Progressive Rehabilitation and Closure Plan

Johnson Extended Project

Prepared for Peabody Energy Australia PCI (C&M Management) Pty Limited | August 2023



Peabody

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Progressive Rehabilitation and Closure Plan

Johnson Extended Project

Prepared for Peabody Energy Australia PCI (C&M Management) Pty Limited | 25 August 2023

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3.0 Rehabilitation planning part

3.1 Project planning

The Johnson Extended Project (JEP, the Project) is owned by joint venture partners Peabody Coppabella Pty Ltd, CITIC Australia Coppabella Pty Ltd, NS Coal Pty Ltd, KC Resources Pty Ltd and Mapella Pty Ltd (the Proponent).

3.1.1 Location details

The Project is located approximately (~)150 kilometres (km) south-west of Mackay and ~ 10 km east of the township of Coppabella in Central Queensland. The Project location is shown in Figure 1.

The Project is north of Coppabella Coal Mine (CCM) and south of South Walker Creek Mine.

3.1.2 Project description

The Project is an extension of CCM planned activities include exploration, access tracks and underground coal mining (both development and bord and pillar extraction).

The underground access point will be the final highwall of CCM. Development is therefore dependent on the schedule and availability of the final highwall at CCM. The Project will use existing facilities at CCM for coal processing and waste storage, gas drainage, maintenance activities, water management and administration. As such, there is minimal surface infrastructure required.

The environmental authority (EA) for the Project is EPML00313313.

3.1.2.1 Mining tenements

The Project is made up of four mining leases (MLs) which total ~ 179 hectares (ha) (Table 1) (Figure 2).

Table 1 EA land tenure

Tenure type	Number	Name	Area (ha)
ML	70384	Johnson Extended No 3	46.5
ML	70385	Johnson Extended No 4	45.3
ML	70386	Johnson Extended No 5	43.9
ML	70387	Johnson Extended No 6	42.6
Total			**178.3**

The cadastral information for the Project is given in Table 2.

Table 2 Lot and plan numbers

Lot	Plan	Ownership
1	SP107309	Peabody Bistrotel Pty Ltd



LEGEND

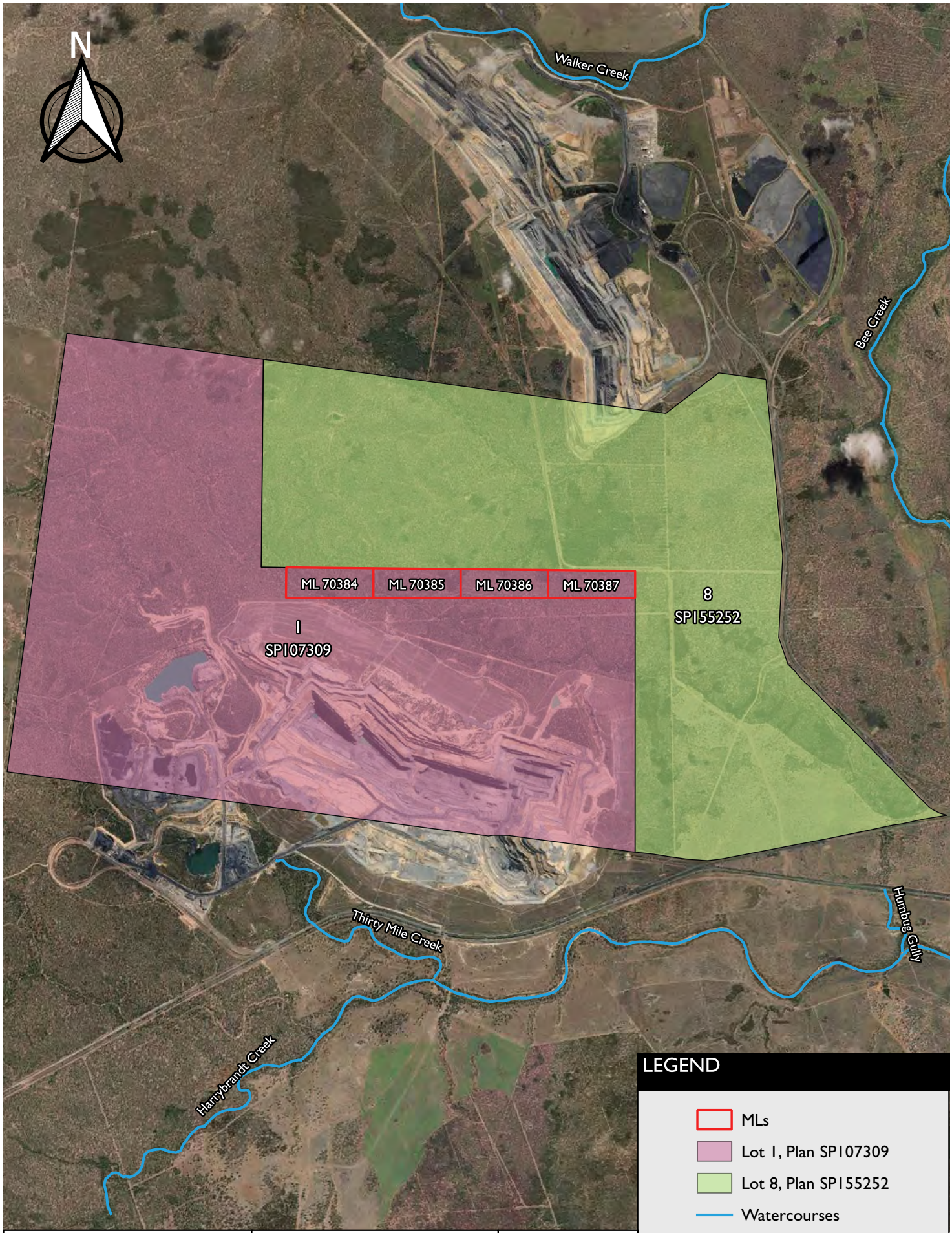
- Johnson Extended Project (JEP)
- Isaac Region
- Populated Areas
- Isaac River
- Peak Downs Highway

Scale 1 : 1 250 000

0 15 30 km

Project: Progressive Rehabilitation and Closure Plan		Client: Peabody Energy Australia PCI (C&M Management) Pty Ltd	
Figure: 1	Title: Project Location	Design: SGM Environmental Pty Ltd 13.09.2022 Scale: 1 : 1,250,000 CRS: GDA2020 / MGA zone 55	SGM environmental

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Project	Progressive Rehabilitation and Closure Plan
Client	Peabody Energy Australia PCI (C&M Management) Pty Ltd
Figure	2
Title	Tenure Boundaries
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3.1.2.2 Environmentally relevant activities

Activities that will, or have the potential to, release contaminants into the environment, which may cause environmental harm are defined as environmentally relevant activities (ERAs), according to the *Environmental Protection Act 1994* (EP Act). In accordance with the Environmental Protection Regulation 2019 (EP Regulation), the Project will be a site-specific mining project for the underground mining of black coal under conditions outlined in the EA. The EA identifies mining black coal as the only relevant activity (ERA 13).

3.1.2.3 Primary mine features / infrastructure

Disturbance is currently limited to access tracks and exploration holes. Future disturbance will include further exploration activity and potential subsidence areas associated with underground mining. Primary features are shown in Figure 3.

3.1.2.4 Type of mining operation

Bord and pillar will be the underground mining method used to extract coal resources. The main entry point will be via CCM's existing open-cut pit. The extent of the bord and pillar operation is limited by the maximum resource extraction footprint. There is minimal subsidence expected based on the bord and pillar extraction method.



Project: Progressive Rehabilitation and Closure Plan		Client: Peabody Energy Australia PCI (C&M Management) Pty Limited	
Figure: 3	Title: Mine Features and Infrastructure	Design: SGM Environmental Pty Limited Scale: 1 : 20,000 CRS: GDA20 / MGA zone 55	Date: 23.08.2023 Author: L McDonald

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3.1.2.5 Proposed duration of operation

The Project has a life of mine (LOM) of ~ five years with all disturbance areas available for progressive rehabilitation after the mining is finished. The bord and pillar design is based on a linked mining plan between CCM and the Project with access to the underground operation dependent on the Coppabella Underground Project (CUG). Milestone dates are not provided as the commencement of mining date is not yet known. Prior to the start of mining, a conditional start date will be nominated in line with the conditions given in Appendix A (section A.1.4).

The PRC plan schedule provides specific timeframes for the achievement of rehabilitation objectives. The rehabilitation schedule is given in Appendix A.

3.1.3 Baseline information

3.1.3.1 Site topography

a Local

Topography ranges from 220–230 metres (m) above sea level and is considered flat to gently undulating with ML 70384 being intersected by Humbug Gully (Figure 4). Slope steepness does not exceed 3 percent (%) while some ephemeral drainage lines are present in the predominantly flat terrain (Peabody Energy 2013).

b Regional

The surrounding region is relatively flat, with the Kerlong and Carborough ranges to the west and the Flora Range to the south(~ 550 m above sea level).

3.1.3.2 Climate

Central Queensland commonly experiences high variability in rainfall, evaporation and temperature. The climate of the region is classified as a hot semi-arid (BSh classification) by Köppen Geiger. Typically, these climates have hot summers and cool to warm winters with minimal rainfall.

Local rainfall, evaporation and temperature data, including historical data, has been sourced from the Bureau of Meteorology's (BoM) surrounding weather stations:

- Moranbah Water Treatment Plant (station no. 034038) — operated 1972 to March 2012 and located ~ 44 km east/south-east of the Project; and
- Moranbah Airport (station no. 034035) —operational from March 2012 and located ~ 45 km south-east of the Project.

a Rain

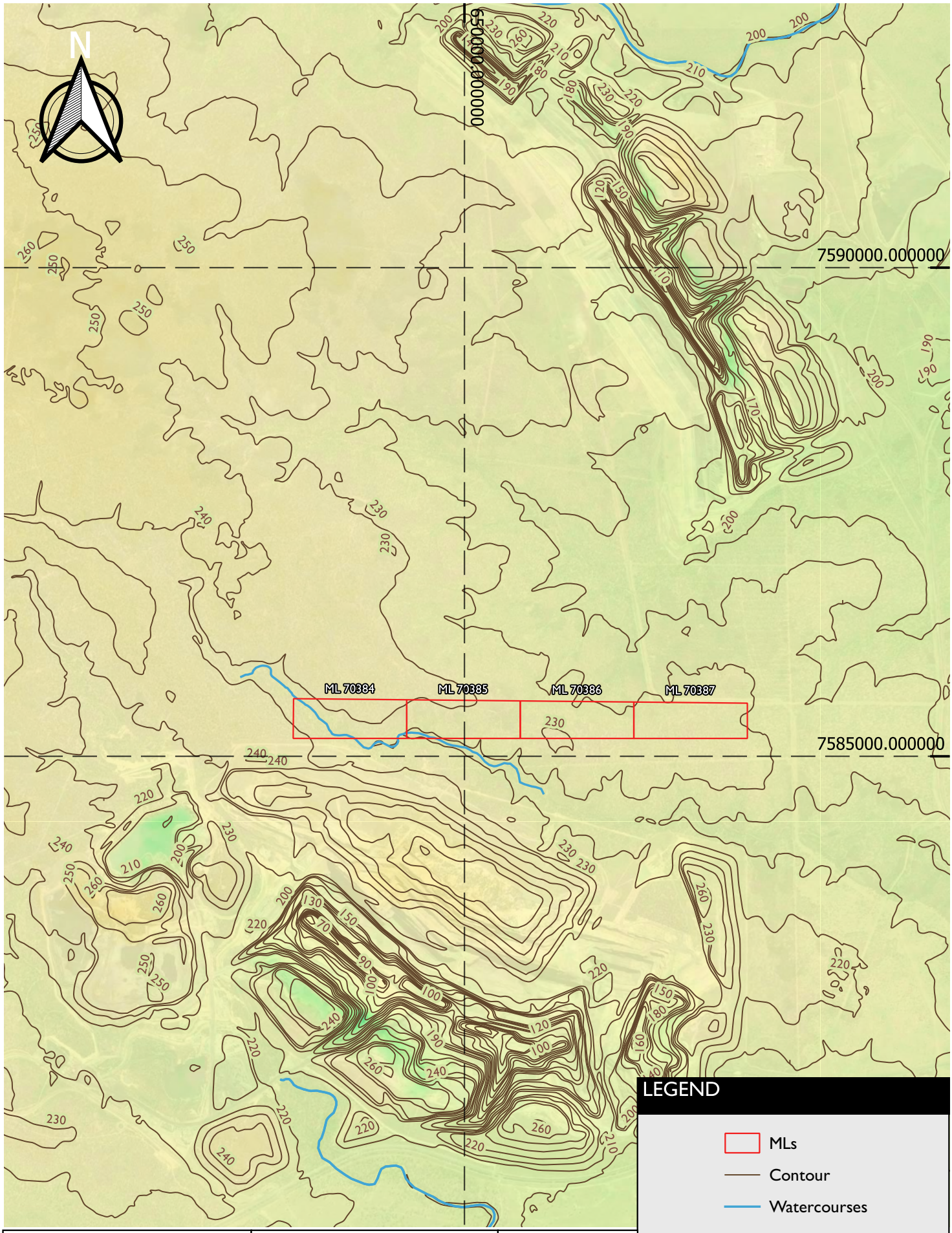
Rainfall within Central Queensland is unreliable in terms of intensity, duration and location. December, January and February exhibit the highest mean monthly rainfall (above 100 millimetres (mm)). The driest month of the year is September averaging under 10 mm of rainfall. The mean annual rainfall for the region is ~ 615 mm. In 2021, mean summer rainfall shows drier conditions compared to averages over the last decade (2012-2022). Average monthly rainfall for both weather stations is given in Table 3.

b Evaporation

The average annual potential evaporation is estimated to be 2,306 mm, around 3.8 times higher than annual rainfall. The evaporation rate varies seasonally, with October - March recording the highest evaporation rates (BoM 2022). Monthly average evaporation for the Moranbah Water Treatment Plant weather station is given in Table 4. Evaporation data is not available for the Moranbah Airport weather station.

c Temperatures

The mean annual maximum temperature is around 30.0 degrees Celsius (°C) with the hottest months (greater than (>) 33°C) being November–February. The mean annual minimum temperature is around 16.7 °C with the coolest months (less than (<)15 °C) being May–September (Table 5).



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Figure: 4	Title: Topography	Design: SGM Environmental Pty Ltd 13.09.2022 Scale: 1 : 50,000 CRS: GDA2020 / MGA zone 55	

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Table 3 Average monthly and 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	54.9	533.7

Table 4 Average monthly and annual evaporation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean evaporation (mm) – Moranbah Water Treatment Plant	248.0	207.2	210.8	171.0	133.3	105.3	114.7	151.9	198.0	248.0	255.0	263.5	2,306.4

Table 5 Average monthly and annual temperature

	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

d Long-term projections

Rain

The State of the Climate 2020 (CSIRO & BoM 2020) says that Australian rainfall is highly variable and is strongly influenced by nearby climate drivers, such as El Niño and La Niña ENSO phases. Long-term trends are evident in Australia despite this natural variability.

Northern Australia and parts of Queensland have been recorded as wetter across all seasons during the northern wet season largely due to increases in rainfall from October to April. The occurrence of intense short-duration extreme rainfall events is responsible for increased rainfall totals, rather than an increase in the number of storms (CSRIO & BoM 2022).

Temperature

The State of the Climate 2020 (CSIRO & BoM 2020) and the *Annual Climate Statement 2021* (BoM 2021) say Australia has recorded warming of around 1 °C with most of the warming occurring post-1950s. According to BoM (2021), the warmest years on record in the last decade are 2013, 2014, 2017, 2019 and 2020. 2019 was the warmest year on record.

In conjunction with the existing La Niña ENSO phase in the Pacific Ocean, 2021 saw warmer than average sea surface temperatures (SST). Sea surface temperatures for 2021 were the sixth-highest recorded and were >0.5 °C above the 1961-1990 average. Over the last decade, 2013, 2015-16 and 2020-21 were the five warmest years on record for SST.

It is possible that future drought or further increases in annual local temperatures could impact rehabilitation. This may reduce plant available water and cause vegetation stress.

Bushfire

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Queensland Fire and Emergency Service (QFES) developed state-wide bushfire hazard area mapping to support the bushfire hazard provisions of the *State Planning Policy* (SPP). The mapping allows accurate identification of areas at risk from bushfire and allows greater confidence in design and mitigation strategies, proportional to the mapped risk level.

A bushfire hazard is the potential fire behaviour characterised by weather, fuel loads and topography. Fuel load is living or dead vegetation that accumulates over time. Natural bushfires can start from lightning strikes. Bushfires can start anytime but the greatest risk is in the dry season when rainfall is lowest (September). During the dry season, vegetation and leaf litter can dry out and become fuel for bushfires.

A small area on the eastern and western side of the Project is mapped as moderately fire prone while all other areas are not considered a bushfire risk (Queensland Government 2022).

Protection from fire is important during the vegetation establishment phase of rehabilitation. Juvenile plant species may be killed by fire and prolong successful rehabilitation and the meeting of rehabilitation milestones and milestone criteria. The risks to rehabilitation from bushfires have been identified in the risk assessment (Section 3.6)

3.1.3.3 Geological setting

The Project is situated in the northern part of the Permian-Triassic Bowen Basin. Deposition in this area commenced during the Early Permian extensional phase, with eastern areas depositing fluvial and marine sediments and volcanics in a series of half graben (single-sided fault), whilst the west saw the thick succession of coals developed. The broader Bowen Basin is part of a connected group of Permo-Triassic basins in eastern Australia which is inclusive of the Sydney and Gunnedah Basins.

The Bowen Basin has undergone extensional and compressional events (north-east to south-west). Structurally, the targeted coal deposit is situated on the Rewan Formation (Triassic) west of the Jellinbah Thrust Belt and the northern part of the deformed Nebo synclinorium.

There are three main Permo-Triassic units that occur within the Project, which are the:

- Fort Cooper Coal Measures (Fair Hill Formation);
- Rangal Coal Measures; and
- the Rewan Group.

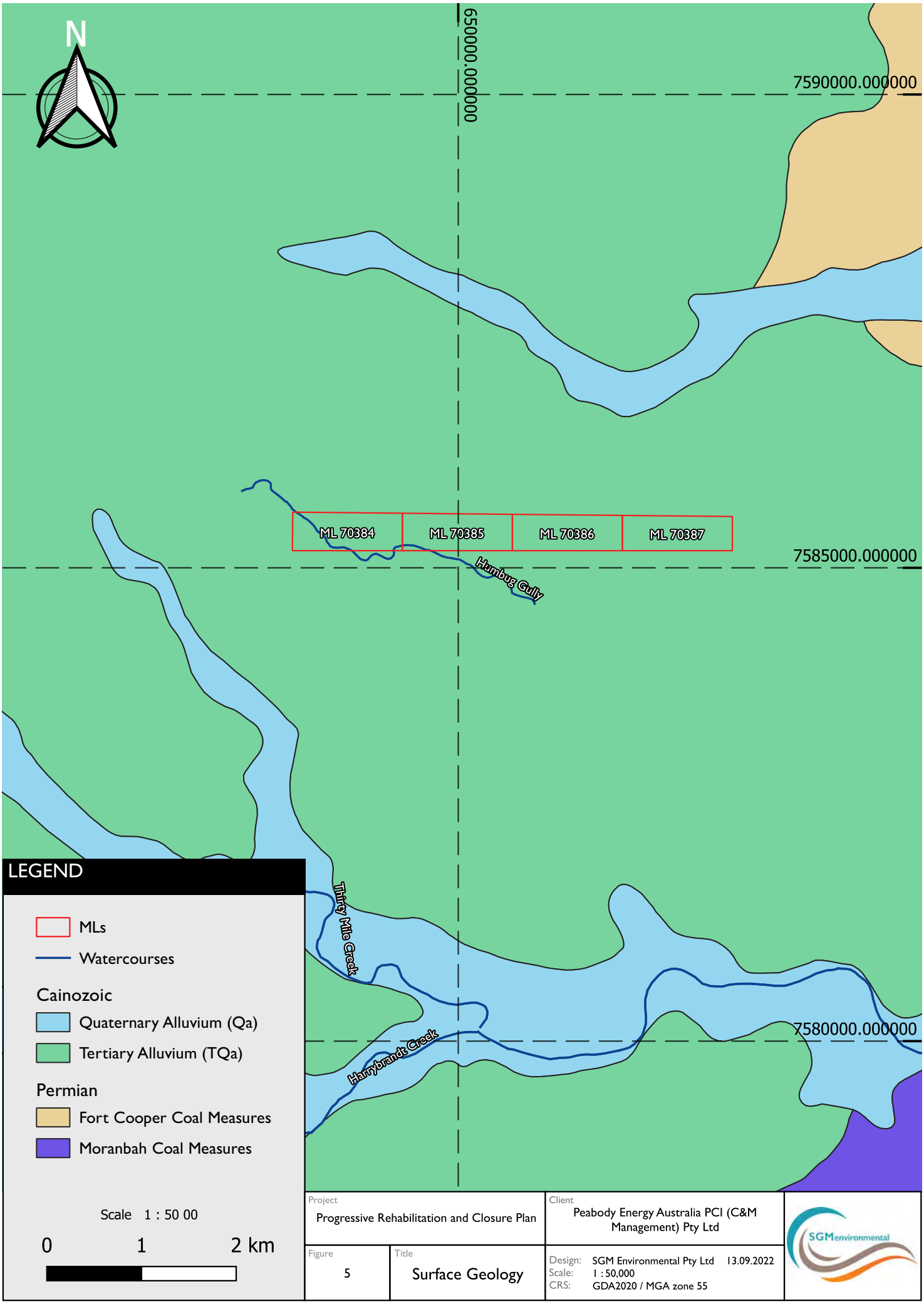
The Rewan Group primarily comprises of sandstones and mudstone with minor volcanilithic pebble conglomerate present. This group was formed during the early-mid Triassic with the dominant rock type in this group is arenite mud rock (Arrow Energy 2013).

The Fort Cooper Coal Measures are approximately 350 m thick and primarily comprise of tuffaceous sediments with mudstone, sandstone, carbonaceous shale and thick ash coal seams. These seams are considered uneconomic due to the high quantity of ash deposited around the seam in addition to the in situ (in-seam) stone bands.

The overlying Upper Permian Rangal Coal Measures (~ 150 m in thickness) comprises of a much smaller quantity of ash coal seams. The lithology of the Rangal Coal Measures is predominantly sandstone, siltstone, mudstone, coal, tuff and conglomerate with sedimentary rock being the primary rock type. The main coal seams from the Rangal Coal Measures (from youngest to oldest) are:

- Phillips (overlying);
- Leichhardt; and
- Vermont (underlying).

The Leichhardt seam is the only available economic seam within the Project with considerations to coal quantity and depth (Peabody Energy 2013). Surface geology is shown in Figure 5.



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Figure: 5	Title: Surface Geology	Design: SGM Environmental Pty Ltd 13.09.2022 Scale: 1 : 50,000 CRS: GDA2020 / MGA zone 55	

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3.1.3.4 Site hydrology and fluvial networks

a Catchment overview

The Project is in the upper Isaac River catchment which falls within the Fitzroy Basin. The closest main watercourse is Thirty Mile Creek, which borders the southern part of CCM and is a tributary of Harrybrandt Creek further south. Around 4 km to the east of the Project is Bee Creek, which meets the east-west watercourse Walker Creek 6–8.5 km north of the Project.

Humbug Gully is ephemeral and is the only drainage feature within the Project. Its catchment rises in the foothills of the Carborough Range to the north-west. It flows through part of ML 70384 and ML 70385 with low sinuosity because it is set in a confined valley with occasional floodplain pockets (Davidson and Twycross 2014). The Humbug Gully catchment area within the Project is ~ 2,900 ha (Cardno 2011).

Humbug Gully flows to Harrybrandt Creek, which ultimately reports to Bee Creek and then the Connors River. Following confluences with other higher-order creeks, this water flows into the Isaac River, which drains into the Fitzroy River (Peabody Energy 2013).

Humbug Gully sub-catchments are given in Table 6.

Table 6 Humbug Gully sub-catchments

Sub-catchment name	Existing catchment area (ha)
A1	401.4
A2	496.7
A3	204.8
A4	229.5
A5	227.9
A6	389.6
A7	322.7
A8	219.5
A9	405.0
Total	~2,897

Source: Coppabella Underground Mine Hydraulic Report (Cardno 2011)

b Hydrologic modelling

The *Coppabella Underground Mine Hydraulic Report* prepared for Macarthur Coal Ltd by Cardno (2011) (Appendix B) was developed to assess existing conditions and the potential impacts of longwall mining on Humbug Gully. The Project is being progressed using the bord and pillar mining methodology which is expected to reduce subsidence below the levels expected by longwall mining. The results of the analysis are included in the following section; however, actual impacts will be less than those predicted by the Cardno (2011) report.

Design rainfall analysis

The Hydraulic Engineering Centre – River Analysis System (HEC-RAS) is a hydraulic modelling package used to simulate long-term trends of bed scour and deposition following modifications to channel geometry and/or water discharge factors.

The software package 'Watershed Bounded Network Model' (WBNM) was used for the analysis of design rainfall events within, and surrounding the Project. WBNM is a hydrologic model designed to deliver a realistic representation of catchments and transforms storm rainfall into a flood hydrograph.

Design storms, ranging in duration from 90–360 mins, were used to determine peak flow estimates (cubic metres per second (m^3/s)) for sub-catchments A5–A9. These estimates are given in Table 7.

Table 7 Summary of peak flow estimates in sub-catchments (Cardno 2011)

Average Recurrence Interval (ARI) (years)	Peak flow (m^3/s) and duration (min)	Sub-catchment				
		A5	A6	A7	A8	A9
100	Peak flow	93.9	104	113.7	119.9	129.9
	Duration	*180*	*270*	*360*	*360*	*360*
50	Peak flow	80.7	89.2	97.1	102.3	110.5
	Duration	*180*	*270*	*360*	*360*	*360*
20	Peak flow	64.7	71.5	77.8	81.4	57
	Duration	*180*	*360*	*360*	*360*	*360*
10	Peak flow	52.5	57.6	62.4	65.1	69.1
	Duration	*180*	*360*	*360*	*360*	*360*
5	Peak flow	43.8	47.5	51.2	53.3	56.2
	Duration	*180*	*270*	*360*	*360*	*360*
2	Peak flow	30	31.7	33.5	34.6	36.2
	Duration	*180*	*270*	*360*	*360*	*360*
1	Peak flow	19.7	20.5	21.2	21.6	22.5
	Duration	*180*	*180*	*180*	*360*	*360*

Historic storm events

Potential subsidence impacts from longwall mining are summarised in Table 8. Both wet and dry year simulations returned predictions of minor bed level changes downstream of the expected subsidence area(s). As per Section 3.5.4.1, the impacts from a bord and pillar operation are predicted to be less than those of longwall mining. Subsidence of Humbug Gully will be minimised by limiting coal extraction within certain proximity to the drainage feature.

Table 8 Summary of average erosion and accretion for Humbug Gully

Case	Average erosion (m)	Average accretion (m)	Average of changes (m)
Dry year (1992)			
Existing	-0.03	+0.03	-0.01
Average	-0.05	+0.01	-0.02

Case	Average erosion (m)	Average accretion (m)	Average of changes (m)
Worst	-0.05	+0.04	-0.01
Wet year (1998)			
Existing	-0.07	+0.07	-0.03
Average	-0.09	+0.07	-0.04
Worst	-0.09	+0.36	-0.09

c Water quality

An *Ecological Survey and Management* report for CUG (including the Project area) was completed in 2011 by FRC Environmental (Appendix C), which assessed the aquatic habitat, water quality, aquatic flora, macroinvertebrates and fish in three sites within Humbug Gully. Site 1 was upstream of CUG, Site 2 was within the CUG area and Site 3 was downstream of CUG.

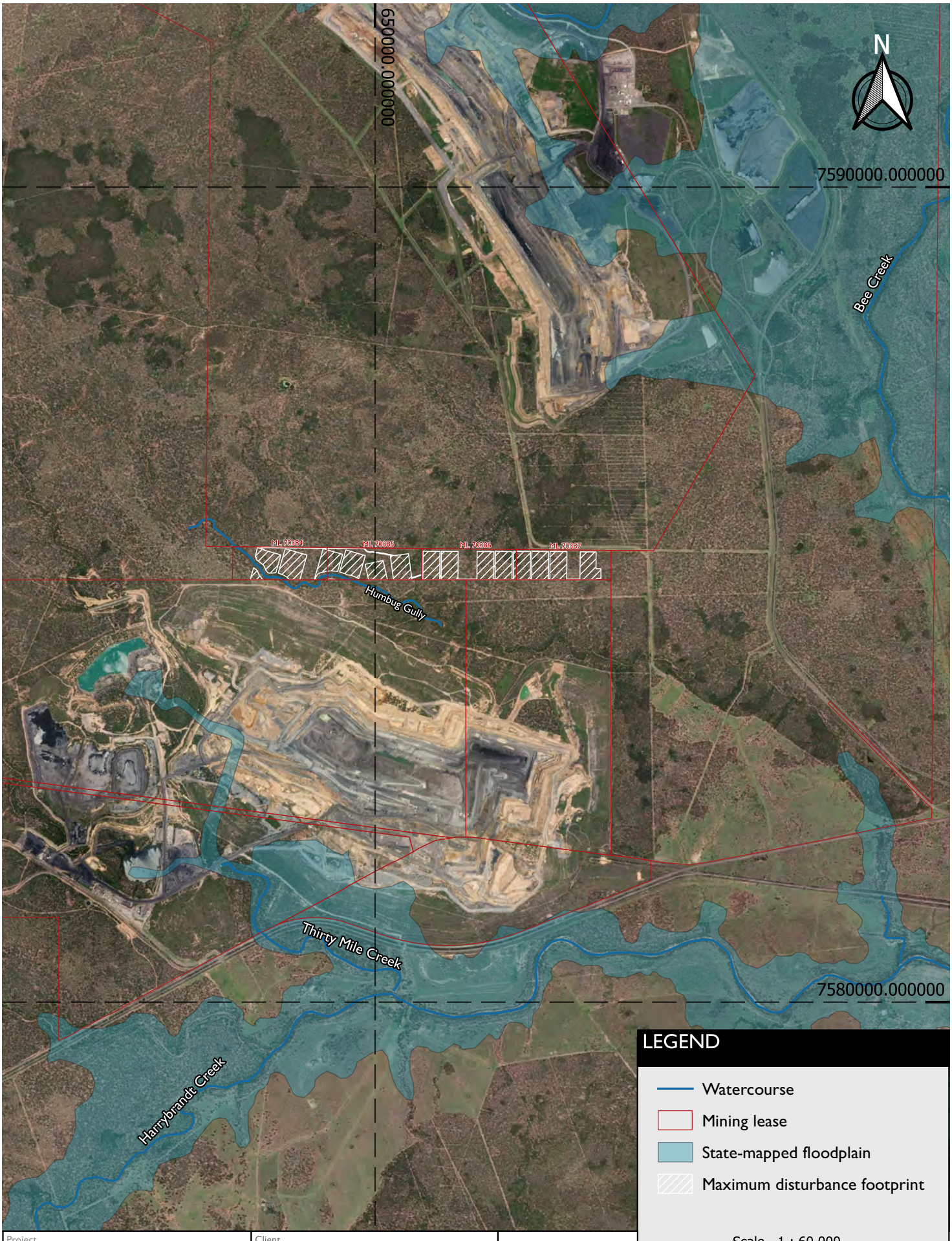
Water quality testing of Humbug Gully samples were compared to the Queensland Water Quality Guideline (QWQG) values for lowland streams in central Queensland (DEHP 2013) and are given in Table 9.

Table 9 Surface water chemistry results

			Humbug Gully sample sites		
Analyte	**Units**	**QWQG for lowland streams[1]**	**Site 1**	**Site 2**	**Site 3**
Water temperature	°C	-	25.7–32.1	25.7–32.1	25.7–32.1
pH	pH units	6.5–8.0	7.5	7.5	6.8
Conductivity[2]	µS/cm	340	227	250–300	477
Dissolved oxygen[3]	%	85–110	65–70	50.4	76.1
Turbidity	(NTU)	50	450–600	256	5,999

[1]QWQG for lowland streams in central Queensland (DEHP 2013). [2]Based on the 75th percentile of data from Fitzroy Central salinity zone. [3]Should only be applied to flowing waters.

The site fluvial network is shown in Figure 6.



Project: Progressive Rehabilitation and Closure Plan		Client: Peabody Energy Australia PCI (C&M Management) Pty Ltd	
Figure: 6	Title: Fluvial Networks	Design: SGM Environmental Pty Ltd 23.08.2023 Scale: 1 : 60,000 CRS: GDA2020 / MGA zone 55	SGM environmental

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3.1.3.5 Groundwater levels and properties

a Environmental values and water quality objectives

The *Environmental Protection (Water) Policy 2009* (EPP) outlined the environmental values (EVs) for the Isaac River sub-basin of the Fitzroy River system. The EPP separates the applicable EVs into several defined categories with all groundwaters grouped for the entire Isaac sub-basin. The EVs listed for the Isaac groundwaters category includes:

- aquatic ecosystems — where baseflow supports permanent streams and water holes to some extent (eg seasonally or permanently). This interaction can occur in tidal and estuarine zones as well as in freshwater areas;
- irrigation — used to grow crops and pastures for commercial purposes;
- farm supply / use — used to provide stock water supplies;
- primary recreation — supports recreational use which involves direct contact and a high probability of water being swallowed (eg diving, swimming, surfing, water skiing and windsurfing);
- drinking water — used for potable water supply; and
- cultural and spiritual values — supports both indigenous and non-indigenous values (eg cultural heritage, symbols, landmarks and lifestyles).

b Hydro stratigraphic units

Information of the groundwater regime is based on data collected for the *Coppabella Underground Project Groundwater Impact Assessment* (AGE 2010) (Appendix D). This report includes the Project area. The hydro stratigraphic units (HSUs) are shown in Table 9.

Table 10 Project HSUs

HSU	Description	Aquifer/aquitard
Alluvial	Silty clayey sand, average sediment thickness of 1.3 m ranging from 0.2–7 m. Shallow, typically dry.	Aquifer present
Tertiary sediment	Sandy to gravelly sand at base, sufficiently porous. Groundwater detected between 17.7 m and 39.3 m below ground level.	Aquifer present
Permian overburden	Predominantly sandstone, not related to coal seams. Groundwater detected between 37.0 and 54.4 m below ground level.	Aquifer present
Permian coal seam	Groundwater detected between 47.0 and 63.9 m below ground level.	Aquifer present

c Hydrogeological properties

Recharge and discharge

Tertiary groundwater recharge is expected to be a combination of direct infiltration of rainfall and surface water runoff and groundwater flow from the underlying Permian geology and Permian coal seam aquifers. Groundwater

associated with the Permian overburden is mainly a result of porosity features such as fracturing, faulting and jointing. Coal seam groundwater in the area is recharged predominantly from infiltration from the rainfall and creek flow into the Tertiary and deeper Permian aquifer sub-crop areas and possibly from leakage from overlying aquifers.

Groundwater bores

A number of bores are discussed in the *Environmental Management Plan* (EMP) (Peabody Energy 2014) (Appendix E) which are in close proximity to the Project area. Two bores are required to be constructed as a condition of the EA (condition E2).

Levels and flow

Permeability of the tertiary groundwater is expected to be low/moderate (0.12–0.03 metres/day (m/day)). Permian overburden aquifer testing shows a variable rate of permeability ranging from 1.3 m/day–0.003 m/day. Coal seam aquifer testing showed conductivity values of 0.003 m/day (AGE 2010).

d Chemistry

Tertiary groundwater at the Project is slightly alkaline and salinity levels exceed the guidelines for cattle consumption. Relatively high sulfate (SO_4^{2-}) and selenium (Se) levels have been recorded but do not exceed guideline limits for livestock. Analysis of the Permian overburden and coal seam groundwater indicates the water is slightly alkaline and saline exceeding the guideline for cattle consumption. High levels of SO_4^{2-} have been detected but not exceeding guideline limits. Selenium (Se) concentrations were detected at levels equivalent to the trigger limits in the livestock guideline.

3.1.3.6 Soil types, properties and productivity

a Soil types

A desktop assessment shows the dominant soil unit mapped in the Project area is sodosol. Based on the Australian Soil Classification (ASC) provided by the *Australian Soil Resource Information System Mapping (*ASRIS), this soil unit is classified as Va52, which is characterised by undulating or gently undulating lands with dominant sandy or loamy duplex soils (ASRIS 2011).

Soil information was ground-truthed during a 2010 *Soil and Land Resource Assessment* of the Project area (GSS 2010). Soils were found to be relatively stable with moderate potential for erosion, dispersion and surface hard setting. Topsoil and subsoils recorded low acid generation with no indication that potential acid sulphate soils exist.

b Soil properties

Sodosols generally have a strong texture-contrast between horizons A and B, exacerbated when sodic B horizons are observed. These soils are typically not strongly acidic (pH > 5.5) and comprise of impermeable subsoils as a result of high available concentrations of sodium (Na) (Hazelton and Murphy 2016). Sodosols are dominant in inland Queensland.

The following soil units occur within the CUG including the Project (GSS 2010):

- brown duplex sandy loam;
- yellow duplex sand; and
- yellow duplex sandy loam.

Brown duplex sandy loam (Brown Chromosol)

This soil unit is distinguished by the abrupt change between the light pale brown sandy loam surface soil and light-brown clay subsurface soil. These soils range from acidic to strongly alkaline at depth. Salinity generally increases with depth and they typically have a moderate soil structure. The topsoils are generally non-sodic unlike the subsoils, which can be relatively sodic.

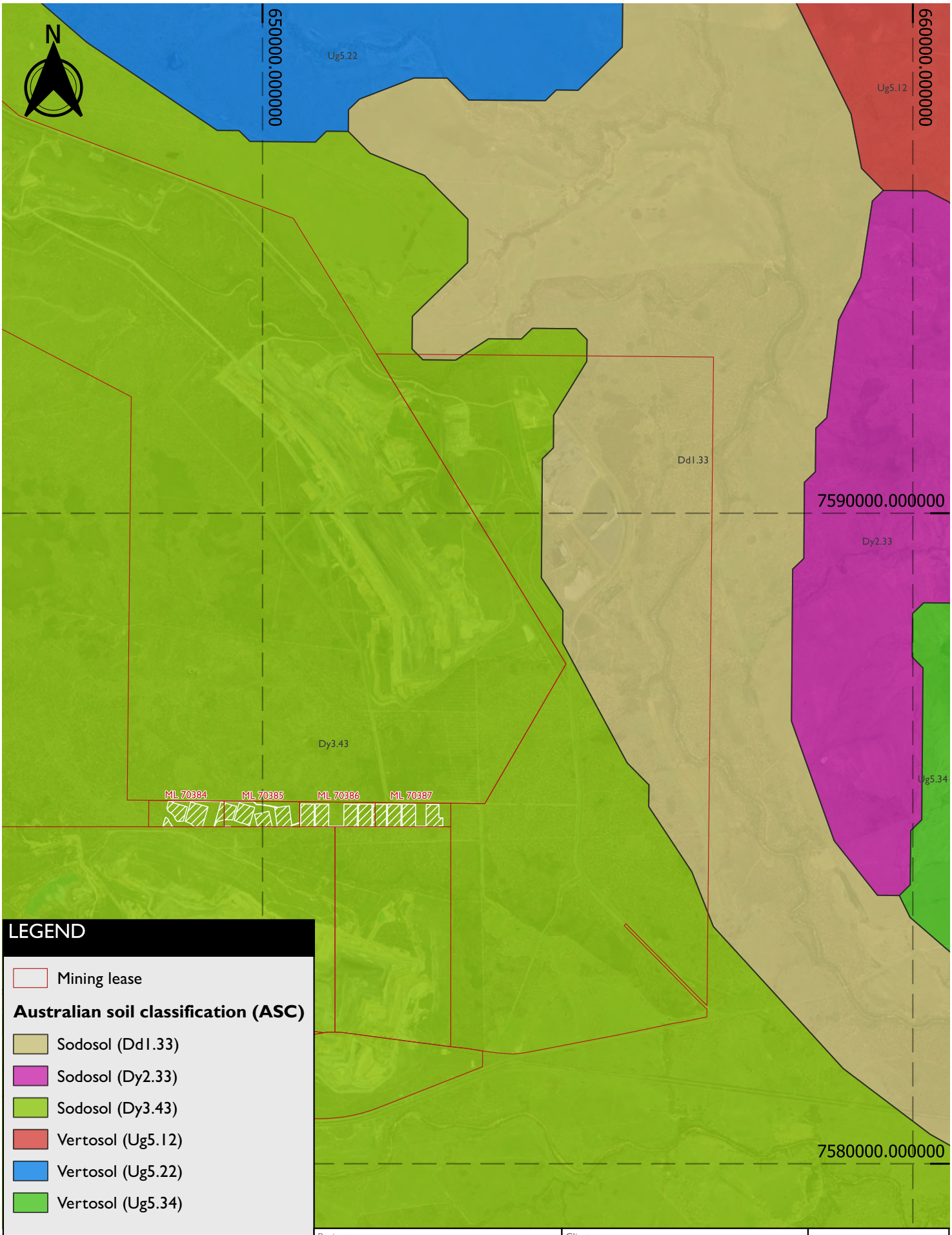
Yellow duplex sand (Yellow Sodosol)

This soil unit is distinguished by the abrupt change between yellowish-brown sandy surface soil and brownish-yellow clay subsurface soil. Soil structure is generally weak and pH ranges from acidic to strongly alkaline at depth. The topsoils are generally non-sodic unlike the subsoils, which can be relatively sodic.

Yellow duplex sandy loam (Yellow Sodosol)

This soil unit typically comprises of light-brown and pale brown sandy loam surface soils on top of a texture contrast of brownish-yellow sandy clay subsurface soils. Topsoil is generally acidic to neutral with relatively alkaline subsurface soils and has moderate structural capacity. Soils are non-saline and usually non-sodic with moderately sodic subsurface soils.

The distribution of dominant soil types are shown in Figure 7. Summary soil properties are given in Table 11 – Table 13.



LEGEND

- Mining lease

Australian soil classification (ASC)

- Sodosol (Dd1.33)
- Sodosol (Dy2.33)
- Sodosol (Dy3.43)
- Vertosol (Ug5.12)
- Vertosol (Ug5.22)
- Vertosol (Ug5.34)

Scale 1 : 75 000

0 1 2 3 km

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Figure: 7	Title: Dominant Soil Types	Design: SGM Environmental Pty Ltd 01.08.2023 Scale: 1 : 75 000 CRS: GDA2020 / MDA zone 55	SGMenvironmental

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Table 11 Brown duplex sandy loam chromosols soil properties

Soil type and depth (m)	Analyte	pH	Emerson Class	Ece	Texture and colour	Description
	Unit	-	-	Decisiemens / metre (dS/m)	-	-
	Sufficiency	6–7.5	-	<1.9	-	-
Layer 1 (0–0.12)		6.1	3	0.01	Pale brown (10YR 6/3) Sandy loam	Weak to moderate pedality (angular blocky 1–5mm) soil. Roots observed with no stones present. Clear and uneven boundary between layers. Low dispersion.
Layer 2 (0.12–0.6)		9.3	2	0.7	Light brown (7.5YR 6/4) Clay	Apedal massive soil with few roots and stones (<1–5mm). Moderately dispersive soil.

Table 12 Yellow duplex sandy sodosols soil properties

Soil type and depth (m)	Analyte	pH	Emerson Class	Ece	Texture and colour	Description
	Unit	-	-	dS/m	-	-
	Sufficiency	6–7.5	-	<1.9	-	-
Layer 1 (0–0.35)		6.3–6.8	3–5	0.01	Yellowish brown (7.5YR 7/2) Sand	Roots and stones observed (<10mm). Sharp wavy boundary between layers. Low dispersion.
Layer 2 (0.35–0.65)		8.7–8.8	2	0.14–0.34	Brownish yellow (10YR 6/6) Sandy clay	Apedal massive soil with no roots or stones present. Moderately dispersive soil.

Table 13 Yellow duplex sandy loam sodosols soil properties

Soil type and depth (m)	Analyte	pH	Emerson Class	Ece	Texture and colour	Description
	Unit	-	-	dS/m	-	-
	Sufficiency	6–7.5	-	<1.9	-	-
Layer 1 (0–0.3)		6.2–6.7	3	0.01	Light brown (7.5YR 6/4) Loam	Weak to single-grained structure with weak pedality (angular blocky <50mm). Roots observed and no stones present. Boundary between Layer 1 and 2 is clear and even. Low dispersion.
Layer 2 (0.3–0.6)		6.2–6.7	3	0.01	Brownish yellow (10YR 6/8) Sandy clay	Apedal massive soil with few roots and no stones. Low dispersion. Boundary between Layer 2 and 3 is clear and even.
Layer 3 (>0.6)		7–8.3	3	0.03–0.25	Brownish yellow (10YR 6/8) Sandy clay–heavy clay	Apedal massive soil with low dispersion and limited roots and stones present.

c Soil productivity

The guidelines for *Agricultural Land Evaluation in Queensland* (DSITI & DNRM 2015), gives a land suitability classification based on landscape and soil characteristics. GSS Environmental (2010) classified all of the soils at the Project as ALC C3, which suggests that this land is not suitable for rainfed cropping, but is marginally suitable for grazing. The current land-use activity is native vegetation with some areas of cattle grazing nearby.

The EMP also identified the land as ALC C3, which is classified as either, low quality grazing or grazing of native pastures with limited possibility for pasture improvement.

Good quality agricultural land

There is no good quality agricultural land (GQAL) within the Project.

Areas of regional interest

According to the *Regional Planning Interests Act 2014* (RPI Act), prior approval is required when a resource or regulated activity is proposed in a zone of regional interest. Zones of regional interest include:

- priority agricultural areas;
- priority living areas;
- strategic cropping areas; and
- strategic environmental areas.

The Project does not overlap or exist within any of these zones of regional interest and is not situated adjacent to any areas that has met these conditions. No further assessment of regional interest areas is required.

3.1.3.7 Land stability

a Pre-existing land degradation and erosion

The pre-mining erosion rate has been calculated using the revised universal soil loss equation (RUSLE). An estimate of average soil loss from sheet and rill erosion can be calculated using RUSLE (1).

The equation is:

$$A = R \times K \times LS \times C \times P \quad (1)$$

Where:

- A = the estimated average annual soil loss in tonnes per hectare per year (t/ha/year);
- R = the rainfall and runoff erosivity factor which describes the intensity and duration of rainfall within a geographical area;
- K = the soil erodibility factor related to soil physical and chemical properties that determine the soil's capacity for soil particle dislodgement.
- LS = a dimensionless topography factor determined by slope length and steepness related to the velocity of runoff.
- C = the cover and management factor. Cover of any kind can help protect the soil from raindrop impact, slow runoff and reduce kinetic energy; and
- P = the factor for supporting practices of land management. This factor considers specific erosion control measures.

The RUSLE is intended for the prediction of long-term rates of gross hillslope erosion only (including rill and interrill erosion). Sediment deposition is not factored into the RUSLE and subsequently is not an estimate of sediment yield. This is also the case for concentrated flow in gullies and stream channels.

Values for R, K, L and S derive directly from the *Queensland Spatial Catalogue* (QSC) datasets provided by DES (Department of Environment and Science).

The calculated erosion rates reflect the pre-mining land-use of the Project area and the regional ecosystem (RE) description of the land. A C factor of 0.04 has been adopted as this value reflects the canopy and ground cover as a sparse woodland ecosystem mixed. A P factor of 0.5 has been used, which assumes minimal land management. This value is consistent with other pre-mining estimations of land management.

Pre-mining erosion rates are given in Table 14.

Table 14 Pre-mining erosion rates

Statistic	Erosion rate (t/ha/year)
Minimum	0.27
Maximum	6.92
Median	2.44
Mean	2.67

The calculated pre-mining erosion rates are reflective of the limited area (~ 179 ha) and flat topography.

There are few Australian studies that have attempted to quantify erosion rates. The *Prediction of Sheet and Rill Erosion Over the Australian Continent, Incorporating Monthly Soil Loss Distribution* (Lu et al 2001) is one of these studies. Lu et al (2001) suggests the average Australian rate of erosion is 6.3 t/ha/year and that a soil loss rate below 0.5 t/ha/year is classified as low erosion, whereas a soil loss rate above 10 t/ha/year is classified as high erosion. The pre-mining erosion rate calculated indicates that the Project currently has a relatively low rate of erosion.

b Predisposition to ongoing stability issues

There is minimal surface infrastructure proposed with no elevated landforms or significant disturbance meaning there is a low predisposition to ongoing stability issues.

3.1.3.8 Vegetation communities and ecological data

a Matters of environmental significance

According to the *Aquatic Ecology* report (Appendix C) for the CUG, no endangered, vulnerable or near-threatened species of aquatic flora or fauna are likely to occur in the waterways of the study area. There are no wetlands of regional, State or national significance in the study area.

The protected matters search tool (PMST) through the Department of Climate Change, Energy, Environment and Water (DCCEEW 2022) identified matters of national significance (MNES), as defined by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). A buffer of 5 km was generated around the Project to identify surrounding MNES. The MNES areas identified are:

- three threatened ecological communities (TEC);
- 20 threatened flora or fauna species; and
- nine migratory bird species.

Critically endangered species within the Project area (including migratory birds and marine species) are:

- Southern Snapping Turtle/White-throated Snapping Turtle *(Elseya albangula)*; and,
- Curlew Sandpiper *(Calidris ferruginea)*.

Endangered species within the Project area, including birds and mammals, are:

- Southern Black-throated Finch *(Poephila cincta cincta)*;
- Australian Painted Snipe *(Rostratula australis)*;
- Star Finch (Eastern/Southern) *(Neochmia ruficauda ruficauda)*;
- Northern Quoll *(Dasyurus hallucatus)*;
- Koala (*Phascolarctos cinereus*); and
- Greater Glider (*Petauroides volans*).

The only endangered or vulnerable species to exist outside of the Project and within the surrounding 5km buffer is the flora species King Bluegrass *(Dichanthium queenslandicum)*.

The TECs within the Project are:

- Brigalow (*Acacia harpophylla* dominant and co-dominant);
- Natural Grasslands of the Central Queensland Highlands and northern Fitzroy Basin; and
- Poplar Box Grassy Woodland on Alluvial Plains.

Under the *Vegetation Management Act 1999* (VM Act), essential habitat for protected wildlife is native wildlife defined in the *Nature Conservation Act 1992* (NC Act) as either 'critically endangered', 'endangered', 'vulnerable' or 'near-threatened' wildlife.

b Environmentally sensitive areas

A search of the DES Environmentally Sensitive Areas (ESAs) mapping tool for ESAs, as described in the EP Regulation identified areas of Category B ESAs within the Project's MLs. This ESA overlays ML 70387, ML 70386 and ML 70385 and is shown in Appendix F.

c Regional ecosystems

Assessment of RE mapping identified eight REs (Figure 8) that exist within or surrounding the Project. Table 15 gives these REs and their corresponding VM Act class and biodiversity status based on the EPBC Act (i.e., least concern, endangered or no concern).

Table 15 RE descriptions

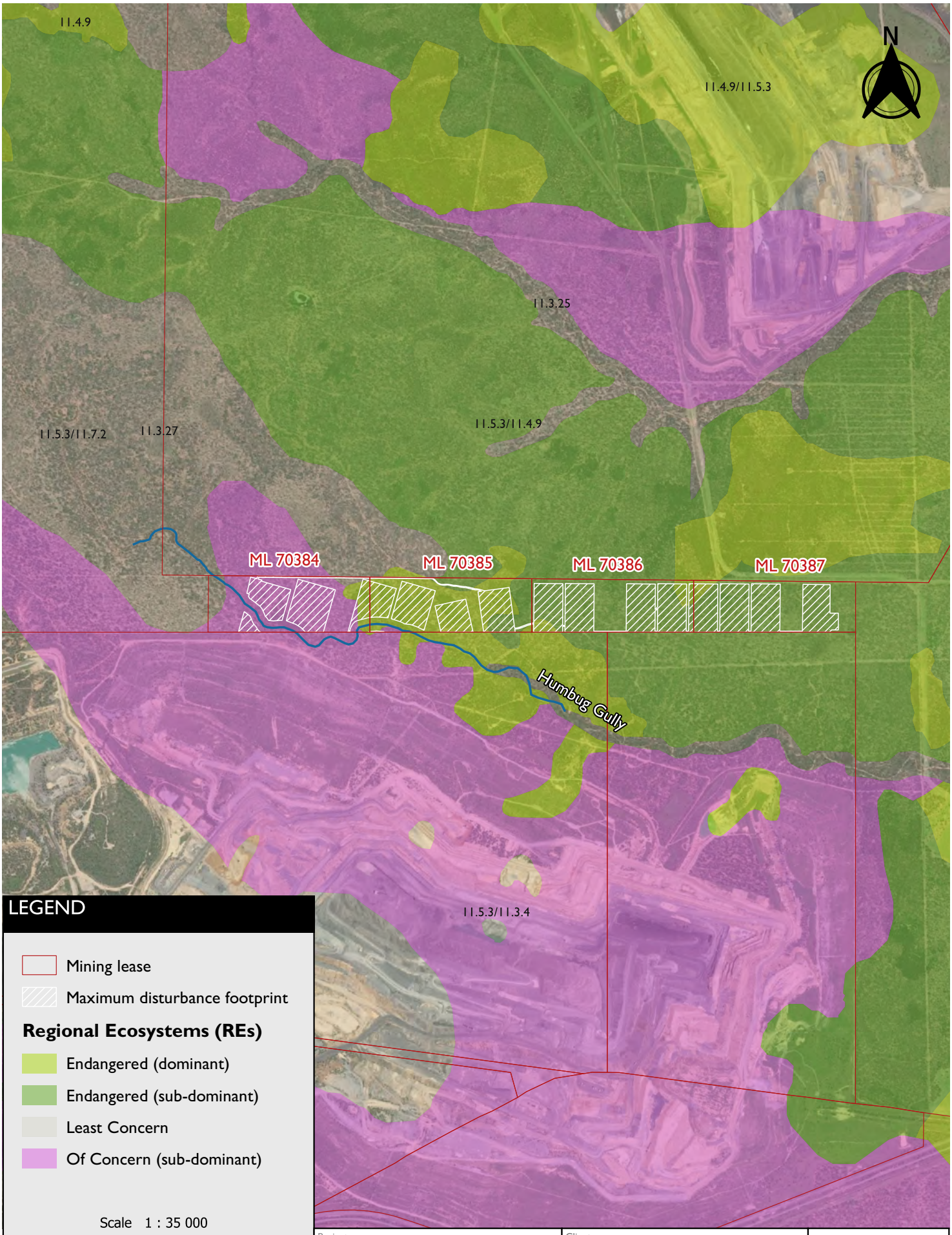
RE Code	Description	VM Act status	EPBC status
Within Project MLs			
11.4.9	*Acacia harpophylla* shrubby woodland with *Terminalia oblongata* on Cainozoic clay plains	Endangered	Endangered
11.5.3	*Eucalyptus populnea, E.melanophloia* and/or *Corymbia clarksoniana* woodland on Cainozoic sand plains/remnant surfaces	Least concern	No concern
11.7.2	*Acacia spp.* woodland on Cainozoic lateritic duricrust. Scarp retreat zone.	Least concern	No concern
11.3.4	*Eucalyptus tereticornis* and/or E. spp. woodland on alluvial plains	Of concern	Of concern
Surrounding (outside) of MLs			
11.3.11	Semi-evergreen vine thicket on alluvial plain	Endangered	Endangered

RE Code	Description	VM Act status	EPBC status
11.3.1	*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plain	Endangered	Endangered
11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest to woodland on fine-grained sedimentary rock	Endangered	Endangered
11.3.25	*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines	Least concern	Of concern

Endangered Regional Ecosystems (EREs) are shown in Figure 8. All REs located within the Project Area are mapped as a combination of ecosystems. Table 16 gives the relevant joint REs and their dominance.

Table 16 Joint REs at the Project

RE ID	Dominance (%)	VM Act status	EPBC status
11.5.3 / 11.7.2	80 / 20	Least Concern	No Concern / No Concern
11.5.3 / 11.3.4	70 / 30	Of Concern (sub-dominant)	No Concern / Of Concern
11.4.9 / 11.5.3	50 / 50	Endangered (dominant)	Endangered / No Concern
11.5.3 / 11.4.9	70 / 30	Endangered (subdominant)	No Concern / Endangered



LEGEND

- Mining lease
- Maximum disturbance footprint

Regional Ecosystems (REs)

- Endangered (dominant)
- Endangered (sub-dominant)
- Least Concern
- Of Concern (sub-dominant)

Scale 1 : 35 000

0 0.5 1 1.5 km

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Figure: 8	Title: State-mapped Regional Ecosystems	Design: SGM Environmental Pty Ltd 01.08.2023 Scale: 1 : 35 000 CRS: GDA2020 / MDA zone 55	

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d Significant flora

Based on the DES REs, the following flora species that could occur are given in Table 17.

Table 17 Significant flora that could occur

Species	Common name	EPBC Status	Presence
Dichanthium queenslandicum	King Bluegrass	Endangered	May be present
Eucalyptus raveretiana	Black Ironbox	Vulnerable	Known presence
Dichanthium setosum	Bluegrass	Vulnerable	Likely
Samadera bidwillii	Quassia	Vulnerable	May be present

3.1.3.9 Fauna presence and populations

A total of 16 vertebrate fauna species were identified using the PMST (Table 18).

Table 18 Significant fauna that could occur

Species	Common name	EPBC status	Presence
Elseya albagula	Southern Snapping Turtle, White-throated Snapping Turtle	Critically endangered	May be present
Calidris ferruginea	Curlew Sandpiper	Critically endangered	May be present
Poephila cincta albaqualf	Southern Black-throated Finch	Endangered	May be present
Rostratula australis	Australian Painted Snipe	Endangered	Likely
Neochmia ruficauda albaqualf	Star Finch (eastern), Star Finch (southern)	Endangered	Likely
Dasyurus hallucatus	Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu]	Endangered	Likely
Phascolarctos cinereus	Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory)	Endangered	Likely
Petauroides Volans	Greater Glider (southern and central)	Endangered	Likely
Geophaps scripta Geosha's	Squatter Pigeon (southern)	Vulnerable	Known presence
Erythrotriorchis radiatus	Red Goshawk	Vulnerable	May be present
Nyctophilus corbeni	Corben's Long-eared Bat, South-eastern Long-eared Bat	Vulnerable	May be present
Falco hypoleucos	Grey Falcon	Vulnerable	May be present
Denisonia maculata	Ornamental Snake	Vulnerable	Likely

Species	Common name	EPBC status	Presence
Egernia rugosa	Yakka Skink	Vulnerable	May be present
Rheodytes leukops	Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver	Vulnerable	May be present
Macroderma gigas	Ghost Bat	Vulnerable	May be present

FRC Environmental (2011) identified no vulnerable, or near-threatened species of aquatic flora or fauna within Humbug Gully.

a Essential habitat

The Project contains essential habitat for one species, the Ornamental Snake. The EPBC status of the Ornamental snake is currently listed as vulnerable with a likely presence within the Project (or within the surrounding 5km of the Project MLs).

3.1.3.10 Environmental offsets

Conditions H6-H7 of the EA require the proponent to provide an offset for the impacts associated with the Project. A *Biodiversity Offset Strategy* (BOS) was developed in 2014 (CO2 Australia Ltd.) to satisfy condition H7. The MNES requiring offsets are provided in Table 19. The BOS requires preparation of an updated strategy for submission to relevant regulators prior to the commencement of underground mining activities.

