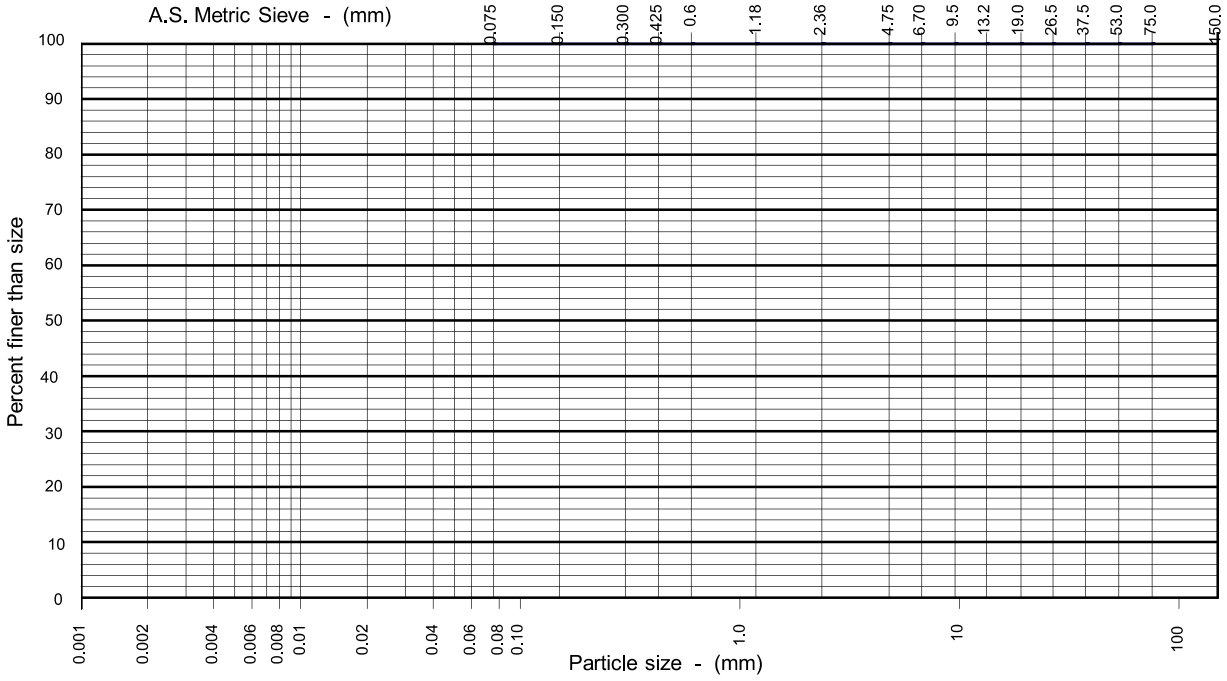
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-3980AB
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 14.00-14.20m(Uncorrected)	**TESTED BY:**	MW,TL	**DATE:**	7-11.10.11
MATERIAL:	XW Claystone	**CHECKED BY:**	KR	**DATE:**	13.10.11
TEST PROCEDURES:	AS 1289.3.1.1, 3.2.1, 3.3.1, 3.4.1, 3.8.1	**CLIENT REF:**	CX3106FC-165753		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
				0	0	0	0	0	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0			
9.5			
4.75			
2.36			
1.18			
0.600			
0.425			
0.300			
0.150			
0.075			

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
43	20	23	12.5	-

Classification:

Emerson Class No.: 5 Type of Water: Distilled Temperature of Water: 23ºC

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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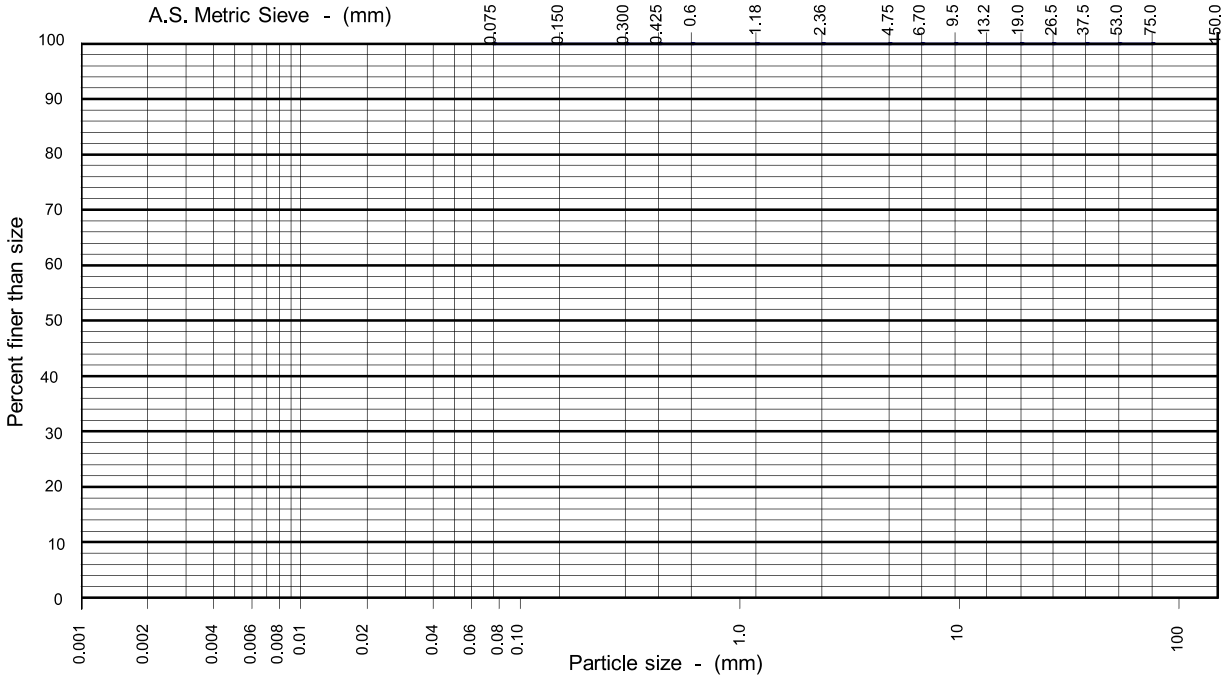
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-3981AB
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 55.00-55.20m(Uncorrected)	**TESTED BY:**	MW,TL	**DATE:**	6-7.10.11
MATERIAL:	HW Claystone	**CHECKED BY:**	KR	**DATE:**	10.10.11
TEST PROCEDURES:	AS 1289.3.1.1, 3.2.1, 3.3.1, 3.4.1, 3.8.1	**CLIENT REF:**	CX3106FC-165765		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
				0	0	0	0	0	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0			
9.5			
4.75			
2.36			
1.18			
0.600			
0.425			
0.300			
0.150			
0.075			

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
30	15	15	8.0	-

Classification:

Emerson Class No.: 6 Type of Water: Distilled Temperature of Water: 23ºC

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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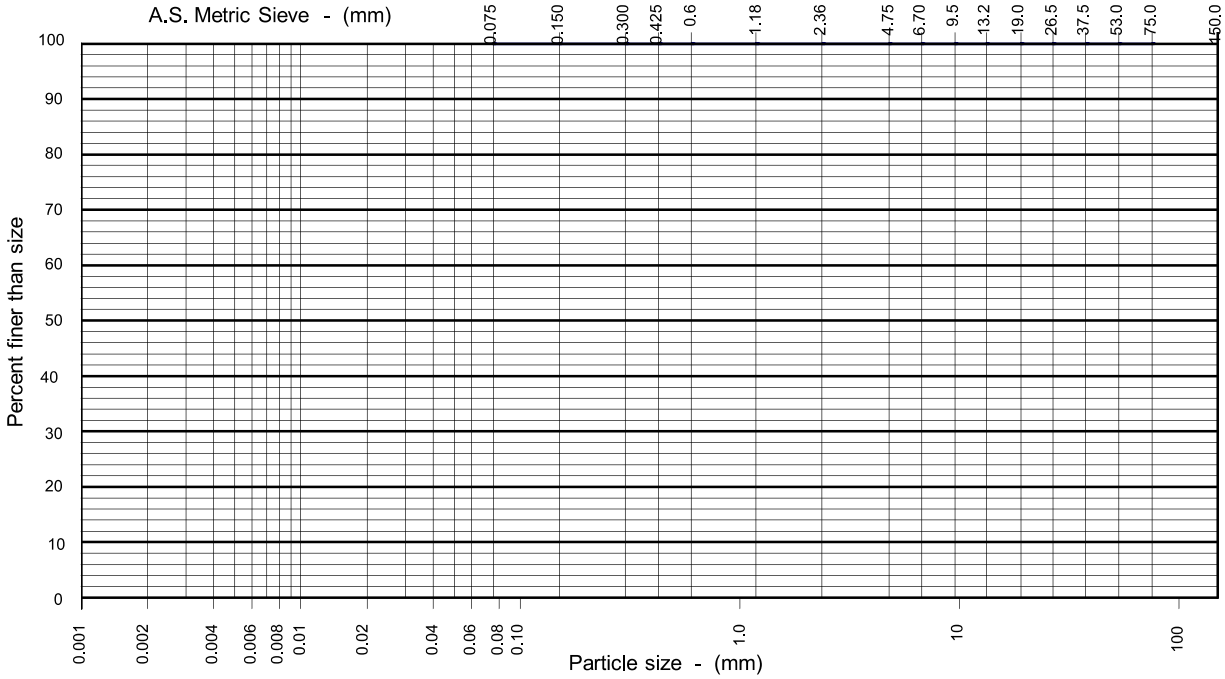
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-3982A
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 57.95-58.25m(Uncorrected)	**TESTED BY:**	MW	**DATE:**	11.10.11
MATERIAL:	HW Conglomerate	**CHECKED BY:**	KR	**DATE:**	13.10.11
TEST PROCEDURES:	AS 1289.3.1.1, 3.2.1, 3.3.1, 3.4.1	**CLIENT REF:**	CX3106FC-165766		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
				0	0	0	0	0	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0			
9.5			
4.75			
2.36			
1.18			
0.600			
0.425			
0.300			
0.150			
0.075			

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
35	20	15	6.5	-

Classification:

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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REPORT ON SLAKE DURABILITY TEST

Sheet 1 of 1 | Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	Refer below
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	29-Sep-11
TEST PROCEDURE:	AS 4133.3.4	**CHECKED BY:**	AW	**CHECK DATE:**	08-Oct-11

Lab Ref No	Borehole	Client Ref	Uncorrected Depth From (m)	Uncorrected Depth To (m)	Slake Durability Index (First Cycle) %	Slake Durability Index (Second Cycle) %	Appearance of Fragments Retained in the drum	Appearance of Fragments Passing the drum
11-3983A	CX3106FC	165785	189.37	189.60	96.5	95.6	Rock lumps still intact	Sandy silt

Temperature of slaking fluid: 23 °C

Slaking fluid used: Potable

Variations from standard: Nil

Signature: _____ Date: 08-Oct-11

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REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-3984A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	01-Oct-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	08-Oct-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.	CX3106FC
Client sample number	165787
Uncorrected Depth from (m)	191.70
Uncorrected Depth to (m)	192.01
Stratigraphic horizon	
Orientation of core axis	Vertical
Lithological description	FR Sandstone
Mass of sample (g)	1200.8
Average sample diameter (mm)	61.0
Diameter variation > 0.3mm?	No
Average height (mm)	151
Length / Diameter ratio	2.5
Cross sectional area (mm^2)	2922
Uniaxial Comp. Strength (MPa)	**20.2**
Number of specimens in sample	1
Moisture content (%)	1.1
Density at as received moisture content (t/m^3)	2.721
Loading rate (N/min)	12500
Time to failure (min)	4.42
Max. applied load (kN)	59.1
Dominant structural features with respect to core axis	Before / After
Secant Young's Modulus (Gpa)	**N/A**
Corrected Poisson's Ratio	**N/A**
Remarks	

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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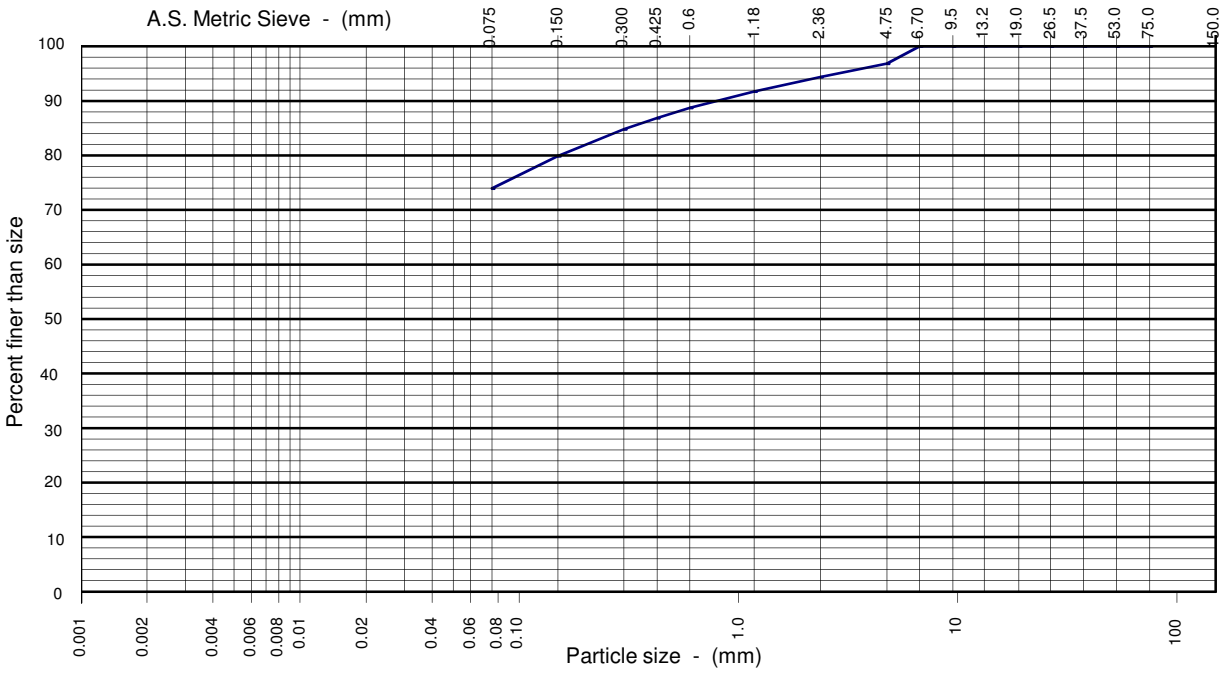
REPORT ON SOIL CLASSIFICATION

 Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-5338ABC
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 10.00-10.30m	**TESTED BY:**	TL, BS	**DATE:**	3-4.1.12
MATERIAL:	Extremely Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	5.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.6.1,3.8.1	**CLIENT REF:**	CX3115FC-933		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
74				8	7	5	4	2	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0			
9.5	100		
4.75	97		
2.36	94		
1.18	92		
0.600	89		
0.425	87		
0.300	85		
0.150	80		
0.075	74		

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
44	14	30	15.0	-

Classification: **Sandy Clay;** sand is fine to coarse grained

(CI)

Emerson Class No.: 4 Type of Water: Distilled Temp. Of Water: 24ºC

Sampled in Accordance with AS 1289.1.2.1 (6.5.3)

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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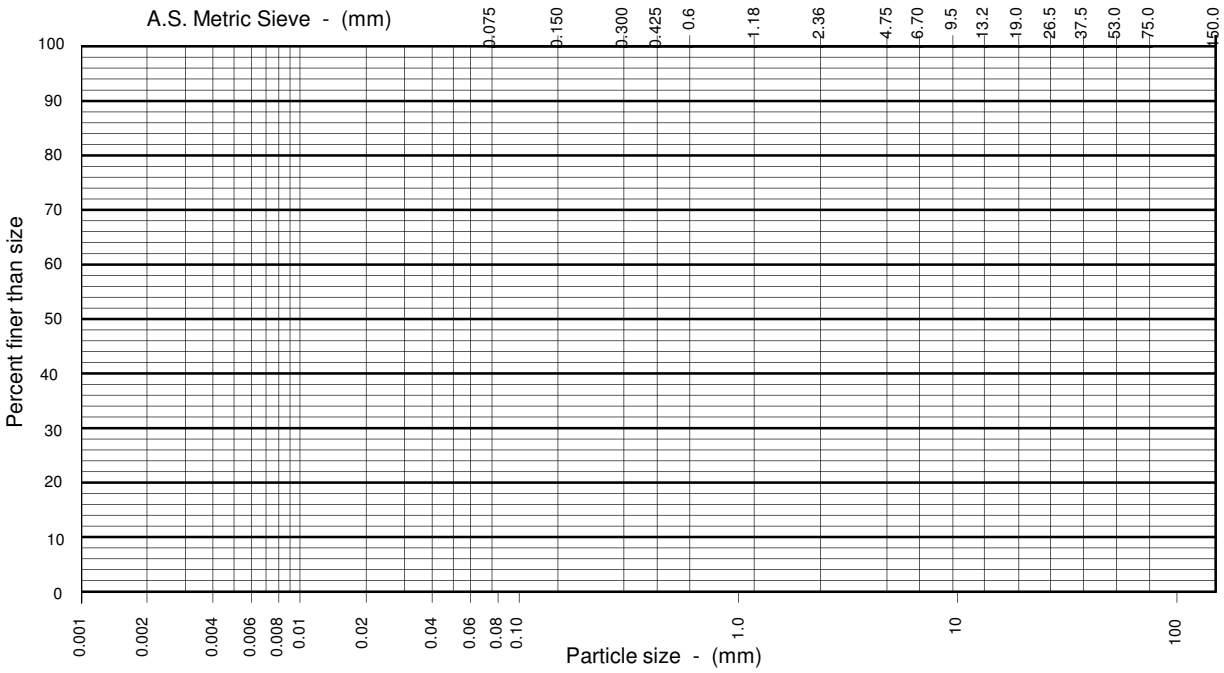
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**			11-5339AB
PROJECT:	Codrilla			**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 15.00-15.68m			**TESTED BY:**	TL, BS	**DATE:**	3-4.1.12
MATERIAL:	Extremely Weathered Claystone			**CHECKED BY:**	CC	**DATE:**	5.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.8.1			**CLIENT REF:**	CX3115FC-935		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
150.0				46	15	31	15.5	-
75.0								
37.5								
19.0								
9.5								
4.75								
2.36								
1.18								
0.600								
0.425								
0.300								
0.150								
0.075								

Classification:

Emerson Class No.: 4 Type of Water: Distilled Temp. Of Water: 24ºC

Sampled in Accordance with AS 1289.1.2.1 (6.5.4)

Preparation History of Atterberg Limits

Sample : ~~Natural~~/Air Dried/~~Oven~~

Sieved: ~~Wet~~/dry

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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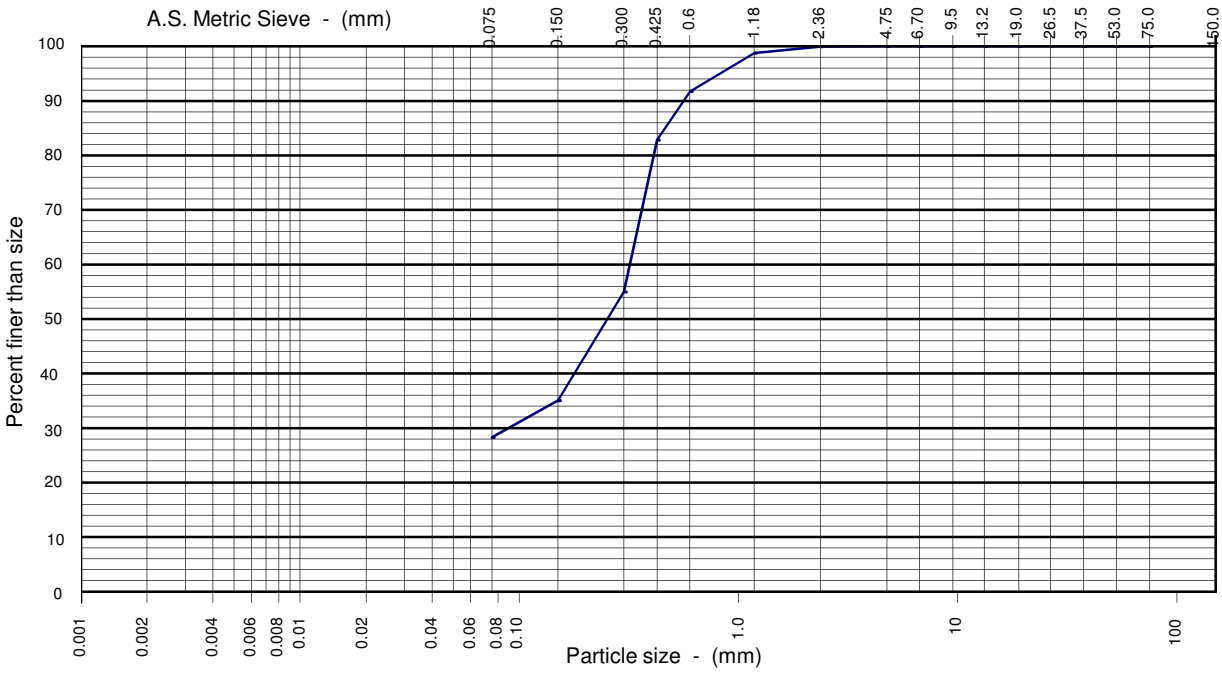
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-5341ABC
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 69.19-69.39m	**TESTED BY:**	LH, BS	**DATE:**	3-5.1.12
MATERIAL:	Highly Weathered Sandstone	**CHECKED BY:**	CC	**DATE:**	6.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.6.1,3.8.1	**CLIENT REF:**	CX3115FC-952		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
28				15	49	8	0	0	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0			
9.5			
4.75			
2.36	100		
1.18	99		
0.600	92		
0.425	83		
0.300	55		
0.150	35		
0.075	28		

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
39	22	17	8.5	-

Classification: **Clayey Sand;** fine to coarse grained

(CI)

Emerson Class No.: 4 Type of Water: Distilled Temp. Of Water: 24ºC

Sampled in Accordance with AS 1289.1.2.1 (6.5.3)

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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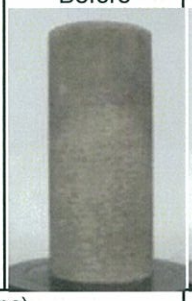
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4895A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	29-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	05-Dec-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3115FC
Client sample number		GT01
Depth from (m)		82.76
Depth to (m)		83.06
Stratigraphic horizon		LL1 Roof
Orientation of core axis		Vertical
Lithological description		Sandstone
Mass of sample (g)		1140.4
Average sample diameter (mm)		61.0
Diameter variation > 0.3mm?		No
Average height (mm)		155
Length / Diameter ratio		2.5
Cross sectional area (mm^2)		2922
Uniaxial Comp. Strength (MPa)		**9.3**
Number of specimens in sample		1
Moisture content (%)		3.7
Density at as received moisture content (t/m^3)		2.518
Loading rate (N/min)		5000
Time to failure (min)		5.25
Max. applied load (kN)		27.1
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard:

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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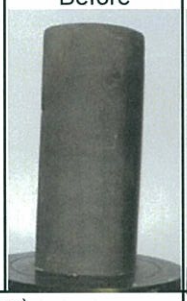
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4896A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	29-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	05-Dec-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3115FC
Client sample number		GT02
Depth from (m)		84.37
Depth to (m)		84.66
Stratigraphic horizon		LL1 Floor
Orientation of core axis		Vertical
Lithological description		Sandstone
Mass of sample (g)		1058.0
Average sample diameter (mm)		60.7
Diameter variation > 0.3mm?		No
Average height (mm)		151
Length / Diameter ratio		2.5
Cross sectional area (mm^2)		2894
Uniaxial Comp. Strength (MPa)		**4.1**
Number of specimens in sample		1
Moisture content (%)		8.2
Density at as received moisture content (t/m^3)		2.421
Loading rate (N/min)		5000
Time to failure (min)		2.24
Max. applied load (kN)		11.9
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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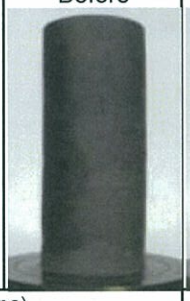
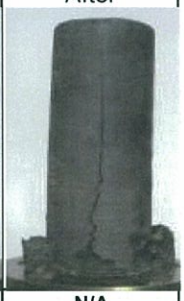
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4897A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	29-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	05-Dec-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3115FC
Client sample number		GT03
Depth from (m)		116.03
Depth to (m)		116.23
Stratigraphic horizon		LL2 Roof
Orientation of core axis		Vertical
Lithological description		XL
Mass of sample (g)		1084.4
Average sample diameter (mm)		60.8
Diameter variation > 0.3mm?		Yes
Average height (mm)		152
Length / Diameter ratio		2.5
Cross sectional area (mm^2)		2903
Uniaxial Comp. Strength (MPa)		**11.6**
Number of specimens in sample		1
Moisture content (%)		4.2
Density at as received moisture content (t/m^3)		2.457
Loading rate (N/min)		5000
Time to failure (min)		6.43
Max. applied load (kN)		33.6
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard:

Young's Modulus method: N/A

Poisson's Ratio method: N/A

NATA

Accredited No.	910
Certificate No.	11-4897A
Date of Issue	05-Dec-11

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Authorised Signatory

Andrew Williams

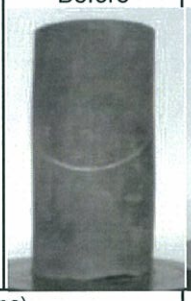
CARDNO ULLMAN & NOLAN GEOTECHNIC PTY LTD

71 CONNORS ROAD MACKAY QLD

REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4898A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	01-Dec-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	05-Dec-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3115FC
Client sample number		GT04
Depth from (m)		119.60
Depth to (m)		119.86
Stratigraphic horizon		LL2 Floor
Orientation of core axis		Vertical
Lithological description		Siltstone
Mass of sample (g)		967.4
Average sample diameter (mm)		60.7
Diameter variation > 0.3mm?		No
Average height (mm)		131
Length / Diameter ratio		2.2
Cross sectional area (mm^2)		2894
Uniaxial Comp. Strength (MPa)		**1.5**
Number of specimens in sample		1
Moisture content (%)		2.4
Density at as received moisture content (t/m^3)		2.552
Loading rate (N/min)		5000
Time to failure (min)		0.90
Max. applied load (kN)		4.4
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Had a natural crack along a lamination that was glued prior to test.
Height to diameter ratio less than 2.5 due to core structural features.
Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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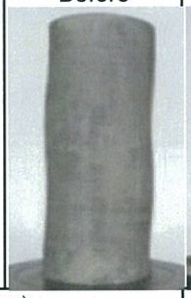
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4899A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	30-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	05-Dec-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3115FC
Client sample number		GT05
Depth from (m)		153.21
Depth to (m)		153.48
Stratigraphic horizon		VU Roof
Orientation of core axis		Vertical
Lithological description		Siltstone
Mass of sample (g)		1131.0
Average sample diameter (mm)		60.6
Diameter variation > 0.3mm?		Yes
Average height (mm)		154
Length / Diameter ratio		2.5
Cross sectional area (mm^2)		2884
Uniaxial Comp. Strength (MPa)		**45.5**
Number of specimens in sample		1
Moisture content (%)		2.3
Density at as received moisture content (t/m^3)		2.546
Loading rate (N/min)		12500
Time to failure (min)		10.30
Max. applied load (kN)		131.1
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard:

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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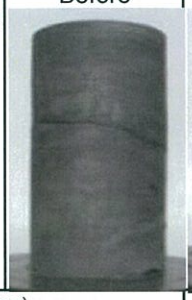
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4900A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	30-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	05-Dec-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3115FC
Client sample number		GT06
Depth from (m)		161.94
Depth to (m)		162.26
Stratigraphic horizon		VU Floor
Orientation of core axis		Vertical
Lithological description		XL
Mass of sample (g)		783.4
Average sample diameter (mm)		60.9
Diameter variation > 0.3mm?		No
Average height (mm)		114
Length / Diameter ratio		1.9
Cross sectional area (mm^2)		2913
Uniaxial Comp. Strength (MPa)		**4.3**
Number of specimens in sample		1
Moisture content (%)		2.9
Density at as received moisture content (t/m^3)		2.359
Loading rate (N/min)		5000
Time to failure (min)		2.30
Max. applied load (kN)		12.6
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Had a natural crack along a lamination that was glued prior to test.
Height to diameter ratio less than 2.5 due to core structural features.
Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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Date of Issue	05-Dec-11

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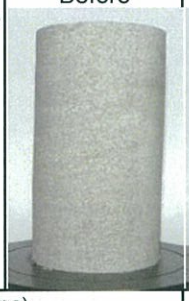
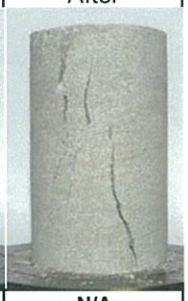
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	12-0270A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	14-Jan-12
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	16-Jan-12
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3115FC
Client sample number		0958
Depth from (m)		169.50
Depth to (m)		169.72
Stratigraphic horizon		-
Orientation of core axis		Vertical
Lithological description		FR Sandstone
Mass of sample (g)		881.8
Average sample diameter (mm)		60.8
Diameter variation > 0.3mm?		No
Average height (mm)		117
Length / Diameter ratio		1.9
Cross sectional area (mm^2)		2903
Uniaxial Comp. Strength (MPa)		**65.7**
Number of specimens in sample		1
Moisture content (%)		1.6
Density at as received moisture content (t/m^3)		2.596
Loading rate (N/min)		25000
Time to failure (min)		7.37
Max. applied load (kN)		190.7
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Height to diameter ratio less than 2.5 due to core structural features.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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Certificate No.	12-0270A
Date of Issue	16-Jan-12

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Authorised Signatory

Andrew Williams

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(6/5/09)

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REPORT ON SLAKE DURABILITY TEST

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	Refer below
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	30/11/2011-14/1/12
TEST PROCEDURE:	AS 4133.3.4	**CHECKED BY:**	AW	**CHECK DATE:**	14-Jan-12

Lab Ref No	Borehole	Client Ref	Depth From (m)	Depth To (m)	Slake Durability Index (First Cycle) %	Slake Durability Index (Second Cycle) %	Appearance of Fragments Retained in the drum	Appearance of Fragments Passing the drum
11-4896B	CX3115FC	GT2	84.37	84.66	82.0	3.1	Rock lumps completely broken down, many small angular particles present	Large quantities of silty material present
11-4898B	CX3115FC	GT4	119.60	119.86	97.1	96.5	Rock lumps completely broken down, many small angular particles present	Gritty material present
11-4900B	CX3115FC	GT6	161.94	162.26	95.2	91.3	Rock lumps completely broken down, many small angular particles present	Large quantities of sandy/silty material present
12-0270B	CX3115FC	0958	169.50	169.72	97.1	96.8	Rock lumps still intact	Fine silt

Temperature of slaking fluid: 23 °C

Slaking fluid used: Potable

Variations from standard: Nil

Signature: Andrew Williams

Date: 14-Jan-12

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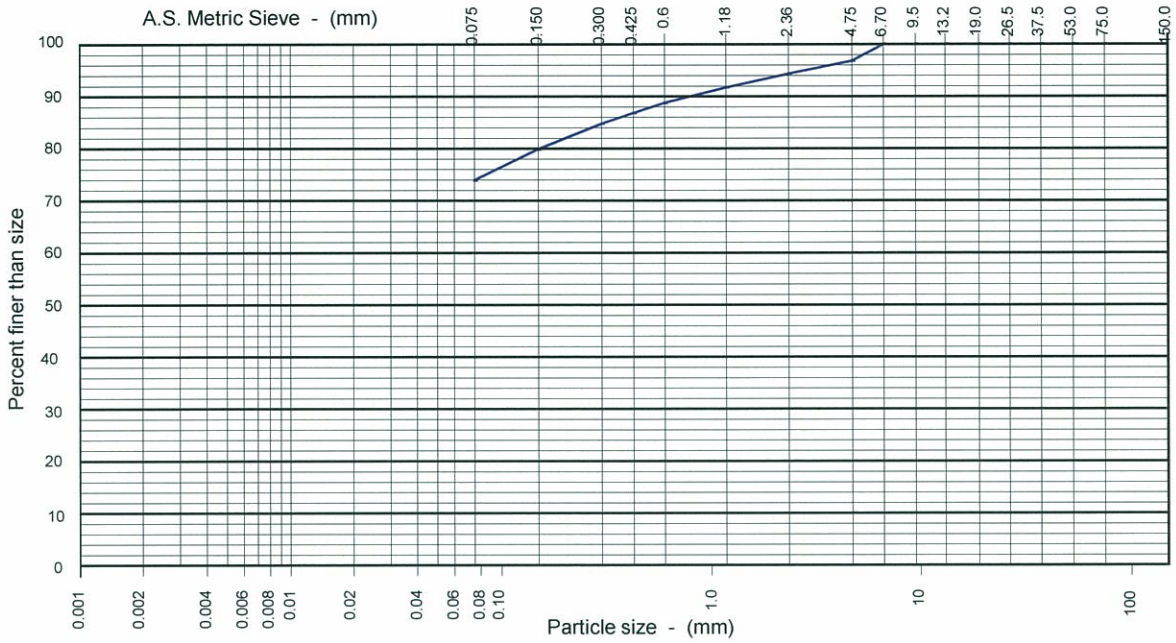
(-/10/10)

REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-5338ABC
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 10.00-10.30m	**TESTED BY:**	TL, BS	**DATE:**	3-4.1.12
MATERIAL:	Extremely Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	5.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.6.1,3.8.1	**CLIENT REF:**	CX3115FC-933		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
74				8	7	5	4	2	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
150.0				44	14	30	15.0	-
75.0				Classification: **Sandy Clay;** sand is fine to coarse grained				
37.5								(CI)
19.0				Emerson Class No.: 4	Type of Water: Distilled			Temp. Of Water: 24ºC
9.5	100			Sampled in Accordance with AS 1289.1.2.1 (6.5.3)				
4.75	97							
2.36	94							
1.18	92							
0.600	89							
0.425	87							
0.300	85							
0.150	80							
0.075	74							

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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Date of Issue	5.1.12

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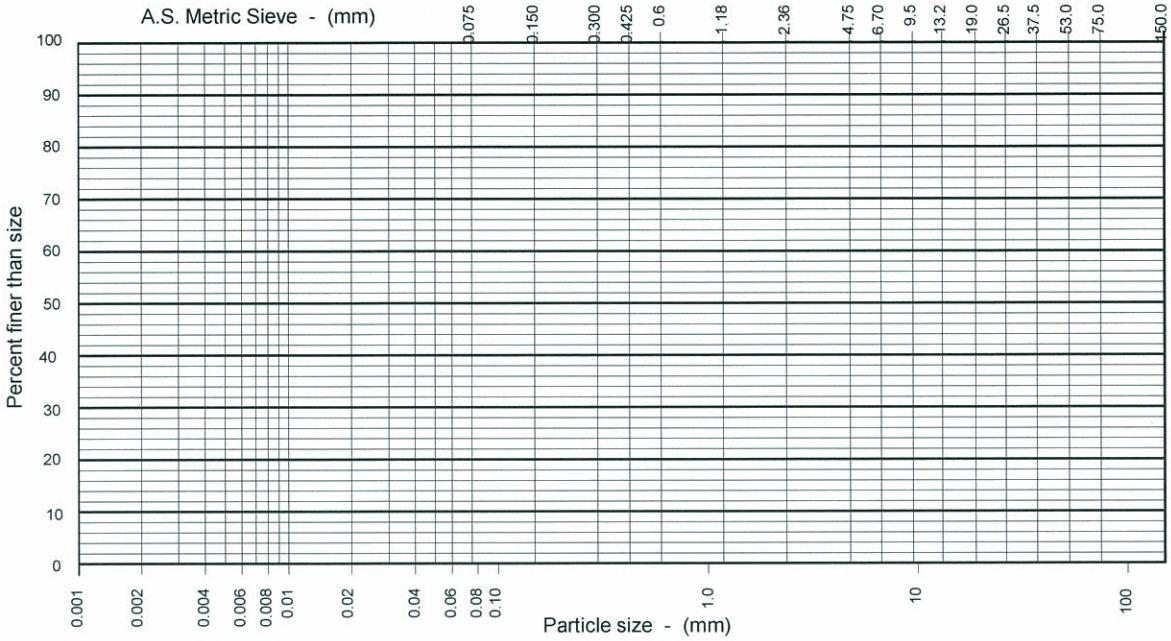
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-5339AB
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 15.00-15.68m	**TESTED BY:**	TL, BS	**DATE:**	3-4.1.12
MATERIAL:	Extremely Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	5.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.8.1	**CLIENT REF:**	CX3115FC-935		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
150.0				46	15	31	15.5	-
75.0				Classification:				
37.5								
19.0				Emerson Class No.: 4	Type of Water: Distilled		Temp. Of Water: 24°C	
9.5				Sampled in Accordance with AS 1289.1.2.1 (6.5.4)				
4.75				Preparation History of Atterberg Limits				
2.36				Sample : ~~Natural~~/Air Dried/~~Oven~~				
1.18				Sieved: ~~Wet~~/dry				
0.600								
0.425				Linear Shrinkage Data				
0.300				Length of Mould (mm) : 250				
0.150				Sample: -				
0.075								

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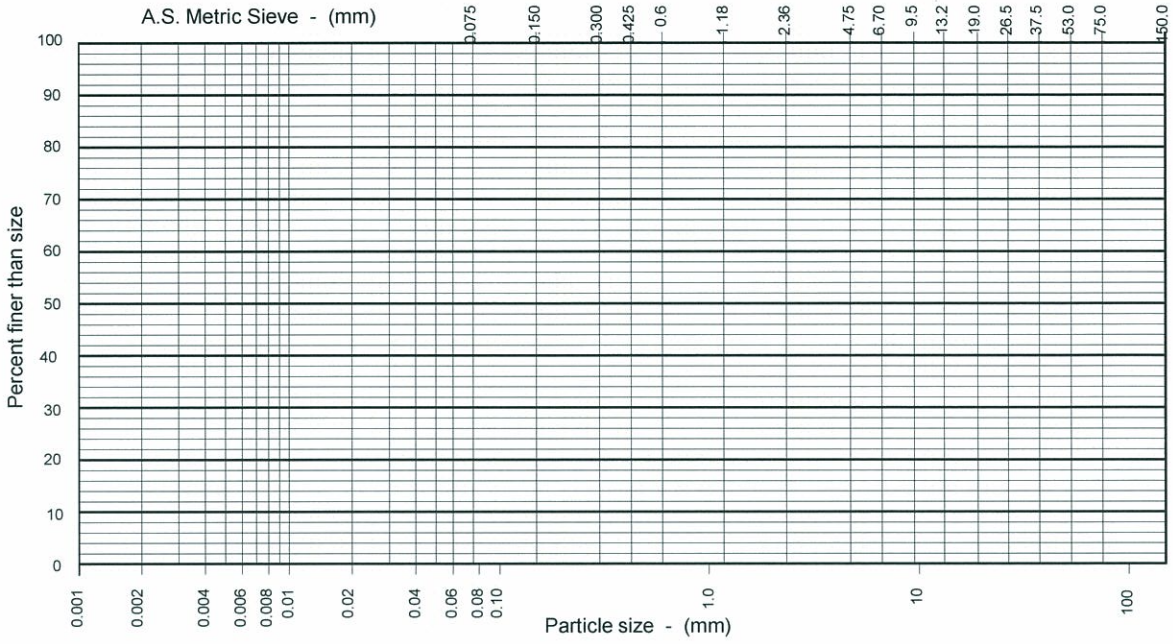
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-5340AB
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 55.00-55.20m	**TESTED BY:**	TL, BS	**DATE:**	3-5.1.12
MATERIAL:	Highly Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	6.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.8.1	**CLIENT REF:**	CX3115FC-947		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
150.0				44	19	25	12.0	-
75.0				Classification:				
37.5								
19.0				Emerson Class No.: 4	Type of Water: Distilled			Temp. Of Water: 24°C
9.5				Sampled in Accordance with AS 1289.1.2.1 (6.5.3)				
4.75								
2.36								
1.18								
0.600								
0.425								
0.300								
0.150								
0.075								