Table 19 MNES requiring offsets at the Project

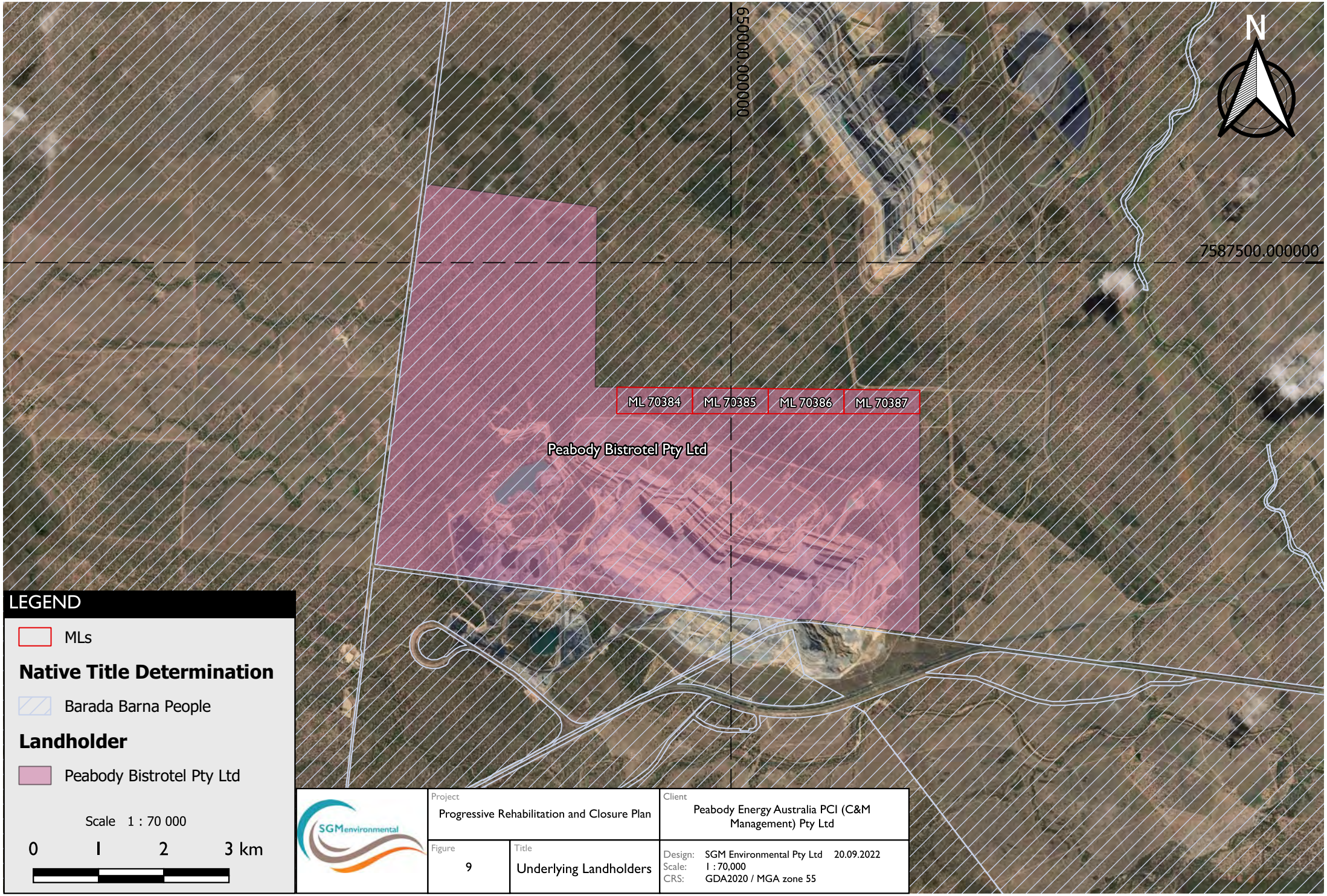
MNES	EPBC Act Status	Impacted Area (ha)
Brigalow TEC	Endangered	18.9
Ornamental Snake	Vulnerable	22.4
Koala	Vulnerable	59.1
Squatter Pigeon (southern)	Vulnerable	77.9
Rainbow Bee-eater	Migratory	77.9
Satin Flycatcher	Migratory	77.9

3.1.3.11 Pre-mining land use

The Project will occur on land that is currently used for woodland/open forest with related areas of pasture grazing nearby. There are no known occupied homesteads, National Parks, nature refuges or declared catchments within or surrounding (10 km) the Project. The nearest National Park (Dipperu) is ~ 20 km away.

3.1.3.12 Identification of underlying landholders

Underlying landholders are shown in Figure 9.



SGMenvironmental	Project: Progressive Rehabilitation and Closure Plan	Client: Peabody Energy Australia PCI (C&M Management) Pty Ltd
	Figure: 9 — Title: Underlying Landholders	Design: SGM Environmental Pty Ltd 20.09.2022 Scale: 1 : 70,000 CRS: GDA2020 / MGA zone 55

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3.1.3.13 Native title

The Project is located within the Barada Barna People's native title determination area (Tribunal no. QCD2016/007, Claim no. QC2008/011) which has been recognised since August 2016, according to the *National Native Title Tribunal* (NNTT) database.

3.1.4 Design for closure

In accordance with the PRC plan guideline, transitional PRC plans are not required to demonstrate how aspects of the mine site have been designed for existing or approved disturbance. However, any expansion to an existing site must demonstrate how it has been designed for closure.

Details on how underground mining has been designed for closure is described in the following sections.

3.1.4.1 Location of mine features

a Location of mine features and infrastructure

Protection of EVs and the receiving environment

Surface disturbance is limited to exploration tracks, drill pads and surface to in-seam (SIS) pads. Areas of potential subsidence above underground operations have also been considered. Surface infrastructure has been located away from the receiving environment of Humbug Gully where possible, while potential subsidence will be avoided in the proximity of Humbug Gully (Section 3.1.4.1 g).

b Surrounding land uses and proximity to sensitive receptors

The surrounding land use is coal mining, native ecosystems and cattle grazing on improved pastures. There are a number of other existing open-cut and underground coal mines surrounding the Project, including South Walker Creek, Moorvale, Carborough Downs, Millennium, Poitrel and Burton mines, all within 25 km of the Project.

There are no major watercourses within 2.5 km of the Project. Sensitive receptors are given in Table 20.

Table 20 Sensitive receptors

Receptor ID	Receptor	Easting	Northing	Distance (km)	Direction
1	Coppabella Township	641,258.5	7,576,840.3	10.5	South-west
2	Harrybrandt Homestead	658,153	7,578,984	~8.0	South-east
3	Oben Park Homestead	648,529	7,579,913	~5.1	South
4	L&G Tones	643,879	7,577,700	~8.8	South-west
5	Wanella Homestead	641,805	7,577,494	~10.0	South-west
6	Spring Creek Homestead	639,308	7,585,409	~9.0	West

c Proximity to the open-pit exit

There are no open pits at the Project.

d Gradient of the footprint area

The area is considered flat graded to gently undulating with a maximum gradient of 3%. Subsidence areas will be remediated to encourage water runoff and limit ponded water.

e Local and regional topography

Regional topography is relatively flat with gently undulating areas. Steep range areas are not close enough to the Project to be considered in closure design.

f Surface and ground water features

There are no water management systems or infrastructure to be constructed. During wet periods, concentrated water flow can be expected at Humbug Gully.

Subsidence areas will be monitored during operations with remedial work being carried out as required. Areas will be reshaped to encourage surface runoff and prevent ponded water. This will help to limit the impact on surface water flows.

g Geotechnical conditions

Geotechnical considerations impacting mine design are given in Section 3.5.4.1.

h Competing water and land uses

The pre-mining land use is primarily p native vegetation communities with areas of grazing nearby. Humbug Gully is ephemeral and not used as a regular water source. Groundwater in the immediate vicinity is above cattle water guidelines and not a usable source (AGE 2010). Water required for underground mining will be supplied from CCM.

i Visual impact

There will be a negligible impact to visual amenity due to minimal surface disturbance.

3.1.4.2 Size, shape and design of mine features

Minimal surface infrastructure will be constructed with limited disturbance.

3.1.4.3 Mining method

The method of mining is bord and pillar (underground mining) and will link to the existing open-cut mining operation at CCM.

3.1.5 Rehabilitation and improvement planning

Progressive rehabilitation must be maximised by starting and completing rehabilitation as soon as practicable after land becomes available. Land is considered available for rehabilitation unless a reason in section 126D(5) of the EP Act is met.

Land is considered available for rehabilitation when:

- the land is no longer being mined;
- the land is no longer being used for operating infrastructure or machinery for mining including dams or water storages;
- the land is not needed for mining of a probable or proved ore reserve; or
- the land contains permanent infrastructure remaining for a post mining land use (PMLU).

3.1.5.1 Relevant activities and progressive rehabilitation

Relevant activities and progressive rehabilitation areas given in Table 21. Existing disturbance is limited to exploration (boreholes and drill pads).

Given the start date of mining is currently unknown, the date of some areas being available from rehabilitation are also unknown. A nominated start date will be given to all relevant activities (excluding existing rehabilitation) based on conditions outlined in the rehabilitation schedule (Appendix A). The conceptual mine plan is shown in Figure 10.

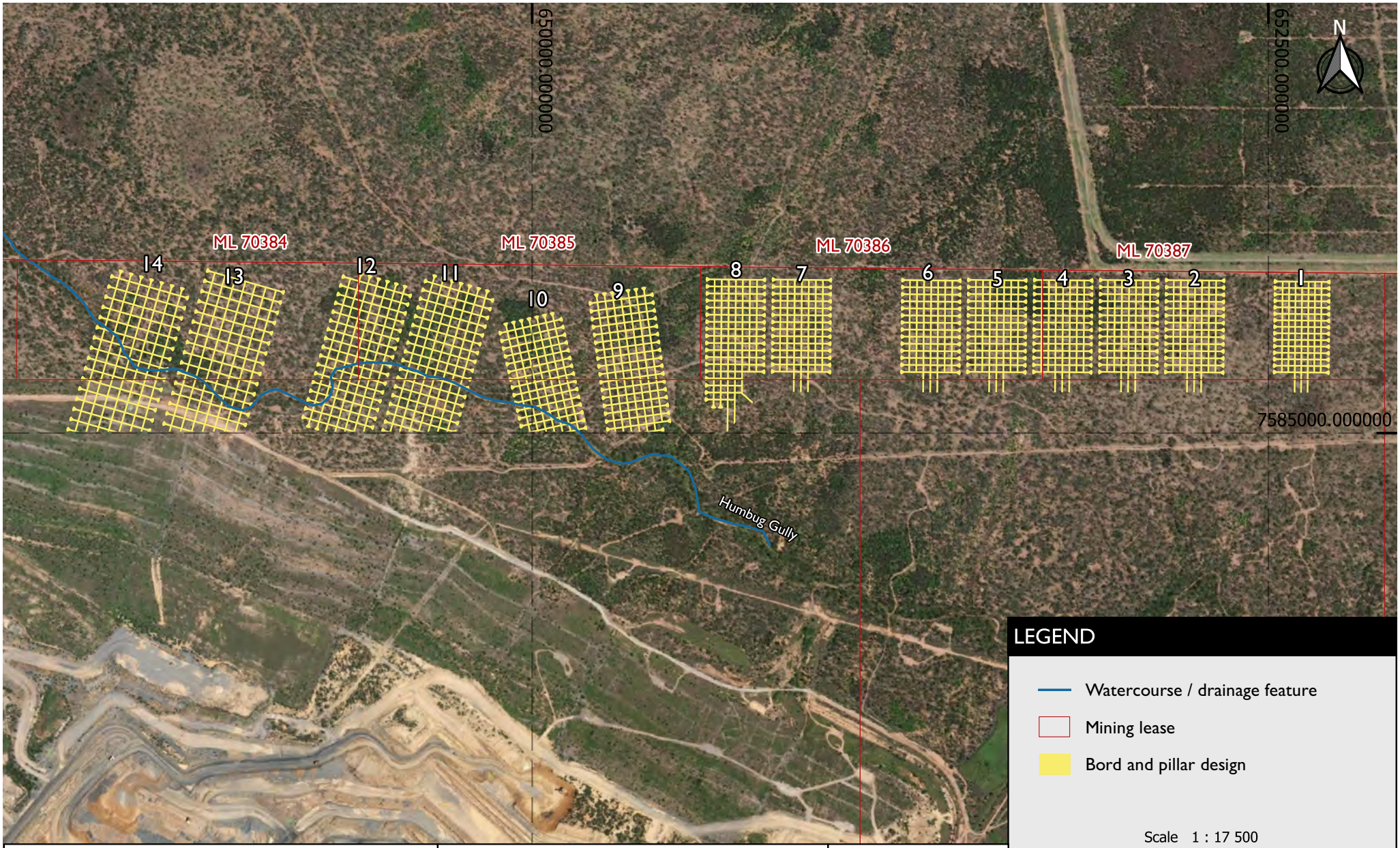
Table 21 Progressive rehabilitation of relevant activities

Relevant activity	Predicted duration	Size (ha)	Availability for progressive rehabilitation
Exploration holes (excluding future exploration —section 3.1.5.1a)	2022–2023	0.5	Available December 2023 following the end of the exploration campaign. To be rehabilitated within 12 months.
SIS pads and tracks	'xxxx' + 5 years[1]	5.5	Availability is contingent on the start of mining. Available following the end of underground mining.
Potential subsidence	'xxxx' + 5 years	98.6[2]	Availability is contingent on the start of mining. Available following the end of underground mining.

1. 'xxxx' is used in place of the nominated start date that is yet to be determined.
2. The area (ha) given for total potential subsidence includes areas of actual disturbance (SIS pads, drillholes and tracks), which are considered 'primary disturbance' areas and will be rehabilitated using the relevant rehabilitation techniques given in section 3.3.5. The potential subsidence excluding primary disturbance areas is 95.4 ha.

a Future exploration areas

The timing of the Project is contingent on the approval of CCM's PRCP schedule. This includes exploration activities that may be required. The timing and location of exploration activities will be determined during detailed planning. The size, location and extent of any future exploration is unknown and has not been spatially represented or transitioned into the PRCP schedule. All future exploration areas will be rehabilitated in accordance with the requirements specified in the *Code of Environmental Compliance for Exploration and Mineral Development Projects* (DEHP 2014).



Project: Progressive Rehabilitation and Closure Plan		Client: Peabody Energy Australia PCI (C&M Management) Pty Limited	
Figure: 10	Title: Conceptual JEP Mine Plan	Design: SGM Environmental Pty Limited Scale: 1 : 17,500 CRS: GDA20 / MGA zone 55	Date: 23.08.2023 Author: L McDonald

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3.2 Community consultation

To comply with section 126C(1)(c)(iii) of the EP Act Peabody has completed a register to provide a record of consultation and engagement outcomes. Consultation has been limited due to the Project being in a conceptual phase and the proponent being the final land holder.

3.2.1 Community consultation register

The community consultation register is given in Table 22.

Table 22 Community consultation register

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by Peabody
10 Feb 2014	Peabody Bistrotel Pty Ltd Peabody Coppabella Pty Ltd CITIC Australia Coppabella Pty Ltd Mapella Pty Ltd KC Resources Pty Ltd NS Coal Pty Ltd	Letter	Compensation agreement between the Holder and the Landowner	The amount ($AUD) entered in the agreement for compensation pursuant to the *Resources Act 1989* for the grant of mining leases.	Compensation is agreed by all parties and there are no further claims for compensation	Compensation was agreed between Holder and Landowner	Confirm and make payment of agreed compensation amount
7 Nov 2013	Rod Dyer (PEA) Bob Gallagher (PEA) Kayleen O'Dowd (PEA)	Meeting	Coppabella MLAs	Confirmation of process through to award, timeframes and EMP	No action required	Title transfer, compensation agreement, EMP requirements and consultants	Continue process and complete EMP

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by Peabody
	Craig Lockhart (PEA) Ian Gray (PEA) Bill Dixon (DEHP) Peter Blumke (DEHP) Chris Loveday (DEHP) Jim Grundy (DNRM) Neil Krosch (DNRM) Mick O'Flynn (DNRM) Debbie-Jo MacDonald (DNRM)			assessment and requirements			
April-Jul 2014	Peabody Energy	Overview of milestones and stakeholder engagement process	Communication plan overview and stakeholder engagement process, including: • Peabody lodges EMP and draft EA conditions proposal with	Milestones – when, what and status. Last updated in June 2014	Listed milestones and status. Q+A section in letter to landholder	No action required	No action required

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by Peabody
			DEHP (now DES); • EMP accepted; • Draft EA conditions provided to Peabody from DEHP; and • DEHP proposes final EA conditions to Mining Registrar				

3.2.2 Community consultation plan

In accordance with section 126C(1)(c)(iv) of the EP Act, a community consultation plan has been developed.

The approach taken is based on locally-accepted standards of leading practice, international and Australian leading practices, particularly methods given in two publications by the *International Council on Mining and Metals – Planning for Integrated Closure Toolkit* (ICMM 2008) and the *ICMM Community Development Toolkit* (ICMM 2006). The specific methods follow those given in the *International Association for Impact Assessment* (IAIA) and the *International Principles for Social Impact Assessment* (Vanclay 2003). The *IAP2 Spectrum of Public Participation (IAP2 Spectrum)* is also taken into consideration for the community consultation plan (IAP2 2014), which defines five tiers for community consultation; noting that only three tiers of community consultation will be used by Peabody.

3.2.2.1 Purpose and objectives

The purpose of developing the community consultation plan is to consult and inform the community member who have been, or may be affected by the closure of the Project or associated rehabilitation activities. Through this process, Peabody will achieve the following objectives:

- identify all relevant community members;
- keep identified community members informed of all relevant activities and progress at the Project;
- maintain and develop rapport, engagement and relationships with identified community members;
- identify, consider and address community concerns regarding rehabilitation and closure of the Project; and
- provide accurate, timely and credible information to the identified community members until relinquishment is achieved.

The community consultation plan forms part of the PRC plan and will be applied by Peabody. Activities will be reviewed regularly to determine their effectiveness and ensure that the register is updated or current.

3.2.2.2 Community profile

The following information on the community profile primarily derives from Australian Bureau of Statistics (ABS) census data. The community profile for the Coppabella region is inclusive of areas north of Mackay that all share the same postcode (4741).

The Project is within the Isaac local government area (LGA) which has an estimated resident population of ~ 22,500 persons, as of 30 June 2021.The 2012 Bowen Basin Report by Queensland Treasury and Trade (2012) estimated the privately-owned town had a resident population of ~ 630 people.

The median age of persons is 44 as of August 2021 (ABS 2021), compared with the Isaac LGA median age of 33.7 (June 2021).

Mining is the largest employer in the region with almost 40% of the employed Coppabella residents working in the mining industry. Rail freight transport was recorded as the second-highest employer with around 18%. Education attainment in the region is relatively low with only ~ 8% of residents aged 15 or older having completed Year 12 as their highest level of educational attainment and ~ 15% having completed a Certificate III or IV.

Given the comparative size of the Mine to other mines in the region, the duration of its operations and the fact that many of the Mine employees resided outside of the local community. This community engagement strategy is a combination of targeted community consultation and broader community communication regarding the closure of the Mine and rehabilitation more generally.

3.2.2.3 Community identification consultation

Potentially affected community members are both internal and external to Peabody. Community members will have varying levels of interest in and influence over closure and rehabilitation processes. Consequently, different communication approaches continue to be employed for each community member.

Community members associated with the Project include the Federal, State and Local Government; private landholders, Native Title party, community groups and non-government organisations, suppliers, internal community members and employees. The methods and level of engagement will vary for each of these groups. Over time the level of engagement of a community member may also vary. These concepts are demonstrated in the following sections, including categorising community members into different tiers of engagement (Table 23).

3.2.2.4 How the community will be engaged / information released for community consultation

Table 23 Community member/Stakeholder interest levels and communication method

Tier	Level of influence	Communication method
1 – Inform	Low	Media articles
2 – Consult	Medium	Newsletters and media articles
3 – Collaborate	High	Face-to-face meetings, dialogue, internal workshops and supplementary email updates or broadcasts

a Inform

The first tier of community members is those who should be ‘informed’. These members are typically local individuals or groups with a general or broader interest in the Project. Newsletters and frequent updates are suitable as a form of communication to these community members. Peabody should provide current and relevant information to keep members aware and up-to-date with Project milestones and progress.

b Consult

The second tier of community members is those who should be 'consulted'. They will have a direct interest and will want to both be informed and to provide feedback. This tier includes selected internal business units, neighbouring operators and most Government stakeholders (excluding key regulators). Meetings will be held with these community members so that concerns and issues can be teased out and practical solutions or actions identified. Targeted supplementary email updates/broadcasts might also be utilised.

c Collaborate

The third tier is those community members who need to be 'engaged' and who have the potential to be directly impacted. This tier is those who have a direct and influential role in Local Government, key State Government agencies, Members of Parliament, cultural heritage groups, adjacent land holders and selected internal business units. The best method of engagement for this tier is regular, face to face meetings enabling candid discussions to occur. With some internal business units, meetings or workshops could be followed by regular targeted supplementary internal email updates/broadcasts.

3.2.2.5 Identified community members

Potential community members that are classified as interested, affected or associated stakeholders are given in Table 24.

Table 24 Community members and tiers of consultation

Key community members	Tier of consultation
Coppabella staff and workforce	Collaborate
Commonwealth members	Inform
State members	Consult
Isaac Regional Council (IRC) • Mayor • Councillors	• Consult • Inform
Government agencies (regulators)	Collaborate
Cultural heritage groups • Barada Barna (Stacy Budby)	Collaborate
Landholders and neighbours • Peabody Coppabella; and • South Walker Creek Coal Mine	Collaborate

3.2.2.6 Information provision and resource requirements

The community consultation plan ensures Peabody provides clear, concise and credible information to identified community members at appropriate intervals suited to each group and / or individual. The plan identifies the key personnel who are required to provide input into the preparation and or delivery of communication materials into the community consultation plan.

3.2.2.7 Proposed consultation frequency

Consultation should occur prior to any PRC plan schedule amendments or commencement of activities at the Project that are likely to impact the community and the register should be updated when this consultation is finished.

Ongoing community consultation will continue throughout the stages of the progressive rehabilitation so that the socio-economic and environmental impacts related to mine closure can be discussed with the community. Consultation frequency should be annually at a minimum once the Project is operational or as issues or opportunities arise.

3.2.2.8 How feedback / comments will be considered

All engagement activities with external, i.e., non-Peabody, community members are to be recorded using Consultation Manager. The following minimum information needs to be recorded:

- invitations, attendance lists and minutes for site inspections;
- invitations, attendance lists and minutes for meetings;
- summaries of informal community interactions, eg with neighbours;
- copies of email updates, eg broadcasts;
- records of discussions (for opportunistic or planned face to face dialogue); and
- copies of any media statements.

Once feedback / comments have been received and logged, Peabody will make an initial assessment to identity classify and / or investigate the root cause and identify any actions needed to address it. Post-workshop updates and newsletters to be distributed to the appropriate community groups when required.

3.2.2.9 Planned future community consultation

The community engagement plan and register of community engagement activities should be reviewed regularly and revised as required.

3.3 Post-mining land use

The *Mined Land Rehabilitation Policy* sets out the government's expectations that mine operators will propose suitable land uses following consideration of the surrounding landscape, community views and the objectives of any local and regional planning strategies.

A PMLU is defined under section 112 of the EP Act as the purpose for which the land will be used after all relevant activities for the PRC plan carried out on the land have ended.

The EP Regulation requires that each PMLU:

- is viable having regard to the use of the land in the surrounding region; and
- satisfies at least one of the following:
  - the use is consistent with how the land was used before a mining activity was carried out on the land;
  - the use is consistent with a development approval relating to the land;
  - the use is consistent with a use of the land, other than a use that is mining, permitted under a State or Commonwealth Act, including, for example, planning instrument under the *Planning Act 2016*;
  - the use will deliver, or is aimed at delivering, a beneficial environmental outcome.

Table H1 of the EA does not clearly nominate the PMLUs for the Project (Table 25).

Table 25 Table H1 of the EA

Mine domain	Mine feature name	Rehabilitation goal	Rehabilitation objectives	Indicators	Completion criteria
Roads and tracks	Exploration access tracks	Rehabilitation to pre-drilling status for access to the area	Refer to *Code of Environmental Compliance for Exploration and Mineral Development Projects*	To be advised (TBA)	TBA
Exploration	Drill pads and seismic lines	Refer to *Code of Environmental Compliance for Exploration and Mineral Development Projects*	Refer to *Code of Environmental Compliance for Exploration and Mineral Development Projects*	TBA	TBA
Infrastructure	TBA	TBA	TBA	TBA	TBA
Subsidence panels	TBA	TBA	TBA	TBA	TBA

3.3.1 PMLU options

Typical PMLU options for resource activities in the Bowen Basin include:

- commercial use:
  - aquaculture;
  - pumped-hydro electrical;

  - landfill;
  - water storage.
- recreational water use;
- solar farm;
- cropping;
- grazing; and
- native ecosystems.

3.3.2 Assessment of PMLU options

An assessment of PMLU options is given in the following sections. Given rehabilitation areas (RAs) are limited to minor surface infrastructure and potential subsidence, it is likely that actual disturbance will be minimal and spatially separated. Preference has been given to rehabilitating disturbed areas back to the pre-mining land use. The existing land use is native vegetation communities.

3.3.2.1 Statutory constraints

No statutory constraints have been identified for the land or the proposed PMLU.

3.3.2.2 Limiting factors

a Exploration areas and surface infrastructure (RA1) and potential subsidence (RA2)

Limiting factors of PMLUs for RA1 and RA2 are provided in Table 26.

Table 26 RA1 and RA2 most limiting factors for PMLUs

Option	Most limiting factors
Commercial use	No planned void or water availability to support this option
Recreational water use	No planned void or water availability to support this option
Solar farm	Small land availability, surrounding PMLUs from other mining activities may impede option, no existing infrastructure to support PMLU
Low intensity grazing	Will require removal of endangered and of concern regional ecosystems, may require land management (weeds, pests, land stability works)
Cropping	ALC 3, unsuitable for rainfed cropping land, water supply
Native ecosystem	May require land management (weeds, pests, land stability works)

The review of limiting factors for the PMLU of RAs shows the most suitable options as native ecosystem (current land use) or low intensity grazing. Native ecosystem is most suited to both RAs as the area has identified Endangered and Of Concern REs present (ERE 11.4.9 and RE 11.3.4), which would require disturbance if another PMLU was chosen. Due to the type of mining proposed (bord and pillar) and the low level of disturbance expected, the existing native ecosystems are not expected to be greatly impacted and rehabilitation requirements should be minor. To ensure rehabilitated areas are consistent with the preclearing vegetation type, a PMLU of 'preclearing native vegetation community' is proposed. This will allow for the existing REs (Table 15) to be retained.

Rehabilitation methods that may be required are discussed in section 3.5. Further support of the preclearing native vegetation community PMLU is provided in section 3.3.3 and 3.3.4.

The PMLU for RA1 and RA2 is preclearing native vegetation community (Table 27).

Table 27 PMLU

Domain	PMLU	Rehabilitation area	Area (ha)
Exploration and surface infrastructure	Preclearing native vegetation community	RA1	6.0
Potential subsidence	Preclearing native vegetation community	RA2	95.4
Total			**101.4**

3.3.3 Consistency with the outcome of community consultation

The PMLU is consistent with the outcome of community consultation because:

- the pre-mining land use will be restored;
- the area can continue as a native vegetation community; and
- environmental values have been maintained by restoring/retaining endangered or of concern ecosystems.

How underlying landholders and other stakeholders views have been addressed:

- the PMLU of preclearing native vegetation community will create a stable land use for the area in keeping with sustainability goals for the region; and
- rehabilitation will be completed in line with the PRC plan schedule.

3.3.4 Consistency with local, State and Commonwealth requirements

3.3.4.1 Local government

The following review of the *Mackay, Isaac and Whitsunday Regional Plan* (DLGP 2012) and the *IRC 2035, Our Community Strategic Plan* (IRC 2015) demonstrate that low intensity grazing and preclearing native vegetation community is consistent with the strategies and plan outlined herein.

a Mackay, Isaac and Whitsunday Regional Plan

The *Mackay, Isaac and Whitsunday Regional Plan* (DLGP 2012) includes the following specific policies for PMLUs:

- identified valuable mineral and extractive resource areas within the region are protected from development that might adversely affect current or future extraction;
- the operation of extraction and processing activities does not compromise:
  - human health;
  - current and future resource use opportunities;
  - regional landscape values; or
  - ecosystem function and services; and
  - must minimise its impact on primary production.
- once extraction ceases, former resource areas are rehabilitated to facilitate multiple end-uses, ensuring continuing contribution to the economic, community and EVs of the region; and
- innovative practices are encouraged, including local processing and value-adding activities, to maximise eco-efficiencies.

The *Mackay, Isaac and Whitsunday Regional Plan* is consistent with a PMLU of low intensity grazing and preclearing native vegetation community because:

- the Mine plan maximises the extraction of economic coal and therefore no potential resource will be sterilised from rehabilitation;
- the PMLU aligns with the regional landscape and will be returned to preclearing native vegetation community ie rehabilitation minimises the impact to Evs; and
- rehabilitation of the land to the PMLUs does not exclude other potential land uses in the future, such as light cattle grazing.

b 2035 Community Strategic Plan

Our 2035 Community Strategic Plan (the strategic plan), IRCs commitment to the long-term future of the region. It is the blueprint for the future, which outlines how IRC will work towards enabling strong, vibrant, diverse, and sustainable communities for our people over the next 20 years.

Inevitable social, economic and political changes mean that IRC to explore new ways of capitalising on opportunities and addressing challenges, to make sure the region reaches its full potential.

The aim of the strategic plan is to provide clear goals and direction towards improving the future of the Isaac region through growth in four key themes:

- community — strong and diverse communities that support all to live, work and raise families;
- economy — continue to be Queensland's number one performing regional economy based upon a thriving, resilient and diverse mix of industry sectors;
- infrastructure — effective and sustainable infrastructure that supports the needs of the region's communities and its economic sectors; and
- environment — appropriate and sustainable balance between environment, economy and community to make sure our natural resources are sustainably managed and protected.

The strategic plan is consistent with a PMLU of preclearing native vegetation community because:

- the rehabilitation options chosen align with the strategic plan as it reflects the previous land use in the area; and
- the rehabilitation options align with the strategic plan as it maintains flora and fauna and supports long-term biodiversity values.

3.3.4.2 State and Commonwealth legislation

Table 28 summarises the State and Commonwealth legislation that may be relevant to the Project.

Table 28 State and Commonwealth legislation

Legislation	Objective	General application	How it relates to the Project
Planning Act 2016	The principal objective of this Act is to achieve ecological sustainability.	Where land is included on a ML pursuant to The *Mineral Resources Act 1989*, closure and rehabilitation activities to not require a planning approval from the local government.	Any identified PMLUs does not require local government approval.
Local Government Act 2009	The purpose of this Act is to provide for the way a Local government is constituted and the nature and extent of its responsibilities and powers. Local laws are made under the Act.	Local laws may apply to the owner of the land as defined under the *Mineral Resources Act 1989*.	The Planning Act 2016 only applies if a built structure that is entered onto the Queensland Heritage Register is found. Therefore, the Planning Act does not apply to development in the ML authorised under the Mineral Resources Act 1989.
EP Act 1994	To protect the environment while allowing development that improves the total quality of life and ecologically sustainable development.	General environmental 'duty of care' to be employed to guarantee that any potential environmental impact from the Project is minimised.	The potential impacts to Evs are assessed in the EMP for Johnson Extended Project. Duty of care is demonstrated for rehabilitation by preparing the PRC plan in accordance with the PRC Guideline from DES.
State Development and Public Works Organisation Act 1971	To provide state planning and organisational legislation that aids in the delivery of ecologically sustainable development.	Commitments during the environmental impact statement (EIS) phase may impact on closure and rehabilitation of the Project.	Duty of care is demonstrated for rehabilitation by preparing the PRC plan in accordance with the PRCP plan Guideline from DES.
Transport Infrastructure Act 1994	The overall objective of the Act is to provide a regime that allows for and encourages effective integrated planning	Approval from the Department of Transport and Main Roads (DTMR) is	The Project does not propose any changes to State Controlled Roads and approvals

Legislation	Objective	General application	How it relates to the Project
	and efficient management of a system of transport infrastructure.	needed under the Act if the project interferes with a State Controlled Road.	for works under s33 of the Act is not required.
Aboriginal Cultural Heritage Act 2003 which give rise to *Duty of Care Guidelines, 2004*	Provide effective recognition, protection and conservation of Aboriginal cultural heritage.	All reasonable and practicable measures need to be taken to ensure closure activities do not harm Aboriginal cultural heritage. General 'cultural heritage duty of care' to be observed.	The *Aboriginal Cultural Heritage Act 2003* requires that, when carrying-out an activity, all reasonable and practicable measures are taken to ensure the activity does not harm Aboriginal cultural heritage and provides a cultural heritage duty of care. There are no current activities expected or planned (eg development or mining operations) to occur at the Project. It is recommended that Peabody implements a cultural heritage management plan (CHMP) in association with the Barada Barna People to manage the potential risk of harm to Aboriginal cultural heritage by activities at the Project.
Land Act 1994	Relates to the administration and management of non-freehold land and deeds of grant in trust and the creation of freehold land, for related purposes.	Relates to opening and closing of road reserves and land dealings relating to changes in land tenure.	The *Land Act 1994* provides a framework for the allocation of State land as leasehold, freehold or other tenure and provides for its management. The Act further regulates the grant, lease and permitting of Unallocated State Land and reserves and roads. No action is needed to satisfy this Act.
Stock Route Management Act 2002	The main purpose of this Act is to provide for stock route network management.	Regulates the management and use of stock routes.	The Project is not expected to begin mining operations or develop infrastructure. Subsequently, the Project will not intersect or disrupt stock routes with any mining or relevant land-use activities. No agreements have been made between landholders to

Legislation	Objective	General application	How it relates to the Project
			modify existing stock routes within and surrounding the Project.
Water Act 2000 (and Water Resource (Fitzroy Basin) Plan, 2011 Fitzroy Basin Resource Operations Plan, 2011)	Provide for the sustainable management of water and other resources and the establishment and operation of water authorities and for other purposes.	Utilisation of groundwater and rehabilitation of bore holes.	Groundwater bore holes to be rehabilitated in compliance with EA conditions and nominated PMLU. No creek diversions or off-lease works are proposed or expected. Subsequently, no action is required.
Nature Conservation Act 1992	To provide a framework for the protection of state listed threatened species	Rehabilitation strategies may include any State-listed threatened species or communities that are present within the Project.	Rehabilitation strategies include consideration for rehabilitation of ERE 11.4.9.
Vegetation Management Act 1999	Regulates clearing of vegetation to guarantee appropriate management and conservation.	Project is required to comply with State and regional vegetation management plans and policies, as well as vegetation management practices on leased and freehold land.	Clearing native vegetation is exempt from requiring a clearing permit when it is conducted within an approved ML. No proposed works will occur outside of the Project and, consequently, development approvals are not required.

3.3.5 Milestone and completion criteria

Milestones and completion criteria are given in Table 29.

Table 29 PMLU completion criteria and justification

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
RM1	Infrastructure decommissioning and removal	a. All drillholes, sumps, exploration tracks and gridlines decommissioned in accordance with the requirements specified in the *Code of Environmental Compliance for Exploration and Mineral Development Projects* (DEHP 2014).	All services must be disconnected before infrastructure is removed. Infrastructure and roads not subject to a written landholder agreement must be removed / rehabilitated.
		b. All bores decommissioned in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (National Uniform Drillers Licensing Committee 2020).	
		c. All infrastructure is removed unless a written agreement with the subsequent landholder is in place.	
RM2	Surface preparation	a. No areas of active subsidence or gully erosion.	
		b. Shallow rip or scarify any surface cracking.	Subsidence areas should be ripped and sealed to prevent capture of overland flow.
		c. Rework surface material to fill cracks and hollows.	Subsidence areas should be infilled with suitable material.
		d. Reshape surface to avoid ponding	Reshaping will encourage water runoff and avoid ponding.
		e. Respread topsoil to a minimum depth of 200 mm (SIS and drill pads only).	Recovered topsoil will be respread over rehabilitated areas at a depth of 200 mm (0.2 m), which will contribute to revegetation establishment and success.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
RM3	Revegetation (preclearing native vegetation community)	a. Ripping to a minimum depth of 0.4 m along the contour.	Ripping the soil along contours improves aeration and the infiltration of water.
		Completed seeding of target species consistent with a seed mix that reflects the preclearing vegetation community as per b. Table 32.	Seed mix and rate is consistent with Table 32(revegetation plan) and the *Regional Ecosystem Technical Guidelines* (DES 2018).
RM4	Achievement of surface requirements (preclearing native vegetation community)	a. No areas of active subsidence or gully erosion.	Land should be 'stable' as defined in section 111A of the EP Act.
		b. Preclearing native vegetation communities must achieve the benchmark criteria (Table 30 of the Rehabilitation Planning Part) using the *BioCondition Assessment* methodology by an AQP.	Version 2.2 of the *BioCondition manual* is used to evaluate the functionality of biodiversity condition. Bio-condition classes consist of categories 1, 2, 3 and 4; with 1 being the best score, and are aligned with the grazing land condition 'ABCD' framework. To achieve bio-condition class 2 or greater, an area must achieve an average score of 60%. As 'achievement of surface requirements' is an intermediate milestone to 'achievement of the PMLU to a stable condition', 20% has been chosen as a conservative measure of rehabilitation progress. Tree canopy cover has been removed as it is unlikely that tree growth will be sufficient to provide canopy cover in the limited timeframe provided.
RM5		a. Certification from an AQP that the area has achieved a stable condition.	Land should be 'stable' as defined in section 111A of the EP Act.

Milestone reference	Rehabilitation milestone	Milestone criteria	Justification of criteria
	Achievement of the PMLU to a stable condition (preclearing native vegetation community)	b. No areas of active subsidence or gully erosion.	
		c. Invasive plants (as defined in the Biosecurity Act) comprise of less than 5% of vegetation groundcover.	Areas of native ecosystem are generally less disturbed and are likely to have less weeds present than grazing areas.
		d. Preclearing native vegetation communities must achieve the benchmark criteria (Table 30 of the Rehabilitation Planning Part) using the *BioCondition Assessment* methodology by an AQP.	Version 2.2 of the *BioCondition manual* is used to evaluate the functionality of biodiversity condition. Bio-condition classes consist of categories 1, 2, 3 and 4; with 1 being the best score, and are aligned with the grazing land condition 'ABCD' framework. To achieve bio-condition class 2 or greater, an area must achieve an average score of 60%.
		e. Certification from an AQP that surface water quality is within 10% of the results of baseline monitoring results, or when baseline is not available, upstream reference sites which have not been impacted by mining activities	Surface water must be of acceptable quality that is similar to pre-mining conditions.
		f. Certification from an AQP that groundwater quality is within 10% of the results of baseline monitoring results, or when baseline is not available, reference bores which have not been impacted by mining activities	Groundwater must be of acceptable quality that is similar to pre-mining conditions.
		g. Certification from an AQP that Humbug Gully is safe and stable and flow conditions are consistent with pre-mining conditions	Geomorphic conditions of Humbug Gully should be consistent with pre-disturbance conditions.

Benchmark values have been calculated for each relevant RE area (Table 30).

Table 30 Progressive and final benchmark values for preclearing native vegetation areas

RE characteristic	Benchmark value (RE reference)	Progressive PRCP benchmark (RM4)	Final PRCP benchmark (RM5)
Recruitment	100%	20%	60%
RE 11.5.3 / 11.7.2			
Tree species richness	6/3	1/1	4/1
Shrub species richness	6/4	1/1	4/2
Grass species richness	6/5	1/1	4/3
Forb species richness	10/5	2/1	6/3
Tree canopy cover	20/40	N/A	12/8
Shrub canopy cover	3/4	1/1	2/1
Native perennial grass cover	19/15	4/3	11/3
Organic litter cover	20/20	4/4	12/4
RE 11.5.3 / 11.3.4			
Tree species richness	6/4	1/1	4/2
Shrub species richness	6/2	1/1	4/1
Grass species richness	6/7	1/1	4/4
Forb species richness	10/10	2/2	6/6
Tree canopy cover	20/17	N/A	12/10
Shrub canopy cover	3/1	1/1	2/1
Native perennial grass cover	19/43	4/9	11/26

RE characteristic	Benchmark value (RE reference)	Progressive PRCP benchmark (RM4)	Final PRCP benchmark (RM5)
Organic litter cover	20/20	4/4	12/12
RE 11.5.3 / 11.4.9			
Tree species richness	6/2	1/1	4/1
Shrub species richness	6/5	1/1	4/3
Grass species richness	6/5	1/1	4/3
Forb species richness	10/10	2/2	6/6
Tree canopy cover	20/25	N/A	12/15
Shrub canopy cover	3/5	1/1	2/3
Native perennial grass cover	19/16	4/3	11/10
Organic litter cover	20/45	4/9	12/27
RE 11.4.9 / 11.5.3			
Tree species richness	2/6	1/1	1/4
Shrub species richness	5/6	1/1	3/4
Grass species richness	5/6	1/1	3/4
Forb species richness	10/10	2/2	6/6
Tree canopy cover	25/20	N/A	15/12
Shrub canopy cover	5/3	1/1	3/2
Native perennial grass cover	16/19	3/4	10/11
Organic litter cover	45/20	9/4	27/12

3.4 Non-use management areas

There are no non-use management areas (NUMAs) at the Project.

3.4.1 Voids in flood plains

There are no voids at the Project.

3.5 Rehabilitation management methodology

3.5.1 General rehabilitation practices

The following sections present information deemed necessary to underpin the development of rehabilitation management methodologies. There are no management methodologies because there are no nominated NUMAs.

3.5.1.1 Hydrogeology

The occurrences of groundwater can be seen in section 0. Groundwater modelling has been completed for the CUG, which includes the Project area.

a Modelling

Modelling for the CUG identifies that operations will depressurise the Permian, coal seam and Tertiary aquifers. It is expected that the piezometric surface of the aquifers will be lowered and create a cone of depression around the area. Impacts on the groundwater is confined to within 1 km of the CUG. Hydrographs generated for the available Quaternary Alluvium bores indicate that groundwater levels have not varied significantly in the last 100 years, with minor declines and recovery of groundwater occurring over time (WorleyParsons Consulting 2015).

b Groundwater contamination

The Project is an underground operation with minimal surface infrastructure. The risk of groundwater contamination is low and is not a consideration for rehabilitation methodology.

Chemicals are used in mining and transport activities, which includes solvents, lubricants, fuels, flocculants and other reagents that have the potential to cause environmental harm (Table 31). Metals and hydrocarbon contamination may occur as a result of spills. Spills are likely to be localised and standard practice requirements including adequate bunding and immediate clean up action will reduce the likelihood and impact of contamination to shallow groundwater systems.

Table 31 Potential groundwater contaminant sources

Sources	Potential contaminants	Mitigation measures
Infrastructure	• petroleum hydrocarbons; • degreasers; • detergents; and • runoff containing suspended solids.	• adequate bunding of fuel and oil storages in accordance with *Australian Standard* (AS) 1940; and • immediate clean-up of spills.

3.5.1.2 Flooding

The Project is not located in any major floodplains. Humbug Gully is ephemeral and may have a minor floodplain during wet periods (Appendix G).Flooding is not a consideration for rehabilitation methodology because of the limited amount of surface infrastructure.

3.5.1.3 Soil and capping material assessment

a Soil types disturbed

Surface disturbance will be limited to exploration holes and tracks, and the construction of SIS pads to support underground mining operations. Potentially subsided areas may require rework to seal cracks and fill low points however major earthworks are not anticipated.

Subsided areas will be ripped and reworked using a dozer. Existing vegetation will be retained as much as possible. The removal of trees and shrubs will be avoided wherever possible.

b Erosion and sediment control

An erosion and sediment control plan (ESCP) will be developed as per condition E8 of the EA and implemented for use during all stages of mining activities on site. Erosion and sediment control methods discussed in the EMP include:

- minimising surface disturbance;
- contour banks at intervals down slopes in order to divide a long slope into a serious of short slopes that prevent runoff reaching a depth of flow that may cause erosion; and
- contour ripping across the grade, achieving erosion control while cultivating the surface for sowing;

c Contaminated land management

The risk of disturbing contaminated land is considered negligible given no records of contaminated land exist for the area. Similarly, no potential for acid-sulfate soils has been found. The exploration activities are not expected to cause any contamination.

In order to mitigate and manage contamination, suggested management strategies include:

- the provision of spill control equipment; and
- the safe storage of exploration equipment and chemical materials (where necessary).

3.5.1.4 Waste characterisation

The Project is an underground operation with no significant volumes of mine waste. Coal will be processed at CCM with rejects and tailings disposed of at that site.

3.5.1.5 Landform design

No landforms will be constructed or remain at closure.

3.5.1.6 Cover design

No areas require a cover system.

3.5.1.7 Water management

Activities to be carried out during exploration that have the potential to impact on surface and groundwater systems are:

- construction and use of access tracks;
- use of hazardous substances; and
- clearing and soil disturbance.

Principles of water management will be provided in a water management plan that must be developed as per Condition E13 of the EA. Given there is minimal surface infrastructure, surface water control is limited to the protection of Humbug Gully from mining activities. No surface water diversions (short or long-term) or disturbance of Humbug Gully are planned. Appropriate erosion and sediment control practices will be used when constructing SIS pads and tracks near the channel.

Potential subsidence within 50 m of Humbug Gully will be avoided by limiting the extraction of coal in these areas (Section 3.5.4.1).

3.5.1.8 Revegetation plan

The preclearing native vegetation community PMLU is consistent with the pre-mining land use. A revegetation plan has been developed to describe activities proposed to establish self-sustaining vegetation communities that suit the intended PMLU.

a Objectives

Revegetation objectives requires certification from an AQP that attributes are ≥20% of values from benchmark criteria of the pre-disturbance RE based on *BioCondition* monitoring, including:

- recruitment;
- tree species richness;
- native shrub species richness;
- native grass species richness;
- native forb species richness;
- shrub canopy cover;
- native perennial grass cover; and
- organic litter cover.

Tree canopy cover is excluded from RM4 criteria because it is unlikely to be sufficient to meet the progressive benchmark values within the suggested timings.

b Seedbed preparation

Following reshaping 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 0.4 m and 1 m. 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 2 m every 200 m. This will reduce the potential for channel erosion to develop within rip lines.

c Key flora species

Key flora species for revegetation is based on pre-mining conditions and is given in section 3.1.3.8d. King Bluegrass (*Dichanthium queenslandicum*) is recognised as an endangered species endemic to the area and has been included in the seed mix. King Bluegrass is a native species.

d Species of conservation significance

Species of conservation significance are given in section 3.1.3.8 and section 3.1.3.9.

e Fauna habitat and use

Significant fauna is discussed in section 3.1.3.9. Disturbance will be limited and rework of subsided areas will only occur where necessary. By limiting earthworks, established fauna habitat such as trees, shrubs, fallen timber, leaf litter and groundcover will be retained.

f Reference sites

No reference sites are currently established. Reference sites will be selected for the preclearing native vegetation community PMLU. The sites will be representative of the PMLU and will provide baseline information to gauge rehabilitation success and the appropriateness of selected criteria. For the purpose of developing the rehabilitation schedule, benchmark values have been used (section 3.3.5).

g Management of revegetation

Revegetation is planned in advance of any earthworks. If areas are reshaped, seeding should occur immediately to minimise the risk large rain events on exposed soil. Seed will be ordered in advance to ensure adequate supply.

h Seed mix

Seed mixes have been developed based on pre-mining species mixes proven to be successful in the Bowen Basin.

The proposed seed mix for areas of preclearing native vegetation community are shown in

Table 32 and is based on species recorded during the ecological field assessment (Wormington 2014a; Worminton 2014b) and representative REs. Species composition for representative REs is sourced from *Regional Ecosystem Technical Descriptions* (DES 2018).

Table 32 Proposed seed mixes for each preclearing native vegetation community

Species	Common name	Seeding rate
RE 11.3.4		
Bothriochloa bladhii	Forest Bluegrass	To be determined from the species composition of the representative RE[1]
Corymbia clarksoniana	Grey Bloodwood	To be determined from the species composition of the representative RE[1]
Corymbia tessellaris	Carbeen / Moreton Bay Ash	To be determined from the species composition of the representative RE[1]
Dichanthium queenslandicum	King Bluegrass	To be determined from the species composition of the representative RE[1]
Dichanthium setosum	Bluegrass	To be determined from the species composition of the representative RE[1]
Eucalyptus melanophloia	Silver-leaved Ironbark	To be determined from the species composition of the representative RE[1]
Eucalyptus platyphylla	White Gum	To be determined from the species composition of the representative RE[1]
Eucalyptus tereticornis	Blue Gum	To be determined from the species composition of the representative RE[1]
Heteropogon contortus	Black Speargrass	To be determined from the species composition of the representative RE[1]

Species	Common name	Seeding rate
Themeda triandra	Kangaroo Grass	To be determined from the species composition of the representative RE[1]
Aristida leptopoda	White Speargrass	To be determined from the species composition of the representative RE[1]
RE 11.4.9		
Acacia harpophylla	Brigalow	To be determined from the species composition of the representative RE[1]
Casuarina cristata	Belah	To be determined from the species composition of the representative RE[1]
Eremophila mitchellii	False Sandlewood	To be determined from the species composition of the representative RE[1]
Geijera parviflora	Wilga	To be determined from the species composition of the representative RE[1]
Lysiphyllum cunninghamii	Jigal Tree	To be determined from the species composition of the representative RE[1]
Terminalia oblongata	Yellow Wood	To be determined from the species composition of the representative RE[1]
RE 11.5.3		
Allocasuarina luehmannii	Bull Oak	To be determined from the species composition of the representative RE[1]
Capparis lasiantha	Nipan	To be determined from the species composition of the representative RE[1]
Corymbia clarksoniana	Grey Bloodwood	To be determined from the species composition of the representative RE[1]
Corymbia dallachiana	Ghost Gum	To be determined from the species composition of the representative RE[1]
Eucalyptus crebra	Narrow-leaved Ironbark	To be determined from the species composition of the representative RE[1]
Eucalyptus melanophloia	Silver-leaved Ironbark	To be determined from the species composition of the representative RE[1]
Eucalyptus populnea	Poplar Box	To be determined from the species composition of the representative RE[1]
Erythroxylum australe	Cocaine Tree	To be determined from the species composition of the representative RE[1]
Geijera parviflora	Wilga	To be determined from the species composition of the representative RE[1]
RE 11.7.2		

Species	Common name	Seeding rate
Acacia catenulata	Bendee	To be determined from the species composition of the representative RE[1]
Acacia shirleyi	Lancewood	To be determined from the species composition of the representative RE[1]
Acacia rhodoxylon	Ringy Rosewood	To be determined from the species composition of the representative RE[1]
Acacia burrowii	Burrow's Wattle	To be determined from the species composition of the representative RE[1]
Acacia sparsiflora	Currawong	To be determined from the species composition of the representative RE[1]
Acacia crassa	Curracabah	To be determined from the species composition of the representative RE[1]
Acacia blakei	Wollomobi Wattle	To be determined from the species composition of the representative RE[1]
Eucalyptus thozetiana	Napunyah	To be determined from the species composition of the representative RE[1]
Eucalyptus crebra	Narrow-leaved Ironbark	To be determined from the species composition of the representative RE[1]
Acalypha eremorum	Turkey Bush / Native Acalypha	To be determined from the species composition of the representative RE[1]
Croton phebalioides	White Croton / Narrow-leaved Croton	To be determined from the species composition of the representative RE[1]
Carissa ovata	Currantbush	To be determined from the species composition of the representative RE[1]

1. *Regional Ecosystem Technical Descriptions* (DES 2018)

The proposed native vegetation seed mix (

Table 32) includes dominant and co-dominant species from each RE and may exclude rarer species that are unlikely to establish. The actual seed mix for each RE may depend on the availability of seed. Any changes to the proposed seed mix are in line with the RE technical descriptions (DES 2018). The seed mix for each RE must be consistent with the ratio of the relevant joint REs (Table 16).

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

i Seed application

Seed and any required ameliorants will be spread by direct application at the same time as seedbed preparation using appropriately modified machinery. If seeding cannot occur during seedbed preparation, seed will be cast over the area using ground-based spreaders mounted on mining or agricultural equipment.

j Infrastructure for revegetation protection

Fencing will be used to restrict access to rehabilitated areas by cattle and other fauna (if required) to protect planting during vegetation establishment.

k Growth media and depth

Topsoil will only be removed for surface infrastructure areas and will be stockpiled adjacent to the area for respreading. Subsidence areas will not have topsoil removed.

3.5.2 Tailings storage facilities

No tailings storage facilities (TSF) will be developed at the Project.

3.5.3 Voids

There are no voids at the Project.

3.5.4 Underground mining

Underground mining (bord and pillar) is the only form of mining that is planned to occur. Previous studies were based on longwall mining methods however the constrained nature of the resource, the availability on entry via CCM and a desire to limit surface subsidence has meant a change to bord and pillar operations. Initial options study designs from Palaris (2023) recommended Ensham style bord and pillar mining. This mining method is considered ideal based on:

- good resource recovery;
- low to negligible subsidence design (dependant on pass);
- high productivity (based on benchmarking databases); and
- flexibility in the design and orientation of panels to work around final open-cut limits and constraints of CCM.

Pillar design and subsidence has been assessed in the *Empirical Review and Assessment of Bord and Pillar Design* report (the geotechnical report) by SCT Operations Pty Limited (SCT 2023) (Appendix H) to address the appropriate pillar dimensions and FoS required to limit surface subsidence.

3.5.4.1 Geotechnical study

The geotechnical report (SCT 2023) recommended a bord and pillar design based on industry practices that minimise subsidence. Adequate long-term pillar design suggests long-term subsidence can be minimised. Panel pillars will be designed with a minimum FoS of 1.6 and W/H ratio of > 5 following first pass development (3 m roadway height) (Table 33). A subsequent pass to remove floor coal will reduce the FoS, however the final FoS will depend on multiple factors. The potential for surface subsidence is highly dependent on pillar design, which can be progressively updated as underground mining progresses. Monitoring of the FoS in the initial panels (Figure 10) will help with the redesign of future panels to get a better understanding of future mining operations and reduce FoS in critical areas, specifically around Humbug Gully.

Table 3 in the geotechnical report (Table 33) shows the degree that FoS decreases with pillar strength during floor coaling (6 m height). The reduced FoS is associated with decreasing pillar W/H ratios. Pillar design will be controlled during operations to minimise potential subsidence. Areas within 50 m of Humbug Gully will have minimal coal extracted to maintain a minimum FoS of 2.11, which is recommended to protect critical areas.

No sink holes are expected given the proposed mining method and cover depths. Underground accesses are confined to CCM. The sealing of underground operations will be completed in line with mine design guidelines and industry best practice (SCT 2023); however they are not a consideration of this PRC plan.

Table 33 Bord and pillar FoS and pillar strength

	Depth of cover range		Pillar height	Pillar width	Pillar length	Hdg width	Pillar width centres	Pillar length centres	W/H ratio	Pillar load	Pillar strength	FoS[1]
Panel no.	**From (m)**	**To (m)**	**(m)**	**(m)**	**(m)**	**(m)**	**(m)**	**(m)**		**(MPa)**	**(MPa)**	
1	110	120	3.0	16.0	16.0	6.0	22.0	22.0	5.3	5.7	12.8	2.26
2	120	140	3.0	18.0	18.0	6.0	24.0	24.0	6.0	6.2	13.5	2.18
3	140	160	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.1	13.5	1.90
4	140	160	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.1	13.5	1.90
5	145	175	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.8	13.5	1.74
6	150	175	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.8	13.5	1.74
7	165	175	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.8	13.5	1.74
8	160	170	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.6	13.5	1.79
9	180	200	3.0	21.0	21.0	6.0	27.0	27.0	7.0	8.3	14.5	1.76
10	170	200	3.0	21.0	21.0	6.0	27.0	27.0	7.0	8.3	14.5	1.76
11	195	215	3.0	25.0	25.0	6.0	31.0	31.0	8.3	8.3	15.8	1.91
12	240	260	3.0	25.0	25.0	6.0	31.0	31.0	8.3	10.0	15.8	1.58
13	260	285	3.0	30.0	30.0	6.0	36.0	36.0	10.0	10.3	17.1	1.67
14	240	285	3.0	30.0	30.0	6.0	36.0	36.0	10.0	10.3	17.1	1.67
1	110	120	6.0	16.0	16.0	6.0	22.0	22.0	2.7	5.7	8.1	1.43
2	120	140	6.0	18.0	18.0	6.0	24.0	24.0	3.0	6.2	8.6	1.38
3	140	160	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.1	8.6	1.21
4	140	160	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.1	8.6	1.21
5	145	175	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.8	8.6	1.10
6	150	175	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.8	8.6	1.10
7	165	175	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.8	8.6	1.10
8	160	170	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.6	8.6	1.13
9	180	200	6.0	21.0	21.0	6.0	27.0	27.0	3.5	8.3	9.2	1.11
10	170	200	6.0	21.0	21.0	6.0	27.0	27.0	3.5	8.3	9.2	1.11
11	195	215	6.0	25.0	25.0	6.0	31.0	31.0	4.2	8.3	10.0	1.21
12	240	**260**	6.0	25.0	25.0	6.0	31.0	31.0	4.2	10.0	10.0	1.00
13	260	**285**	6.0	30.0	30.0	6.0	36.0	36.0	5.0	10.3	10.8	1.06
14	240	285	6.0	30.0	30.0	6.0	36.0	36.0	5.0	10.3	10.8	1.06

1. Being the final mining areas at the Project, the FoS for panels 11–14 are assessed based on pre-mining modelling. A realistic FoS will be modelled based on the monitoring of mining in the initial panels. Pillar strength (W/H ratio) will be reassessed to get a better understanding on future mining operations.
2. Green = first pass development (3 m). Orange = second pass development (6 m).

3.5.4.2 Subsidence management

The EA requires the development of a subsidence management plan prior to the commencement of activities that result in subsidence, i.e., underground mining.

The plan will be required to address potential surface disturbance impacts, including monitoring and remedial actions. Subsidence is low to negligible for all panels during first pass development, with the highest probability of failure (lowest FoS) being 1 in 1,000 (or 0.1%) based on the University of New South Wales (UNSW) pillar FoS probability of failure. If pillar design remains unadjusted during second pass development (6 m height), surface disturbance from subsidence can be expected. During second pass development, pillars designs can be controlled to minimise subsidence. Subsidence management activities outlined in the EMP include:

- installing temporary ESC measures for minor works;
- deep ripping, backfilling or required reshaping of the ground surface in areas of surface cracking;
- minor earthworks to reduce sudden elevation changes and minimise slope angles within the final land surface, especially within the vicinity of drainage lines;
- recontouring as required to remove and reduce the interruption to flows; and
- fencing to exclude livestock or other surface traffic from disturbed areas until adequately rehabilitated.

By maintaining a minimum FoS of 2.11, subsidence impacts to Humbug Gully are considered negligible. Monitoring during operations will allow for early intervention should any impacts be noted.

Further subsidence aspects required under the PRC plan guideline will be addressed in any updated geotechnical assessments.

3.5.4.3 Groundwater

Potential groundwater impacts from underground mining are discussed in Section 3.5.1.1 and the *Coppabella Underground Project Groundwater Impact Assessment* (AGE 2010) (Appendix D). The assessment concluded that:

- the zone of significant drawdown at the end of mining is limited to within 1 km of the mine area;
- the nearest water supply bores are around 4.5km from the site which is beyond the zone of predicted drawdown;
- there are no groundwater dependent ecosystems likely to be impacted; and
- potential groundwater contamination is limited to mining of the coal seam aquifer.

Further groundwater aspects required under the PRC plan guideline will be addressed in any updated assessments.

3.5.5 Built infrastructure

Built infrastructure is limited to exploration (tracks and drill pads) and SIS infrastructure, which accounts for ~ 6 ha of minor disturbance.

3.5.6 Methods to rehabilitate land to a stable condition

A summary of key rehabilitation practices for each relevant activity to meet stable condition are given in Table 34. There are no proposed NUMAs, therefore management practices are not required.

Table 34 Summary of key rehabilitation practices

Relevant activity	Key rehabilitation practices
Exploration	• decommissioning of boreholes, sumps and tracks; • general reshaping and surface preparation • revegetation; • establishment of groundcover; • monitoring to determine that surface requirements have been met; and • be able to show that the land is stable.
SIS infrastructure	• general reshaping and surface preparation; • placement of topsoil; • revegetation; • establishment of groundcover; • monitoring to determine that surface requirements have been met; and • be able to show that the land is stable.
Subsidence areas	• general reshaping and surface preparation to avoid ponding and encourage water runoff; • revegetation; • establishment of groundcover; • monitoring to determine that surface requirements have been met; and • be able to show that the land is stable.

3.5.6.1 Relationship to the PRC plan schedule

A rehabilitation area is defined the EP Regulation as an area of land to which a rehabilitation milestone for the PMLU relates. The Project consists of two rehabilitation areas (RA1 and RA2) which have homogenous rehabilitation methods and a preclearing native vegetation community PMLU.

3.6 Risk assessment

Identifying environmental, community, social and economic impacts and risks associated with closure and rehabilitation is critical for effective closure and rehabilitation planning. The overall objective of the closure and rehabilitation risk assessment (the risk assessment) is to identify risks of a stable condition for land not being achieved and how Peabody intends to manage or mitigate the identified risks in accordance with Section 126C(1)(f) of the EP Act. The meaning of a 'stable condition' is given in Section 111A of the EP Act:

111A Meaning of a 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 assessment was developed considering the standard AS ISO 31000:2018 Risk Management — Guidelines. Risks and opportunities were identified for all decommissioning, demolition and closure and rehabilitation related activities that are yet to have occurred, or already have occurred at the Project. The post closure and rehabilitation monitoring periods were also included. The risk management process is shown in Figure 11.

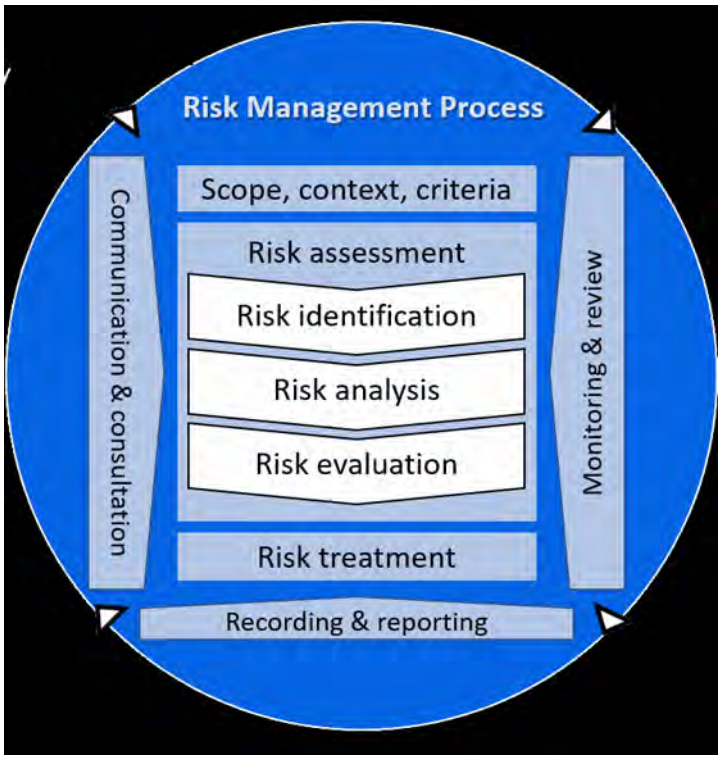


Figure 11 Risk management process overview

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 EVs; and
- identify and define risks to land sustaining the PMLU.

3.6.2 Risk analysis

The risk analysis process considered the maximum probable outcome for each identified risk with the current control measures in place. Each identified risk was then analysed using the consequence categories and associated criteria given in Figure 12 and the likelihood categories in Figure 13. This determined the risk rankings also given in Figure 13.

The 'Environmental' consequence category from the Peabody standard consequence table was the only category considered during the risk assessment process. This is to ensure that only environmental risks associated with land not achieving a stable condition are considered, as per the requirements of the PRC guideline. This consequence category was further broken down into three broad categories based on the EP Act definition of a 'stable condition'. These categories are:

- safe and stable;

- impact to environmental values (EV's); and
- impact to the potential PMLU.

	Consequence descriptions					
Consequence Category	1 - Low	2 - Minor	3 - Moderate	4 - Significant	5 - Major	6 - Catastrophic
Harm to People	Near miss, near hit, no medical treatment, report only (RO)	Slightly injured, first aid treatment (FAI)	Medical treatment (MTI), disabling reversible impairment, restricted work (RWI) or lost time (LTI)	Serious bodily injury or disabling irreversible impairment, permanent partial disability (PPD)	Single fatality incident. Total and permanent disability (TPD). Major irreversible health effects	Multiple fatality incident. Major injury / disease among multiple employees
Environmental	• Negligible or reversible environmental impact • Nil to minor remediation (typically a shift) • No breach of regulations or requirement to report to regulators	• Minor reversible environmental impact • minor remediation (typically < 5 days) • Non-compliances and breaches of regulation that may result in a citation (NOV) • May require reporting to the regulators	• Incident resulting in moderate reversible onsite and/or off-site impact causing short term effect. • Moderate remediation required (typically a month) • Non-compliances and breaches of regulation that may result in prosecution or citation or punitive fine. • Requirement or obligation to report to the regulators	• Incident resulting in significant onsite or off-site environmental impact causing medium to long term environmental harm • Significant remediation required (typically less than 12 months) • Significant legal issues, non-compliances and breaches of regulation that results in a prosecution or citation or fine • Moderate litigation issues involving many weeks of senior management time	• A major incident resulting in regional environmental impact causing long term environmental harm • Major long term remediation required (greater than 12 months) • Major litigation or prosecution resulting in long term interruption to operations or loss of licence at a site	• Incident resulting in catastrophic widespread regional environmental harm causing disastrous effect • Major long term remediation required (over multiple years) • Major litigation or prosecution , Loss of License to operate at Multiple sites
Finance (higher of cost or NPV)	<$10,000	$10,000 - $100,000	$100,000 - $1 mil	$1 mil - $20 mil	$ 20 mil-$100 mil	> $100 mil
Impact on reputation	Minor impact, no public concern; Market cap impact < $20 M (< $0.07 per share)	Local media or public concern; Market cap impact $20 M - $30 M ($0.07 - $0.12 per share)	Regional media or public concern. Local criticism; Market cap impact $30 M - $100 M ($0.12 - $0.40 per share)	National adverse media or public criticism; Market cap impact $100 M - $250 M ($0.40 - $1.00 per share)	International adverse media or public criticism. International public concern; Market cap impact $250 M - $500 M ($1.00 - $1.85 per share)	Significant international public or media criticism or condemnation; Market cap impact > $500 M (> $1.85 per share)
Law / Compliance / regulatory	Minor, one-off violations of law, regulation, permit or policy; minimal fines, penalties or costs.	Recurring or systemic minor violations of law, regulation, permit or policy.	Violations of law, regulation, permit or policy with moderate fines or penalties, Moderate Litigation, MSHA imminent danger order or similar	Significant violation of law or permit with material fines, penalties or costs. Serious dispute with strategic customer. Major Litigation.	Material Litigation. Serious investigation by SEC, DOJ or foreign equivalent. Code of Conduct violations.	Criminal investigation or proceedings involving officers or directors. Litigation with allegations of executive fraud or misappropriation
Strategic risk	Event does not have a meaningful impact to Strategic Outlook	Event does not have meaningful impact to Strategic Outlook, but may require further monitoring	Event may have a material impact on near-term outlook for a region or mine	Event has a material impact on strategic outlook for a region or basin that may require a change to operations to mitigate risk	Event causes mines in a region or basin to cease current operations	Event or threat such that BTU would cease to exist as an ongoing concern in coal operations

Figure 12 Consequence table

			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

Figure 13 Likelihood table and risk matrix

3.6.3 Risk evaluation

Risk evaluation involves comparing the results of the risk analysis with the establishment of risk criteria to determine where additional action is required. Additional actions may include:

- do nothing further;
- consider risk treatment options;
- undertake further analysis;
- maintain existing controls; or
- reconsider objectives.

Additional controls are always applied for calculated risk scores of 20 or above. Additional controls may also be applied for lower calculated scores as required. The results of the risk assessment are given in Table 35.

3.6.4 Risk treatment

Risk treatment involves evaluating options for the management or mitigation of identified risks. The most appropriate risk treatment options (proposed actions) have been selected based on multiple criteria including cost benefit, regulatory obligations, community responsibility and protection of EVs. Actions to apply these options have been allocated to the appropriate work parties, scheduled and performance measures and constraints identified. The risk treatment plan is included in Table 35.

3.6.4.1 Residual risk

The nominated treatment options have been assessed as adequate in reducing the original risk ranking to an acceptable level. The risk treatments and the remaining risk should be monitored and reviewed regularly with any significant changes or emerging issues communicated with relevant parties. Treatments may be modified, replaced, or complemented with additional treatments as needed to make sure an acceptable level of risk is maintained.

Table 35 Risk identification, analysis and evaluation

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
RM 1 — exploration infrastructure decommissioning and removal	Inadequate removal of exploration infrastructure	Safe and stable	Infrastructure may create erosion points causing instability Remnant infrastructure is a hazard to fauna	2	3	6	Location of exploration holes recorded PRC plan includes infrastructure decommissioning and removal Infrastructure included in ERC	Including in PRC and ERC ensures a documented and auditable record of infrastructure removal requirements and provides direction for planning and provisioning.	Site management team	Survey support GIS support	Survey and record review	Visual inspection	Following removal	2	2	4
RM 2 — Surface preparation	Surface cracking not adequately sealed	Safe and stable, PMLU	Surface cracking causes erosional instability, loss of topsoil or poor vegetation establishment	3	3	15	Ripping / scarifying of surface Subsidence monitoring	Ripping / scarifying of surface will seal cracks. Subsidence monitoring will give an early indication of areas requiring maintenance.	Site management team	Survey support	Survey and subsidence data	As per section 3.7.6	Following the start of bord and pillar mining and ongoing	2	2	4
RM 3 — Revegetation	Seed quality or application not sufficient for vegetation establishment	PMLU	Vegetation does not adequately establish to support PMLU	2	3	6	Seed mix and rate based on local conditions Seed quality and viability testing included in procurement Rehabilitation monitoring	Seed mix is based on successful vegetation under existing conditions. Seed testing will ensure quality. Rehabilitation monitoring will measure success of revegetation.	Site management team	Seed quality and validation tests Rehabilitation monitoring program	Test results Rehabilitation monitoring results	As per section 3.7.3	Prior to and immediately after seeding	2	2	4
RM4 — achievement of surface requirements	Subsidence impacts Humbug Gully	Impact to EV's	Subsidence damages creek structure or impacts flow	4	3	30	Subsidence monitoring Subsidence management plan (to be developed)	Subsidence monitoring will allow for early detection of issues and remedial action	Site management team	Subsidence management plan	Subsidence monitoring data	As per section 3.7.6	As per Table 37	3	2	10

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
RM5— achievement of the PMLU to a stable condition	Inadequate vegetation cover for PMLU	PMLU	Vegetation cover insufficient to support the PMLU	2	3	6	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 existing vegetation.	Site management team	Rehabilitation monitoring program	Rehabilitation monitoring data	As per section 3.7.3	As per Table 37	2	2	4
	Groundcover not sufficient for surface stabilisation	Safe and stable	Inadequate groundcover establishment causes excessive erosion rates	2	3	6	Seed mix and rate based on local conditions. Established vegetation areas retained as much as possible during earthworks.	Seed mix is consistent with existing vegetation Existing established vegetation provides groundcover	Site management team	Rehabilitation monitoring program	Rehabilitation monitoring data	As per section 3.7.3	As per Table 37	2	2	4
	Revegetated areas dominated by weeds	PMLU	Weeds impact land use or establishment of favourable species	2	3	6	Seed testing included in procurement Weed inspections of rehabilitation machinery Rehabilitation monitoring Weed management plan	Seed testing to verify the quality of seed and the absence of weed species. Inspection and cleaning of equipment to help stop spread of weed species. The weed management plan will outline management options.	Site management team	Rehabilitation monitoring program Equipment inspection checklist Weed management plan	Rehabilitation monitoring data	As per section 3.7.3	As per Table 37	2	2	4
	Lack of rehabilitation maintenance (ie. Repair of significant erosion)	Safe and stable	Excessive erosion impacts surface stability	2	3	6	Rehabilitation monitoring determines maintenance requirements Rehabilitation maintenance program	Regular monitoring and maintenance of rehabilitation allows issues to be addressed promptly.	Site management team	Rehabilitation monitoring and maintenance program	As per section 3.7.3	As per section 3.7.3	As per Table 37	2	2	4

Milestone	Risk / threat	Consequence category	Impact	Risk evaluation			Proposed controls	Justification of treatment option	Responsibility	Resource requirements	Performance measures	Reporting and monitoring	Timing and scheduling	Residual risk		
				Consequence	Likelihood	Risk score								Consequence	Likelihood	Risk score
	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	Site management team	Rehabilitation monitoring program	Rehabilitation monitoring data	As per section 3.7.3	As per Table 37	2	2	4
	Rehabilitation vegetation lost or damaged due to bushfire	Impact to EV's	Loss of biodiversity Damage to previously completed rehabilitation	2	2	4	Rehabilitation monitoring Bushfire management	Rehabilitation monitoring will identify areas requiring grazing or fire management to reduce fuel load	Site management team	Rehabilitation monitoring program Bushfire management plan	Visual inspection and as per section 3.7.3	Visual inspection and as per section 3.7.3	As per Table 37	2	2	4
	Surface water runoff causes environmental harm	Impacts to EV's	Environmental harm from contaminated runoff	2	2	4	Surface water monitoring	Monitoring to provide early indication of potential contamination	Site management team	Surface water monitoring program	As per section 3.7.4	As per section 3.7.4	As per Table 37	2	2	4
	GW contamination from rehabilitated area	Impacts to EV's	Contamination of groundwater	2	2	4	GW monitoring	Monitoring to confirm modelling predictions of low risk to groundwater or to provide an early indication of potential issues	Site management team	GW monitoring program	As per section 3.7.5	As per section 3.7.5	As per Table 37	2	2	4
	Area does not meet same condition as reference sites	PMLU	Delay in achievement of stable condition	2	3	6	BioCondition monitoring	BioCondition monitoring provides a quantitative measure of rehabilitation performance against reference sites	Site management team	BioCondition monitoring program	As per section 3.7.3	As per section 3.7.3	As per Table 37	2	2	4

3.6.5 Rehabilitation trials

No rehabilitation trials are required for the Project.

3.7 Monitoring and maintenance

3.7.1 Reference sites

Reference sites will be established and will be used as indicators for rehabilitation monitoring. Sites will be chosen based on the REs and vegetation community structures associated with the PMLU. Reference sites will be nominated prior to mining. The assessment of reference sites will be used to indicate the success and achievement of relevant completion criteria.

3.7.2 Milestone monitoring

The following sections of the PRC plan describe monitoring and maintenance activities that will be done post-rehabilitation. Information collected during monitoring will demonstrate that the rehabilitation criteria have been met and contribute to satisfying DES's decision to progress surrender of the EA.

The post-rehabilitation phase will start when all rehabilitation activities are finished. Rehabilitation monitoring will be conducted to assess whether the closure objectives and rehabilitation criteria are being met, while maintenance will be done to address where the objectives and rehabilitation criteria remain incomplete or unsatisfactory. Data collected during this time will enhance monitoring data requirements for the post-closure monitoring period.

3.7.3 Rehabilitation monitoring

Monitoring at the site will be completed by following the methodology in Table 36.

Table 36 Summary of rehabilitation methodology

Plot area	Parameter measured	Description (to be recorded)
General description and supplementary information	Plot characteristics	Record the slope, plot landform location (upper, middle, lower slope), postmining land use and plot aspect.
	Weed presence/abundance	List all declared weed species and subjectively record their abundance as sparse, moderately abundant, or abundant. If the weed outbreak is deemed to be a significant outbreak, 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) (ie 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.

Plot area	Parameter measured	Description (to be recorded)
	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, eg pigs or rabbits.
2 m x 2 m Quadrats	Lower story density and richness	At 10 m 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-story cover	Record total lower-storey cover (ie 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	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 0–15 cm soil samples (ie one sample taken from each quadrat) and bulk, to produce one composite sample per transect.
50 m cover transect	Mid-story and upper-story cover	Using the 50 m cover transect, record the start and finish foliage intercepts. These intercepts are then added and divided by the total length (50 m), 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 50 cm quadrats/frame will be located at 10 m intervals along, but adjacent to the cover transect. The contribution of competent rock (rock defined as >50 mm in diameter) will also be assessed.
10 m either side of cover transect	Upper story & mid-story density/richness	Record the total number of trees and shrubs for each species located 10 m 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 2 m x 2 m 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 (ie slopes, length) detailed within the site EA.

3.7.4 Surface water

Surface water monitoring requirements will be determined by the water management plan which will be implemented before mining activities occur.

3.7.5 Groundwater

Groundwater monitoring will occur during rehabilitation and closure. Groundwater is to be monitored as per condition E1–E16 of the EA. Two groundwater bores must be monitored at different locations within the Project area. Groundwater will be tested and assessed against the contaminant trigger levels outlined in Table E1 of the EA. Trigger levels for groundwater contaminants will be provided based on planned groundwater baseline studies. Contaminants to be tested for include:

- pH;
- EC;
- total dissolved solids;
- carbonate, bicarbonate and total alkalinity;
- SO_4^{2-};
- Chloride (Cl-);
- major cations (calcium (Ca), magnesium (Mg), potassium (K) and Na);
- metals (aluminium (Al), antimony (Sb), arsenic (As), molybdenum (Mo), Se, silver (Ag), iron (Fe), mercury (Hg)); and
- petroleum hydrocarbons including fractions C6–C9, C10–C14, C29–C36, C10–C36.

3.7.6 Geotechnical monitoring

Geotechnical monitoring will be undertaken by a qualified geotechnical engineer who will assess the stability of post-rehabilitation features. Data collected will be used to assess the progress of the rehabilitation milestones and closure criteria. This includes subsidence monitoring of bord and pillar areas and Humbug Gully.

3.7.7 Schedule of monitoring, reporting and review of each milestone

The monitoring schedule is given in Table 37.

Table 37 Milestone monitoring and validation methods

Milestone reference	Rehabilitation milestone	Milestone criteria	Monitoring and validation method	Maintenance issues and treatments	Frequency
RM1	Exploration infrastructure decommissioning and removal	a. All drill holes, sumps exploration tracks and gridlines decommissioned in accordance with the requirements specified in the *Code of Environmental Compliance for Exploration and Mineral Development Projects* (DEHP 2014); b. All bores decommissioned in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (National Uniform Drillers Licensing Committee 2020); and c. All infrastructure is removed unless a written landholder agreement with the subsequent landholder is in place	Visual monitoring.	N/A	Once (after decommissioning)
RM2	Surface preparation	a. No areas of active subsidence or gully erosion; b. Reshape surface to avoid ponding; c. Respread of topsoil to a depth of 200 mm (SIS and drill pads only). d. Shallow rip or scarify any surface cracking; and e. Rework surface material to fill cracks hollows	Erosion and soil monitoring.	Remediate areas as required	As determined by the Subsidence Management Plan and immediately following topsoiling

Milestone reference	Rehabilitation milestone	Milestone criteria	Monitoring and validation method	Maintenance issues and treatments	Frequency
RM3	Revegetation	a. Ripping to a minimum depth of 0.4 m along the contour; and b. Completed seeding of target species consistent with a seed mix that reflects the preclearing vegetation community as per Table 32	Vegetation rehabilitation monitoring.	Review appropriateness of controls if required	• Ongoing during works; • First year followed by every 2 years.
RM4	Achievement of surface requirements	a. No areas of active subsidence or gully erosion; and b. Preclearing native vegetation communities must achieve the benchmark criteria (Table 30 of the Rehabilitation Planning Part) using the *BioCondition Assessment* methodology by an AQP.	Vegetation rehabilitation monitoring, LiDAR assessment erosion monitoring and water quality monitoring.	Reseed as required.	Annually until achievement of RM4

Milestone reference	Rehabilitation milestone	Milestone criteria	Monitoring and validation method	Maintenance issues and treatments	Frequency
RM5	Achievement of the PMLU to a stable condition	a. Certification from an AQP that the area has achieved a stable condition. b. No areas of active subsidence or gully erosion. c. Preclearing native vegetation communities must achieve the benchmark criteria (Table 30 of the Rehabilitation Planning Part) using the *BioCondition Assessment* methodology by an AQP. d. Invasive plants (as defined in the Biosecurity Act) comprise of less than 5% of vegetation groundcover. e. Certification from an AQP that surface water quality is within 10% of the results of baseline monitoring results, or when baseline is not available, upstream reference sites which have not been impacted by mining activities. f. Certification from an AQP that groundwater quality is within 10% of the results of baseline monitoring results, or when baseline is not available, reference bores which have not been impacted by mining activities; and	• Geotechnical and subsidence monitoring • Review final rehabilitation monitoring report.	• Subsidence remediated as determined by monitoring • Revegetation methodology, planting rate, species etc.	• Subsidence monitoring will be determined by the Subsidence Management Plan (when developed) • First year followed by every 2 years until achievement of RM5.

Milestone reference	Rehabilitation milestone	Milestone criteria	Monitoring and validation method	Maintenance issues and treatments	Frequency
		g. Certification from an AQP that Humbug Gully is safe and stable and flow conditions are consistent with pre-mining conditions.			

3.7.7.1 QA/QC

Monitoring, data assessment and reporting will be done by an AQP. This could be staff (eg environment officer) or an external consultant. All monitoring data files will be stored onsite. Mine staff will be responsible for reviewing monitoring data, analysis, reports and managing consultants.

Aspects to consider when reviewing the data, analysis and reports include QA/QC of data, methodologies used, fluctuating trends in data from previous years, accuracy of figures and graphs and general conclusions made about rehabilitation progress.

3.7.7.2 Review

This monitoring plan will be reviewed by if circumstances change. The review will consider:

- evaluation of rehabilitation objectives and indictors;
- opportunities for improvement identified in inspection checklist records;
- reports of environmental incidents;
- any amendments to relevant legislation, policy and guidelines;
- any changes to mining plans, mining activities or construction / mining / rehabilitation works contractors; and
- rehabilitation completion criteria based on the above items.

3.7.7.3 EA surrender

DES must be satisfied with the rehabilitation before it can certify progressive rehabilitation for part of the Project or accept the surrender of the EA for the whole or part of the Project tenure. DES's decision is based on an assessment of either a progressive rehabilitation report for part of the Mine (refer to section 318Z of the EP Act) or a final rehabilitation report (refer to section 264 of the EP Act) for the whole Project tenure or a singular part being surrendered.

The Proponent is required to prepare a progressive / final rehabilitation report, including a compliance statement and submit it to DES for assessment (ie this Plan). DES will consider the relevant rehabilitation requirements (refer to section 318ZI or section 268 of the EP Act) when deciding whether to certify progressive rehabilitation or whether to approve a surrender application. The Proponent is also required to develop a post-relinquishment management plan to assist ongoing land management beyond surrender of the Project tenures.

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Appendix A
PRC plan schedule



A.1 PRC plan schedule

A proposed PRC plan schedule has been prepared in accordance with section 126D of the EP Act and includes:

- a PMLU for all land within the relevant resource tenures including undisturbed land;
- identification of when land becomes available for rehabilitation or improvement;
- rehabilitation milestones to meet the PMLU;
- milestone criteria that demonstrate when each rehabilitation milestone is completed;
- completion dates for each milestone; and
- any conditions considered necessary.

A.1.1 Final site design

The final site design delineates the total area of the PRC plan as planned for surrender including all proposed undisturbed areas (and their proposed uses identified as a PMLU) and the proposed PMLU.

The final site design is shown in Figure 14 and includes:

- the maximum disturbance foot print;
- resource tenure boundaries;
- PMLUs for the land within the resource tenure; and
- the flood plain extent.

A.1.2 Rehabilitation and improvement areas

The PMLU identified in the final site design is broken down into rehabilitation areas. The boundaries for the rehabilitation area (RA1 — preclearing native vegetation community) is identified in Figure 15.

A.1.3 Rehabilitation and management milestones and criteria

Rehabilitation milestones and milestone criteria relevant to each rehabilitation area listed in Table 29. There are no management milestones because there are no proposed NUMAs.

A.1.4 PRC plan schedule template

The proposed PRC plan schedule template has been submitted as part of the PRC plan application.

The following conditions are relevant for the commencement of mining:

- PRCP 1;
  - Prior to any significant disturbance occurring within an authorised mining area the holder must nominate in writing to the administering authority, a commencement date for the mining activities in the format of a calendar year. (Note that for the purposes of this condition significant disturbance means mechanical disturbance of the land surface or clearing of vegetation but does not include access tracks for land management, fire breaks or disturbance associated with environmental monitoring);
- PRCP 2; and
  - Mining activities must not commence earlier than the nominated calendar year under condition PRCP 1.
- PRCP 3:
  - Once a calendar year is nominated under condition PRCP 1, that nominated year is to be read in place of 'xxxx' in the PRCP schedule milestone completed by and area available timeframes.



LEGEND

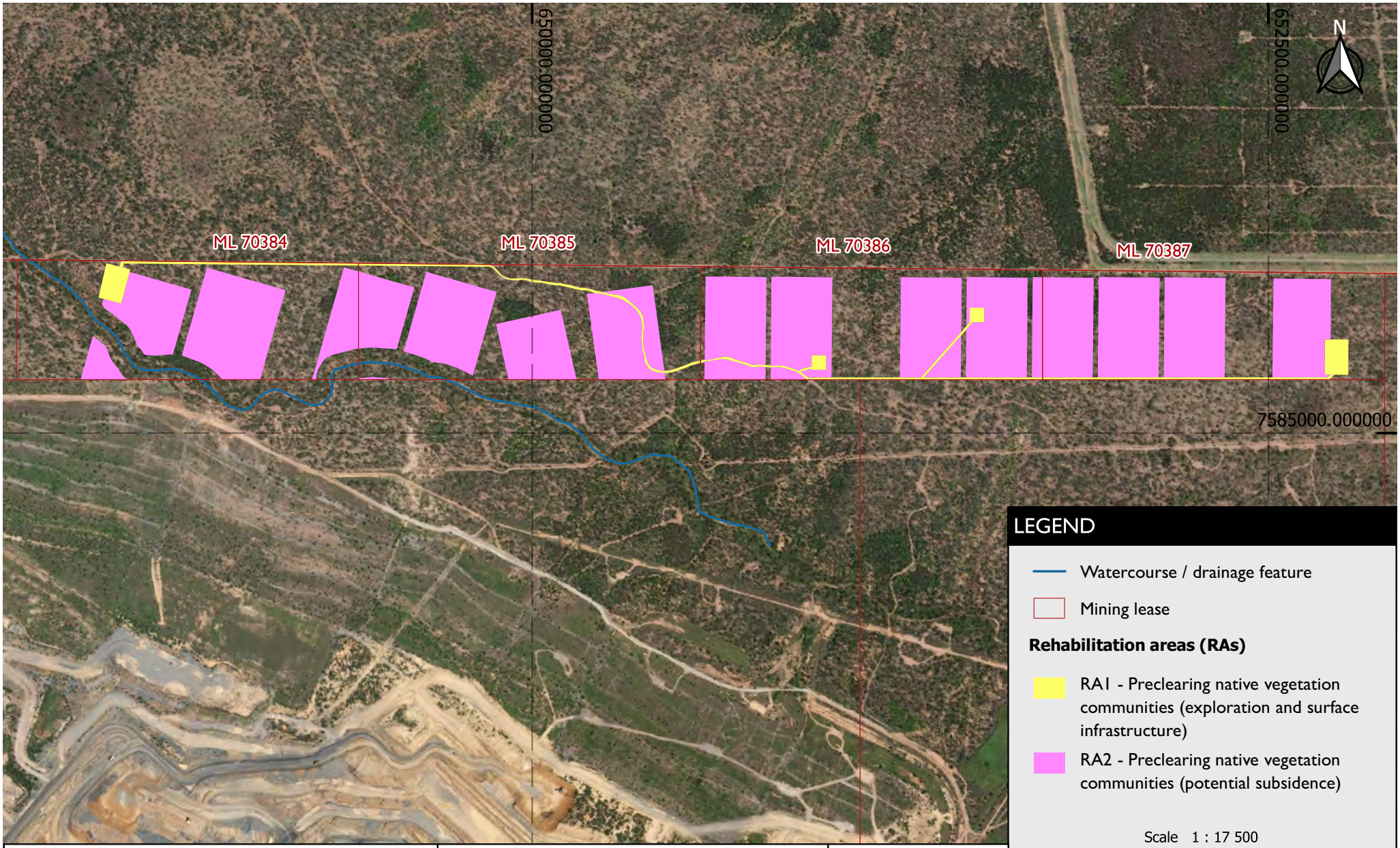
- Watercourse / drainage feature
- Mining lease
- Native ecosystem
- Undisturbed (native ecosystem)

Scale 1 : 17 500

0 0.5 1 km

Project: Progressive Rehabilitation and Closure Plan		Client: Peabody Energy Australia PCI (C&M Management) Pty Limited	
Figure: 14	Title: Final Site Design	Design: SGM Environmental Pty Limited Scale: 1 : 17,500 CRS: GDA20 / MGA zone 55	Date: 23.08.2023 Author: L McDonald

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Project: Progressive Rehabilitation and Closure Plan		Client: Peabody Energy Australia PCI (C&M Management) Pty Limited	
Figure: 15	Title: Rehabilitation Areas (RAs)	Design: SGM Environmental Pty Limited Scale: 1 : 17,500 CRS: GDA20 / MGA zone 55	Date: 23.08.2023 Author: L McDonald

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Appendix B
Hydraulic Report (Cardno 2011)



Coppabella Underground Mine

Hydraulic Report

Job Number LJ8899_D1

Prepared for Macarthur Coal Limited

April 2011

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Document Control

Version	Date	Author		Reviewer	
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APPENDICES

Appendix A WBNM Model Layout; HEC-RAS Model Layout

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1 INTRODUCTION

1.1 Project Background

Coppabella Mine is an open cut coal mine located in the Bowen Basin, near the township of Coppabella, approximately 110km south-west of Mackay. As the existing pit approaches the end of its life open cut operations are scheduled to ramp down, to be replaced by a new underground longwall mining project.

This report outlines the work undertaken in investigating potential mine impacts on the surrounding surface water features.

1.2 Scope of Works

Cardno's scope of works on this project is outlined by the McCollum Environmental document "*Coppabella Underground Project – Scope of Work Surface Water and Flood Study".* This study is intended to assess water quality and quantity in the Humbug Gully watercourse, situated adjacent to the proposed underground project, and identify potential impacts. Key items of work include:

- Mapping and analysis of the drainage catchments within the project area;
- Estimation of the effects of long wall mine subsidence on the watercourse topography;
- Identification of existing flood regimes in Humbug Gully, and the possible changes to flood characteristics as a result of subsidence; and,
- Analysis of the likely bed scour to be expected during representative wet and dry years, for both existing and post-subsidence scenarios.

1.3 Methodology

This scope of works for this study will be completed using the following methodology:

- Review of previous baseline studies, current water management and all other available reports and references;
- Collection of required data including conducting appropriate survey;
- Creation / acquisition of hydrologic model;
- Calibration / review of hydrologic model;
- Creation of hydraulic model;
- Incorporation of proposed works and potential subsidence scenarios;
- Formulation of strategies / recommendations for water management, balance and quality, and flooding aspects, for the proposed site conditions;
- Completion of GIS mapping of flood behaviour;
- Provide advice / plans for future management, monitoring, protection and rehabilitation of water quality / quantity, up to and following site decommissioning.

2 HYDROLOGY

2.1 Catchment Description

Humbug Gully catchment rises in the foothills of the Carborough Range, about 10 km northwest of the existing mine site. The watercourse is ephemeral and is essentially linear in shape, with only minor tributary gullies branching from the main flow path. Total catchment area to the downstream extent of the project area is calculated as 28.97 km^2. A map of the catchment in relation to the project area is presented in Appendix A.

2.2 Design Rainfall Analysis

The software package Watershed Bounded Network Model (WBNM) was chosen for the analysis of design rainfall events. WBNM is an event based hydrologic model designed to provide a physically realistic representation of the catchments it transforms storm rainfall into a flood hydrograph. It has built in lag relations, based on catchment geomorphology, derived using recorded rainfall and flood hydrograph data. Because of this, it requires a minimum of parameters to be evaluated in its basic form, yet still gives good hydrograph reproduction.

In order to model the design rainfall events in WBNM, Humbug Gully catchment was split into a number of sub-catchments, as shown in Appendix A. Individual sub-catchment areas are listed below in Table 1.

Table 1 Humbug Gully Sub-Catchments

Name	Area (ha)
A1	401.4
A2	496.7
A3	204.8
A4	229.5
A5	227.9
A6	389.6
A7	322.7
A8	219.5
A9	405.0
Total	2897.1

Using the hyetographs described in Australian Rainfall and Runoff (AR&R) hydrographs were generated for each sub catchment for the 1, 2, 5, 10, 20, 50 and 100 year Average Recurrence Interval (ARI) design rainfall events, with storm durations ranging from 90 to 360 minutes.

The catchment is ungauged and as such no calibration against recorded rainfall events is possible. As an alternative, the Rational Method was used to calculate peak discharges at the catchment outlet, and compared against the values obtained from WBNM, as shown in Table 2.

Table 2 WBNM Comparison to Rational Method

ARI (y)	Peak Flow Estimate (m3/s)		
	WBNM	Rational Method	Difference (%)
2	37.7	36.2	- 4.1
5	54.7	56.2	+ 2.7
10	65.7	69.1	+ 4.9
20	80.3	87.0	+ 7.7
50	104.6	110.5	+ 5.3
100	122.9	129.9	+ 5.4

The comparison shows that there is a good level of agreement between the two methods, particularly for the higher ARI events, and provides sufficient confidence in the validity of using the WBNM hydrographs as inputs to our hydraulic analysis.

Sub-catchments A5 to A9 fall within the HEC-RAS model extent (refer Section 3). Critical storm durations (in terms of total flow at the outlet) for these catchments were found to increase from 180 minutes to 360 minutes with increasing distance downstream distance. Therefore, this requires three sets of design hydrographs to be tested in HEC-RAS. A summary of peak flows by sub-catchment and storm duration is presented in Table 3.

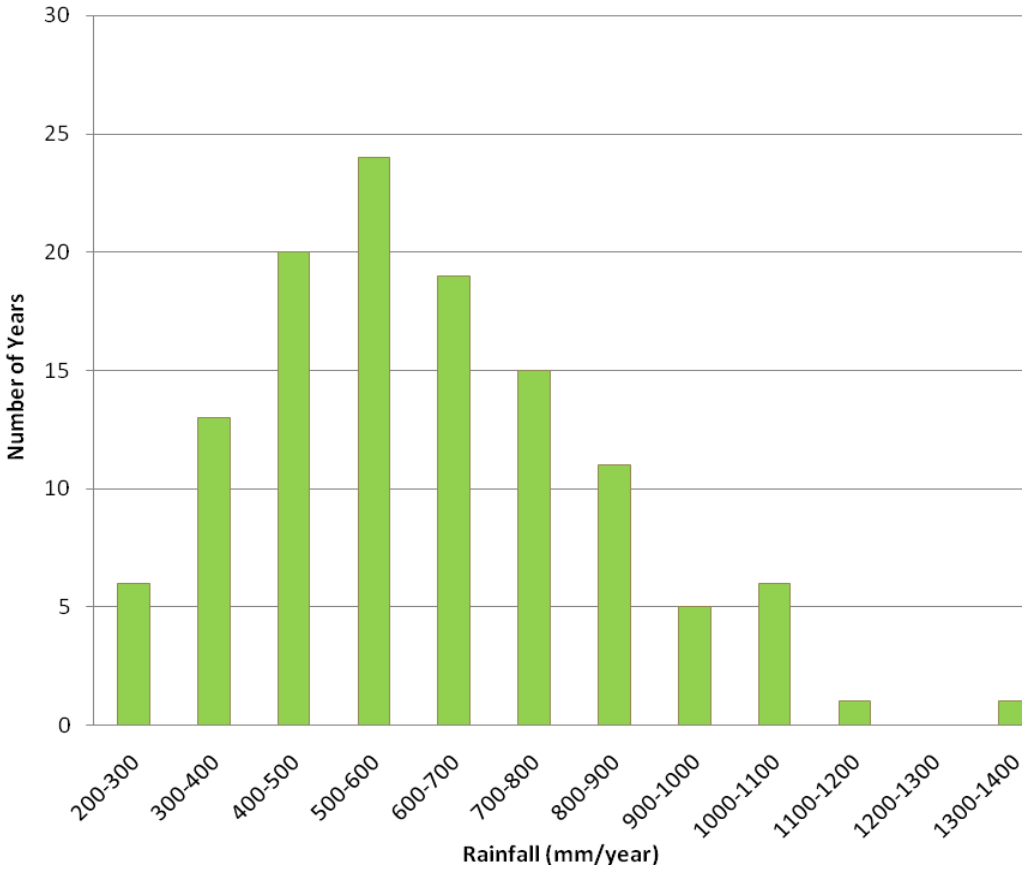
Table 3 Design Storm Event Peak Flows

ARI (y)	Item	Sub-catchment Name				
		A5	A6	A7	A8	A9
100	Peak Flow (m^3/s)	93.9	104	113.7	119.9	129.9
	Duration (min)	*180*	*270*	*360*	*360*	*360*
50	Peak Flow (m^3/s)	80.7	89.2	97.1	102.3	110.5
	Duration (min)	*180*	*270*	*360*	*360*	*360*
20	Peak Flow (m^3/s)	64.7	71.5	77.8	81.4	57
	Duration (min)	*180*	*360*	*360*	*360*	*360*
10	Peak Flow (m^3/s)	52.5	57.6	62.4	65.1	69.1
	Duration (min)	*180*	*360*	*360*	*360*	*360*
5	Peak Flow (m^3/s)	43.8	47.5	51.2	53.3	56.2
	Duration (min)	*180*	*270*	*360*	*360*	*360*
2	Peak Flow (m^3/s)	30	31.7	33.5	34.6	36.2
	Duration (min)	*180*	*270*	*360*	*360*	*360*
1	Peak Flow (m^3/s)	19.7	20.5	21.2	21.6	22.5
	Duration (min)	*180*	*180*	*180*	*360*	*360*

2.3 Recorded Rainfall Analysis

Recorded daily rainfall data spanning 121 years from 1889 to 2009 was obtained from the Bureau of Meteorology. Daily values were summed to calculate annual totals, which were then examined to find representative wet and dry years to be used to generate flood hydrographs for the Humbug Gully bed scour analysis. The distribution of annual rainfall is shown in Figure 1.

Figure 1 Historic Annual Rainfall Distribution



For the purpose of this report a dry year is defined as having an annual total below the 10th percentile and a wet year above the 90th percentile. On this basis, 1992 and 1998 were chosen as the dry and wet years, respectively, as outlined in Table 4.

Table 4 Annual Rainfall Percentiles

Year	Percentile	Annual Rainfall (mm)
1992	6th	315.9
Dry year threshold	<10th	< 364.5
Wet year threshold	>90th	> 902.8
1998	93rd	957.7

The daily rainfall totals for the two chosen years were imported into the software package MUSIC and routed through the Humbug Gully catchment to generate creek flow hydrographs, which in turn serve as inputs to the sediment transport analysis discussed in Section 3.4.

Runoff characteristics of the two chosen years are summarised in Table 5.

Table 5 Wet and Dry Year Runoff Characteristics

Calendar Year	Average Flow (m^3/s)	Maximum Flow (m3/s)	Number of Flow Days
1992 (dry year)	1.3	12.3	82
1998 (wet year)	2.6	54.2	121

3 HYDRAULICS

3.1 Hydraulic Modelling Software

Hydraulic Engineering Center – River Analysis System (HEC-RAS) is a versatile hydraulic modelling package capable of one-dimensional steady or dynamic flow calculations, sediment transport and mobile bed computations, and water temperature modelling. It is applicable to both natural and constructed channels and can model a wide range of hydraulic structures such as bridges, weirs and culverts.

HEC-RAS was chosen for this study primarily for its detailed sediment transport module. It is designed to simulate long term trends of scour and deposition in a stream channel that result from modifications to frequency and duration of water discharge or channel geometry. For the purposes of this report the module will be used to estimate a base-line erosion/accretion profile in Humbug Gully, and to assess the changes to this profile caused by possible mine subsidence scenarios.

3.2 Survey Data

Several data sources were used to describe the topography of the study area, including:

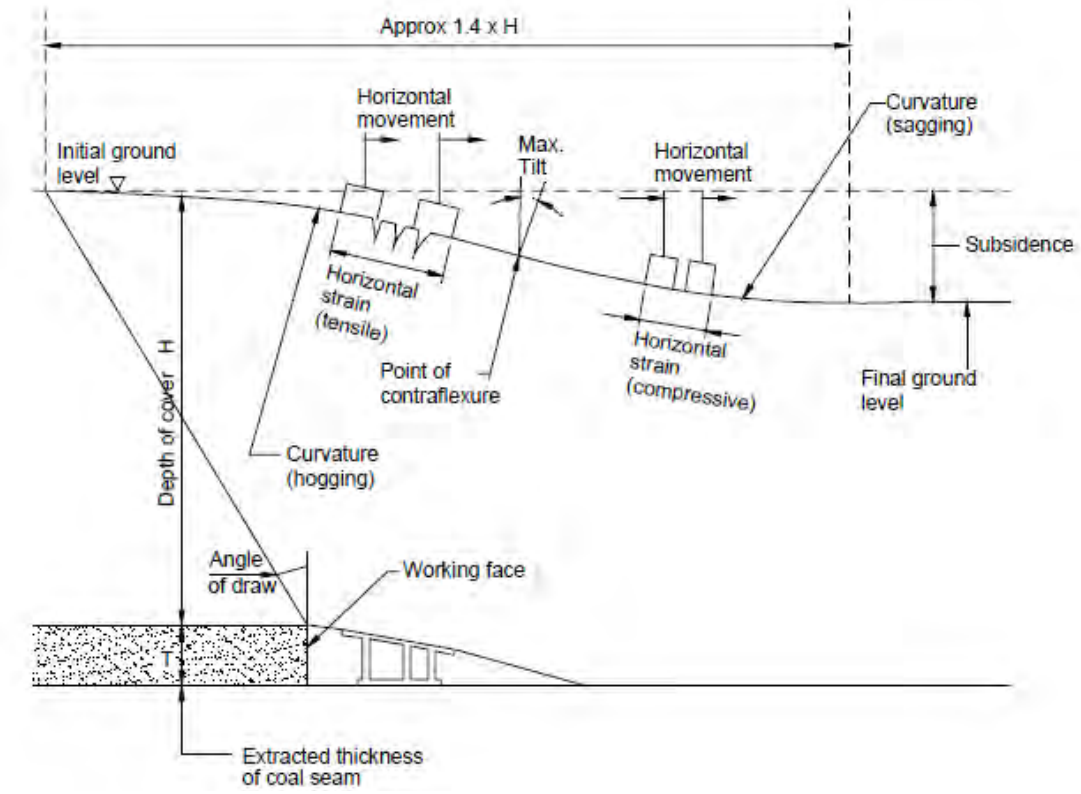
- Contours, at 2 metre intervals;
- Detailed site survey, in xyz format;
- Digital Terrain Model, at 20m grid resolution.

The data were processed in 12d to create a composite terrain surface covering Humbug Gully. Cross-sections were then taken at regular intervals along the watercourse, with particular attention to constrictions, tributaries and other hydraulic controls. The sections were exported from 12d to form the basis of the HEC-RAS geometry file. The HEC-RAS model layout is shown in Figure 2 of Appendix A.

3.3 Subsidence Data

In longwall mining a large panel of coal, several metres high and several hundred metres in width, is extracted from the surrounding coal seam by shearing machinery travelling back and forth across the coal face. The mining process creates a void behind the working face, into which the roof is subsequently allowed to collapse. The resulting fracturing and settlement propagates upwards through the above-lying strata and manifests as subsidence of the ground above. Figure 2 shows the development of a typical subsidence profile behind the working face.

Figure 2 Typical Subsidence Profile



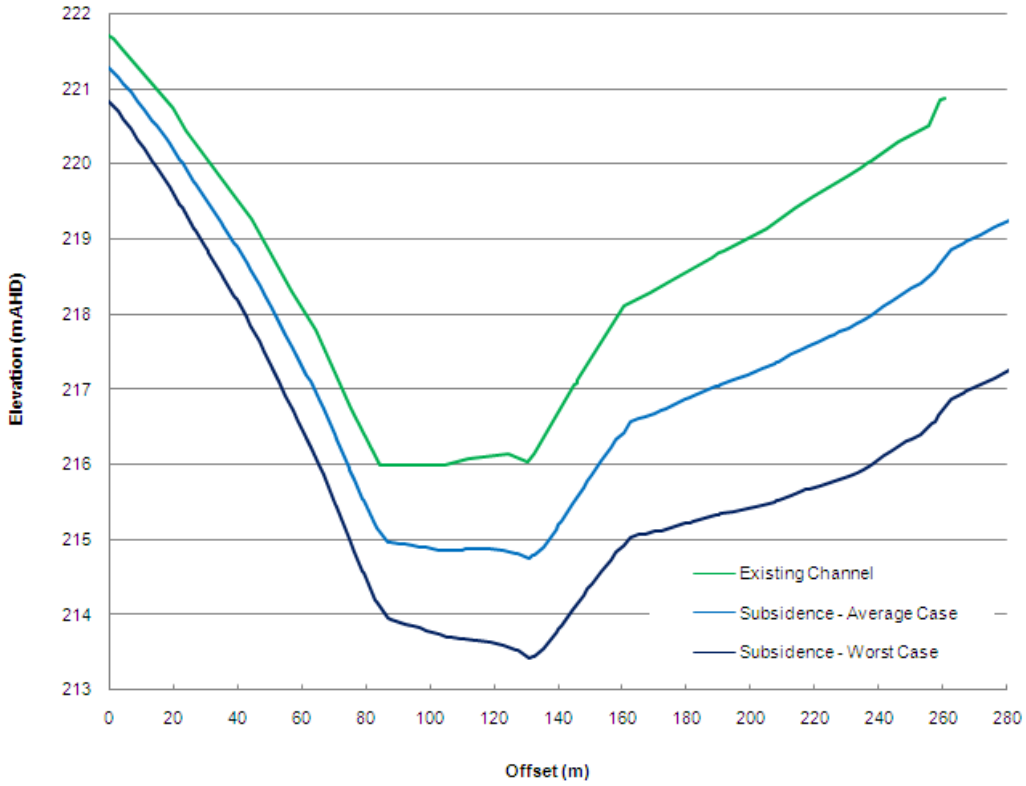
As can be seen above, a line projected at the angle of draw from the working face to the surface describes the outermost limit of subsidence. Similarly, by projecting upwards in both the x and y axes from the final extent of mined coal, the limits of subsidence can be estimated for the entire project. Such an estimate describing the final subsidence extents was provided by Macarthur Coal, in the form of a CAD polygon.

In assessing the post-subsidence ground profile, several assumptions are made:

- In the transition zone between no subsidence and maximum subsidence (ie. the dimension marked in Figure 1 as “Approx 1.4 x H”) the ground profile has been assumed to transition linearly in order to simplify the alterations required to the terrain model
- The depth of cover, H, is assumed to remain constant at 215m – around the middle of the 160m-260m range of expected coal depths. This in turn sets 1.4 x H equal to 300m.
- At this preliminary stage of mine planning the entire underground area is assumed to be mined, and no allowance is made for supporting pillars. This adds a degree of conservatism to the results as the additional roof support provided by coal pillars can significantly reduce surface subsidence.
- Two subsidence scenarios will be considered: an average scenario with a maximum vertical displacement of 2 metres, and a worst case scenario with a maximum vertical displacement of 4 metres.

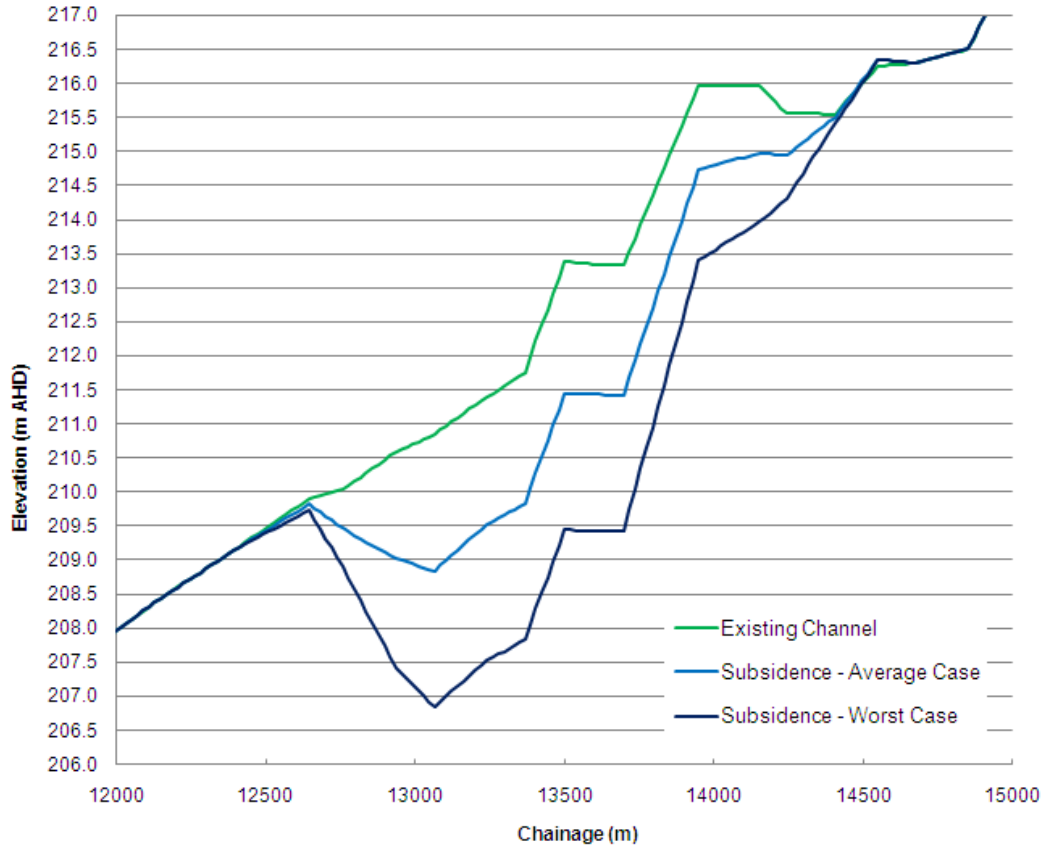
Using these assumptions two new ground surface elevation models were created in 12d to reflect the likely changes to the topography. Cross-section were extracted at the same locations as per the existing case, and exported to HEC-RAS. Figure 3 illustrates the typical change to a cross section within the subsidence zone, whilst Figure 4 profiles the longitudinal change in the creek bed invert level.

Figure 3 Effect of Creek Bed Subsidence on HEC-RAS Cross-Section 13952



In this particular instance, the left edge of the cross-section sits near the outer extent of subsidence and only a minor downwards vertical shift is noted. Moving to the right, predicted subsidence increases up to the maximum of 2m or 4m respectively, at around offset 230m. The effects that this has on the hydraulic regime is assessed in Section 4.1

Figure 4 Longitudinal Profile of Bed Invert Level



3.4 Sediment data

Samples of the bed material at three locations in Humbug Gully were collected by Coppabella site staff and sent to Australian Laboratory Services in Brisbane for testing and analysis. Sample locations are denoted by the red triangles on Figure 5, and the resulting particle size distribution curves are detailed in Table 6.

Figure 5 Creek Bed Sample Locations



Table 6 Particle Size Distribution of Creek Bed Samples

Sieve Size (mm)	Percentage Finer Than		
	Site 1	Site 2	Site 3
0.002	1	4	1
0.06	3	5	4
0.075	3	5	5
0.15	6	10	10
0.3	28	38	38
0.425	66	71	72
0.6	91	93	92
1.18	100	100	99
2.36	100	100	100

The particle size distribution curves show the samples to be composed predominately of silt and fine grained sand. The samples were taken on the dry creek bed surface. It is currently unknown how the grading of bed material might vary with depth, and it was therefore assumed that the samples collected are representative of the typical depth likely to be eroded by the flooding.

4 RESULTS

4.1 Design Storm Events

The HEC-RAS steady flow analysis module was used to determine peak water surface levels and velocities resulting from the peak runoff values calculated in Section 2.2. The following cases were considered:

- Existing case: topography 'as-is'
- Average case: topography lowered by up to 2m due to mine subsidence
- Worst case: topography lowered by up to 4m due to mine subsidence

For each case simulations were carried out for the range of ARI's between 1 and 100 years, and across the three identified critical storm durations, for a total of 63 model runs. Results were analysed to identify the storm duration creating the highest water level at each location within Humbug Gully, to give an overall 'composite' of peak levels throughout the reach.

Peak water level and water level afflux plots for the 100 year ARI design storm are presented below in Figures 5 and 6. Longitudinal peak velocity and velocity afflux plots are presented in Figure 7 and Figure 8 respectively.

Figure 6 100yr ARI Peak Water Surface Level

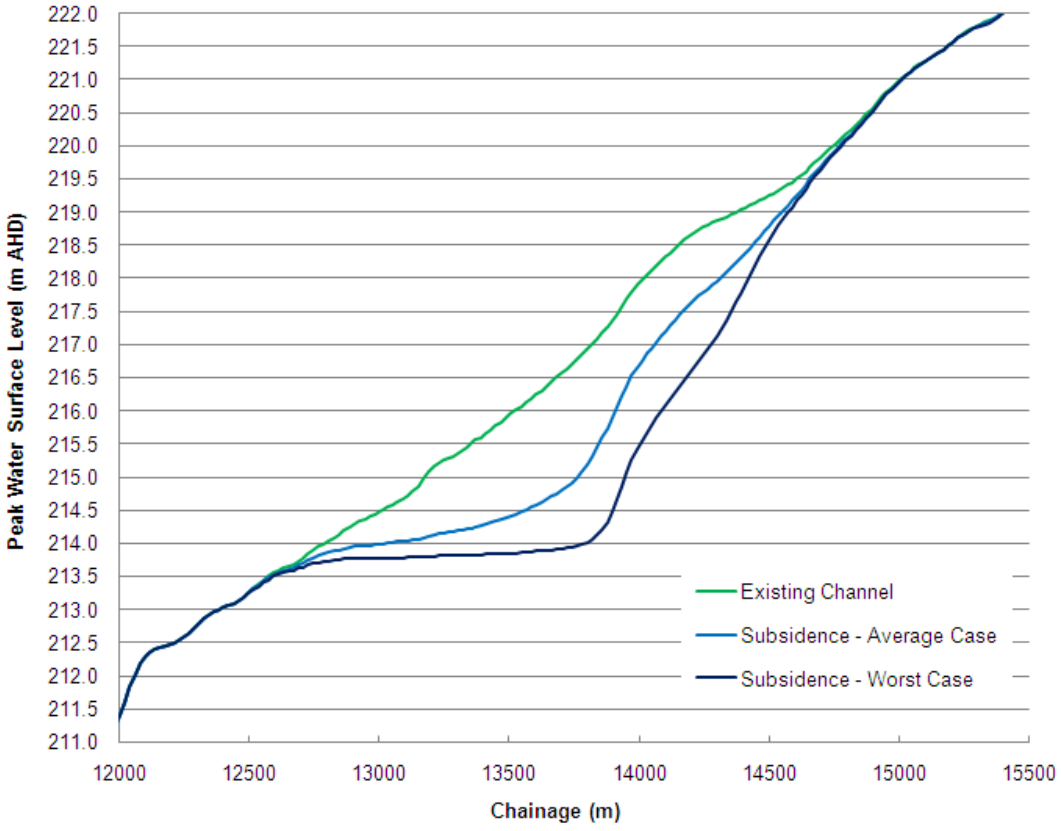


Figure 7 100yr ARI Water Surface Level Afflux

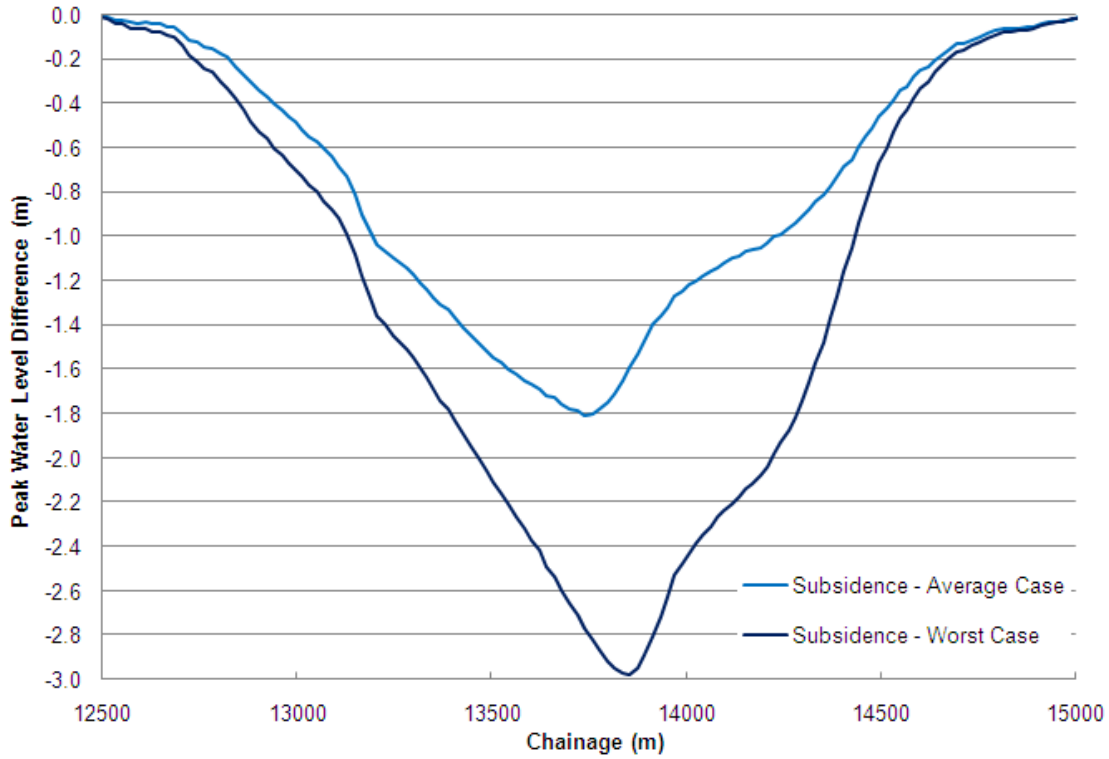


Figure 8 100yr ARI Peak Velocities

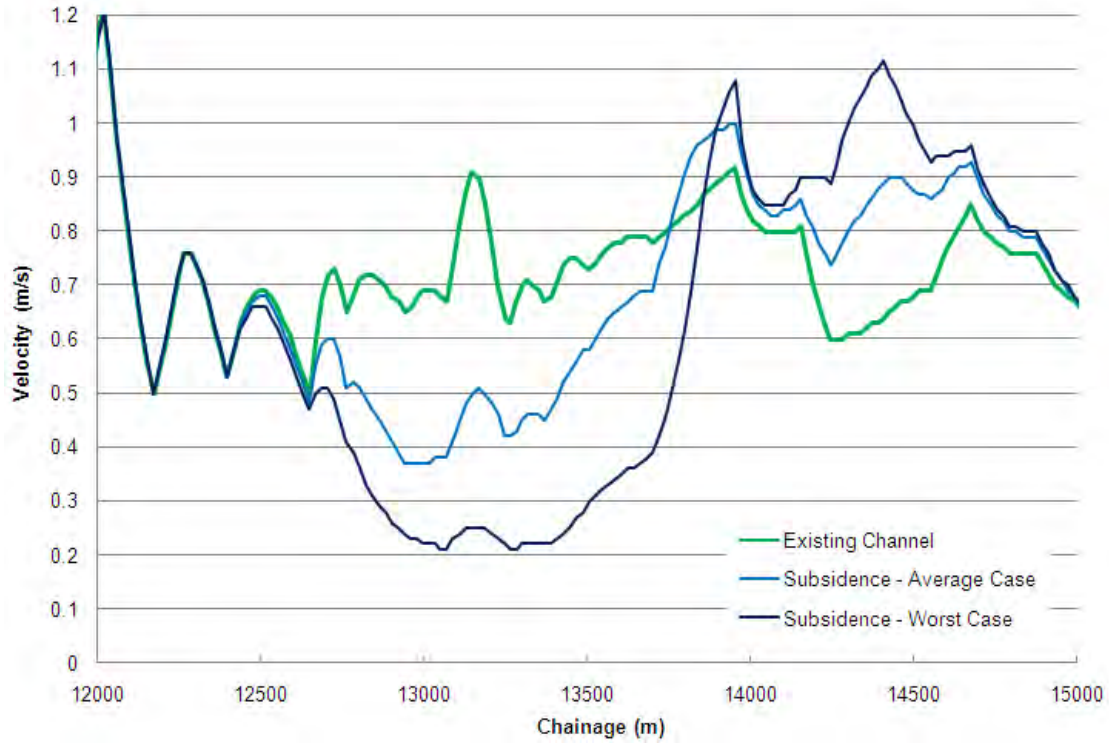
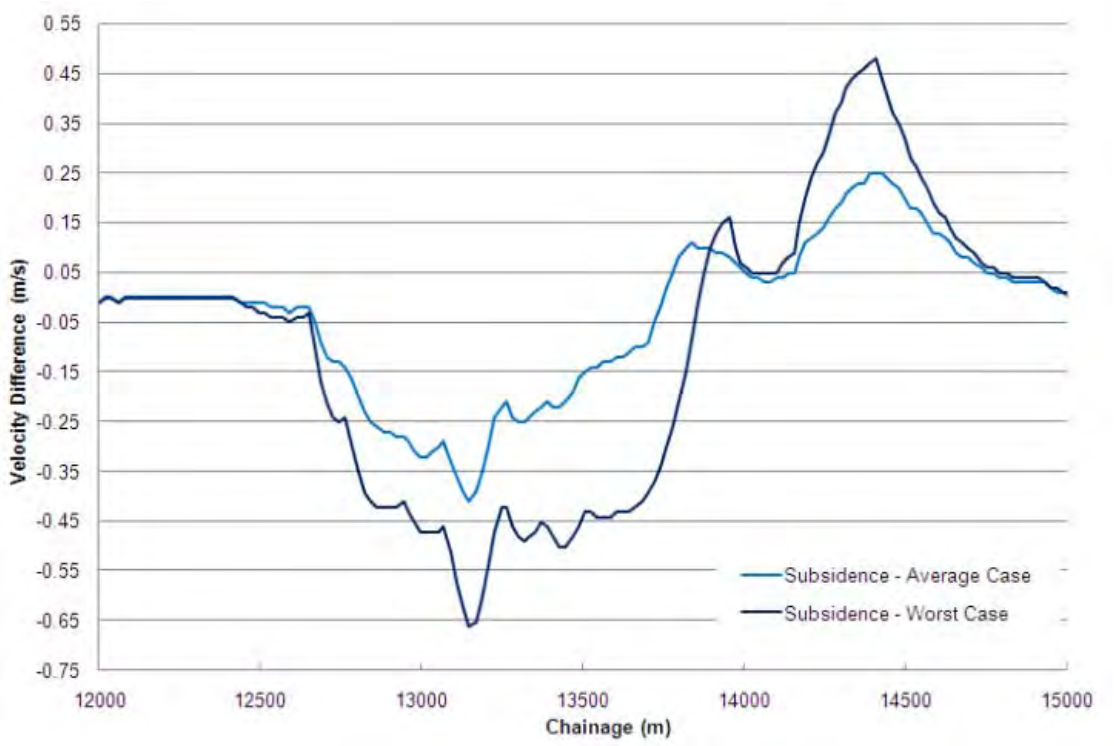


Figure 9 100yr ARI Velocity Afflux



The results clearly show the effect that lowering the bed level has upon peak water surface levels, with a marked decrease evident in Humbug Gully between Chainage 12500 and Chainage 14500. As could be expected, the decrease in water levels roughly parallels the expected longitudinal subsidence profile shown in Figure 4. A similar trend, albeit with lower absolute levels, is observed for the smaller magnitude ARI's (not shown in the figures above).