Preparation History of Atterberg Limits

Sample : ~~Natural~~/Air Dried/~~Oven~~

Sieved: ~~Wet~~/dry

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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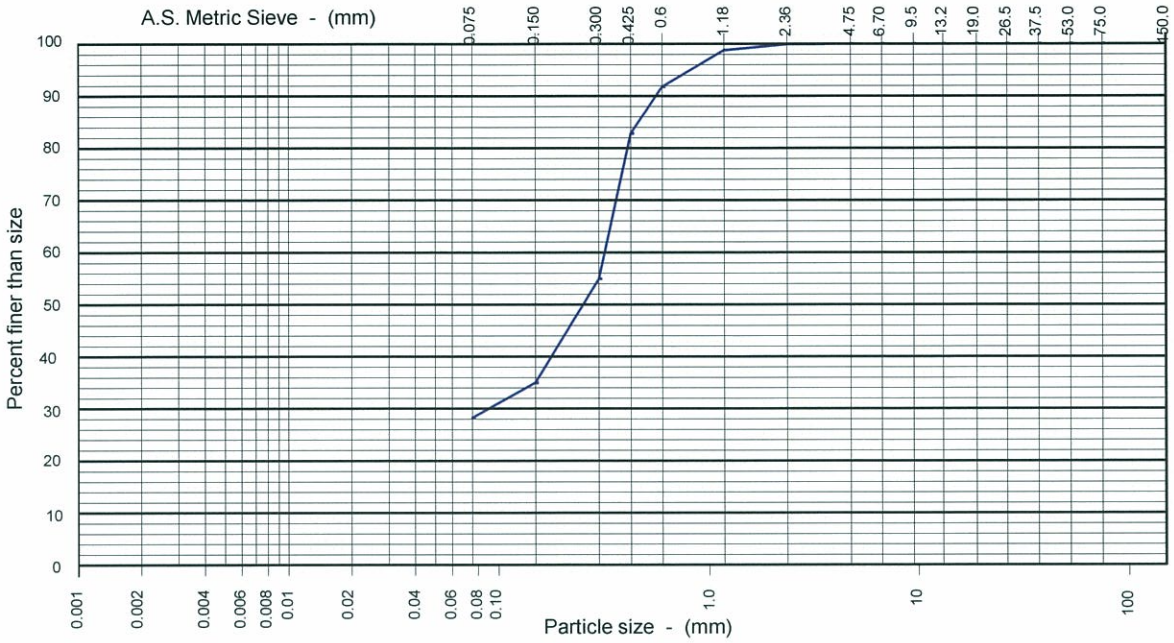
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-5341ABC
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 69.19-69.39m	**TESTED BY:**	LH, BS	**DATE:**	3-5.1.12
MATERIAL:	Highly Weathered Sandstone	**CHECKED BY:**	CC	**DATE:**	6.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.6.1,3.8.1	**CLIENT REF:**	CX3115FC-952		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
28				15	49	8	0	0	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
150.0				39	22	17	8.5	-
75.0				Classification: **Clayey Sand;** fine to coarse grained				
37.5								(CI)
19.0				Emerson Class No.: 4	Type of Water: Distilled			Temp. Of Water: 24°C
9.5				Sampled in Accordance with AS 1289.1.2.1 (6.5.3)				
4.75								
2.36	100							
1.18	99							
0.600	92							
0.425	83							
0.300	55							
0.150	35							
0.075	28							

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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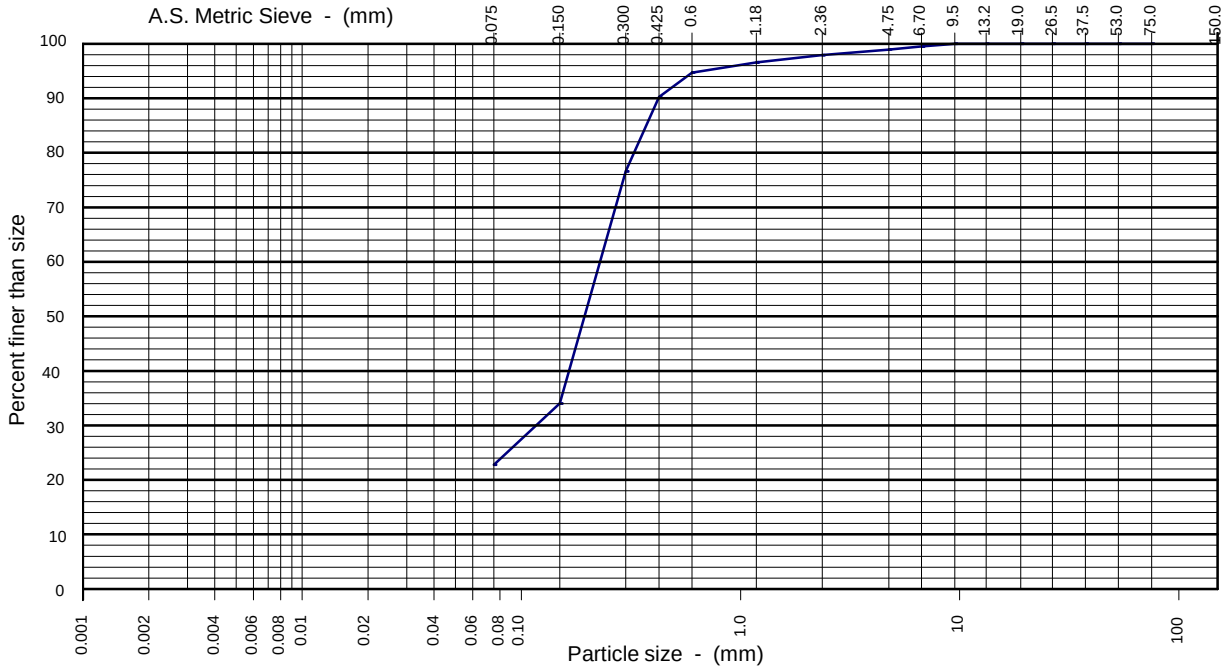
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-4346AB
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 10.00-10.20m	**TESTED BY:**	MW,LH	**DATE:**	2.11.11
MATERIAL:	XW Sandstone	**CHECKED BY:**	KR	**DATE:**	3.11.11
TEST PROCEDURES:	AS 1289.3.1.1, 3.2.1, 3.3.1, 3.4.1, 3.6.1	**CLIENT REF:**	CX3122FC-6221		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
23				29	43	3	1	1	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0	100		
9.5	100		
4.75	99		
2.36	98		
1.18	97		
0.600	95		
0.425	90		
0.300	77		
0.150	34		
0.075	23		

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
26	18	8	2.5	-

Classification: **XW Sandstone;** fine to coarse grained

(SC)

Sampled in Accordance with AS 1289.1.2.1 (6.5.3)

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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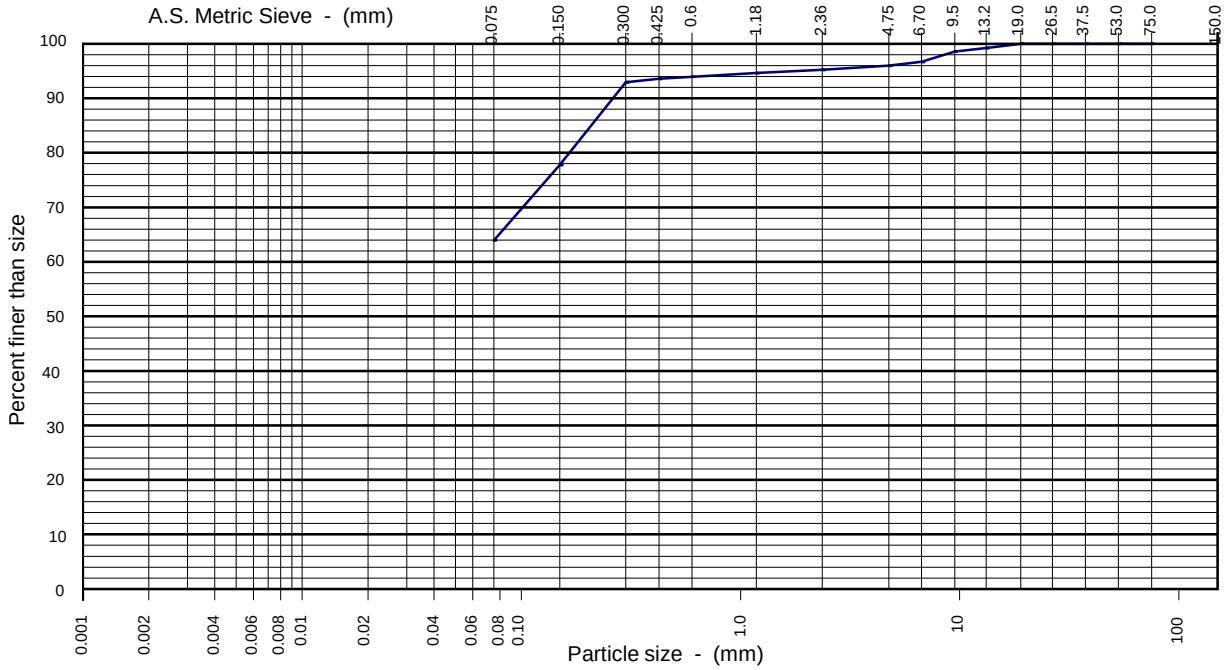
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	11-4348AB
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 24.24-24.44m	**TESTED BY:**	MW,LH	**DATE:**	3-8.11.11
MATERIAL:	HW Claystone	**CHECKED BY:**	KR	**DATE:**	9.11.11
TEST PROCEDURES:	AS 1289.3.1.1, 3.2.1, 3.3.1, 3.4.1, 3.6.1	**CLIENT REF:**	CX3122FC-6225		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
64				20	10	1	2	3	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0	100		
9.5	99		
4.75	96		
2.36	95		
1.18	95		
0.600	94		
0.425	94		
0.300	93		
0.150	78		
0.075	64		

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
37	19	18	8.5	-

Classification: **HW Claystone;** sand is fine to coarse grained

(CI)

Sampled in Accordance with AS 1289.1.2.1 (6.5.3)

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 150

Sample: -

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Certificate No.	11-4348A
Date of Issue	9.11.11

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REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4469A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	07-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.	CX3122FC
Client sample number	GT01
Depth from (m)	78.04
Depth to (m)	78.84
Stratigraphic horizon	LU Roof
Orientation of core axis	Vertical
Lithological description	Siltstone
Mass of sample (g)	601.7
Average sample diameter (mm)	60.5
Diameter variation > 0.3mm?	Yes
Average height (mm)	89
Length / Diameter ratio	1.5
Cross sectional area (mm^2)	2875
Uniaxial Comp. Strength (MPa)	**1.1**
Number of specimens in sample	1
Moisture content (%)	10.2
Density at as received moisture content (t/m^3)	2.352
Loading rate (N/min)	1250
Time to failure (min)	2.32
Max. applied load (kN)	3.1
Dominant structural features with respect to core axis	Before / After
Secant Young's Modulus (Gpa)	**N/A**
Corrected Poisson's Ratio	**N/A**
Remarks	

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Height to diameter ratio less than 2.5 due to core structural features.
Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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Certificate No.	11-4469A
Date of Issue	14-Nov-11

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REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4470A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	07-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3122FC
Client sample number		GT02
Depth from (m)		80.69
Depth to (m)		80.99
Stratigraphic horizon		LU Floor
Orientation of core axis		Vertical
Lithological description		Siltstone
Mass of sample (g)		954.4
Average sample diameter (mm)		60.4
Diameter variation > 0.3mm?		Yes
Average height (mm)		151
Length / Diameter ratio		2.5
Cross sectional area (mm^2)		2865
Uniaxial Comp. Strength (MPa)		**1.7**
Number of specimens in sample		1
Moisture content (%)		13.1
Density at as received moisture content (t/m^3)		2.206
Loading rate (N/min)		1250
Time to failure (min)		3.48
Max. applied load (kN)		4.8
Dominant structural features with respect to core axis	Before	After
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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Certificate No.	11-4470A
Date of Issue	14-Nov-11

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REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4471A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	07-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.	CX3122FC
Client sample number	GT03
Depth from (m)	99.13
Depth to (m)	99.40
Stratigraphic horizon	LL1 Roof
Orientation of core axis	Vertical
Lithological description	Sandstone
Mass of sample (g)	1130.7
Average sample diameter (mm)	60.8
Diameter variation > 0.3mm?	No
Average height (mm)	153
Length / Diameter ratio	2.5
Cross sectional area (mm^2)	2903
Uniaxial Comp. Strength (MPa)	**13.0**
Number of specimens in sample	1
Moisture content (%)	3.6
Density at as received moisture content (t/m^3)	2.545
Loading rate (N/min)	5000
Time to failure (min)	7.32
Max. applied load (kN)	37.7
Dominant structural features with respect to core axis	Before / After
Secant Young's Modulus (Gpa)	**N/A**
Corrected Poisson's Ratio	**N/A**
Remarks	

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard:

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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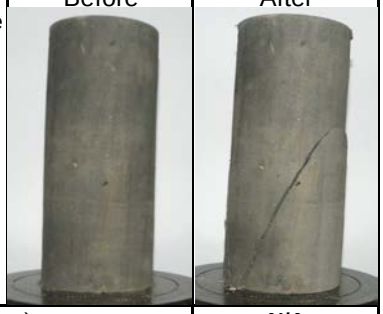
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4472A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	07-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.	CX3122FC
Client sample number	GT04
Depth from (m)	101.57
Depth to (m)	101.87
Stratigraphic horizon	LL1 Floor
Orientation of core axis	Vertical
Lithological description	Sandstone
Mass of sample (g)	1104.2
Average sample diameter (mm)	60.8
Diameter variation > 0.3mm?	No
Average height (mm)	152
Length / Diameter ratio	2.5
Cross sectional area (mm^2)	2903
Uniaxial Comp. Strength (MPa)	**6.4**
Number of specimens in sample	1
Moisture content (%)	4.0
Density at as received moisture content (t/m^3)	2.502
Loading rate (N/min)	5000
Time to failure (min)	3.43
Max. applied load (kN)	18.6
Dominant structural features with respect to core axis	Before / After
Secant Young's Modulus (Gpa)	**N/A**
Corrected Poisson's Ratio	**N/A**
Remarks	



Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4473A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	07-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.	CX3122FC
Client sample number	GT05
Depth from (m)	136.87
Depth to (m)	137.18
Stratigraphic horizon	LL2 Roof
Orientation of core axis	Vertical
Lithological description	Siltstone/ Mudstone
Mass of sample (g)	1080.9
Average sample diameter (mm)	60.6
Diameter variation > 0.3mm?	No
Average height (mm)	149
Length / Diameter ratio	2.5
Cross sectional area (mm^2)	2884
Uniaxial Comp. Strength (MPa)	**9.9**
Number of specimens in sample	1
Moisture content (%)	3.3
Density at as received moisture content (t/m^3)	2.515
Loading rate (N/min)	2500
Time to failure (min)	11.36
Max. applied load (kN)	28.4
Dominant structural features with respect to core axis	Before / After
Secant Young's Modulus (Gpa)	**N/A**
Corrected Poisson's Ratio	**N/A**
Remarks	

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard:

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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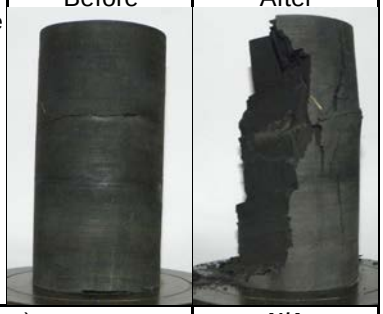
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4474A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	07-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.	CX3122FC
Client sample number	GT06
Depth from (m)	142.59
Depth to (m)	142.85
Stratigraphic horizon	LL2 Floor
Orientation of core axis	Vertical
Lithological description	Siltstone
Mass of sample (g)	897.1
Average sample diameter (mm)	60.8
Diameter variation > 0.3mm?	No
Average height (mm)	130
Length / Diameter ratio	2.1
Cross sectional area (mm^2)	2903
Uniaxial Comp. Strength (MPa)	**2.9**
Number of specimens in sample	1
Moisture content (%)	6.1
Density at as received moisture content (t/m^3)	2.377
Loading rate (N/min)	2500
Time to failure (min)	3.24
Max. applied load (kN)	8.5
Dominant structural features with respect to core axis	Before / After
Secant Young's Modulus (Gpa)	**N/A**
Corrected Poisson's Ratio	**N/A**
Remarks	



Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Had a natural crack along a lamination that was glued prior to test.
Height to diameter ratio less than 2.5 due to core structural features.
Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4475A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	07-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.	CX3122FC
Client sample number	GT07
Depth from (m)	165.73
Depth to (m)	165.96
Stratigraphic horizon	VU Roof
Orientation of core axis	Vertical
Lithological description	Siltstone
Mass of sample (g)	1086.5
Average sample diameter (mm)	60.6
Diameter variation > 0.3mm?	No
Average height (mm)	149
Length / Diameter ratio	2.5
Cross sectional area (mm^2)	2884
Uniaxial Comp. Strength (MPa)	**14.4**
Number of specimens in sample	1
Moisture content (%)	2.6
Density at as received moisture content (t/m^3)	2.528
Loading rate (N/min)	5000
Time to failure (min)	8.18
Max. applied load (kN)	41.5
Dominant structural features with respect to core axis	Before / After
Secant Young's Modulus (Gpa)	**N/A**
Corrected Poisson's Ratio	**N/A**
Remarks	

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard:

Young's Modulus method: N/A

Poisson's Ratio method: N/A

Accredited No.	910
Certificate No.	11-4475A
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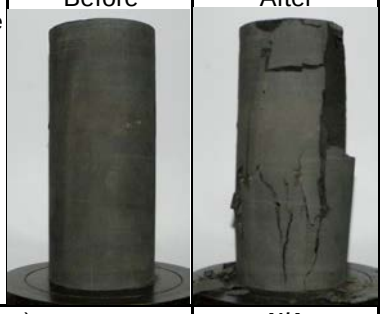
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4476A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	07-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.	CX3122FC
Client sample number	GT08
Depth from (m)	175.00
Depth to (m)	175.27
Stratigraphic horizon	VU Floor
Orientation of core axis	Vertical
Lithological description	Siltstone
Mass of sample (g)	1094.9
Average sample diameter (mm)	60.6
Diameter variation > 0.3mm?	No
Average height (mm)	153
Length / Diameter ratio	2.5
Cross sectional area (mm^2)	2884
Uniaxial Comp. Strength (MPa)	**16.5**
Number of specimens in sample	1
Moisture content (%)	3.9
Density at as received moisture content (t/m^3)	2.481
Loading rate (N/min)	5000
Time to failure (min)	9.30
Max. applied load (kN)	47.5
Dominant structural features with respect to core axis	Before / After
Secant Young's Modulus (Gpa)	**N/A**
Corrected Poisson's Ratio	**N/A**
Remarks	



Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard:

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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REPORT ON SLAKE DURABILITY TEST

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	Refer below
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	08-Nov-11
TEST PROCEDURE:	AS 4133.3.4	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11

Lab Ref No	Borehole	Client Ref	Depth From (m)	Depth To (m)	Slake Durability Index (First Cycle) %	Slake Durability Index (Second Cycle) %	Appearance of Fragments Retained in the drum	Appearance of Fragments Passing the drum
11-4470B	CX3122FC	GT02	80.69	80.99	61.4	3.5	Rock lumps completely broken down, many small angular particles present	Fine silt
11-4472B	CX3122FC	GT04	101.57	101.87	94.3	92.5	Rock lumps still intact	Fine silt
11-4474B	CX3122FC	GT06	142.59	142.85	91.6	44.7	Rock lumps completely broken down, many small angular particles present	Large quantities of angular, flaky material present
11-4476B	CX3122FC	GT08	175.00	175.27	94.6	86.1	Rock lumps broken down, many small angular particles present	Gritty material present

Temperature of slaking fluid: 23 °C

Slaking fluid used: Potable

Variations from standard: Nil

Signature: _____ Date: 14-Nov-11

Andrew Williams

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REPORT ON EMERSON CLASS NUMBER OF A SOIL

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	Refer below
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	LH	**TEST DATE:**	01-Nov-11
TEST PROGRAM:	Emerson Class program	**CHECKED BY:**	CC	**CHECK DATE:**	07-Nov-11
TEST PROCEDURES:	AS 4133.3.8.1				

Borehole.: CX3122FC Sample ID.: 6224

Lab Ref No.: 11-4347A From: 21.00 To: 21.24

Stratigraphic Location:

Soil Description: HW Claystone

Type of Water Used: Distilled

Temperature of Water: 23 °C

Emersion Class Number: 4

Variation to standard: Nil

Borehole.: CX3122FC Sample ID.: 6239

Lab Ref No.: 11-4349A From: 69.04 To: 69.24

Stratigraphic Location:

Soil Description: MW Siltstone

Type of Water Used: Distilled

Temperature of Water: 23 °C

Emersion Class Number: 7

Variation to standard: Nil

Borehole.: Sample ID.:

Lab Ref No.: From: To:

Stratigraphic Location:

Soil Description:

Type of Water Used:

Temperature of Water: °C

Emersion Class Number:

Variation to standard:

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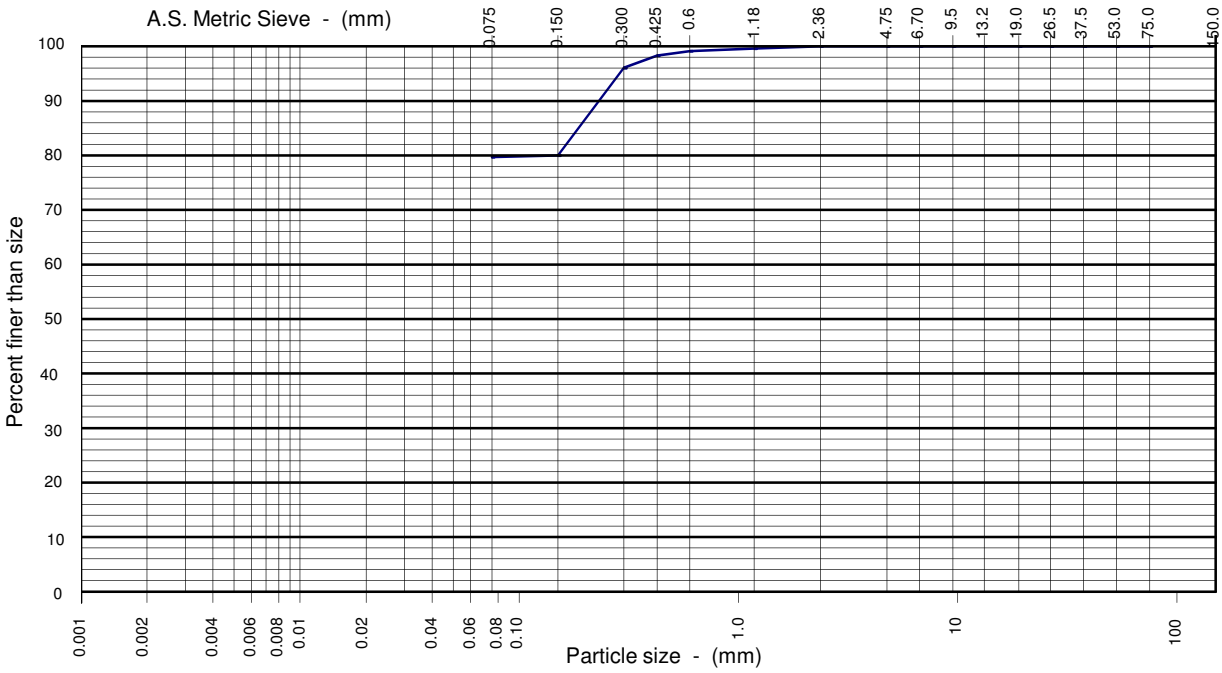
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	12-0012ABC
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 10.30-10.50m	**TESTED BY:**	TL, AR	**DATE:**	5-6.1.12
MATERIAL:	Extremely Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	6.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.6.1	**CLIENT REF:**	CX3127FC-6257		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
80				7	12	1	0	0	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
150.0				44	13	31	14.5	-
75.0				Classification: **Sandy Clay;** sand is fine to coarse grained				
37.5								(CI)
19.0								
9.5				Sampled in Accordance with AS 1289.1.2.1 (6.5.3)				
4.75				Preparation History of Atterberg Limits				
2.36				Sample : ~~Natural/Air Dried/Oven~~				
1.18	100			Sieved: ~~Wet/dry~~				
0.600	99							
0.425	98			Linear Shrinkage Data				
0.300	96			Length of Mould (mm) : 250				
0.150	80			Sample: -				
0.075	80							

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Date of Issue 6.1.12

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(10/10)

REPORT ON EMERSON CLASS NUMBER OF A SOIL

Sheet 1 of 1 Mackay Laboratory

CLIENT:	Macarthur Coal(C.M Management)	**JOB NO.:**	U23209	**LAB REF NO.:**	12-0013A
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC676, Depth 15.14-15.42m	**TESTED BY:**	BS	**DATE:**	4.1.12
MATERIAL:	Extremely Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	4.1.12
TEST PROCEDURES:	AS 1289.3.8.1	**CLIENT REF:**	CX3127FC-6258		

Soil Description: Extremely Weathered Claystone

Type of Water Used: Distilled

Temperature of Water: 24 °C

Emerson Class Number: 4

NATA

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Certificate No. 12-0013A

Date of Issue 4.1.12

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Authorised Signatory:.....

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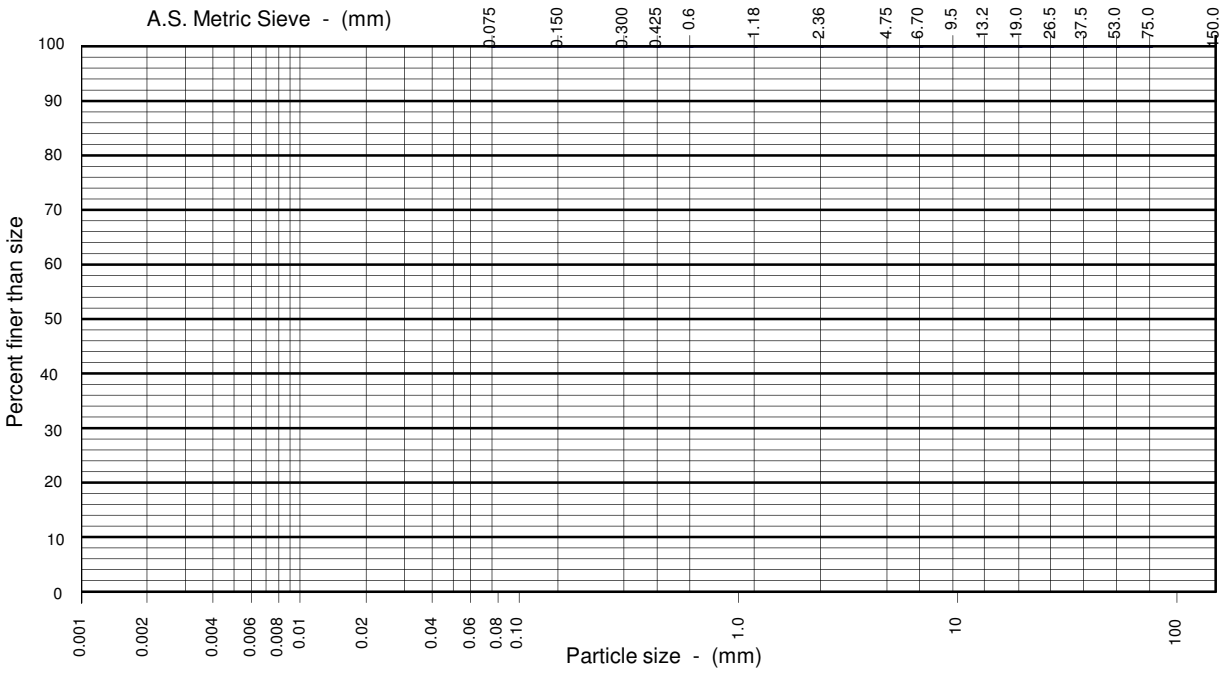
UNGR 1 G

(-/10/10)

REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	12-0014A
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 36.04-36.24m	**TESTED BY:**	TL	**DATE:**	5.1.12
MATERIAL:	Extremely Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	6.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1	**CLIENT REF:**	CX3127FC-6264		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
150.0				56	24	32	14.0	-
75.0				Classification:				
37.5								
19.0								
9.5				Sampled in Accordance with AS 1289.1.2.1 (6.5.3)				
4.75								
2.36								
1.18								
0.600								
0.425								
0.300								
0.150								
0.075								

Preparation History of Atterberg Limits

Sample : ~~Natural~~/Air Dried/~~Oven~~

Sieved: ~~Wet~~/dry

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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Certificate No.	12-0014A
Date of Issue	6.1.12

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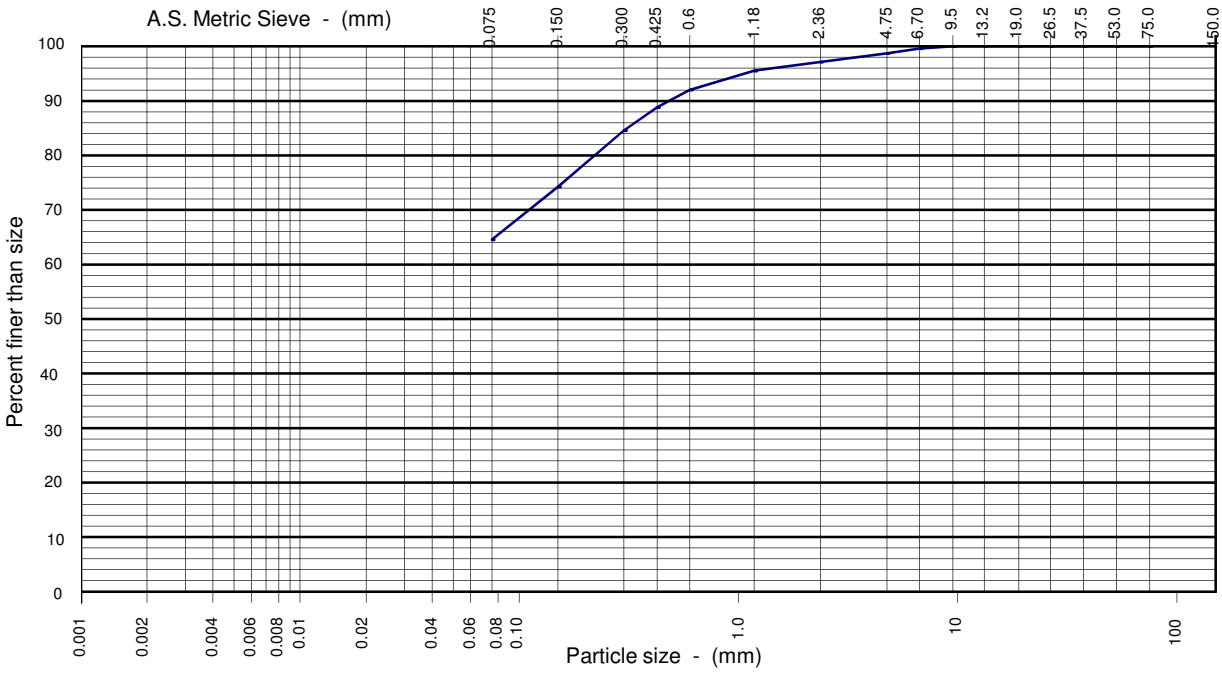
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	12-0015ABC
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 44.63-44.85m	**TESTED BY:**	TL, BS	**DATE:**	4-6.1.12
MATERIAL:	Highly Weathered Siltstone	**CHECKED BY:**	CC	**DATE:**	6.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.6.1,3.8.1	**CLIENT REF:**	CX3127FC-6267		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
65				14	13	5	2	1	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0			
9.5	100		
4.75	99		
2.36	97		
1.18	96		
0.600	92		
0.425	89		
0.300	85		
0.150	74		
0.075	65		

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
65	28	37	19.0	-

Classification: **Sandy Clay;** sand is fine to coarse grained

(CH)

Emerson Class No.: 4 Type of Water: Distilled Temp. Of Water: 24ºC

Sampled in Accordance with AS 1289.1.2.1 (6.5.3)

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

NATA

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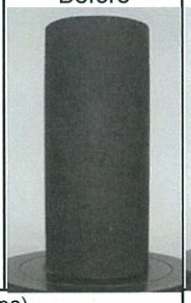
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4481A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	05-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3127FC
Client sample number		GT01
Depth from (m)		72.64
Depth to (m)		72.98
Stratigraphic horizon		VU Roof
Orientation of core axis		Vertical
Lithological description		XL
Mass of sample (g)		1013.5
Average sample diameter (mm)		60.5
Diameter variation > 0.3mm?		No
Average height (mm)		152
Length / Diameter ratio		2.5
Cross sectional area (mm^2)		2875
Uniaxial Comp. Strength (MPa)		**2.2**
Number of specimens in sample		1
Moisture content (%)		9.8
Density at as received moisture content (t/m^3)		2.319
Loading rate (N/min)		2500
Time to failure (min)		2.32
Max. applied load (kN)		6.3
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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Accredited No.	910
Certificate No.	11-4481A
Date of Issue	14-Nov-11

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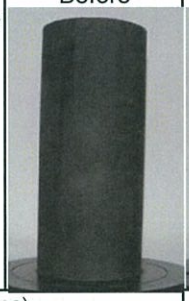
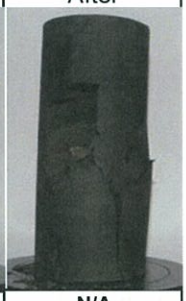
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	11-4482A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	05-Nov-11
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	14-Nov-11
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3127FC
Client sample number		GT02
Depth from (m)		82.42
Depth to (m)		82.71
Stratigraphic horizon		VU Floor
Orientation of core axis		Vertical
Lithological description		XM
Mass of sample (g)		977.6
Average sample diameter (mm)		60.2
Diameter variation > 0.3mm?		No
Average height (mm)		151
Length / Diameter ratio		2.5
Cross sectional area (mm^2)		2846
Uniaxial Comp. Strength (MPa)		**2.2**
Number of specimens in sample		1
Moisture content (%)		10.8
Density at as received moisture content (t/m^3)		2.275
Loading rate (N/min)		2500
Time to failure (min)		2.32
Max. applied load (kN)		6.4
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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Certificate No.	11-4482A
Date of Issue	14-Nov-11

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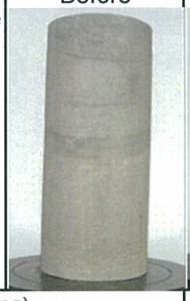
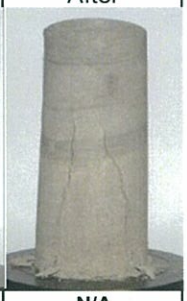
REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	12-0016A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	14-Jan-12
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	16-Jan-12
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3127FC
Client sample number		6294
Depth from (m)		84.93
Depth to (m)		85.15
Stratigraphic horizon		-
Orientation of core axis		Vertical
Lithological description		FR Sandstone
Mass of sample (g)		1080.7
Average sample diameter (mm)		60.2
Diameter variation > 0.3mm?		Yes
Average height (mm)		151
Length / Diameter ratio		2.5
Cross sectional area (mm^2)		2846
Uniaxial Comp. Strength (MPa)		**18.9**
Number of specimens in sample		1
Moisture content (%)		3.0
Density at as received moisture content (t/m^3)		2.514
Loading rate (N/min)		12500
Time to failure (min)		4.18
Max. applied load (kN)		53.7
Dominant structural features with respect to core axis	Before	After
		
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Time to failure less than standard 5 to 15 minutes.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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Accredited No.	910
Certificate No.	12-0016A
Date of Issue	16-Jan-12

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REPORT ON STRENGTH (UCS) TEST FOR ROCK MATERIALS

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	12-0017A
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	14-Jan-12
TEST PROGRAM:	UCS Testing program	**CHECKED BY:**	AW	**CHECK DATE:**	16-Jan-12
TEST PROCEDURES:	Q186 AS 4133.1.1.1				

Borehole No.		CX3127FC
Client sample number		6295
Depth from (m)		99.00
Depth to (m)		99.21
Stratigraphic horizon		-
Orientation of core axis		Vertical
Lithological description		FR Sandstone
Mass of sample (g)		650.7
Average sample diameter (mm)		60.6
Diameter variation > 0.3mm?		No
Average height (mm)		89
Length / Diameter ratio		1.5
Cross sectional area (mm^2)		2884
Uniaxial Comp. Strength (MPa)		**22.7**
Number of specimens in sample		1
Moisture content (%)		1.8
Density at as received moisture content (t/m^3)		2.535
Loading rate (N/min)		12500
Time to failure (min)		5.14
Max. applied load (kN)		65.5
Dominant structural features with respect to core axis	Before	After
Secant Young's Modulus (Gpa)		**N/A**
Corrected Poisson's Ratio		**N/A**
Remarks		

Storage History of specimens: Supplied by client, sealed. Stored at room temperature and humidity and tested at as received moisture content.

Compression machine: Shimadzu U.E.H. -50 S/N 79097

Variations from standard: Height to diameter ratio less than 2.5 due to core structural features.