The largest change is peak water level for the average subsidence case is -1.81m and occurs at Ch 13739. For the worst case subsidence the largest decrease is predicted to be 2.98m, at Ch 13836. During periods of low or no-flow the lowered bed levels may cause isolated pools to appear.

The lowered bed levels cause a flattening of the hydraulic grade line in the region from Ch 12750 to Ch 13750. As a result peak velocities are predicted to decrease, by up to 0.65 m/s. Further upstream a small increase is noted, however both positive and negative changes are relatively small in magnitude, and are unlikely to cause adverse environmental impacts.

Overall, the ephemeral nature of the creek and its isolated location mean that the changes to hydraulic regime from subsidence are unlikely to cause deleterious impacts further downstream.

4.2 Historic Storm Events

The HEC-RAS quasi-unsteady sediment transport module was used to assess the likely changes to the bed level that could due to erosion and accretion throughout one calendar year. For both the historically wet year (1998) and historically dry year (1992), the following cases were considered:

- Existing case: topography 'as-is'
- Average case: topography lowered by up to 2m due to mine subsidence
- Worst case: topography lowered by up to 4m due to mine subsidence

For each case, a total of one year of historic rainfall runoff was routed through the HEC-RAS model and the results were analysed to assess to what degree the change in bed level influences the predicted sediment transportation rate.

For the dry year, predicted changes to the creek bed level after one year of simulated flows are presented below in Figure 10, whilst longitudinal bed profiles are presented in Figure 11 and 12. Similarly, bed changes for the wet year are presented in Figure 13, with longitudinal profiles shown in Figure 14 and Figure 15.

Figure 10 Estimated Bed Level Change – Dry Year (1992)

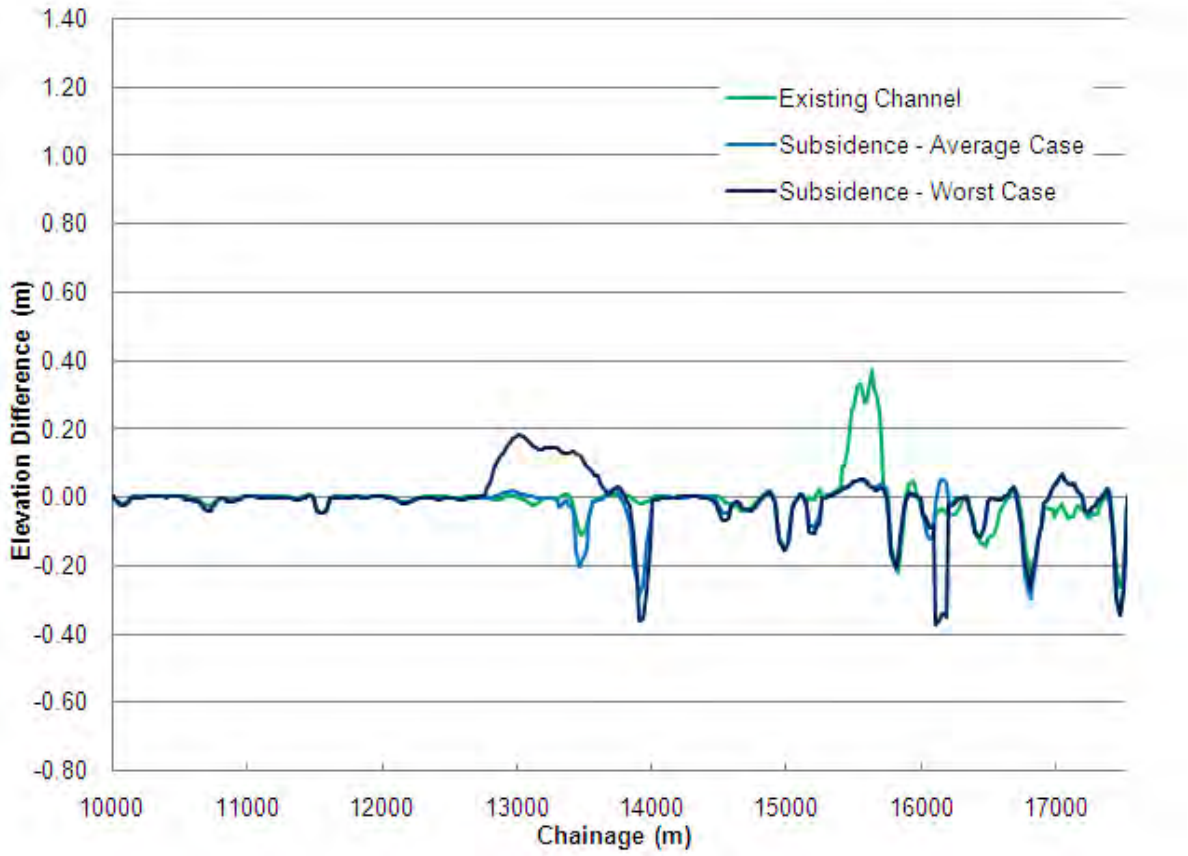


Figure 11 Longitudinal Bed Profile – Dry Year (1992), Average Case Subsidence.

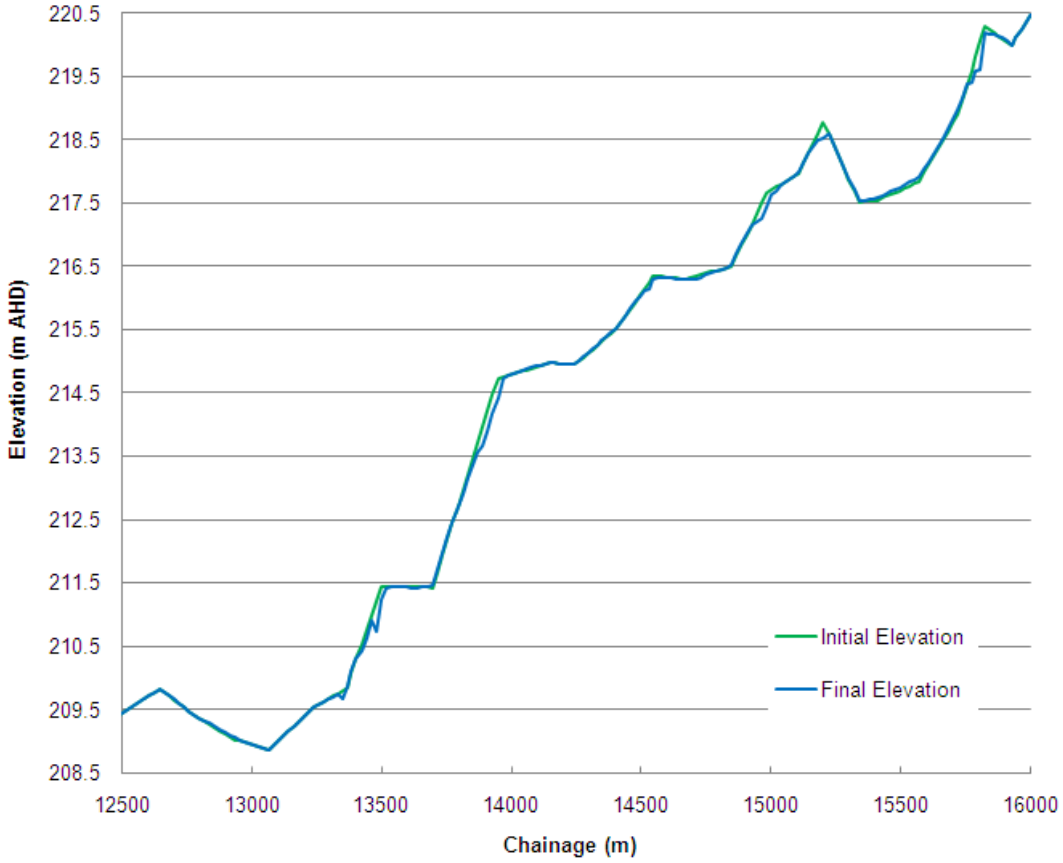
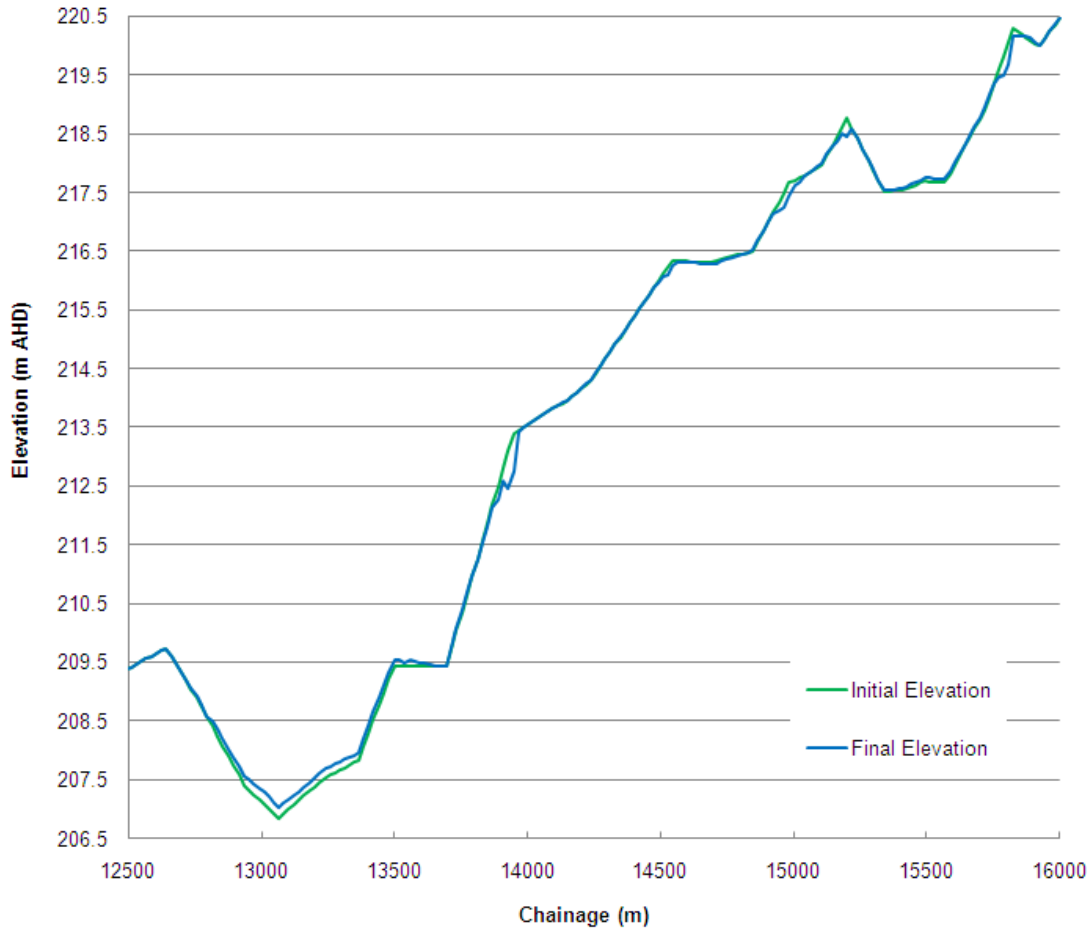


Figure 12 Longitudinal Bed Profile – Dry Year (1992), Worst Case Subsidence.



In the region affected by subsidence (ie. Ch 12700 to Ch 14700), results from the Existing Case and Average Subsidence Case are roughly similar to one another, whilst in the Worst Case 0.2 m of accretion is predicted. It would appear that large depressions in the creek bed have a tendency to fill up with sediment, as might well be expected. The decreased velocities in this region (as discussed in Section 4.1) provide a good opportunity for entrained sediment to settle to the bed, so that further downstream the bed profile remains relatively unchanged.

Elsewhere approximately 0.4 m of accretion is predicted at Chainage 15500, but only in the Existing Case. It is difficult to put forward a reasoned argument for why this should be so, suffice to say that the sediment transport function is complex, and sensitive to small changes in input variables such as longitudinal grade.

Figure 13 Estimated Bed Level Change – Wet Year (1998)

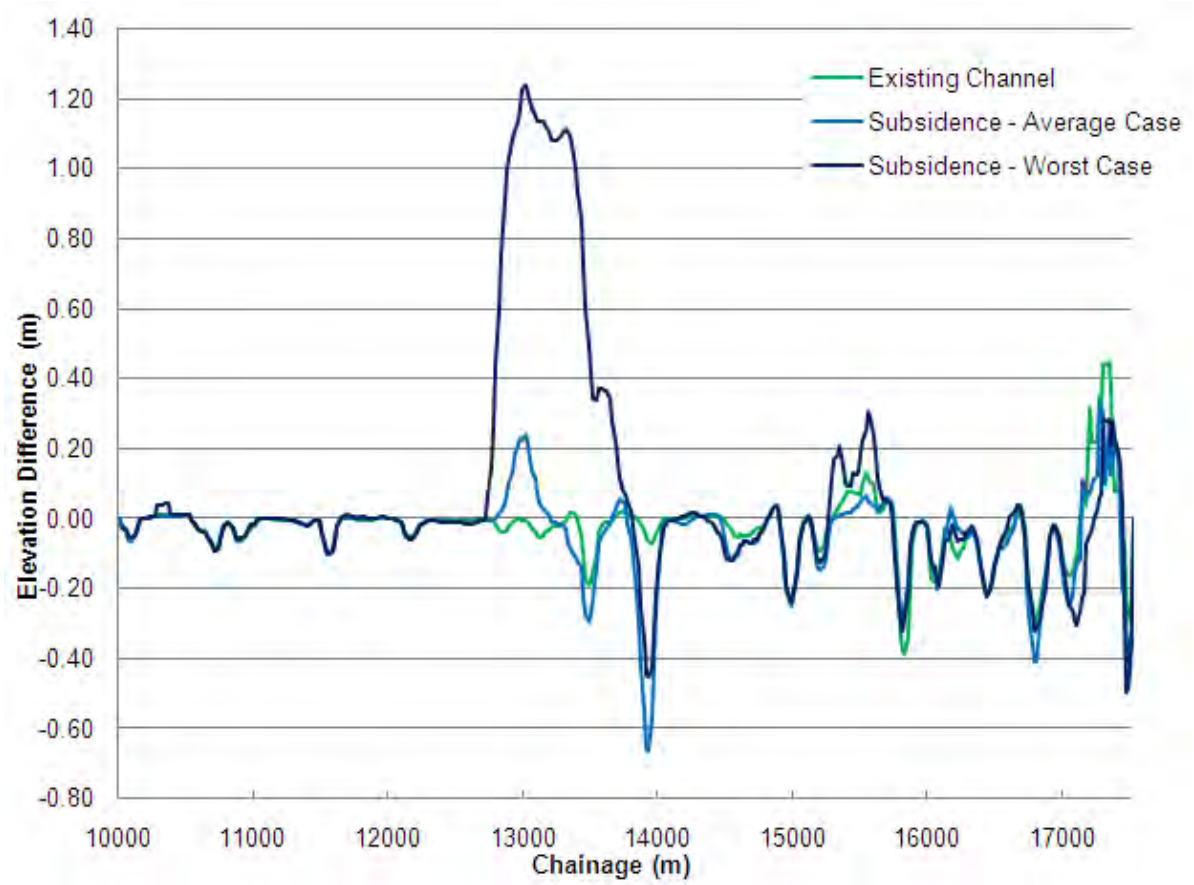


Figure 14 Longitudinal Bed Profile – Wet Year (1998), Average Case Subsidence.

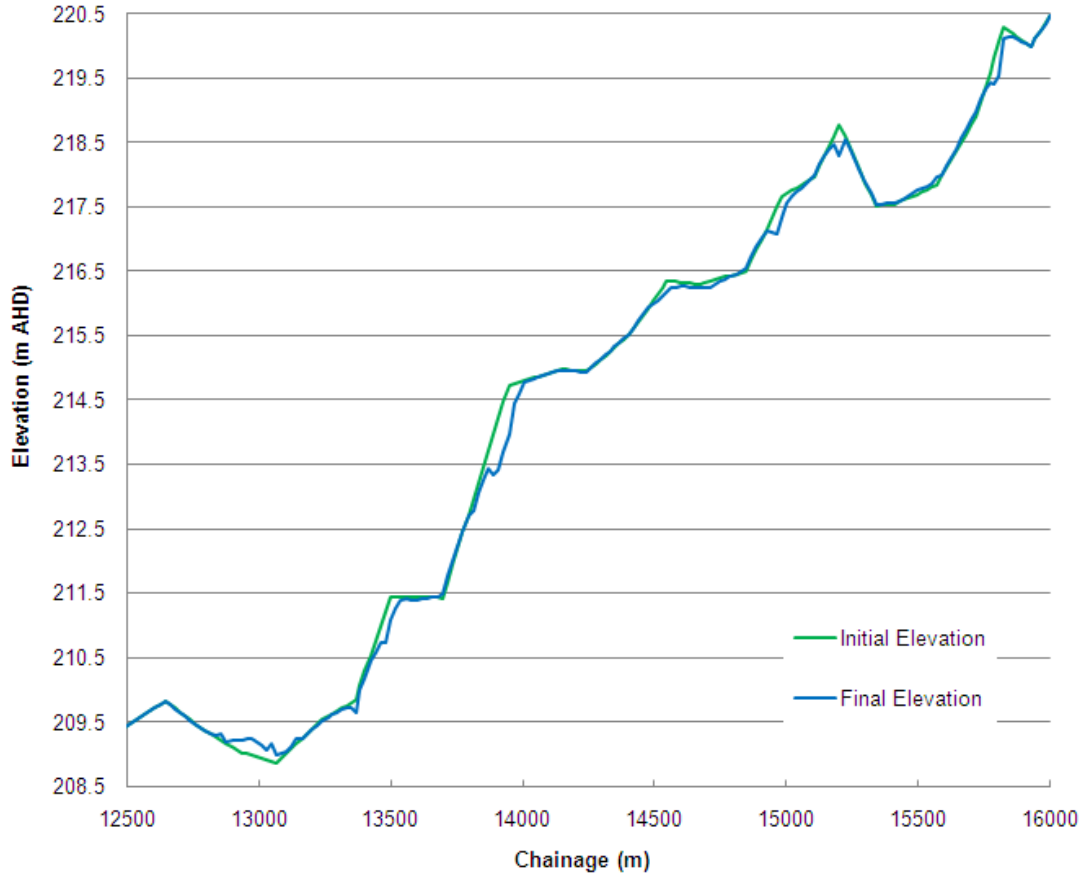
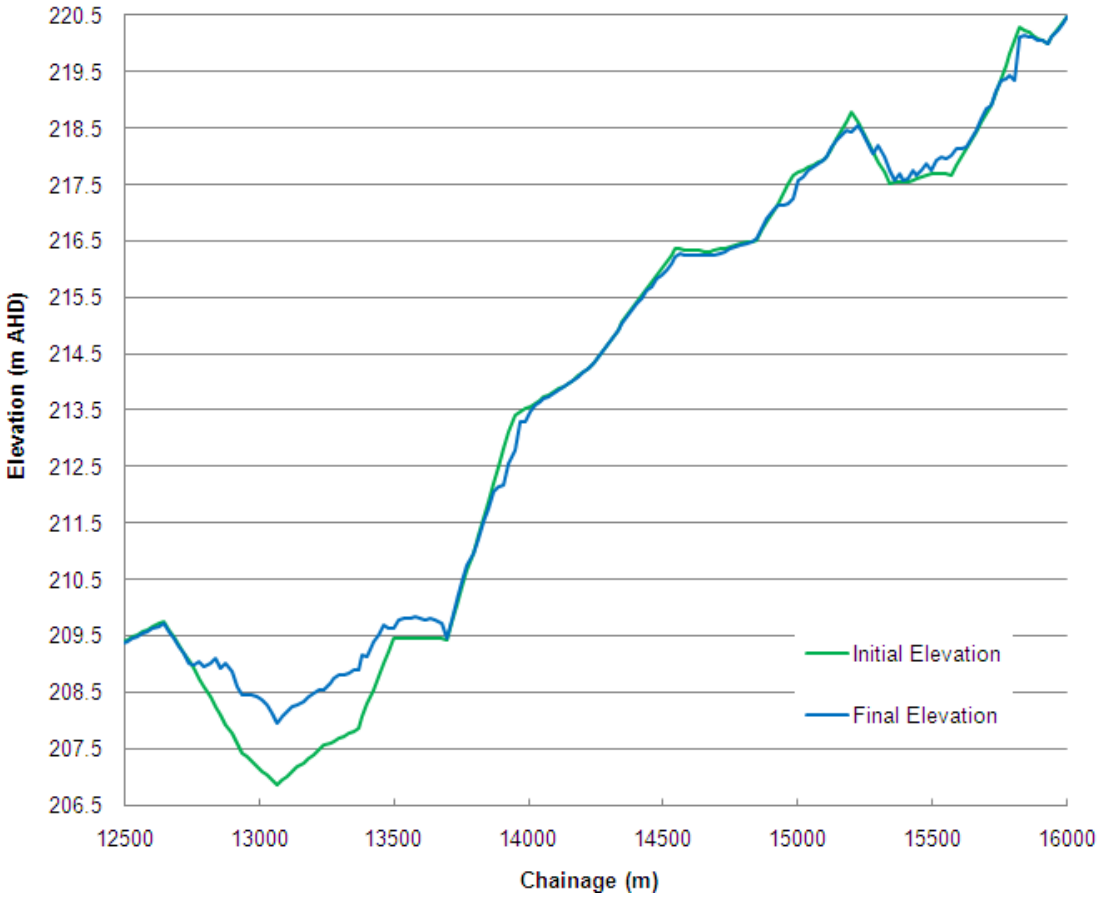


Figure 15 Longitudinal Bed Profile – Wet Year (1998), Worst Case Subsidence.



The wet year results exhibit similar characteristics to those of the dry year, albeit more exaggerated, as the greater annual flow results in an increase in the total volume of transported sediment. Most notably, this has affected the deposition profile for the Worst Case such that the bed level within the maximum subsidence zone has increased by about 1.2 m.

As with the Dry Year simulations, only minor bed level changes are predicted downstream of the subsidence zone.

Table 7 outlines the average amounts of erosion and accretion for each case.

Table 7 Average Erosion and Accretion Amounts

Year and Case	Average Erosion (m)	Average Accretion (m)	Average of All Changes (m)
Dry Year – 1992			
Existing Channel	- 0.03	+ 0.03	- 0.01
Average Case Subsidence	- 0.05	+ 0.01	- 0.02
Worst Case Subsidence	- 0.05	+ 0.04	- 0.01
Wet Year – 1998			
Existing Channel	- 0.07	+ 0.07	- 0.03
Average Case Subsidence	- 0.09	+ 0.07	- 0.04
Worst Case Subsidence	- 0.09	+ 0.36	- 0.09

Overall, the sediment transport simulations predict outcomes that appear reasonable, however it should be noted that the model is uncalibrated with respect to important transport function variables such as Shield's Number and Threshold Mobility. These are typically determined via laboratory experiment and are beyond the scope of this report.

5 CONCLUSIONS AND RECOMMENDATIONS

An investigation has been conducted in order to better understand the potential effects of longwall coal mining on water courses close to the Coppabella mine site. Hydrologic modelling has been undertaken to develop both design storm event and historical runoff, whilst hydraulic modelling has been to better understand how mine subsidence affects water levels, velocities, and sediment transport rate. Key conclusions and recommendations from this work are summarised below.

- The ephemeral Humbug Gully is the only watercourse of note close to the proposed longwall mining area. The total catchment area was found to be 28.97 km2. Catchment runoff has been modelled using WBNM for design rainfall, and MUSIC for historic rainfall.
- A comparison between WBNM design flood events and the Rational Method showed a good level of agreement. For ARI's between 2 years and 100 years the results were within at most 8% of each other, from which we can conclude that the adopted hydrologic model parameters are appropriate for the catchment conditions.
- Representative wet and dry years were selected from an annual rainfall series spanning 121 years. 1992 was chosen as the dry year, with annual rainfall of 315.9 mm placing it in the 6th percentile. 1998 was chosen as the wet year, with annual rainfall of 957.7 mm placing it in the 93rd percentile. Daily rainfall totals from these two years were routed through MUSIC to obtain the historic streamflows used in the sediment modelling.
- In the absence of a finalised mine plan and detailed geological data, the extent of longwall subsidence was estimated by using the proposed mining extents and some rules of thumb as a guide. Two cases were considered for total subsidence depth – 2m and 4m – as advised by Macarthur Coal engineers. It is recommended that subsidence parameters be reviewed in the future to ensure they remain appropriate as the mine planning proceeds towards the final design.
- Three creek bed soil samples were collected and analysed, and the resulting PSD curves used as the basis for the transport function in the HEC-RAS sediment transport modelling. The samples were collected at the surface of the creek bed, and due to natural armouring and sorting effects, may not be representative of the underlying strata. Cardno recommends exercising caution in interpreting the sediment transport results, until such time as more information is made available regarding the changes in soil composition with depth.
- The effect of subsidence on the hydraulics of Humbug Gully was investigated by modifying HEC-RAS creek bed levels and simulating design storm events. In general, subsidence was predicted to cause a decrease in peak water levels, with the magnitude of change being roughly equivalent to the depth of subsidence – a maximum water level decrease of 1.81 m and 2.98 m for the average and worst case simulations, respectively.
- Peak velocities are predicted to decrease by up to 0.65 m/s in the area affected by subsidence, due to the flatter hydraulic grade line caused by the subsidence. This is consistent with the observation that a localised decrease in bed levels will generally lead to the creation of a slower flowing pool area, surrounded at either end by a ripple.
- Sediment transport simulations were performed to assess the likely changes to bed profile that might occur for representative wet and dry years. In each case the simulation was run using the existing bed profile, anticipated bed profile under average subsidence conditions, and anticipated bed profile under worst case subsidence conditions. The key finding was that large bed depressions (ie. caused by mine subsidence) were likely to accumulate sediment at a higher rate than other regions of the creek. Otherwise, erosion and accretion were not predicted to be severe, with the largest average change in bed level predicted to be -0.09m for the wet year, high subsidence case.

6 QUALIFICATIONS

This report has been prepared by Cardno Lawson and Treloar for Macarthur Coal, specifically to provide advice in relation to the proposed underground mine expansion at the Coppabella mine site. As such, its application is limited and any third parties wishing to use or reference the report should seek advice from Cardno as to its applicability.

In preparing this report, we have relied upon information provided by others, including:

- AR&R Design Rainfall Intensities;
- BOM historical rainfall records
- Contour and ground survey information;
- Proposed mine expansion drawings.
- Soil sample particle size distribution curves

The accuracy of the report is contingent upon the accuracy of this information.

Whilst this report accurately assesses peak flows from design storms, the local catchments are ungauged and consequently future observed flows may vary from those predicted by the hydrologic model.

It should be noted that the sediment transport model is uncalibrated with respect to important transport function variables such as Shield's Number and Threshold Mobility. These are typically determined via laboratory experiment and are beyond the scope of this report.

Appendix A

WBNM & HEC RAS Model Layout



0.5 0 0.5 1 1.5 2.0 2.5km
1:50,000

Images sourced from Near Map 2011.
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Scale 1:50,000 (A3)

FIGURE A1
WBNM MODEL LAYOUT

Rev: Orig. Date: March 2011

Project No.: LJ8899

Coomera Town Centre

CAD FILE: O:\WorkLAT\J8899\Figures\Figure 1 - WBNM Model Layout.dwg
XREF's:

PRINT DATE: 17 March, 2011 - 2:20pm

Cardno Lawson Treloar



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150 0 150 300 450 600 750m
1:15,000

Scale 1:15,000 (A3)

FIGURE A.2
HEC-RAS MODEL LAYOUT

Rev: Orig. Date: April 2011

Project No.: LJ8899

PRINT DATE: 30 March, 2011 - 3:54pm

CAD FILE: O:\WorkLAT\J8899\Figures\Figure 1 - WBNM Model Layout.dwg
XREF's:

Appendix C
Aquatic Ecology report (ESM 2011)



Coppabella Underground Project

Aquatic Ecology

Draft

Prepared for:

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Draft

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Summary

The report has been prepared for Ecological Survey and Management. It contributes baseline aquatic ecology information for the proposed Coppabella Underground Project (the Project), which involves an underground expansion of the existing Coppabella Mine.

The Coppabella Mine is in the Isaac-Connors Catchment of the Fitzroy Basin. Humbug Gully flows through the proposed underground expansion area, and into Harrybrandt Creek approximately 12 km downstream of the expansion area.

The aquatic habitat, water quality, aquatic flora, and macroinvertebrate and fish communities of Humbug Gully were assessed during a field survey in February 2010. Three sites were surveyed: one upstream of, one within (site 2), and one downstream of the proposed underground expansion area.

The biological values of aquatic ecosystems within the study area are relatively low when compared with those of the wider catchment. Environmental values are dictated primarily by the ephemeral nature of Humbug Gully, although agricultural development and mining within the region has likely influenced water quality and the physical characteristics of aquatic habitats in the study area.

Physico-chemical water quality in the study area was poor to moderate during the survey, and was characterised by high turbidity and low dissolved oxygen levels. Biodiversity was low, with only fish and macroinvertebrate species that are tolerant of varying and often harsh conditions inhabiting the study area. Nevertheless, the creeks within the study area provide 'upstream' dispersal habitat for the fish species that were recorded in the study area (and possibly breeding habitat for some species). Therefore, macroinvertebrate and fish communities found within the study area are likely to contribute to the success of downstream populations through movement/migration.

No endangered, vulnerable, or near threatened species of aquatic flora or fauna have been recorded from, or are likely to occur in, the waterways of the study area. There are no wetlands of regional, State or national significance in the study area.

Draft

1 Introduction

The report has been prepared for Ecological Survey and Management. It contributes baseline aquatic ecology information for the proposed Coppabella Underground Project (the Project).

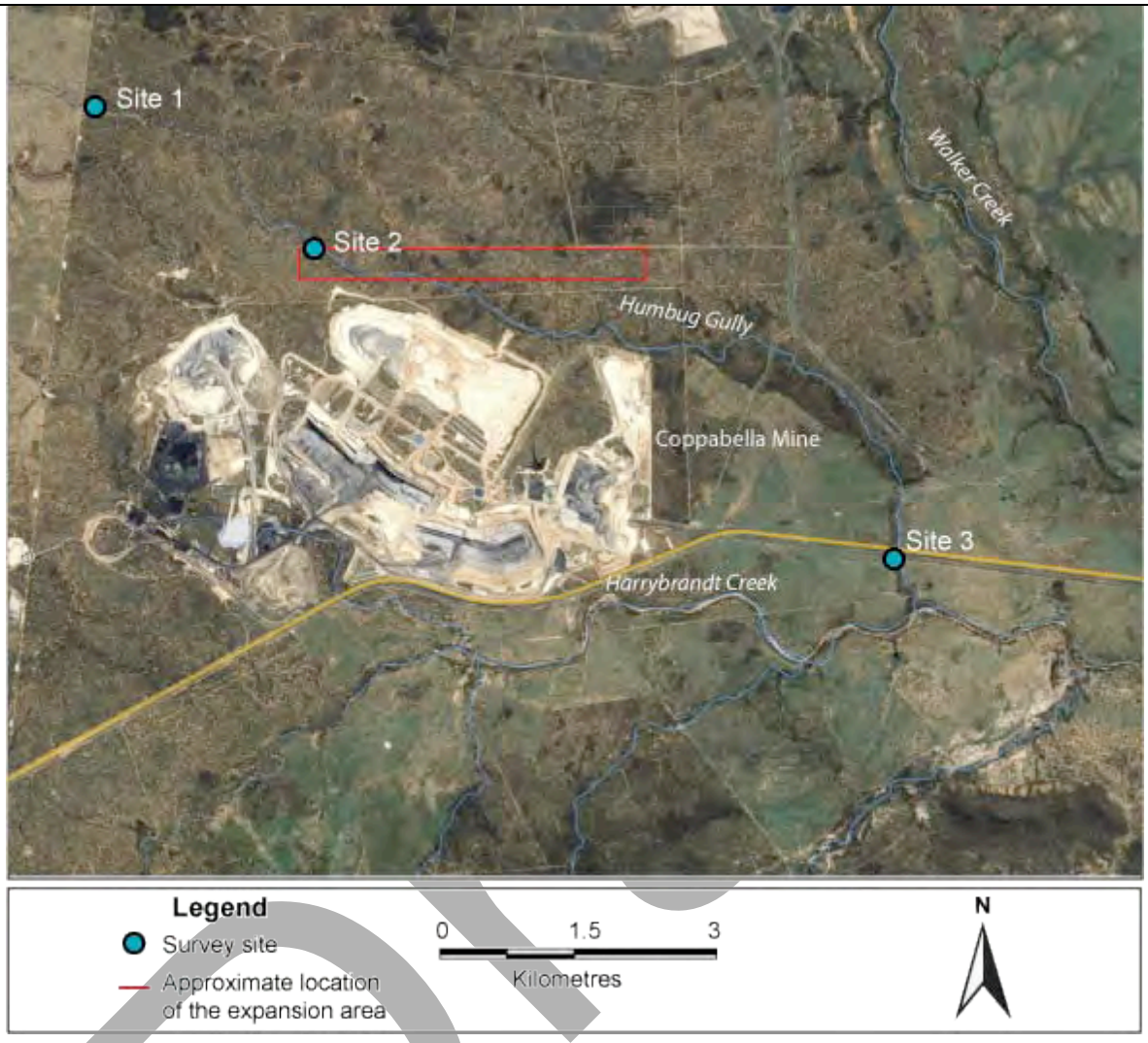
The Project involves a new underground longwall mining project, which will replace the existing open cut operations at Coppabella Mine.

1.1 Description of Study Area

The Coppabella Mine is in the Isaac-Connors Catchment of the Fitzroy Basin (Appendix B). Humbug Gully flows through the proposed underground expansion area (Figure 1.1), and into Harrybrandt Creek approximately 12 km downstream of the expansion area, which then flows into Bee Creek. Bee Creek flows into Funnel Creek, which flows into the Connors River. The Connors River flows into the Isaac River, with both rivers having a number of braided channels and associated off-stream wetlands near this confluence. The Isaac River enters the Mackenzie River, which joins with the Dawson River to become the Fitzroy River, approximately 85 km south west of Rockhampton.

The predominant land use in the Isaac-Connors Catchment is dryland grazing; however, there are also several mines in the catchment. The Burton, North Goonyella, Goonyella, Moranbah North, Isaac Plains, Moorvale and Millenium and Poitrel mines are in the Isaac River Catchment, upstream of the confluence with the Connors River. South Walker Creek Mine discharges to Walker Creek, which joins with Harrybrandt Creek downstream of the Fitzroy Developmental Road to form Bee Creek. Hail Creek Mine discharges to Bee Creek upstream of the Coppabella Mine.

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frc environmental AQUATIC ECOLOGISTS deep thinking. science.	Coppabella Underground Project, Aquatic Ecology	
	Figure 1.1 Location of the waterways surrounding the Coppabella Underground Project, showing the sites surveyed.	
	Google Earth (2010)	March 2010

2 Relevant Legislation and Guidelines

2.1 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* [1]

Any actions that are likely to have a significant impact on a Matter of National Environmental Significance (MNES) are subject to assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval process. Matters of National Environmental Significance include:

- World Heritage properties
- National Heritage places
- wetlands of International importance
- threatened species and ecological communities
- migratory species
- Commonwealth marine areas, and
- nuclear actions.

The Project is unlikely to impact on MNES (Appendix A).

2.2 Queensland *Fisheries Act 1994* [2]

All waters of the state are protected against degradation by direct or indirect impact under section 125 of the *Fisheries Act 1994* (Fisheries Act).

Under Division 8 of the Fisheries Act, a waterway barrier works approval may be needed to build structures across a freshwater waterway. Such structures include culverts and road crossings, which will be constructed as a part of the Project.

[1] Act no. 91 of 1999 as amended, prepared on 25 November 2009 taking into account amendments up to Act No. 107 of 2010. Prepared by the Office of Legislative Drafting and Publishing, Attorney-General's Department, Canberra.

[2] Reprint No. 6F, Reprinted as in force on 1 July 2010. Reprint prepared by the Office of the Queensland Parliamentary Council.

Draft

2.3 Queensland *Nature Conservation Act 1992*

Rare and threatened species are protected in Queensland under the *Nature Conservation Act 1992* (NCA); protected species are listed in the Nature Conservation (Wildlife) Regulation 2006 (NCWR). Of the species known to occur within the Fitzroy Basin, two are listed on the Federal MCWR. The Fitzroy River turtle and estuarine crocodile are listed as vulnerable and the white throated snapping turtle is listed as 'least concern' under the NCWR.

The white-throated snapping turtle (*Elseya albagula*), which has been recorded in the Fitzroy River, is not listed under the EPBC Act, but has been identified as a high priority for conservation in the EPA's species prioritisation framework. For more information of the Fitzroy River and white-throated snapping turtles, see Appendix E.

2.4 Queensland *Environmental Protection Act 1994*

The environmental values of waterways in Queensland are protected under the *Environmental Protection Act 1994* (EP Act) and the subordinate *Environmental Protection (Water) Policy 2009* (EPP Water)[3].

2.5 Queensland *Water Act 2000*[4]

The purpose of the *Water Act 2000* (Water Act) is to provide for the sustainable management of water and other resources. The Project may require approvals under the Water Act for the construction, control and management of works with respect to water conservation and protection, drainage, supply, flood control and prevention. Under Section 269 of the Water Act, a riverine protection permit is required from DERM to:

- remove vegetation in a watercourse
- excavate in a watercourse, and / or
- place fill in a watercourse.

[3] Reprint No. 1A, Reprinted as in force on 18 December 2009. Reprint prepared by the Office of the Queensland Parliamentary Council.

[4] Reprint No. 7D, Reprinted as in force on 23 May 2010. Reprint prepared by the Office of the Queensland Parliamentary Council.

Draft

2.6 Wetlands of National, State or Regional Significance

Palustrine and lacustrine wetlands and riverine systems have been mapped within, adjacent to and downstream of the proposed mining lease in the DERMs recent wetland mapping program (Appendix A). Lacustrine wetlands in the study area are likely to be farm dams (pers. obs.). None of the wetlands in the study area are recognised as being of National, State or Regional Significance.

Draft

3 Description of Existing Environment

3.1 Methods

Field Survey

The aquatic habitat, water quality, aquatic flora, and macroinvertebrate and fish communities of Humbug Gully were assessed during a field survey on 4 – 5 February 2010. Three sites were surveyed: one upstream of (site 1), one within (site 2), and one downstream of (site 3) the proposed underground expansion area (Figure 1.1).

Aquatic habitat was surveyed using the Australian River Assessment System (AUSRIVAS) methods (Appendix C).

Aquatic flora (macrophytes) were surveyed over a 100 m reach at each site. Plants were identified, and the following recorded:

- taxonomic richness
- whether the plant was native or exotic to Australia
- growth form of each species (submerged, floating (free-floating or rooted) and emergent), and
- total percent cover (% of substrate (bed / bank) covered by each species).

Aquatic macroinvertebrates were surveyed using AUSRIVAS protocols (Appendix D).

Fish were surveyed using a combination of backpack electrofishing and baited traps (Appendix E).

At the time of survey, the water was very shallow (i.e. <10 cm) and as such, turtle traps could not be set at any of the sites.

Literature Review

The aquatic habitat, flora and fauna of the creeks in the Fitzroy Basin were described through literature review, to provide a regional context for the condition of the creeks in the study area.

Draft

3.2 Aquatic Habitat

Humbug Gully has been moderately affected by human activities. Mining and cattle grazing dominated land-use in the study area. Cattle access up- and downstream of the mine had caused some disturbance, such as erosion. This is consistent with impacts to waterways throughout the region.

Road crossings in the study area were typically in the form of bridges with instream pylons or dirt crossings (site 2; Figure 3.1). During flood events, these crossings, are likely to alter flow patterns and potentially trap debris, which may prevent or restrict aquatic fauna passage (Cotterell 1998). Fence crossings in the study area, such as at site 1 may also trap debris and restrict fauna passage (Figure 3.2).

Waterway barriers such as weirs, causeways, pondage banks and roads have restricted fish passage within the Fitzroy Basin.

Figure 3.1

Dirt crossing at site 2.



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Figure 3.2

Fence crossing Humbug Gully with some trapped debris at site 1.



Riparian Vegetation

The riparian zone was relatively wide (between 30 – 50 m) and included tall trees, shrubs and grasses. There has been some riparian vegetation clearing along Humbug Gully, however large trees still grow on the creek banks. The riparian vegetation was dominated by native species, such as eucalypts, wattles and grasses, however prickly pear (*Opuntia* spp.), a declared Class 2 pest in Queensland under the *Land Protection (Pest and Stock Route Management) Act 2002*, grew at site 1, and throughout the study area.

Riparian habitat is considered to be relatively good in the context of riparian habitat throughout the region: one of the main impacts to aquatic habitat in the Fitzroy Basin is clearing of riparian vegetation.

Bank and Bed Stability

Throughout the study area, the banks were moderately stable and comprised of fines (e.g. sand and silt). The banks were sloping or vertical and while mostly well vegetated, there were undercut banks and / or exposed tree roots at each site, indicative of erosion due to high flows (Figure 3.3).

Stream beds were generally stable, however, there was scouring and deposition of fines at bends (Figure 3.4). At all sites, bars were located along the edge of the channel.

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Figure 3.3

Vertical banks with exposed tree roots at site 1.



Figure 3.4

Sediment deposition on the outside meander bend at site 2.



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Channel Diversity

Instream habitat was comprised of runs and pools at sites 1 and 2, whereas habitat at site 3 was comprised of runs, pools, riffles and falls. Bends and changes in water depth also provided some channel diversity at site 3.

For the majority of the year, Humbug Gully is likely to be dry. Larger waterways in the catchment, such as the Connors River, contain perennial pools that provide important refuge habitat for aquatic species in the dry season.

Habitat Bioassessment Scores

Habitat Bioassessment Scores were moderate at all sites. Site 3 had the highest Habitat Bioassessment Score, which was related to the high coverage of instream habitat such as small and large woody debris, detritus, trailing bank vegetation and boulders, and high channel diversity.

Water Quality

Physico-chemical water quality was characterised by low dissolved oxygen concentrations and elevated turbidity, particularly at site 3. Conductivity levels were below the preliminary Queensland Water Quality Guidelines (QWQG) value except at site 3. The pH levels were within the QWQG value range.

3.3 Aquatic Flora (Macrophytes)

Only one macrophyte species, *Lomandra hystrix* (creek mat rush), was recorded during the survey at site 3 (<1% cover).

Aquatic flora (macrophyte) diversity and coverage is low in the ephemeral waterways of the Coppabella Mine receiving environment downstream of the study area, with only occasional emergent aquatic plants such as *Cyperus* spp. (sedges), *L. hystrix*, *Alternanthera denticulata* (lesser joyweed) and *Juncus* sp. (rushes) growing in and along the channels (SKM 2009).

3.4 Aquatic Macroinvertebrates

Macroinvertebrate communities were dominated by non-biting midges (subfamilies Chironominae and Tanypodinae), crane flies (Tipulidae) and water boatmen (Corixidae). These macroinvertebrate families are typically tolerant of a range of environmental conditions (Chessman 2003).

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Richness

In February 2010 in Humbug Gully, taxonomic richness was low in both bed and edge habitats, with only two to six families recorded in each sample. Taxonomic richness at all sites was below the QWQG range (DERM 2009), and below that recorded in nearby Nebo and Dennison creeks in surveys by the Department of Environment and Resource Management (DERM). This is likely to reflect more stable aquatic habitat in Nebo and Dennison creeks, which are larger waterways than Humbug Gully.

In bed and edge habitats, taxonomic richness within the proposed underground expansion area (site 2) was greater than that at sites up- and downstream of the proposed underground expansion area (sites 1 & 3).

PET Richness

In February 2010, no PET families were recorded in Humbug Gully, which may be indicative of habitat degradation and / or that the available habitat was less suited to sensitive taxa. Similar to taxonomic richness, PET richness was substantially higher in Nebo and Denison creeks than that at sites in Humbug Gully.

SIGNAL 2 / Family Bi-plots

In February 2010 in Humbug Gully, macroinvertebrate communities sampled from bed habitat were predominantly in quadrant 3 (Figure 3.5), which is indicative of toxic pollution or harsh physical conditions. Macroinvertebrate communities in Humbug Gully are likely to be affected by the harsh physical conditions characteristic of ephemeral waterways. Communities sampled from edge habitat were in quadrant 4, which is indicative of urban, industrial or agricultural pollution, or the downstream effects of dams.

In June 1997 in Nebo and Denison creeks, macroinvertebrate communities in both bed and edge habitats were predominantly in quadrant 1 (DERM 2010), which is indicative of favourable habitat and chemically dilute waters. It is likely that these sites had good habitat and water quality.

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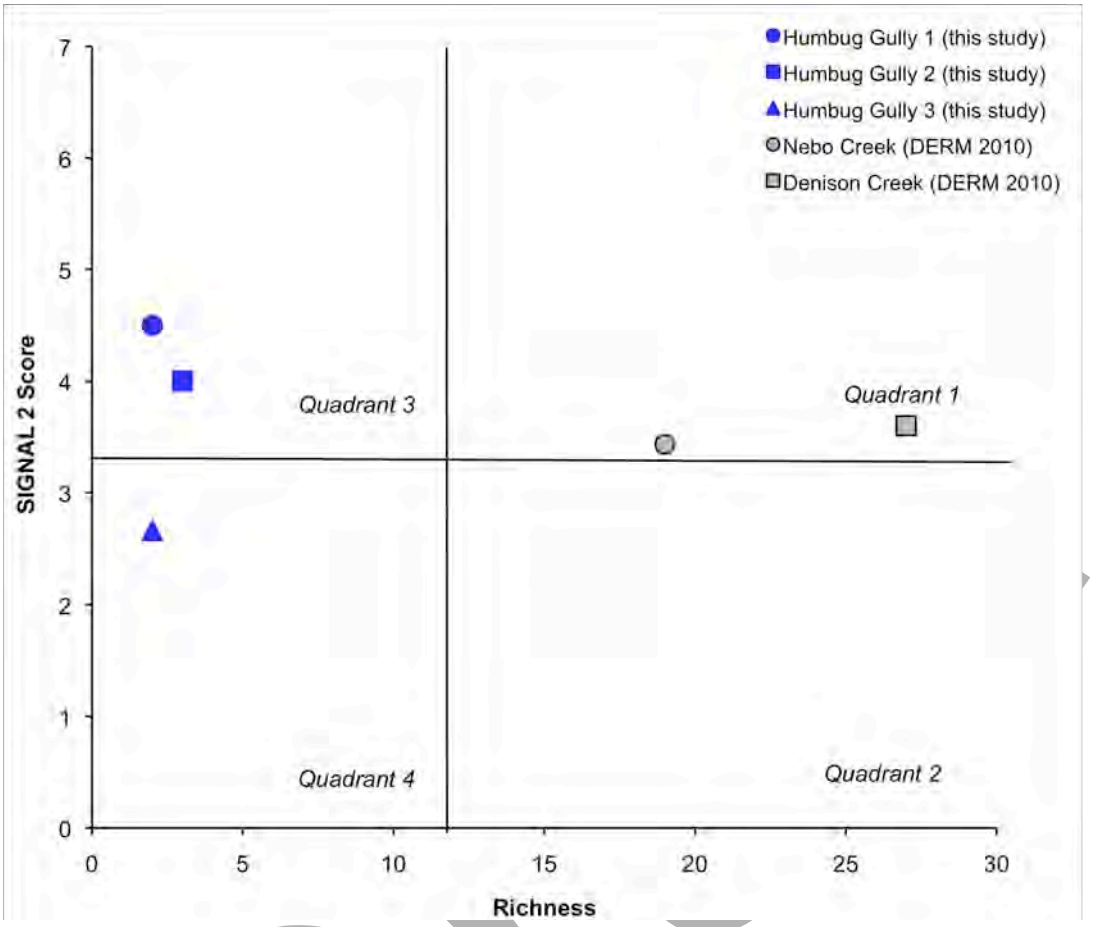


Figure 3.5 SIGNAL 2 / family by-plot for macroinvertebrate communities in bed habitat from creeks in the study area, and the QWQG for slightly to moderately disturbed streams in central Queensland.

Macrocrustaceans

In February 2010, no macrocrustaceans were recorded in Humbug Gully. In June 1997, freshwater shrimp (family Atyidae) and river prawns (family Palaemonidae) were recorded in Nebo and Denison creeks in surveys by DERM.

3.5 Aquatic Vertebrates

Fish communities in Humbug Gully were species poor and abundance was low. Of the 36 fish known from the Fitzroy Basin, only four species were recorded during the survey: Agassiz's glassfish (A*mbassis agassizii*), carp gudgeon (*Hypseleotris* spp.), Hyrtl's tandan (*Neosilurus hyrtlii*) and spangled perch (*Leiopotherapon unicolor*). No exotic or listed rare or threatened species were recorded during the survey. No fish were recorded within the proposed underground expansion area; only one fish was recorded upstream of the expansion area, while 13 fish were recorded downstream of the proposed expansion area.

Given their known habitat preferences, water quality tolerances and distribution, 11 of the fish species known in the Isaac-Connors Catchment may occur in the study area from time to time. These species are tolerant species that can live in water characterised by low dissolved oxygen levels, high conductivity and relatively high turbidity.

While the Fitzroy Basin has a high conservation value with respect to freshwater turtles, due to the high number of species found in the basin (six), no turtles or potential nesting habitat for turtles were observed in the study area. While it is unlikely that turtles occur in the ephemeral creeks in the study area, they may be present in local farm dams. However the Fitzroy River turtle (*Rheodytes leukops*) and the white throated snapping turtle (*Elseya albagula*), species of concern within the Fitzroy Basin, are unlikely to occur in the study area due to their habitat preferences.

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4 Summary of Aquatic Ecological Values

The biological values of aquatic ecosystems within the study area are relatively low when compared with those of the wider catchment. Environmental values are dictated primarily by the ephemeral and intermittent nature of the region's waterways; although agricultural development and mining within the region has influenced water quality and the physical characteristics of aquatic habitats. Creeks in the catchment are generally in moderate condition and are characterised by low habitat diversity, cattle access to creeks, road crossings that restrict passage of fish and other aquatic fauna and invasion of weed species (Henderson 2000); all features of the creeks within the study area (refer Appendix C).

Physico-chemical water quality in the study area was poor to moderate during the survey, and was characterised by high turbidity and low dissolved oxygen levels. Biodiversity was low, with only fish and macroinvertebrate species that are tolerant of varying and often harsh conditions inhabiting the study area. Nevertheless, the creeks within the study area provide 'upstream' dispersal habitat for the fish species that were recorded in the study area (and possibly breeding habitat for some species). Therefore, macroinvertebrate and fish communities found within the study area are likely to contribute to the success of downstream populations through movement/migration.

No endangered, vulnerable, or near threatened species of aquatic flora or fauna have been recorded from, or are likely to occur in, the waterways of the study area. There are no wetlands of regional, State or national significance in the study area.

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Appendix A Relevant Legislation and Guidelines

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Draft

1 Legislative Recognition of Conservationally Significant Aquatic Habitat and Flora and Fauna Species

1.1 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*[1]

Any actions that are likely to have a significant impact on a Matter of National Environmental Significance (MNES) are subject to assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval process. Matters of National Environmental Significance include:

- World Heritage properties
- National Heritage places
- wetlands of International importance
- threatened species and ecological communities
- migratory species
- Commonwealth marine areas, and
- nuclear actions.

World Heritage Properties (Great Barrier Reef)

The EPBC Act regulates actions that will, or are likely to, have a significant impact on the World Heritage values of a World Heritage property. This includes relevant actions that occur outside the boundaries of a World Heritage Area. The Fitzroy Basin drains to the Great Barrier Reef World Heritage Area (GBRWHA) and Great Barrier Reef Marine Park (GBRMP), approximately 620 km downstream from the Coppabella Underground Project (the Project). The Project is unlikely to impact the GBRWHA or GBRMP.

There are no other World Heritage properties that are likely to be impacted by activities within the proposed mining lease.

[1] Act no. 91 of 1999 as amended, prepared on 25 November 2009 taking into account amendments up to Act No. 107 of 2010. Prepared by the Office of Legislative Drafting and Publishing, Attorney-General's Department, Canberra.

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National Heritage Places

There are no National Heritage Places within the proposed mining lease or within 5 km of the proposed mining lease.

Wetlands of International Importance (Ramsar Wetlands)

The EPBC Act regulates actions that will, or are likely to, have a significant impact on the ecological character of a Ramsar wetland (wetlands of international significance). This includes relevant actions that occur outside the boundaries of a Ramsar wetland.

There are no Ramsar wetlands within the Project area. However, the Fitzroy River drains into the ocean approximately 70 km south of the Shoalwater and Corio Bays Ramsar site (DEWHA 2009), which is approximately 690 km downstream from the Project. The Project is unlikely to impact the Shoalwater and Corio Bays Ramsar site.

Threatened Species and Ecological Communities

Of the species known to occur within the Fitzroy Basin, two are listed on the Federal EPBC Act (Table 1.1).

The Fitzroy River turtle (*Rheodytes leukops*) is listed as vulnerable under the EPBC Act. It has only been recorded in the Fitzroy River and its tributaries (Cogger 1996), including the Connors River (Limpus 2007). The white-throated snapping turtle (*Elseya albagula*), which has been recorded in the Fitzroy River, is not listed under the EPBC Act, but has been identified as a high priority for conservation in the EPA's species prioritisation framework. For more information of the Fitzroy River and white-throated snapping turtles, see Appendix E.

As listed marine species, the estuarine crocodile (*Crocodylus porosus*) is only protected under the EPBC Act where they are found in Commonwealth Marine Waters. They have been recorded in the Fitzroy River at Glenroy, approximately 430 km downstream of the Project (Britton 2007; Limpus 2007; DEWHA 2008); but they are unlikely to be encountered in the upper freshwater reaches of the Fitzroy River.

Other listed animals have been recorded in the Fitzroy Estuary and / or the Great Barrier Reef, approximately 620 km downstream of the proposed mining lease; however, the Project is unlikely to impact these species (DERM 2010a).

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Table 1.1 State and Commonwealth conservation status of aquatic fauna found in the Fitzroy Basin (DEWHA 2008).

Species	Common Name	NCWR*	EPBC Act**
Chelidae			
Rheodytes leukops	Fitzroy River turtle	V	V
Elseya albagula	white throated snapping turtle	LC	–
Crocodylidae			
Crocodylus porosus	estuarine crocodile	V	M

* The status of species under the Queensland Nature Conservation (Wildlife) Regulation 2006[2]:
V – Vulnerable, LC = least concern.
** The status of species under the *Environmental Protection & Biodiversity Conservation Act 1999*:
M – Migratory, V – Vulnerable.

Commonwealth Marine Areas

There are no Commonwealth Marine Areas within the proposed mining lease, however the Fitzroy Basin drains to Commonwealth Marine Areas, approximately 600 km downstream from the Project. The Project is unlikely to impact on Commonwealth Marine Areas.

Nuclear Actions

Nuclear actions are not relevant to this Project.

1.2 Queensland *Fisheries Act 1994* [3]

All waters of the state are protected against degradation by direct or indirect impact under section 125 of the *Fisheries Act 1994* (Fisheries Act). If litter, soil, a noxious substance, refuse or other polluting matter is on land (including the foreshore and non-tidal land), in waters, or in a fish habitat, and it appears to the Chief Executive that the polluting matter

[2] Reprint No. 6D, Reprinted as in force on 26 June 2010. Reprint prepared by the Office of the Queensland Parliamentary Council.
[3] Reprint No. 6F, Reprinted as in force on 1 July 2010. Reprint prepared by the Office of the Queensland Parliamentary Council.

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is likely to adversely affect fisheries resources or a fish habitat, the Chief Executive of the Department of Employment, Economic Development and Innovation (DEEDI) may issue a notice requiring the person suspected of causing the pollution to take action to redress the situation.

Under Division 8 of the Fisheries Act, a waterway barrier works approval is needed to build any structure across a freshwater waterway. The purpose of this part of the Act is to provide a balance between the need to construct dams and weirs and the need to maintain fish movement. Such structures include culverts and road crossings, which will be constructed as a part of the Project. If approval is given for the Coppabella Coal Project to proceed, the Chief Executive, DEEDI may direct the building of a specified fishway for the barrier.

To get an approval, an application must be made to Fisheries Queensland, part of the Queensland Primary Industries and Fisheries (QPIF) group within the DEEDI, and lodged with the required fees. An assessment is undertaken by QPIF staff to see whether or not an approval should be issued, and whether a fishway is required to be built with the structure. To assess the requirements for a fishway on a proposed structure, the following is considered:

- are there fish in the waterway that need to move across the site of the waterway barrier works?
- are there habitats upstream and / or downstream of the proposed works that the fish need to move into?
- what are the effects of existing barriers (natural or man-made) up or downstream of the site of the waterway barrier works?
- will the drown-out characteristics of the proposed waterway barrier works allow adequate fish passage? and
- can a fishway be incorporated into the proposed works?

When a fishway is required, QPIF have developed a standard design process that ensures that both biologists and engineers are involved in developing the fishway design. Once the fishway is built, monitoring is required to confirm that the fishway is effective, or to identify any adjustments needed. The provision of effective fish passage will be required for this project where waterway barriers (temporary or permanent) will be installed. However, fishways are not expected to be a requirement for the Coppabella Coal Project, and have not been considered further.

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1.3 Queensland *Nature Conservation Act 1992*

Rare and threatened species are protected in Queensland under the *Nature Conservation Act 1992* (NCA); protected species are listed in the Nature Conservation (Wildlife) Regulation 2006 (NCWR). Of the species known to occur within the Fitzroy Basin, two are listed on the Federal MCWR (Table 1.1). The Fitzroy River turtle and estuarine crocodile are listed as vulnerable and the white throated snapping turtle is listed as 'least concern' under the NCWR.

1.4 Queensland *Environmental Protection Act 1994*

The *Environmental Protection Act 1994* (EP Act) is the key legislation for environmental management and protection in Queensland. The EP Act establishes a general environmental duty and a duty to notify environmental harm that applies to all persons and corporations. The EP Act provides for environmental protection policies that establish the environmental values to be preserved and which may set quality standards for segments of the environment (such as water, air, waste and noise). The environmental values of waterways in Queensland are protected under the EP Act and the subordinate *Environmental Protection (Water) Policy 2009* (EPP Water)[4].

1.5 Queensland *Water Act 2000*[5]

The purpose of the *Water Act 2000* (Water Act) is to provide for the sustainable management of water and other resources. The Project may require approvals under the Water Act for the construction, control and management of works with respect to water conservation and protection, drainage, supply, flood control and prevention. Under Section 269 of the Water Act, a riverine protection permit is required from the Department of Environment and Resource Management (DERM) (formerly the Department of Natural Resources and Water, DNRW) to:

- remove vegetation in a watercourse
- excavate in a watercourse, and / or
- place fill in a watercourse.

[4] Reprint No. 1A, Reprinted as in force on 18 December 2009. Reprint prepared by the Office of the Queensland Parliamentary Council.

[5] Reprint No. 7D, Reprinted as in force on 23 May 2010. Reprint prepared by the Office of the Queensland Parliamentary Council.

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Water Resource (Fitzroy Basin) Plan 2007

A Water Resource Plan (WRP) for the Fitzroy Basin was developed in 1999, including the Isaac River and associated tributaries (i.e. the area where the proposed mining lease is located), and provides a balance between environmental needs and consumptive uses. The WRP sets the strategic framework for the allocation and sustainable management of water within the region.

Fitzroy Basin Resource Operations Plan (ROP) 2004

The ROP is a plan prepared under the provisions of the Water Act by the Chief Executive to implement a WRP for certain water in all or part of the plan area. The Fitzroy Basin ROP defines the rules that govern the allocation and management of water in order to achieve the WRP objectives.

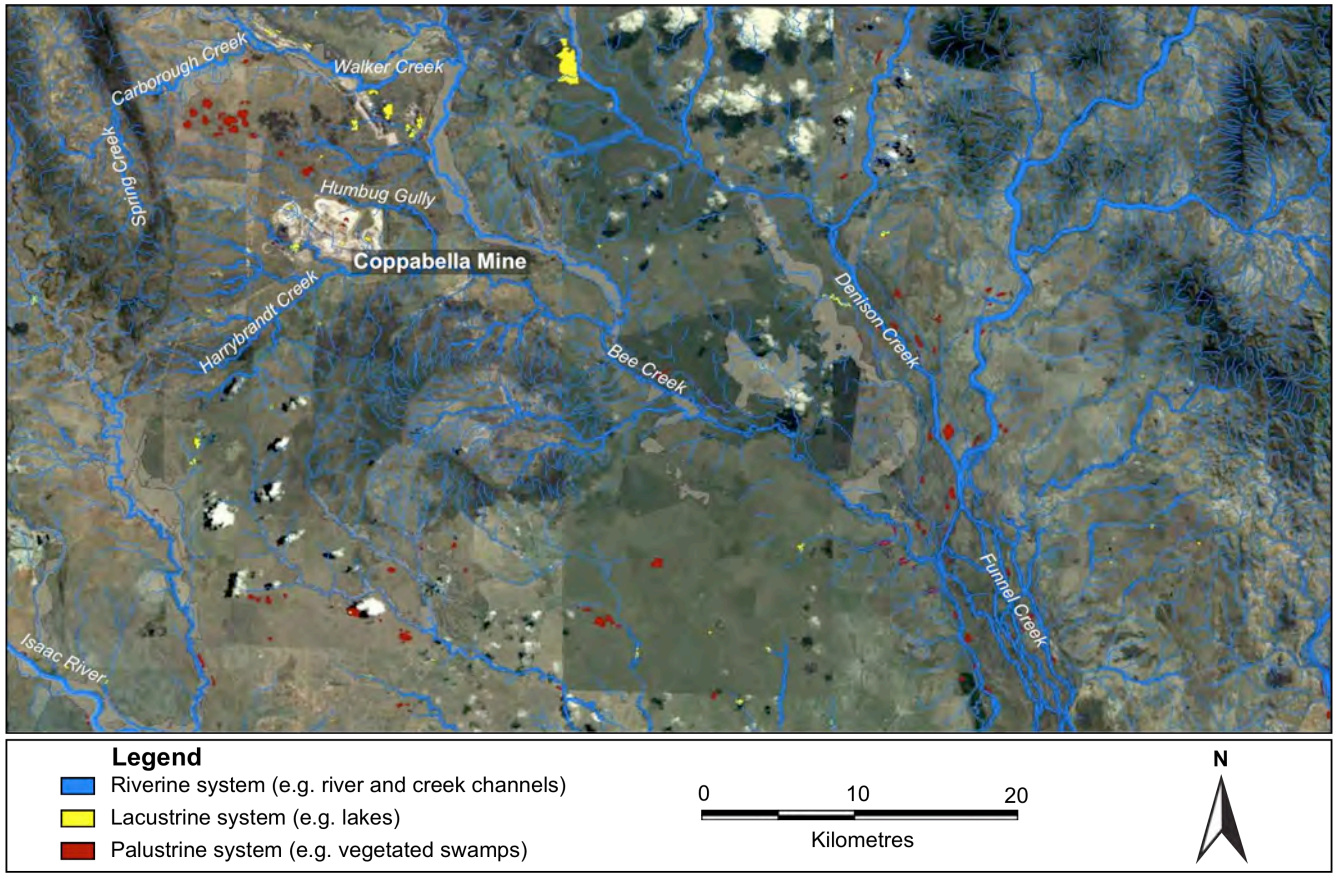
1.6 Wetlands of National, State or Regional Significance

Palustrine and lacustrine wetlands and riverine systems have been mapped within, adjacent to and downstream of the proposed mining lease in the DERMs recent wetland mapping program (Figure 1.1). Palustrine systems (e.g. vegetated swamps) are wetlands dominated by persistent emergent vegetation or where maximum water depth is less than 2 m; there are no active wave-formed shores or bedrock features. Lacustrine systems (e.g. lakes) are wetlands and deepwater habitats situated in topographic depressions, dammed river channels or artificial waterbodies, and include areas where emergent perennial vegetation has less than 30% coverage and the total waterbody area exceeds 8 ha. Lacustrine wetlands within the study areas are likely to be farm dams (pers. obs.). Riverine systems (e.g. river and creek channels) are wetlands and deepwater habitats contained within a channel.

The Fitzroy River Floodplain, Fitzroy River Delta and Great Barrier Reef Marine Park are designated as Wetlands of National Importance (Environment Australia 2001), however the Project is unlikely to impact these wetlands.

Lacustrine wetlands in the study area are likely to be farm dams (pers. obs.). None of the wetlands in the study area are recognised as being of National, State or Regional Significance.

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frc environmental AQUATIC ECOLOGISTS deep thinking. science.	Coppabella Underground Project, Aquatic Ecology	
	Figure 1.1 Waterbodies and wetlands mapped in the vicinity of the Coppabella Mine.	
	Adapted from (DERM 2010b)	June 2011

2 References

Britton, A., 2007, Proposal for raising Eden Bann Weir and construction of Rookwood Weir - An Assessment of the Potential Implications and Proposed Mitigation Measures for Saltwater Crocodiles (Crocodylus porosus), study commissioned by Department of Natural Resources and Water, Queensland.

Cogger, H.G., 1996, Reptiles and Amphibians of Australia, Reed Books Australia, Port Melbourne.

DERM, 2010a, Protected Matters Search Tool, http://www.environment.gov.au/erin/ert/epbc/index.html, accessed June 2011.

DERM, 2010b, 'Regional Ecosystems [online database]'.

DEWHA, 2008, Protected Matters Search Tool [online database], http://www.environment.gov.au/erin/ert/epbc/index.html, accessed June 2011.

DEWHA, 2009, EPBC Protected Matters Report, http://www.deh.gov.au/erin/ert/epbc/index.html, accessed June 2011.

Environment Australia, 2001, A Directory of Important Wetlands in Australia, Third Edition, Environment Australia, Canberra.

Limpus, C.J., Limpus. D.J., Parmenter, C.J., Hodge, J., Forrest, M.J. & McLachlan, J.M. , 2007, Proposal for raising Eden Bann Weir and construction of Rookwood Wier – An assessment of the potential implications and mitigation measures for Fitzroy Turtles (Elseya albagula and Rheodytes leukops), Periodical.

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Appendix B Survey Design

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1 Description of Survey Area

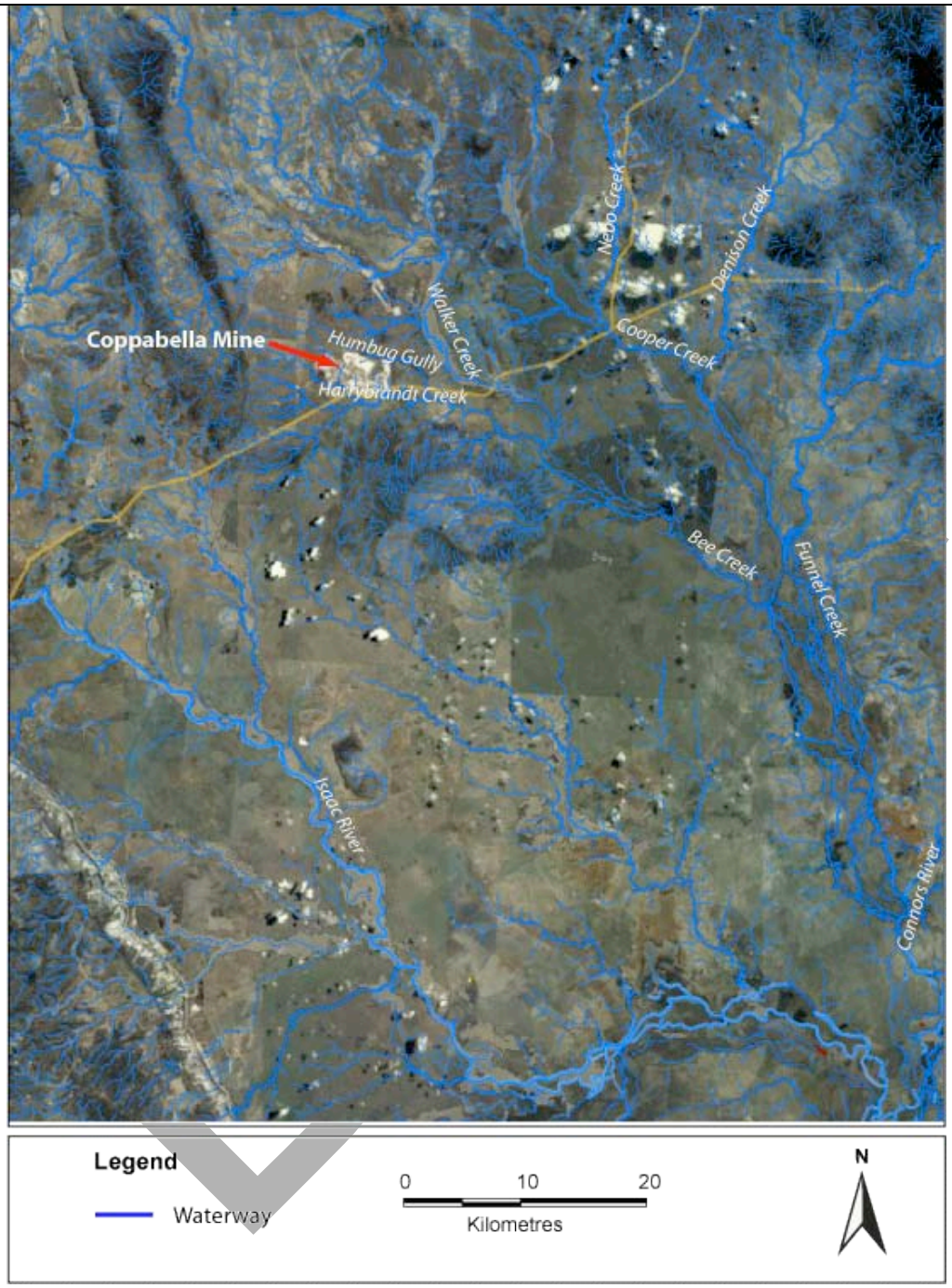
The Coppabella Mine is in the Isaac-Connors Catchment of the Fitzroy Basin (Figure 1.1). Humbug Gully flows through the proposed expansion area, and into Harrybrandt Creek approximately 12 km downstream of the expansion area (Figure 1.2). Harrybrandt Creek then flows into Bee Creek. Bee Creek is a larger watercourse and has perennial pools at least 1 m deep (SKM 2009). Bee Creek flows into Funnel Creek, which flows into the Connors River. The Connors River flows into the Isaac River, with both rivers having a number of braided channels and associated off-stream wetlands near this confluence. The Isaac River enters the Mackenzie River, which joins with the Dawson River to become the Fitzroy River, approximately 85 km south west of Rockhampton.

The predominant land use in the Isaac-Connors Catchment is dryland grazing; however, there are also several mines in the catchment. The Burton, North Goonyella, Goonyella, Moranbah North, Isaac Plains, Moorvale and Millenium and Poitrel mines are in the Isaac River Catchment, upstream of the confluence with the Connors River. South Walker Creek Mine discharges to Walker Creek, which joins with Harrybrandt Creek downstream of the Fitzroy Developmental Road to form Bee Creek. Hail Creek Mine discharges to Bee Creek upstream of the Coppabella Mine.

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frc environmental AQUATIC ECOLOGISTS deep thinking. science.	Coppabella Underground Project, Aquatic Ecology	
	Figure 1.1 Approximate location of the Coppabella Mine in the Fitzroy Basin.	
	DERM (2009)	June 2011



frc environmental AQUATIC ECOLOGISTS deep thinking. science.	Coppabella Underground Project, Aquatic Ecology	
	Figure 1.2 Waterways in the broader study area.	
	DERM (2009)	June 2011

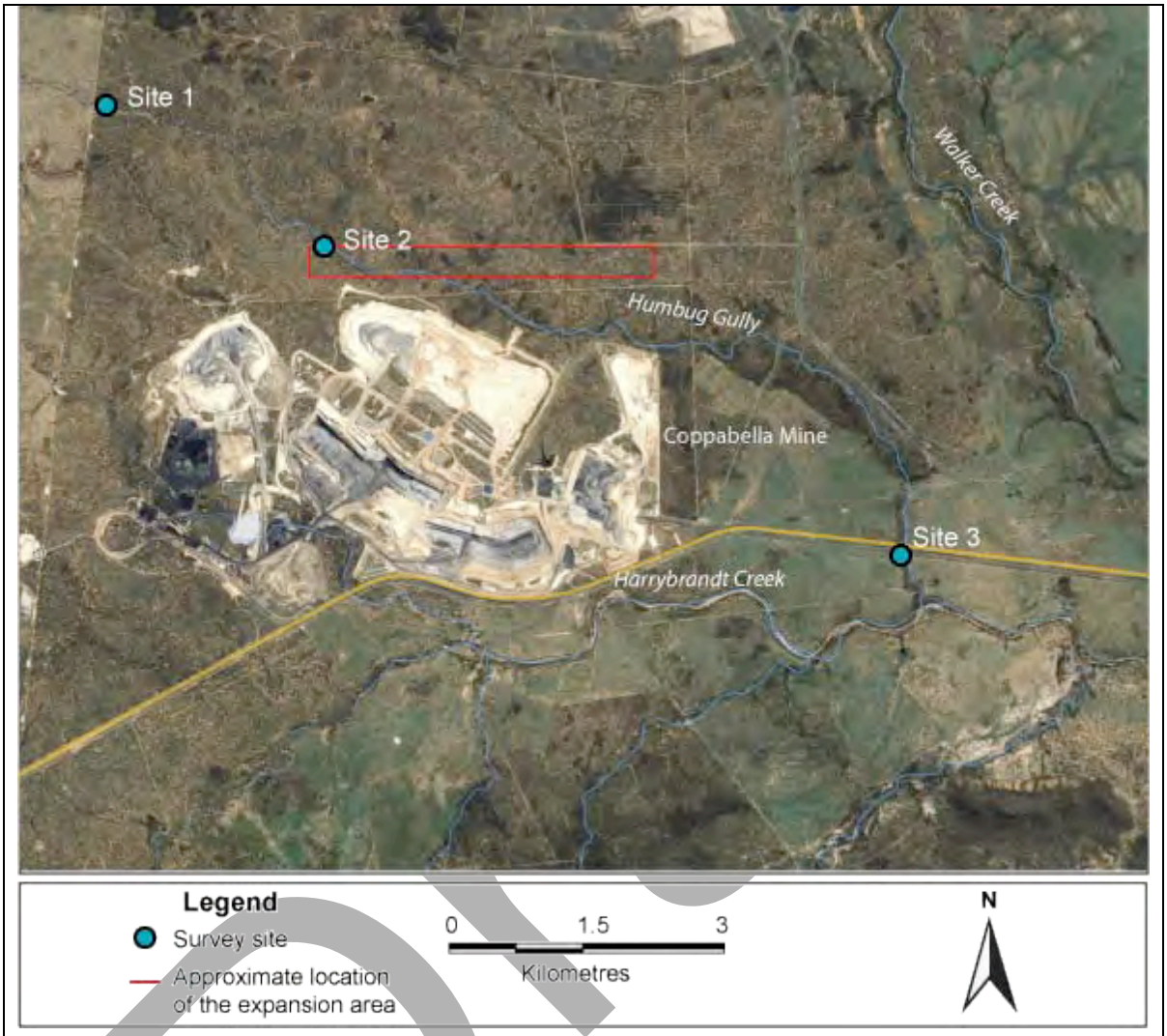
2 Survey Design

Aquatic habitat, water quality, aquatic flora, and macroinvertebrate and fish communities of Humbug Gully were assessed during a field survey on 4 – 5 February 2010 (Table 2.1). Three sites were surveyed: one upstream of (site 1), one within (site 2), and one downstream of (site 3) the proposed underground expansion area (Figure 2.1).

2.1 Limitations

At the time of survey, the water was very shallow (i.e. <10 cm) and as such, turtle traps could not be set at any of the sites.

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frc environmental AQUATIC ECOLOGISTS deep thinking. science.	Coppabella Underground Project, Aquatic Ecology	
	Figure 2.1 Location of sites surveyed.	
	Google Earth (2010)	June 2011

Table 2.1 Location of sites and type of survey at each site.

Site	Location on Humbug Gully	UTM (GDA94, Zone 55K)		Survey				
		Easting (m)	Northing (m)	Aquatic Habitat	Water Quality	Aquatic Flora	Macroinvertebrates	Fish
1	upstream of proposed underground expansion area	645 114	7 587 468	✓	✓	✓	✓	✓
2	within proposed underground expansion area	648 290	7 585 582	✓	✓	✓	✓	✓
3	downstream of proposed underground expansion area	656 220	7 581 288	✓	✓	✓	✓	✓

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3 References

DERM, 2009, Fitzroy Basin Water Planning Area Map, http://www.derm.qld.gov.au/wrp/pdf/fitz/fitzroy_map.pdf, accessed June 2011.

Google Earth, 2010, Google Earth Map, http://earth.google.com/, accessed June 2011.

SKM, 2009, *Connors River Dam and Pipelines Environmental Impact Statement*, Sinclair Knight Merz, Brisbane.

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Appendix C Aquatic Habitat

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1 Methodology

1.1 Aquatic Habitat of the Study Area

The aquatic habitat of Humbug Gully was assessed during a field survey on 4 – 5 February 2010. Three sites were surveyed: one upstream of (site 1), one within (site 2), and one downstream of (site 3) the proposed underground expansion area (see Appendix B for a map). For more information on the survey design refer to Appendix B.

Aquatic Habitat

At all sites, the quality of aquatic habitat was assessed using *Queensland AusRivAS Sampling and Processing Protocols* (DNRM 2001). The location of each site was recorded (GPS point with ± 4 m accuracy) and photographs were taken. We visually assessed the instream habitat condition at the time of survey using the following measures of habitat quality:

- the type and condition of riparian vegetation
- habitats (pools, riffles, runs, etc.)
- mean water depth
- substrate and the presence of bars
- bed and bank stability
- the presence of snags (large woody debris), overhangs, undercuts, and other forms of shelter, and
- the presence of any physical barriers to fish passage.

Habitat Bioassessment Scores

Habitat Bioassessment Score datasheets (DNRM 2001) were also completed in the field. The assessment of aquatic habitat described above was used to numerically assess nine criteria, and assign them to one of four categories: excellent, good, moderate and poor. The numerical ratings from each category were then summed to produce an overall Habitat Bioassessment Score, and this score used to give an indicative overall condition category, based on the following total Habitat Bioassessment Score categories: Excellent >110; Good 75 – 110; Fair 39 – 74; and poor <38 (Table 1.1).

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Table 1.1 Habitat Bioassessment Score used to derive overall physical habitat condition categories (adapted from DNRM 2001).

Habitat Variable	Minimum Possible Score Within Each Condition Category			
	Excellent	Good	Moderate	Poor
Bottom substrate / available cover	16	11	6	0
Embeddedness	16	11	6	0
Velocity / depth category	16	11	6	0
Channel alteration	12	8	4	0
Bottom scouring & deposition	12	8	4	0
Pool / riffle, run / bend ratio	12	8	4	0
Bank stability	9	6	3	0
Bank vegetative stability	9	6	3	0
Streamside cover	9	6	3	0
Total	**111**	**75**	**39**	**0**

Water Quality

The objective of water quality sampling was to describe water quality at the time of the survey, to aid in the interpretation of biological data. For a full description of water quality, refer to the Surface Water Quality report.

Water quality was measured at each site using a Hydrolab QUANTA water quality meter. The following parameters were measured:

- water temperature (°C)
- conductivity (µS/cm)
- pH
- dissolved oxygen (DO) (% saturation), and
- turbidity (NTU, Nephelometric Turbidity Units).

To provide an indication of water quality at the time of sampling, spot water quality measurements were compared to the Queensland Water Quality Guideline (QWQG) values for lowland streams in central Queensland (EPA 2007) (Table 1.2).

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Table 1.2 QWQG for lowland streams in central Queensland (EPA 2007).

Parameter	Units	QWQG for Lowland Streams
Temperature	ºC	–
Dissolved Oxygen[1]	% saturation	85 – 110
pH	pH units	6.5 – 8.0
Conductivity[2]	µS/cm	340
Turbidity	NTU	50

[1] DO guidelines should only be applied to flowing waters, as stagnant pools in intermittent streams naturally experience DO levels below 50% saturation.

[2] Preliminary guideline only, based on the 75th percentile of data from the Fitzroy Central salinity zone.

1.2 Aquatic Habitat of the Region

The aquatic habitat and water quality of the creeks in the Fitzroy Basin were described through literature review, to provide a regional context for the condition of the creeks in the study area.

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2 Aquatic Habitat of the Study Area

2.1 Aquatic Habitat

For a description of the sites surveyed, see Table 2.1.

Table 2.1 Site descriptions for the sites on Humbug Gully

Site	Description	Photographs
Site 1 Humbug Gully, approximately 4 km upstream of the proposed underground expansion area.	The site had a run that was approximately 3.5 m wide and shallow (0.1 m). The site is likely to be dry for most of the year. Instream habitat was limited and was dominated by small woody debris, boulders and detritus. The left bank was stable and sloping, while the right bank was moderately stable and vertical. Sediment was dominated by sand, pebbles and gravel. The riparian zone was wide (50 m) and comprised of trees, shrubs and grasses.	
Site 2 Humbug Gully, within the proposed underground expansion area.	The site had a run that was approximately 2.0 m wide and shallow (0.1 m). The site is likely to be dry for most of the year. Instream habitat was varied and dominated by small woody debris and overhanging and trailing bank vegetation. Banks were sloping and stable, however, there was some deposition of sediment along the lower banks. Sediment was dominated by sand, silt and clay. The riparian zone was wide (50 m) and comprised of trees, shrubs and grasses.	

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Site	Description	Photographs
Site 3 Humbug Gully, approximately 10 km downstream of the proposed underground expansion area.	The site had a run that was approximately 2 m wide with a small fall and some pools (1 m) at the upstream end of the site. Instream habitat was varied and dominated by small woody debris, cobbles and overhanging vegetation. Banks were sloping and stable. Sediment was dominated by sand, silt, clay and cobbles. The riparian zone was relatively wide (30 m) and comprised of trees, shrubs and grasses.	

Reach Environs

Overall, the reach environs (land immediately adjacent to the riparian zone) of Humbug Gully have been moderately affected by human activities. Mining and cattle grazing dominated land-use in the study area. Cattle access up- and downstream of the mine had caused some disturbance, such as erosion.

Road crossings in the study area were typically in the form of bridges with instream pylons (site 3; Figure 2.1) or dirt crossings (site 2; Figure 2.2). During flood events, these crossings, are likely to alter flow patterns and potentially trap debris, which may prevent or restrict aquatic fauna passage (Cotterell 1998). Fence crossings in the study area, such as at site 1 may also trap debris and restrict fauna passage (Figure 2.3).

Figure 2.1

Bridge with instream pylons at site 3.



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Figure 2.2

Dirt crossing at site 2.



Figure 2.3

Fence crossing Humbug Gully with some trapped debris at site 1.



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Riparian Vegetation

The riparian zone was relatively wide (between 30 – 50 m) and included tall trees, shrubs and grasses (Figure 2.4). There has been some riparian vegetation clearing along Humbug Gully, however large trees still grow on the creek banks. The riparian vegetation was dominated by native species, such as eucalypts, wattles and grasses, however prickly pear (*Opuntia* spp.), a declared Class 2 pest in Queensland under the *Land Protection (Pest and Stock Route Management) Act 2002*, grew at site 1, and throughout the study area.

Figure 2.4

The riparian zone at site 3 included tall trees, shrubs and grasses.



Bank and Bed Stability

Throughout the study area, the banks were moderately stable and comprised of fines (e.g. sand and silt). The banks were sloping or vertical and while mostly well vegetated, there were undercut banks and / or exposed tree roots at each site, indicative of erosion due to high flows (Figure 2.5).

Stream beds were generally stable, however, there was scouring and deposition of fines at bends (Figure 2.6). At all sites, bars were located along the edge of the channel.

Figure 2.5

Vertical banks with exposed tree roots at site 1.



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Figure 2.6

Sediment deposition on the outside meander bend at site 2.



Channel Diversity

Channel diversity was comprised of runs and pools at sites 1 and 2, whereas, channel diversity at site 3 was comprised of runs, pools, riffles and falls. Bends and changes in water depth also provided some channel diversity at site 3.

For the majority of the year, Humbug Gully is likely to be dry and aquatic habitat is likely to be limited to isolated pools.

Microhabitat

Microhabitat, such as large woody debris or boulders, provides important habitat for aquatic fauna and can be critical to the maintenance of native fish communities (EHMP 2007). Microhabitat in Humbug Gully was generally moderate, with some instream habitat found at all sites in the form of small woody debris, detritus and trailing bank vegetation. However, boulders and large woody debris were also present at site 3.

2.2 Habitat Bioassessment Scores

Habitat Bioassessment Scores were moderate at all sites (Figure 2.7). Generally, these scores were related to the moderate to extensive bank erosion, fine substrate (e.g. silt and sand), and the moderate to high habitat variability. Site 3 had the highest Habitat Bioassessment Score, which, as discussed, was related to the high microhabitat and channel diversity.

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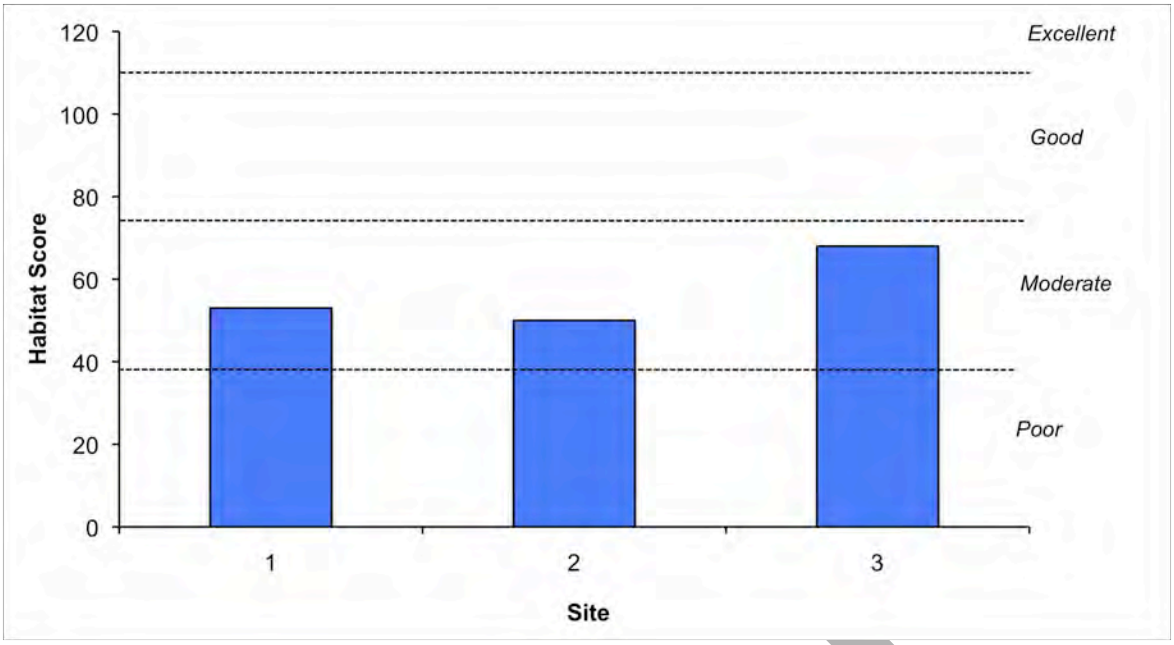


Figure 2.7 Habitat Bioassessment Score at each site in February 2010.

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3 Water Quality of the Study Area

3.1 Water Temperature

In February 2010, water temperature ranged from 25.7°C to 32.1°C.

3.2 Conductivity

In February 2010, conductivity ranged from 227 µS/cm at site 1 to 477 µS/cm at site 3 (Figure 3.1). Conductivity exceeded the QWQG at site 3, but was below the QWQG at sites 1 and 2.

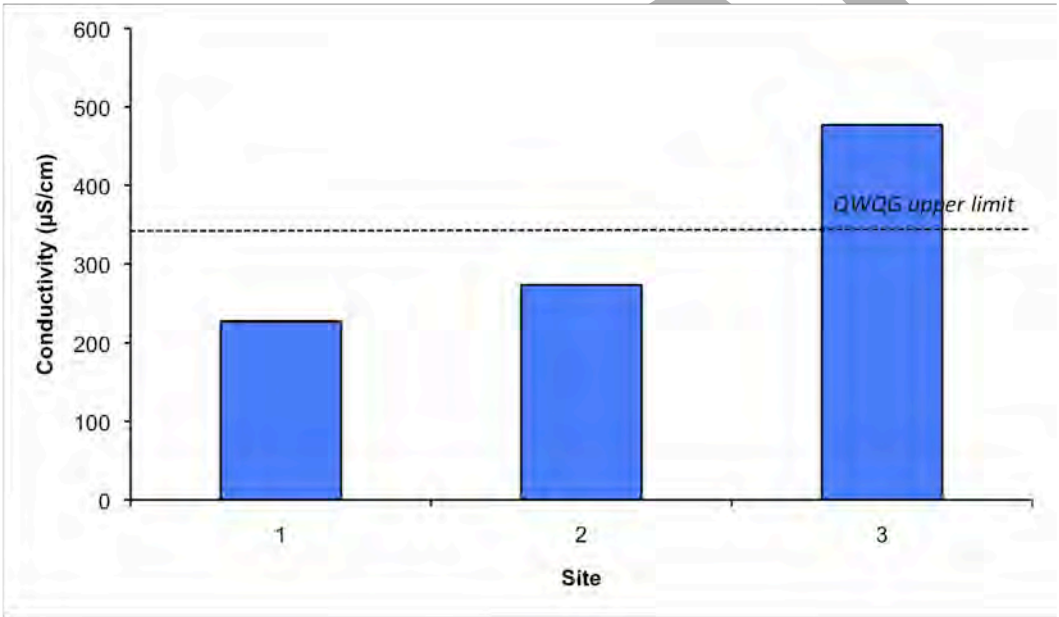


Figure 3.1 Conductivity at each site in February 2010, compared with the preliminary QWQG for lowland streams in central Queensland (DERM 2009).

3.3 pH

In February 2010, pH ranged from 6.8 at site 3 to 7.5 at sites 1 and 2 (Figure 3.2), and was within the QWQG range at all sites.

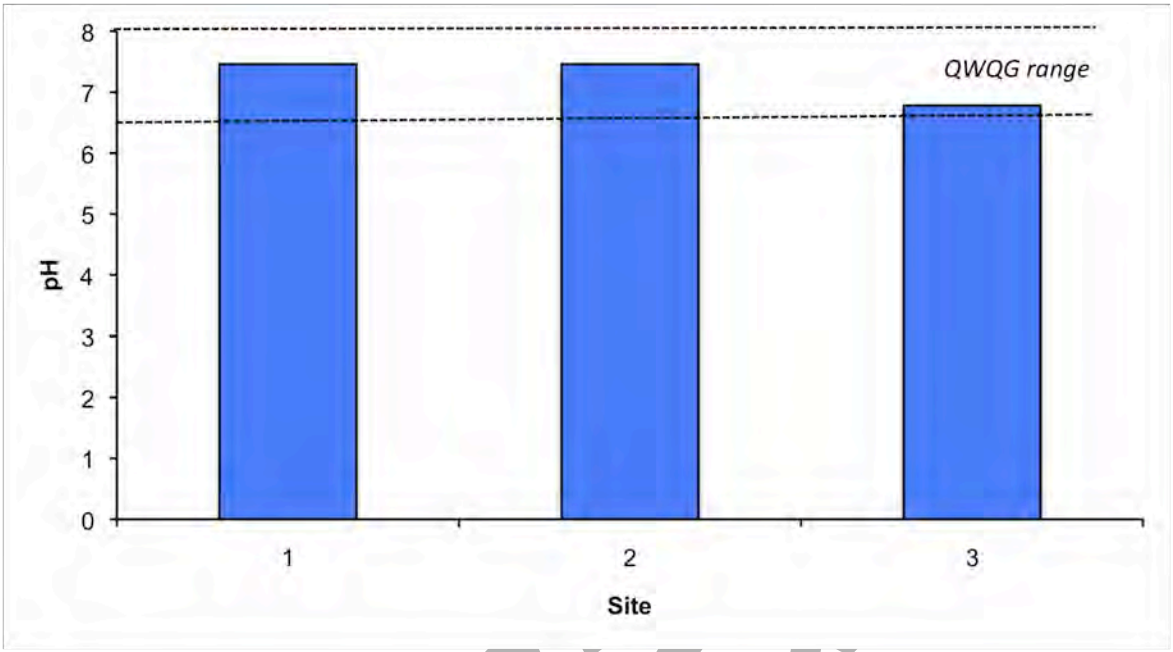


Figure 3.2 pH at each site in February 2010, compared with the QWQG range for lowland streams in central Queensland (DERM 2009).

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3.4 Dissolved Oxygen

In February 2010, DO varied between sites, ranging from 50.4% saturation at site 2 to 76.1% saturation at site 3 (Figure 3.3). All sites were below the QWQG range (EPA 2007). The low DO levels are likely to be related to the high water temperatures, as the solubility of oxygen is low in warm water.

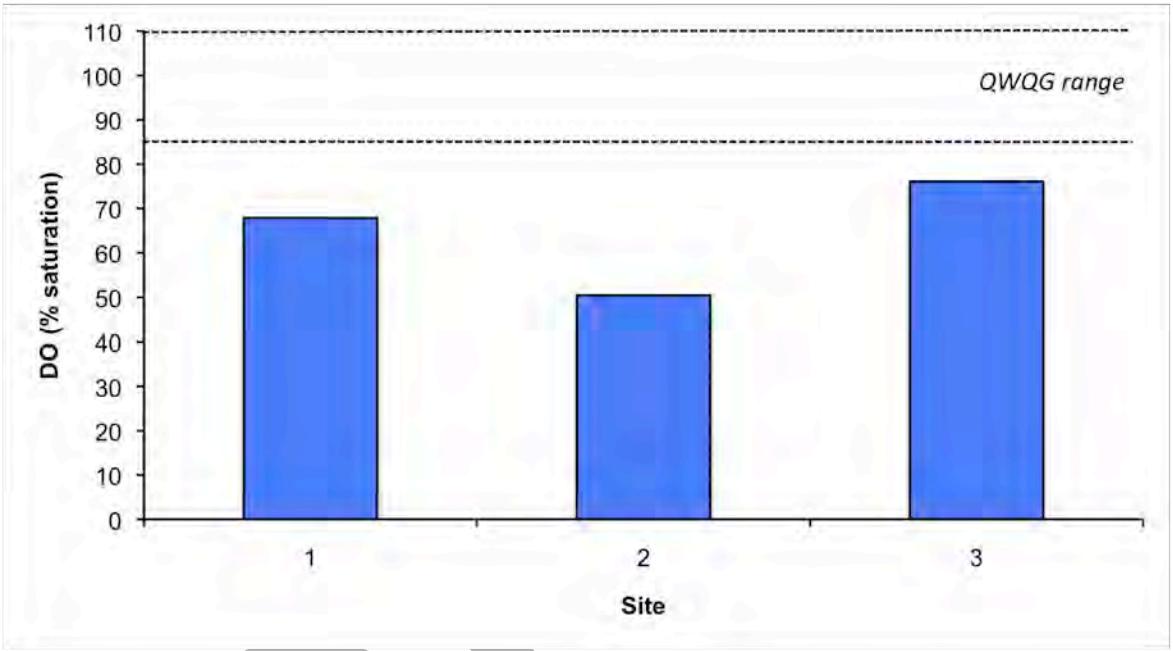


Figure 3.3 DO at each site in February 2010, compared with the QWQG range for lowland streams in central Queensland (DERM 2009).

3.5 Turbidity

In February 2010, turbidity at all sites exceeded the QWQG (EPA 2007), ranging from 256 NTU at site 2 to 5 999 NTU at site 3 (Figure 3.4). High turbidity levels are typical of ephemeral streams, due to heavy rainfall and subsequent high suspended sediment loads in runoff.

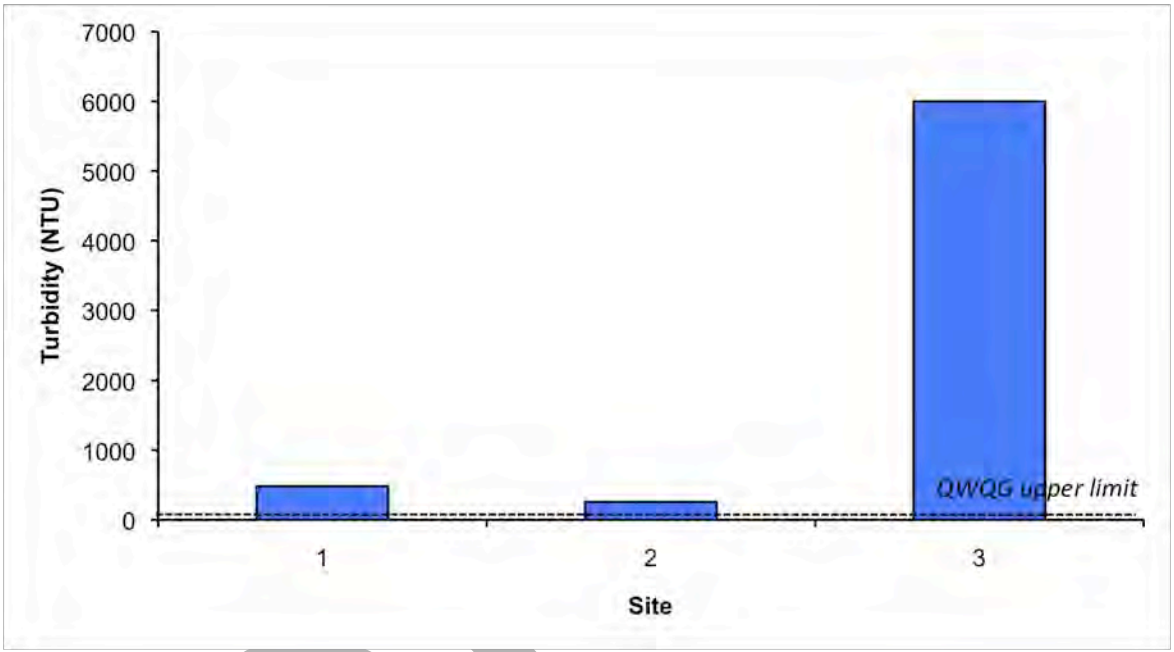


Figure 3.4 Turbidity at each site in February 2010, compared with the QWQG upper limit for lowland streams in central Queensland (DERM 2009).

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4 Aquatic Habitat and Water Quality of the Region

The Fitzroy Basin includes the Connors, Mackenzie, and Fitzroy rivers and their subcatchments (including Humbug Gully).

4.1 Aquatic Habitat

Creeks in the headwaters of the Isaac-Connors Catchment (including Humbug Gully) are generally small creeks, with ephemeral water-bodies and flow regimes (SKM 2009). These creeks are typically dry for most of the year, however they do provide aquatic habitat to fauna when they flow (including riffle and run habitat). There is evidence of erosion along the creek banks, and cattle access to creeks has caused some disturbance to stream banks (SKM 2009).

The Connors River consists of a series of large, isolated pools during the dry season (Limpus 2007). During the wet season, there are riffle habitats that connect the deeper pools, though the riffles tend to dry up during the dry season (Limpus 2007). Although pool habitats typically offer little habitat diversity, they can still support a range of flora and fauna species, and they are important refuge habitat during periods of low flow or drought (DNR 1998).

Channel diversity is relatively low in the Mackenzie and Fitzroy rivers, and is dominated by pools and runs during the dry season. There are offstream palustrine and lacustrine wetlands (typically farm dams) on the floodplains of the Mackenzie and Fitzroy rivers (EPA 2008b; a).

Land use in the Fitzroy Basin is primarily agricultural; 90% of land is grazed and 6% is cropped (Noble et al. 1996). Accordingly, levels of total nitrogen and phosphorus are elevated in the waterways. Nutrient levels exceed the QWQG (EPA 2007) values at times, especially during periods of moderate and high flows (based on data presented by Noble et al. 1996).

The main impact to aquatic habitat in the Fitzroy Basin is clearing of riparian vegetation, cattle grazing, and waterway barriers such as weirs, causeways, pondage banks and roads. The clearing of riparian vegetation can increase sediment runoff into creeks and elevate turbidity. The deposition of fine sediment has the potential to decrease stream-bed roughness and fill existing pools. In larger watercourses (second order and higher), sediment deposition typically leads to a decline in habitat diversity and a reduction in the

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number of pools available as 'refuge' habitat in the dry season. Such impacts on physical habitat contribute to a decline in the abundance and diversity of both macroinvertebrate and fish communities.

Barriers such as weirs, causeways, pondage banks and roads are found throughout the Fitzroy Basin, and the study area. Barriers typically trap debris and restrict flow during flow events resulting in aggradation of sediments behind the barrier (DNR 1998). This aggradation of sediments and the creation of lacustrine habitat can reduce habitat diversity within the affected reach.

4.2 Water Quality

Water quality in the Fitzroy Basin received a report card score of 'C' (fair) for freshwaters above the Fitzroy Barrage (near Rockhampton), 'F' (fail) for the barrage itself and 'D' (poor) for estuarine waters (when compared to other central Queensland catchments) (Meecham 2003). Water quality in this catchment is compromised by:

- pesticide and herbicide contamination, particularly in irrigation areas
- erosion and runoff increasing sedimentation and nutrients levels in waterways
- high risk of blue-green algal bloom in still waters
- rising salinity, particularly instream between Theodore and Rockhampton
- acid mine drainage in localised areas including Blackwater Creek, Crinum Creek, Don River and Dee River
- heavy metal contamination, mostly from cadmium and copper in parts in of the Mackenzie, Nogoa and lower Dawson catchments, and
- substantial areas of poor riparian vegetation cover, particularly in the Dawson catchment and Central Highlands (Meecham 2003).

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Appendix D Macroinvertebrate Communities

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1 Methodology

1.1 Macroinvertebrates of the Study Area

Macroinvertebrates of Humbug Gully were assessed during a field survey on 4 – 5 February 2010. Three sites were surveyed: one upstream of (site 1), one within (site 2), and one downstream of (site 3) the proposed underground expansion area (see appendix B for a map).

Sample Collection

A standard Australian River Assessment System (AusRivAS) macroinvertebrate sample was collected from bed (pool / run) and edge habitat at each site. Sampling methodology followed the procedures set out in the Queensland AusRivAS sampling manual (DNRM 2001). A standard triangular-framed, cone-shaped net with 250 µm mesh was used to collect all samples.

Sample Processing

Samples were frozen and returned to frc environmental's Brisbane benthic laboratory where they were sorted, counted and identified to the lowest practical taxonomic level (in most instances family), to comply with AusRivAS standards and those described in Chessman (2003a).

Data Analysis

A number of indices have been developed for freshwater macroinvertebrate communities to provide an indication of ecosystem health, as described below. For each sample, taxonomic richness, PET richness and SIGNAL 2 scores were calculated. These indices were used to provide an indication of the current ecological health of Humbug Gully, and to compare the health of Humbug Gully to other waterways in the catchment. The results from this study were compared to the biological guidelines outlined in the Queensland Water Quality Guidelines (QWQG) for slightly to moderately disturbed streams in central Queensland (Table 1.1) (DERM 2009).

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Table 1.1 QWQG biological guidelines for central Queensland (DERM 2009).

Indicator	Habitat	Biological Guideline
taxonomic richness	Bed	12 – 21
	Edge	23 – 33
PET richness	Bed	2 – 5
	Edge	2 – 5
SIGNAL 2 score	Bed	3.33 – 3.85
	Edge	3.31 – 4.20

Taxonomic Richness

Taxonomic richness is the number of taxa (typically families) in a sample. Taxonomic richness is the most basic and unambiguous diversity measure, and is considered to be one of the most effective. It is however, affected by arbitrary choice of sample size and location. Where all samples are considered to be of equal size, species richness index is considered to be a useful tool when used in conjunction with other indices. Richness does not take into account the relative abundance of each taxa, so rare taxa have as much 'weight' as common ones.

PET Richness

While some groups of macroinvertebrates are tolerant of pollution and environmental degradation, others are sensitive to these stressors (Chessman 2003a). The **P**lecoptera (stoneflies), **E**phemoptera (mayflies), and **T**richoptera (caddisflies) are referred to as PET taxa, and they are particularly sensitive to disturbance. There are typically more PET families at sites with good habitat and water quality than at degraded sites, and PET taxa are often the first to disappear when water quality or environmental degradation occurs (EHMP 2004). The lower the PET score, the greater the inferred degradation.

SIGNAL 2 Scores

SIGNAL (**S**tream **I**nvertebrate **G**rade **N**umber — **A**verage **L**evel) scores are also based on the sensitivity of each macroinvertebrate family to pollution or habitat degradation. The SIGNAL system has been under continual development for over 10 years, with the current version known as SIGNAL 2. Each macroinvertebrate family has been assigned a grade number between 1 and 10 based on their sensitivity to various pollutants. A low number

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means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution (e.g. suspended sediments and nutrient enrichment).

SIGNAL 2 scores are weighted for abundance, such that the relative abundance of tolerant or sensitive taxa can be taken into account (instead of only the presence / absence of these taxa). The overall SIGNAL 2 score for a site is based on the total of the SIGNAL grade (multiplied by the weight factor) for each taxa present at the site, divided by the total of the weight factors for each taxa at the site.

SIGNAL 2 scores should be interpreted in conjunction with the number of families found in the sample. This can be achieved using a SIGNAL 2 / Family bi-plot (Chessman 2003b). The plots are divided into quadrants, with each quadrant indicative of particular conditions (Figure 1.1). Quadrant boundaries for the SIGNAL 2 / Family bi-plot used for this study are based on the QWQG (DERM 2009) for slightly to moderately disturbed streams in central Queensland. Recently, an alternative approach has been recommended, which includes boundary setting for each study (Chessman 2003b). This technique would require considerable sampling (in effect calibration) within the region. Interpretation of the bi-plot with regard to quadrant boundaries should therefore be approached with caution.

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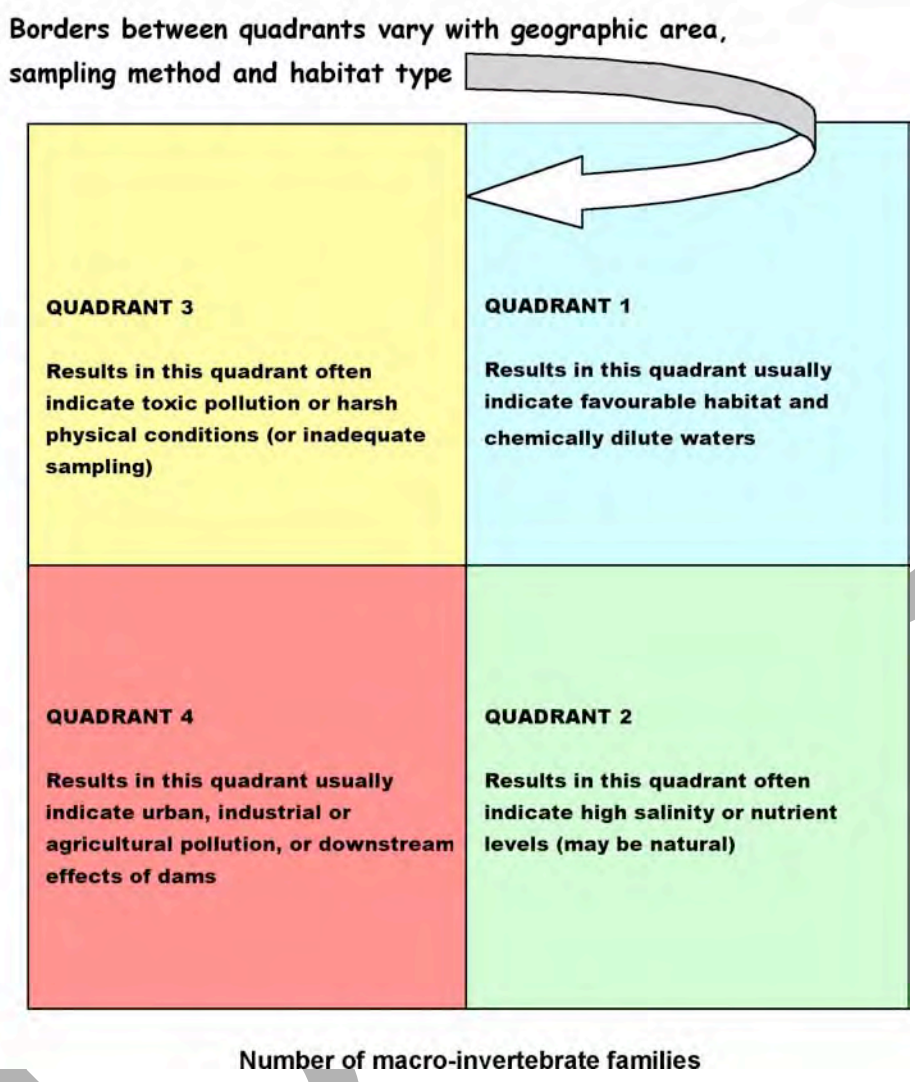


Figure 1.1 The quadrant diagram for the family version of SIGNAL 2 (Chessman 2003b).

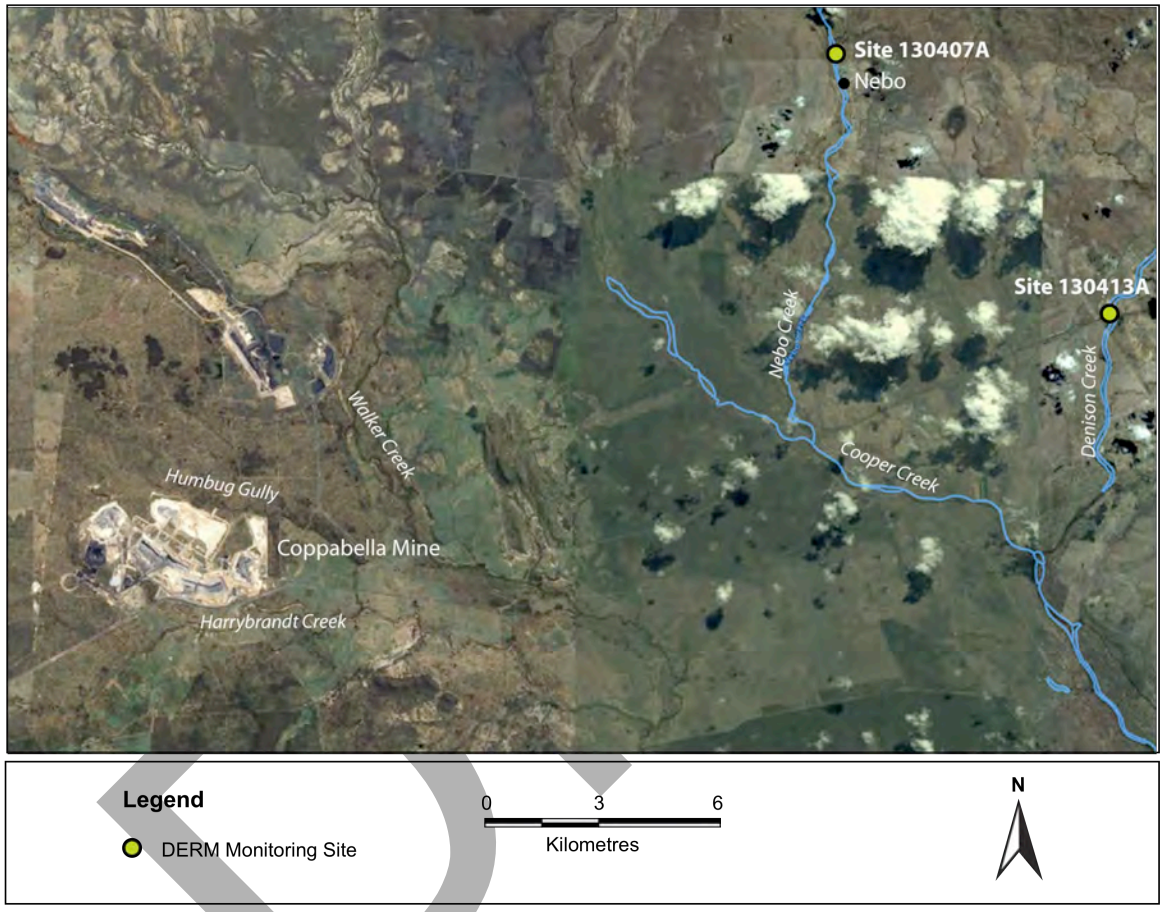
1.2 Macroinvertebrates of the Region

The macroinvertebrate communities of the region were described through literature review. The Department of Environment and Resource Management (DERM) has previously undertaken macroinvertebrate surveys of the waterways near the study area, including on Nebo (site 130407A) and Denison (site 130413A) creeks in June 1997 (Figure 1.2).

In order to use the macroinvertebrate communities as an indicator of the likely health / condition of the sites sampled by DERM, taxonomic richness, PET richness and SIGNAL 2 scores were calculated[1] and compared to macroinvertebrate communities of the sites in this study.

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[1] "Based on / or contains data provided by the State of Queensland (DERM 2010). In consideration of the State permitting use of this data we acknowledge and agree that the State gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws."



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	Figure 1.2 Location of the sites previously surveyed in the region.	
	Google Earth (2010)	June 2011

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2 Macroinvertebrate Communities

2.1 Community Richness and Composition

Macroinvertebrate communities were dominated by non-biting midges (subfamilies Chironominae and Tanypodinae), crane flies (Tipulidae) and water boatmen (Corixidae). These macroinvertebrate families are typically tolerant of a range of environmental conditions (Chessman 2003b).

In February 2010 in Humbug Gully, taxonomic richness was low in both bed and edge habitats, with only two to six families recorded in each sample (Figure 2.1 & Figure 2.2). Taxonomic richness at all sites was below the QWQG range (EPA 2007). In bed and edge habitats, taxonomic richness within the proposed underground expansion area (site 2) was greater than that at sites up- and downstream of the proposed underground expansion area (sites 1 & 3).

In June 1997 in Nebo and Denison creeks, taxonomic richness was within the QWQG range and was substantially higher than at sites in Humbug Gully (DERM 2010), which may be due to seasonal differences in macroinvertebrate communities. High taxonomic richness in Nebo and Denison creeks may also be indicative of good habitat and water quality.

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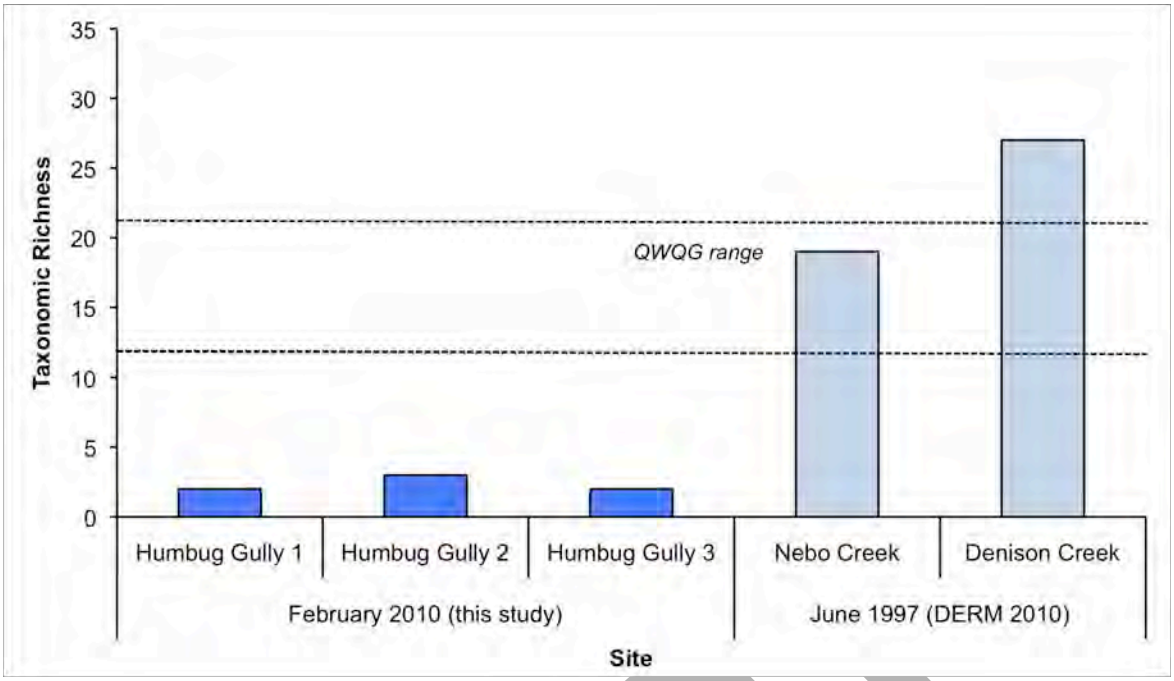


Figure 2.1 Taxonomic richness in bed habitat from creeks in the study area, and the QWQG range for slightly to moderately disturbed streams in central Queensland.

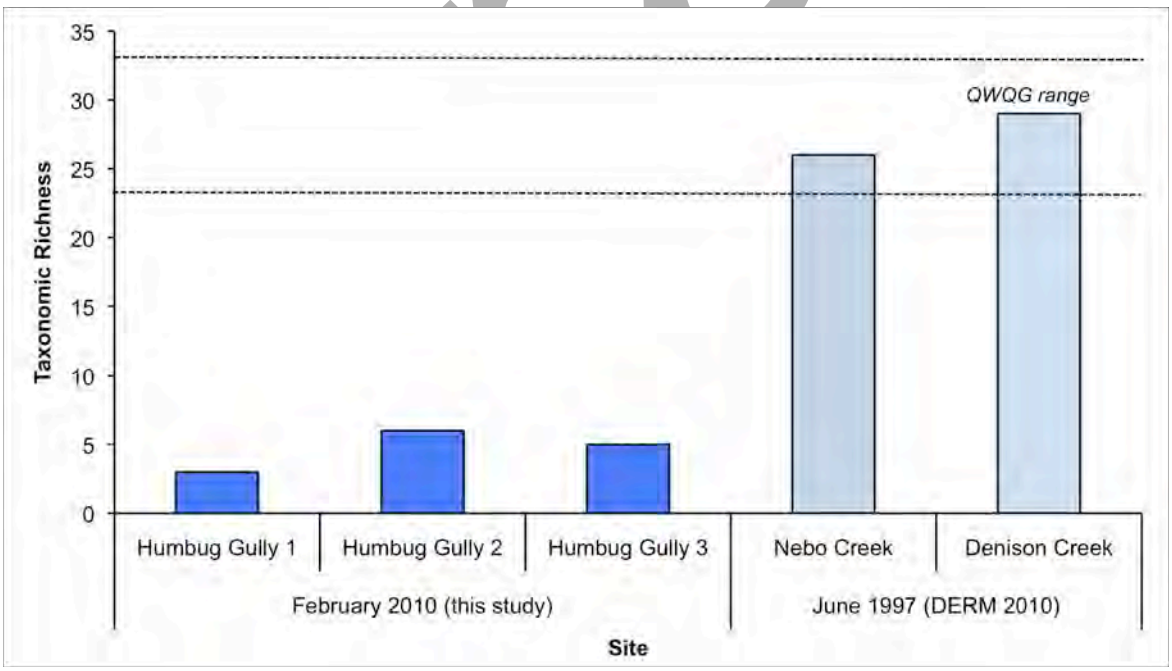


Figure 2.2 Taxonomic richness in edge habitat from creeks in the study area, and the QWQG range for slightly to moderately disturbed streams in central Queensland.

2.2 PET Richness

In February 2010, no PET families were recorded in Humbug Gully, which may be indicative of habitat degradation and / or that the available habitat was less suited to sensitive taxa (Figure 2.3 & Figure 2.4). PET taxa are particularly sensitive to poor water quality and disturbance.

In June 1997 in Nebo and Denison creeks, PET richness was relatively high and was within or exceeded the QWQG range (DERM 2010). Similar to taxonomic richness, PET richness was substantially higher in Nebo and Denison creeks than that at sites in Humbug Gully.