Young's Modulus method: N/A

Poisson's Ratio method: N/A

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Certificate No.	12-0017A
Date of Issue	16-Jan-12

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Andrew Williams

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(6/5/09)

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REPORT ON SLAKE DURABILITY TEST

Mackay Laboratory

CLIENT:	Macarthur Coal (C&M Management) Pty Ltd	**JOB NO.:**	U23142	**LAB REF NO:**	Refer below
PROJECT:	Codrilla	**SAMPLED BY:**	Client	**SAMPLE DATE:**	Not supplied
LOCATION:	EPC676	**TESTED BY:**	RD	**TEST DATE:**	5/11/2011-14/1/12
TEST PROCEDURE:	AS 4133.3.4	**CHECKED BY:**	AW	**CHECK DATE:**	14-Jan-12

Lab Ref No	Borehole	Client Ref	Depth From (m)	Depth To (m)	Slake Durability Index (First Cycle) %	Slake Durability Index (Second Cycle) %	Appearance of Fragments Retained in the drum	Appearance of Fragments Passing the drum
11-4482B	CX3127FC	GT02	82.42	82.71	87.3	11.2	Rock lumps completely broken down, many small angular particles present	Large quantities of angular, flaky material present
12-0017B	CX3127FC	6295	99.00	99.21	96.3	95.4	Rock lumps still intact	Fine silt

Temperature of slaking fluid: 23 °C

Slaking fluid used: Potable

Variations from standard: Nil

Signature: _____ Andrew Williams

Date: 14-Jan-12

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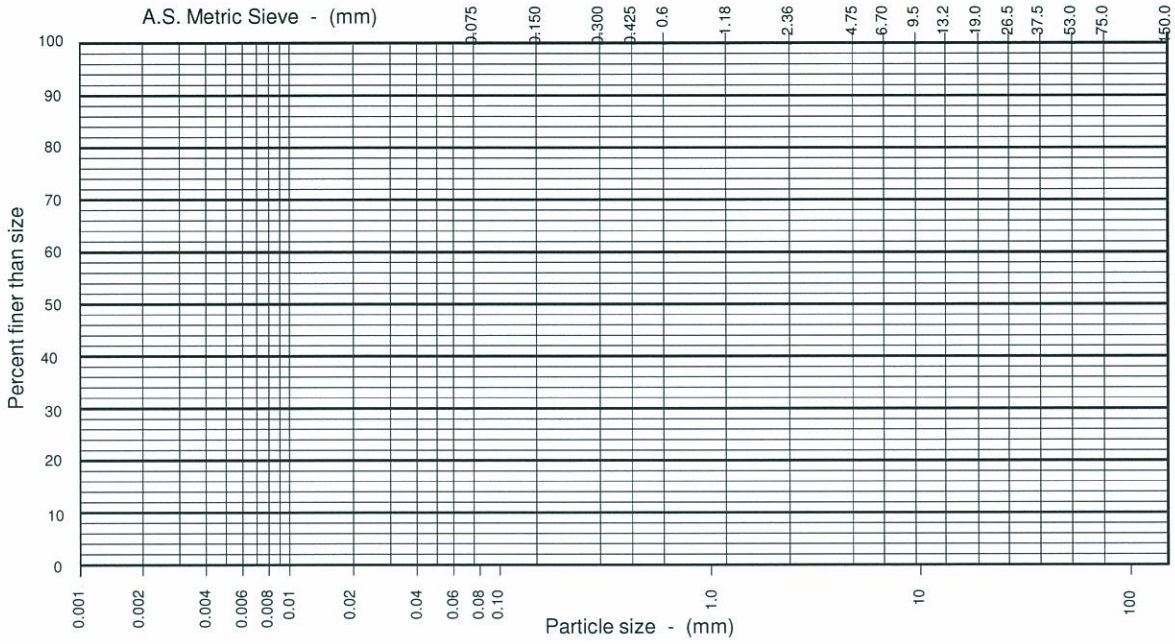
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	12-0014A
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 36.04-36.24m	**TESTED BY:**	TL	**DATE:**	5.1.12
MATERIAL:	Extremely Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	6.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1	**CLIENT REF:**	CX3127FC-6264		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0			
9.5			
4.75			
2.36			
1.18			
0.600			
0.425			
0.300			
0.150			
0.075			

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
56	24	32	14.0	-

Classification:

Sampled in Accordance with AS 1289.1.2.1 (6.5.3)

Preparation History of Atterberg Limits

Sample : ~~Natural~~/Air Dried/~~Oven~~

Sieved: ~~Wet~~/dry

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

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Accredited No.	910
Certificate No.	12-0014A
Date of Issue	6.1.12

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(10/10)

REPORT ON EMERSON CLASS NUMBER OF A SOIL

Sheet 1 of 1 | Mackay Laboratory

CLIENT:	Macarthur Coal(C.M Management)	**JOB NO.:**	U23209	**LAB REF NO.:**	12-0013A
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC676, Depth 15.14-15.42m	**TESTED BY:**	BS	**DATE:**	4.1.12
MATERIAL:	Extremely Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	4.1.12
TEST PROCEDURES:	AS 1289.3.8.1	**CLIENT REF:**	CX3127FC-6258		

Soil Description: Extremely Weathered Claystone

Type of Water Used: Distilled

Temperature of Water: 24 °C

Emerson Class Number: 4

NATA

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Date of Issue 4.1.12

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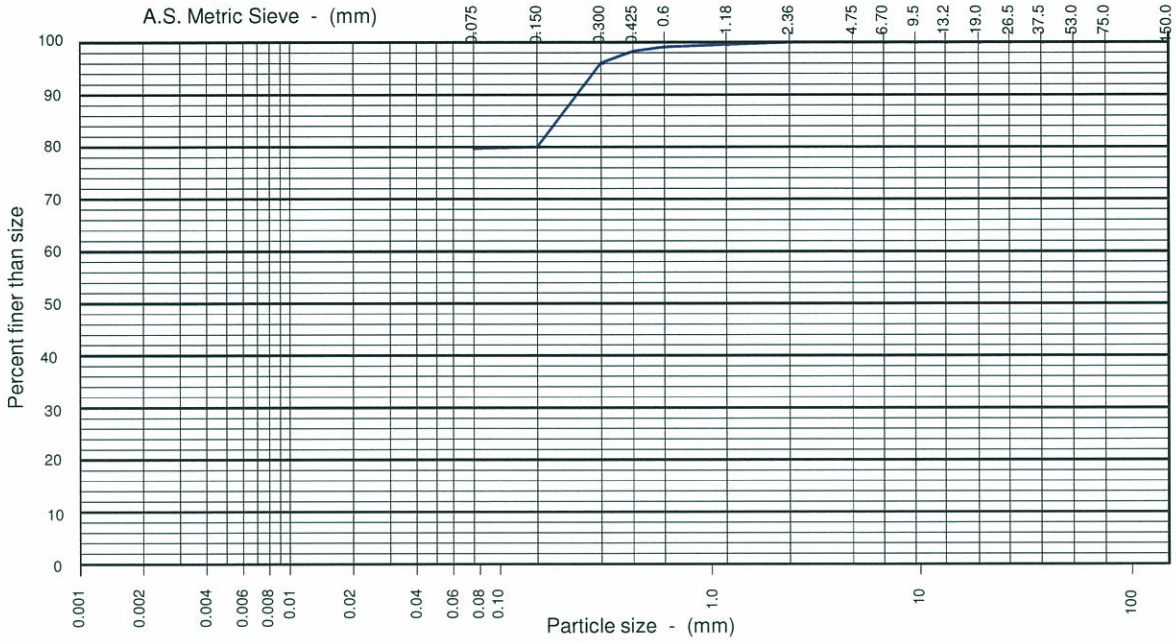
REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	12-0012ABC
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 10.30-10.50m	**TESTED BY:**	TL, AR	**DATE:**	5-6.1.12
MATERIAL:	Extremely Weathered Claystone	**CHECKED BY:**	CC	**DATE:**	6.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.6.1	**CLIENT REF:**	CX3127FC-6257		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
80				7	12	1	0	0	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0			
9.5			
4.75			
2.36			
1.18	100		
0.600	99		
0.425	98		
0.300	96		
0.150	80		
0.075	80		

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
44	13	31	14.5	-

Classification: **Sandy Clay;** sand is fine to coarse grained

(CI)

Sampled in Accordance with AS 1289.1.2.1 (6.5.3)

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

NATA

Accredited No.	910
Certificate No.	12-0012A
Date of Issue	6.1.12

This document is issued in accordance with NATA's accreditation requirements.

Authorised Signatory ..... N. J. Richardson

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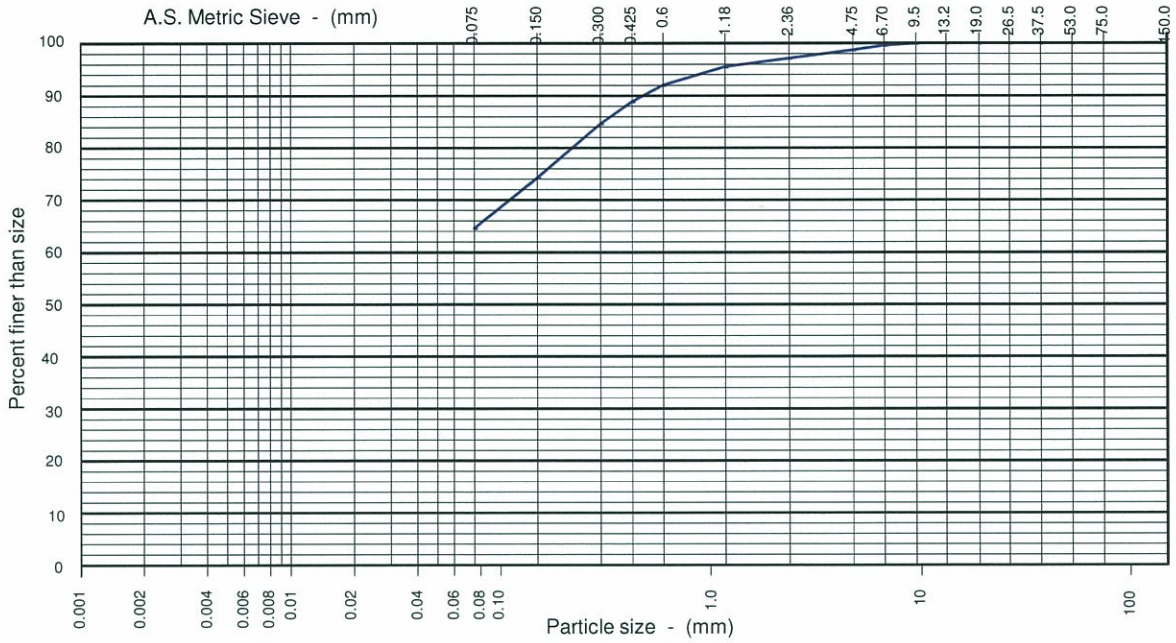
(-/10/10)

REPORT ON SOIL CLASSIFICATION

Mackay Laboratory

CLIENT:	Macarthur Coal (C.M Management)	**JOB NO:**	U23142	**LAB REF NO:**	12-0015ABC
PROJECT:	Codrilla	**SAMPLED BY:**	CLIENT	**DATE:**	Not Supplied
LOCATION:	EPC 676, Depth 44.63-44.85m	**TESTED BY:**	TL, BS	**DATE:**	4-6.1.12
MATERIAL:	Highly Weathered Siltstone	**CHECKED BY:**	CC	**DATE:**	6.1.12
TEST PROCEDURES:	AS 1289.3.1.1,3.2.1,3.3.1,3.4.1,3.6.1,3.8.1	**CLIENT REF:**	CX3127FC-6267		



clay	silt			sand			gravel			cobbles
	fine	medium	coarse	fine	medium	coarse	fine	medium	coarse	
65				14	13	5	2	1	0	0

Particle Size (mm)	Percent Passing (%)	Particle Size (mm)	Percent Passing (%)
150.0			
75.0			
37.5			
19.0			
9.5	100		
4.75	99		
2.36	97		
1.18	96		
0.600	92		
0.425	89		
0.300	85		
0.150	74		
0.075	65		

Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Soil Particle Density (g/cm^3)
65	28	37	19.0	-

Classification: **Sandy Clay;** sand is fine to coarse grained

(CH)

Emerson Class No.: 4 Type of Water: Distilled Temp. Of Water: 24°C

Sampled in Accordance with AS 1289.1.2.1 (6.5.3)

Preparation History of Atterberg Limits

Sample : ~~Natural/Air Dried/Oven~~

Sieved: ~~Wet/dry~~

Linear Shrinkage Data

Length of Mould (mm) : 250

Sample: -

NATA

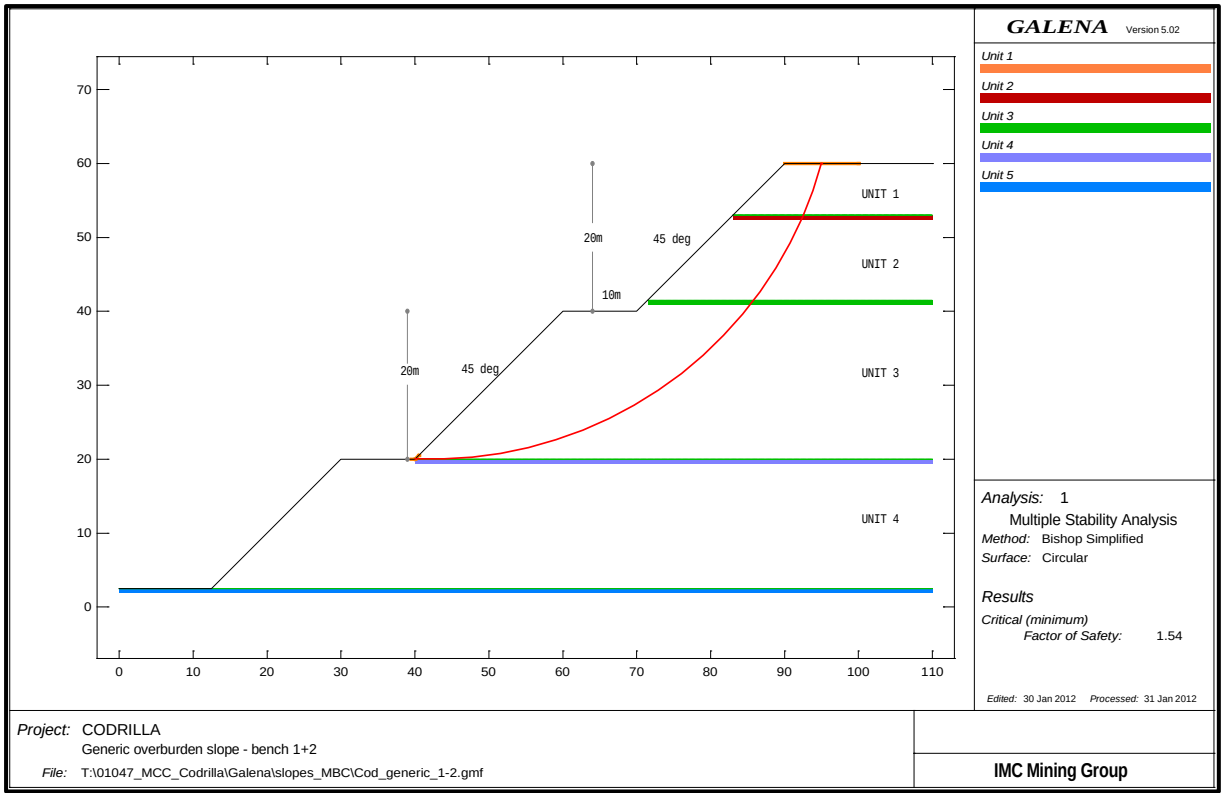
Accredited No.	910
Certificate No.	12-0015A
Date of Issue	6.1.12

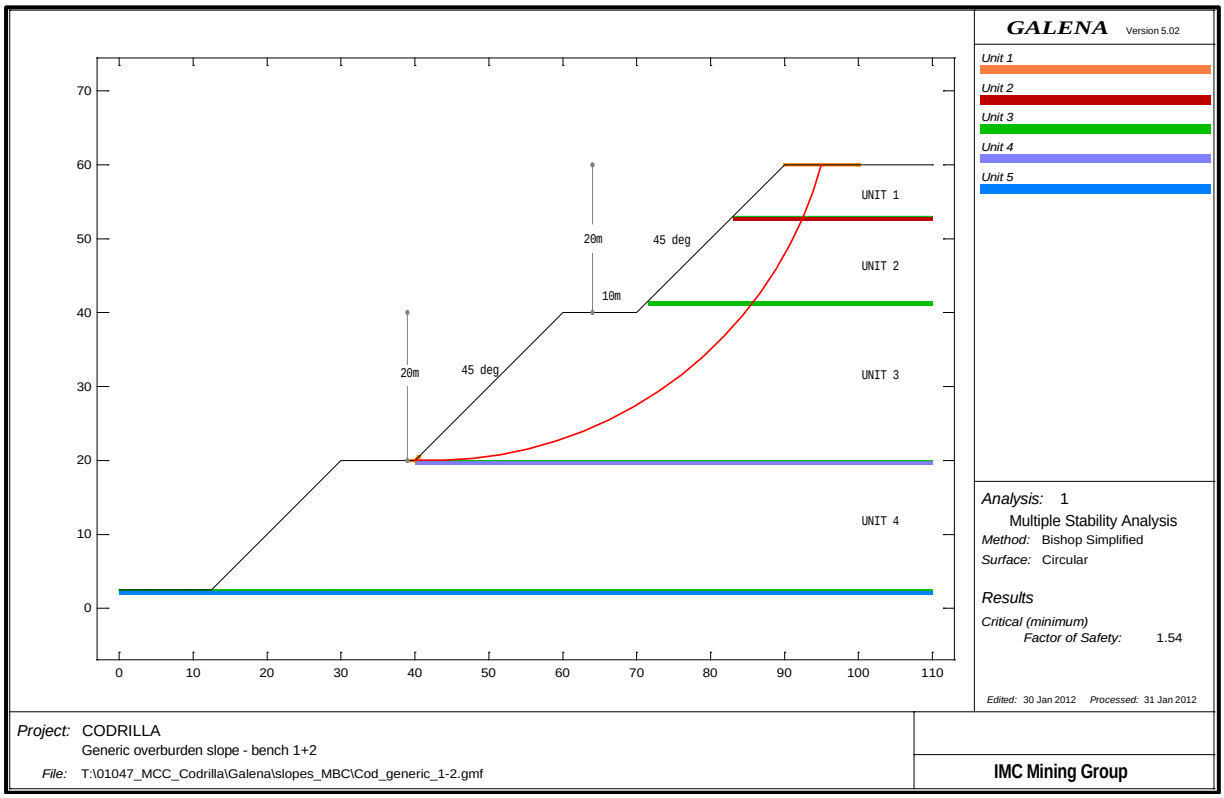
This document is issued in accordance with NATA's accreditation requirements.

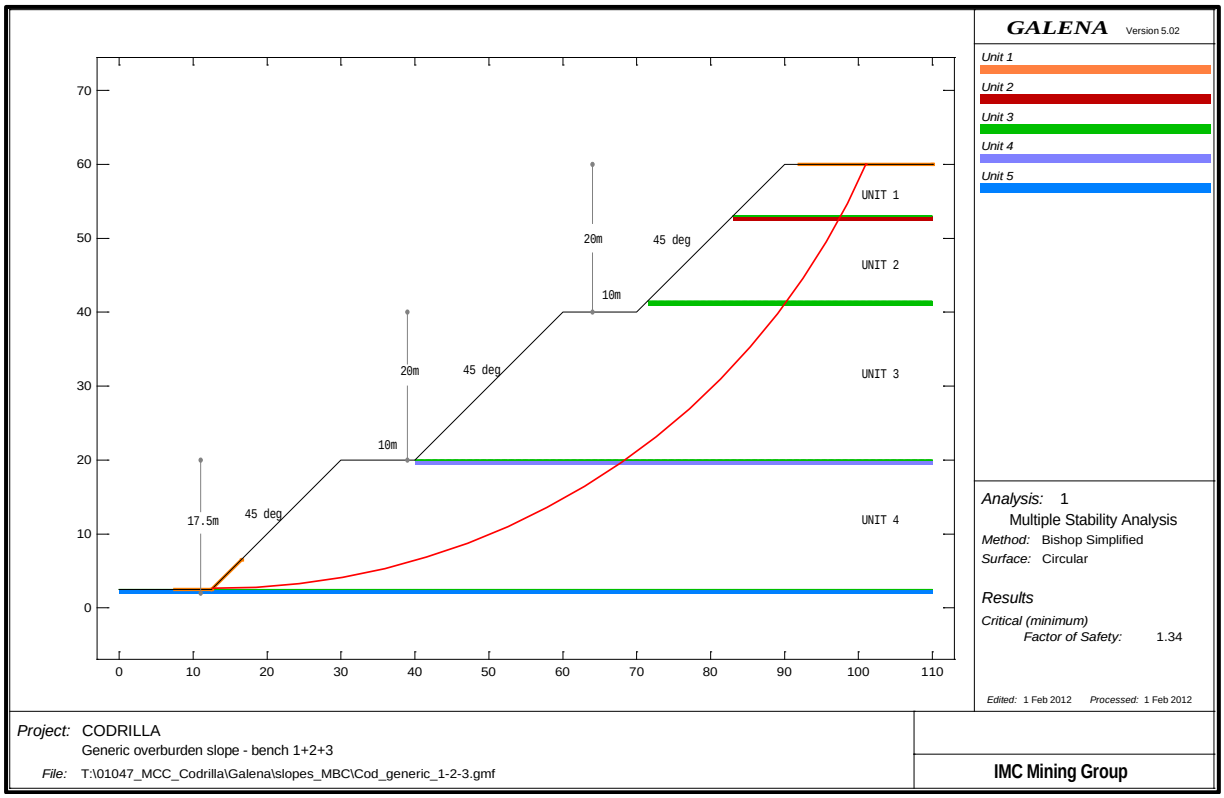
Authorised Signatory ..... N. J. Richardson

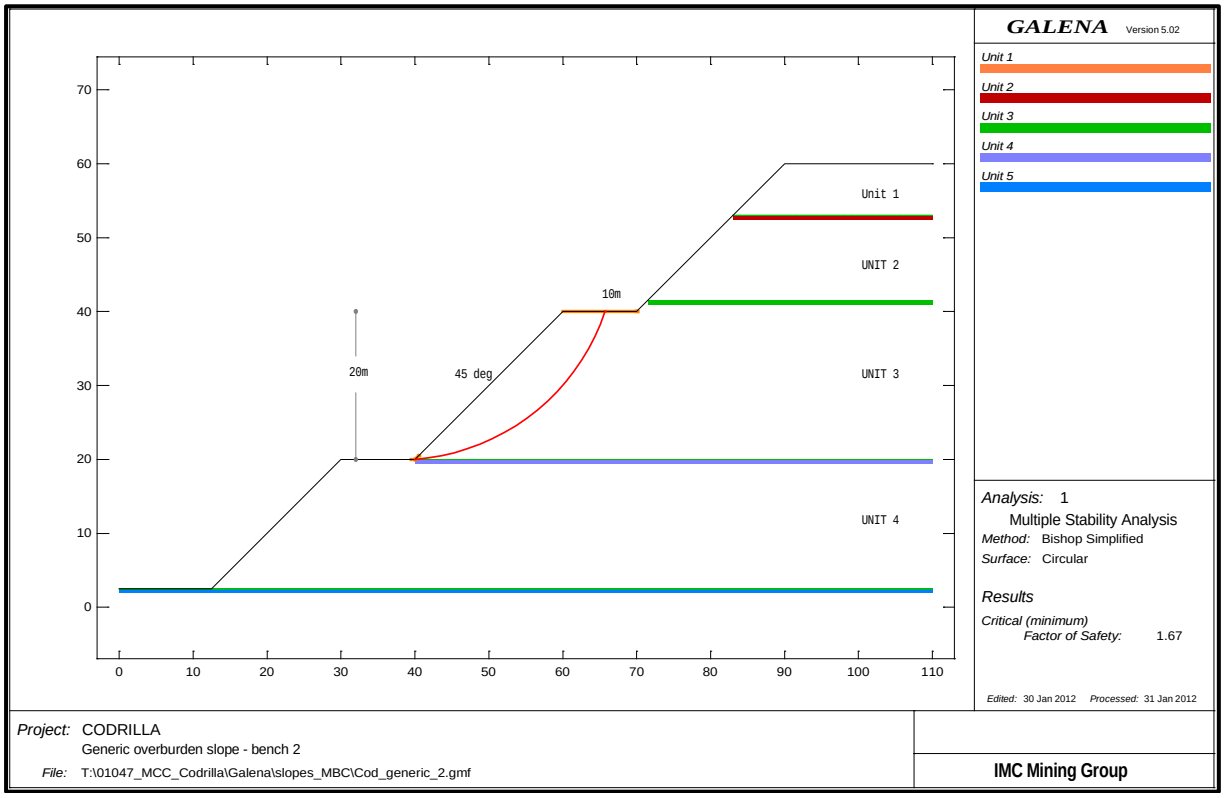
APPENDIX C – Slope Stability Analysis Results

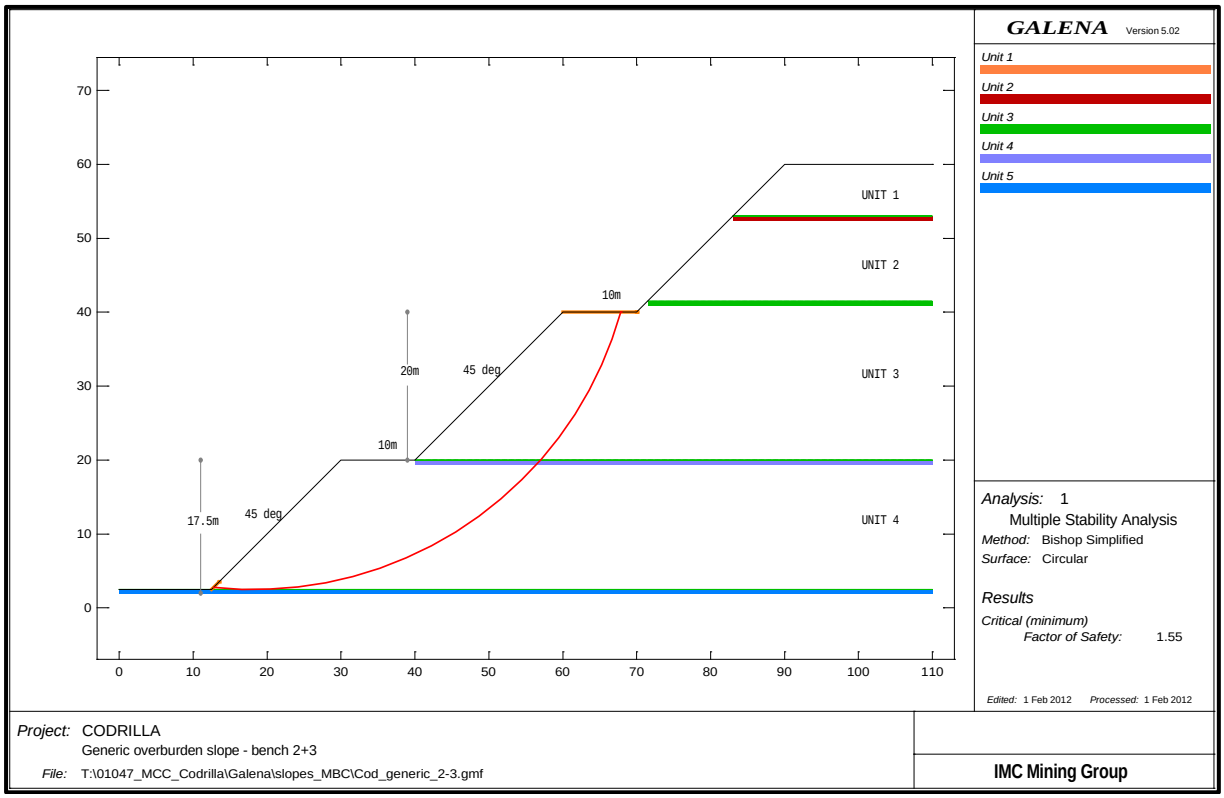
C1 – Generic Slope Stability Analysis Results

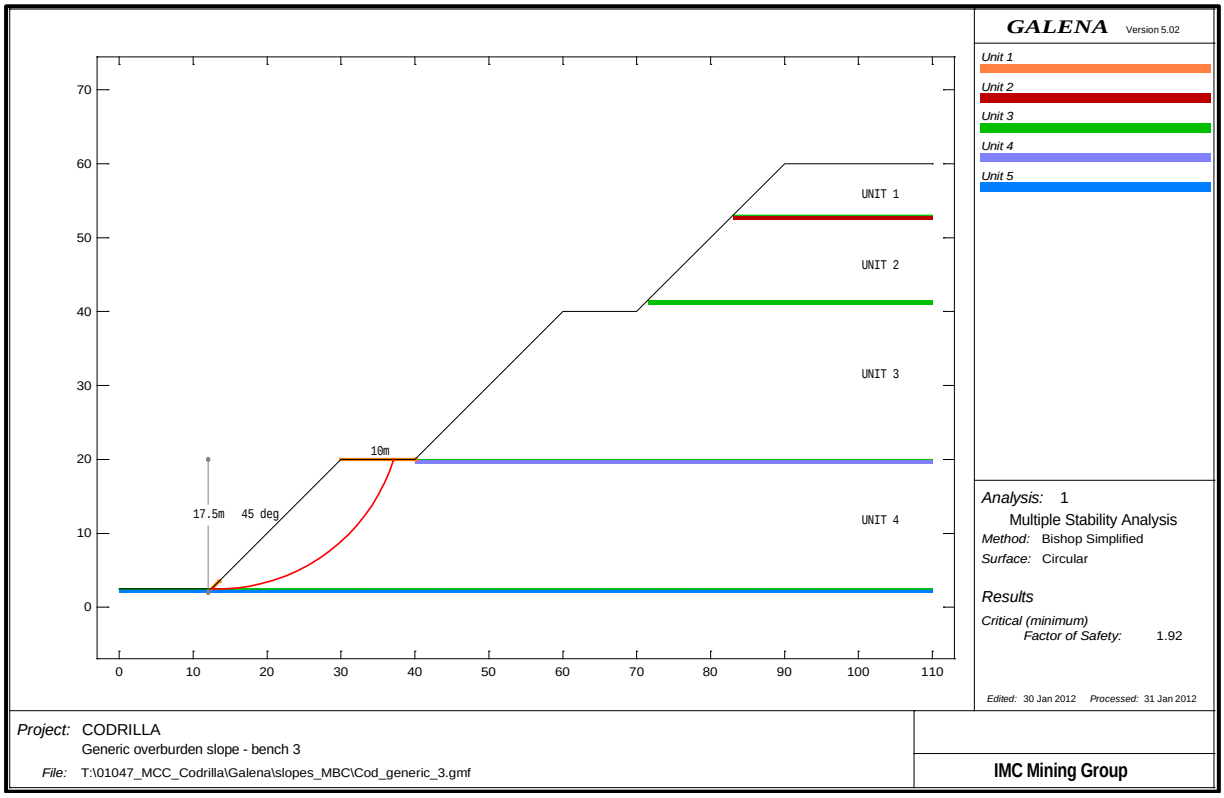




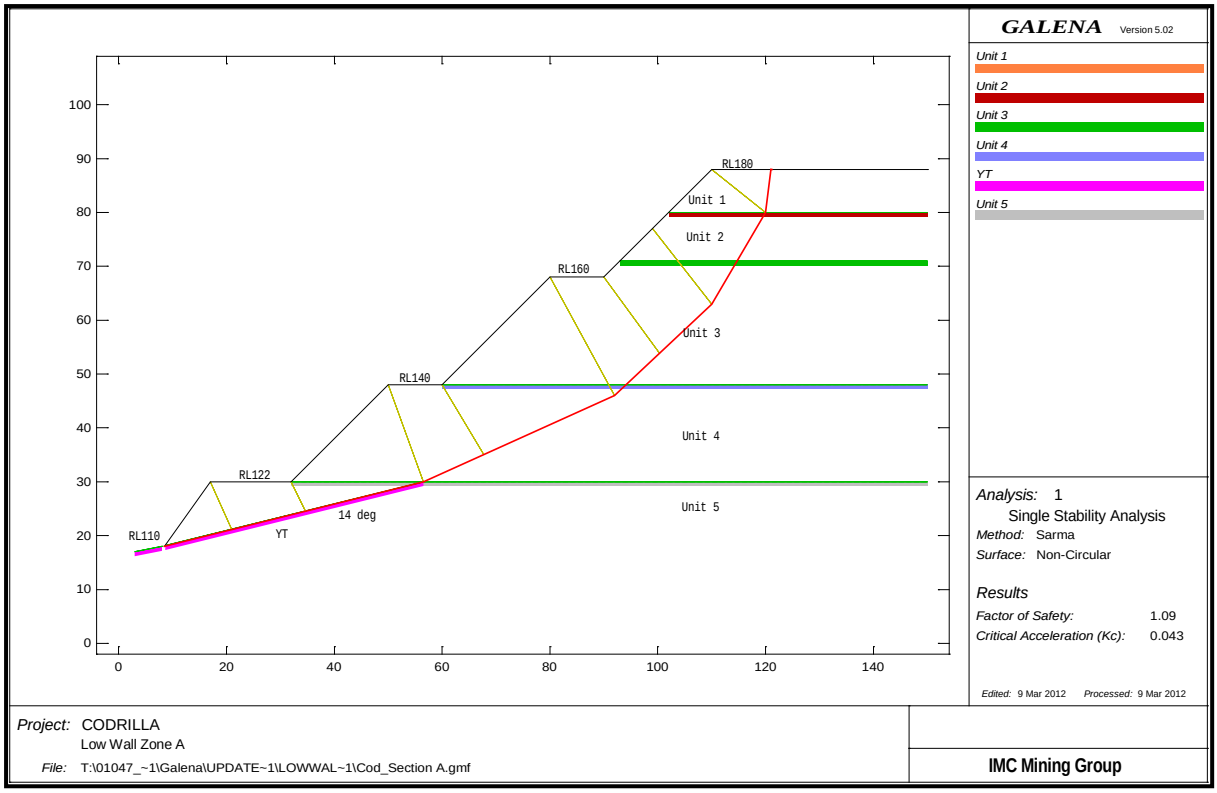

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
UNIT 1
UNIT 2
UNIT 3
UNIT 4
17.5m
45 deg
10m
20m
45 deg
10m
20m
45 deg
Analysis: 1
Multiple Stability Analysis
Method: Bishop Simplified
Surface: Circular
Results
Critical (minimum)
Factor of Safety: 1.34
Edited: 1 Feb 2012 Processed: 1 Feb 2012
Project: CODRILLA
Generic overburden slope - bench 1+2+3
File: T:\01047_MCC_Codrilla\Galena\slopes_MBC\Cod_generic_1-2-3.gmf
IMC Mining Group

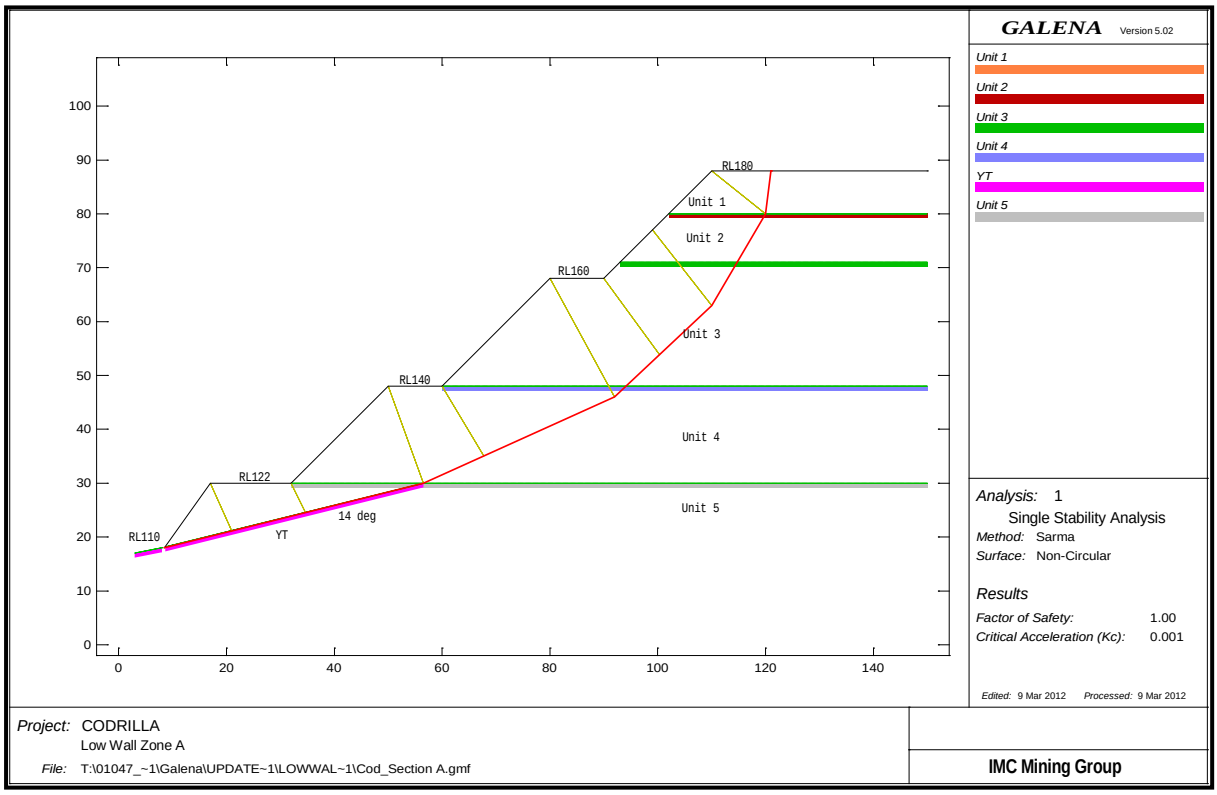

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
Unit 1
UNIT 2
UNIT 3
UNIT 4
10m
20m
45 deg
Analysis: 1
Multiple Stability Analysis
Method: Bishop Simplified
Surface: Circular
Results
Critical (minimum)
Factor of Safety: 1.67
Edited: 30 Jan 2012 Processed: 31 Jan 2012
Project: CODRILLA
Generic overburden slope - bench 2
File: T:\01047_MCC_Codrilla\Galena\slopes_MBC\Cod_generic_2.gmf
IMC Mining Group