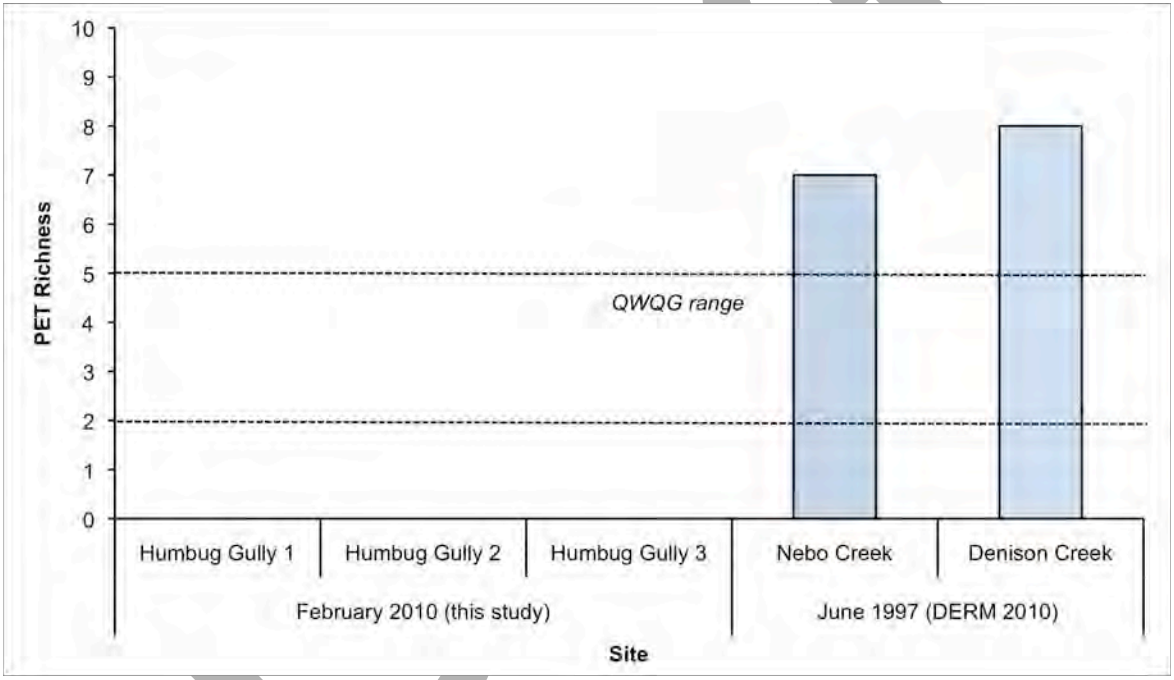


Figure 2.3 PET richness in bed habitat from creeks in the study area, and the QWQG for slightly to moderately disturbed streams in central Queensland.

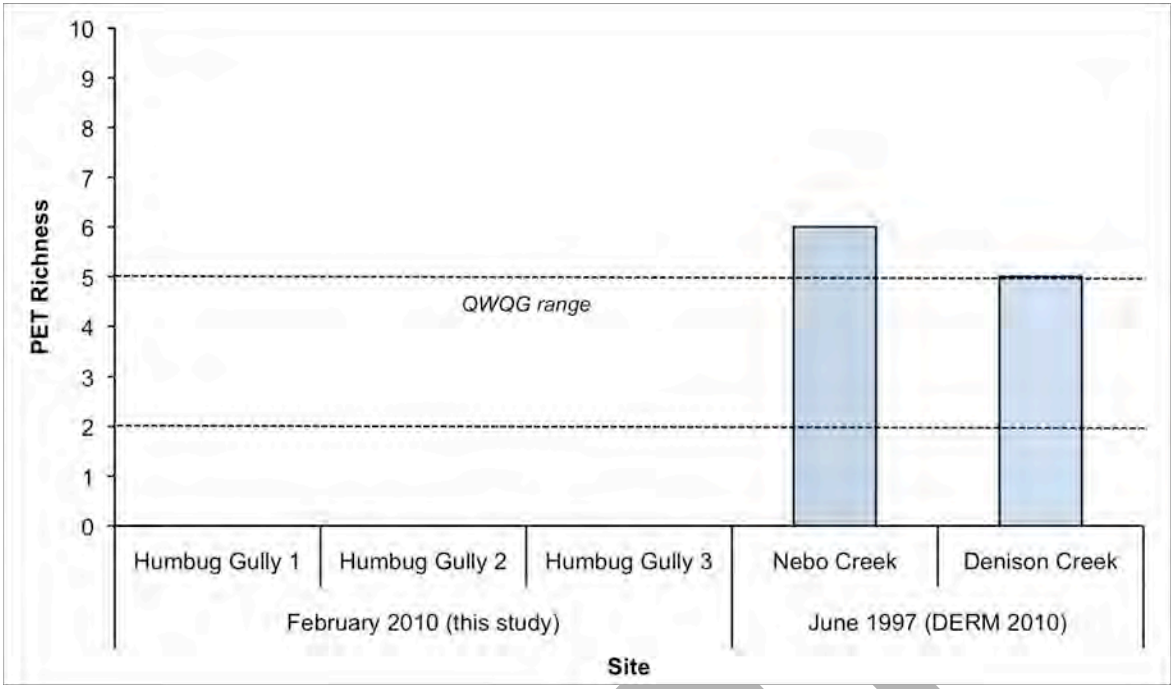


Figure 2.4 PET richness in edge habitat from creeks in the study area, and the QWQG for slightly to moderately disturbed streams in central Queensland.

2.3 SIGNAL 2 / Family Bi-plot

In February 2010 in Humbug Gully, macroinvertebrate communities sampled from bed habitat were predominantly in quadrant 3 (Figure 2.5), which is indicative of toxic pollution or harsh physical conditions. Macroinvertebrate communities in Humbug Gully are likely to be affected by the harsh physical conditions characteristic of ephemeral waterways. Communities sampled from edge habitat were in quadrant 4 (Figure 2.6), which is indicative of urban, industrial or agricultural pollution, or the downstream effects of dams.

In June 1997 in Nebo and Denison creeks, macroinvertebrate communities in both bed and edge habitats were predominantly in quadrant 1 (DERM 2010), which is indicative of favourable habitat and chemically dilute waters. It is likely that these sites had good habitat and water quality.

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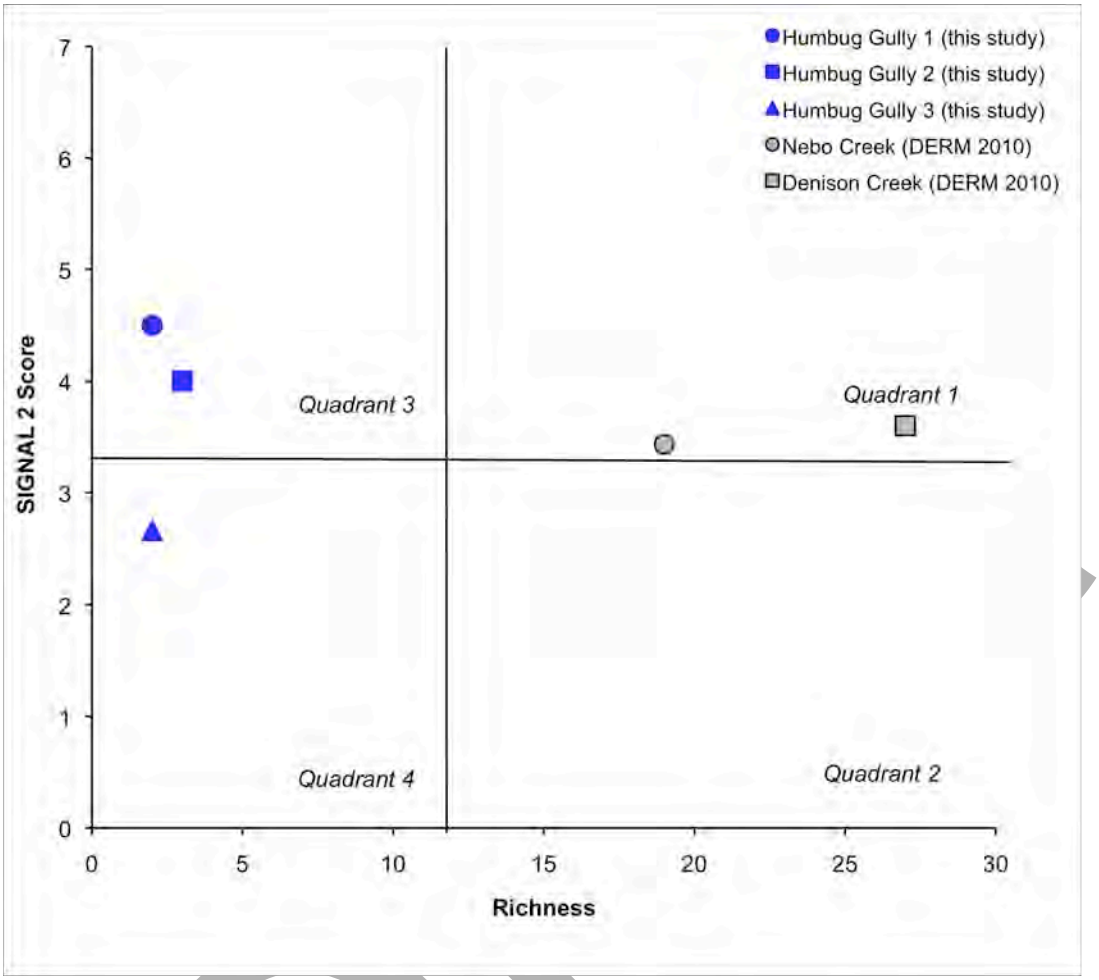


Figure 2.5 SIGNAL 2 / family by-plot for macroinvertebrate communities in bed habitat from creeks in the study area, and the QWQG for slightly to moderately disturbed streams in central Queensland.

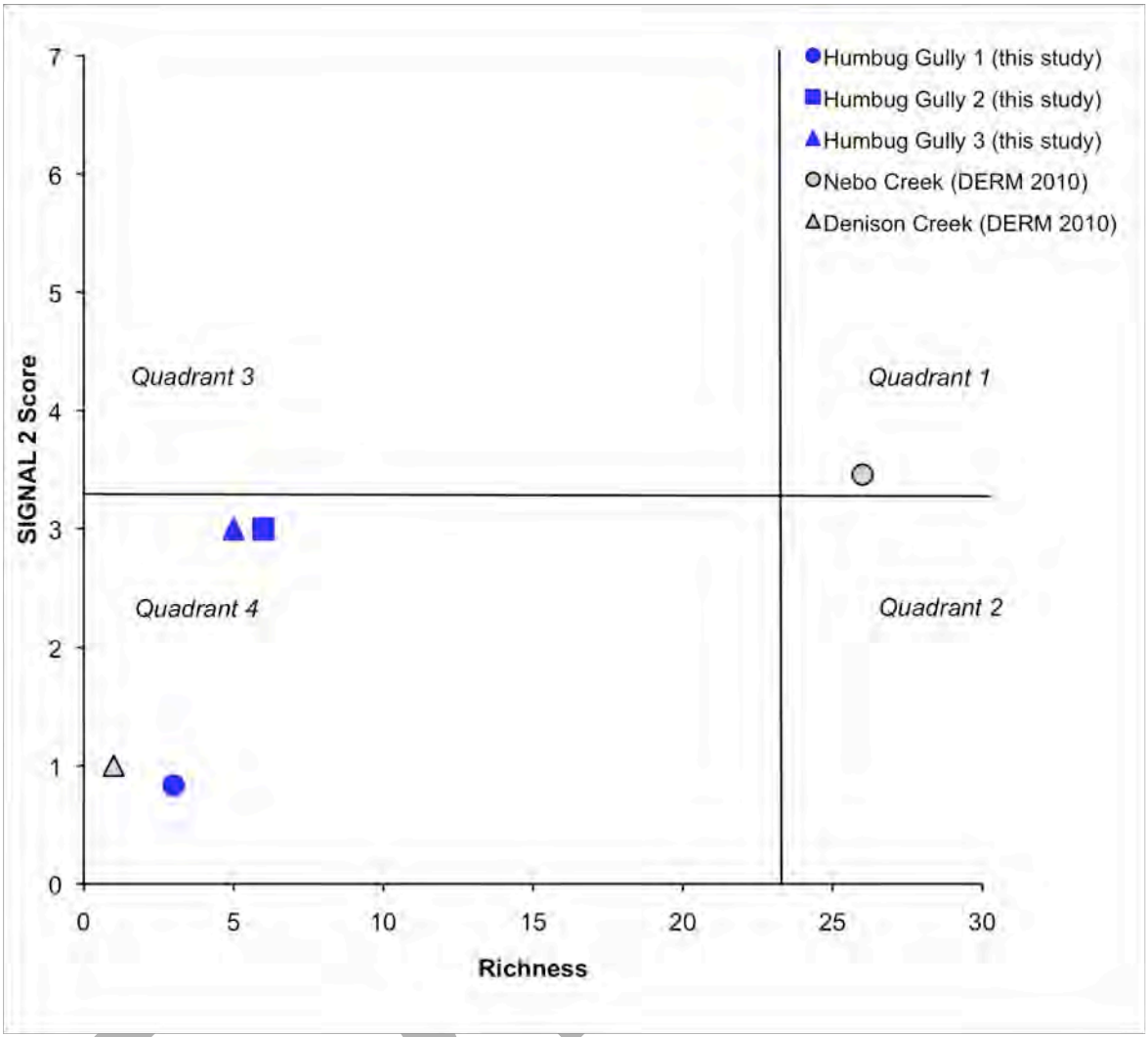


Figure 2.6 SIGNAL 2 / family by-plot for macroinvertebrate communities in edge habitat from creeks in the study area, and the QWQG for slightly to moderately disturbed streams in central Queensland.

3 Macrocrustacean Communities

In February 2010, no macrocrustaceans were recorded in Humbug Gully. In June 1997, freshwater shrimp (family Atyidae) and river prawns (family Palaemonidae) were recorded in Nebo and Denison creeks (DERM 2010).

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Appendix E Aquatic Vertebrate Communities

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1 Methodology

1.1 Aquatic Vertebrates of the Study Area

Aquatic vertebrates of Humbug Gully were assessed during a field survey on 4 – 5 February 2010. Three sites were surveyed: one upstream of (site 1), one within (site 2), and one downstream of (site 3) the proposed underground expansion area (see appendix B for a map of the study area).

Fish Communities

Fish communities were surveyed using a combination of backpack electrofishing and baited traps. Electrofishing was the preferred method and was used at all of the sites. Sampling effort is presented in Table 1.1.

Electrofishing was conducted using a Smith-Root LR-24 backpack electrofisher. Field sampling followed the methods used in the south-east Queensland Ecological Health Monitoring program (EHMP 2007), adapted where appropriate to suit local conditions. All available habitat units were fished at each site. Electrofishing was conducted in accordance with the *Australian Code of Electrofishing Practice 1997*.

At site 3, five samples were also collected using small (2 mm mesh) baited traps, which are designed to capture fish. Water depth was too shallow to set baited traps at sites 1 and 2.

Table 1.1 Sampling effort at each site.

Site	Method	Habitat	Date	Time In	Time Out	Settings	Effort
1	backpack electrofishing	run	04/02/10	17:00	17:25	280 V, 12%, 30Hz	302 seconds
2	backpack electrofishing	run	04/02/10	14:00	14:25	230 – 280 V, 12%, 30Hz	272 seconds
3	backpack electrofishing	run, riffle & pool	05/01/10	09:00	09:30	250 V, 12%, 30Hz	468 seconds
3	baited traps (x5)	run & pool	05/01/10	09:40	10:40	–	5 hours

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At each site, the species present, the abundance of each species by life history stage (juvenile, intermediate, adult) and the apparent health of individuals was recorded.

The sampling of fishes was conducted under General Fisheries Permit No. 54790 and Animal Ethics Approval No. CA 2009/03/343 issued to frc environmental.

Data Analysis

For each site, the taxonomic richness, total abundance, abundance of rare and threatened species, abundance of exotic species, and the abundance of each life history stage was determined.

Turtles Communities

At all sites, water depth was too shallow to set baited cathedral traps, which are typically used to capture turtles. Potential turtle nesting habitat was recorded.

1.2 Aquatic Vertebrates of the Region

The aquatic vertebrate communities in the Fitzroy Basin were described through literature review, to provide a regional context for the condition of the creeks in the study area.

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2 Aquatic Vertebrates of the Study Area

2.1 Fish Communities

Fish communities in Humbug Gully were species poor and abundance was low and fish were only recorded up- and downstream of the proposed underground expansion area (sites 1 & 3; Table 2.1).

A total of 14 fish including four species were recorded in Humbug Gully: Agassiz's glassfish (A*mbassis agassizii*; Figure 2.1), carp gudgeon (*Hypseleotris* spp.; Figure 2.2), Hyrtl's tandan (*Neosilurus hyrtlii*; Figure 2.3), and spangled perch (*Leiopotherapon unicolor*). Agassiz's glassfish were the most abundant species.

Species richness was relatively low across the study area compared to other locations in the Isaac-Connors Catchment (see Section 3.1 below). This may be attributable to the ephemeral nature of Humbug Gully and physical factors such as the size of the pool surveyed, the presence and abundance of aquatic habitat such as large woody debris, and restricted fish passage within the waterway.

No exotic or listed rare or threatened species were recorded during our survey.

Figure 2.1

Agassiz's glassfish recorded at site 3.



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Figure 2.2

Gudgeon recorded at site 3.



Figure 2.3

Hyrtl's tandan recorded at site 3.



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Table 2.1 Fish abundance at each site in the study area in February 2010.

Family	Latin Name	Common Name	Native / Exotic	Life History Stage	Site		
					1	2	3
Chanidae	*Ambassis agassizii*	Agassiz's glassfish	N	adult			5
				intermediate			4
				juvenile			2
Eleotridae	*Hypseleotris* spp.	gudgeon	N	juvenile			1
Plotosidae	*Neosilurus hyrtlii*	Hyrtl's tandan	N	intermediate			1
Terapontidae	*Leiopotherapon unicolor*	spangled perch	N	adult	1		
Total					**1**	**0**	**13**

2.2 Turtle Communities

No turtles or potential nesting habitat for turtles were observed in the study area.

2.3 Other Aquatic Vertebrates

One frog (species unknown) was observed at site 3.

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3 Aquatic Vertebrates of the Region

3.1 Fish Communities

A total of 36 species of fish belonging to 20 families have been recorded in the freshwater reaches of the Fitzroy Basin, of these 25 species have been recorded in the Connors and Isaac rivers (Table 3.1).

Generally, the fish communities in the tributaries of the headwaters of the Connors and Isaac rivers have fewer species than those further downstream (Wormington et al. 2006; SKM 2009b). For example, only three species were recorded from North and 13 Mile creeks, which are tributaries of the Isaac River (Wormington et al. 2006), and only four species were recorded in Humbug Gully (this study). Additionally, few larger species have been recorded in the vicinity of the Coppabella Mine (SKM 2009b). The aquatic habitat in the headwaters of the Connors and Isaac rivers is poorer than that found further downstream, which is likely to inhibit larger fish from populating these creeks (SKM 2009b).

No exotic species have been recorded from the Isaac-Connors Catchment, although they have been recorded in the Fitzroy Basin (Berghuis & Long 1999; frc environmental 2009).

Given their known habitat preferences, water quality tolerances and distribution, 11 of the fish species known in the Isaac-Connors Catchment may occur in the study area. These species are tolerant species that can live in water characterised by low dissolved oxygen levels, high conductivity and relatively high turbidity (Table 3.2).

The relative composition and abundance of fish communities within the study area is largely controlled by the life history requirements of the species involved. Many of the fish known in the region are native to intermittent and ephemeral systems of central and western Queensland, and move up and downstream, and between different habitats, at particular stages of their lifecycle (Cotterell 1998; Marsden & Power 2007). Stimuli for movement include small and large discharge events and changes in temperature. The water quality of Australian rivers is notoriously unstable, and fish may need to move up- and downstream to avoid undesirable water quality and the drying out of pools (Freshwater Fisheries Advisory Committee 1996; Kennard 1997), and are unlikely to inhabit the smaller tributaries (Table 3.1).

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Table 3.1 Fish species known from the Isaac-Connors Catchment, and their presence / abundance in the vicinity of the Coppabella Mine.

Family	Species	Common Name[1]	Humbug Gully[2]	Tributaries to the Connors River in the vicinity of the Mine[3]	Tributaries to the Upper Isaac River[3]	Upper Connors River and Tributaries[4]	Lower Connors / Isaac Rivers[5]
Ambassis	*Ambassis agassizii*	Agassiz's glassfish*	√	√	–	√	√
Anguillidae	*Anguilla reinhardtii*	marbled eel*	–	√	–	√	√
Apogonidae	*Glossamia aprion*	mouth almighty	–	–	–	√	√
Ariidae	*Arius graeffei*	fork-tailed catfish	–	–	–	√	√
Atherinidae	*Craterocephalus stercusmuscarum*	fly-specked hardyhead*	–	√	√	√	√
Belonidae	*Strongylura krefftii*	freshwater longtom	–	–	–	√	√
Clupeidae	*Nematolosa erebi*	bony bream*	–	√	–	√	√
Eleotridae	*Hypseleotris* spp.	carp gudgeon*	√	√	–	√	√
	Hypseleotris compressa	empire gudgeon	–	–	–	–	√
	Morgunda adspersa	purple-spotted gudgeon*	–	√	–	√	√
	Oxyeleotris lineolata	sleepy cod*	–	√	–	√	√
	Philypnodon grandiceps	flathead gudgeon	–	–	–	√	√
Gobiidae	*Redigobius bikolanus*	speckled goby	–	–	–	√	√
Hemirhamphidae	*Arramphus sclerolepis*	snub-nosed garfish	–	–	–	–	√

Family	Species	Common Name[1]	Humbug Gully[2]	Tributaries to the Connors River in the vicinity of the Mine[3]	Tributaries to the Upper Isaac River[3]	Upper Connors River and Tributaries[4]	Lower Connors / Isaac Rivers[5]
Melanotaeniidae	*Melanotaenia splendida splendida*	eastern rainbowfish*	–	√	√	√	√
Osteoglossidae	*Scleropages leichardti*	southern saratoga	–	–	–	√	√
Percichthyidae	*Macquaria ambigua oriens*	golden perch	–	–	–	√	√
Plotosidae	*Neosilurus ater*	black catfish	–	–	–	√	√
	Neosilurus hyrtlii	Hyrtl's tandan*	√	–	–	√	√
	Porochilus rendahli	Rendahl's catfish	–	–	–	√	√
	Tandanus tandanus	eel-tailed catfish*	–	√	–	√	√
Pseudomugilidae	*Pseudomugil signifer*	pacific blue eye	–	–	–	√	√
Terapontidae	*Amniataba percoides*	barred grunter	–	–	–	√	√
	Leiopotherapon unicolor	spangled perch*	√	√	√	√	√
	Scortum hillii	leathery grunter	–	–	–	√	√

[1] astrix (*) indicates that this species may be found in the Coppabella Mine study area

[2] this study

[3] Wormington et al. 2006

[4] SKM 2009a

[5] Berghuis & Long 1999; Pusey et al. 2004; Marsden & Power 2007

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Table 3.2 Known water quality tolerances of fish species known from, or likely to occur in the study area (data sourced from Pusey et al. 2004).

Family	Latin Name	Common Name	Water Temperature (º C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Turbidity (NTU)
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish	11.0 – 33.0	0.3 – 19.5	6.3 - 9.9	19.5 – 15 102	0.2 – 144
Anguillidae	*Anguilla reinhardtii*	marbled eel	8.4 – 31.7	0.6 – 16.2	5.6 – 9.1	19.5 – 2 247	–
Atherinidae	*Craterocephalus stercusmuscarum*[B]	fly-specked hardyhead	15 – 38	2.6 – 11.9	6.8 – 8.3	50 – 790	0.3 – 190
Clupeidae	*Nematalosa erebi*	bony bream	24 – 29	4.8 – 11	6.9 – 8.8	70 – 770	4 – 160
	Hypseleotris spp.[A]	carp gudgeon	8.4 – 31.2	0.3 – 19.5	4.4 – 8.9	51 – 4 123	0.1 – 331.4
	Mogurnda adspersa[A]	purple-spotted gudgeon	11.9 – 31.7	0.6 – 12.8	5.6 – 8.8	72 – 2 495	0.2 – 200
	Oxyeleotris lineolata	sleepy cod	20.6 – 32.0	4.6 – 11.0	7.0 – 9.2	81 – 650	1 – 22 but up to 600 (frc pers. obs.)
Melanotaeniidae	*Melanotaenia splendida splendida*[C]	eastern rainbowfish	15.0 – 32.5	1.1 – 10.8	6.8 – 8.5	49 – 790	0.6 – 16, but up to 600 (frc pers. obs.)
Plotosidae	*Neosilurus hyrtlii*[C]	Hyrtl's tandan	21.0 – 33.0	2.6 – 11.0	6.7 – 8.5	56 – 790	0.25 – 16, but up to 600 (frc pers. obs.)
	Tandanus tandanus[A]	eel-tailed catfish	8.4 – 33.6	0.3 – 17.1	4.8 – 9.1	19.5 – 3 580	0.2 – 250
Terapontidae	*Leiopotherapon unicolor*	spangled perch	5 – 41	≥ 0.4	4 – 8.6	0.2 – 35.5 ppt salinity	1.5 – 260

A environmental data from captures during surveys in south-east Queensland

B environmental data from captures during surveys in the Burdekin and Fitzroy river systems

C environmental data from captures during surveys in the Burdekin River system

D environmental data from captures during surveys in the Fitzroy River system

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Ecology of Fish in the Study Area

Agassiz's Glassfish (Ambassis agassizii)

Agassiz's glassfish is commonly found in rivers, creeks, ponds, reservoirs, drainage ditches and swamps from Cairns in Queensland to Lake Hiawatha in New South Wales, and in the Murray-Darling system (McDowall 1996; Allen et al. 2002). This species can be found in a variety of still or slow-flowing habitats in lowland larger rivers, upland rivers and streams and small coastal streams, and occasionally in lakes, and river impoundments, particularly in areas with submerged macrophyte and bank side vegetation (Pusey et al. 2004). This species has a wide temperature range (Merrick & Schmida 1984), although they are not tolerant of low dissolved oxygen levels (Tait & Perna 2001), and are generally found in areas of low turbidity (Pusey et al. 2004). The diet of this species consists largely of small crustaceans and adult and larval insects, including mosquitoes (McDowall 1996). This species spawns and completes its lifecycle in freshwater, and during spawning deposits and fertilises demersal eggs on aquatic vegetation (Merrick & Schmida 1984). Information on the migration habits of Agassiz's glassfish is limited, however it appears that this species may undertake upstream migrations triggered by increased flow (Pusey et al. 2004).

Marbled Eel (Anguilla reinhardtii)

In Australia, marbled eels have been reported from the tip of Cape York Peninsula in Queensland to Melbourne in Victoria (Pusey et al. 2004). Larger marbled eels are typically found near the mouth of the river, in reaches dominated by sand, fine gravel and rock substrate, whilst smaller marbled eels are typically found further upstream in reaches dominated by cobble and rock substrate.

Anguillids migrate from freshwater to oceanic spawning grounds in the Coral Sea and the young migrate back to freshwaters to complete their lifecycle (Pusey et al. 2004). The downstream migration can occur over an extended period, but generally peaks during summer and autumn (December to May) (Cotterell 1998). It is believed that the adults die after spawning. Oceanic currents carry the larvae to the coast where they develop and return to freshwater environments. The upstream movement of juveniles is concentrated during the wet spring and summer months (September to March) (Cotterell 1998). The migration of juvenile eels into rivers has been correlated with river discharge, which may guide the eels towards the rivers (Martin 1995, cited in Brizga et al. 2003).

The marbled eel is a carnivorous species, consuming small food items as juveniles and switching to larger diet items and a more diverse array of food types with growth (Pusey et

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al. 2004). Aquatic insects (89%) dominate the diet of smaller marbled eels (<200 mm TL) with microcrustaceans, terrestrial invertebrates, and fish consumed in a smaller proportion. Adults consume fish (28%), macrocrustaceans (21%), and aquatic insects (30%) and also terrestrial vertebrates, aquatic algae, terrestrial vegetation, and terrestrial invertebrates.

The marbled eel occurs across a range of water quality conditions throughout south eastern Queensland. Anguillids are a hardy group of fish and are able to survive out of water for a long time by absorbing oxygen from the atmosphere through the skin or by gulping air (FRC Coastal Resource & Environmental 1999; McDowall 1994, as cited in Pusey et al. 2004).

Fly-specked Hardyhead (Craterocephalus stercusmuscarum)

The fly-specked hardyhead is a very widespread species found in coastal and inland drainages of eastern and northern Australia, south to the Queensland border (Pusey et al. 2004). This species is common and widely distributed in central Queensland, and is known to occur in the Fitzroy Basin (Berghuis & Long 1999; Pusey et al. 2004). Fly-specked hardyheads can be found in a variety of habitats including rivers, streams, lakes, water impoundments, and in brackish river estuaries, with moderate to fast water flows (Pusey et al. 2004). This species is likely to migrate year round, migrating upstream to spawn (Marsden & Power 2007), although only low numbers have been found in fishways in the Fitzroy Basin (Pusey et al. 2004).

This tropical species is moderately tolerant of a wide range of temperatures, dissolved oxygen, pH and conductivity levels, however appears to be intolerant to high turbidity levels (>100 NTU) (Pusey et al. 2004 and references within). This species is a microphagic carnivore consuming aquatic insects and microcrustaceans and to a lesser extent aquatic algae and macrophytes (Pusey et al. 2004 and references within).

Bony Bream (Nematalosa erebi)

Bony bream are abundant detritivores / algivores that form the basis of the food chain for a number of higher order consumers including larger fishes and birds such as cormorants and pelicans (Pusey et al. 2004).

Bony bream commonly occur in the shallows of still or slow-flowing streams, particularly in turbid conditions such as those of the region (Allen et al. 2002). Within the Fitzroy River system, bony bream have been recorded from water temperatures between 24 – 29 °C

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(Pusey et al. 2004). They have a wide pH tolerance and have been recorded from waters with salinity levels approaching those of the seawater (Ruello 1976). High salinity tolerance is undoubtedly one of the factors influencing the widespread distribution of bony bream throughout Australia's freshwater habitats. However, they cannot tolerate low dissolved oxygen levels (Allen et al. 2002), and are often the first species to die when ephemeral habitats start to dry up (Allen et al. 2002).

Carp Gudgeon (Hypseleotris spp.*)*

There is considerable taxonomic uncertainty within this genus (especially in juveniles), with some species capable of hybridising. Carp gudgeons are common in coastal drainage basins of eastern Australia, from the northern section of the Murray-Darling Basin and parts of coastal NSW to north Queensland. Gudgeons often shelter around aquatic vegetation and under logs and tree roots, commonly in slow moving water in streams, ponds, swamps and drains (Allen et al. 2002); (Marsden & Power 2007). Adult carp and firetailed gudgeons feed on invertebrates, such as mosquito larvae (Diptera: Culicidae), and small crustacea such as cladocerans and ostracods (Merrick & Schmida 1984; Allen et al. 2002). These species are quite tolerant to changes in water quality, and under ideal conditions can rapidly increase in number (Merrick & Schmida 1984). Most *Hypseleotris* spp. undertake upstream spawning migrations in low to high water flow, however the timing of migration and spawning varies with species (Marsden & Power 2007).

Purple-spotted Gudgeon (Mogurnda adspersa)

The purple-spotted gudgeon is common within it's distribution from the Clarence River in New South Wales to the Cape York Peninsula in Queensland. It is found in a wide range of temperatures and prefers slow-flowing weedy habitats, found over a wide range of substrates (Pusey et al. 2004). It appears to tolerate a wide range of physico-chemical conditions and in particular, low dissolved oxygen levels. This species spawns and completes its lifecycle in freshwater, and during spawning deposits and fertilises demersal eggs on aquatic vegetation and woody debris, where the male fans and guards the eggs for a number of days (Allen et al. 2002). This species predominantly feeds on aquatic and terrestrial insects, microcrustaceans and macroscrustaceans (Pusey et al. 2004).

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Sleepy Cod (Oxyeleotris lineolata)

Sleepy cod are common and widespread in northern Australia between the Ord River on the west coast and Noosa on the east coast (Allen et al. 2002). They are a hardy species that inhabit rivers, creeks and billabongs, usually in quiet or slow-flowing water among vegetation, around woody debris or beneath undercut banks (Merrick & Schmida 1984; Allen et al. 2002). This species is a sluggish bottom dwelling carnivore that feeds on insects, small fishes and crustaceans (Merrick & Schmida 1984; Allen et al. 2002). Sleepy cod appear to have a lower thermal limit of 15 °C and Northern Territory populations can withstand temperatures to 32 °C (Merrick & Schmida 1984). Sleepy cod generally do not undertake substantial migrations, with spawning usually occurring between October and February (Allen et al. 2002), when water temperatures reach 24 °C. The nest is located on a solid surface (usually rock, tree roots or submerged log) and the male guards the nest for the incubation period of 5 – 7 days (Merrick & Schmida 1984; Allen et al. 2002).

Eastern Rainbowfish (Melanotaenia s. splendida)

The eastern rainbowfish is the common rainbowfish in many parts of north-eastern and central Australia, and is usually abundant wherever it occurs (Allen et al. 2002). Where found, this species usually prefers areas of sluggish water flow, and can be found in a variety of habitats including streams, wetlands, floodplains and lowland rivers (Pusey et al. 2004). This tropical species is tolerant of a wide range of environmental conditions, however is not often found in highly degraded streams (Marsden & Power 2007). This species spawns all year round, although spawning peaks immediately before and during flood periods (Merrick & Schmida 1984). Adults migrate upstream to spawn during the wet season from (November to April) when water flows are high and juveniles disperse from the spawning grounds (Merrick & Schmida 1984).

Hyrtl's tandan (Neosilurus hyrtlii)

This species is very common and widespread in coastal drainages of northern Australia, as far south as Mary River on the east coast and the Pilbara on the west coast (Allen et al. 2002). It also occurs widely throughout central Australia (Allen et al. 2002) and has been recorded in the Fitzroy River (Merrick & Schmida 1984). Hyrtl's tandan is a shoaling species that occupies a diverse range of habitats including still or flowing waters, pools and billabongs (Allen et al. 2002). This species feeds on insects, molluscs, small crustaceans and worms (Allen et al. 2002). The spawning behaviours of interior populations are unknown; however, northern populations breed at the beginning of the

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wet season in shallow, sandy areas in the upper reaches of streams (Allen et al. 2002). Further research is required as this species may actually represent more than one species (Allen et al. 2002).

Eel-tailed catfish (Tandanus tandanus)

Eel-tailed catfish have been stocked throughout eastern Australia for recreational angling. They are found in a range of habitats, from small-order streams to rivers, and they are generally more abundant when the riparian zone is intact and there is abundant terrestrial debris in the channel to provide habitat (Pusey et al. 2004). In general, they are tolerant of low oxygen concentrations and a range of temperatures, although they can be sensitive to sudden decreases in temperature (Pusey et al. 2004). Juveniles mainly feed on aquatic insects while adults have a more varied diet. Adults exhibit some parental care by building circular nests in gravel beds.

Spangled Perch (Leiopotherapon unicolor)

Spangled perch are Australia's most widespread native fish, being abundant within most habitats (Allen et al. 2002). They can tolerate wide ranges of temperature, salinity and pH. Of particular relevance to their abundance in western and central Queensland creeks is their ability to aestivate in wet mud or under moist leaf litter in ephemeral water holes during droughts (Allen et al. 2002). As an adaptation to living in quick-drying waterholes, spangled perch eggs hatch in 2 days and the larvae develop in 24 days (Ivanstoff & Crowley 1996; Allen et al. 2002).

3.2 Turtle Communities

The Fitzroy Basin has a high conservation value with respect to freshwater turtles, due to the high number of species found in the basin (Limpus 2007). Six species of turtle have been described from the Fitzroy Basin: Krefft's river turtle (*Emydura macquarii krefftii*); eastern long neck turtle (*Chelodina longicollis*); broad-shelled river turtle (*Chelodina expansa*); sawshelled turtle (*Wollumbinia latisternum*); white throated snapping turtle (*Elseya albagula*) and Fitzroy River turtle (*Rheodytes leukops*) (Limpus 2007). Of these species, only the Krefft's river turtle has been recorded near the Coppabella Mine, approximately 50 km downstream in Funnel Creek (SKM 2009a). Given the ephemeral nature of creeks in the study area, these species are unlikely to occur in creeks in the study area, however they may be present in local farm dams.

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The Fitzroy River turtle and the white throated snapping turtle are species of concern within the Fitzroy Basin. The Fitzroy River turtle is listed as 'vulnerable' both in Queensland (under the *Nature Conservation Act 1992*, as listed in the Nature Conservation (Wildlife) Regulation 2006 (NCWR))[1] and nationally (under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)). The white-throated snapping turtle is listed as 'least concern' under the NCWR, but has been identified as a high priority for conservation in the DERM's species prioritisation framework. Given the preferred habitat of these species (see below), it is likely that they will be found in the study area.

Fitzroy River Turtle (*Rheodytes leukops*)

The Fitzroy River turtle has only been recorded in the Fitzroy River and its tributaries (Cogger 1996). Its habitat comprises a total area of less than 10 000 km² and includes the Fitzroy, Mackenzie, Dawson, Isaac, and Connors rivers.

The preferred habitat of the Fitzroy River turtle is shallow, fast-flowing riffle zones characterised by well-oxygenated water (Cann 1998; Tucker et al. 2001). Riffle zones are an important habitat for the Fitzroy River turtle, with home ranges of individuals typically overlapping these areas of fast-flowing water, and with turtles usually not far from riffle zones (Tucker et al. 2001). The apparent correlation between riffle habitats and the home ranges of the Fitzroy River turtle may be due to a greater abundance of invertebrate prey, and an increase in foraging success in these habitats (Legler & Cann 1980); or may reflect a greater efficiency of aquatic cloacal respiration in highly oxygenated waters.

Under low flow events, or as riffle zones became seasonally ephemeral (i.e. dried completely) female Fitzroy River turtles retreat to deeper sections of pool habitats, or even isolated waterholes, adjacent to riffle zones (Tucker et al. 2001; Limpus 2007).

Fitzroy River turtles eat the benthic invertebrates and algae that are abundant in riffle zones, in order to take up nutrients and build fat reserves for the dry season, which is essential for preparing to breed (Limpus 2007).

White-throated Snapping Turtle (*Elseya albagula*)

The white-throated snapping turtle was only described in 2006 (Thomson et al. 2006); previously it had been regarded as a form of the more common and widely distributed

[1] Reprint No. 6D, Reprinted as in force on 26 June 2010. Reprint prepared by the Office of the Queensland Parliamentary Council.

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northern snapping turtle (*Elseya dentata*). It is found in the Fitzroy, Raglan, Burnett and Mary river drainages in central and southern Queensland, but has also been recorded in small adjacent coastal waterways, including the Kolan and Gregory-Burrum Rivers (Haman et al. 2007).

Within the greater Fitzroy, Burnett and Mary River catchments, the white-throated snapping turtle has been recorded almost exclusively in close association with permanent flowing stream reaches, typically characterised by a sand-gravel substrate with submerged rock crevices, undercut banks and / or submerged logs and fallen trees (Haman et al. 2007). Within the Fitzroy and Mary River catchments, the white-throated snapping turtle is regularly associated with areas of high shade, including submerged logs and overhanging riparian vegetation, during the day; and shallow riffle zones at night (Haman et al. 2007).

The white-throated snapping turtle has not been recorded from man-made water bodies isolated from flowing streams, such as farm dams or sewage treatment plants, suggesting that *E. albagula* does not move extended distances over dry land (Haman et al. 2007).

3.3 Other Aquatic Vertebrates

No other aquatic mammals, reptiles or amphibians of conservation significance have been recorded from, or are likely to occur within the study area (DEWHA 2009; EPA 2009).

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Appendix D
Groundwater Assessment (AGE 2010)















Australasian Groundwater & Environmental Consultants Pty Ltd

REPORT on

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COPABELLA UNDERGROUND PROJECT

GROUNDWATER IMPACT ASSESSMENT

prepared for
McCARTHUR COAL (C&M MANAGEMENT) PTY LTD

Project No. G1474
December 2010

ABN:64 080 238 642

Australasian
Groundwater & Environmental
Consultants Pty Ltd

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REPORT ON

COPPABELLA UNDERGROUND PROJECT

GROUNDWATER IMPACT ASSESSMENT

1.0 INTRODUCTION

The Coppabella and Moorvale Joint Venture (C&M JV) own the Coppabella open cut mine that is operated by Macarthur Coal (C&M Management) Pty Ltd, a subsidiary of Macarthur Coal Limited. Coppabella Mine is located in Central Queensland region, approximately 110km south-west of Mackay and 37km north-east of Moranbah Township. The C&M JV propose to develop an underground mining operation as an extension of the current mine operation when mining activities in the open cut pits are ramped down. The underground project has an identified coal resource of approximately 118 million tonnes which is proposed to be mined at no more than the current approved production rate of 6 Mtpa over a project life of around 10 years.

In order to obtain mining leases over the underground portion of the resource, an Environmental Authority (EA) is required under the Environmental Protection Act 1994, which may trigger the need for an Environmental Impact Statement (EIS). Hence this report has been prepared to the level required for an EIS and addresses the potential impact of the project on the groundwater resources and features related to the groundwater regime. The report describes the hydrogeological regime of the area and provides an assessment of the potential impact of the project on this regime. Potential risks and constraints are identified and where necessary mitigation and/or containment strategies developed.

McCollum Environmental Management Services (MEMS) has been engaged by C&M JV to manage the Mining Lease Application (MLA) and Environmental Approvals processes on their behalf, and this report has been prepared by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) at the request of MEMS.

2.0 PROJECT OVERVIEW

The intent of the C&M JV is to develop an underground replacement operation towards the end of the current open cut mining activities. It is proposed the underground mining methodology will utilise a Longwall Top Coal Caving (LTCC) extraction methodology in conjunction with the more traditional longwall mining method board and pillar underground mining method. Mining will target the locally named Macarthur Seam which comprises the coalesced Leichhardt Upper and Leichhardt Lower Seams, and is the primary economic unit mined at Coppabella.

The existing coal handling and preparation plant (CHPP) will process the run of mine (ROM) coal, with process waste disposed on site into the existing Co-Disposal Tailing Storage Facility (TSF). No expansion or alterations to the current CHPP are proposed. Product coal will be loaded onto the existing Coppabella Mine train load-out facility and transported to the Dalrymple Bay Coal Terminal (DBCT) by coal trains for export overseas.

Additional project infrastructure will include development of an in pit underground portal, new overland conveyor from the mine portal to the ROM coal stockpile adjacent to the CHPP, store and additional workshop infrastructure adjacent to the mine portal, additional service roads to the mine portal and underground mining infrastructure.

The project is located within existing mining leases ML70161, ML70163, ML70164, ML70236, and ML70237 with the proposed future development into areas currently off the mining leases but covered by MLA70384, MLA70385, MLA70386 and MLA70387 (the MLAs).

3.0 TERMS OF REFERENCE AND METHODOLOGY

3.1 Project Terms of Reference

The scope of work for this assessment has been based on those defined by the Department of Environmental and Resource Management (DERM) Generic Draft Terms of Reference (ToR) for Environmental Impact Statements (EPA, 2008), and information provided by MEMS. The generic ToR requires that the nature of the groundwater in the area of interest be fully described and the impacts, in terms of potential groundwater harm of the proposal on the groundwater resources be assessed.

Section 4 Environmental Values Affected and Management of Impacts

Section 4.5.1.2 Groundwater

The EIS must include a groundwater investigation study to assess the impacts of the project on existing groundwater users and the aquifers in the area. The report should review the quality, quantity and significance of groundwater in the proposal area, together with groundwater use in neighbouring areas. The report will include a survey of existing groundwater supply facilities (bores, wells, or excavations, users and uses), with the information gathered including:

- *location;*
- *usage and significance of use;*
- *pumping parameters*
- *draw down and recharge at normal pumping rates; and*
- *seasonal variations (if records exist) of groundwater levels and dissolved solids concentrations or electrical conductivity.*

A network of observation points which would satisfactorily monitor groundwater resources both before and after commencement of operations should be developed and described in the EIS. This section of the EIS should address the nature and hydrology of the aquifers and provide a description of the:

<u>Nature of the aquifer/s</u>

- *Geology/stratigraphy - such as alluvium, volcanic, metamorphic*
- *Aquifer type - such as confined, unconfined*
- *Depth to and thickness of the aquifers*

Hydrology of the aquifer/s

- *Depth to water level and seasonal changes in levels*
- *Groundwater flow directions (defined from water level contours)*
- *Interaction with surface water*
- *Interaction with saline water*
- *Possible sources of recharge*
- *Vulnerability to pollution*

The data obtained from the groundwater survey should be sufficient to enable specification of the major ionic species present in the groundwater, pH, electrical conductivity and total dissolved solids. A description of the environmental values of the underground waters of the affected area should be provided in terms of:

- *values identified in the* EPP Water*;*
- *sustainability, including both quality and quantity;*
- *physical integrity, fluvial processes and morphology of groundwater resources.*

4.5.2 Potential impacts and mitigation measures

Section 4.5.2.2 Groundwater

The EIS should include an assessment of the potential environmental harm caused by the proposal to local groundwater resources.

The EIS should include recommendations for mitigating any impacts of the project on existing users and the aquifers in the area. Where water supply is identified as likely to be affected the proponent will be required to enter into agreements with the landholders to mitigate these impacts by providing alternate water supply or other arrangements.

The impact assessment should define the extent of the area within which groundwater resources are likely to be affected by the proposed operations and the significance of the proposal to groundwater depletion or recharge and proposed management options available to monitor and mitigate these effects. The response of the groundwater resource to the progression and finally cessation of the proposal should be described.

An assessment should be undertaken of the impact of the proposal on the local ground water regime caused by the altered porosity and permeability of any land disturbance. An assessment of the potential to contaminate groundwater resources and measures to prevent, mitigate and remediate such contamination should be addressed.

3.2 Methodology

In order to address the ToR, the methodology adopted for the study was as follows:

- review available exploration and geological data relevant to the Coppabella Underground Project area in order to develop an appreciation of the hydrogeological setting of the area sufficient to identify groundwater resources or usage in the vicinity of the site which could be impacted by the project;
- assess the potential for any groundwater impacts resulting from the Proposal;

- assess the post-mine groundwater impacts;
- develop groundwater management strategies;
- assess the potential for any groundwater impacts resulting from the construction or use of any proposed new infrastructure;
- identify any groundwater impact mitigation measures necessary for the project;
- provide a pre- and post- approval groundwater monitoring and post approval groundwater management program.

4.0 LEGISLATION / POLICY

The following sections briefly summarize Queensland Government legislation and policy that will apply to the project with respect to groundwater.

4.1 Environmental Protection (Water) Policy 2009

The *Environmental Protection (Water) Policy 2009 (EPP Water)* provides a framework to protect and/or enhance the suitability of Queensland waters for various beneficial uses. This policy guides the setting of indicators that will protect the environmental values of any resource.

Indicators for environmental values are those quantitative properties of the water, such as physical and chemical parameters, that can be measured. The Australian Water Quality Guidelines (ANZECC, 2000) prescribe the quantitative properties that protect specific environmental values.

4.2 Water Act 2000

The purpose of the Water Act 2000 is to advance sustainable management and efficient use of water and other resources by establishing a system for planning, allocation and use of water. To achieve this, the Act provides for:

- the sustainable management of water and other resources;
- a regulatory framework for providing water and sewerage services;
- the establishment and operation of water authorities; and
- other purposes.

Several permits are likely to be required for the project under the Act including the taking of and interfering with groundwater.

4.3 Declared Sub-Artesian Areas

In Queensland a number of sub-artesian areas have been declared under the Water Act 2000, most of which have been declared under the Water Regulation 2002, which is subordinate legislation to the Act. The project is located in the Highlands Sub-artesian Area where any development works located within the declared sub-artesian area:

- require a water entitlement, water permit or seasonal water assignment notice is required to take or interfere with sub-artesian water, other than for a purpose mentioned in Schedule 11 (column 2) of Water Regulation 2002;
- are assessable development under the Sustainable Planning Act 2009 for taking sub-artesian water other than solely for a purpose mentioned in Schedule 11 (column 3) of the Water Regulation 2002.

Schedule 11 states that a water entitlement or works defined as assessable development are not required in the Highlands Sub-artesian Area for domestic purposes or for stock watering.

4.4 Water Resource Plan and Regulations

The project area falls in the Water Resource (Fitzroy Basin) Plan 1999 (reprinted as in force on 18 December 2009). Water to which this plan applies comprises water in watercourses and lakes, water in springs and overland flow water. The plan does not apply to groundwater resources. However, a revised water resource plan is currently under preparation and is expected to include groundwater.

In the interim, a Queensland Government Water Regulation 2000 Moratorium Notice which took effect on 15 December 2006 regulates groundwater in the Isaac River and Connors River Catchment. More specifically this Notice applies to:

(a) subartesian water in the alluvial aquifers in the unconsolidated Quaternary deposits in the Area associated with the Isaac River, the Connors River and all tributaries of those Rivers; and

(b) for that part of the Area that is declared as the Highlands Subartesian Area – to all applications for or about water licences to take the subartesian water mentioned in paragraph (a), whether made before or after this Notice is published; and

(c) for that part of the Area that is undeclared (outside the Highlands Subartesian Area) - works to take the subartesian water mentioned in paragraph (a).

It does not apply to an application to take subartesian water for mining purposes, provided it relates to the taking of water for dewatering purposes and there is no other suitable water supply available; or for a significant project as declared under Section 26 of the State Development and Public Works Organization Act 1979.

5.0 PHYSICAL SETTING

5.1 Location

The proposed mine is located within the northern region of the Bowen Basin, approximately 110km south-west of Mackay and 37km north-east of Moranbah Township. The nearest operational mine to the Coppabella site is the South Walker Creek Coal Mine located approximately 10km to the north. The location of the mine is shown on Drawing No. 1.

5.2 Topography and Drainage

The nearest topographic features include The Kerlong Range located some 10km to 15km to the west, and Mount Marion and Mount Orange located 10km to 15km to the south-east. Much of the existing mine site has been cleared of trees but the surrounding land has been selectively cleared and vegetated with *Eucalyptus sp* trees. The land surrounding land the site is currently used for cattle grazing.

Local relief within the mine area ranges from approximately 250m AHD along the western boundary to 200m AHD along to the south-eastern boundary. The highest feature within the mine site is the spoil dump within the northern portion of the site which extends as high as 290m AHD, whilst the lowest elevation within the open pits is down to around 90m AHD. The topography is shown on Drawing No. 2.

The project area is located within the catchment of Harrybrandt Creek. Two smaller creeks drain into Harrybrandt Creek, Humbug Gully along the northern side of the site and Thirty Mile Creek along the southern side of the site. Both these creeks drain from west to east into Harrybrandt Creek which also drains to the west and south-west into Bee Creek. Ultimately surface water runoff from the region drains into the Isaac River some 60km to the south-east. The locations of Humbug Gully, Thirty Mile and Harrybrandt Creeks in relation to the project area are shown in Drawing No. 2.

5.3 Land Use and Existing Environment

The land on which the project area is located is within the existing Coppabella Open Cut Mine property and comprises the following features that dominate the site:

- five pits, these being from west to east – Creek Pit, Johnson Pit Extended, Johnson Pit, South Pit and East Pit; and
- seven out of pit spoil heaps located strategically around the above pits.

Associated mine infrastructure includes a ROM and CHPP, Co-Disposal and Reject Co-Disposal areas, a raw water dam, a raw coal stockpile area, and administration and workshop buildings. A number of small sediment and surface water containment dams have been constructed across the project area which are generally located on creeks or gullies.

5.4 Climate

The nearest operating weather station which monitors temperature, rainfall and evaporation and has data dating back to 1972, is the Bureau of Meteorology Station 034038 located at the Moranbah Water Treatment Plant, approximately 37km south-west of the Coppabella Mine site. Longer term rainfall data is available from the Nebo weather station (033054) which opened in 1870.

The climate of the Moranbah area which includes the Codrilla Coal Project area, can be classified as sub-tropical with warm, dry winters and hot, humid summers and a high degree of variability. Rainfall can be received in any month, although it is more prevalent in the summer months, with the majority falling between November and March. Climate data obtained from the Bureau of Meteorology Station 034038 located at the Moranbah Water Treatment Plant is presented in Table 1 below. The table indicates that the annual average rainfall for the area is about 588mm

(1972-2009) and that the annual average evaporation is about 2,336mm, that is, about 4 times the rainfall. It can be seen from Table 1 that evaporation greatly exceeds rainfall for each month of the year. This has implications for the storage of water in dams and the availability of rainfall for recharge of the aquifer systems.

Table 1: CLIMATE DATA – MORANBAH WATER TREATMENT PLANT (STN 034038)

Month	Temperature		Relative Humidity (%)		Average Monthly Rainfall (mm)	Average Daily Pan Evaporation (mm)	Average Monthly Pan Evaporation (mm)
	Mean Maximum	Mean Minimum	9:00am	3:00pm			
January	33.9	21.9	69	43	102.0	8.2	254.2
February	33.2	21.8	74	47	98.3	7.6	212.8
March	32.3	20.2	70	41	47.4	7.1	220.1
April	29.6	17.6	72	43	37.4	5.8	174.0
May	26.5	14.4	73	43	35.9	4.3	133.3
June	23.8	11.2	73	44	22.1	3.6	108.0
July	23.7	9.8	69	39	18.5	3.8	117.8
August	25.5	11	66	35	22.5	4.9	151.9
September	29.3	14.1	59	29	7.9	6.7	201.0
October	32.4	17.6	58	31	36.1	8.1	251.1
November	33.3	19.5	60	34	67.1	8.6	258.0
December	34.1	21.1	64	38	94.7	8.7	261.0
Annual Average	29.8	16.7	67	39	-	6.4	-
Annual Total	**-**	**-**	**-**	**-**	**587.9**	**-**	**2336.0**

In order to place recent rainfall years into an historical context, the Cumulative Rainfall Departure (CRD) which is a summation of the monthly departures of rainfall from the long-term average monthly rainfall, was calculated as follows:

$$CRD_n = CRD_{n-1} + (R_n - R_{av})$$

Where:

- CRD_n = CRD for a given month
- CRD_{n-1} = CRD for a preceding month
- R_{av} = long term average rainfall for a given month
- R_n = actual rainfall for given month

Due to the relatively short period over which rainfall data has been recorded at Moranbah (open since 1972), long term rainfall data for Nebo (1900 to 2010) which is located approximately 32km to the north-east, has been included to calculate the CRD trends for the region. The calculated CRD between 1900 and 2010 for Moranbah and Nebo are shown in Figure 1 below. A rising slope in the CRD plot indicates periods of above average rainfall which will also tend towards positive values, whilst a falling slope indicates periods when rainfall is below average.

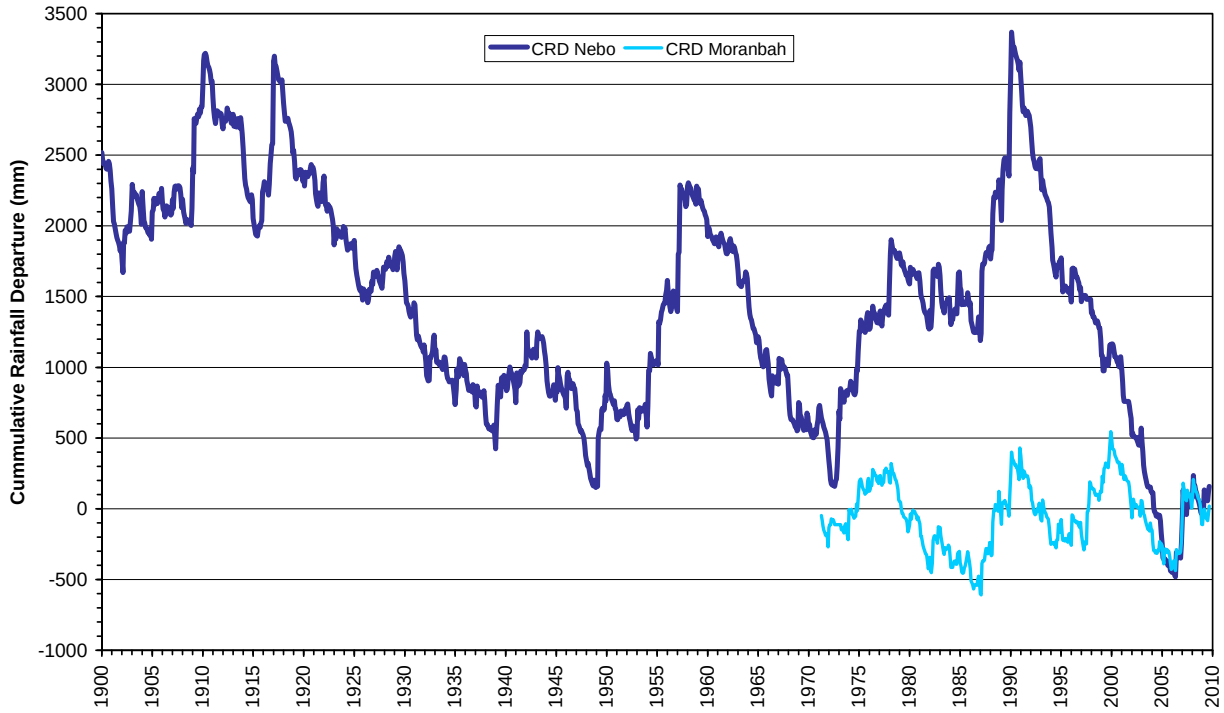


Figure 1: Cumulative Rainfall Departure – Moranbah and Nebo Meteorology Stations (mm)

The following comments can be made in regard to the CRD chart:

- Moranbah experiences a more moderate and reliable rainfall pattern compared to that for Nebo which is characterised by greater variations in rainfall.
- The region experienced a prolonged period of below average rainfall between 2001 and 2007.
- It appears the region is currently experiencing an overall period of above average rainfall with only a relatively minor event of below average rainfall during 2009.
- The current CRD is historically relatively low indicating the groundwater levels in the aquifers are also likely to be low.

6.0 PREVIOUS INVESTIGATIONS

No specific groundwater investigations have previously been undertaken within the proposed lease area of the Coppabella Mine; however groundwater studies have been undertaken for other coal mines in a similar geological setting all of which target the same Permian coal seam stratigraphy. These include Carborough Downs, Moorvale, Peak Downs East and Poitrel Mines.

Based on data from investigations from those mines, the groundwater regime in the area consists of shallow alluvium along creek alignments, regolith zones in Triassic/Permian Formations, and deeper aquifers associated with the fresh Permian units and coal seams. Typically the coal seams are the prime aquifers within the Permian sequence which can be hydraulically connected with the shallower aquifer where they traverse the coal seam sub-crop. Typically within the Bowen Basin area the shallower coal seams have a low to moderate permeability of the order 10^{-6}m/sec (0.08m/day) which declines with increasing depth, with the permeability of the floor and

overburden rocks being at least an order of magnitude lower. Groundwater in the coal seam is of poor quality, being generally brackish to saline whilst the alluvial groundwater varies from fresh to brackish. In general these mines do not experience significant groundwater issues during mining with inflow into the open pits or underground workings managed via footwall open drains and pumping from sumps strategically located within the mine area.

7.0 FIELD INVESTIGATIONS

Field investigations were undertaken within the Coppabella Mine area to describe and characterise the groundwater regime that will be intersected by the proposed underground mine operation.

7.1 Coal Exploration Borehole Review

A review of coal exploration drilling data provided by the C&M JV within the project area was undertaken to locate appropriate areas for investigation of the site's hydrogeological regime and development of a groundwater monitoring bore network. The data provided some useful information such as depth to coal seams, intersection depths, yields and standing water levels which were useful in predicting where groundwater could be expected to occur.

Based on this review, a field investigation program was formulated to obtain relevant data specific to the project area, focusing on investigating groundwater associated with the upper Tertiary sediments and underlying Permian geology. Based on this review, 11 monitoring bores (MB1 to MB11) were identified at eight locations (refer Table 2), across the project area to investigate the groundwater regime (water pressures, flow directions, aquifer interconnection and quality), for the EIS, and where possible were selected to remain as permanent monitoring bores during the mining phase.

7.2 Monitoring Bores

Following review of the coal exploration drilling data, drilling, installation and construction of the monitoring bores was undertaken by Tropical Water Bores, under supervision of a hydrogeologist from AGE. The monitoring bores were installed between 24 September and 6 November 2009. Two additional monitoring bores, MB3B and MB9B, were included adjacent to bores MB3 and MB9 respectively, resulting in 13 groundwater monitoring bores, the locations of which are shown on Drawing No. 3.

The monitoring bore sites were located to provide an overall coverage of the proposed underground mine footprint where access was readily available, and where possible, away from future proposed site development such that they could be used for long term monitoring during the life of the open pit and underground mine. Where notable yields of groundwater were intersected within the overburden of the Rangal Coal Measures, the bore was terminated at that depth and the monitoring bore constructed.

All bores were drilled with a rotary rig generally using compressed air to evacuate the cuttings. Initially a 6½" blade bit was used to drill to the base of the Tertiary sediments followed by a 4¾" blade or hammer bit to drill the Permian sediments. At one location (MB11) where drilling intersected saturated, sandy alluvial sediments, rotary mud circulation drilling methods were used. The Tertiary sediments were cased off using 125mm Class 9 or 12 PVC casing where drilling continued into the Permian for establishment of a monitoring bore. All monitoring bores

were constructed using a 6m to 12m section of factory slotted 50mm diameter, Class 18, PVC screen installed across the water bearing zone of the holes, with Class 12, 50mm diameter, PVC blank casing lengths completing the borehole to the surface. The annulus of the hole was filled with a clean, gravel filter to above the screened section, and a bentonite seal (bentonite chips) was placed above the gravel. The holes were then backfilled using drill cuttings and a 6m thick cement grout seal placed from the ground surface to prevent ingress of surface water. A lockable, monument style, steel protector was concreted around each protruding PVC casing.

A summary of the construction details for the monitoring wells is summarised in Table 2 below with more detail provided on the borehole logs in Appendix A.

Table 2: MONITORING BORE CONSTRUCTION DETAILS

Bore ID	Easting (m)	Northing (m)	Ground Elevation (mAHD)	Bore Depth (mbgl)	Screened Section from – to (mbgl)	Gravel Pack from – to (mbgl)	Standing Water Level (mbtoc)	Standing Water Level (mAHD)
MB1	649432.905	7584687.807	228.42	104	92 – 98 98 – 104	89 – 104	49.11	180.167
MB2	649436.783	7584687.514	228.5	48	36.8 – 43.8	36.6 – 43.8	39.075	190.222
MB3	648300.698	7583783.188	225.25	119	113 – 119	102 – 119	48.8	177.446
MB3B	648302.185	7583786.144	225.33	21	11 – 14 18 – 21	8 – 21	Dry	Dry
MB4	650847.431	7584037.574	220.09	112	103 – 106 109 – 112	82.5 – 112	37.99	183.099
MB5	648986.250	7583194.418	225.32	76	67 – 70 70 – 76	62 – 76	48.395	177.922
MB6	648989.316	7583194.024	225.25	43	37 – 43	35.5 – 43	40.285	185.964
MB7	649797.636	7582857.636	229.61	101	86 – 89 95 – 101	84 – 101	55.45	175.163
MB8	649794.966	7582855.249	229.66	39	33 – 39	25 – 39	Dry	Dry
MB9	651604.138	7582566.027	224.69	118	111 – 117	105.5 – 118	64.94	160.751
MB9B	651605.883	7582565.396	224.72	27	21 – 27	17.5 – 27	Dry	Dry
MB10	647539.869	7583160.329	220.19	89	83 – 89	75.3 – 89	47.97	173.221
MB11	651818.930	7580810.094	199.4	26	20 – 26	16.5 – 26	18.65	181.746

Note: Projection is AGD 66 Zone 55
mbgl = metres below ground level
mbtoc = metres below top of casing
AHD = Australian Height Datum

7.3 Water Sample Collection

Groundwater samples were collected from the monitoring bores between 31 October and 2 November 2009. The sampling methodology was in accordance with the Murray Darling Basin Commission Groundwater Sampling Guidelines (1997).

Prior to the samples being collected, the bores were purged until the water quality parameters monitored in the field stabilised, and three bore volumes were removed. Samples for the dissolved

metals analysis were filtered in the field. The samples were collected in laboratory prepared containers and stored on ice in an esky. The water samples were then delivered to Australian Laboratory Services (ALS), a NATA registered laboratory in Mackay on the next working day. The report provided by ALS is included in Appendix B.

Field values of pH and electricity conductivity (EC) were monitored during purging and sampling, using an MC-81 pH-conductivity-salinity meter manufactured by TPS Electronics Pty Ltd. The instrument was calibrated in the field using factory-supplied solutions.

8.0 GEOLOGICAL SETTING

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 Coppabella Mine site is located within the Nebo Synclinorium which is up-thrust and separated from the undeformed Collinsville Shelf sediments to the west by a series of north-northwest trending thrust faults. Folding within the Nebo Synclinorium along axes roughly parallel to the thrust system comprise a series of anticlines and synclines which include the Carborough Syncline with the project site is located on its eastern limb.

8.1 General Stratigraphy

The stratigraphic sequence making up the economic coal deposits of the Coppabella Mine comprise a Permian sequence which is unconformably overlain by Tertiary sediments. Thin, localised linear deposits of unconsolidated Quaternary alluvium are associated with the Harrybrandt Creek alignment and associated tributaries, traversing the northern and southern portions of the site. The steeply dipping thrust faults associated with large throws terminate the Permian coal measures to the south and south-west against Triassic Rewan Formation sediments.

The general stratigraphy of the project area within the Coppabella Mine site is summarized in Table 3. The surface geology of the region is presented in Drawing No. 4, with the underlying Bowen Basin geology presented in Drawing No. 5.

Table 3: SUMMARY OF STRATIGRAPHIC SEQUENCE AT COPPABELLA MINE

Age	Unit	Lithology	Thickness
Quaternary	Recent Alluvium (Qa)	Soils, clays, silts, sands and gravels	up to 7m
Tertiary - Quaternary	TQr	Clay, silt, sand and gravel: high-level alluvium and colluvium	4–56m
Triassic	Rewan Formation (Rr)	Coarse green lithic sandstone, pebbles in places, some fine and pebble conglomerate and red and green mudstone	0–650m(?)
Upper Permian	Rangal Coal Measures (Pwj)	Coal seams, carbonaceous shales and mudstone, light grey litho felspathic sandstone, grey to dark grey siltstones and mudstones	150m
	Fort Cooper Coal Measures (Pwt)	Labile sandstones and siltstones, with thick seams of interbedded coal, carbonaceous mudstone and tuffaceous claystone	400m(?)

The Rangal Coal Measures which include the economic coal seams mined at Coppabella Mine are present beneath the site. These inturn are underlain by the Fort Cooper Coal Measures which are characterised by the Vermont Seam, Yarrabee Tuff Bed and Girrah Seam, which are understood will not to be intersected by the underground mining. The top of the Fort Cooper Coal Measures is typically around 35m below the Macarthur/Leichhardt Lower Seams mined at this site by open cut mining. Typically the Rangal Coal Measures are around 150m thick and consist of lithic sandstone interbedded with siltstone, minor carbonaceous shale, mudstone and coal.

Within the Johnson Pit the economic coal seams include a coalesced Leichhardt Upper 1, 2 and Leichhardt Lower Seams, locally referred to as the Macarthur Seam and forming the primary economic unit at the Coppabella Mine. This coal seam averages 11m in thickness and ranges from 7.8m to 13.7m with infrequent, generally thin partings.

To the north-west towards Creek Pit the Macarthur Seam splits variably, with three major splits identified as the Leichhardt Upper, Middle and Leichhardt Lower Seams. The Leichhardt Lower Seam is the thickest with an average thickness of 6.5m and forms the economic resource in the Creek Pit area as well as being the largest component of the composite Macarthur Seam.

The Macarthur Seam extends northwards, progressively becoming thinner as the uppermost plies split off and form the Leichhardt Upper Seam which occurs as a discrete seam in the northern half of the central Coppabella area and extends into the Spring Creek area north of Coppabella Mine. Further splitting of the Leichhardt Lower Seam into two seams, results in the formation of the Leichhardt Middle Seam.

Where present the Triassic Rewan Formation conformably overlie the Permian sediments to the west of the thrust faulting described above and to the north within the Spring Creek area. The Permian-Triassic boundary is gradational and marks the change from the carbonaceous sediments of the coal measures to the non-carbonaceous thick sandstone sequence distinguished by their green tint.

The youngest formations in the project area include the Tertiary and Quaternary sediments to the which comprise mainly soft, weathered, unconsolidated clays, sands and silts and minor sands and gravels towards the base. The depth of the Tertiary Sediment cover averages 25m, ranging from 4m to 56m. The thickness of these sediments is greatest (between 40m and 50m), within the Johnson Pit and its southern extension areas, and beneath the central portion of the northern spoil heap. Elsewhere the Tertiary Sediments thickness is generally between 20m and 30m and to less than 10m in the Creek Pit area. This inferres the presence of a shallow palaeo-channel at the base of the Tertiary Sediments that possibly drained towards the south/south-east.

The Quaternary to Recent alluvial sediments consist of sand, gravel, clay and silt of varying content that have been unconformably deposited in an eroded drainage alignment that coincides with Harrybrandt Creek and associated creeks in the project area. The alluvial deposits are generally thin, linear, and irregular in nature.

A generalised geological profile showing the stratigraphic sequence described above was provided by C&M JV[1] for the Coppabella Mine and is presented in Figure 2.

[1] Email correspondence Mr. K. Henderson, 17 July 2009.

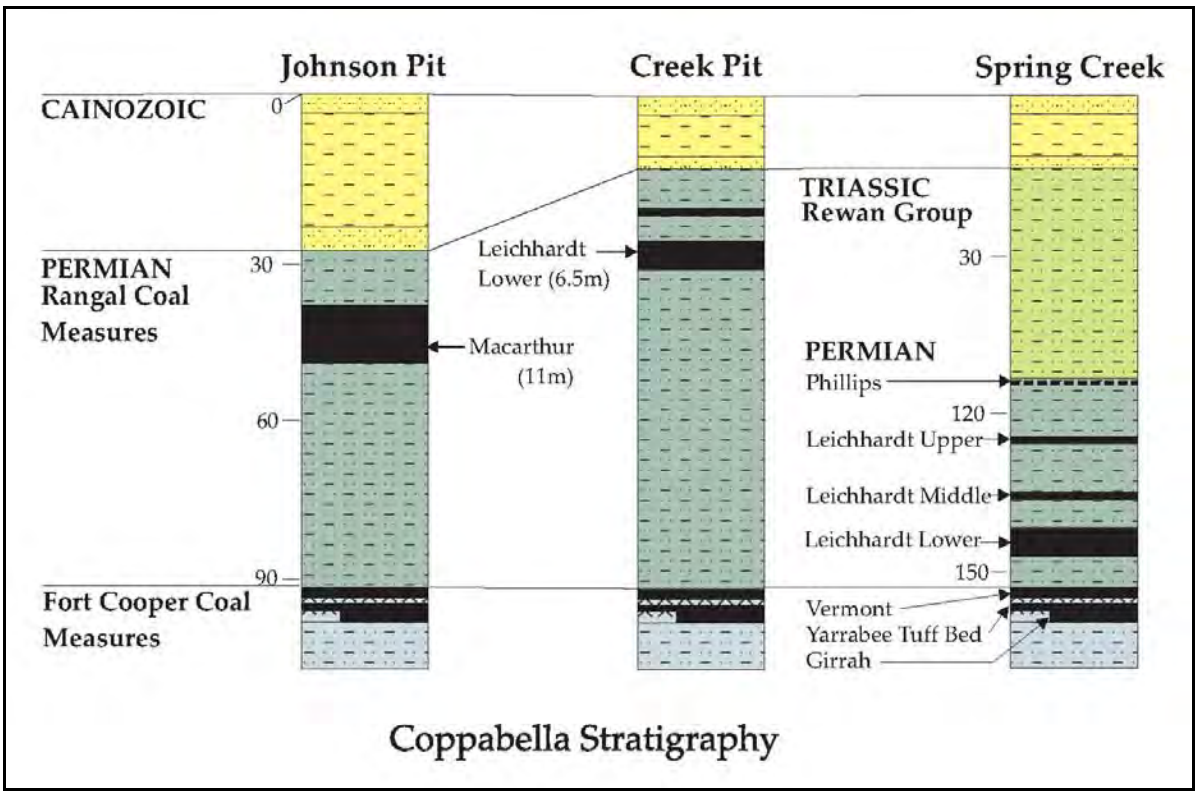


Figure 2: Generalised Geology for Coppabella Mine

8.2 Structure

Macarthur Coal (C&M Management) Pty Ltd[2] describe the structure of the Coppabella area as being dominated by a broad syncline which closes to the south-east resulting in a U-shaped zone containing the stratigraphic units that include the Coppabella Underground Project coal seams. The syncline axis is orientated north-west in the mine area with Johnson Pit located on the its western limb. Structure within the syncline is uniform, with coal seams essentially planar and dipping on average 5° to 6° to the north-east. A series of north-northwest trending faults with an estimated throw of between 10m and 60m offset the subcrop in the north and east. The coal seam subcrop in the Johnson and Creek Pits is terminated in the west and south-west by a north-west trending line of thrust faults with large throws and steep dips and upthrust against Rewan Formation sediments (refer Drawing No. 5).

Intrusive sills up to 0.5m thick occur throughout the Johnson Pit area, generally either in the upper or lower parts of the coal seams. These intrusions are typically weathered and have decomposed to soft, light grey clays with limited effect on the coal. However, in the East and South Pits, the intrusions are more pervasive resulting in much of the coal seam being cindered. However, their distribution and thickness is highly erratic and variable.

[2] Email correspondence Mr. K. Henderson, 17 July 2009.

9.0 HYDROGEOLOGICAL REGIME

As discussed, no groundwater investigations have been undertaken at the Coppabella Mine leases prior to the current investigation. The following description of the "groundwater regime – existing environment" of the project site and surrounds is based on a review of the site geology and data from the exploration drilling, that is lithological logs, water intersections, yield, quality and standing water level in exploration holes, from the installation of the monitoring bores and from data obtained from the investigations undertaken on other mining leases in the region.

9.1 Groundwater Occurrence

It is assessed that there are four aquifer[3] systems within the existing mining lease area associated with the following strata:

- shallow alluvium along creek lines;
- regolith zones in Tertiary sediments;
- deeper Permian and Triassic overburden/interburden units; and
- coal seams.

This section of the report discusses these aquifer systems and the data used to develop the conceptual model of the groundwater regime relevant to the Coppabella Underground Project.

9.2 Alluvial Aquifers

9.2.1 Distribution

The alluvium in the project area is typically associated with Harrybrandt Creek and its tributaries (Thirty Mile Creek), south of the current mine area and along the southern boundary, where it is generally confined to a relatively narrow band along the creeks and tributary channels. The extent of mapped alluvium is shown in Drawings Nos. 3 and 4.

The alluvium consists of silty clayey sand, sand and gravel which appear to be generally not well developed and relatively thin. Review of exploration borelogs indicates an average thickness for alluvial sediments of 1.3m ranging from 0.2m to 7m. Typically the sand and gravel deposits generally occur at the base of the drainage alignments above the interface with the underlying Tertiary sediments where they have incised the alluvial floodplain, with the generally flat overbank deposits comprising silty and clayey sediments.

Only one monitoring bore (MB11) was constructed in an area of alluvium. Adjacent exploration bores identify the alluvial sediments in this area being only 1m to 1.7m thick in this area, with the depth and thickness of the alluvial sediments in bore MB11 being around 1m. These sediments comprised light brown, medium to coarse grained clayey gravelly sand which were dry at the time of drilling.

Based on these observations, this aquifer would be considered of limited extent and typically dry, and would only contain water following periods of rainfall. Hence, where this aquifer exists either

[3] An aquifer is defined as a groundwater bearing formation sufficiently permeable to transmit and yield water in useable quantities.

within or adjacent to the mining lease area, it would not have any significance in relation to the current and proposed mine development.

It is considered this aquifer would be of limited extent where alluvial sediment exist either within or adjacent to the mining lease area, and hence is not of significant in relation to the current and proposed mine development.

9.3 Tertiary Aquifers

9.3.1 Distribution

As discussed in Section 8.1, the Tertiary sediments represent a covering of unconsolidated sandy clay sediments (Figure 3 and Figure 4) above a buried palaeo-surface characterised by a north-south trending palaeo-channel that appears to have drained towards the south/south-east. The extent of this palaeo-channel is shown in Figure 5 which shows the elevation of base of the Tertiary sediments ranging from RL220m in shades of red to RL170m in shades of light blue to dark blue representing deeper/thicker sediment cover. This figure indicates the palaeo-channel extending southwards above the proposed underground mine area, and then further south-east. A thin layer of fine to coarse-grained sand and gravel sediments occur at the base of the palaeo-channel.



Figure 3: View to the North of Tertiary Sediments Overlying Permian Sedimentary Sequence in Johnson Pit



Figure 4: Typical Sequence of Sandy Clay Tertiary Sediments in South Pit

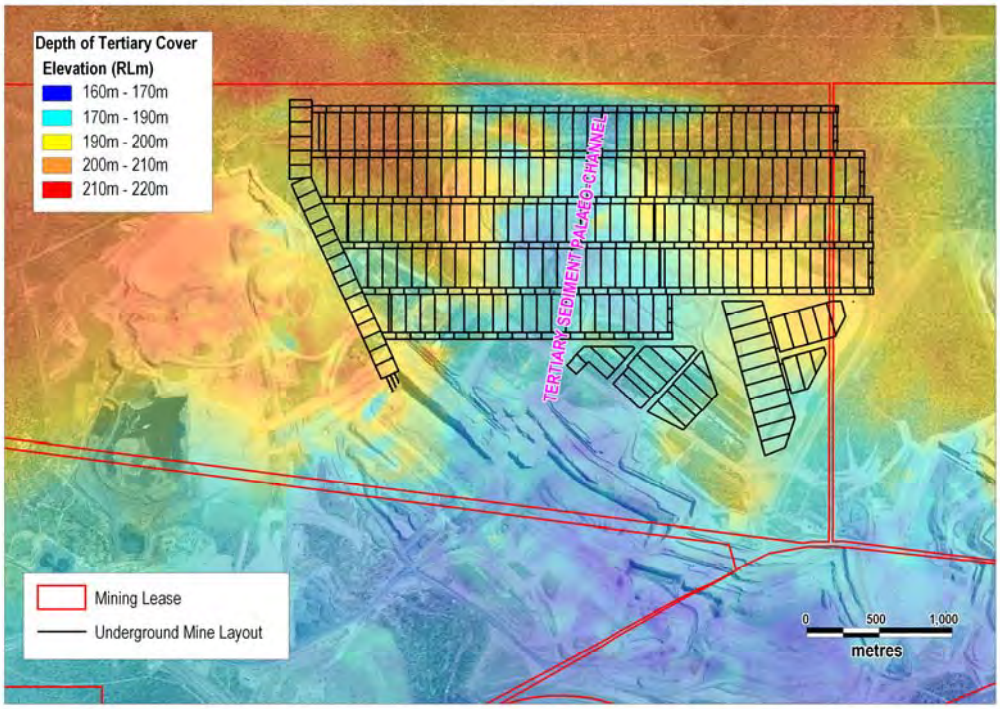


Figure 5: Depth of Tertiary Sediment Cover and Inferred Extent of Palaeo-Channel

Drawing No. 4 shows the extent of these sediments across the entire mining lease areas and over most of the exploration lease. The depth of these sediments inferred from exploration bore and the monitoring bore drilling indicated an average thickness of 25m (between 4m and 56m). Six monitoring bores, of which three intersected groundwater, were constructed as Tertiary aquifer monitoring bores, these being bores MB2, MB3B, MB6, MB8, MB9B and MB11.

9.3.2 Groundwater Occurrence, Recharge and Flow

Groundwater was intersected towards the base of the Tertiary between 22m (MB11) and 40m (MB6). Hence the aquifer occurs at the base of the Tertiary sediments where the sandy to gravelly sand layer is present and is sufficiently porous to host groundwater. The occurrence and depth of the aquifer is likely to be variable and depend on the depth and extent of these more porous sandy and gravelly layers. Seepage from this aquifer occurs where intersected in Johnson Pit, (Figure 6).



Figure 6: Seepage from Tertiary Sediments along Eastern Extents of South Pit

Groundwater levels in this aquifer ranged between 17.7m (MB11) and 39.3m (MB6) below ground level which is slightly shallower than the depths intersected whilst drilling. This indicates this aquifer is confined to semi-confined beneath the overlying more clayey sediments. Recharge of this aquifer is expected to be a combination of:

- direct infiltration of rainfall/surface water runoff where the more permeable features described above sub-crop or outcrop; and
- groundwater flow from the underlying Permian geology and Permian Coal Seam aquifers where the respective rock types of these underlying aquifers sub-crop at the base of the Tertiary aquifer and are hydraulically connected.

9.3.3 Hydraulic Parameters and Yield

Permeability testing of these sediments was undertaken in monitoring bores MB2, MB6 and MB11 using a falling head, slug test method, which requires a "slug" of water being poured into the bore and the rate of decline in water level being monitored. Spot water levels were recorded with an electronic dipper in each bore, prior to and at regular intervals during each test. The falling head data sheets and graphical analysis for each monitoring bore tested are presented in Appendix C. The data was analysed using the Hvorslev Method (1951) for confined aquifers using *Aquifer Test Version 2.5* software, (Waterloo Hydrogeologic, 1996).

The results of the analyses indicated a permeability range of 1.4 x 10^{-6}m/s to 3.8 x 10^{-7} m/s (0.12 to 0.03m/day in bores MB2 and MB6 respectively), indicating a low to moderate permeability for groundwater hosted in the Tertiary sediments. None of the bores recorded a measurable airlift flow rate whilst drilling or development.

9.3.4 Water Quality

Groundwater quality was only able to be determined from bore MB6, as samples could not be collected from the bores MB2 and MB11 due to difficulties experienced retrieving a representative sample from those bores. The water quality of the Tertiary aquifer as indicated by bore MB6 is presented in Table 4 below. The analyses indicate that the Tertiary groundwater has a slightly alkaline pH and is dominated by sodium and chloride with total dissolved solids (TDS) of around 8,500mg/L making it saline exceeding the guideline level for cattle. A relatively high sulphate level was recorded; however this was still within the range for livestock. Metal concentrations for selenium are equivalent to that for the livestock guideline, whilst concentrations of the other metals were either below the laboratory detection limit or below the relevant guideline level. Total petroleum hydrocarbon concentrations were below the laboratory detection limits for the C_6 – C_{14} fractions analysed, but at detectable levels between 220µg/L and 550µg/L for the C_{15} – C_{36} fractions. It is likely that the source for these hydrocarbon fractions is an oil based lubricant used whilst drilling the borehole and not hydrocarbon contamination from within the aquifer.

Table 4: SUMMARY OF TERTIARY AQUIFER WATER QUALITY

Analyte	Unit	LOR	MB6 (7/11/09)	Livestock Guidelines (2000)
pH Value	pH Unit	0.01	7.83	-
Electrical Conductivity	µS/cm	1	12,400	-
Total Dissolved Solids	mg/L	1	**8,540**	4000
Major Ions				
Carbonate	mg/L	1	<1	-
Bicarbonate	mg/L	1	694	-
Total Alkalinity	mg/L	1	694	-
Sulphate	mg/L	1	793	1000-2000
Chloride	mg/L	1	4,590	-
Calcium	mg/L	1	148	1000
Magnesium	mg/L	1	310	-
Sodium	mg/L	1	2,870	-

Table 4: SUMMARY OF TERTIARY AQUIFER WATER QUALITY				
Analyte	**Unit**	**LOR**	**MB6 (7/11/09)**	**Livestock Guidelines (2000)**
Potassium	mg/L	0.001	94	-
Trace Metals				
Aluminium	mg/L	0.001	0.1	5
Antimony	mg/L	0.001	<0.001	-
Arsenic	mg/L	0.001	0.002	0.5
Molybdenum	mg/L	0.001	0.002	0.15
Selenium	mg/L	0.001	**0.02**	0.02
Silver	mg/L	0.001	0.001	-
Iron	mg/L	0.05	0.4	-
Mercury	mg/L	0.0001	<0.0001	0.002
Total Petroleum Hydrocarbons				
C_6 - C_9 Fraction	µg/L	20	<20	-
C_{10} - C_{14} Fraction	µg/L	50	<50	-
C_{15} - C_{28} Fraction	µg/L	100	330	-
C_{29} - C_{36} Fraction	µg/L	50	220	-
C_{10} - C_{36} Fraction (sum)	µg/L	50	550	-

Note: TDS guideline is for beef cattle
- No guideline level determined

9.4 Permian Overburden Aquifers

As discussed, the Permian Rangal Coal Measures comprise claystone, mudstone, sandstone, siltstone and shale, which although not recognized as a significant aquifer, can provide localised supplies of variable but generally low yielding, poor quality groundwater. Similarly the Permian overburden and interburden sequences at most mines in the Bowen Basin are essentially impervious to groundwater movement and form aquitards. However, an exception to this can result in the occurrence of groundwater in the overburden that contains significant faulting and jointing. Hence the Permian strata can be categorized into the following hydrogeological units:

- hydrogeologically “tight” and hence very low yielding to essentially dry claystone, mudstone, lithic sandstone, siltstone and shale that make up much of the Permian overburden (and interburden); and
- localised fracture or fault systems which are open and have not been healed by clay/carbonate deposition that have the capacity to store and transmit groundwater (Figure 7).



Figure 7: Localised Seepage from Fractured Permian Overburden Sediments in Johnson Pit Highwall

9.4.1 Distribution

The Permian aged sediments include the Rangal Coal Measures and Fort Cooper Coal Measures within the project area. These sediments do not outcrop within the mining lease but underlie the Tertiary sediments (refer Section 8.1). The extent of these sediments across the entire mining lease area and over most of the exploration lease is shown in Drawing No. 5.

9.4.2 Groundwater Occurrence, Recharge and Flow

Groundwater associated with the overburden sequences that is, not related to the coal seams, was intersected at four locations across the site at varying depths, from 63m in bore MB5 to greater than 100m in bores MB3 and MB4. Similarly the extent of groundwater inflows also varied from minor inflow at bore MB7 (<0.1L/s) to 2.2L/s in bore MB5 and was mostly associated with sandstone. On the basis that the Permian aged sediments are not recognized as host rocks for a significant aquifer, the hydraulic properties of the aquifer for permeability (hydraulic conductivity) and storativity (aquifer storage potential) are considered:

- to be mainly a function of secondary porosity features, such as fracturing, faulting and jointing, that is, structural features that have developed subsequent to the host rock's emplacement; and
- to a lesser extent primary porosity, that is, the intergranular spaces or pore openings which formed when the sediment was deposited.

With this in mind, the occurrence and depth of the aquifer is likely to be variable depending on factors such as the:

- depth, extent, frequency and interconnection of fractures on a local scale, and faulting on a more regional scale within the sedimentary sequences; and
- depth and lateral extent of any porous sediments.

Groundwater levels measured in the five monitoring bores constructed in this aquifer ranged from 37.0m (bore MB4) to 54.4m (bore MB7) below ground level. This indicates this aquifer is confined beneath the overlying less permeable sedimentary layers. Recharge of this aquifer would be expected to be combination of:

- direct infiltration of rainfall/surface water runoff where the more permeable features described above sub-crop or outcrop; and
- possibly from groundwater flow from the overlying Tertiary aquifer where the more permeable features described above subcrop beneath the Tertiary sediments.

9.4.3 Groundwater Yield

Groundwater airlift flow rates were measured during and on completion of drilling the monitoring bore drill holes, with measurable airlift flow rates recorded in each borehole. The recorded flow rates were:

- <0.1L/s (MB4 & MB7), 0.6L/sec (MB1), 1L/sec (MB3) and 2.2L/s (MB5).

The higher groundwater yields measured in bores MB3 and MB5 are considered to be a function of fractured or faulted sedimentary sequences at these locations. Long term pumping at this site may well indicate this flow is not sustainable as the radius of influence of the bore extends into surrounding less fractured rock.

9.4.4 Hydraulic Parameters and Yield

Permeability testing of these sediments was undertaken in bores MB1, MB3, MB4 and MB5 using the pneumatically displaced rising head slug test method (Butler, 1997). No testing was performed in bore MB7 due to the site being inaccessible at the time. An electronic pressure sensor and data logger was used to record the recovering water level in each bore. Spot water levels were also recorded with an electronic dipper in each bore, prior to and on completion of each test. The rising head data sheets and graphical analysis for each monitoring bore tested are presented in Appendix C. The data was analysed using the Hvorslev Method (1951) for confined aquifers using *Aquifer Test Version 2.5* software, (Waterloo Hydrogeologic, 1996).

The results of these tests indicated permeability values ranging between 1.8×10^{-5}m/s (1.3m/day) and 3.1×10^{-8}m/sec (0.003m/day) in bores MB5 and MB4 respectively. Bore MB7 which could not be tested drilled generally “dry” with only a minor groundwater seepage noted from 83m depth to the base of the borehole at 101m depth, similar to that observed in bore MB4. An overall airlift flow rate was measured at <0.1L/s on completion of drilling which was again similar to that measured in bore MB4. Thus it can be assumed that the aquifer permeability at MB7 would be similar to that determined for MB4, around 3×10^{-8}m/sec (0.003m/day).

9.4.5 Water Quality

Representative samples of Permian overburden aquifer water were collected from each monitoring bore, the results if which are summarised in Table 5 below. The analyses indicate that groundwater from this aquifer has a slightly alkaline pH and is dominated by sodium and chloride with total dissolved solids (TDS) in excess of 12,500mg/L making it saline and exceeding the guideline levels for cattle. A relatively high sulphate level was recorded in bore MB5; however this was still within the range for livestock. Levels for selenium were equivalent to the livestock threshold in each bore. 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.

Table 5: SUMMARY OF PERMIAN OVERBURBEN AQUIFER WATER QUALITY

Analyte	Unit	LOR	MB1 (7/11/09)	MB3 (6/11/09)	MB4 (6/11/09)	MB5 (7/11/09)	MB7 (6/11/09)	Livestock Guidelines (2000)
pH Value	pH Unit	0.01	8.06	8.03	8.27	7.93	8.12	-
Electrical Conductivity	µS/cm	1	13,600	12,600	13,300	13,700	16,000	-
Total Dissolved Solids	mg/L	1	**9,600**	**8,020**	**9,580**	**9,360**	**16,200**	4000
Major Ions								
Carbonate	mg/L	1	<1	<1	<1	<1	<1	-
Bicarbonate	mg/L	1	135	179	163	608	175	-
Total Alkalinity	mg/L	1	135	179	163	608	175	-
Sulphate	mg/L	1	2	2	2	583	4	1000-2000
Chloride	mg/L	1	4,960	4,360	4,760	4,660	6,970	-
Calcium	mg/L	1	270	165	266	165	524	1000
Magnesium	mg/L	1	113	49	70	248	331	-
Sodium	mg/L	1	2,620	2,580	2,640	2,790	3,520	-
Potassium	mg/L	0.001	27	16	18	73	67	-
Trace Metals								
Aluminium	mg/L	0.001	<0.01	<0.01	0.01	0.02	<0.01	5
Antimony	mg/L	0.001	0.007	<0.001	<0.001	0.005	<0.001	-
Arsenic	mg/L	0.001	0.005	0.003	0.001	0.014	0.001	0.5
Molybdenum	mg/L	0.001	<0.001	<0.001	0.002	0.004	<0.001	0.15
Selenium	mg/L	0.001	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	0.02
Silver	mg/L	0.001	0.004	0.002	0.002	0.002	0.002	-
Iron	mg/L	0.05	0.57	0.27	0.43	0.4	0.8	-
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002
Total Petroleum Hydrocarbons								
C_6 - C_9 Fraction	µg/L	20	<20	<20	<20	<20	<20	-
C_{10} - C_{14} Fraction	µg/L	50	<50	<50	<50	<50	<50	-
C_{15} - C_{28} Fraction	µg/L	100	<100	<100	<100	<100	<100	-
C_{29} - C_{36} Fraction	µg/L	50	<50	<50	<50	<50	<50	-
C_{10} - C_{36} Fraction (sum)	µg/L	50	<50	<50	<50	<50	<50	-

Note: TDS guideline is for beef cattle
- No guideline level determined

9.5 Coal Seam Aquifers

Typically throughout the Bowen Basin, the coal seams are considered to be the main aquifers within the Permian sequences, with the surrounding overburden and interburden sedimentary sequences forming aquitards, except where these sediments are fractured or faulted.

9.5.1 Distribution

The target coal seams are restricted to the Permian Rangal Coal Measures which include the Macarthur Seam (average thickness of 11m), and Leichhardt Lower Seam (average thickness of 6.5m), within the Coppabella Mine area. Other Permian coal seams include the Vermont and Girrah Seams within the Fort Cooper Coal Measures which are stratigraphically lower than the Rangal Coal Measures and are understood will not be intersected by the underground mining. Within the site the Rangal Coal Measures were been intersected in monitoring bores MB9 and MB10.

9.5.2 Groundwater Occurrence, Recharge and Flow

The coal seams are confined aquifers which generally exhibit low transmissivity and recharge rates, that is, of low to moderately permeability. Groundwater storage and movement occurs within the coal seam cleats and fissures and within open fractures that intersect the seams. These hydraulic parameters (permeability and storativity), are likely to be variable and dependent on depth due to changes in thickness, extent, frequency and interconnection of fractures and cleats within the coal seam.

Groundwater levels measured in the two monitoring bores constructed in this aquifer ranged from 47.0m (bore MB10) to 63.9m (bore MB9) below ground level. Recharge of this aquifer would be expected to be combination of:

- direct infiltration of rainfall/surface water runoff where the coal seams sub-crop or outcrop;
- groundwater flow into and from the overlying Tertiary aquifer where the coal seams sub-crop at the base of the Tertiary aquifer; and
- leakage from the overburden aquifer.

9.5.3 Groundwater Yield

In each borehole the Tertiary sequences were cased and sealed off, with the resultant groundwater inflows representative of the coal seam intersected. Groundwater airlift flow rates measured during drilling and at completion of drilling of the monitoring bores were both very low at around 0.1L/s. It would appear that where intersected, groundwater pressures in the coal seams have declined considerably as a result of their proximity to the existing open pits and resultant depressurisation from discharge to the pits.

9.5.4 Hydraulic Parameters

In-situ permeability testing of monitoring bores MB9 and MB10 using the pneumatic displacement, rising head slug tests method (Butler, 1997), described in Section 9.4.4, indicated a hydraulic

conductivity values of 3.5 x 10^{-8}m/sec (0.003m/day). The rising head data sheets and graphical analysis for each monitoring bore tested are presented in Appendix C.

9.5.5 Water Quality

Representative samples of Permian coal seam aquifer waters were collected from bores MB9 and MB10, the results of which are summarised in Table 6 below. The analyses indicate that the Permian coal seam aquifer groundwater has a slightly alkaline pH and is dominated by sodium and chloride with TDS levels in excess of 10,500mg/L making it saline which exceed the guideline levels for cattle. Levels for selenium were equivalent to the livestock threshold in each bore. Other metal concentrations were either below the laboratory detection limit or below the relevant livestock guideline. Detectable total petroleum hydrocarbon levels were measured for the C_6 - C_9 and C_{29} to C_{36} fractions in bore MB9 whilst those in bore MB10 were all below the laboratory detection limits for the fractions analysed. It is likely the source for these carbon fractions is either an oil based lubricant used whilst drilling the borehole or a naturally occurring organic compound in the coal, and not hydrocarbon contamination from within the aquifer.

Table 6: SUMMARY OF COAL SEAM AQUIFER WATER QUALITY

Analyte	Unit	LOR	MB9 (7/11/09)	MB10 (6/11/09)	Livestock Guidelines (2000)
pH Value	pH Unit	0.01	7.71	8.37	-
Electrical Conductivity	µS/cm	1	16,400	13,800	-
Total Dissolved Solids	mg/L	1	**17,500**	**10,600**	4000
Major Ions					
Carbonate	mg/L	1	<1	<1	-
Bicarbonate	mg/L	1	133	302	-
Total Alkalinity	mg/L	1	133	302	-
Sulphate	mg/L	1	49	2	1000-2000
Chloride	mg/L	1	7,650	5,610	-
Calcium	mg/L	1	580	150	1000
Magnesium	mg/L	1	214	150	-
Sodium	mg/L	1	3,690	3,330	-
Potassium	mg/L	0.001	27	45	-
Trace Metals					
Aluminium	mg/L	0.001	0.01	0.01	5
Antimony	mg/L	0.001	<0.001	<0.001	-
Arsenic	mg/L	0.001	0.003	0.008	0.5
Molybdenum	mg/L	0.001	0.002	0.001	0.15
Selenium	mg/L	0.001	**0.02**	**0.02**	0.02
Silver	mg/L	0.001	0.002	0.001	-
Iron	mg/L	0.05	1.05	0.27	-
Mercury	mg/L	0.0001	<0.0001	<0.0001	0.002

Table 6: SUMMARY OF COAL SEAM AQUIFER WATER QUALITY					
Analyte	**Unit**	**LOR**	**MB9 (7/11/09)**	**MB10 (6/11/09)**	**Livestock Guidelines (2000)**
Total Petroleum Hydrocarbons					
C_6 - C_9 Fraction	µg/L	20	20	<20	-
C_{10} - C_{14} Fraction	µg/L	50	<50	<50	-
C_{15} - C_{28} Fraction	µg/L	100	<100	<100	-
C_{29} - C_{36} Fraction	µg/L	50	70	<50	-
C_{10} - C_{36} Fraction (sum)	µg/L	50	70	<50	-

Note: TDS guideline is for beef cattle
- No guideline level determined

9.6 Piezometric Elevation

Groundwater levels were measured on two occasions, the first between 4 and 8 November 2009 and then again between 9 to 20 September 2010, providing detail on groundwater levels within the Tertiary and the Permian sequences. The water levels were measured as depth below the surface collar and reduced to Australian Height Datum (AHD). The water level records are summarised in Table 7 and are shown as interpolated contours for the Tertiary aquifer and Permian aquifer, which includes groundwater associated both the overburden and coal seam sequences, in Drawing No. 3.

Table 7: SUMMARY OF GROUNDWATER LEVEL MEASUREMENTS								
Hole	**Location**		**PVC Collar (mRL)**	**Total Depth (m)**	**Static Water Level**			
	(mE)	**(mN)**			**4 to 8 Nov 2009**		**9 to 20 Sept 2010**	
					(mBTOC)	(mRL)	(mBTOC)	(mRL)
MB1	649432.905	7584687.807	228.42	104	49.11	180.17	-	-
MB2	649436.783	7584687.514	228.5	48	39.075	190.22	-	-
MB3	648300.698	7583783.188	225.25	119	48.8	177.45	49.96	176.29
MB3B	648302.185	7583786.144	225.33	21	Dry	Dry	Dry	Dry
MB4	650847.431	7584037.574	220.09	112	37.99	183.10	-	-
MB5	648986.250	7583194.418	225.32	76	48.395	177.92	50.77	175.55
MB6	648989.316	7583194.024	225.25	43	40.285	185.96	41.16	185.09
MB7	649797.636	7582857.636	229.61	101	55.45	175.16	-	-
MB8	649794.966	7582855.249	229.66	39	Dry	Dry	16.85	Dry
MB9	651604.138	7582566.027	224.69	118	64.94	160.75	19.80	160.92
MB9B	651605.883	7582565.396	224.72	27	Dry	Dry	18.92	Dry
MB10	647539.869	7583160.329	220.19	89	47.97	173.22	18.11	174.07
MB11	662980.7	7553120.6	199.4	26	18.65	181.75	Dry	**181.03**

* Water level not stabilised following drilling.
mBTOC – metres below top of casing.
- not measured

The potentiometric surface of the Permian sequences indicates a gradient from around RL180m near the northern boundary of the mining lease to around RL160m along the north-western corner of East Pit (refer Drawing No. 3). A separate and more elevated potentiometric surface was measured within the Tertiary sediments up to 10m higher than that for the Permian sequences, ranging from RL190m north of the mine area to RL181m at the south-east corner of the mine lease area. These contours indicate an overall groundwater gradient towards the open pit which will have depressurised the surrounding aquifers intersected by the mine.

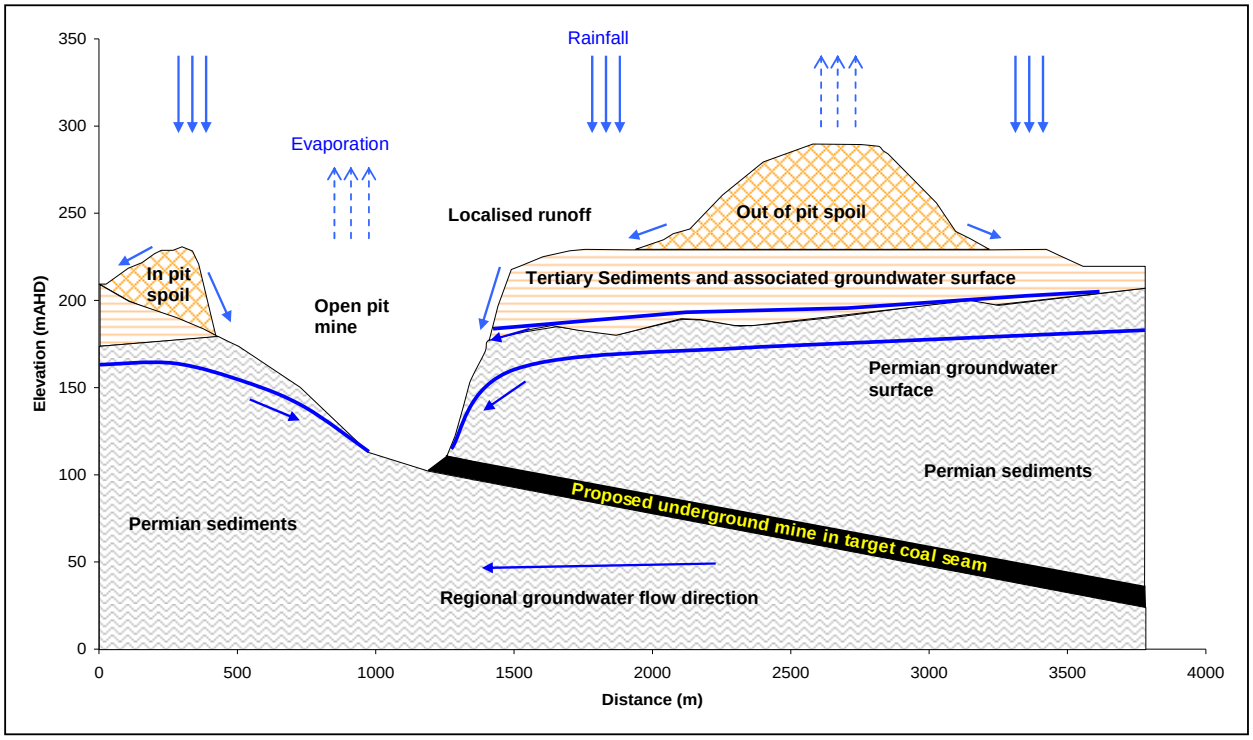
9.7 Conceptualisation of Groundwater Regime

The existing information and recently collected data discussed in the above sections was used to develop a conceptual understanding (conceptual model) of the hydrogeological regime. This conceptual model forms the basis of the assumptions used when developing the more detailed numerical model. Murray Darling Basin Commission (2000) defines a conceptual model as an "*idealised summary of the current understanding of catchment conditions, and the key aspects of how the flow system works…subject to some simplifying assumptions.*"

The data indicate the area supports three separate regional groundwater systems:

- localised regolith zones at the base of the Tertiary sediments;
- deeper Permian overburden units; and
- coal seams.

The three separate groundwater systems are described further below and illustrated in a north south cross section in Figure 8 generalised for Johnson Pit.



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

Figure 8: Conceptual Cross Section

This conceptualisation shows groundwater occurs:

- locally at the base of the Tertiary sediments where more permeable sediments occur within the deeper palaeo-channel sequences; and
- regionally where it effectively includes the combined hydraulic heads of the deeper saline aquifers hosted within the Permian Rangal Coal Measures. The Rangal Coal Measures include the Macarthur and Lower Leichhardt Coal Seams which are the target coal seams at the mine.

Differences in groundwater levels between the Tertiary and deeper Permain aquifers suggest these aquifers are not necessarily hydraulically interconnected.

Recharge would principally be from infiltration from the rainfall and creek flow into the Tertiary and Permian aquifer sub-crop areas, and possibly from leakage from overlying aquifers. However, this would be considered to be significantly reduced due to the predominantly clayey content of the upper Tertiary sequences.

The regional groundwater levels are a subdued reflection of the surface topography except adjacent to the open pit mine area where localised discharge/seepage in to the pits results in the steeper gradients around the pits. Regionally groundwater discharge within the deeper aquifers is expected to be into incised creeks/rivers that intersect the regional groundwater surface, primarily to the south-east of the Coppabella Mine area.

10.0 GROUNDWATER USE, QUALITY AND ENVIRONMENTAL VALUE

10.1 Groundwater Use

In Queensland, a number of areas have been declared as subartesian areas under the *Water Act 2000* which is administered by the Department of Environment and Resource Management (DERM). The Coppabella Mine and proposed underground extension are located within the Highlands Declared Subartesian Area and under this legislation all water supply bores drilled in the area must be approved and licensed by DERM. DERM maintains a database of all registered groundwater bores in Queensland and a search of the groundwater database covering an area that could potentially be impacted by the mine was undertaken. The database indicates that there are 11 registered bores within a 15km radius of the proposed mine, of which only two bores (RN 81,848 and RN 85,078) were located within 5km of the Mining Lease boundary. It is noted that four of the bores RN 13,040,112 to RN 13,040,115 are government monitoring bores located within the Bee Creek alluvium, of which three (RN 13,040,113 to RN 13,040,115) are reported abandoned. The location of the bores in relation to the mine is shown on Drawing No. 2 and their details are summarised in Appendix D.

As stock and domestic bores did not have to be licensed in the past, the database may not list all bores in the region of the proposed mine. Discussions with C&M JV have identified three groundwater investigation bores (HBW001 to HBW003) located approximately 4.5km south-east of the mine which were drilled on Harrybrandt Station in June 2005. Two of the bores (HBW001 and HBW002) intersected groundwater flows between 2.5L/sec and 4L/sec in a sand and gravel layer at the base of the Tertiary sediments between 45m and 52m depth. The third (HBW003) was abandoned at 36m due to hole collapsing (with sand) whilst drilling. Recommendations were made to utilise HBW002 for a water supply.

10.2 Groundwater Quality

The groundwater quality data presented in Section 9.0 indicates that groundwater quality in the Tertiary and deeper Permian and Coal Seam aquifers in the area is poor and would not provide water of suitable quality for cattle consumption. The salinity levels in water samples collected from the Tertiary and deeper Permian and Coal Seam aquifers is typical of these aquifers indicating low hydraulic conductivity and poor lateral and vertical interconnection.

10.3 Environmental Value

10.3.1 Environmental Protection (Water) Policy 2009

The Environmental Protection (Water) Policy (2009) serves to protect Queensland's environment while allowing for ecologically sustainable development. This is achieved through the policy by providing a framework for:

(a) identifying environmental values for Queensland waters; and

(b) stating water quality guidelines and water quality objectives to enhance or protect the environmental values; and

(c) providing a framework for making consistent, equitable and informed decisions about Queensland waters; and

(d) monitoring and reporting on the condition of Queensland waters.

Part 3, Section 6 of the policy states that the **"environmental values"** of waters, which include groundwaters, to be enhanced or protected under this policy are the qualities given in subsections (2) and (3), viz:

(2) *For subsection (1)(b), the environmental values are as follows—*

(a) for high ecological value waters—the biological integrity of an aquatic ecosystem that is effectively unmodified or highly valued;

(b) for slightly disturbed waters—the biological integrity of an aquatic ecosystem that has effectively unmodified biological indicators, but slightly modified physical, chemical or other indicators;

(c) for moderately disturbed waters—the biological integrity of an aquatic ecosystem that is adversely affected by human activity to a relatively small but measurable degree;

(d) for highly disturbed waters—the biological integrity of an aquatic ecosystem that is measurably degraded and of lower ecological value than waters mentioned in paragraphs (a) to (c);

(e) for waters that may be used in primary industry or for agricultural purposes, the suitability of the water for—

- *(i) agricultural use; or*
- *(ii) aquacultural use; or*
- *(iii) producing aquatic foods for human consumption;*

(f) for waters that may be used for recreation or aesthetic purposes, the suitability of the water for—

(i) primary recreational use; or

(ii) secondary recreational use;

(g) for waters that may be used for drinking water – the suitability of the water for supply as drinking water;

(h) for waters that may be used for industrial purposes – the suitability of the water for industrial use;

(i) the cultural and spiritual values of the water.

(3) *In this section—*

cultural and spiritual values*, of water, means its aesthetic, historical, scientific, social or other significance, to the present generation or past or future generations.*

primary recreational use*, of water, means full body contact with the water, including, for example, diving, swimming, surfing, waterskiing and windsurfing.*

secondary recreational use*, of water, means contact other than full body contact with the water, including, for example, boating and fishing.*

An assessment was made of the groundwater quality in terms of the relevant ANZECC criteria and environmental values. The ANZECC (2000) guideline refers to the term "environmental value" rather than "beneficial use" which is often used, and states that the term beneficial use has lost favour because of its exploitative connotations. The guidelines state (p2-7) that: *"...where two or more agreed environmental values are defined for a water body, the more conservative of the associated guidelines should prevail and become the water quality objectives.".* The assessment of "environmental value" of groundwater for the Codrilla Coal Project area and surrounds given in this report is based on this guideline and is discussed below in the terms used in the *Environmental Protection (Water) Policy 2009*.

10.3.2 Aquatic Ecosystems

Aquatic or specifically Groundwater Dependent Ecosystems (GDEs) are defined as *"those parts of the environment the species composition and natural ecological process of which are determined by the permanent or temporary presence or influence of groundwater"* (DEH 2001).

Five management principles establish a framework by which groundwater is managed in ways that ensure, whenever possible, that ecological processes of dependent ecosystems are maintained or restored. A summary of the principles follows:

- GDEs can have important values. Threats should be identified and action taken to protect them;
- Groundwater extractions should be managed within the sustainable yield of aquifers;
- Priority should be given to ensure that sufficient groundwater is available at all time to identified GDEs;
- Where scientific knowledge is lacking, the precautionary principle should be applied to protect GDEs; and

- Planning, approval and management of developments should aim to minimise adverse affects on groundwater by maintaining natural patterns, not polluting or causing changes to groundwater quality and rehabilitating degraded groundwater systems.

No GDEs have been identified or are known to exist within the Coppabella Mine area. Similarly, on the basis that the groundwater table in the Tertiary aquifers was in excess of 18m below ground level and even deeper for the Permian and Coal Seam aquifers, and the water quality within these deeper aquifers was saline, it can be concluded that mining within the Coppabella Mine area will not intersect or impact on groundwater associated with a GDE.

10.3.3 Agricultural Use

The DERM bore database and discussions with C&M JV indicates that no bores have been constructed on either the property on which the existing Coppabella Mine and proposed Coppabella Underground Project are located, or the surrounding properties. Whilst concentrations of dissolved metals are relatively low and generally within guidelines for livestock, Section 4.3.3.5 of the ANZECC guidelines (2000) states that loss of production and a decline in animal health occurs if stock are exposed to high salinity drinking water for prolonged periods. For beef cattle, this limit is in the range of 7,500µS/cm to 15,000µS/cm. Given the salinity of the Tertiary and Permian aquifers is generally equivalent to the upper limit (15,000µS/cm), the regional groundwater is considered to not be suitable for livestock.

10.3.4 Recreational Use

This category of environmental value is not considered relevant to the groundwater regime of the area.

10.3.5 Drinking Water

The water quality data obtained from the monitoring bores indicate that the regional groundwater is saline and as such is unsuitable for human consumption (NHMRC and NRMMC, 2004).

10.3.6 Industrial Use

The nearest industry is the South Walker Creek Coal Mine located some 10km to the north where it is understood no use is made of groundwater. There are no other industrial users of groundwater within the project area or surrounds. Industrial users generally have the capital required to drill and equip bores and if necessary to treat the water before use. Since industry tends to require a large volume of groundwater, it would depend on the volumes of groundwater available from the Tertiary, deeper Permian and coal seam aquifers within the area of the Coppabella Mine area, as to whether there was sufficient groundwater available for industrial purposes such as dust suppression or as a process water supply (ANZECC, 2000).

10.3.7 Cultural and Spiritual Values

There is no known environmental value in relation to cultural and spiritual values of groundwater within the project area.

10.3.8 Summary

In summary, evaluation of the environmental values of the Coppabella Underground Project hydrogeological regime has identified that aquifers associated with the Tertiary, Permian and coal seam sequences are of no (or limited) value for most uses, with the only value being that for industrial purposes in relation to the proposed coal mine operation, as is the case at other Bowen Basin coal mines.

Hence in accordance with Part 3, Section 6 of the Environmental Protection (Water) Policy (2009), the environmental values for suitability of groundwater within Coppabella Underground Project area that would need to be enhanced or protected under this policy would be those for industrial use only.

11.0 PROPOSED MINE DEVELOPMENT PLAN AND SUBSIDENCE IMPACTS ON GROUNDWATER

The current open pit mine operation has a projected life of 13 years to 2023 after which the underground operation will commence in 2024 and has a projected life of mine for 10 years. As discussed in Section 2.0, the proposed underground mining methodology will utilise the Longwall Top Coal Caving technology and will target the locally named Macarthur Seam and Leichhardt Upper and Leichhardt Lower Seams.

The mine plan proposes for the underground operation to commence from an in-pit portal coming off the Johnson Pit North highwall to the northwest. Five longwall panels around 300m wide extend between 2,000m and 3,750m eastwards, from depths generally increasing from about 140m to 220m from south to north, and some of which are beneath the northern waste dump. C&M JV[4] advise there will some board and pillar extraction along the south-western portion of the mine where the coal seam orientation precludes retrieval using the longwall panels. The extent of the longwall panels and board and pillar extraction areas is shown in Figure 9. No detail on timing for this mine plan has been made available.

[4] Email correspondence Mr. K. Henderson, 19 October 2010.

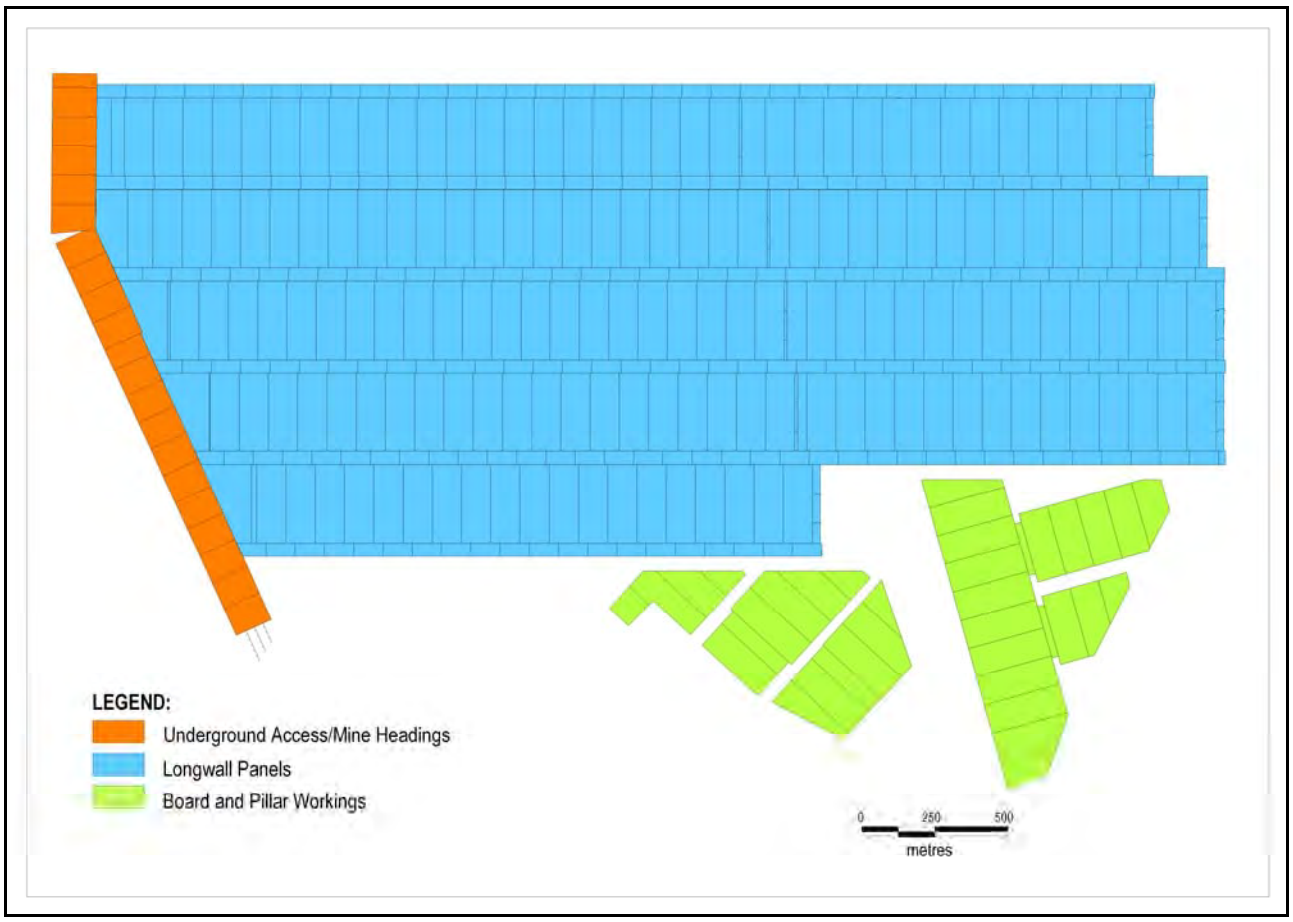


Figure 9: Generalised Mine Development Plan

11.1 Generic Description of Strata Disturbance Zones

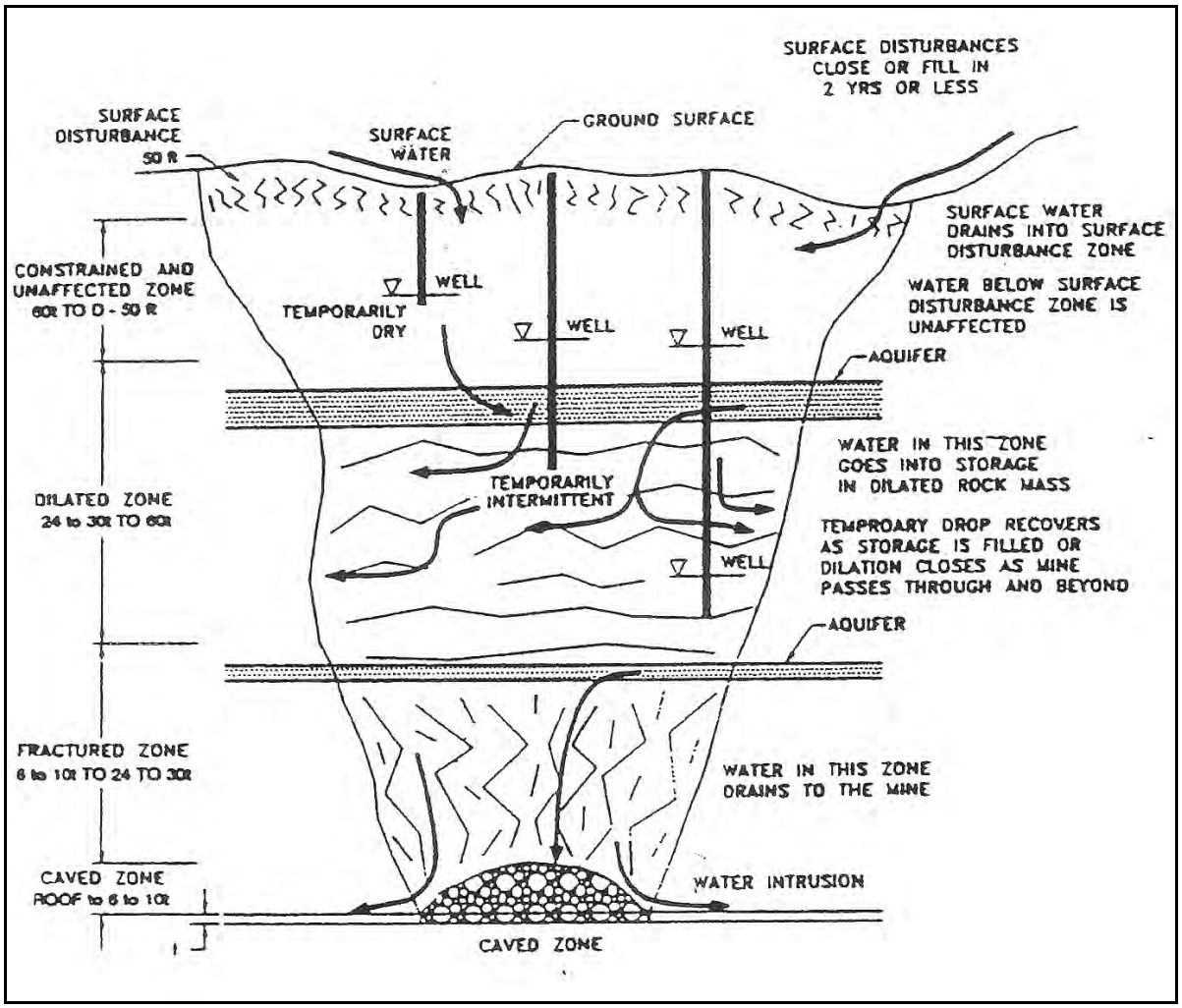
Longwall Top Coal Caving results in collapse of the overlying rock strata into the void left following coal extraction. The collapsed or disturbed overburden material is referred to as the goaf. The collapse propagates upwards from the extracted seam until bulking within the goaf limits vertical movement and the tensile strength of the rock strata is sufficient to hold up the overburden without failure. The concept of the strata disturbance zone as defined by Kendorski (1993) is illustrated on Figure 10.

Kendorski defines five subsidence zones above the area of longwall extraction as summarised below:

- Caved Zone: This is the zone of complete disruption of broken and rubble-sized strata extending to 6 to 10 times (6t to 10t) the seam thickness in height above the caving roof.

- Fractured Zone: This zone occurs above the caved zone to a height of 24t to 30t. The strata does not fall and detach but cracks and settles, resulting in fractures extending through individual beds, opening of bedding planes and shearing and dislocation of beds. The caved and fractured zones have increased vertical and horizontal transmissivity and storativity and both attributes decrease exponentially with height above the seam roof.