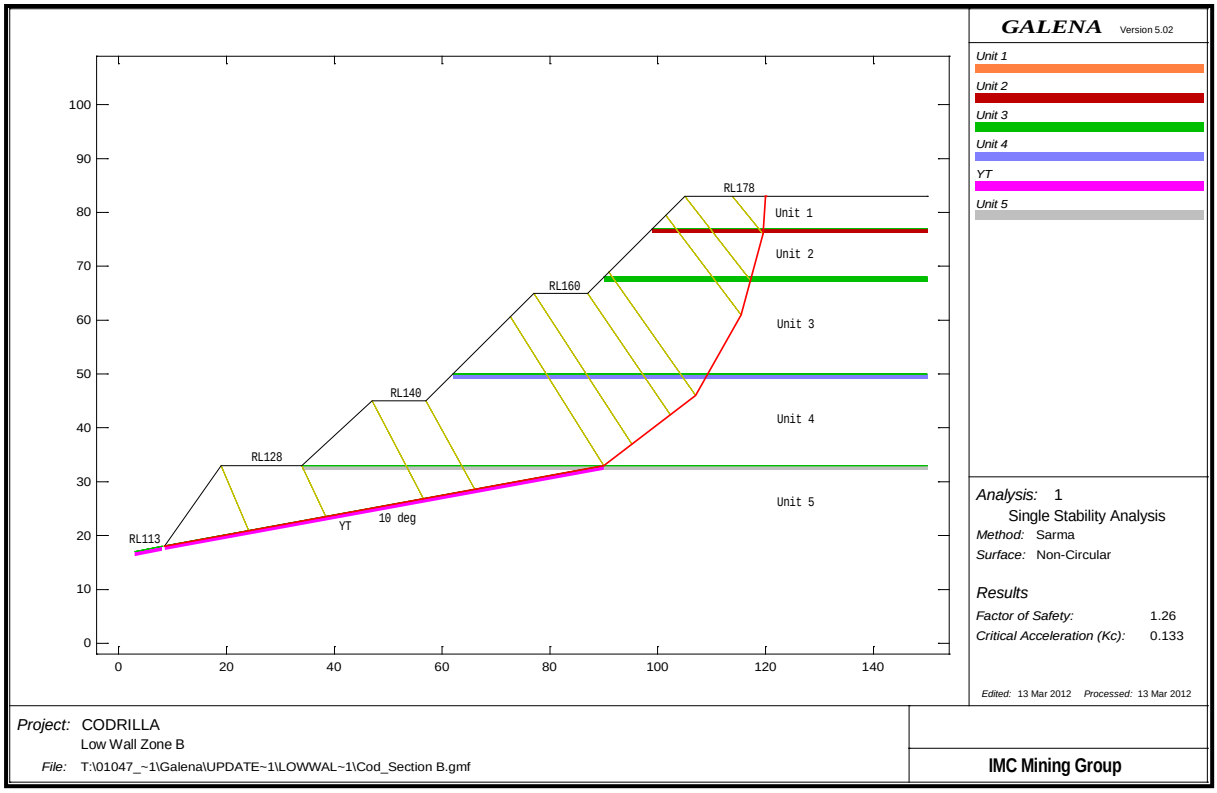

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
UNIT 1
UNIT 2
UNIT 3
UNIT 4
10m
20m
45 deg
10m
17.5m
45 deg
Analysis: 1
Multiple Stability Analysis
Method: Bishop Simplified
Surface: Circular
Results
Critical (minimum)
Factor of Safety: 1.55
Edited: 1 Feb 2012 Processed: 1 Feb 2012
Project: CODRILLA
Generic overburden slope - bench 2+3
File: T:\01047_MCC_Codrilla\Galena\slopes_MBC\Cod_generic_2-3.gmf
IMC Mining Group

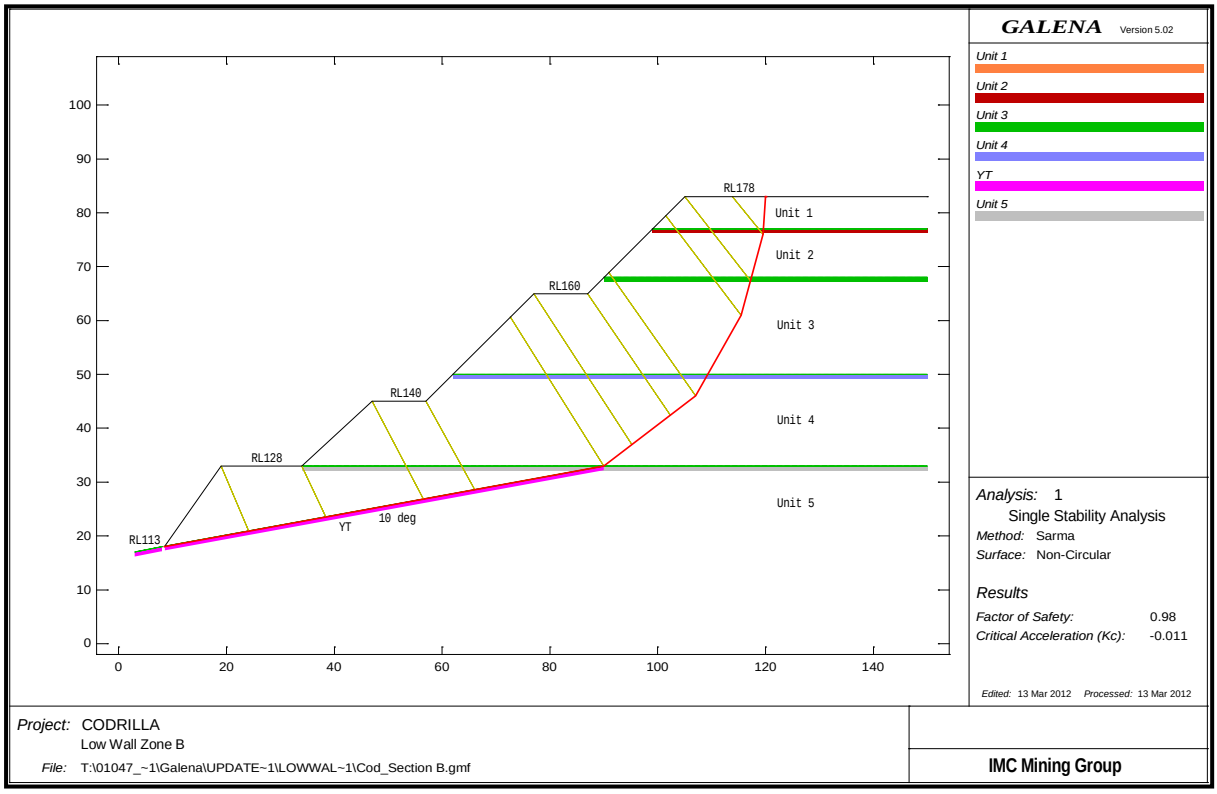

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
UNIT 1
UNIT 2
UNIT 3
UNIT 4
10m
17.5m
45 deg
Analysis: 1
Multiple Stability Analysis
Method: Bishop Simplified
Surface: Circular
Results
Critical (minimum)
Factor of Safety: 1.92
Edited: 30 Jan 2012 Processed: 31 Jan 2012
Project: CODRILLA
Generic overburden slope - bench 3
File: T:\01047_MCC_Codrilla\Galena\slopes_MBC\Cod_generic_3.gmf
IMC Mining Group

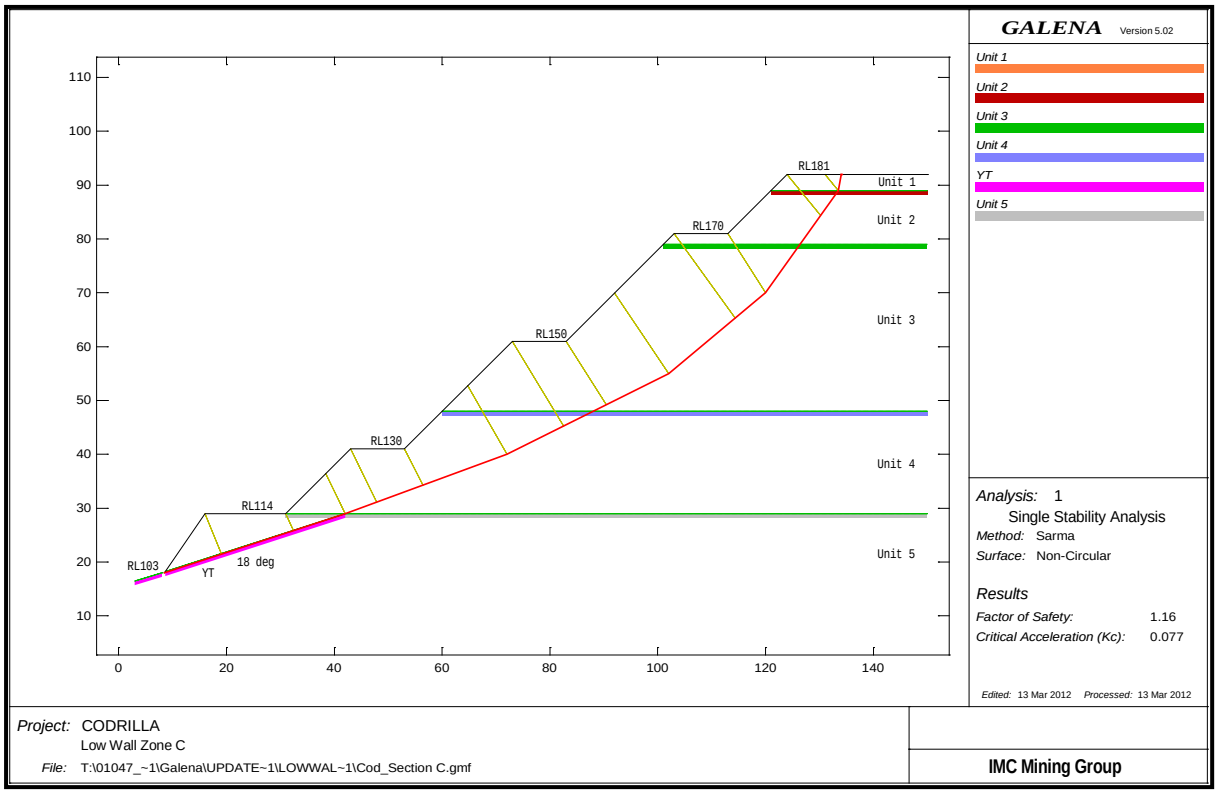
C2 – Low wall Stability Analysis Results

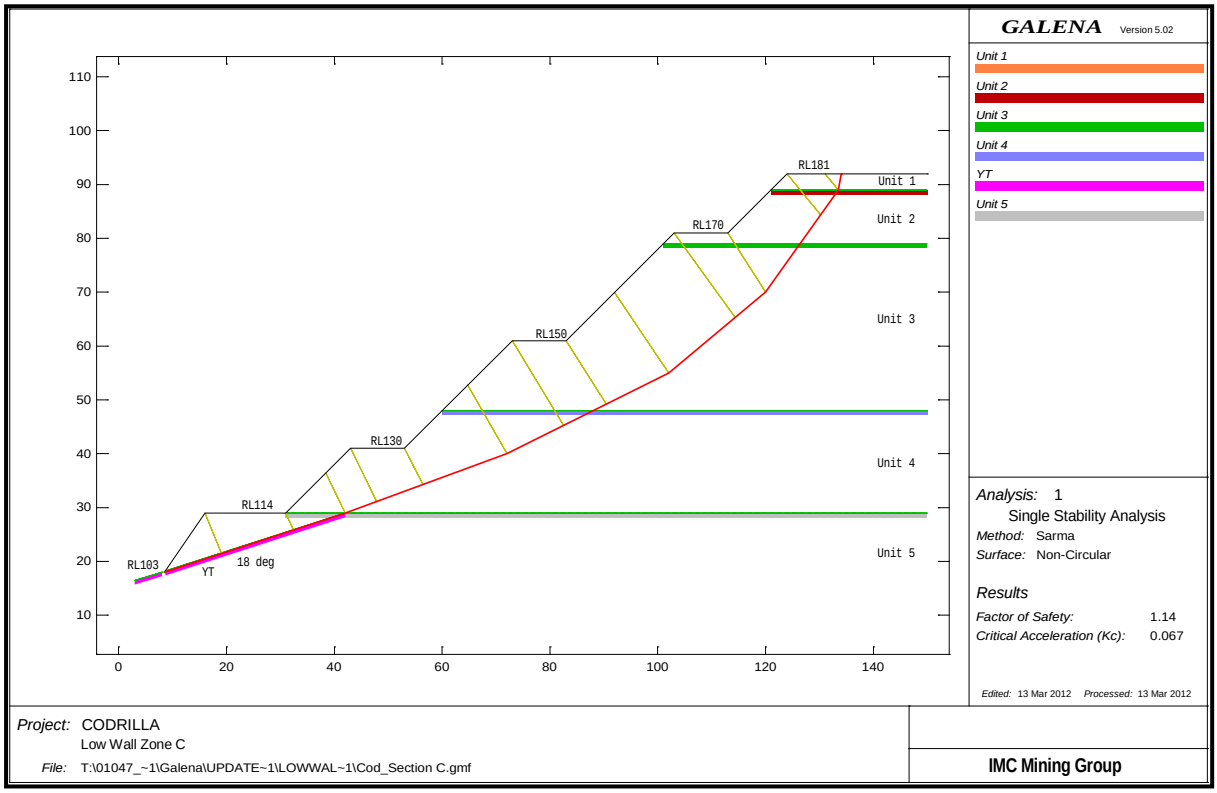


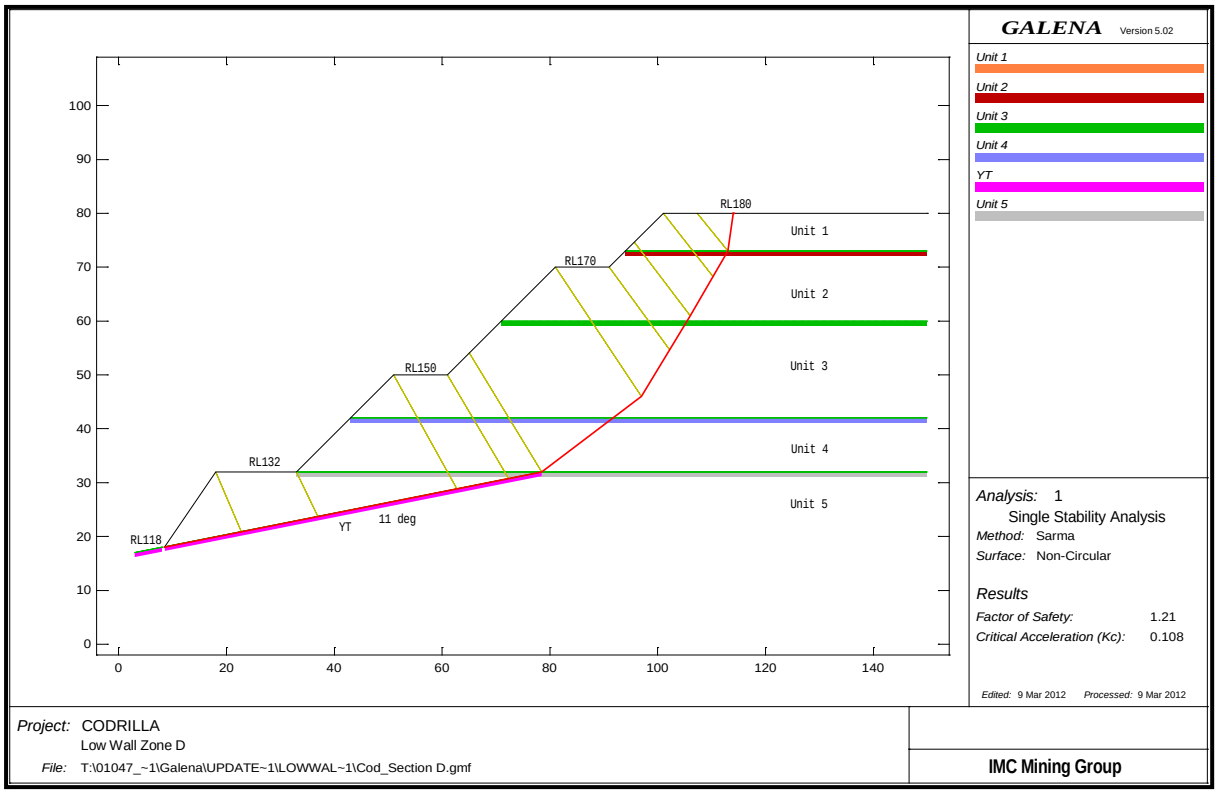


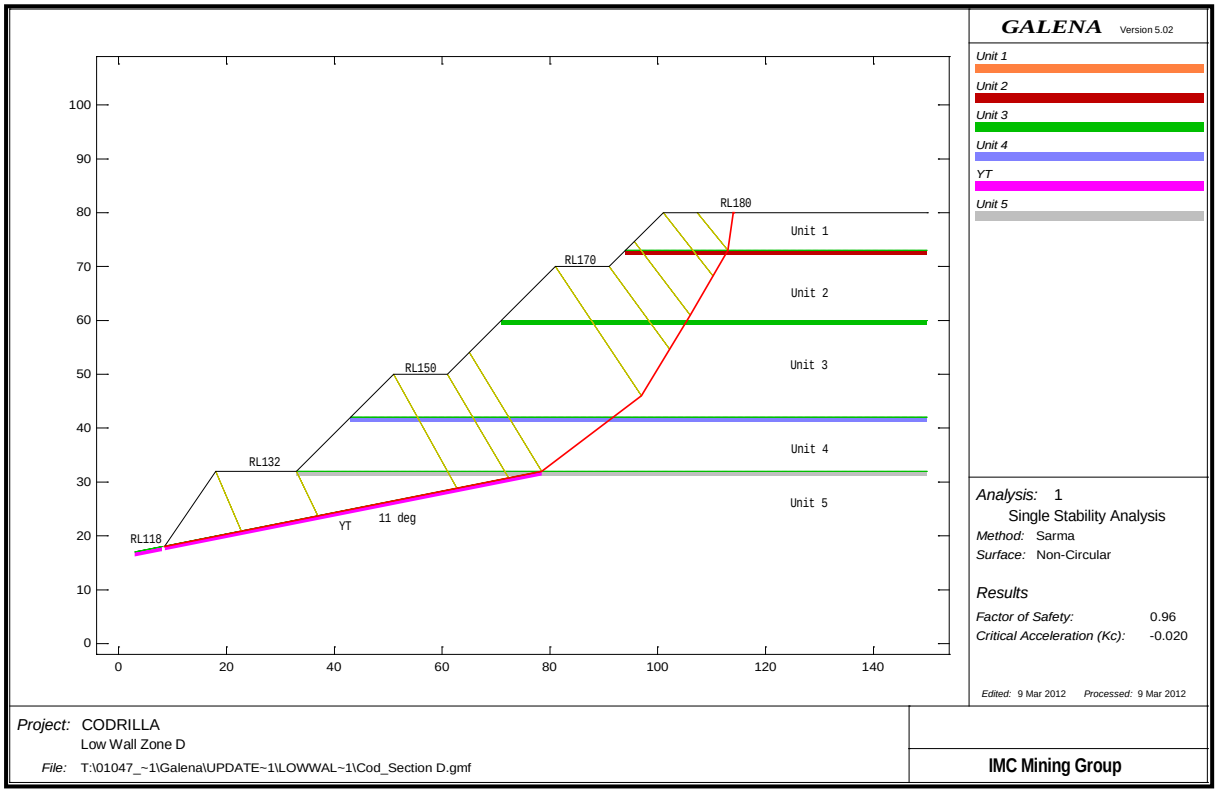

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL178
RL160
RL140
RL128
RL113
YT
10 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.26
Critical Acceleration (Kc): 0.133
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone B
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section B.gmf
IMC Mining Group

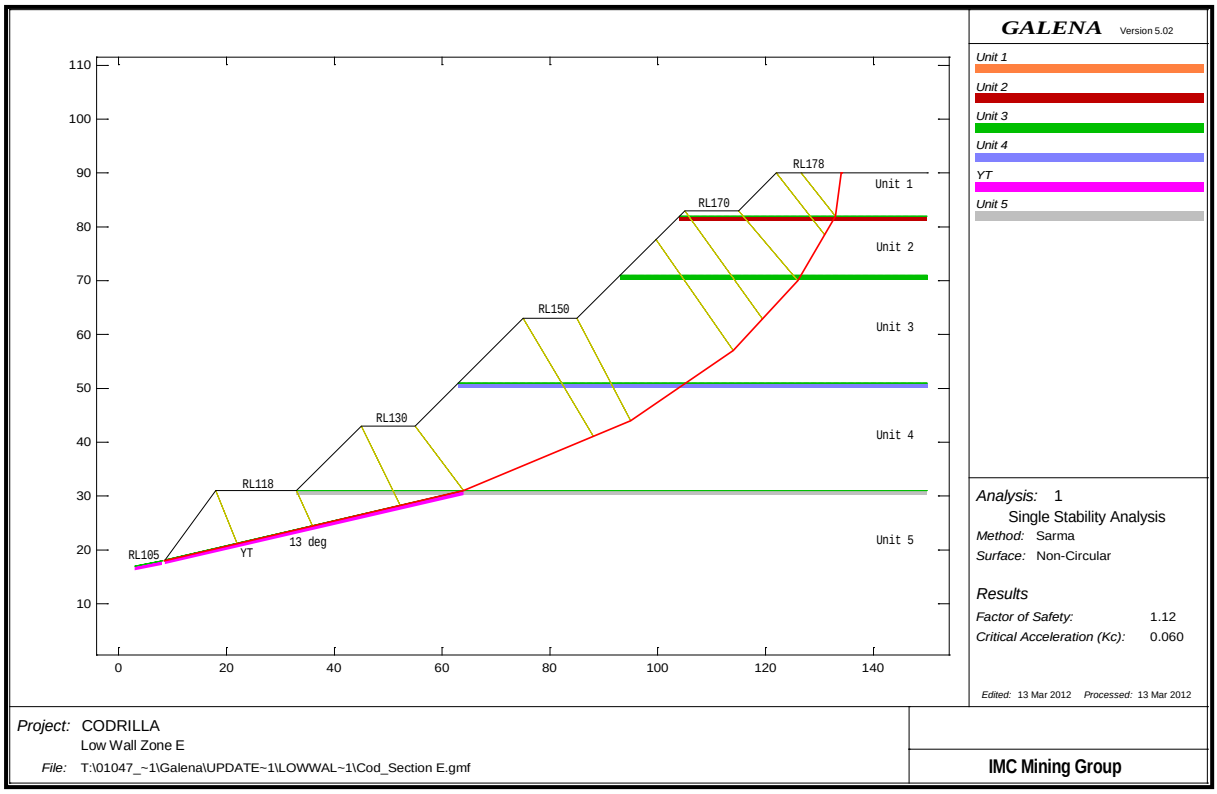

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL178
RL160
RL140
RL128
RL113
YT
10 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 0.98
Critical Acceleration (Kc): -0.011
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone B
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section B.gmf
IMC Mining Group

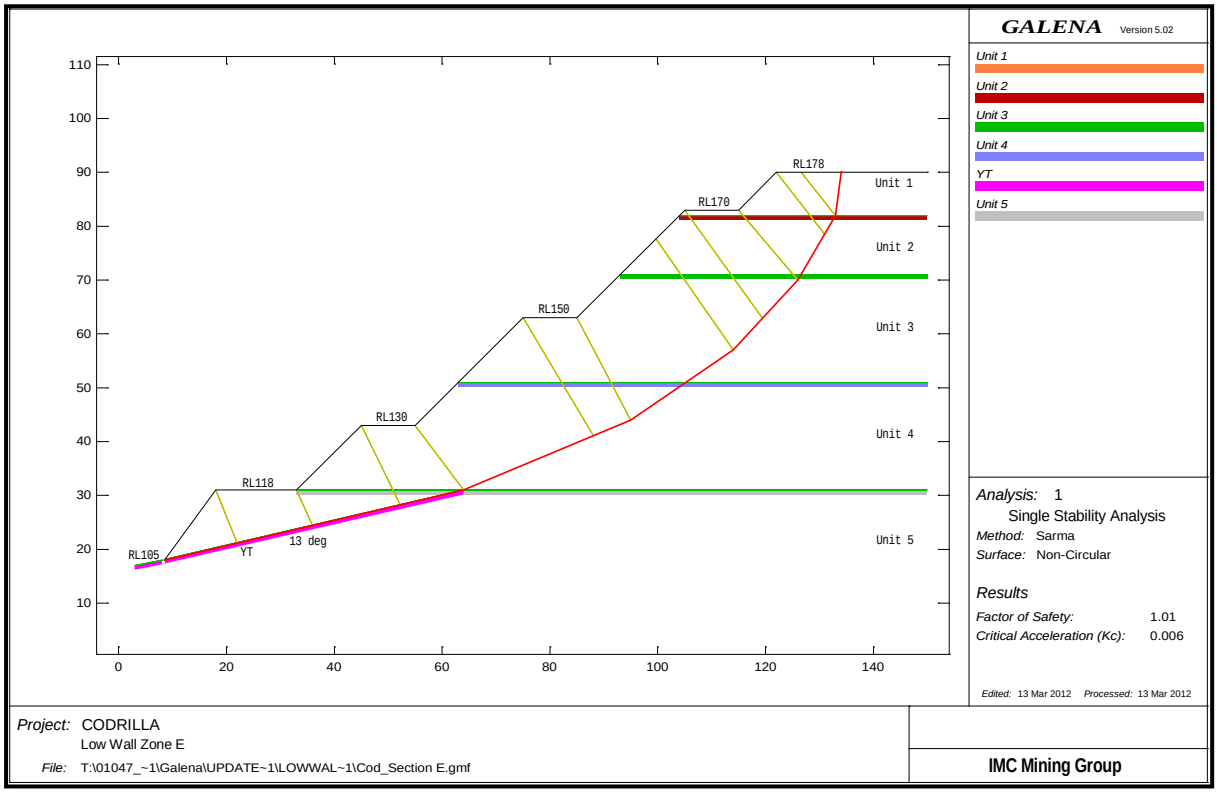

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL181
RL170
RL150
RL130
RL114
RL103
18 deg
YT
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.16
Critical Acceleration (Kc): 0.077
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone C
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section C.gmf
IMC Mining Group

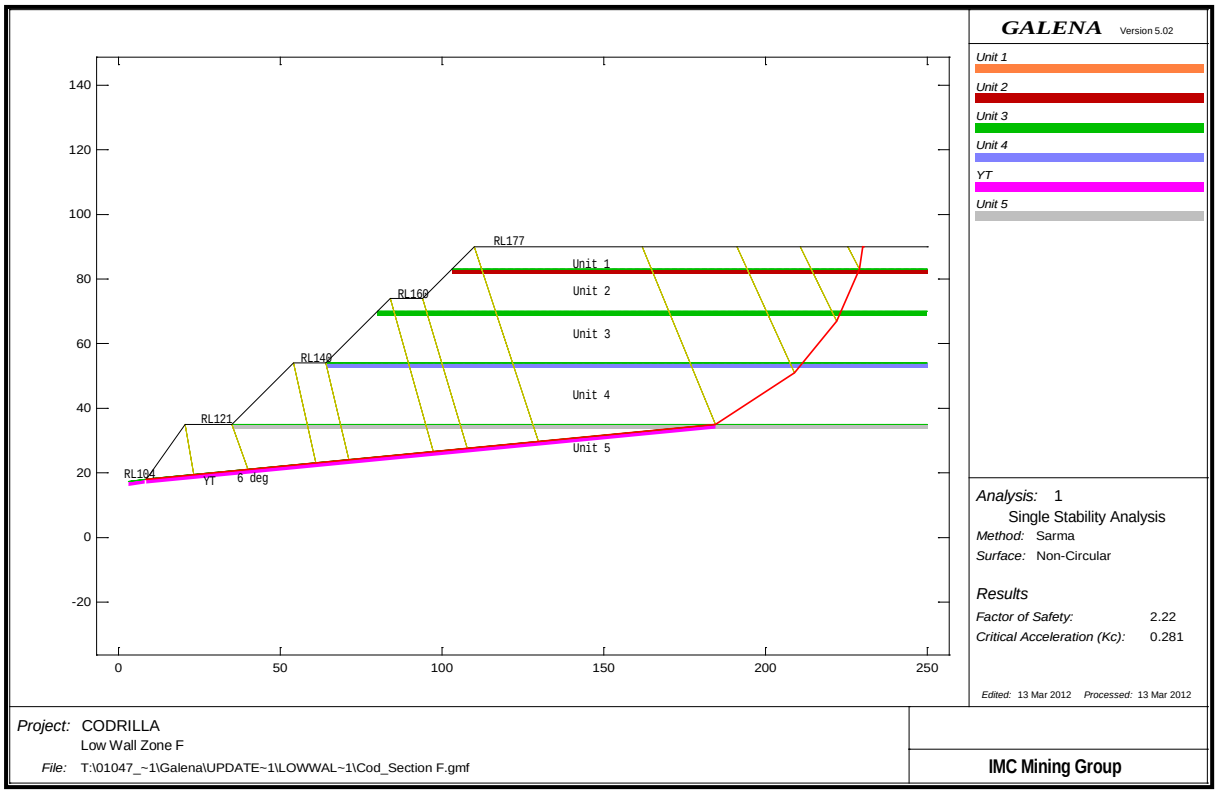

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL181
RL170
RL150
RL130
RL114
RL103
18 deg
YT
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.14
Critical Acceleration (Kc): 0.067
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone C
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section C.gmf
IMC Mining Group

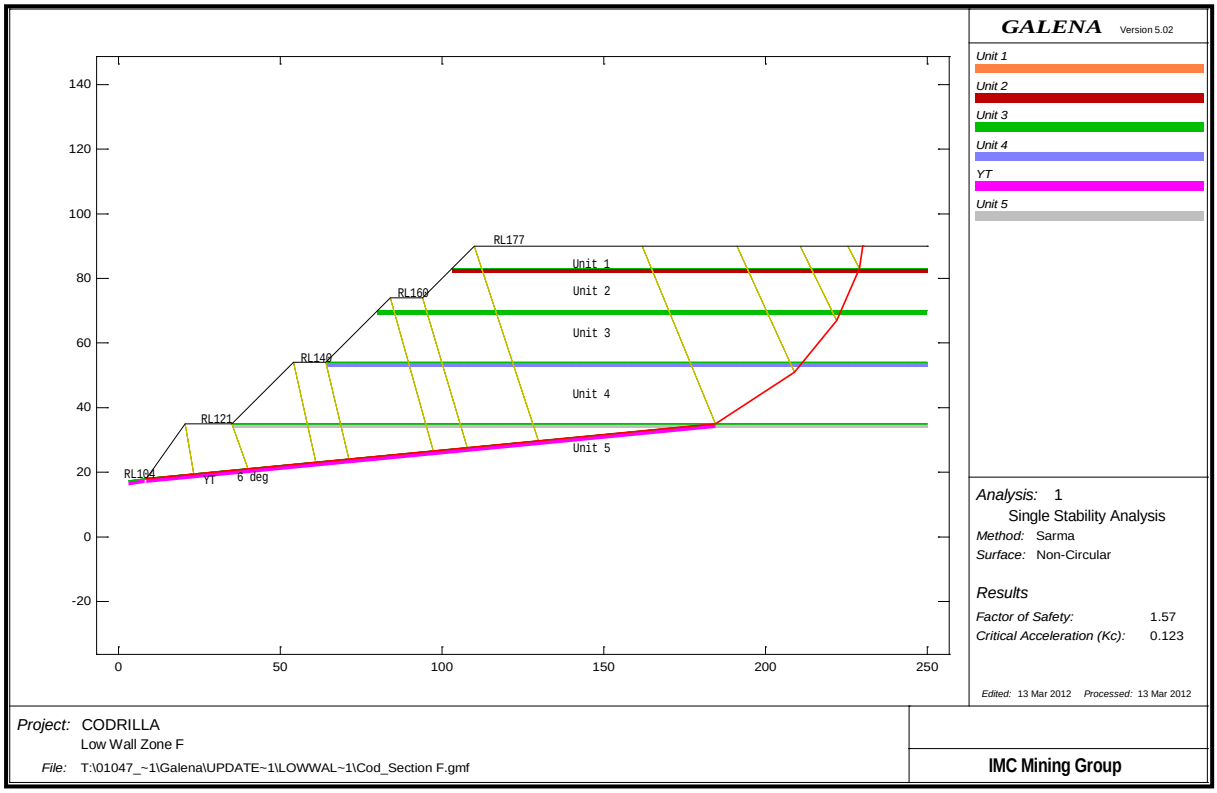

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL180
RL170
RL150
RL132
RL118
YT
11 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.21
Critical Acceleration (Kc): 0.108
Edited: 9 Mar 2012 Processed: 9 Mar 2012
Project: CODRILLA
Low Wall Zone D
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section D.gmf
IMC Mining Group

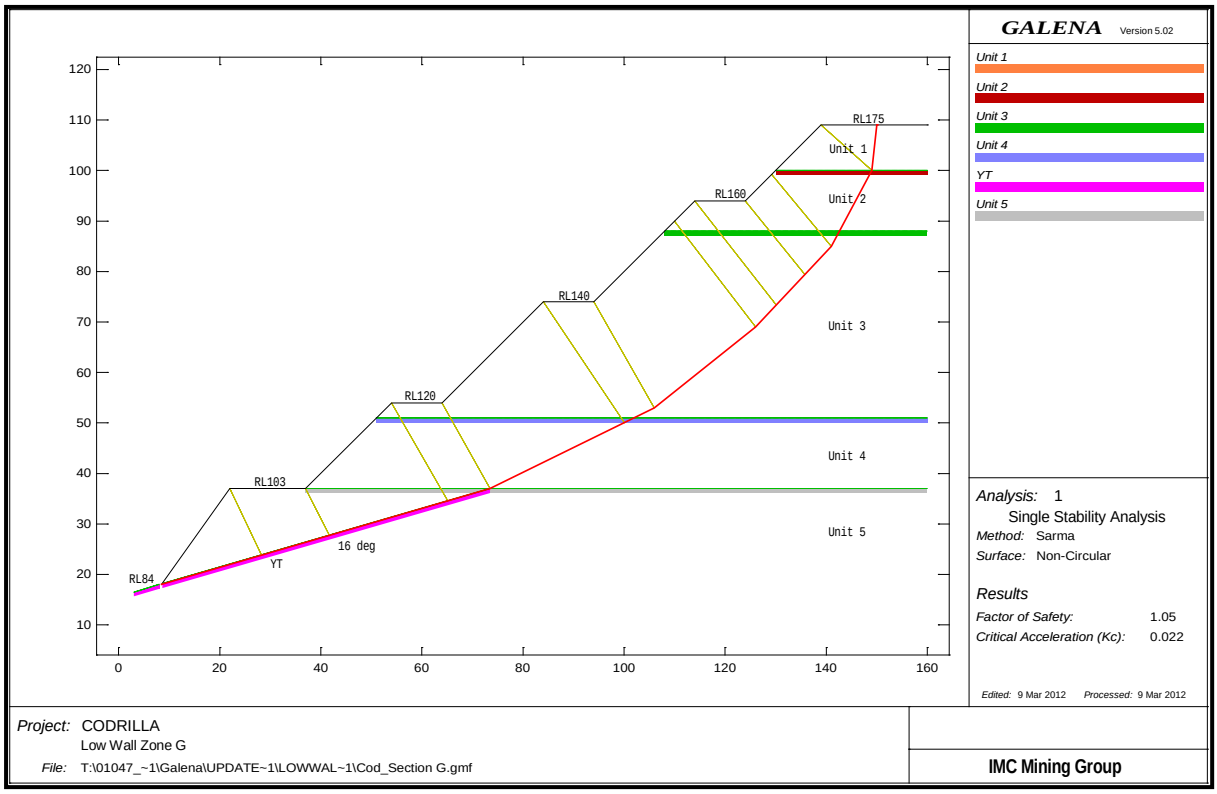

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL180
RL170
RL150
RL132
RL118
YT
11 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 0.96
Critical Acceleration (Kc): -0.020
Edited: 9 Mar 2012 Processed: 9 Mar 2012
Project: CODRILLA
Low Wall Zone D
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section D.gmf
IMC Mining Group

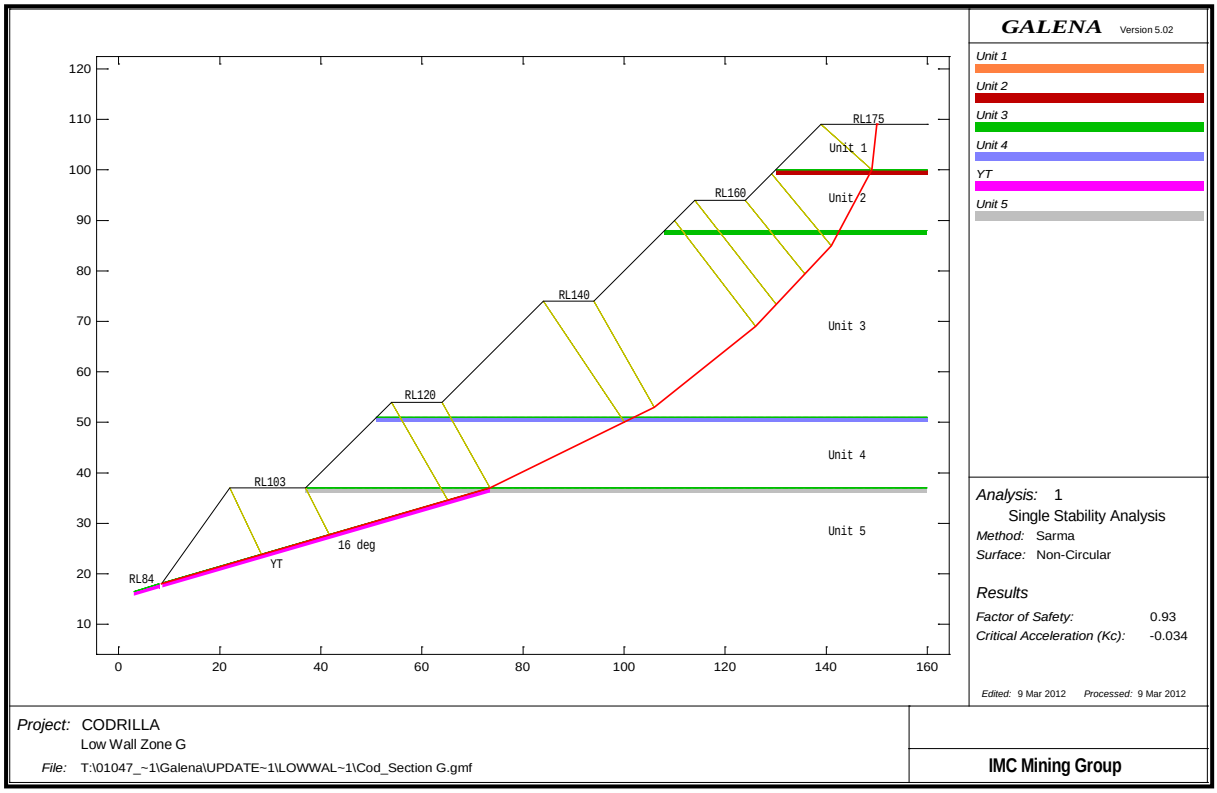

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL178
RL170
RL150
RL130
RL118
RL105
YT
13 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.12
Critical Acceleration (Kc): 0.060
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone E
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section E.gmf
IMC Mining Group

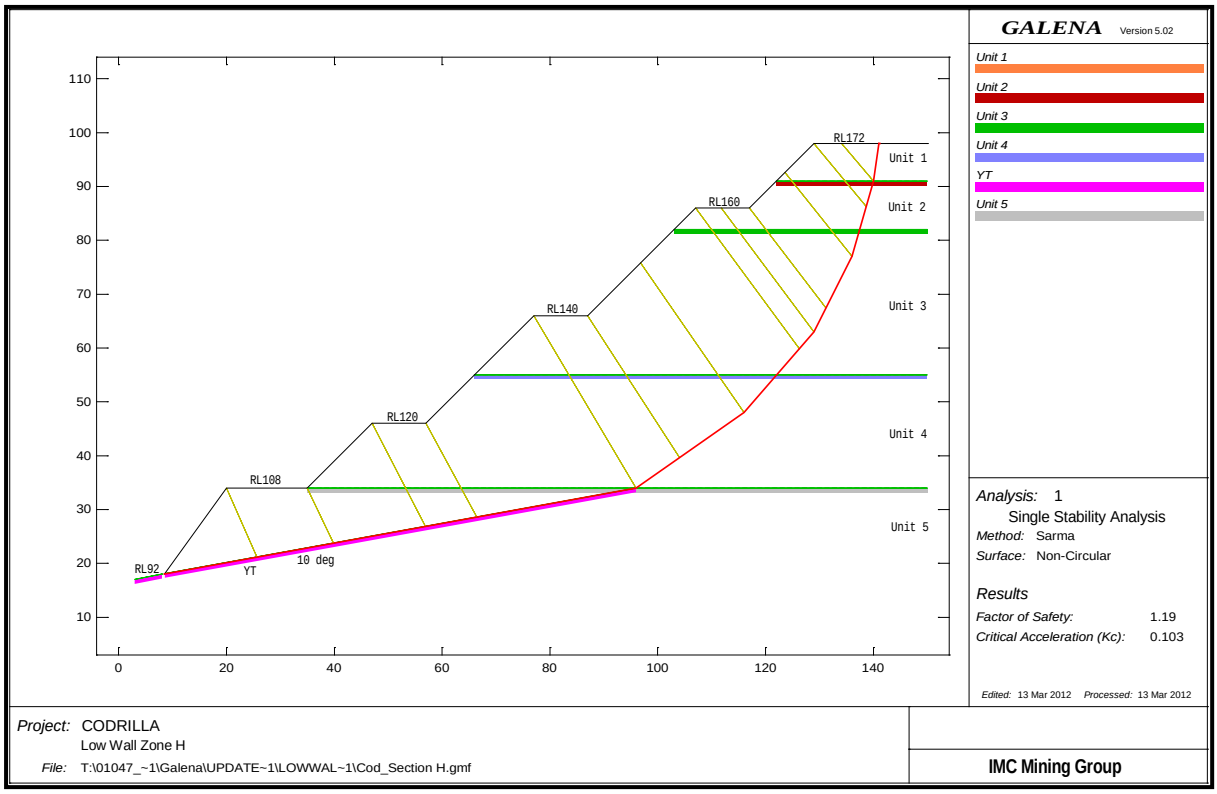

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL178
RL170
RL150
RL130
RL118
RL105
YT
13 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.01
Critical Acceleration (Kc): 0.006
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone E
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section E.gmf
IMC Mining Group

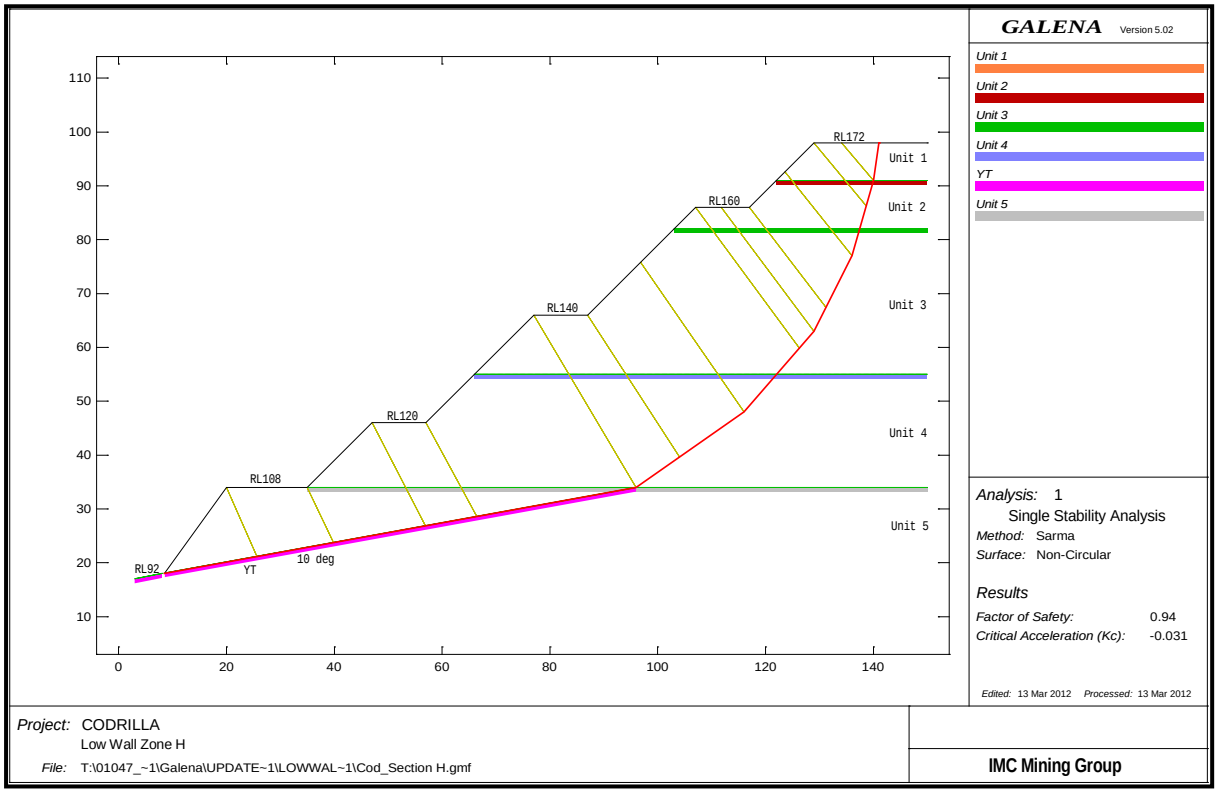

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL177
RL160
RL140
RL121
RL104
YT 6 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 2.22
Critical Acceleration (Kc): 0.281
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone F
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section F.gmf
IMC Mining Group

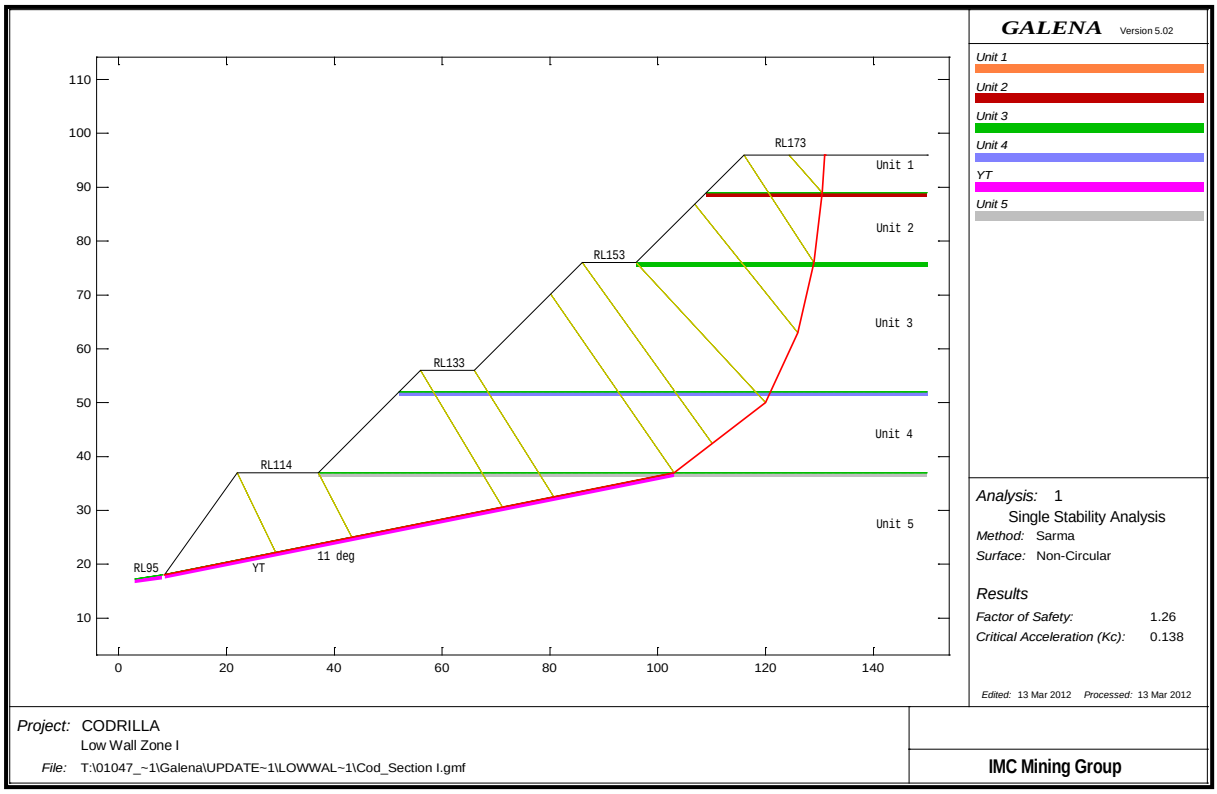

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL177
RL160
RL140
RL121
RL104
YT 6 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.57
Critical Acceleration (Kc): 0.123
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone F
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section F.gmf
IMC Mining Group

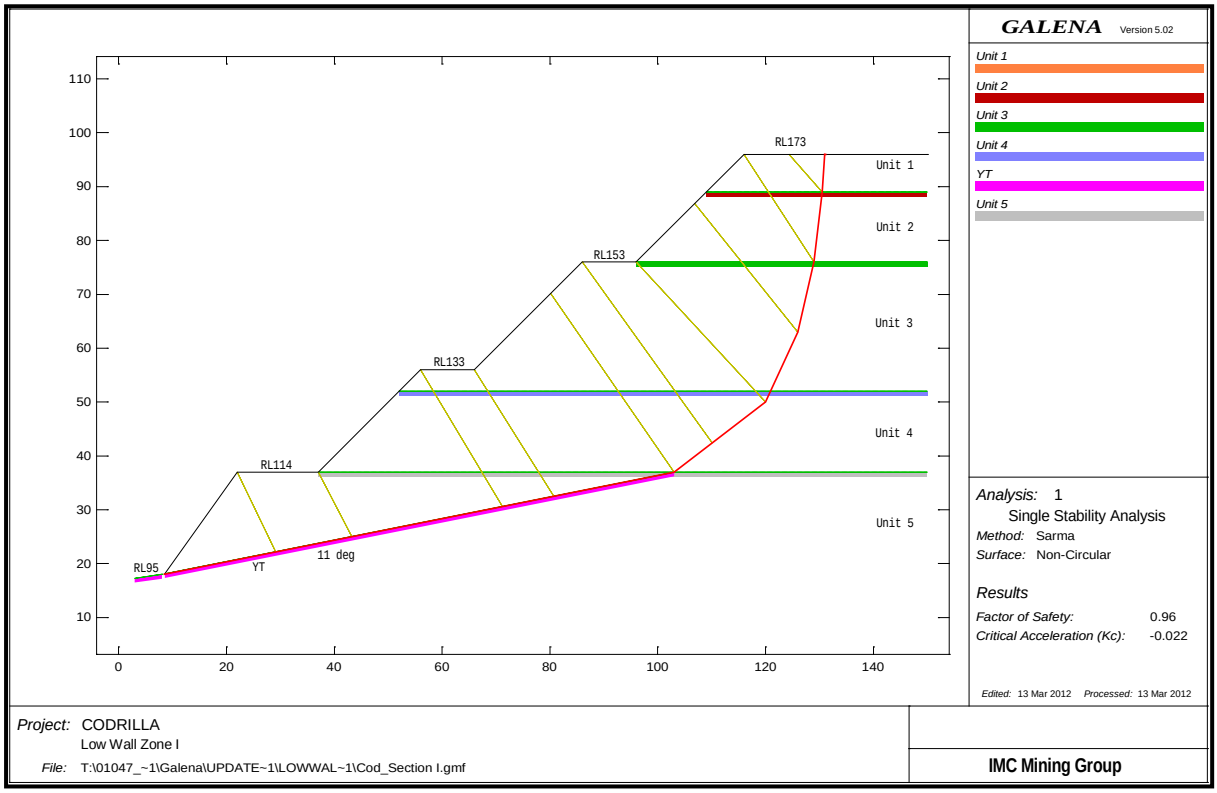

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL175
RL160
RL140
RL120
RL103
RL84
16 deg
YT
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.05
Critical Acceleration (Kc): 0.022
Edited: 9 Mar 2012 Processed: 9 Mar 2012
Project: CODRILLA
Low Wall Zone G
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section G.gmf
IMC Mining Group

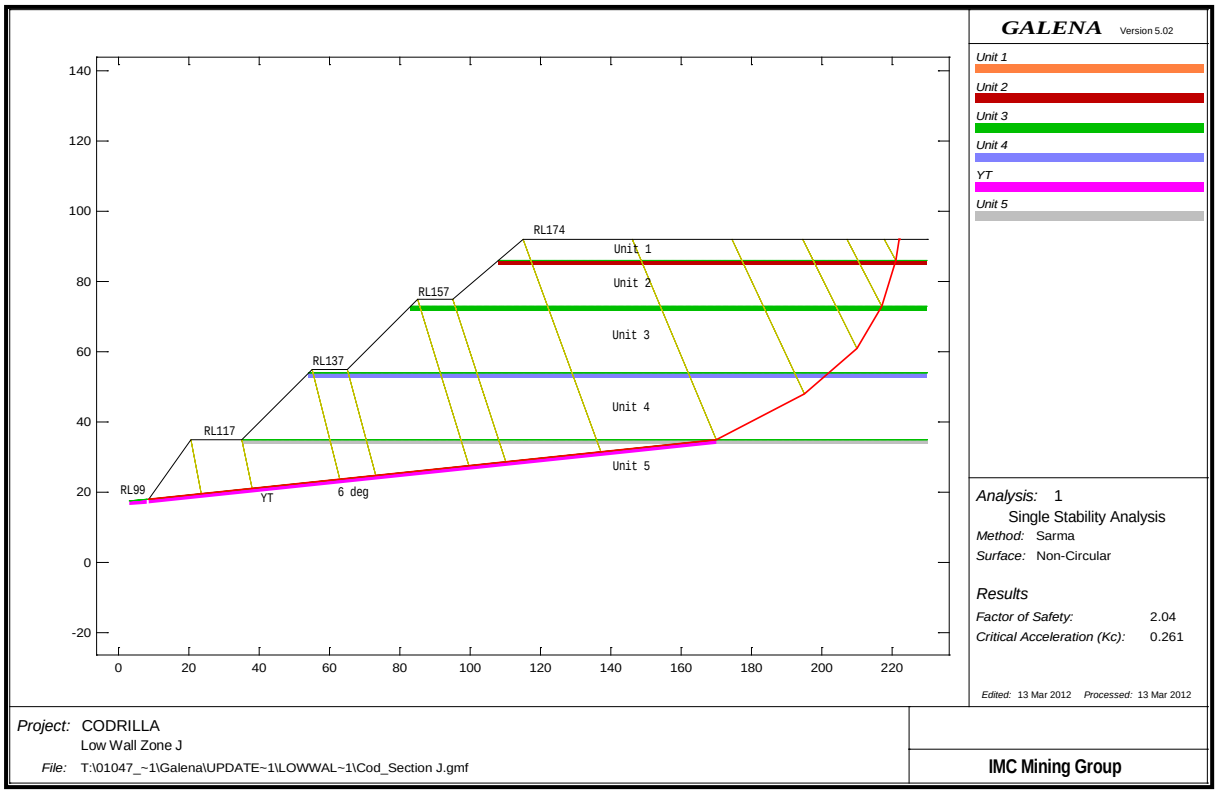

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL175
RL160
RL140
RL120
RL103
RL84
16 deg
YT
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 0.93
Critical Acceleration (Kc): -0.034
Edited: 9 Mar 2012 Processed: 9 Mar 2012
Project: CODRILLA
Low Wall Zone G
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section G.gmf
IMC Mining Group

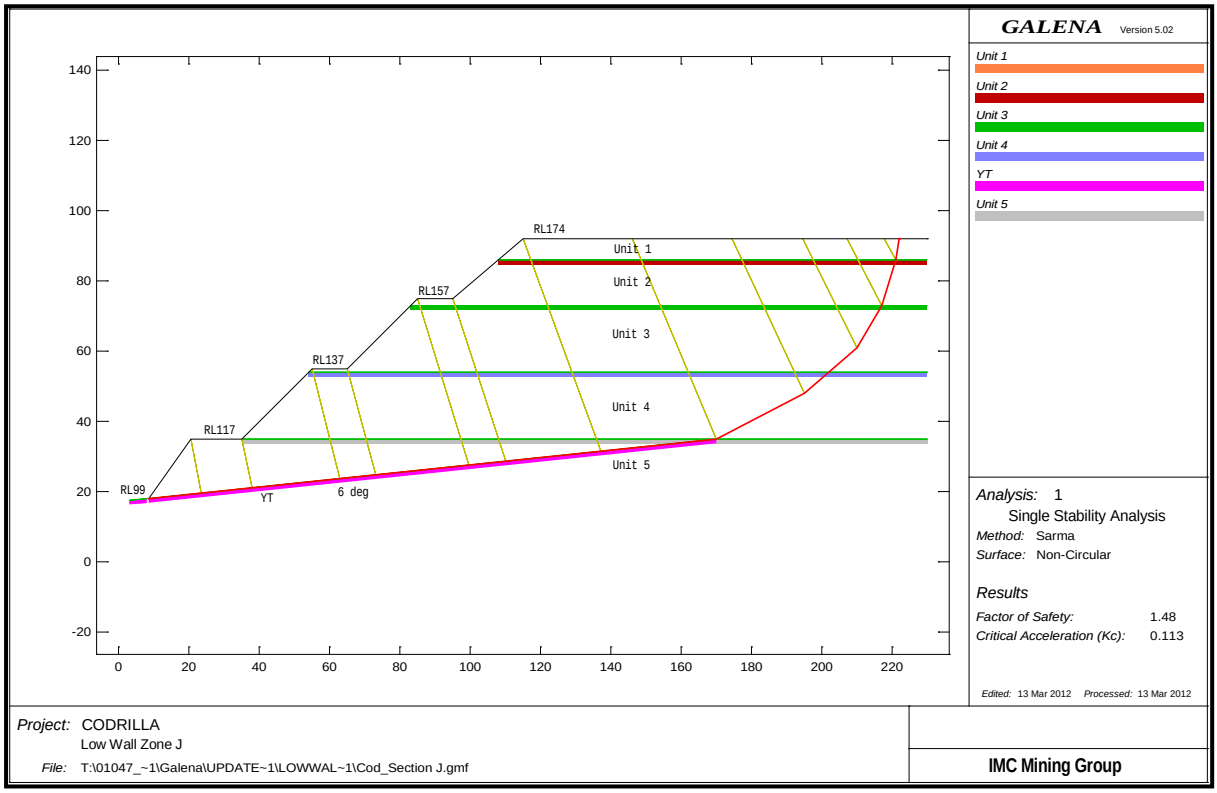

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL172
RL160
RL140
RL120
RL108
RL92
YT
10 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.19
Critical Acceleration (Kc): 0.103
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone H
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section H.gmf
IMC Mining Group

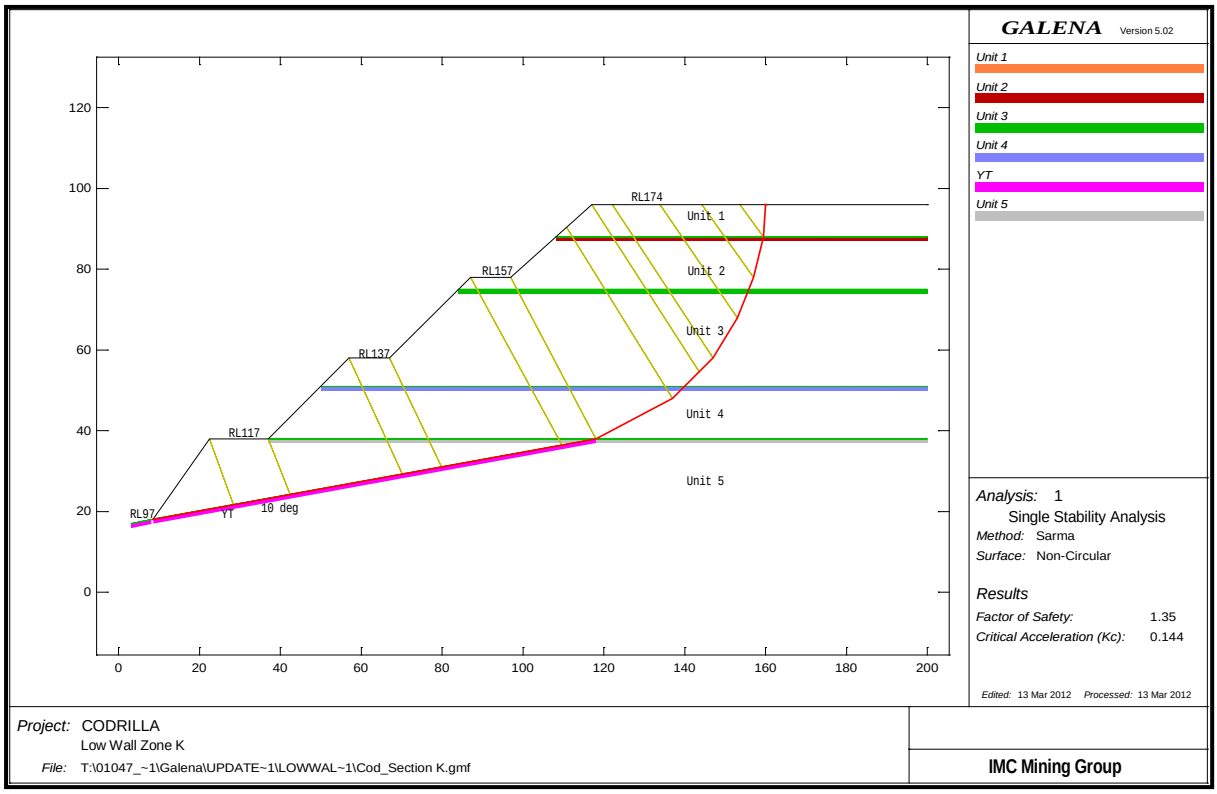

GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL172
RL160
RL140
RL120
RL108
RL92
YT
10 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 0.94
Critical Acceleration (Kc): -0.031
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone H
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section H.gmf
IMC Mining Group


GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL173
RL153
RL133
RL114
RL95
YT
11 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.26
Critical Acceleration (Kc): 0.138
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone I
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section I.gmf
IMC Mining Group


GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL173
RL153
RL133
RL114
RL95
YT
11 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 0.96
Critical Acceleration (Kc): -0.022
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone I
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section I.gmf
IMC Mining Group


GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL174
RL157
RL137
RL117
RL99
YT
6 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 2.04
Critical Acceleration (Kc): 0.261
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone J
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section J.gmf
IMC Mining Group


GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL174
RL157
RL137
RL117
RL99
YT
6 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.48
Critical Acceleration (Kc): 0.113
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone J
File: T:\01047_~1\Galena\UPDATE~1\LOWWAL~1\Cod_Section J.gmf
IMC Mining Group


GALENA Version 5.02
Unit 1
Unit 2
Unit 3
Unit 4
YT
Unit 5
RL174
RL157
RL137
RL117
RL97
YT
10 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.35
Critical Acceleration (Kc): 0.144
Edited: 13 Mar 2012 Processed: 13 Mar 2012
Project: CODRILLA
Low Wall Zone K
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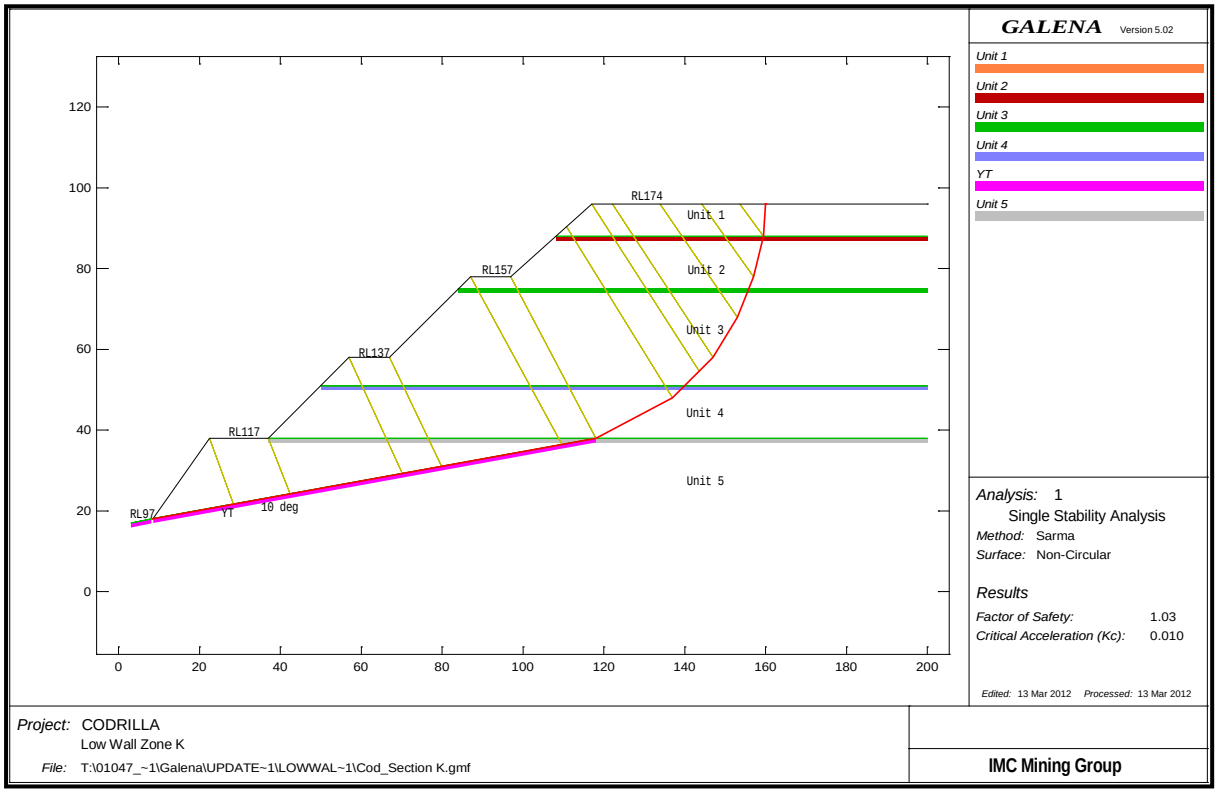
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Method: Sarma
Surface: Non-Circular
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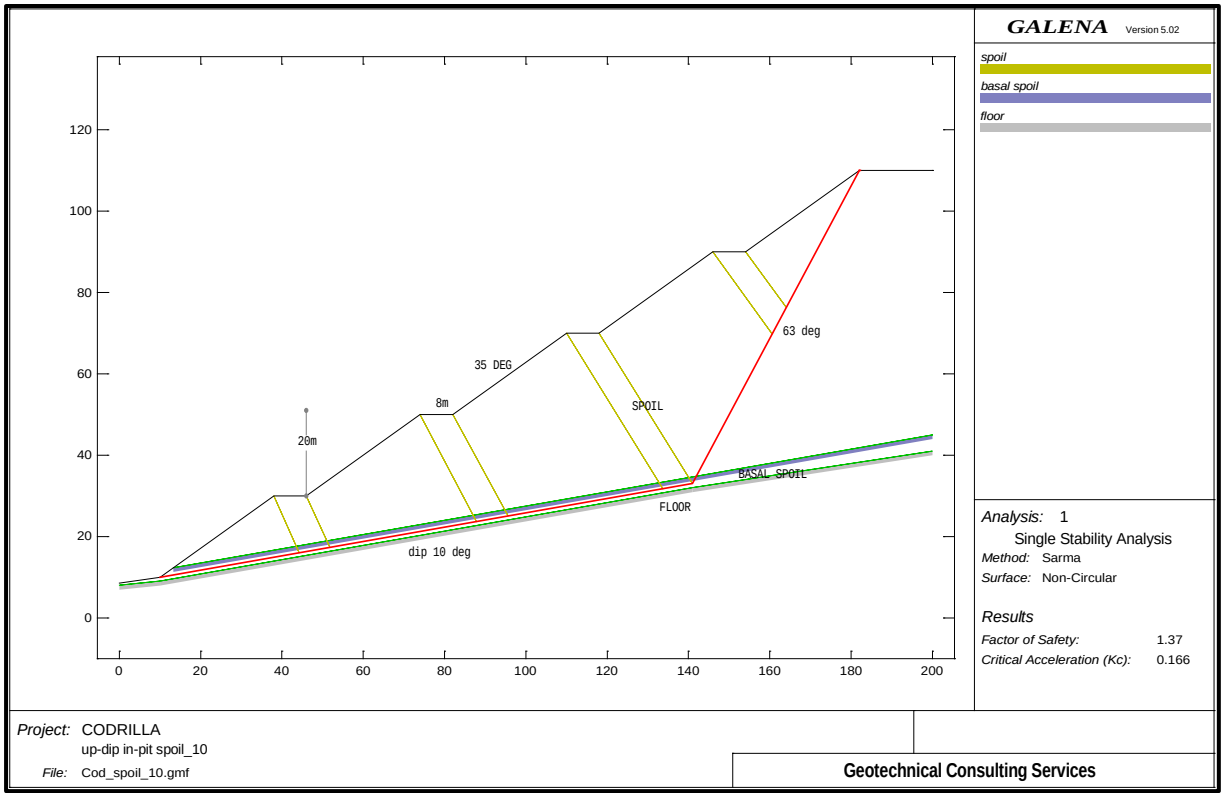
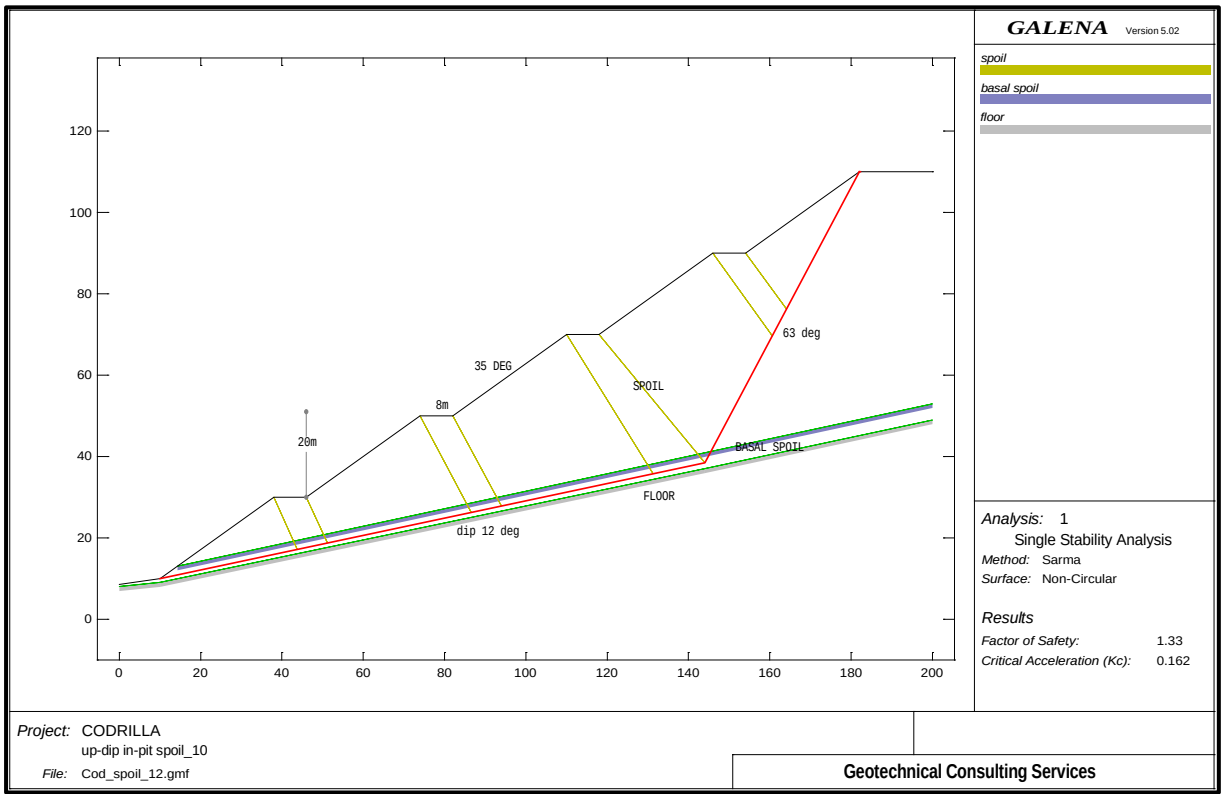
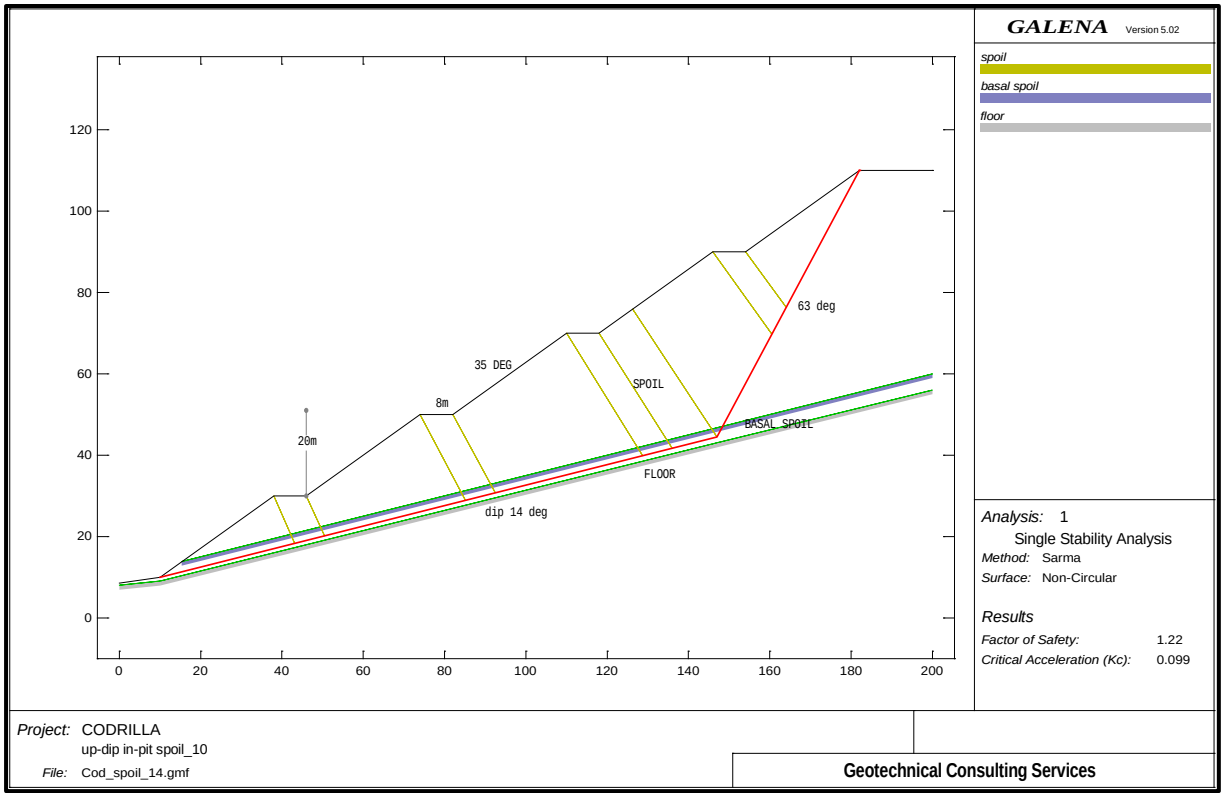
IMC Mining Group

APPENDIX D – Spoil Stability Analysis Results

In-Pit Spoil Stability






GALENA Version 5.02
spoil
basal spoil
floor
63 deg
35 DEG
SPOIL
8m
20m
BASAL SPOIL
FLOOR
dip 14 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.22
Critical Acceleration (Kc): 0.099
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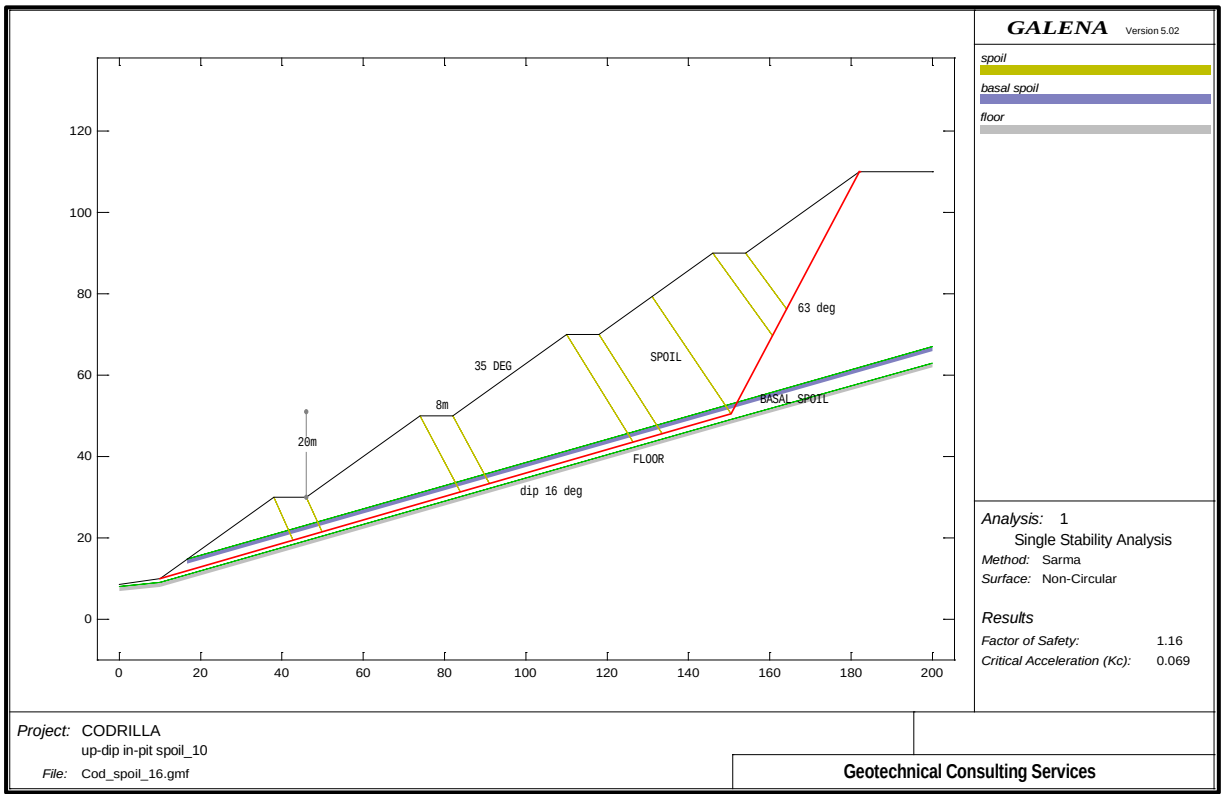
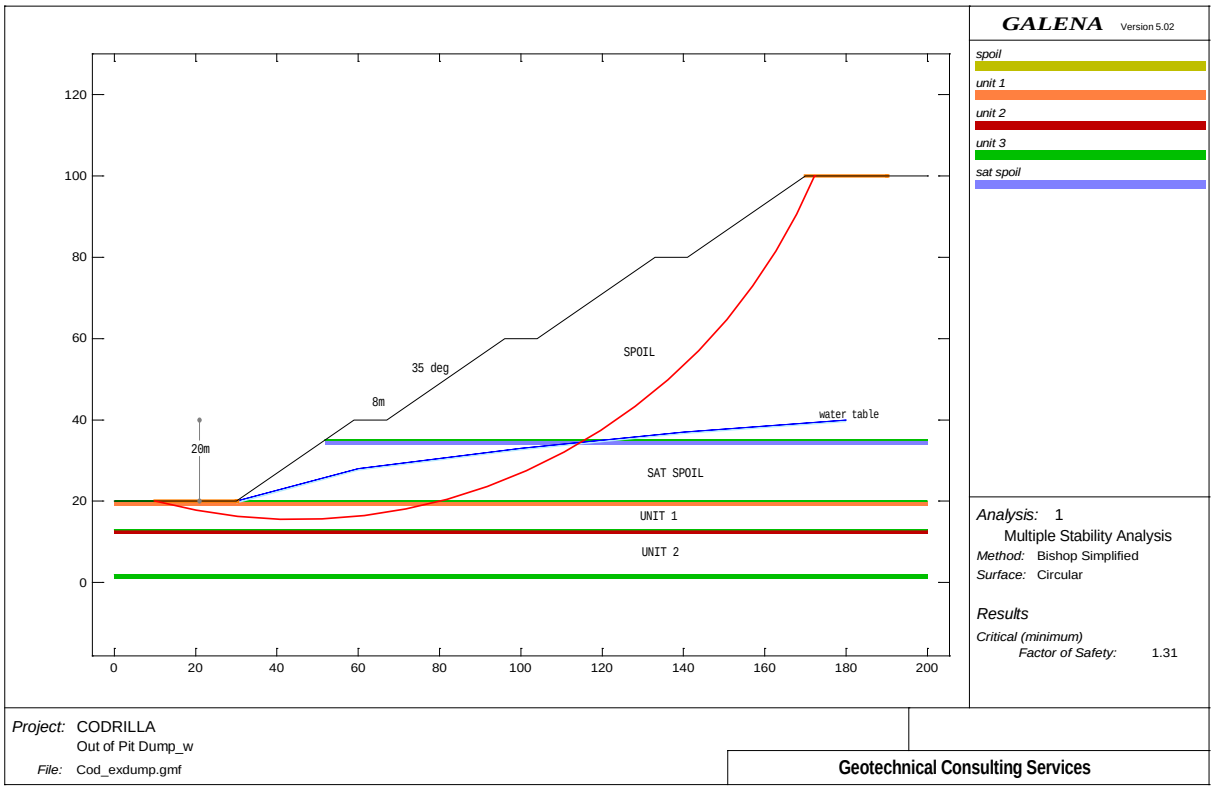
up-dip in-pit spoil_10
File: Cod_spoil_14.gmf
Geotechnical Consulting Services


GALENA Version 5.02
spoil
basal spoil
floor
63 deg
35 DEG
SPOIL
8m
20m
BASAL SPOIL
FLOOR
dip 16 deg
Analysis: 1
Single Stability Analysis
Method: Sarma
Surface: Non-Circular
Results
Factor of Safety: 1.16
Critical Acceleration (Kc): 0.069
Project: CODRILLA
up-dip in-pit spoil_10
File: Cod_spoil_16.gmf
Geotechnical Consulting Services

Ex-Pit Spoil Stability



GEOTECHNICAL CONSULTING SERVICES

MILLENNIUM MINE

RESIDUAL VOID SLOPE STABILITY STUDY

For

MILLENNIUM COAL PTY LTD

Report No. 170
August 2017

MILLENNIUM MINE

RESIDUAL VOID SLOPE STABILITY STUDY

Contents

1. INTRODUCTION 1
2. MINE LAYOUT 1
3. GEOLOGY 2
4. SLOPE DESIGN 3
   4.1 Highwalls and Endwalls 3
   4.2 Spoil Dumps 5
   4.3 Compliance 7
5. MILLENNIUM PITS 8
   5.1 Highwall Stability 9
   5.2 Dump Stability 13
   5.3 Highwall Augering 17
6. MAVIS PITS 19
   6.1 Highwall Stability 20
   6.2 Dump Stability 24
   6.3 Highwall Augering 28
7. ENVIRONMENTAL STABILITY 29
8. WATER MANAGEMENT 30
9. EXCLUSION 31
10. CONCLUSIONS 33
11. RECOMMENDATIONS 34

Figures

	page
1. Mine Layout	1
2. Lithological Sequence	2
3. Millennium Highwall Design	4
4. Mavis Highwall Design	4
5. In-Pit Spoil Dump Design	5
6. External Dump Slope Design	6
7. Millennium Mining Area	8
8. Cross Section ML1 - A Pit west wall	10
9. Cross Section ML5 - B Pit dump	14
10. Cross Section ML8 - West Dump	16
11. Cross Section ML6 - South Dump	16
12. Cross Section ML7 - South Dump	17
13. Cross Section ML4 - south highwall	18
14. Cross Section ML3 - east highwall	19
15. Mavis Mining Area	20
16. Cross Section MV1 - D North Pit	22
17. Cross Section MV2 - E North Pit	22
18. Cross Section MV3 - E North Pit	25
19. Cross Section MV4 - E South Pit	26
20. Cross Section MV5 - S Pit	27
21. Cross Section MV7 - D Pit dump	27
22. Cross Section MV6 - E Pit dump	28
23. Cross Section MV2 - highwall augering	28
24. Bund Location Guide	32

MILLENNIUM MINE

RESIDUAL VOID SLOPE STABILITY STUDY

Geotechnical Consulting Services Pty Ltd
Report No. 170

Barry Ward
August 2017

1. INTRODUCTION

Mining commenced at the Millennium Mine complex in 2005, with a current projected finish to opencut truck and shovel mining in late 2018, after which it is proposed to conduct highwall scavenging using highwall augering or highwall mining methods.

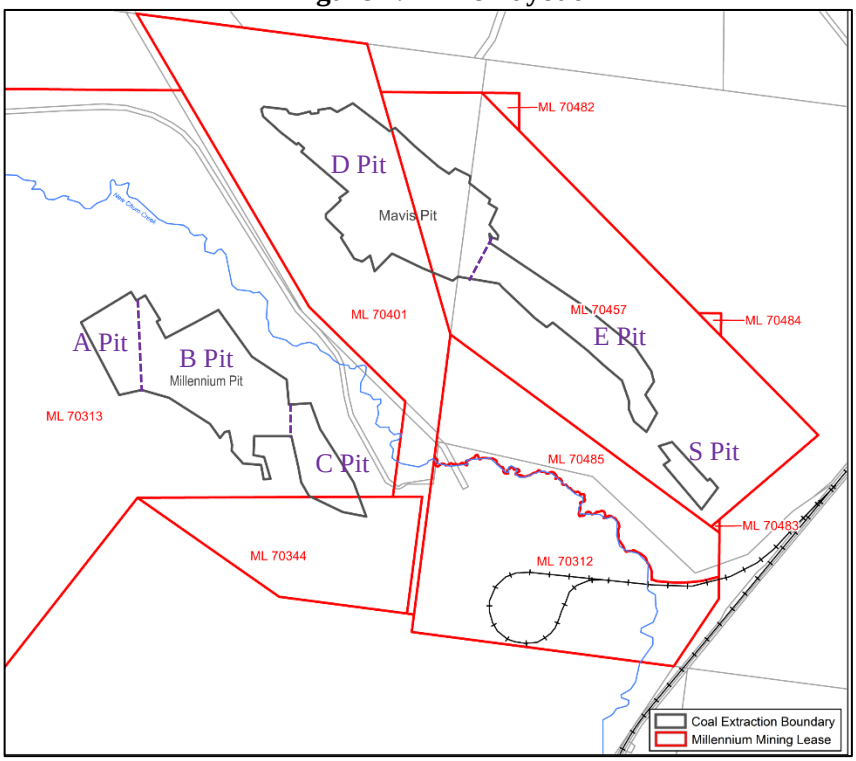
Under the conditions of Environmental Authority Permit No.EPML00819213, Clause F7 (d), a pit wall stability study must be undertaken with proposals for meeting the residual void design. A geotechnical site inspection was accordingly undertaken during the period 8 to 12 May 2017 to assess the stability of the pit walls and dumps with respect to final void conditions.

This report presents an assessment of the geotechnical stability of highwall and low wall slopes and provides an indication of the remedial measures needed to achieve geotechnical stability. It is based on the site inspection, discussions on site and slope stability calculations where appropriate.

2. MINE LAYOUT

Figure 1 shows the general layout of the Millennium Mine complex, with mining leases and opencut pit areas. The mine site comprises two opencut mining areas, Millennium Pit and Mavis Pit, which are separated by a major fault system. Mining is by truck and shovel in both cases. New Chum Creek runs between the two mining areas.

Figure 1: Mine Layout



Millennium Pit was originally developed as three conjoined pits, A Pit, B Pit and C Pit, the mining areas being separated by major fault systems. B Pit and C Pit have been mined out with current mining confined to A Pit. Mining is on a block basis against advancing highwalls on two sides with an advancing in-pit spoil dump on the south-east side.

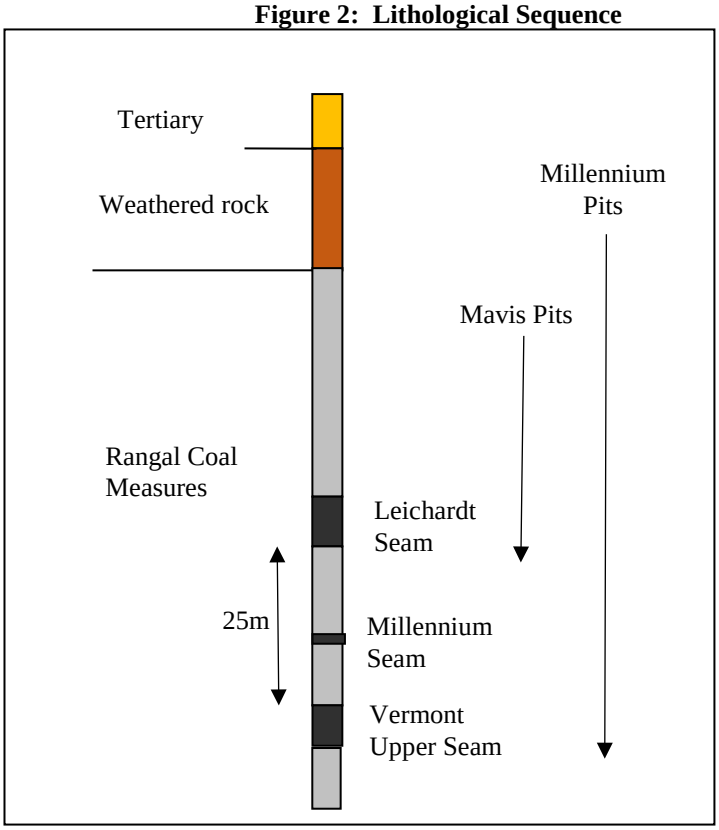
Mavis Pit comprises the conjoined D Pit and E Pit, with the small S Pit at the southern end of the strip, now combined with E Pit. Mining is in down-dip strips with a highwall advancing towards the north-east and with spoil dumping on the low wall side and externally out-of-pit. S Pit was excavated as a boxcut which was then used for water storage between 2013 and 2017. It has since been dewatered with another two strips currently being excavated. Opencut mining has ceased in E Pit, except for the southern end which is being linked up to S pit. D Pit has reached its down-dip limit but there is a possibility of extending the pit to the north depending on arrangements with the adjacent leaseholder (Carborough Downs Mine).

Highwall augering has been undertaken at Millennium Mine on three occasions in 2008, 2011 and 2015/6, and is currently underway in D/E Pits. Further augering or highwall mining is under consideration for remaining exposed highwalls in both Millennium and Mavis Pits as a post opencut mining operation.

3. GEOLOGY

Millennium coal mine is situated in the Rangal Coal Measures in the northern part of the Bowen basin. A generalised succession of strata is illustrated in Figure 2 below.

Figure 2: Lithological Sequence



The main units forming the overburden are:

Tertiary/residual soil:	mostly sand and silt, with some clay
Weathered rock:	weak to moderately strong brown sandstone, siltstone
Coal Measures:	moderately strong to strong grey siltstone and sandstone

The sandy superficial deposits are generally between 2m and 10m thick, beneath which is weathered rock to a depth (base of weathering) of between 20m and 30m. These layers are generally mined as free-dig benches.

Fresh rock comprises thinly interbedded sandstone and siltstone typical of Rangal coal measures overburden. The main overburden down to the Leichardt Seam contains thicker beds of stronger sandstone, with finer grained laminite forming the interburden between the seams. The rock overburden is up to 70m in the highwalls.

The main target seam for both mining areas is the Leichardt Seam, which is typically about 4.5m thick. The 2.0m thick Vermont Upper Seam occurs 20m to 30m below the Leichardt Seam and is mined in Millennium Pit only. The lesser 0.7m thick Millennium Seam, which occurs at a variable location within the interburden, is also a possible target seam but is not normally taken during mining operations.

The seams generally dip at less than 10^0 (between 3^0 and 10^0) within the pits in a direction generally between south-west and north-northwest but the strata are interrupted by large scale reverse faults with local steepening of the dip. The main structural disturbance at Millennium is the A/B Fault which runs NNW-SSE and separates A Pit from B Pit. This fault dips at between 25^0 and 35^0 to the west and has a vertical displacement of about 80m. There are however numerous lesser faults at various orientations.

Mavis Pit is highly disturbed with a number of major faults intersecting the highwalls plus strike faults along the pit. Local steepening of the pit floor in association of these faults is not uncommon.

The groundwater table varies from 17m to 54m below ground level, with an average depth of 32m for the mining areas.

4. SLOPE DESIGN

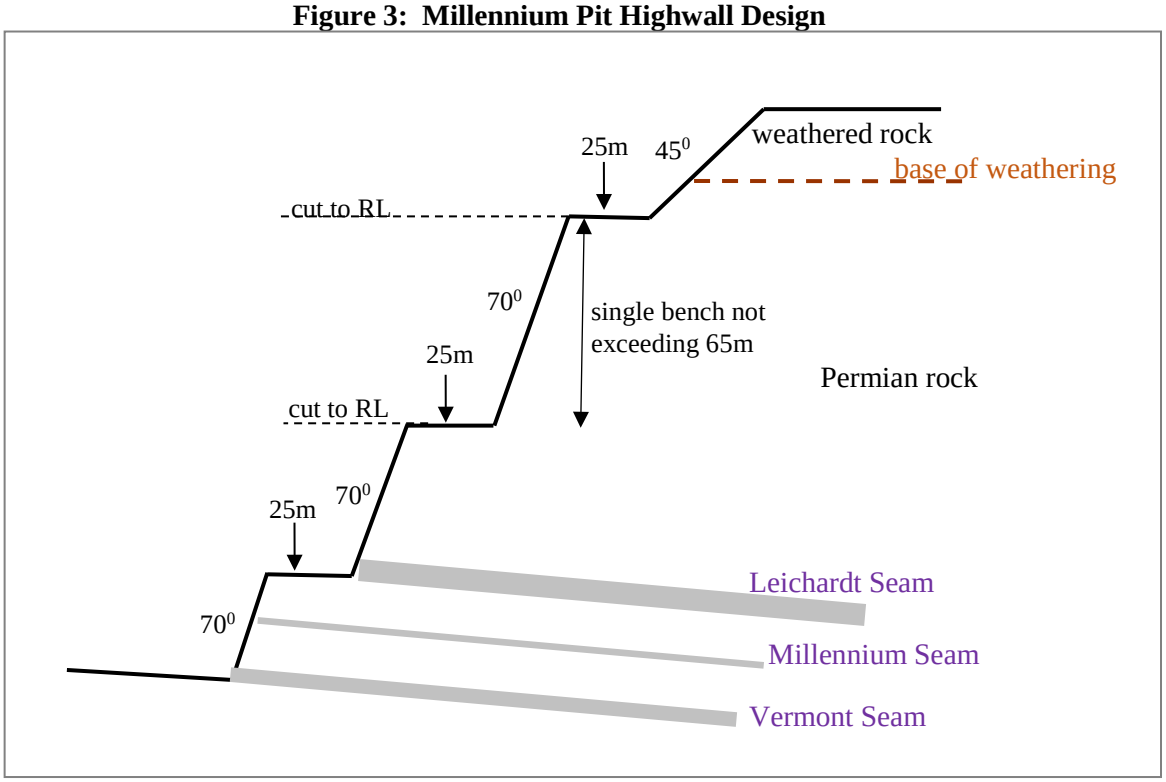
4.1 Highwalls and Endwalls

The standard slope design for insitu walls is illustrated in Figure 3 below. The main points are:

- Berms are designed to RL to ensure consistent drilling horizons, unless following a floor of coal;
- Batter angle in the superficials/weathered rock is 45^0;
- Rock benches are pre-split at 70^0;
- The maximum bench height in rock is 65m;

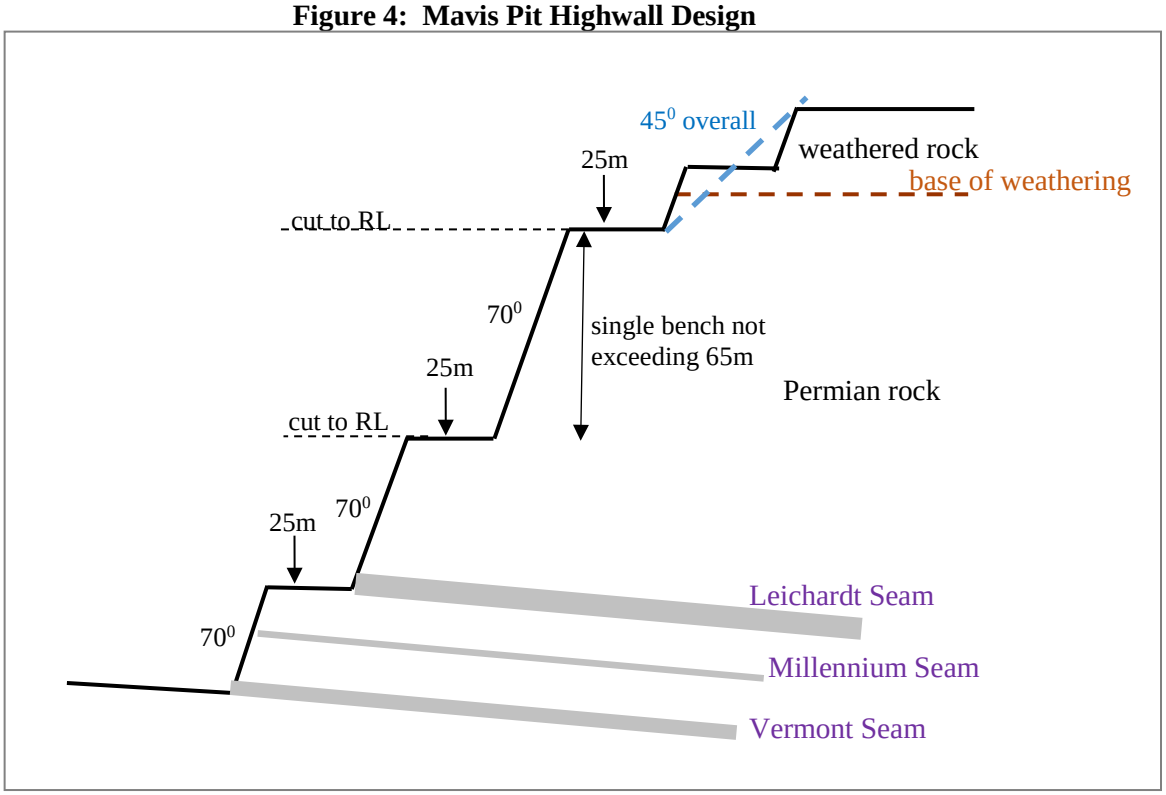
This design is used for all insitu side wall slopes in normal conditions; modifications may be made for local situations where fault zones intersecting the walls and could create conditions of instability.

Figure 3: Millennium Pit Highwall Design



A 'rough-cut' design variation is used in Mavis Pits where the soft overburden is dug by excavator. In this case the top bench through softer ground (soil/Tertiary/weathered Permian) is excavated as two individual benches cut to suit the excavator swing, with a berm of suitable width to ensure the overall slope angle of both benches does not exceed 45^0. This variation is shown in Figure 4 below.

Figure 4: Mavis Pit Highwall Design



The photo below shows a typical highwall representation.

E Pit Highwall

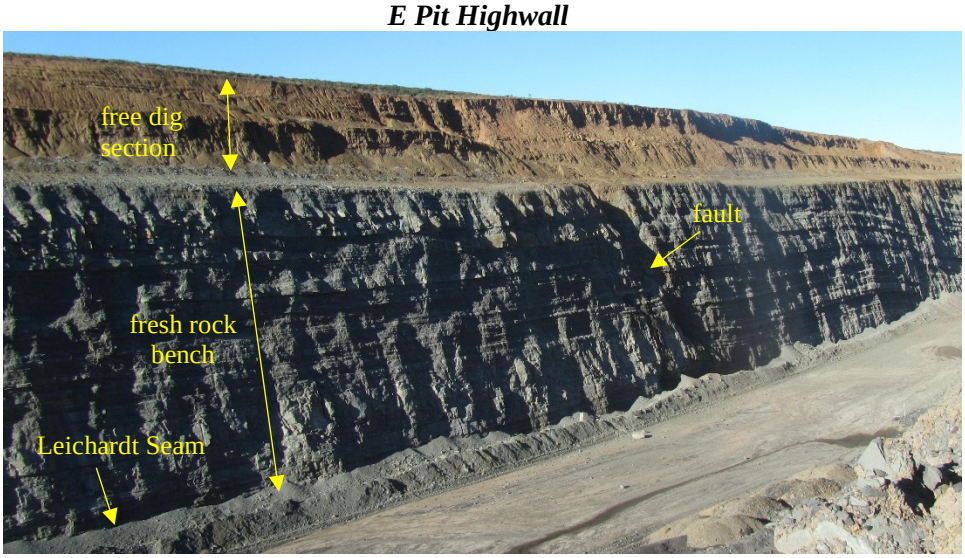


Photo taken 28/06/2016, looking ENE

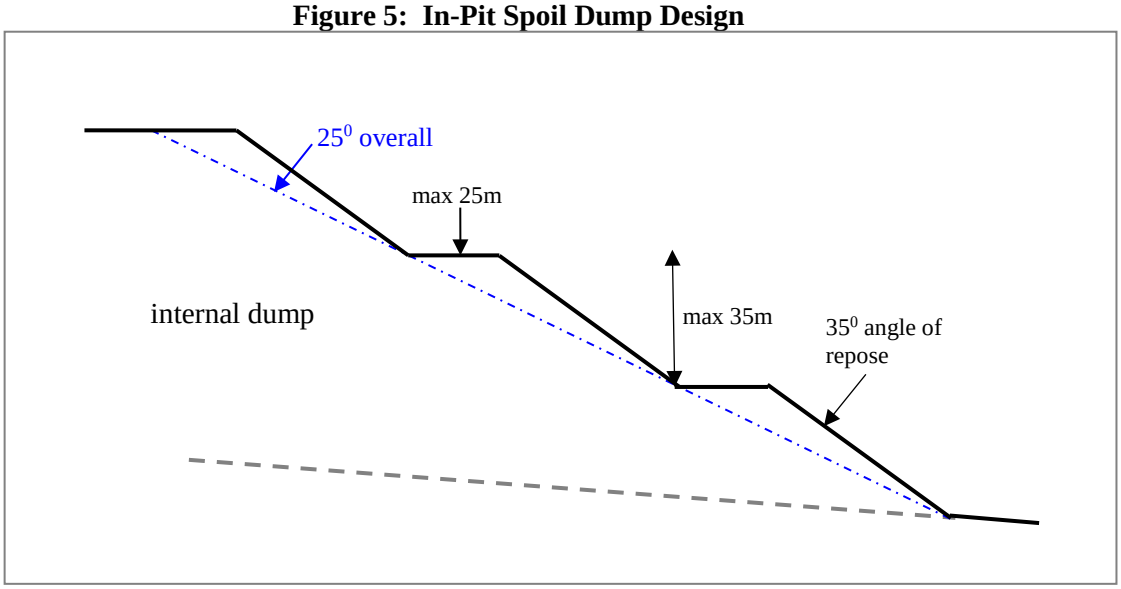
4.2 Spoil Dumps

In-pit spoil dumps are built up in lifts at angle of repose batters with berms. Angle of repose is 35^0 on average. The final profile may depend on operational factors but is within the following constraints:

- Maximum dump bench height 35m;
- Maximum berm width 25m;
- Maximum overall slope angle (toe to toe) not to exceed 25^0 (46%).

The design profile is illustrated in Figure 5 below.

Figure 5: In-Pit Spoil Dump Design



The general aspect of the in-pit dump is illustrated in the photo below, which shows the face of the advancing dump in B Pit.

B Pit in-pit dump

Photo taken 9/05/2017, looking SW

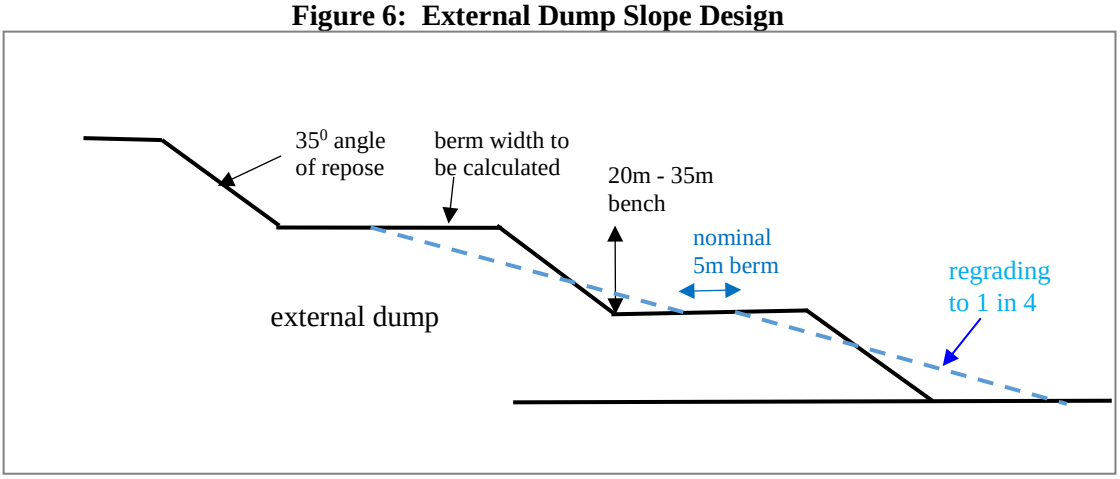
Floor treatment is used to disrupt bedding or slip planes prior to dumping or casting spoil on steeper floor dips to ensure the in-pit dump remains stable. This is only applicable to parts of Mavis Pit where the dip exceeds 12½^0.

External dump faces are formed to facilitate re-grading to 1 in 4 slopes for rehabilitation. The final dump profile will be depend on the circumstances and will be calculated to give a cut-and-fill balance for the re-grading push-down. Berm width varies according to the bench height and is designed to leave a nominal 5m residual berm after pushing down the batter. The overall guide is:

- Maximum bench height 35m;
- Nominal bench height 20m;
- Residual berm width nominally 5m;
- Final re-graded batter 1 in 4 (14^0).

The design profile is illustrated in Figure 6 below. For a 20m bench height, which is the usual design, the berm width would be 56m.

Figure 6: External Dump Slope Design



The photos below show as-constructed external slopes of the low wall spoil dump at D Pit and re-graded rehabilitated external slopes at E Pit.

Pit external low wall spoil dump face

Site photo 143458861 taken 18/07/2017, looking ENE

E Pit external low wall rehabilitated spoil dump face

Photo taken 9/05/2017, looking NE

4.3 Compliance

The Environmental Authority (EA) specifies that highwall slopes in competent rock can remain as constructed if they are geotechnically stable or otherwise benched with 15m berms at 20m intervals. This would be equivalent to a maximum overall slope angle of 63^0 for benched slopes. Low wall spoil dumps are to be benched or reshaped accordingly to ensure geotechnical stability. External spoil slopes (landform) must not exceed 1 vertical to 3 horizontal (18^0). The specified and as-formed slope angles are tabulated below.

Slope Type	EA requirement	As constructed
Highwall – competent rock	geotechnically stable	70^0 benches; 15m berms
Low wall – void side	geotechnically stable	benched, 25^0 overall
Landform – external dump side	max 1 v : 3 h	re-graded to 1 in 4 (14^0)

The EA requirements for pit slopes are not specific in terms of design parameters, the criterion being that they should be geotechnically stable. The as constructed highwall slope profiles are typical opencut coal industry designs that have proven adequate for general application.

Normal coal measures rock is too strong to undergo shear failure under gravitational loading and requires the presence of pre-existing separation planes, such as pervasive joint planes, faults or dykes to create conditions of potential instability. So that in the absence of adverse structure, 70^0

or vertical highwalls can be expected to stand indefinitely without risk of major collapse. The Millennium Mine design is thus compliant in providing geotechnically stable highwalls.

Instances of where faults intercept or occur close to pit walls are treated on an individual basis with the standard design modified as necessary to ensure any instability can be managed.

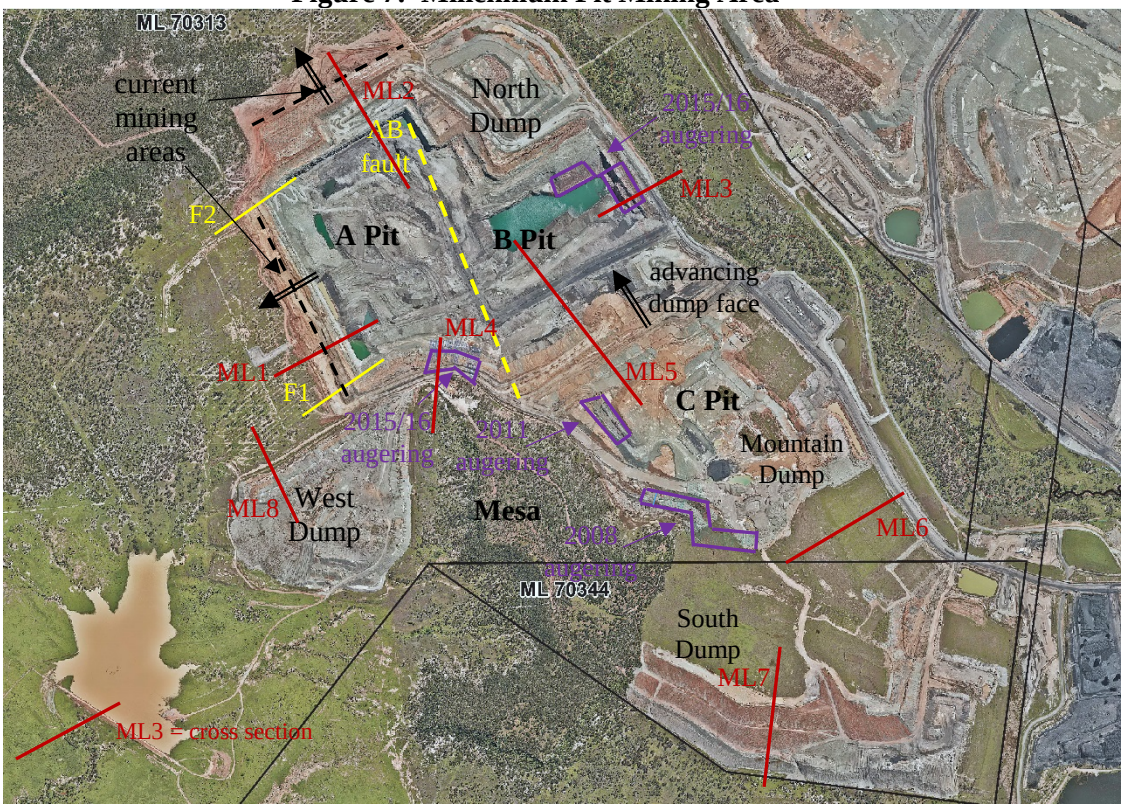
Low wall dumps are built up in benches at angle of repose to a maximum lift height of 35m between berms, which is a typical well-proven industry design for rockfill dumps on flat or gently dipping ground, and thus complies with the EA requirement for geotechnical stability. In-pit dumps are generally susceptible to mass failure if the floor is sloping, particularly if there are weaknesses in the floor. Steeper dips are a feature of some parts of Mavis Pit but there are design variations involving floor treatment or re-assessment of the design if the dip exceeds a threshold value of $12\frac{1}{2}^0$.

External dumps have been re-graded to 1 in 4 which is flatter than the EA requirement.

5. MILLENNIUM PITS

The aerial photo below (Figure 7) shows the salient features of the Millennium Pit mining area. These include the designated pit areas A Pit, B Pit and C Pit and the out-of-pit dumps which are built above ground level. Also shown are the highwall augering blocks, the lease boundaries and the locations of cross sections (ML1 etc) referred to in the text.

Figure 7: Millennium Pit Mining Area



Mining commenced in C Pit which is now mined out and completely infilled with spoil and built up to RL305, some 50m above ground level. This referred to as Mountain Dump. The initial boxcut spoil for C Pit was dumped to the south as the South Dump; this old dump has been regraded and largely rehabilitated. Other out-of-pit spoil was placed in the North and West Dumps. The main in-pit dump is advancing north across B Pit and a new dump is being established in A Pit.

A mesa forms high ground between the south and west dumps which constrained mining on the south side. This feature contains cultural heritage sites. As the insitu low wall was exposed along the mesa on the south side, successive periods of auger mining were undertaken, extending under the low wall. The east highwall and north wall of B Pit was also subject to highwall augering after they had been established as final wall locations.

Current opencut mining is restricted to the north and west walls of A Pit, where one or two strips are planned. The eastern half of the north highwall was not visible at the time of the inspection as it had been blasted and was obscured by cast blast material. There could be a potential for highwall mining in the final north and west highwalls.

The final plan will leave a void against the north and west walls in the current mining areas in A Pit. It is intended to infill B Pit to ground level, at least for the most part, with a possible spoil-bounded void in the middle. B Pit is currently occupied by a pond that can be seen in Figure 7. Preliminary modelling results of maximum long term void inundation levels by Hatch indicates the water level in Millennium Pit would rise to a maximum of RL164 after 10 years and would fluctuate around RL160 thereafter.

5.1 Highwall Stability

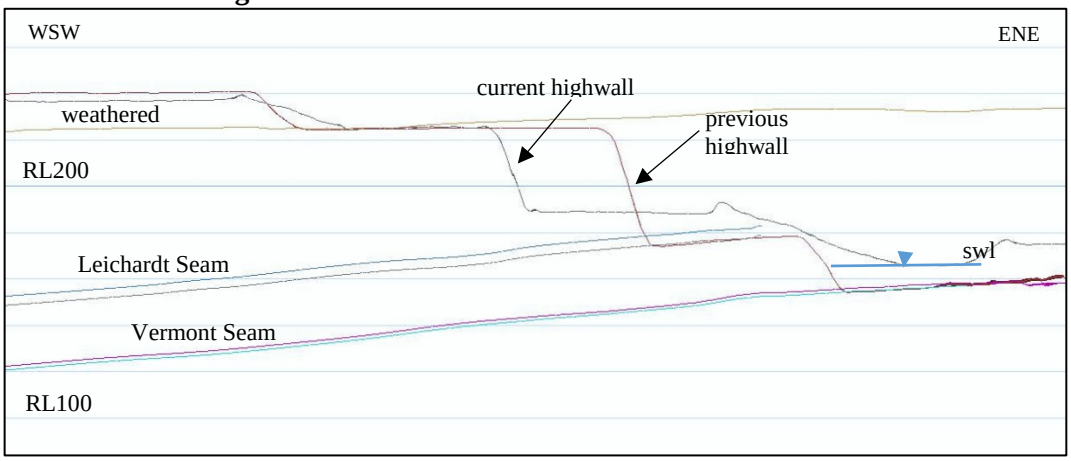
In normal conditions the pre-split rock benches are clean and stable. In some cases the walls have not been pre-split but have been scaled to present a reasonably clean face. In either case there will always be a background risk of small blocks becoming detached through weathering and falling out. The Rangal Coal Measures, particularly the finer grained rock, are susceptible to slaking and this allows the softer material to weather out and undercut the harder sandstone blocks. This has no impact on the overall geotechnical stability of the slope but represents a long term weathering effect. The photo below shows a typical scaled highwall bench with undercutting of the harder sandstone bands.

A Pit south highwall

Photo taken 4/12/2016, looking NE

Full height final highwall faces will be left along the west and north sides of A Pit. Cross Section ML1 in Figure 8 below shows the current configuration for the west wall, with the partially exposed highwall for the next strip. More strips may be mined but the final configuration should be the same, comprising a 45^0 upper bench up to 30m high through the weathered zone and a 70^0 pre-split main overburden bench up to 55m high. Also shown is the predicted long term void water level at RL164.

Figure 8: Cross Section ML1 - A Pit west wall



The highwalls are cut through material that is too strong to permit material failure by shearing and hence will stand indefinitely subject only to weathering degradation. The systematic risk of massive block slippage can also be discounted since the bedding dips back into the wall. However, rock failure conditions can be created by adverse pervasive discontinuities such as fault planes, joint planes or combinations of planes producing block or wedge configurations.

The main structural disturbance at Millennium Pit is the A/B Fault which runs NNW-SSE and separates A Pit from B Pit. This fault dips at between 25^0 and 35^0 to the west and has a vertical displacement of about 80m. Localised instability has occurred as a result of slippage down the fault plane but this was an interim mining issue that could be managed by judicious location of the temporary faces within the pit. No instability has been noted where this fault system intersects the north highwall, as the fault system is perpendicular to the wall, which tends to neutralise any potential instability from adversely dipping planes.

Several large steep reverse faults occur within the mining areas, but most of these are also more or less perpendicular to the wall and do not usually result in any significant instability. Where these faults are parallel to and just behind a face they can create a risk of large scale wall collapse. One of these was in the north wall of B Pit; this was remedied by cutting back the upper part and buttressing the affected part of the wall with spoil after mining the coal.

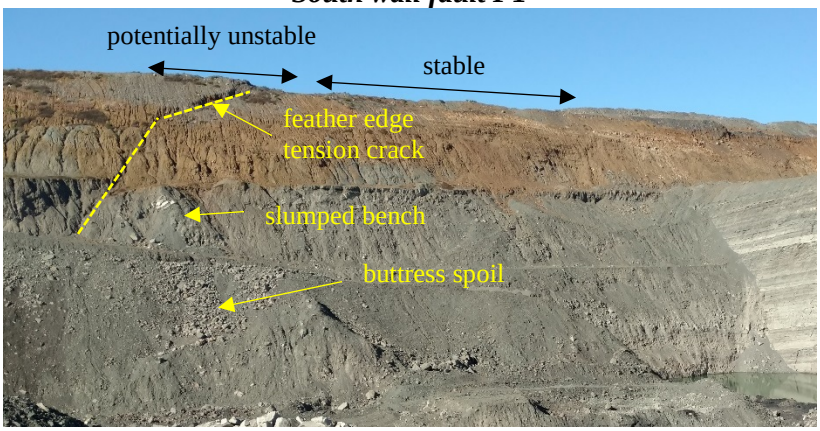
Two other instances of potential fault-induced instability occur at each end of the west wall, marked as F1 and F2 on Figure 7. F1 appears to be a high angle fault running behind and sub-parallel to the south wall, dipping out of the wall. It has incurred some movement, manifest as a tension crack along the edge of the haul road and slumping of the lower bench. The tension crack enlarged significantly following inflow from cyclone Debbie in March 2017 as shown in the photo below.

F1 tension crack

Site Photo taken 9/05/2017, looking NE

Inspection of the face reveals that the movement is due to a slumping collapse of the feather-edging fault intersection with the wall – too much weight on too narrow a base – and that the main section of wall in front of the crack appears to be intact. The feather-edging tension crack is shown in the photo below cutting down across the upper weathered benches. The lower rock batter has incurred slumping collapse.

South wall fault F1



Site Photo IMG_20170524_ 091625948 taken 24/05/2017, looking NE

A spoil buttress has been placed against the wall and this has effectively buttressed the lower bench against any further slumping. The residual risk would be shallow slip failure through the top of the weathered material and haul road spoil at the top.

In terms of remedial action for final void, because the failure is fault controlled it will not extend any further back than the fault itself marked by the tension crack, the recommended action would be to leave as is with a rock bund along the haul road 15m from the tension crack. As the fault trend is moving further away from the wall the potential for mass failure should be reduced and it is unlikely to have any impact on the stability of the next strip endwall.

The other fault (F2) is also projected to run almost parallel to the northern endwall of the next strip. This fault can be seen daylighting in the current north wall but with no indication of instability. The fault plane appears to be dipping back into the wall which would negate the potential to induce a similar collapse of strata off the fault plane. As the fault trend is also slightly oblique to the wall, it will be further back from the face on the next strip which would minimise the risk of fault-induced endwall failure in the next west wall strip.

In either case the consequences of wall failure would be material movement into the residual void, with a failure extend defined by the fault line, hence the recommendation to bund off behind the line of the fault or tension crack to prevent access into a potentially failing edge area. The alternative would be to buttress the wall to ground level with the in-pit spoil dump.

The top bench is cut through weathered rock for the most part. Circular slip type failure is theoretically possible but can be discounted given the absence of lower strength Tertiary clay or completely weathered mudstone (clay type material) in the batter and the inherently higher shear strength of weathered rock which tends to include some stronger sandstone bands.

Rockfall is more prevalent from the top bench however due to softer soil-like material eroding out from around the more resistant blocks, particularly if a steeper batter has been formed. The upper bench of B Pit north wall shown in the photo below is an example of a steep rough-cut batter.

B Pit north wall

Photo taken 9/05/2017, looking NW

In this instance a band of strong sandstone has prevented the formation of the normal 45^0 batter and although there is no risk of mass failure, there is a likelihood of large blocks weathering out. Any rockfall will report to the void and will in any case be contained on the wide rock berm.

B Pit north wall bund

Photo taken 9/05/2017, looking E

It is planned to leave an access road along the wall behind this bench as part of the final works. There should not be an issue with that provided the substantial rock bund already in place some 15m back from the crest to protect the current haul road, is left as a permanent exclusion against the edge area.

The upper bench east wall of A Pit is also likely to be left as a final wall off the void. This is shown in the photo below. In this instance the standard 45^0 batter has been cut through the weathered rock creating an intrinsically stable bench but still subject to minor rockfall from weathering effects. There is a 25m catch berm below for rockfall.

B Pit east wall

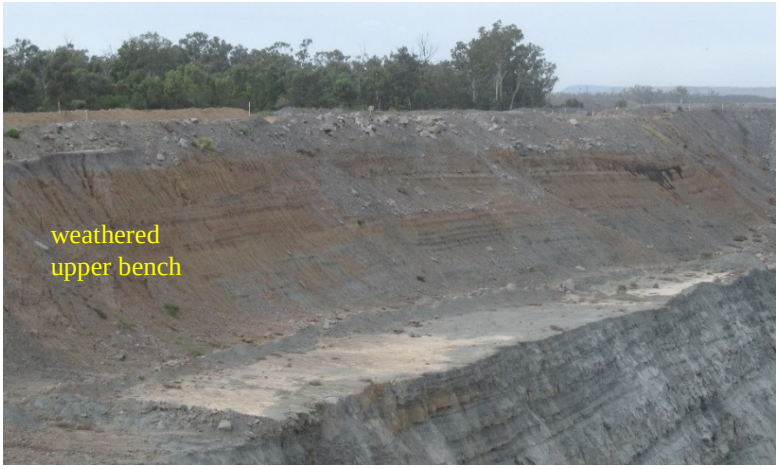


Photo taken 9/05/2017, looking SE

From experience to date and the current condition of the walls, it can be concluded that the highwall design is appropriate for producing a stable final wall, except for those areas where faults are present behind and parallel to the face as discussed above.

In terms of long term void water level, the predicted RL164 mark would result in inundation of the lower rock bench to a height of about 5m and 10m above the pit floor respectively for the north and west final highwalls. Submergence of fresh rock benches does not normally change the stability condition and hence would not be expected to trigger any failure.

Slopes in weathered rock would be susceptible to slaking and erosion and the batter could degrade due to slumping if the water level reached higher than the base of weathering. As the base of weathering is between RL225 to RL240, the top bench in weathered material would be well above the maximum predicted void inundation levels and this situation would not arise.

5.2 Dump Stability

There is no apparent history of low wall failures in Millennium Pit, other than localised slippage on steep dips associated with the AB Fault. Both the in-pit dump and the external dumps are clearly stable, nevertheless slope stability analyses were carried out to confirm the Factor of Stability (FoS). Shear strength parameters used for analyses, based on the foregoing, were as follows.

Shear Strength Parameters

Material	**Density (kN/m^3)**	**c (kPa)**	**ø**	**Reference**
Fresh spoil	20.0	50	30^0	Category 3 dry
Aged spoil	20.0	30	28^0	Category 2 dry
Basal spoil (submerged)	20.0	15	23^0	Category 2 saturated
Weathered rock	22.0	25	35^0	estimate

Rock spoil is blocky when fresh and appears to be mostly BMA Category 3[1] (blocky spoil with fines) with a reasonably high shear strength. Over time the spoil will undergo slaking with breakdown of the lumps so that the spoil has more fines than blocks. Testing of spoil from the nearby Moorvale Mine[2] shows predominantly low plasticity for the fines which would tend towards a Category 2 spoil type (fines with blocks). Spoil from the weathered zone already can be assumed to be similar to the same material at Moorvale Mine, which testing showed to be low to intermediate plasticity with high dispersivity, that is equivalent to Category 2.

Analyses were made for specific as constructed profiles represented by the selected cross sections, together with the standard design in the case of the in-pit dump profile. The analyses were made using the Galena code for circular failure for external dumps and bi-planar slippage for the in-pit dump. The results are summarised below. The inundated case is for the void flooded to the maximum 10 year level at RL164.

[1] Simmons J V & McManus D A 'Shear Strength Framework for Design of Dumped Spoil Slopes for Opencut Mines' Advances in Geo Engineering, The Skempton Conference, Thomas Telford, London, pp981-991

[2] Ward B 'Moorvale Mine Residual Void Slope Stability Study' Geotechnical Consulting Services Pty Ltd, Report No.158 November 2014

Analysis Results (FoS)

Section	Dip	Current	Inundated
West Dump (Section ML8)	flat	2.44	-
In-pit standard	6^0	1.61	1.40
West wall void (Section ML1)	6^0	1.68	1.58
North wall void (Section ML2)	1.5^0	1.72	1.67

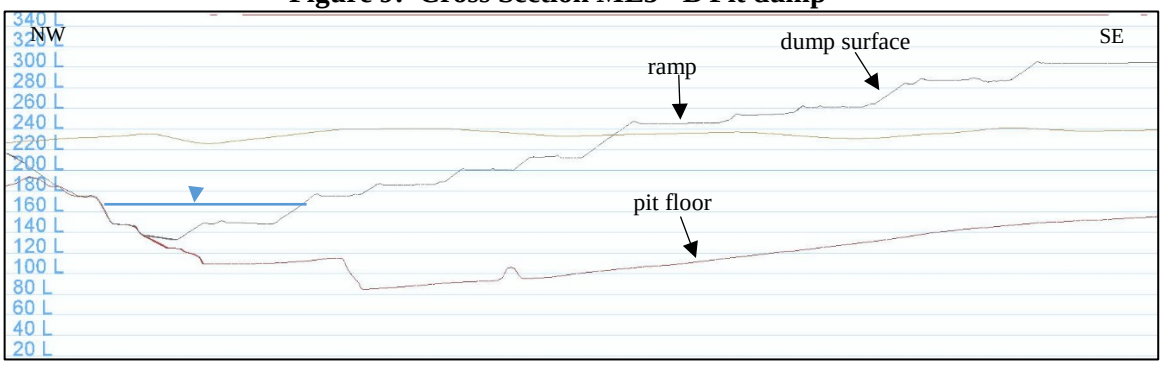
The FoS criteria in common use in the coal mining industry are:

FoS $\geq$ 1.2 short term run-of-mine slopes
FoS $\geq$ 1.5 long term slopes or where slope failure could impact on infrastructure etc

Figure 9 shows the profile along Cross Section ML5 through the advancing in-pit dump face from pit bottom to the top of the Mountain Dump. This is as per the standard design although the overall slope is flatter due to the insertion of ramps at various levels across the dump face.

The in-pit standard analysis was based on this cross section from pit bottom to the elevated top height at RL305 on the 6^0 dipping floor but without the ramps. In practice there are ramps crossing the face of the dump which would reduce the overall slope angle so that the profile without ramps represents the worst case. The results indicate stable conditions for this hypothetical case with the inundated condition having a slightly less than desirable FoS for long term stability, noting however that the FoS for the as-constructed low wall would be higher with the inclusion of the ramps in the profile.

Figure 9: Cross Section ML5 - B Pit dump

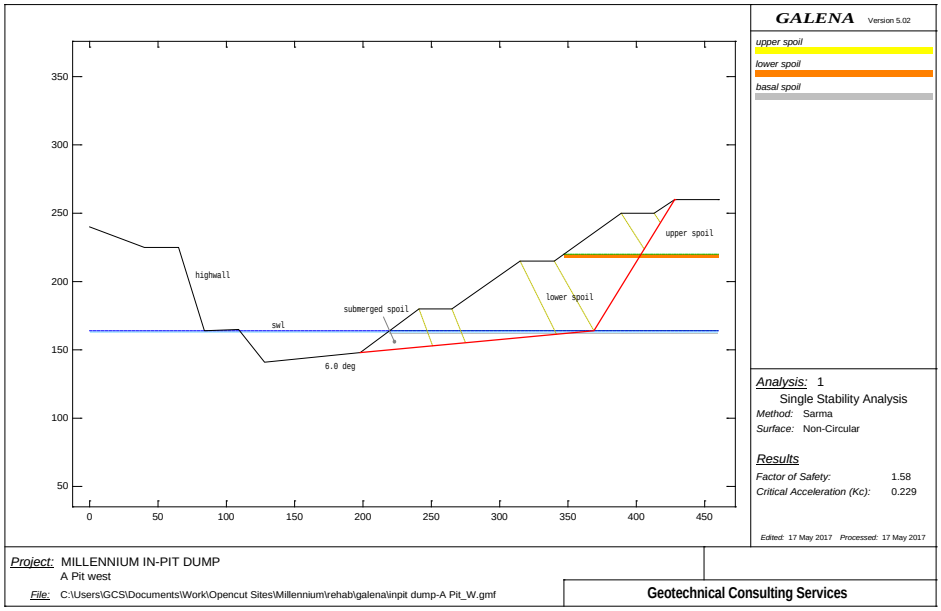


Irrespective of the analysis results however, Cross Section ML5 shows that the spoil dump extends to the opposite highwall and is buttressed against that and the Vermont Seam bench. This would preclude the possibility of mass failure for the current in-pit dump.

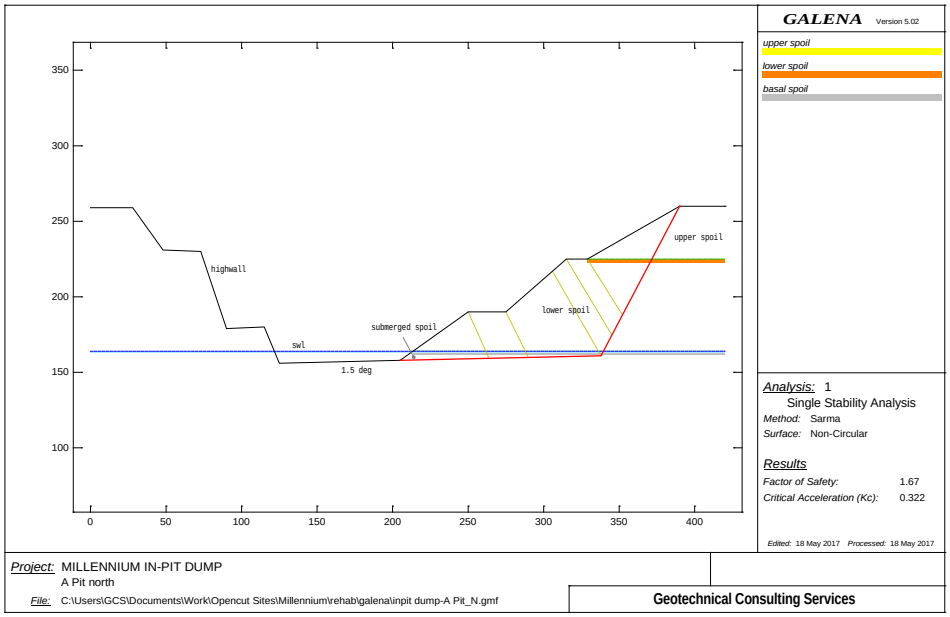
Unbuttressed in-pit dump faces would be formed at the completion of mining in A Pit opposite the west and north walls. For these cases the standard dump design was applied to Cross Sections ML1 and ML2, assuming the A Pit dump is raised to ground level at RL260. Analyses were made for a presumed final void profile, allowing for inundation to RL164. The upper spoil forming the top bench may include some weathered material and has thus been treated as Category 2, with submerged spoil as Category 2 saturated. Failure mode is bi-planar with slippage on the pit floor and shearing back up through the spoil dump.

The results tabulated above show FoS in excess of the long term design value for both as constructed (drained) and inundated conditions. This would indicate that internal dump failure would be highly unlikely. Note that displaced material from failing slopes would in any case be contained within the pit void. The outputs from the Galena program are presented below. The FoS for the north facing dump are higher because of the shallower dip in that direction.

A Pit west wall void



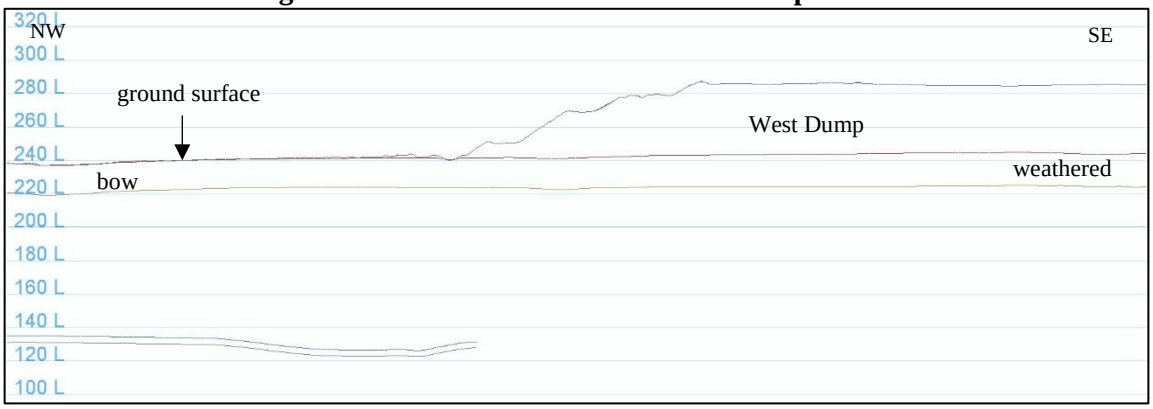
A Pit north wall void



External dump profiles are currently determined from a calculator designed to balance the cut and fill to allow for pushing down the batters to an overall 1 in 4 rehabilitation slope. In theory they would normally be 20m benches at angle of repose with 56m wide berms. With a wide-bermed profile like this the possibility of mass failure is eliminated. Slumping of individual benches is possible under extreme conditions of saturation but is highly unlikely.

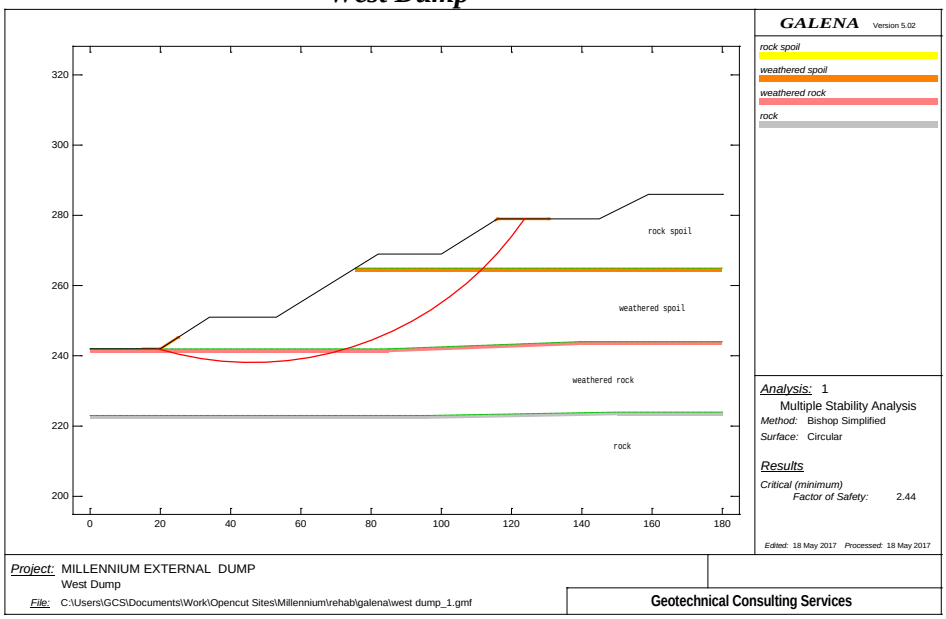
Earlier out-of-pit dumps were steeper with narrower berms and this includes the North and West Dumps. Both of these have an as-constructed profile as they have not yet been re-graded, although technically they are in compliance with the EA requirements. Figure 10 below shows the profile for Cross Section ML8 through the northern side of the West Dump.

Figure 10: Cross Section ML8 - West Dump



Analysis of this profile shows a high FoS of 2.44 for circular slip failure, with the most critical failure surface through to the third bench as illustrated on the Galena model below.

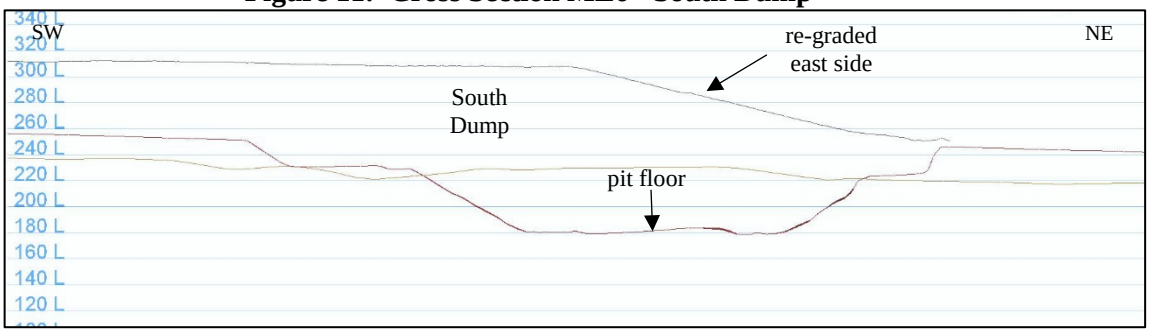
West Dump



It can be concluded that the external dump faces with as-constructed profiles are geotechnically stable.

Final external dump faces are re-graded to 1 in 4, covered in rock mulch and grassed for rehabilitation status (see Section 4.2). Cross Section ML6 below shows the profile through the east side of the old south dump. This is an example of early re-grading without any berms.

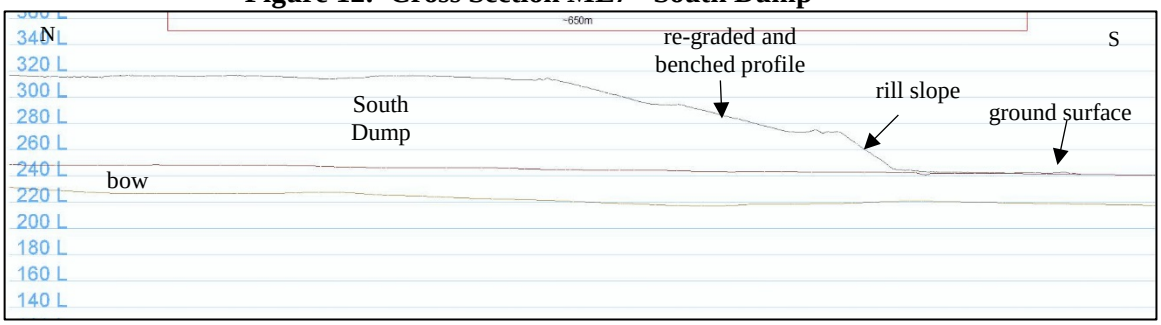
Figure 11: Cross Section ML6 - South Dump



The top of the dump is flat to reduce run-off as per the requirements of the EA. In this respect it has been the practice to bury tailings in cells in the spoil – this causes differential compaction which tends to create temporary ponding on the surface over the cells.

The south side of the South Dump has also been re-graded as shown in Cross Section ML7 below. In this case however, final works have not been completed pending agreement to push material over onto the adjacent lease. As a consequence the bottom batter is still as-dumped at angle of repose.

Figure 12: Cross Section ML7 - South Dump



Due to the shallow slope profile created by the re-grading, there is no risk of mass slope failure and rehabilitated slopes can be considered geotechnically stable over the long term.

5.3 Highwall Augering

Highwall augering has been undertaken at Millennium on three occasions in 2008, 2011 and 2015/6. The locations of the auger mining are shown on Figure 7. The 2008 augering was in C Pit low wall at the southern end of the mine area, with single row panels in both the Leichardt and Vermont Upper Seams. Subsequent augering was in the Leichardt Seam only with a double row of holes wherever possible.

The next section of B Pit low wall was mined in 2011, together with an internal panel along a north wall in B Pit. These entries, and the earlier ones, have all been buried under the in-pit dump.

B Pit Highwall Augering

In 2015/16 augering was undertaken in the next section of low wall in A Pit together with east and north walls in B Pit. The photo shows auger holes in the north wall of B Pit.

Photo taken 12/04/2016, looking E

Auger designs are based on a Factor of Stability (FoS) of not less than 1.2 for the coal pillars under maximum overburden loading and not less than 1.5 at the portal under the highwall face[3].

[3] Ward B 'Millennium Mine Highwall Augering' Geotechnical Consulting Services Pty Ltd, Report No.165, September 2015

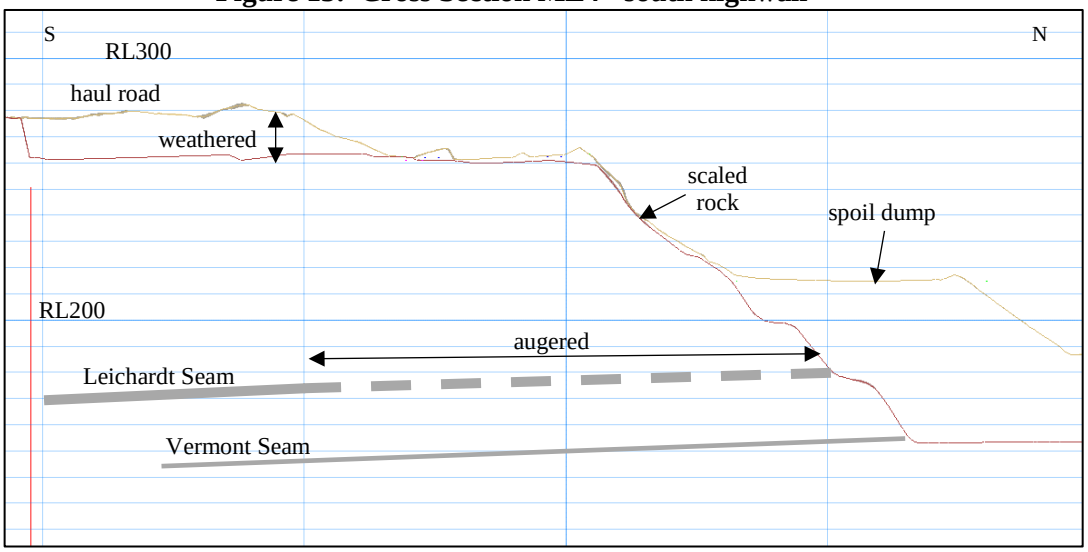
These general design FoS values are for run-of-mine extraction and are not adequate for ensuring long term stability, and although there has not been any indication of distress in any of the auger entries or pillars to date at Millennium, there will be a possibility of long term deterioration (creep) of the coal pillars over time, allowing the pillars to eventually fail and crush down. The consequences of a long term deterioration and collapse would be subsidence at the surface but this would not be expected to exceed about 0.75m.

Pillar failure at the portal would undermine the highwall and could result in a collapse of the highwall face. Slope failures from this cause tend to be relatively shallow, more of a collapse type slump than a deep seated slope failure, and do not extend far behind the highwall. The use of the higher long term stability FoS value under the highwall should reduce the risk of highwall collapse in isolation, although a widespread collapse of pillars inbye could run forward under the highwall.

The 2008 and 2011 auger blocks are now buried under spoil such that highwall instability is now irrelevant and any subsidence reporting to ground level through the spoil would not be of any consequence.

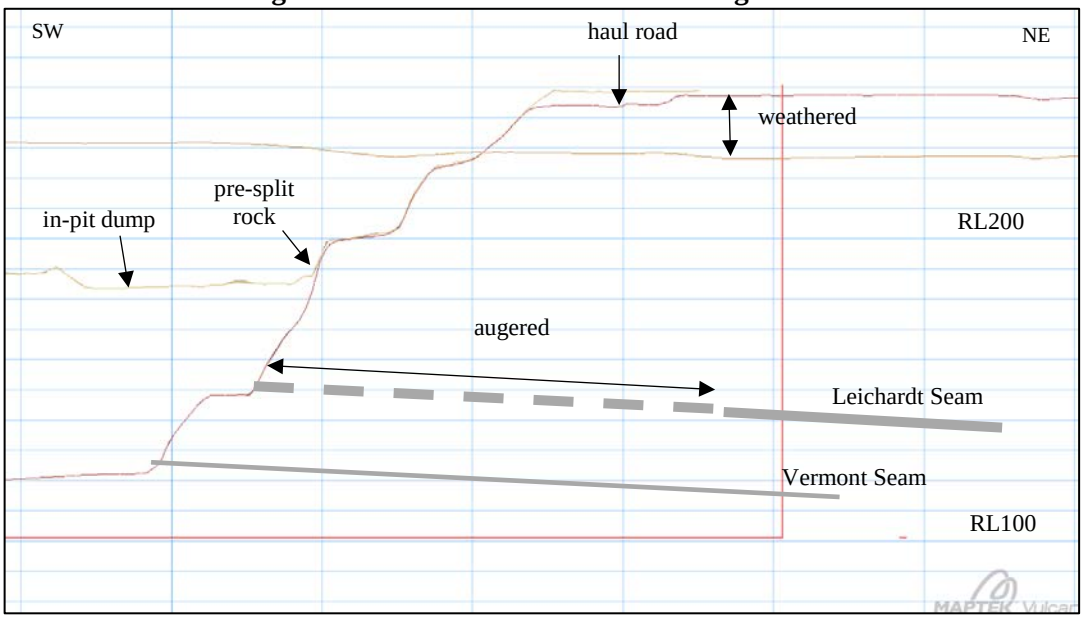
A cross section through the south wall is shown in Figure 13 below. The auger holes generally penetrated between 80m and 160m, with a maximum of 200m in places, so did not penetrate further in than the haul road, which would not therefore be affected by any long term subsidence. The stability of the scaled 50^0 upper batters would not be affected by any subsequent pillar crushing and only the bottom rock bench would be at risk of face collapse. However the holes are now buried under a buttressing spoil dump which would offer greater confinement to the pillars under the face and reduce the opportunity for pillar failure.

Figure 13: Cross Section ML4 - south highwall



A similar case applies to the east wall auger holes, as illustrated in Figure 14 below. The auger holes penetrated some 140m to 155m and passed beneath the haul road but were stopped well short of the New Chum Creek levee. As the pit is already partially backfilled there is no residual risk of face collapse from long term pillar deterioration but a possibility of some small amount of easily remedied subsidence under the haul road if this is to be left as an access road.

Figure 14: Cross Section ML3 - east highwall



The other 2016 holes in the internal north wall are limited to the lower rock bench which will be buried beneath the in-pit spoil dump.

Consideration is being given to post opencut scavenging of the current highwalls (north and west) using highwall mining. Unlike augering which produces round holes, mining is carried by a continuous mining machine which cuts a rectangular section typically 3.5m wide. Nevertheless the same comments in regard to long term stability and the possibility of pillar creep apply. Full penetration is 300m, geological structure permitting, which may result in undermining a greater area of the crest.

6. MAVIS PITS

The aerial photo overleaf (Figure 15) shows the salient features of the Mavis Pit mining area. These include the designated pit areas D Pit, E Pit and S Pit together with dump areas and the highwall augering block. Also shown are the locations of cross sections (MV1 etc) supplied for analytical purposes.

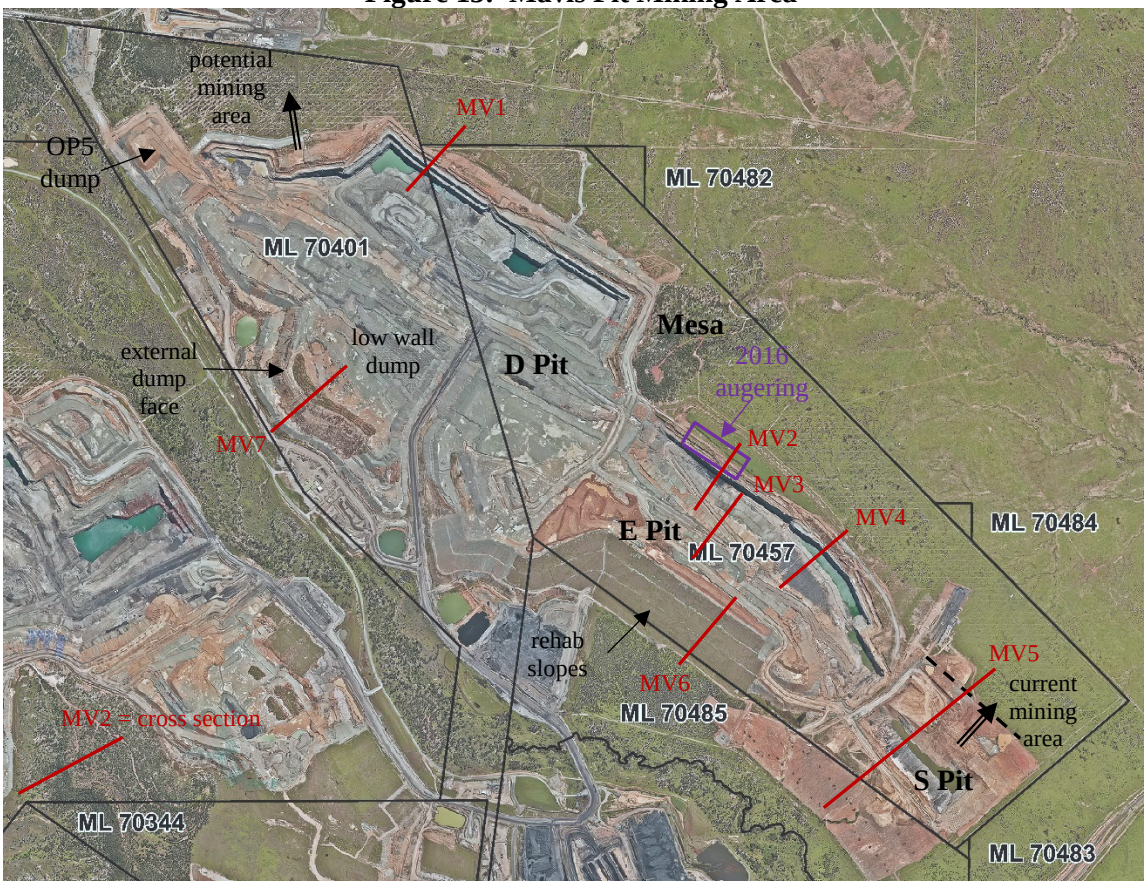
Mavis Pit is a strip mine, with successive strips being mined down-dip against an advancing highwall on the north-east side and spoil dumped behind each strip on the south-west side. The initial boxcut spoil was dumped west of the low wall on natural ground and the dump raised and advanced by spoil from subsequent strips. A small out-of-pit dump (OP5) was formed at the northern end of the strip.

S Pit was developed as a boxcut with spoil dumped externally on the low wall side. It was then used for water storage but is now currently being mined with one or more strips towards the north-east where it will terminate against a major fault.

Spoil is dumped in lifts on the up-dip side to form an advancing low wall dump leaving an external face on the south-west side. Re-grading and rehabilitation has been undertaken on the E Pit external face.

Current opencut mining operations are restricted to D Pit and S Pit, with a potential to extend the pit to the north (D Pit North) towards the lease boundary. A small mesa forms high ground behind the D Pit southern endwall. Highwall augering is underway in the final E Pit highwall, as indicated in Figure 15 below, with plans to extend over the rest of the northern half of the pit. The seam dip in the southern half is too steep for auger mining.

Figure 15: Mavis Pit Mining Area



Current final void planning is for partial infilling of the northern end of E Pit with open voids against the remainder of the highwall and extending into S Pit and an open void against the whole of D Pit highwall, including the north wall where there is a potential extension into D North Pit. Preliminary modelling results of maximum long term void inundation levels by Hatch indicates the water level in D Pit would rise to a maximum of RL182 after 10 years and would fluctuate around RL180 thereafter, whilst in E Pit it would be at RL174 and vary between RL170 and RL175 over the longer term.

6.1 Highwall Stability

The highwall slopes are formed in moderately strong back-dipping bedded rock and are inherently stable for the most part. The walls are intersected by a number of large high angle faults but these have tended to be perpendicular to the face and thus do not create a potential for mass failure. In some cases there has been some spalling or shallow slumping to create a vee-shaped notch down the wall but this is a very local feature confined to the fault intersection and does not prejudice the stability of the rest of the face.

The photo below shows a typical highwall face, together with a fault intersection.

E Pit north highwall

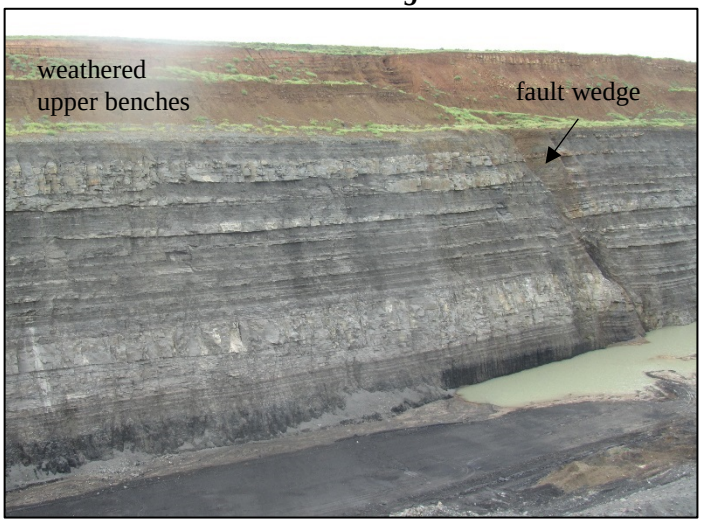


Photo taken 5/01/2017, looking E

A more substantial wedge failure has occurred in D Pit highwall due to a major joint plane intersecting a fault in the face. Material within the wedge has slipped down or been scaled back to the intersecting sliding planes. In terms of long term effect, the zone of instability is confined to within the triangle on the berm formed by the intersecting discontinuities. The failure cannot extend any further back into the highwall in the absence of any other contributing planes and any residual material left suspended will slide down into the void.

D Pit wedge failure

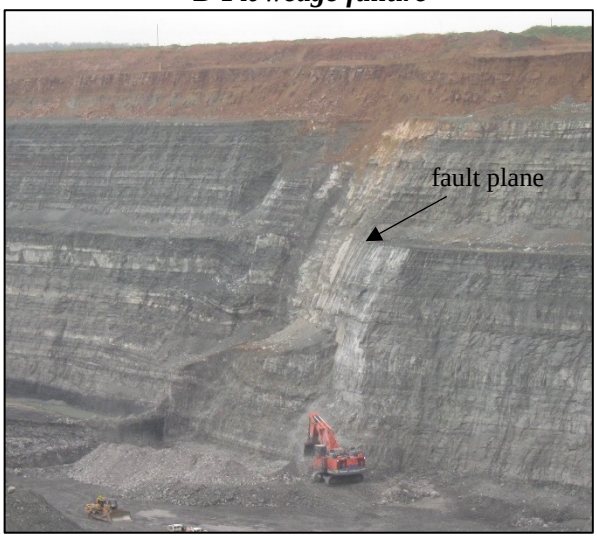
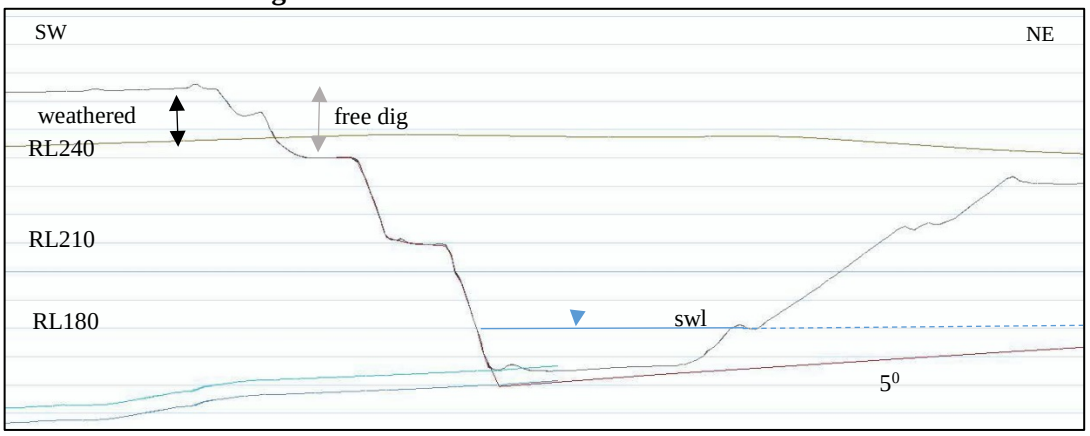


Photo taken 11/05/2017, looking N

The failure has cut back to and slightly undercut the weathered rock bench. This may cause some shallow slumping or erosion in the softer material but would not prejudice the geotechnical stability of the upper benches. No further action would be needed for residual void protection other than the standard exclusion bund at the crest.

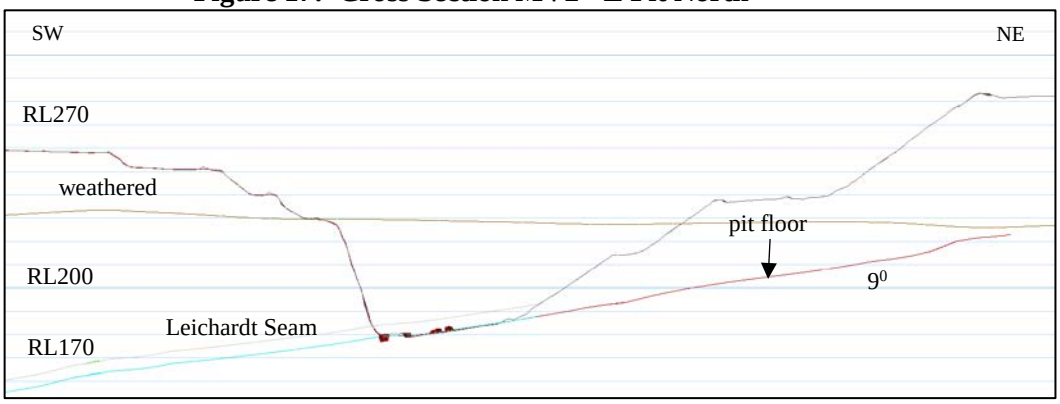
Cross Section MV1 at the northern end of D Pit is presented below. This shows the general configuration for an 80m high double bench highwall, with 70^0 pre-split benches and 15m berms at RL210 and RL240. It also illustrates the shape of the 'rough-cut' free-dig benches through the weathered material. The benched in-pit spoil dump is constructed on the pit floor up-dip of the mining void at angle of repose. The predicted long term water level is shown at RL180.

Figure 16: Cross Section MV1 - D Pit North



In E Pit the rock highwall is 50m to 60m high and has been cut as a single bench, as illustrated in Figure 17 below (Cross Section MV2). The pit floor in the northern part of E Pit is at RL180 or so and would be above the predicted long term water level.

Figure 17: Cross Section MV2 - E Pit North



In terms of long term void water level, the predicted RL180 mark in D Pit would result in inundation of the lower rock benches to a height of about 20m above the Leichardt Seam. In E Pit only the southern part would accumulate water for a predicted long term level of RL175, again indicating a maximum submergence depth of 20m at the highwall. In each case only the lower part of the fresh rock bench would be impacted, and this would not be expected to induce any instability in the rock face.

The northern limit of mining in S Pit is apparently a fault running parallel to the pit. Faults parallel to the highwall present a significant risk to wall stability, as discussed in Section 5.1, however it is understood that the current plan is mine out to the other side of the fault plane such that the fault would not be left behind the highwall thus removing the risk of instability.

As per Millennium Pit, the walls slake readily, leading to undercutting of the harder sandstone blocks and a creating a background risk of small blocks becoming detached through weathering and falling out.

Upper spoil benches are cut through weathered rock, which has a variable nature depending on the presence of more durable sandstone beds. In Mavis Pits the weathered zone appears to be more soil-like with less harder bands but still has a high enough strength to form stable batters. However, the silty and clayey fractions are dispersive and prone to erosion which can effect environmental stability without impacting on the geotechnical stability.

The condition of the upper batters is illustrated in the photo below. The batters were 'rough-cut' design and are individually too steep for long term environmental stability and, as a consequence, are gullying from run-off and eroding into lower angle rill slopes.

E Pit upper highwall benches

Photo taken 11/05/2017, looking ESE

There is no risk of mass failure but the degradation will continue to eventually create a 35^0 or so slope. There is adequate room on the rock berm to accommodate rilled material.

The upper benches at the northern end of D Pit are steeper with a greater proportion of harder material. This is resulting in a different weathering profile whereby the top section is failing by toppling collapse which thus creates and maintains a near-vertical top part, with a smaller rill slope.

D North Pit upper highwall benches

Photo taken 11/05/2017, looking E

The long term implication of this is that the toppling collapse could cause the shape to be retained and allow the crest to be eaten back further over time rather than degrading to a continuous rill slope. One option for remediating this would be to push down the batters to say 28^0 (typical angle for dozer-push) which would remove the toppling type degradation.

The overall conclusion is that the highwall design is appropriate for producing a stable final wall but with the likelihood of ongoing long term degradation of the over-steep 'rough-cut' batters through the weathered zone.

6.2 Dump Stability

Low wall dumps on a dipping floor are at risk of mass failure due to basal slippage, particularly if the floor contains weak or sheared horizons. In Mavis Pit the experience has been that dumps are stable on dips up to 8^0 in general, or $12½^0$ on sound floor. No dump instability was apparent from the site inspection. The photo below shows the stable low wall configuration with good quality spoil forming the base.

E Pit low wall spoil

Photo taken 11/05/2017, looking SE

The dip on the floor varies along Mavis Pit, increasing from north to south with the change commonly occurring across faults. The general situation is summarised in the following table.

Floor dip

Area	D pit	E North Pit	E South Pit	S Pit
Dip	4^0 to 5^0	9^0	16^0	20^0

In-pit spoil dumps have only been formed on the shallower dip areas of D Pit and E Pit North. The stability of the dumps in these two cases was examined by carrying out slope stability analyses for bi-planar slippage along the pit floor using the Galena code for Sarma's method. The shear strengths used were as per the Millennium Pit analyses (see table on page 13).

The results are summarised below. The inundated case is for the void flooded to the maximum 10 year level at RL180 in D Pit and RL175 in E Pit.

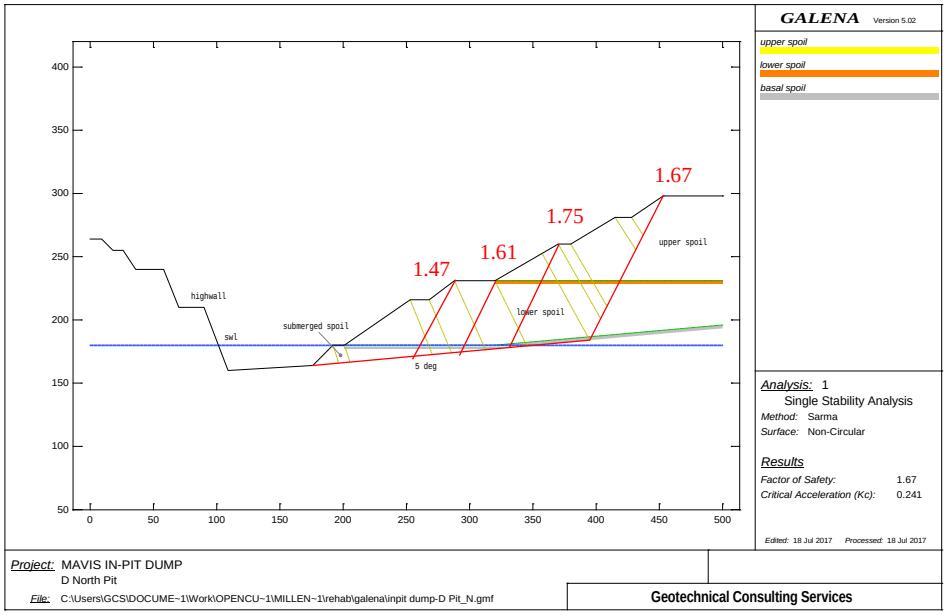
Analysis Results (FoS)

Section	**Dip**	**Current**	**Inundated**
D Pit (Section MV1)	5^0	1.73	1.47
E North Pit (Section MV2)	9^0	1.71	1.71

The analyses for D Pit North were based on Cross Section MV1 in Figure 16 **(**p.22), extended up to the full height of the dump at about RL300. The Galena analysis model showing the full profile is presented below.

Analyses were made failure configurations ranging from the RL230 crest up to the top of the dump at the RL300 crest as shown above. The results show FoS from 1.73 to 1.90 for the as-constructed dry conditions, well in excess of the long term design value. The FoS for the inundated condition are shown on the model section; these are lower but still more than adequate for the most part.

D Pit North void



The influence of the submerged spoil becomes more apparent towards the toe of the dump causing a reduction in the FoS. A minimum FoS of 1.47 was noted at the RL230 crest as indicated on the plot above.

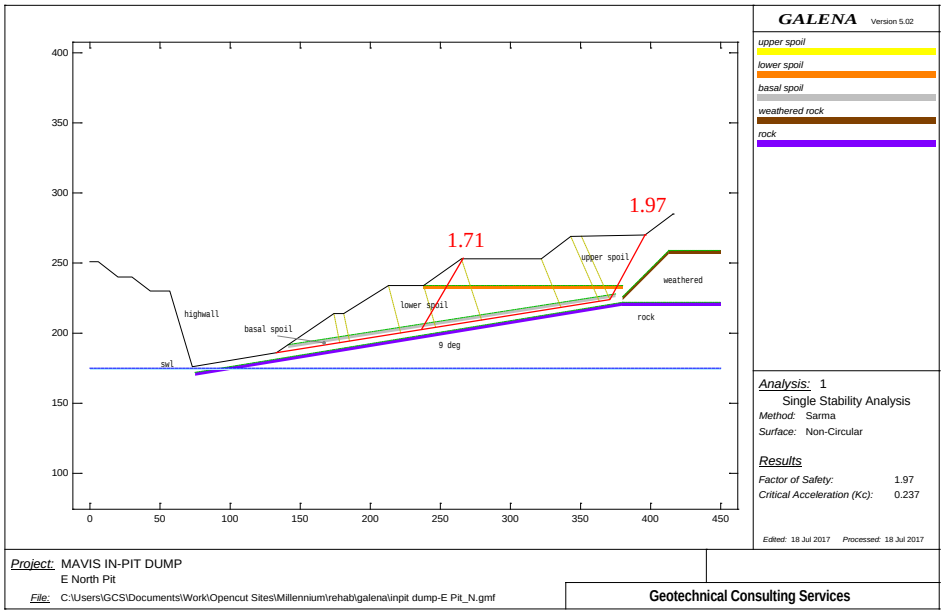
These results would indicate that mass failure of the internal dump would be highly unlikely, with the worst case FoS of partial failure under inundation still more or less acceptable for long term stability. Although inundation to the predicted level would not prejudice the dump in terms of mass instability, it could possibly cause some shallow slumping if the slope was undercut by notching at the water line. The spoil is not dispersive but has a high potential for slaking from wetting and drying.

The analyses for E Pit North were based on the profile in Cross Section MV3, as illustrated in Figure 18 below, which extends to the full dump height but using the floor profile from Figure 17 (p.22).

Figure 18: Cross Section MV3 - E Pit North

The floor level in the void in this part of E Pit is generally above the predicted flood level so that inundation is not a factor in stability analysis. The other issue is the geometric constraint on failure due to the upper part of the dump being situated on insitu ground. This would preclude full height failure as bi-planar slippage would be limited to the front part only, where the spoil has been dumped on the pit floor. The farthest back for failure is thus on the RL270 bench. The Galena analysis model is presented below.

E Pit North void

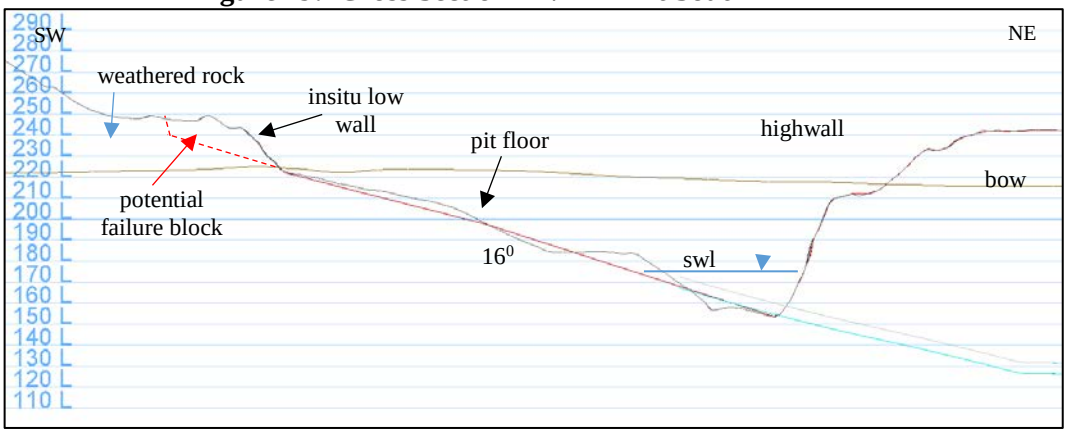


The FoS are high, despite the steeper dip, because of the lower dump height and the lack of submergence of the spoil. Mass failure of the in-pit spoil dump can be discounted in this instance. Notwithstanding the foregoing, the long term plan is to continue to infill E Pit North with spoil, which will mean that the low wall will be buttressed against the highwall. This will remove any possible risk of mass movement of the low wall.

In both D Pit and E Pit North there will be a residual risk of downwash and scouring of fines but any displaced material would be contained within the pit void.

Steep dips are a feature of E Pit South and S Pit and no spoil has been dumped on the pit floor in these areas because of the risk of slumping. Cross Section MV4 in Figure 19 below shows the configuration for E Pit South.

Figure 19: Cross Section MV4 - E Pit South

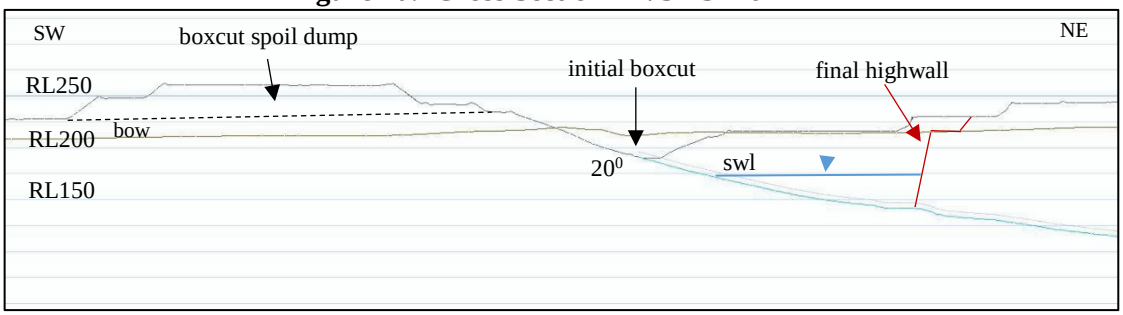


In this case however an insitu low wall has been cut down to the base of weathering, which leaves a residual risk of low wall failure due to slippage along the relict coal horizon extending up through the weathered zone. The potential failure configuration is shown above. The FoS is obviously more than 1.00 but as the dip angle is at least as much as the expected friction angle on the relict slip plane, the FoS can be presumed to be close to 1.00. This means there will be a high probability of failure in the insitu low wall at some stage, as consequence of softening of the shear strength and increased pore pressure from ingress of water, particularly during storm events.

In terms of long term exposure, the low wall would not have an acceptable margin of stability and failure can be expected. This condition could be alleviated by pushing down the low wall bench in front of the out-of-pit dump to match the pit floor. Alternatively it could be left to fail as any displaced material would migrate down the pit floor towards the highwall and would be contained within the void.

S Pit was developed as a boxcut with all the spoil being dumped out-of-pit away from the low wall because of the high dip. After being used for water storage, mining has now been resumed. The cross section through S Pit and the boxcut spoil dump is shown below.

Figure 20: Cross Section MV5 - S Pit

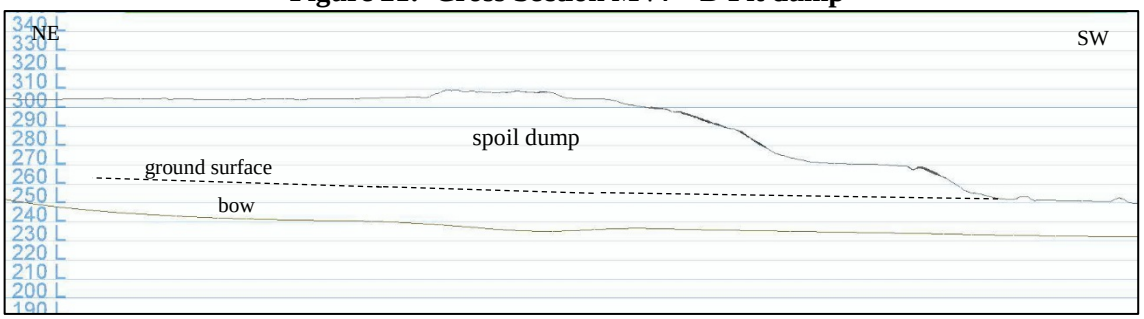


The initial insitu low wall was cut down at the dip angle so there is no material resting on the potential relict coal slip plane and the pit floor, which is effectively a footwall, is not steep enough to present any risk of slab failure. As a result the pit configuration is stable with no kinematic condition conducive to failure.

The outer face of the D Pit spoil, the small out-of-pit OP5 dump and the S Pit dump are as-constructed following the standard design. These slopes are clearly stable having been there for some time. Out-of-pit dump stability was discussed in Section 5.2 with analysis of the standard profile showing FoS of over 2.40 for circular slip failure.

Figure 21 below shows a cross section through the outer part of the D Pit dump, illustrating the shape of the benches and the flat top.

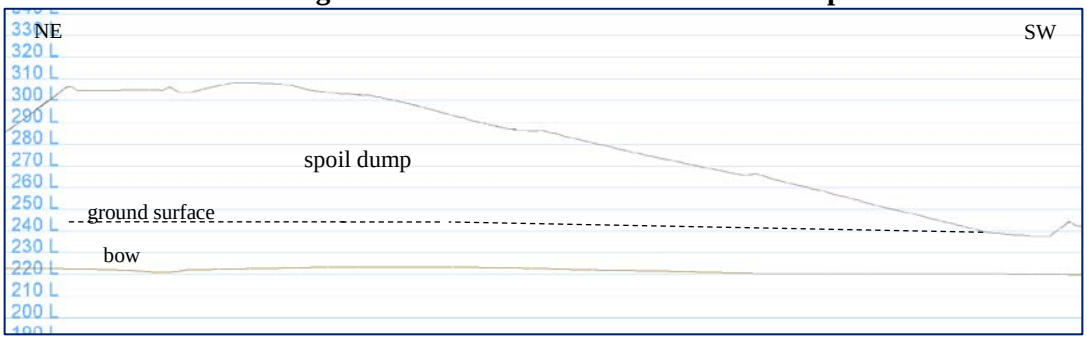
Figure 21: Cross Section MV7 - D Pit dump



These slopes formed as per the standard design can be considered to be inherently stable for the long term in regard to potential mass failure. In terms of environmental stability they will be subject to ongoing surface erosion which will gradually over millennia flatten the batter angle of the faces.

The outer face of the E Pit dump has been re-graded and rehabilitated; Figure 22 below shows the final profile at 1 in 4 slopes with nominal 5m berm, giving an overall slope angle of 13^0. There is no risk of mass failure with re-graded slopes at this angle.

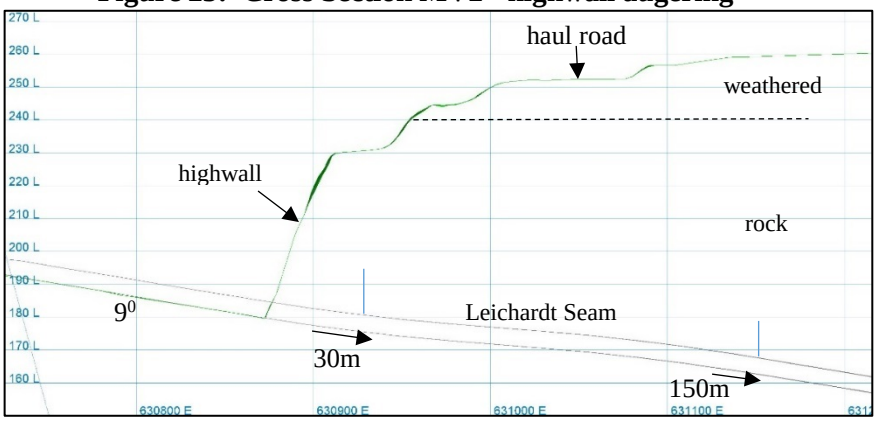
Figure 22: Cross Section MV6 - E Pit dump



6.3 Highwall Augering

Highwall augering has been carried in the northern half of E Pit North with a double row of holes in the Leichardt Seam. The location of the mined block, along a section of highwall between two faults, is shown in Figure 15. A cross section through the highwall is shown in Figure 23 below.

Figure 23: Cross Section MV2 - highwall augering



Full penetration of 200m was not achieved due to the presence of an unknown fault running at an angle behind the highwall, penetration depths being between 30m and 150m. Many of the holes would have extended under the haul road along the crest, but stopping a long way short of the perimeter drain and levee, which is approximately 200m back from the crest.

Augering is planned at other locations in D Pit highwall but these are of very limited lateral extent, being confined between faults, and would not be wide enough to present a risk of long term extensive pillar creep or subsidence.

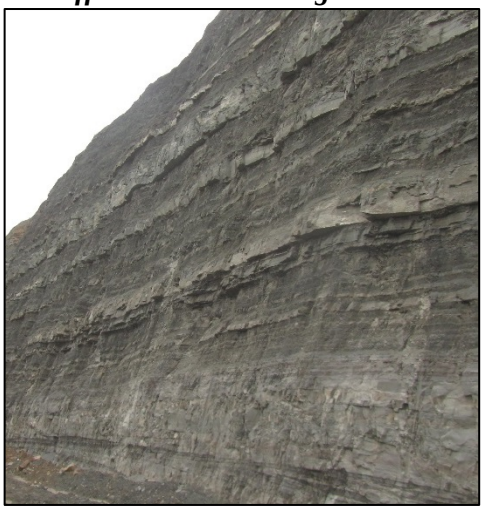
The implications of augering with respect to the long term stability of Millennium Pit highwalls is discussed in Section 5.3 and the same comments apply to E Pit although the FoS are probably higher in E Pit since the web widths would have been conservative, being designed for full penetration.

Consideration is also being given to possible highwall mining in D Pit. There are no structures behind the highwall, other than access roads, that would be affected by any long term subsidence of pillars. Any pillar collapse at the portal should not result in deep-seated failure of the highwall, any slumping or collapse being most likely confined to the lower rock bench.

7. ENVIRONMENTAL STABILITY

The preceding section on geotechnical stability refers to the possibility of mass failure of the slope. However, regardless of the overall stability, there will be a residual effect of slope degradation due to weathering and erosion, referred to as environmental stability.

Differential weathering – E Pit



The Permian Rangal coal measures are prone to slaking, in particular the siltstone, which slakes and falls as fines continuously from the highwall. This action undercuts the harder more durable sandstone beds and leads to ongoing rockfall. Observations of highwalls at Burton Mine suggest a degradation rate of 40mm to 50mm per year on the highwall, equivalent to 1m after 20 years.

Photo taken 10/05/2017

In the long term the entire highwall face will move back, however it should still maintain its profile as the harder bands act as reinforcement within the slope. This process has no impact on the geotechnical stability of the highwall and as there are 25m berms at rockhead there is no risk of undercutting the upper weathered benches. The ongoing rockfall hazard means that people should not enter final voids.

The weathered rock and the thin cover of superficial deposits in the upper benches is likely to be slake susceptible and dispersive, and will gradually degrade to a flatter slope angle. There is ample room on the rockhead berm to allow this process without significant displacement of material into the void. The only exception is where fault wedge failures have occurred, for example D Pit South, where the wedge has cut back through the rock berm and is undercutting the weathered material above. In these cases rilling of weathered rock will run down the wedge into the void.

As the softer weathered rock and superficial deposits at the crest will degrade, especially if there is surface or concentrated run-off over the edge, allowance should be made with the placement of bunds or fences (see Section 9). Run-off over the rock edge is unlikely to have any detrimental impact of the rock face.

Fresh rock spoil is blocky with little fines but the rock slakes and breaks down so after 12 months or more the blocks are less apparent and there is a significant amount of fines. Aging spoil dump surfaces will be susceptible to erosion from surface run-off with a possibility of 10% loss of fines. This would apply to untreated low wall dump faces or other in-pit dumps. In these instances this would result in fines reporting to the enclosed void, which is inconsequential. Outer dump faces are to be re-graded and rehabilitated with rock mulch and grassed which will reduce the potential for downward migration of fines.

8. WATER MANAGEMENT

There is higher ground to the north of Millennium Pit with run-off mainly going into New Chum Creek which flows to the south between the Millennium Pit and Mavis Pit opencut areas. A levee runs along the B Pit eastern highwall to protect the opencut operations from flooding in New Chum Creek. This will not be needed for that purpose at the end of mining, however it may be advisable to retain it to prevent direct run-off over the highwall.

Run-off over the highwall should have no impact on the stability of the rock benches – no areas of potential mass instability have been identified – but concentrated run-off will erode and gully the upper free-dig benches in weathered rock. This should not result in slope failure but gullying will tend to eat back from the crest over time.

As discussed in Section 5.3 the highwall augering in the east wall stopped well short of the New Chum Creek levee and hence would not create any potential for subsidence issues.

Run-off towards the A Pit north wall is intercepted by a catch drain and directed round the pit towards the south-west. A permanent drain and bund will be needed to prevent uncontrolled erosive discharge over the highwall, or alternatively, a rock-lined discharge point could be cut into the crest to direct run-off into the pit at a given location. The potential for subsidence damage may need to be taken into account in the event that highwall mining of the north and west walls penetrates far enough to undermine any flood protection drains and bunds.

A drain runs along the south highwall at the base of the Mesa, directing run-off to the west via a vee-drain. As the top benches of the south highwall are to be left exposed, this drain will form part of long term water management.

The ground behind D Pit highwall slopes to the north-east or east-northeast, away from the highwall such that long term run-off would be limited to the immediate crest area and haul road. At the northern end of D Pit there is drainage towards the highwall and a discharge point would need to be considered to control the flow into the pit.

Water draining south off the small mesa is by a drain that runs south along E Pit highwall but well back from the edge. The E Pit highwall augering did not penetrate as far as this drain. The drain will eventually discharge into S Pit void, together with general run-off from behind the highwall. S Pit is a current mining area and the highwall was not exposed at the time of the slope assessment inspection. A review of the final highwall condition should be undertaken to check that there are no major instability issues with respect to discharging run-off over the highwall, given that there is a predicted major fault close to the proposed highwall location.

In general terms, water management is not seen as presenting a risk to geotechnical stability as run-off scouring would have only a limited impact on the stability of the highwall due to the lack of easily eroded unconsolidated material and the presence of hard rock layers in the weathered zone. No action would be needed with respect to the overall stability of the final void, other than a small bund, minimum height 1m (or 0.5m above the predicted 1 in 100 flood level if this is applicable) around the highwalls in order to limit the run-off area behind the crest. Exclusion bunds, as discussed in Section 9, may be used for this purpose.

Notwithstanding the low geotechnical risk, there is nevertheless a potential for concentrated run-off over highwalls in some places which is likely to cause erosion damage in the top benches in softer material without having any significant impact on the stability of the rock benches. Training run-off around the affected areas with bunds and drains is an option for limiting this but for long term effectiveness it is preferable to run with the flow as water will eventuate find the direct gravitational pathway.

In these cases where the general flow direction is towards the highwall, run-off could be directed into rock-lined discharge points over the highwall, or alternatively be allowed to drain freely over a wider area through gaps in a boulder-size rock exclusion bunds, as mentioned in Section 9.

Run-off pathways may develop over time in the internal spoil dump faces as water drains towards the pit and these would result in minor scouring of fines, as the spoil appears to be liable to dispersion, but would not prejudice the stability of the dump.

9. EXCLUSION

All abandoned pit walls contain some residual risk to people standing beneath or climbing on them. There is an obvious risk of rockfall with steep rock slopes as the faces weather and joint-bounded blocks can be released but there is also a risk of boulders on flatter or re-graded slopes weathering out or being washed out and rolling down the slope.

It is not practicable to treat slopes to entirely eliminate such hazards. The approach taken is minimize the likelihood of such hazards by re-grading slopes that present a significant risk, as described in the preceding sections, and then restrict access to the pit itself. This is achieved by bunding off the access ramps and placing exclusion bunds along final void highwalls.

It is understood that the entire mining area is fenced off to restrict access, however a more durable physical barrier is advisable around the voids to restrict access to the crest of pit walls as the edges will become eroded, crumbly and ill-defined over time. Limits of access should be marked by a bund wall and signs. Bund walls for this purpose should have a minimum height of 2m and should be constructed of non-dispersive material, or alternatively by placing large rocks which would prevent vehicular access without constricting run-off if water is being directed into the void.

Exclusion bunds need to be located at adequate distances from the highwall edge to avoid damage from slope failures or degradation, but from a psychological perspective should be close enough to allow the hazard to be seen or identified from the bund. There are no official guidelines in Queensland pertaining to the appropriate location of exclusion bunds, however the following generic guidelines have been developed, based on unpublished comprehensive studies of opencut voids at German Creek by Ward[4] and at Oaky Creek by Klenowski[5].

1. Highwalls that are geotechnically stable:

Inside edge of bund to be offset 10m from projected lines as illustrated below:

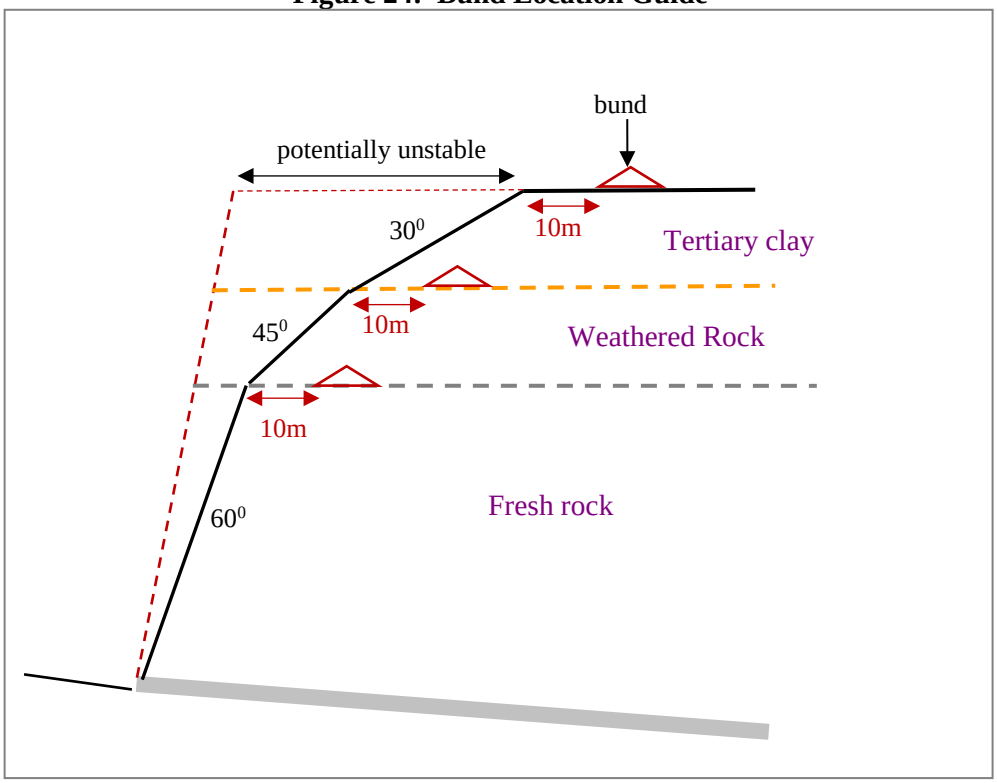
- 60^0 from toe for fresh rock;
- 45^0 from base of weathering through weathered rock;
- 30^0 from base of Tertiary to surface.

This is illustrated diagrammatically in Figure 24 below. Any part of the highwall profile steeper than the projected lines is deemed potentially unstable with regard to the possibility of failures cutting back into the crest and the bund is to be located 10m back as shown.

[4] Ward B 'Slope Design for Long Term Stability at German Creek Mine' Geotechnical Consulting Services Pty Ltd, Report No.109, Feb 1999 (Report for Capricorn Coal Management)

[5] Klenowski G 'Report on Highwall Safety Bunds for Final Voids at Oaky Creek Mines' Australian Mining Engineering Consultants, Mar 2017 (Report for Glencore Coal Queensland)

Figure 24: Bund Location Guide



The bund location relative to the actual crest is thus determined according to the thickness of the three material types present in the highwall, and the projected angles.

2. Highwalls with a history of slope failure or with a potential for slip failure:

Inside edge of bund to be offset as follows:

- existing failures - 5m back from the farthest tension crack;
- potential failures - 5m back from the location of the backscarp for the most critical slope failure path;
- rock slopes subject to structural disturbance with closely spaced discontinuities - at the point defined by where a line drawn at 50^0 from the toe of the slope meets the ground surface (that is 50^0 line instead of the 60^0 line in Figure 24).

These cases need to be assessed on an individual basis to check the failure geometry. Slopes where the dip is towards the face such that block slippage is possible have the potential to fail a long way back from the crest. Where failure is a result of movement on major discontinuities such as fault planes or combinations of faults and major joint planes, the distance back into the crest may be determined by the failure geometry.

There is very little if any Tertiary in the highwalls at the Millennium Mine complex, the only significant Tertiary thickness occurring under the mesas. The bund location will therefore be governed by the weathered rock profile. At Millennium Pit the standard design is for a 45^0 top bench so the bund would normally be located 10m back from the crest. In some cases, however the batter has been undercut to a steeper angle, for example B Pit north wall (see p.12) in which case the bund should be 10m back from a projected 45^0 line, or to make it simple 15m back from the crest.

In the case of Mavis Pit with a double undercut bench, the bund should be 10m back from a projected 45^0 line from the toe of the upper bench, again 15m back from the edge would provide a general approximation.

The only case of major instability is at the fault intersection in the south wall of A Pit (see **p.10**), where a large tension crack is visible in the access road. The criterion here would be 5m back from the tension crack or 10m back from a projected line from the base of weathering in the highwall face, whichever is the furthest back.

The foregoing is primarily directed at reducing the risk to people. At the Millennium opencut consideration is being given to post-operational use for agricultural purposes, specifically for running cattle. In this situation cattle could have free access to partially filled voids where grass is growing, and in particular, to within close proximity of abandoned highwall faces. Although over time it is likely that small scree slopes will form at the toe of exposed rock walls from weathering which will inhibit growth and thus discourage cows from foraging close to the wall.

Protection of personnel from rockfall hazards during mining operations is by means of a 10m wide exclusion zone at the toe of the wall which is normally marked by a small bund; cognisance of risk is obviously not an appropriate control for animals. Protection for animals (and landowners) could be addressed by a physical barrier along the exclusion zone such as an agricultural type wire fence. However, given the very low likelihood of occurrence and the low level of consequence, protective measures may not be justified and the decision to install fencing may be left to the landowner.

10. CONCLUSIONS

- The standard slope designs meet the EA requirements for as-constructed pit slopes to be geotechnically stable with regard to the ground conditions at the Millennium Mine complex;

- The highwalls are inherently stable against mass failure but local instability can occur where fault planes daylight in the wall and any new exposed final highwalls should be subject to geotechnical inspection to check for geological structure that could give rise to instability;

- Major wall failures due to faulted ground are present in the final south highwall in A Pit and at the wedge in D Pit but these failures are localised and fault-constrained and do not prejudice the overall long term stability of the highwall;

- The ‘rough-cut’ upper benches in Mavis pits are individually too steep for long term environmental stability and will degrade through gullying and erosion into lower angle rill slopes or in the case of the northern end of D Pit with the harder bands causing toppling failure,, could continue to eat back randomly into the crest;

- Pushing down the ‘rough-cut’ upper benches would be a means of preventing the continuous toppling cut-back effect on the crest;

- In-pit low wall dumps are stable with a more than adequate long term Factor of Stability, including a condition of partial submergence to the predicted 10 year water level;

- Historical instability in the low wall has been counter-acted by floor treatment and by avoiding dumping on the steeper floors, or by buttressing the spoil against the highwall;

- The external dump slope for E Pit and most of the south dump over the former C Pit have been regraded and rehabilitated in accordance with the EA specifications but the external slopes of other out-of-pit dumps are as-constructed with angle of repose batters and are not compliant with the final void requirements;

- The dump faces that require re-grading are the bottom bench of the south dump along the lease boundary, the West Dump, the small OP5 Dump and the whole of the external slopes at D Pit;

- There are no issues relating to potential risk of geotechnical instability due to run-off entering the void;

- The spoil has a susceptibility to slaking resulting in low plasticity fines which have a strong dispersive reaction which will wash down into the void;

- Highwall augering (and highwall mining if undertaken) has the potential to cause subsidence or collapse the highwall if the pillars fail due to long term creep;

- The highwall augering has not penetrated far enough back from the highwall to undermine any significant structures such as levees, so that any potential long term surface subsidence should not present any significant concern;

- Any subsidence induced face failure is only likely to impact on the lower rock bench, with material collapsing into the void, and should not extend back far enough to prejudice the upper benches through the weathered part or the crest.

11. RECOMMENDATIONS

The general findings of this study are that there are no significant issues in regard to mass slope instability and as a consequence there are no specific recommendations for remedial treatment. However mining is still underway in a number of places. A further review of highwall and ground stability is recommended for the following cases.

- The final A Pit north and A Pit west highwalls, and any new section of D Pit highwall, to be inspected and checked for any structural instability.

- Sections of highwall subject to highwall mining to be checked for potential damage from undermining and monitored (see below) with photographic recording immediately after mining and 12 months later.

The softer upper benches in weathered material will be subject to environmental instability with erosion from weathering and run-off. Consideration should be given to options for treatment of the following situations.

- Run-off management where the natural flow is towards the highwall at the northern end of D Pit and also A Pit north wall and A Pit south wall at the base of the Mesa where there are permanent drains. There may be a case for long term management by directing water flow over the highwall into the void by means of a rock-rubble drain or by diffusive flow through a permeable bund.

- Erosion of free-dig upper benches from weathering of over-steep batters. The slope will degrade over time to become self-stabilising or in the case of D Pit north, the crest may migrate back through toppling type degradation. There may be a case for pushing down

the batters to a flatter angle which would reduce the potential for uncontrolled eating back into the crest. This would be recommended in any case if there was any a risk of animals or people using the surface area in front of the exclusion bund as otherwise the edges could be crumbly and unstable.

One means of monitoring the performance of the residual slopes over time is through photographic records. The recommendation would be to undertake drone surveys at say 5 year intervals (plus a survey after 12 months of completion of any highwall mining to check for pillar creep damage), with oblique shots of highwalls to show the overall aspect and condition. This would provide a means of monitoring areas of ongoing environmental degradation. Oblique shots of the dump faces and upper surfaces could be used to monitor the performance of rehabilitation practices and identify any unplanned areas of erosion.

MAusIMM CP (Geotech); RPEQ No.14047

Principal
Geotechnical Consulting Services Pty Ltd