- Dilated Zone: This zone is often referred to as the “Aquiclude Zone”. In this zone the strata sags allowing bed separations, but not allowing connecting fracturing and drainage into the mine. It occurs at a height of 30t to 60t or greater. The water level of aquifers located in this zone may be lowered in response to the relatively rapid increases in void space laterally, that is, due to an increase in storage volume, but the water level generally recovers given sufficient time, as the voids are filled.



after Kendorski (1993)

Figure 10: Schematic Subsidence - Groundwater Inflow Model

- Constrained Zone: This zone occurs where the extracted seam from 60t to about 15m below the surface, and is characterised by overall tensile strains of less than 1mm/m i.e., a stress level at which rock masses are not disrupted sufficiently to increase their permeability. Hence there is no significant change in transmissivity or storativity and therefore aquifers, which occur in this zone, are largely unaffected.

- Surface Fracture Zone: The surface fractures generally relate to panel and trough edges and extend to a depth of about 15m. If transmitted into soils, the soil properties may allow little or no crack development due to the plastic and non-brittle nature of many soils. If in rock, the natural pre-existing fracturing will be dilated, having little effect on continuity. The cracks are transmissive zones and the increased void space may result in a temporary lowering of shallow groundwater levels as the voids fill. The cracks will not provide pathways for deeper

migration of groundwater unless extending into the “fracture zone”. This may happen where the “dilated zone” is absent due to shallow mining, that is, shallow overburden thickness. Surface cracks also generally fill quickly with sediment or close due to spalling.

The subsidence zones of Kendorski described above are generic and are based on super critical extraction. They provide a general overview of what can occur, however the depth of cover, overlying stratigraphy and panels widths vary between mines and each of these factors have to be taken into account in assessing the subsidence impact at a specific mine site. The impact from subsidence on the groundwater regime at the proposed Coppabella Underground Mine is described in the following section.

11.2 Impact from Subsidence from Longwall Mining

In the absence of a site specific assessment for the proposed Coppabella Underground Mine, the impact assessment undertaken for the Ellensfield Coal Mine Project (AGE, 2008) has been adopted considering the similar geological environment for the two sites. Of importance in assessing the impact of mining on the groundwater regime and groundwater inflow to the mine, is the height of fracturing above the longwall panels that will provide hydraulic connection between overlying groundwater bearing zones and the mine. For the Ellensfield Coal Mine Project, it was concluded that the extent of fracturing above the coal seam (the caved and fractured zones of Kendorski) was most probably limited to overburden up to 100m in thickness, but this may be could be greater in areas where adverse geological conditions where there is significant faulting.

Based on this, a height of 100m above the Macarthur Seam and the Leichhardt Upper and Leichhardt Lower Seams was adopted for the Coppabella Underground Mine numerical model for simulation of continuous fracturing above the longwall panels from which water bearing strata could drain into the mine workings after the seam has been extracted. This being the case, it appears unlikely the caved zone would extend above the top of the Permian sediments overburden, but it is possible that the fractured zone could extend into the base of the Tertiary Sediments. That is, any water bearing strata above the underground working within both the Permian sequences and the Tertiary Sediments would likely drain into the underground mine workings.

12.0 NUMERICAL GROUNDWATER MODEL

12.1 Modelling Objectives

The overall objective of the numerical modelling was to simulate the impact of the Coppabella Underground Project operations on the hydrogeological regime of the area. In particular, the objectives are to undertake predictive modelling in order to:

- assess the potential groundwater inflow volumes to the underground workings over the mine life;
- 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

- predict the rate of groundwater recovery and long term impacts occurring after cessation of mining.

12.2 Conceptual Model

As standard practice, every numerical groundwater model has as its foundation a conceptual model. The conceptual model of the groundwater regime for this project has been described in Section 9.7 and forms the basis of the numerical model. The conceptual model is an understanding of how the groundwater system operates and is an idealised and simplified representation of the natural system.

Detailed information on the natural system is therefore required to develop a representative but simplified conceptual groundwater model, which makes this a crucial step in the development of the groundwater model. MDBC (2000) define a conceptual model as an "*idealised summary of the current understanding of catchment conditions, and the key aspects of how the flow system works…subject to some simplifying assumptions".* Care taken during this stage helps eliminate errors which typically cannot be corrected during the model calibration, or at any later stage of the modelling study, without making major revisions. It also provides an opportunity to highlight gaps in data or deficiencies in understanding of the groundwater system.

The development of the numerical model using the conceptual model as its basis is described below.

12.3 Model Code Selection

Numerical simulation of groundwater flow in the aquifers was undertaken using the MODFLOW SURFACT code (Hydrogeologic, 1997), hereafter referred to as SURFACT. A commercial derivative of the standard MODFLOW code, SURFACT is distributed by Hydrogeologic Inc and has some distinct advantages over MODFLOW, advantages that are critical for the simulation of groundwater flow at the Coppabella site.

The MODFLOW code (on which SURFACT is based) is the most widely used code for groundwater modelling and is presently considered an industry standard. Use of the SURFACT modelling package is becoming increasingly widespread, particularly in mining applications where groundwater dewatering and recovery are simulated.

First and foremost, SURFACT is capable of simulating unsaturated conditions. This is critical for the requirements of the proposed mine where coal seams will be progressively dewatered with time until the end of mining when active dewatering will cease and groundwater recovery will rewet the seams. SURFACT is also supplied with more robust numerical solution schemes to handle the more complex numerical problem resulting from the unsaturated flow formulation. Added to the more robust numerical solution schemes is an adaptive time-stepping function that aides the progression of the solution past difficult and complex numerical situations such as oscillations.

The MODFLOW pre- and post processor PMWIN (Chaing and Kinzelbach, 1996) was utilised to generate some of the input files for the SURFACT model, such is the similarity between it and the standard MODFLOW. Where files differ to allow for the additional capabilities of SURFACT, these changes were undertaken through manual editing of the model files.

12.4 Modelling Strategy

Modelling was undertaken in a number of stages as follows:

- creating the model structure by simulating the geometry of the model layers and applying appropriate parameters and boundary conditions;
- calibration of the model to steady state conditions prior to commencement of mining in 1998;
- calibration of the model to transient conditions representative of current open pit mining operations to 2009 and the recently installed monitoring bores described in Section 7.2;
- transient predictive modelling for three scenarios;
    1. impact of operation of the open pit mine over a 13-year period from 2011 to 2023 in accordance with the specified mine plan;
    2. impact of operation of the underground mine for a 10-year period from 2024 to 2033 in accordance with the proposed extent of the underground mine;
    3. long-term recovery of the water levels in the final mine voids for the underground mine and remaining open pits.

12.4.1 Model Geometry and Boundary Conditions

The structure of the coal seams within the project area is relatively complex and comprises a Permian sequence overlain by the either the Triassic Rewan Formation or the Tertiary sediments. The Permian and Triassic rocks form a regular layered sedimentary sequence which was simplified for the numerical model by merging several formations into single model layers, while preserving the measured thickness of the coal seams, to ensure the transmissivity remained the same. The model consisted of seven layers as follows:

- Layer 1 represented the generally unconsolidated Tertiary sediments, consisting of clays, fine to coarse grained sands and gravel but also includes the alluvium. The thickness of this layer varies from a minimum of 1m to 45m within the mine area but is set at a uniform 15m outside the mine area;
- Layer 2 represented the weathered bedrock below the Tertiary sediments and was modelled with uniform thickness of 10m outside the mine area where there was no data and a varying thickness from 2m to 40m within the mine area;
- Layers 3 & 4 represented the Triassic Rewan Formation where present, overlying the Rangal Coal Measures, comprising non-carbonaceous lithic sandstone and siltstone with no associated coal. The thickness of this layer is variable, ranging from a nominal thickness of 2m from where it sub-crops beneath Layer 1 up to 120m.

The Rangal Coal Measures have an average thickness of 150m and underlie the Rewan Formation and have been modelled as four separate layers as detailed below:

- Layers 5 & 6 represent overburden sedimentary rocks above the coal seam. The thickness of these layers is variable from where they sub-crop beneath either Layers 2, 3 or 4 and ranges from a nominal thickness of 2m to 210m;
- Layer 7 represents the target coal seams in the model which is either the Macarthur Seam or the Leichhardt Seam. The seam has a thickness varying from 1m to 10m;

- Layer 8 represents the Rangal Coal Measures sedimentary rocks below the target coal seams. The layer has a variable thickness but for modelling purposes was set with a constant base elevation of RL-133m which is 50m below the lowest point of the target coal seam in the Coppabella Mine area.

The outline of the active model grid is overlain on the regional geology in Drawing No. 6. The model domain comprises 40,596 rectangular cells with 176 rows and 216 columns, which are of variable dimension ranging from 50m by 50m within the mining area up to 500m by 500m outside the project area, as shown on Drawing No. 6. The north-west corner of the grid is located at 632,800mE and 7,604,000mN (GDA94 Z55) and the model extent is about 26km x 36km, covering an area of approximately 922km^2. The eastern boundary represents the sub-crop alignment of the Rangal Coal Measures and hence the model basement (Layer 8), as defined by the regional geological mapping for the area. The western boundary is located along the thrust fault alignment where the Rangal Coal Measures are abruptly terminated by the displaced Rewan Formation. Cells located outside of these boundaries have been excluded from the simulation as they are not considered representative of the geology in hydraulic connection with the mine site and the extent of the numerical model area.

Within the Coppabella mining lease, exploration drilling has resulted in more precise mapping. The ground surface and structure of the underlying geological sequences has been interpreted from data provided by the C&M JV, particularly with respect to the coal seams being mined. Elsewhere, publicly available data through NASA's Shuttle Radar Topography Mission (SRTM) with 90m x 90m grid spacing was used as a basis for generating the regional ground surface in the model. The elevations of the top of the targeted coal seams distant from the mine area have been determined using data sourced from:

- coal seam gas bore log data within the western portion of the model area thereby providing indicative depths of the respective layers distant from the mine area; and
- extrapolation of the contour data to the north and east of the proposed mine area to provide the extents of sub-crop elevations.

The major creeks along the model's northern and southern boundaries were defined as constant head boundaries, as shown in Drawing No. 6. This boundary condition assumes a fixed groundwater level for the entire period of simulation, allowing water to pass into or out of the model domain depending on the direction of flow defined by the relative groundwater water levels in the adjoining portion of the model.

With the exception of these constant head boundaries, the numerical model domain is surrounded by inactive or "no flow" boundaries as follows:

- along the western boundary coincident with the concealed thrust fault alignment;
- the coal seam sub-crop alignments that mark the eastern boundary;
- along the northern and southern boundaries where it was considered beyond the influence of the proposed Coppabella Mine operations; and
- the base of Layer 8 in the model.

12.4.2 Hydraulic Parameters

The permeability testing undertaken for this assessment (refer Section 9.0) yielded values for hydraulic conductivity for the sedimentary sequences that make up the individual layers of the model as outlined below in Table 8.

Table 8: SUMMARY OF PERMEABILITIES

Model Layer	Geology Description	Thickness (m)	Bore Used For Testing	Permeability	
				(m/s)	(m/d)
1	Tertiary Sediments	1-45	MB2,MB6, MB11	3.59×10^{-6}	0.3
2	Weathered bedrock	2-40	-	-	-
3 & 4	Triassic Rewan	2 – 120	-	-	-
5 & 6	Permian Rangal CM	10 – 210	MB1, MB3, MB4, MB5, MB7	4.6×10^{-6}	0.4
7	Target Coal Seam	1-10	MB9, MB10	3.4×10^{-8}	0.003
8	Permian Rangal CM	410	-	-	-

Note: - Not tested

The assessed hydraulic conductivities obtained from analysis of the permeability testing described in Section 9.0 for the geological sequences intersected, were used as a starting point for the model layer hydraulic conductivity values. Following calibration, the final values adopted for the respective model layers are shown in Table 9. Comparison with Table 8 shows the modification required to achieve calibration. Note that as the alluvium within this site is neither laterally nor vertically extensive and was included within Layer 1 and not as a separate layer.

The values for aquifer specific yield and specific storage adopted for each layer in the numerical model have been based on those for other coal mines in the Bowen Basin and used in other similar numerical modelling simulations.

Table 9: HYDRAULIC PARAMETERS

Layer	Parameter	Value
Layer 1 (Quaternary Alluvium & Tertiary Sediments)	Horizontal Hydraulic Conductivity [kh]	4.48×10^{-2} m/day for Tertiary 9.70×10^{-1} m/day for Quaternary
	Vertical Hydraulic Conductivity [kv]	10% of Kh (above)
	Specific Yield [Sy]	20%
	Specific Storage [Ss]	1×10^{-5}
Layer 2 (Weathered Permian or Triassic Bedrock)	Horizontal Hydraulic Conductivity kh	2.66×10^{-2} m/day
	Vertical Hydraulic Conductivity kv	Kv / Kh = 0.29
	Specific Yield S_y	1%
	Specific Storage S_s	1×10^{-3} m^{-1}
Layers 3 & 4 (Triassic Rewan Formation)	Horizontal Hydraulic Conductivity kh	1.45×10^{-4} m/day
	Vertical Hydraulic Conductivity kv	Kv / Kh = 0.11
	Specific Yield S_y	1%
	Specific Storage S_s	6.12×10^{-4} m^{-1}

Table 9: HYDRAULIC PARAMETERS		
Layer	**Parameter**	**Value**
Layers 5 & 6 (Overburden Rangal Coal Measures)	Horizontal Hydraulic Conductivity kh	9.62×10^{-4} m/day
	Vertical Hydraulic Conductivity kv	Kv / Kh = 0.09
	Specific Yield S_y	1%
	Specific Storage S_s	3.13×10^{-4} m^{-1}
Layers 7 (Target Coal Seam)	Horizontal Hydraulic Conductivity kh	5.81×10^{-2} m/day
	Vertical Hydraulic Conductivity kv	Kv / Kh = 0.16
	Specific Yield S_y	1%
	Specific Storage S_s	3.77×10^{-4} m^{-1}
Layers 8 (Rangal Coal Measures – Basement)	Horizontal Hydraulic Conductivity kh	1.44×10^{-5} m/day
	Vertical Hydraulic Conductivity kv	Kv / Kh = 0.15
	Specific Yield S_y	1%
	Specific Storage S_s	2×10^{-5} m^{-1}

12.4.3 Recharge and Discharge

Rainfall sourced recharge is the only external input into the model domain and has been applied to the topographic surface of the uppermost layer (Layer 1) in the model. The recharge has been applied at a constant rate, with no adjustment for seasonality. While it is accepted that the source of the recharge is rainfall, which is indeed seasonally dependent, the variability of the recharge is difficult to quantify, nor is it measurable to any certainty, and as such it is appropriate to model this as a constant rate.

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.

The combination of relatively low precipitation and high evaporation rates in conjunction with the low permeability of the top layer most probably limits the net annual recharge from rainfall to the groundwater regime hosted within the Tertiary sediments. With this in mind, calibration of the steady state model required adjustment of this net recharge which is discussed in Section 12.5.

Surface discharge of groundwater was modelled using the SURFACT Drain (DRN) package by assigning drain cells in Layer 1 only coincident with the creek alignments. The DRN package compares the water level in the aquifer against a reference level, whereby if the aquifer water level is above the reference water level then water is removed at a rate specified by the drain conductance. The drain elevation (reference levels) were set to the ground surface elevations at corresponding model cells throughout the model domain with exception for Bee Creek which is the major drainage feature in the model domain east of the mine area. The drain elevation in Bee Creek was set to 8m below ground surface which is equivalent to the groundwater level observations in the registered monitoring bore RN13040112.

Groundwater inflow to the mine workings was modelled using the DRN package by setting open pit drain cells at the base of Layer 7 (target coal seam), to represent the base of the open pits.

12.5 Model Calibration

Anderson and Woessner (1992) note that *"calibration of a groundwater flow model refers to a demonstration that the model is capable of producing field measured heads and flows which are the calibration values. Calibration is accomplished by finding a set of parameters, boundary conditions and stresses that produce simulated heads and fluxes that match field measured values within an acceptable range of error".*

Calibration of the groundwater flow model to observed water level measurements was undertaken for different stages of the open pit mine development from commencement of operation in 1998 to installation of the groundwater monitoring bores, as part of this assessment, in 2009. Water level measurements from four separate monitoring events were used over this period, which included:

- Groundwater levels measured in 141 exploration drill holes and one registered bore before mining commenced in January 1998. These were use for calibration of the steady state groundwater model and represent groundwater conditions prior to mine development. It is noted that these drill holes may not have been cased in a single aquifer, and that the measured water levels represent hydraulic pressures in both the Tertiary and Permian sedimentary sequences. The locations of the mine exploration bores used for the model calibration are shown in Figure 11.
- Groundwater levels measured in the open exploration drill holes after commencement of mining in July 1998.
- Long-term monitoring data from the registered bore RN13040112 located west of the mine in the Tertiary Bee Creek alluvium.
- Water level observations from 10 of the newly installed monitoring bores in November 2009 (MB1 to MB7, MB9 to MB11), details of which are provided in Section 9.0.

Using this approach, the calibration involved running both a steady state groundwater model to simulate the pre mine groundwater conditions, and then a transient groundwater model simulating mine development up to the time of this assessment.

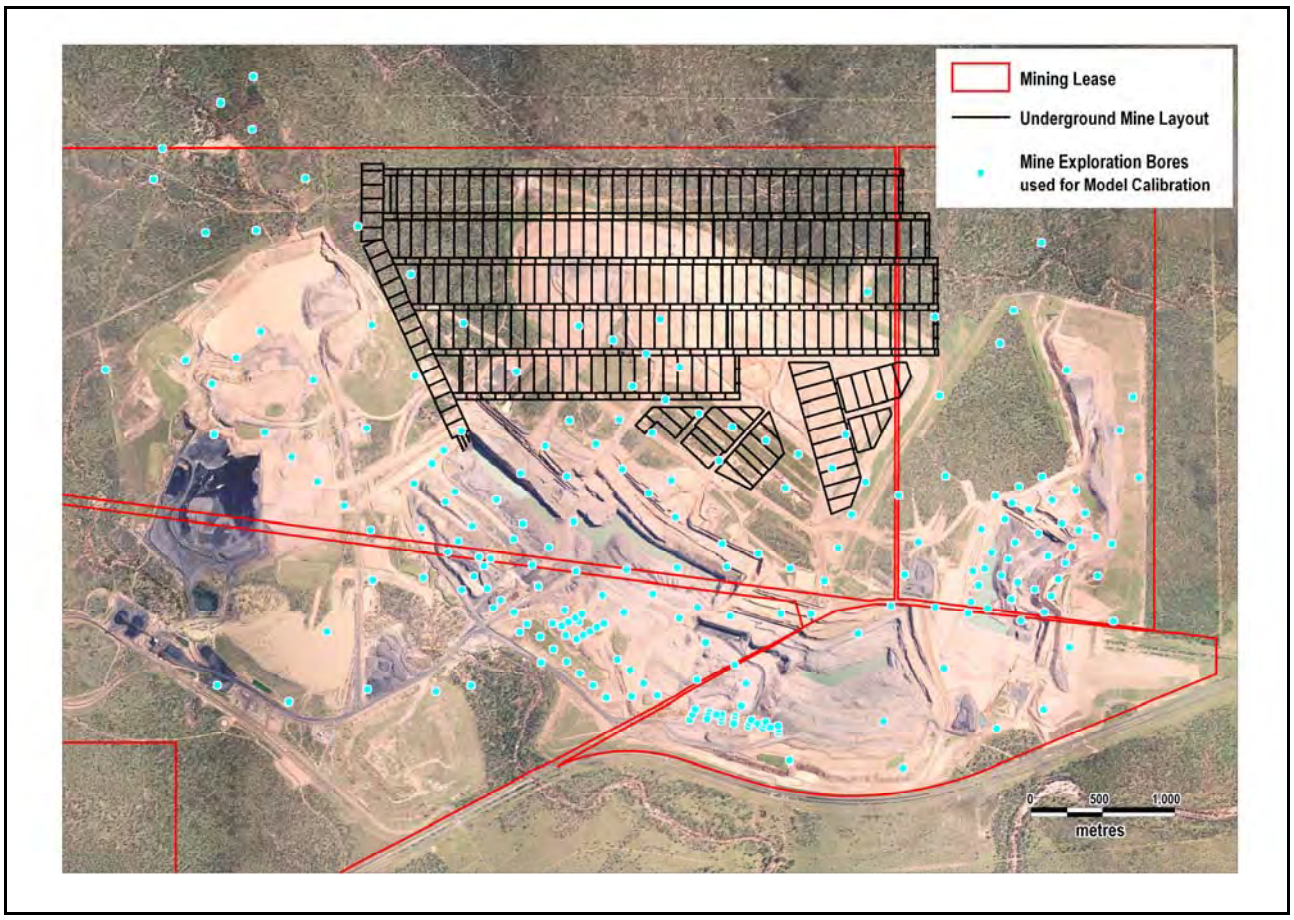


Figure 11: Exploration Bores used for Model Calibration

Calibration of the groundwater flow model to observed steady state water levels was undertaken as the first step in modelling, with the accuracy dependent on the number, quality and distribution of observation data, as well as the data defining the model domain such as aquifer geometry, boundaries, hydraulic properties and stresses imposed on the aquifer. The simulated pre-mining groundwater levels for Layer 1 (Tertiary aquifer) and Layer 7 (target coal seam aquifer) are presented in Drawing No. 7. The calibration parameters were hydraulic conductivity and recharge, which correlate highly under steady state conditions. Once the appropriate ratio between hydraulic conductivity and recharge is determined, it is possible, as long as the ratio is maintained, to assign any combination of hydraulic conductivity and recharge to the system and still obtain a reasonable match to observed water levels.

Subsequent calibration of the transient model was undertaken using the groundwater level observations made after commencement of mining which includes those for water level measurements made in the exploration drill holes, recent groundwater monitoring bores and the registered bore.

Whist the horizontal and vertical extent of the model and model boundaries were considered sufficiently well defined to calibrate the groundwater model, the quality of the steady state calibration target groundwater levels was not optimal due to:

- the calibration targets within the mine site being clustered within a relatively small area within the model domain;

- the lack of any time series data available for these boreholes with only a single data set of groundwater level data; and
- availability of only one registered bore in the model domain distant from the mine site with limited time series data.

Ideally, calibration requires a longer term record of groundwater levels (i.e. several years), to confirm that a steady state water level can be adopted. However, as no other registered bores outside the proposed mining area had any groundwater level records, the available bores were deemed acceptable to be used to calibrate the model.

The recharge rate was adjusted such that the pattern of groundwater contours and direction of groundwater flow under steady state conditions generally matched those measured in the monitoring bores. Using this approach, the rate of recharge to Layer 1 was set at 5mm/year within the Quaternary alluvium associated with the creek drainage alignments and 0.01mm/year for the rest of the model domain, which is equivalent to 0.85% and 0.002% of the average annual rainfall respectively.

12.5.1 Calibration Results

Comparison of observed and simulated groundwater levels in the model area are shown in Figure 12 and are presented in Appendix E. In total, 353 groundwater level observations from the four monitoring events listed in Section 12.5 were used. Due to the uncertainty with the accuracy of the data obtained from the exploration drill holes (i.e., whether or not these bores were cased off in a single aquifer), the data was weighted depending on its reliability. That is, the data from the newly installed monitoring bores was considered to be more reliable and was assigned a higher weighting factor, as these monitoring bores were specifically designed and screened for monitoring individual aquifers. The observations from the exploration drill holes after 1998 were assigned a lower weighting factor due to the uncertainty as to which aquifers these bores were monitoring after mining commenced. The weighting factors assigned to individual observation is provided in Appendix E. Final calibration was derived using the automatic calibration software package PEST (Doherty *et al*, 1994).

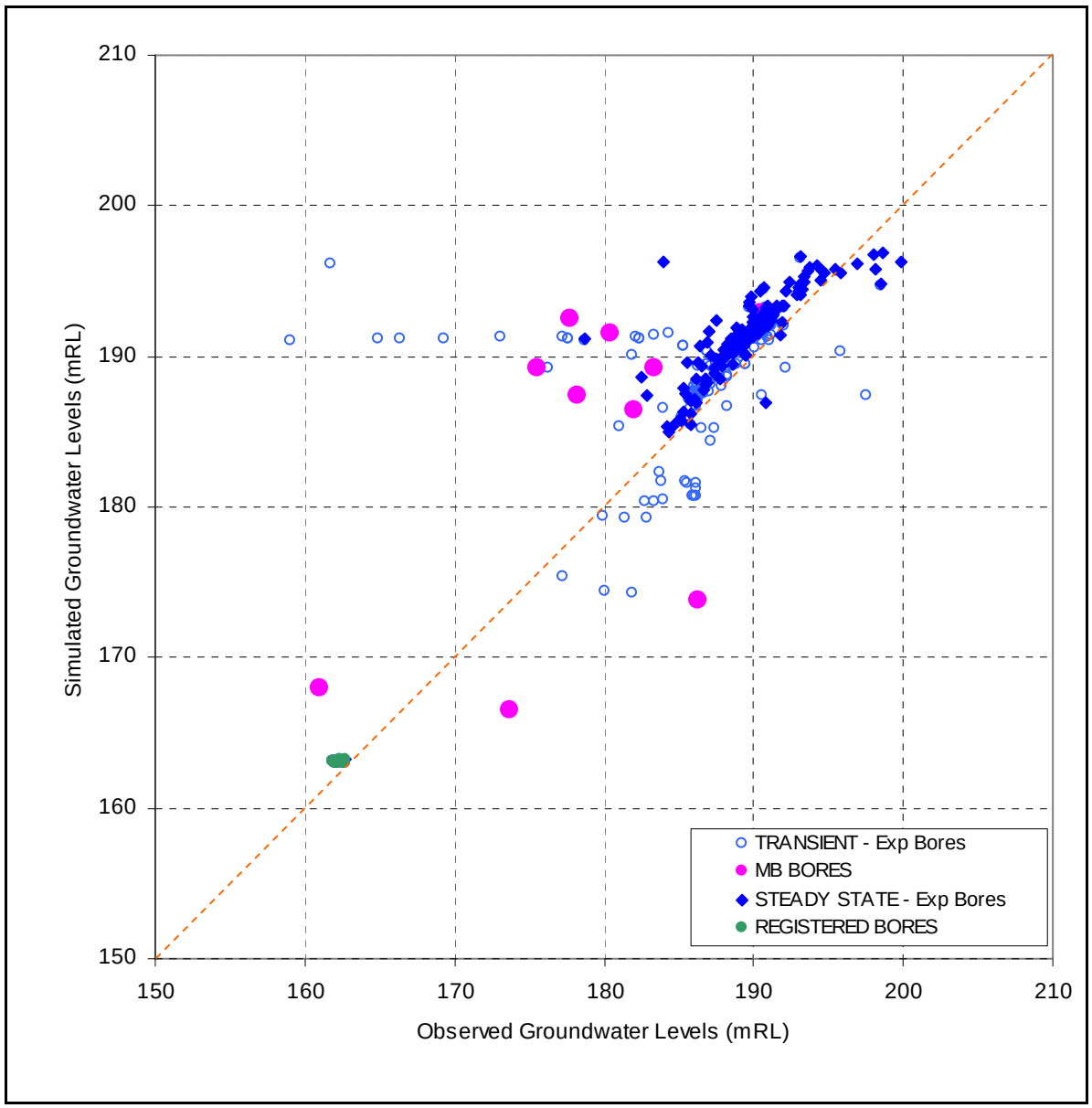


Figure 12: Observed vs Simulated Groundwater Levels - Steady State and Transient Models

An objective method to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. One such method is by measurement of the error between the modelled and observed (measured) water levels. The root mean square (RMS) error is expressed as follows:

$$RMS = \left[1/n \sum (h_o - h_m)_i^2\right]^{0.5}$$

where:

	n	=	number of measurements
	h_o	=	observed water level
	h_m	=	simulated water level

The RMS error calculated for the calibrated model was 4.9m. The maximum acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total change is small, known as the Scaled RMS (SRMS), the errors are only a small part of the overall model response (Anderson and Woessner, 1992). The ratio of RMS (4.9m) to the total head change across the calibration points (40.7m) indicated a SRMS of 12% which is considered a poor calibration. The acceptable target for SRMS varies between models but is typically below 5% (MDBC, 2000). However when the following points are taken into account the calibration is considered to be the best achievable based on the available data:

- the steady state model used a simplified uniform representation of permeability based on limited data to represent a complex heterogeneous fractured rock system;
- the water levels recorded at the calibration points are mostly from a single set of data, and hence reflect a snap shot in time of groundwater levels within the study area. Of these, only one point has longer term groundwater level data available which is bore RN13040112 (since September 1976) during which time the level has remained relatively static; and
- the calibration points are clustered around the mining area with no other bores outside the mining area available for calibration.

Assessment of the model budget is also undertaken to firstly ensure the converged solution is adequately conserving mass during the simulation, and secondly to define the bulk water movements in and out of the model domain. The mass balance error which is the difference between calculated model inflows and outflows at the completion of the calibration run expressed as percent of discrepancy, was 0.1% for the steady state calibration and 0.0% for the transient calibration, indicating good accuracy of the numerical solution and overall stability of the model as the percent discrepancy of water budget across the model domain should be below 1% as suggested in the MDBC guidelines.

Table 10 presents the model water balance for the steady state simulation. This shows recharge to the model domain was 0.8ML/day compared to water loss from the model domain of 0.1ML/day as outflow across the constant head boundary and 0.7ML/day as discharge to the creek drain cells.

Table 10: CALIBRATED STEADY STATE MODEL WATER BALANCE

Component	Rate for Simulation (ML/day)
IN	
CONSTANT HEAD =	0.04
DRAINS =	0.00
RECHARGE =	0.79
TOTAL IN =	0.83
OUT	
CONSTANT HEAD =	0.10
DRAINS =	0.73
RECHARGE =	0.00
TOTAL OUT =	0.83
IN - OUT =	8.0×10^{-5}
PERCENT DISCREPANCY =	0.01%

The transient calibration model was set up with 52 stress periods, each of 91.3 days duration representing quarterly development of the mine over the 13 years life of mine period. The simulated steady state heads from the calibrated steady state model calibration were used as initial conditions representing groundwater levels at the start of the transient predictive simulation.

The transient calibration simulation water balance is presented in Table 11 below. The rates for each water balance component are an average across the entire 13 year simulation. The increase in the recharge rate (to 1.3ML/day) over the steady state simulation is from additional recharge sourced from the waste rock dumps, which was required to provide adequate fit between the model predicted groundwater levels and observed water levels in the recently installed monitoring bores.

Table 11: CALIBRATED TRANSIENT MODEL WATER BALANCE

Component	Rate for Simulation (ML/day)
IN	
STORAGE =	6.69
CONSTANT HEAD =	0.04
DRAINS =	0.00
RECHARGE =	1.31
TOTAL IN =	8.04
OUT	
STORAGE =	0.35
CONSTANT HEAD =	0.10
DRAINS =	7.59
RECHARGE =	0.00
TOTAL OUT =	8.04
IN - OUT =	3.8×10^{-4}
PERCENT DISCREPANCY =	0.00%

It should be noted that the storage term appearing in Table 11 is not an indication of how much water is stored in the aquifer, rather it is a numerical balance term that refers to the water that is mobile within the model context, and is only retained above for completeness.

13.0 PREDICTIVE SIMULATIONS

The current mine plan provides for the open pit mining operation continuing until 2023 after which the proposed underground mine operation will commence and continue until 2033. Predictive simulation of these operations was undertaken in two stages:

- continuation of open-cut mining between 2011 and 2023, followed by
- the underground mining operation between 2024 and 2033.

Setup and results of these two separate simulations are presented below.

13.1 Future Open Cut Simulation

The open-cut mine advancement has been based on the mining schedule provided by the C&M JV[5]. The mine plan and timing used for the transient model impact assessment for the open cut simulation is presented in Drawing No. 8. This simulation represents the period from 2011 to 2023.

To achieve the transient simulation of mine progression, dewatering of the open cut mining operations was represented by the introduction of SURFACT drain cells as discussed in Section 12.4.3, to the floor of the seam being mined. The simulation of the open cut mining operations required the following simplified assumptions for each pit:

- Drain cells (DRN package) located coincident with the base of the open pit footprints were placed at the floor of the target coal seam (Layer 7) 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 at 100m^2/day to ensure groundwater levels were reduced to the floor of the pit.
- Placement of spoil disposal in the pit area was not represented during the transient analysis thereby making the dewatering assumptions for the open pit modelled scenario conservative – that is the amount of water being removed from the pit being greater than will be the case in reality.
- Once the drain cells were activated, they remained active for the entire mine simulation. Drain cells activated during the transient calibration simulation also remained active during this simulation.

The predicted water budget for the simulation representing the future open cut mining (i.e. 2011 to 2023) is presented below in Table 12.

Table 12: FUTURE OPENCUT MINING MODEL WATER BALANCE

Component	Rate for Simulation (ML/day)
IN	
STORAGE =	10.78
CONSTANT HEAD =	0.02
DRAINS =	0.00
RECHARGE =	2.94
TOTAL IN =	13.75
OUT	
STORAGE =	0.81
CONSTANT HEAD =	0.14
DRAINS =	12.80
RECHARGE =	0.00
TOTAL OUT =	13.75
IN - OUT =	-0.01
PERCENT DISCREPANCY =	0.00%

[5] Email correspondence Mr. K. Henderson, 12 December 2009.

13.2 Underground Mining Simulation

For the underground mining operation, simulation of the advancement through the target coal seam was based on a preliminary mine schedule provided by C&M JV[6] in October 2010, but also considered three different mining scenarios to identify any differences in the extent of groundwater inflows into the mine. Specifically, the options considered mining the underground in different directions, i.e., up-dip versus down-dip, and continuous dewatering versus selective dewatering whilst mining. Details of the three underground schedule options modelled are described below.

Options 1 & 2: considered mining advancement from south to north thereby following the coal seam down-dip. Assumptions made for these options included:

- Development of the mine headings in Mine Year 1 to Mine Year 2.
- Commencement of Longwall Mining in Mine Year 2 and completion in Mine Year 10.
- Board and pillar mining in the southern portion of the mine in Mine Years 7 and 8.
- Dewatering/pumping of groundwater inflows from the active mine area only for Option 1.
- Continuous dewatering/pumping of groundwater inflows from all mined areas for Option 2.
- Cessation of mine dewatering/pumping of groundwater inflows at the end of Mine Year 10.

Option 3: considered mining advancement from north to south effectively following the coal seam up-dip toward the open cut mine area. Assumptions made for this option included:

- Development of the mine headings in Mine Year 1 and Mine Year 2.
- Commencement of Longwall Mining in Mine Year 3 and completion in Mine Year 10.
- Board and pillar mining in the southern portion of the mine in Mine Years 9 and 10.
- Dewatering/pumping of groundwater inflows from the active mine area only.
- Cessation of mine dewatering/pumping of groundwater inflows at the end of Mine Year 10.

The mine plans and timing used for the transient model impact assessment for Options 1 - 3 as described above, are presented in Drawing No. 9 and Drawing No. 10.

To achieve the transient simulation of mine progression, dewatering of the underground mining operations was represented by the introduction of SURFACT drain cells as discussed in Section 12.4.3, to the floor of the seam being mined. This is similar to the setup adopted for the open cut simulation. 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 underground mine footprints were assigned to Layer 7 (representing the target coal seam). This allows for water to be removed from the model domain, thereby representing mine dewatering of the underground workings.
- The amount of water removed was determined by the drain conductance which was specified nominally at 100m^2/day to ensure groundwater levels were reduced to the floor of the pit.

[6] Email correspondence Mr. K. Henderson, 25 & 26 October 2010.

- For the Option 2 underground simulations, once the drain cells were activated, they remained active for the entire life of mine simulation.
- During simulation of all underground options, the drain cells representing the open cut remained active for the Johnson Pit Extended. The other pits began their recovery phase through removal of the representative drain cells.

The resultant disturbance and cracking of the overburden for underground mining was undertaken based on the following assumptions:

- a period of one year was adequately small enough to account for the advancement of the goaf with inclusion of the goaf starting in Year 2024 (underground mine year 2;
- changes to the aquifer parameters were uniform across the panel;
- the height of the cracking zone was assumed to be 105m above the roof of the coal seam; and
- changes to seam storage were made as the majority of the seam dewatered, to ensure increases in the seam storage did not “create” water into the model.

As mentioned above, the 10 years of underground mining were subdivided into 10 stages, representing advancement in one year step intervals. At the end of each stage the model was stopped and the last predicted groundwater levels for the simulation were used as starting points for the next stage simulation. At this point changes in aquifer parameters resulting from the effects of the subsidence of material into the mined panel and the formation of a goaf above the panel were applied. The vertical conductance term was increased in order to simulate this action in the model. This change can only occur during the change between one stage and the next, that is, after each one year simulation period.

The model water balance for the three scenarios of the transient underground analysis are presented in Table 13, Table 14 and Table 15. These show the percent discrepancy was -0.02% for Option 1, -0.01% for Option 2 and -0.04% for Option 3, which indicate good accuracy of the numerical simulations and overall stability of the three models.

Table 13: UNDERGROUND MODEL WATER BALANCE (OPTION 1)

Component	Predicted Rate at the end of Underground Mining (ML/day)
IN	
STORAGE =	8.20
CONSTANT HEAD =	0.02
DRAINS =	0.00
RECHARGE =	2.94
TOTAL IN =	11.16
OUT	
STORAGE =	1.45
CONSTANT HEAD =	0.16
DRAINS =	9.55
RECHARGE =	0.00
TOTAL OUT =	11.16
IN - OUT =	-0.001
PERCENT DISCREPANCY =	-0.01%

Table 14: UNDERGROUND MODEL WATER BALANCE (OPTION 2)	
Component	**Predicted Rate at the end of Underground Mining (ML/day)**
IN	
STORAGE =	18.54
CONSTANT HEAD =	0.02
DRAINS =	0.000
RECHARGE =	2,94
TOTAL IN =	21.50
OUT	
STORAGE =	0.43
CONSTANT HEAD =	0.16
DRAINS =	20.92
RECHARGE =	0.00
TOTAL OUT =	21.51
IN - OUT =	-0.007
PERCENT DISCREPANCY =	-0.03%

Table 15: UNDERGROUND MODEL WATER BALANCE (OPTION 3)	
Component	**Predicted Rate at the end of Underground Mining (ML/day)**
IN	
STORAGE =	6.63
CONSTANT HEAD =	0.02
DRAINS =	0.00
RECHARGE =	2.94
TOTAL IN =	9.59
OUT	
STORAGE =	0.89
CONSTANT HEAD =	0.16
DRAINS =	8.54
RECHARGE =	0.00
TOTAL OUT =	9.59
IN - OUT =	-0.001
PERCENT DISCREPANCY =	-0.01%

The losses from drain cells include dewatering from the underground pits as well as discharge into the creeks within the model domain.

13.3 Piezometric Surface / Water Table Levels

SURFACT predicts groundwater heads and cell by cell flows and reports these for each specified model output time. Model simulated water levels at various stages of open cut and underground mining from 2010 to end of mining in 2033 in Layers 1 and 7, which represent the Tertiary sediments and the target coal seam respectively, are presented in Drawing Nos. 11 to 15. The zone of depressurisation around the open pit and underground mine footprints is clearly evident as observed by the steeply declining contours around the mined areas.

The predicted drawdown within the Tertiary sediment and the target coal seam attributable to the proposed mine development at the end of 2023 when open pit mining ceases and at the end of underground mining in 2033 are presented in Drawing Nos. 16 to 19. This shows a generally steep drawdown within each layer, with the resultant cone of depression proximal to the Open Pits and Underground mining areas. The predicted extent of drawdown in Layer 1 as depicted by the 1m contour ranges from 400m north and south, 500m east and between 200m and 300m to the west of the open pit mined area. A lesser drawdown response as depicted by the 1m contour observed in Layer 7 representing the coal seam being mined extends up 200m around the open pit mined area. A wedge can be observed where the Rangal Coal Measures either subcrop or have been displaced by faulting along the southern boundary with the open pit footprint.

Similar responses with only marginal increases in the extent of the 1m drawdown contour are predicted at the end of underground mining in 2033 with between 300m and 600m in Layer 1 representing the Tertiary sediments, and up to 350m in Layer 7 representing the coal seam being mined.

Simulated water levels at locations representing the centre of Johnson Pit and the northern extents of the underground workings are shown in Figure 13. The modelling indicates a steep drawdown response within the highwall sequences whilst mining progresses through that section of the open pit. Once the open pit mining ceases, the modelling predicts water levels remaining around RL50m whilst mining progresses northwards as an underground operation and in response to the continued dewatering from the underground mine. Response to groundwater levels during underground mining between 2024 and 2033 generally show a rapid, steep drawdown response in water levels when the mining extends into that portion of the mine. However, once mining progresses past that section of the underground operation, responses to groundwater levels depend on the dewatering option in place, with those for:

- Options 1 and 3 showing a rapid and steep recovery in that part of the mine in response to cessation of dewatering.
- Option 2 shows a slow and gradual recovery response in that part of the mine due to the continuation of dewatering.

It should be noted that the simulation does not consider progressive placement of spoil within the open pit(s), which potentially overestimates 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.

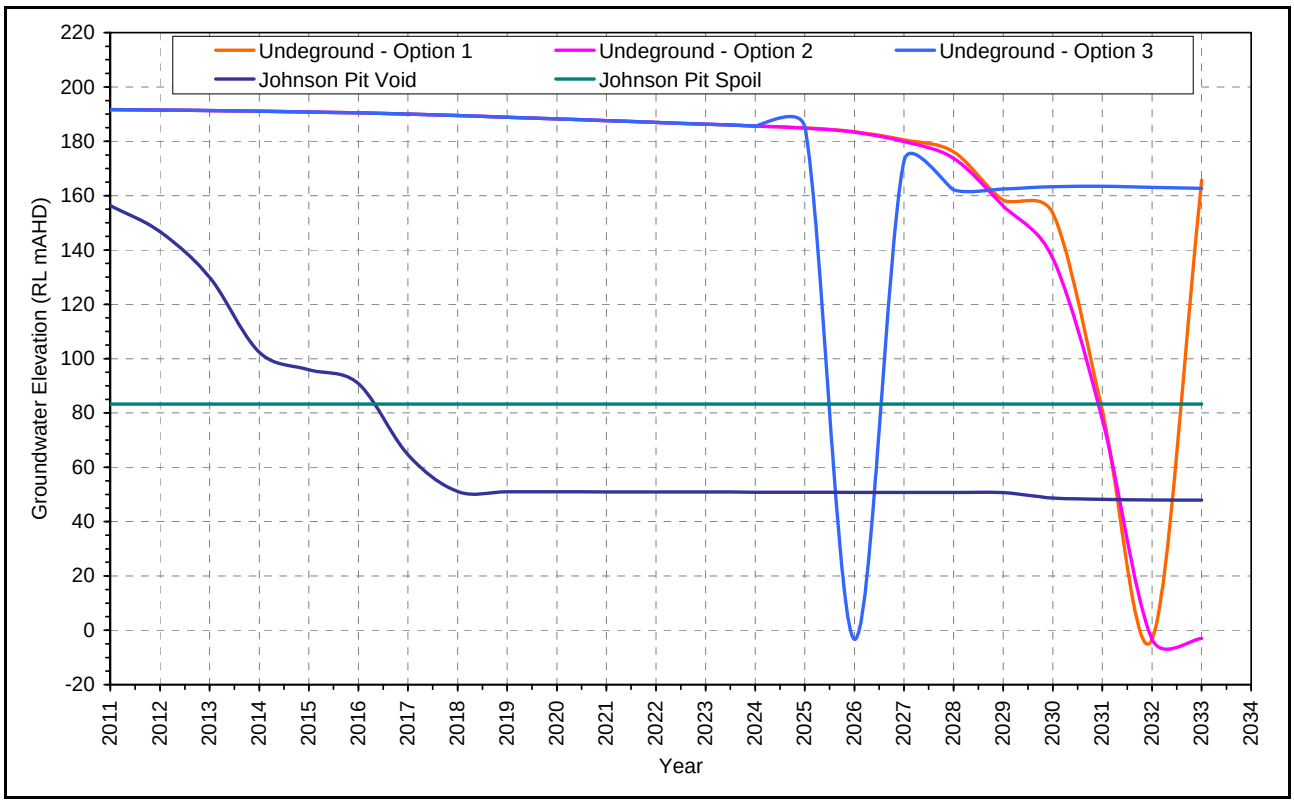


Figure 13: Simulated Drawdown to the Johnson Pit and the Underground Workings during Mining

13.4 Inflow to Mined Void

SURFACT predicts groundwater heads and cell by cell flows and reports these for each specified model output time. The flows were extracted from the model to assess the magnitude of gross inflows to the open pit mine and underground mine operations as well as determining the contribution of each of the model layers to the total flow. Simulated inflow rates predicted into the open pit and for the three underground mining options are shown in Figure 14 to Figure 16.

The simulated inflow to the open pit mine area remains relatively steady at between 6ML/day and 7ML/day during the future open cut period from the beginning of 2011 to the end of 2023. After cessation of the open pit mining operation in 2023, inflow to the pit gradually reduces with the advancement of underground mining to about 3.6ML/day by the end of mine life in 2033.

On commencement of underground mining, simulation of each of the three underground mining options show a decline in total groundwater inflows for the initial two years (to 2025), which can be attributed to the development of the mine headings. Thereafter predicted inflows vary considerably depending on the underground mining option simulated. That is, Options 1 and 3 simulate mine dewatering of the active area of mining only, whilst Option 2 considers continuous dewatering/pumping of groundwater inflows from all mined areas. It is noted there is little difference in groundwater inflows between the two mining directions simulated in Options 1 and 3.

Inflows into the underground mine increase steadily after Year 1 (2024) to around 5.5ML.day in 2031 (Option 1) and 2028 (Option 3), after which inflows decline as mining continues into the board and pillar areas which have been previously dewatered by the adjacent longwall mining. In contrast Option 2 which simulates continuous dewatering for all mined areas predicts much higher groundwater inflows up to 17ML/day up until Year 9 (2032). Total inflows from both the open pit and underground for the same periods increase to 9.5ML/day for Options 1 and 3, and 19.5ML/day for Option 2.

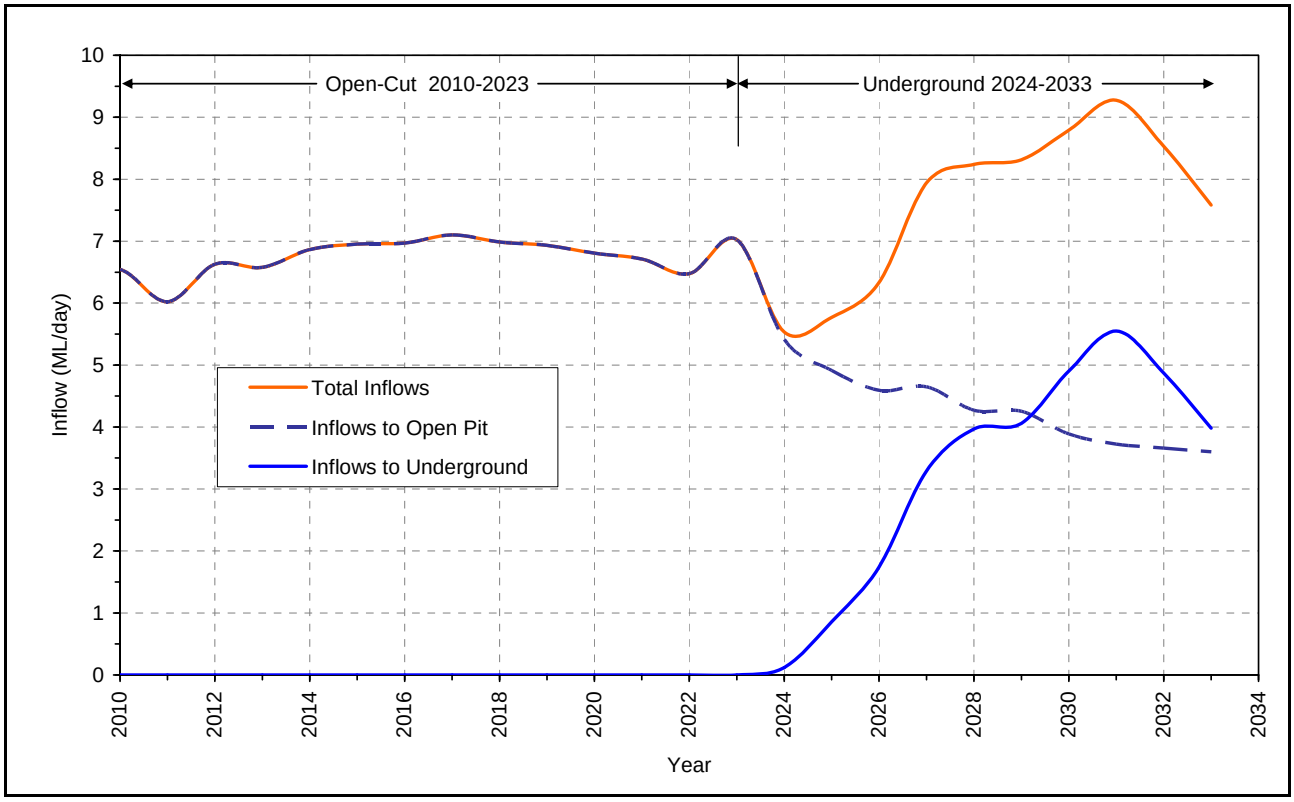


Figure 14: Simulated Seepage into the Johnson Pit and the Underground Workings during Mining for Option 1

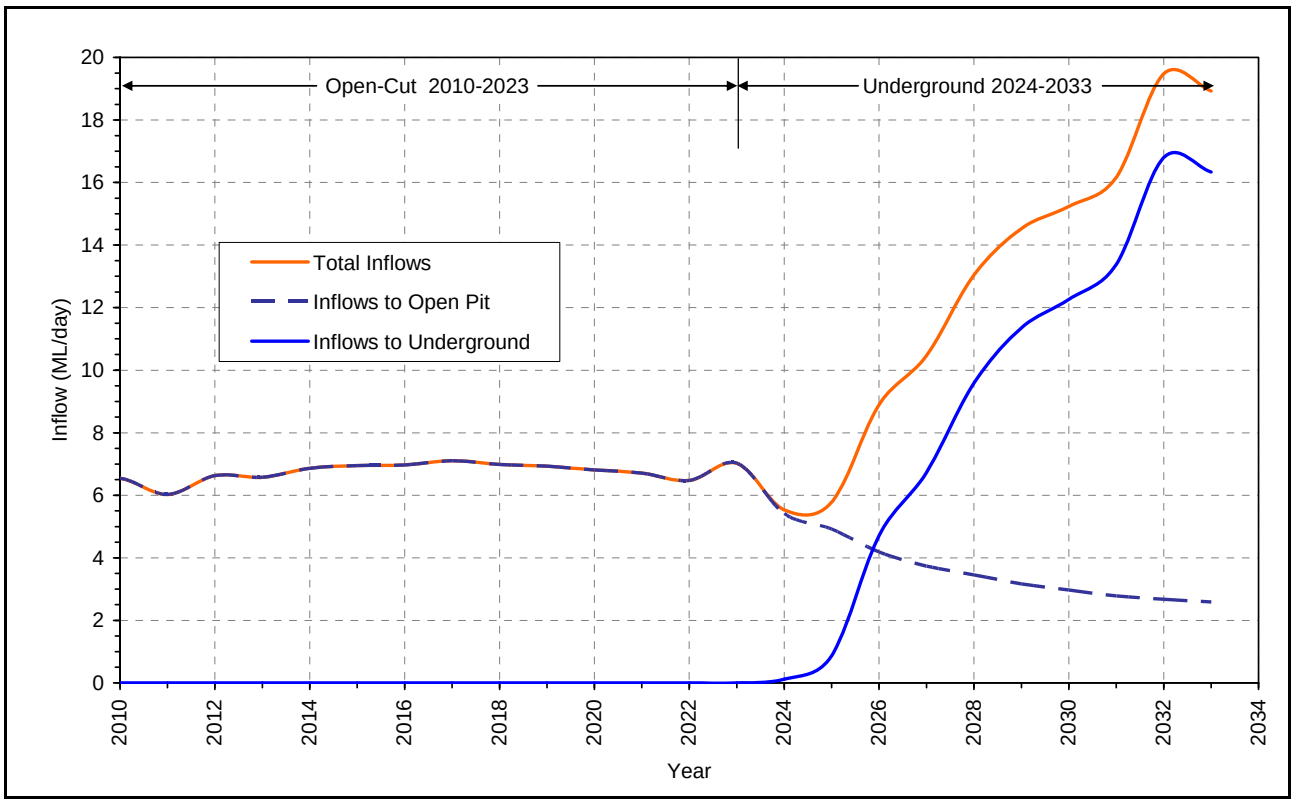


Figure 15: Simulated Seepage into the Johnson Pit and the Underground Workings during Mining for Option 2

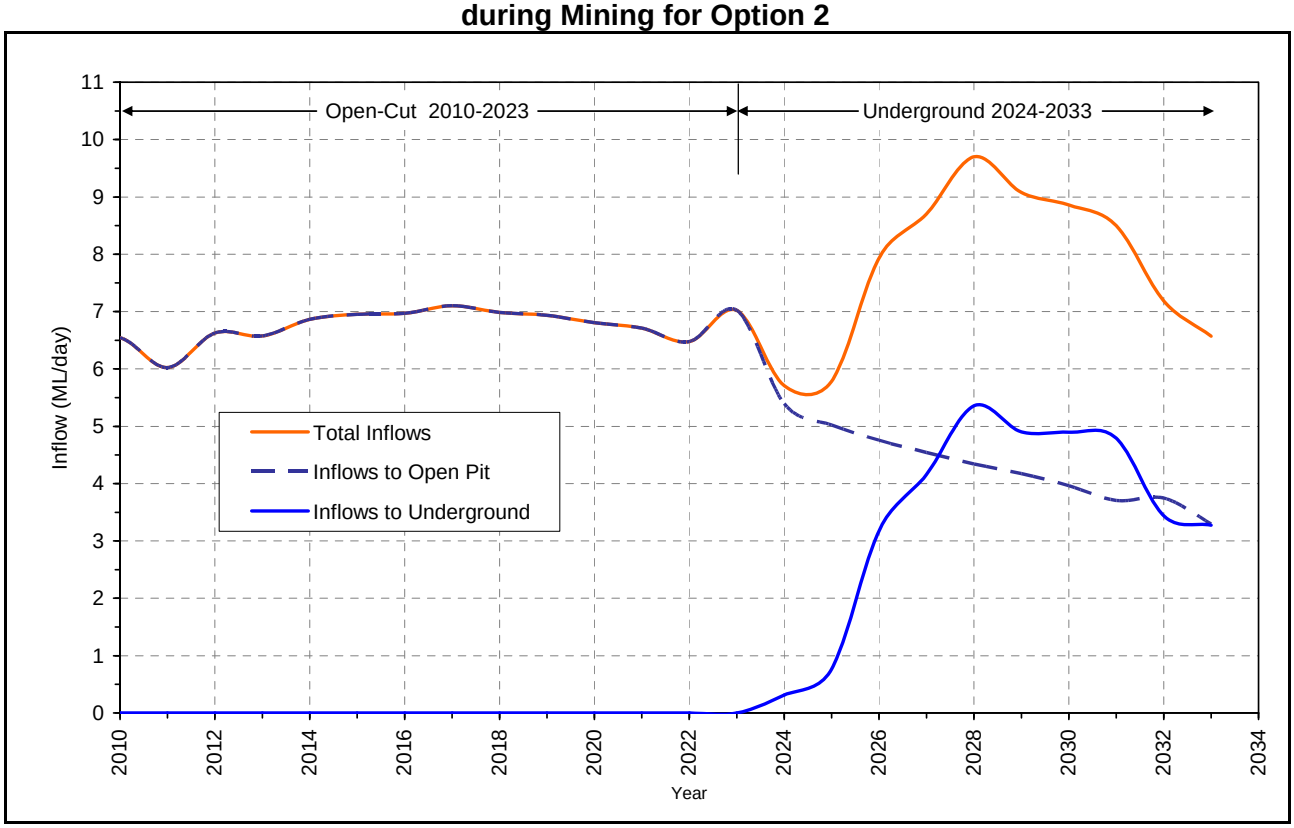


Figure 16: Simulated Seepage into the Johnson Pit and the Underground Workings during Mining for Option 3

When assessing these predictions, it is important to note that a large proportion of the groundwater inflow that will be lost from the aquifer will not report to dewatering pumps in the mine. This is because the model does not account for loss of water through water removed as a vapour by the ventilation system for the underground mine and from water that is removed with the coal. Similarly there are losses from the open pit operation in relation to water removed with the coal and overburden/interburden, and evaporation from the coal face.

No detail on mine tonnage/volumes have been provided for the underground operation other than an identified coal resource of approximately 118 million tonnes, and a proposed production rate at no more than the current approved 6 Mtpa over a project life of around 10 years. This assumes a similar annual volume of coal will be removed from the underground operation. Details of projected groundwater losses from entrained water for the remainder of the open cut operation and the underground operation are detailed in Table 16.

It is difficult to quantify the total volume of water removed as a vapour by the ventilation system as no specific detail has been provided in relation to this. However, based on other studies for underground coal mines in the Bowen Basin (AGE, 2008), indicative water losses from the mine ventilation system could be as high as 5L/s.

Taking the above into consideration, water removed for the underground operation as moisture with coal could therefore account for approximately 9L/s (0.8ML/day), with a total groundwater loss via the ventilation shafts and moisture in the coal potentially accounting for up to between 12L/s and 15L/s (1ML/day and 1.3ML/day). Depending on the total inflows predicted for the three options simulated, this could account for between 19% (for Options 1 & 3) and 8% (for Option 2) of the total inflows predicted at the end of the underground mining operation.

Table 16: ESTIMATED ENTRAINED GROUNDWATER LOSSES

Rock Type	Volume Mined (m^3)	Moisture Content	Life of Mine (years)	Groundwater Loss			
				(ML)	(ML/year)	(ML/day)	(L/sec)
Underground Mine Operation from 2024 to 2033							
Coal	42,008,782	7%	10	2,941	294	0.8	9.3
Open Cut Operation from 2010 to 2023							
Overburden/ Interburden	543,933,163	1%	10	5,439	544	1.5	17.2
Coal	42,008,782	7%	10	2,941	294	0.8	9.3
Total	*585,941,945*	-	-	*8,380*	*838*	*2.3*	*26.6*

For the open cut operation, water removed in coal as moisture may account for approximately 9L/s (0.8ML/day), assuming a throughput of up to 6Mt/year and 7% moisture content (adopted from the Codrilla Coal Project[7]). Similarly, water removed in overburden and interburden waste rock could account for approximately 17L/s (1.5ML/day), assuming the volume of waste rock to be removed has a 1% moisture content. Therefore the total groundwater loss via evaporation and moisture in the coal and waste rock could account for up to 27L/s (2.3ML/day) or as much as 40% of the total inflows predicted at the end of the open pit mining.

Therefore when groundwater losses from evaporation, ventilation shafts and coal moisture are considered, the actual volumes reporting to either the in-pit sumps in the open cut pits or coal face in the underground mine, would be expected to remain relatively low as is understood to be the current situation for the open cut operation.

[7] Email correspondence Mr. P. Tett, McCollum Environmental Management Services, 31 March 2010.

It should also be noted that the simulated inflows are potentially a conservative overestimate as the model does not include the numerous faults in the area and simulates a continuous aquifer system. Assuming some of the faults act as barriers to groundwater flow, inflows to the model will be lower than predicted by simulation of laterally continuous aquifers.

13.5 Leakage from Alluvial Aquifers

As discussed in Section 9.2, the closest alluvium to the existing open pits and proposed underground mine is associated with Harrybrandt Creek and its tributary (Thirty Mile Creek) south of the current mine area and along the southern boundary of the mining lease. Where present, the alluvium is of limited extent and generally confined to a relatively narrow band along the creeks and tributary channels. Model simulation indicates that the alluvium and associated alluvial aquifer, will not be intersected by the cone of depression created by dewatering either the open pit or the proposed underground operations.

This being the case, and provided the mining does not intersect the Harrybrandt Creek alluvium, it is unlikely that the mine dewatering and resultant depressurisation of the underlying Tertiary and Permian aquifers will impact on groundwater associated with the alluvium (alluvial aquifer).

13.6 Impact on Groundwater Users

As discussed in Section 13.3 the depressurised zone in the Tertiary sediments and underlying bedrock sequences extends up to 600m and 350m respectively around the active mining area. Since the closest known groundwater users are located approximately 4.5km south-west of the mining lease area (registered bores RN81848 and RN85075), none of the 11 registered bores and four non-registered bores will be intersected by this drawdown.

Therefore as all known water supply bores are located beyond the extent of impact simulated in the transient analysis, they should not be influenced by the mine development and resultant impact from aquifer dewatering of the planned open pit and proposed underground mining operations.

13.7 Transient Modelling – Groundwater Recovery

At the end of the open pit simulation, dewatering of the open void continues as a result of the underground mining operations. Once dewatering ceases at the end of the underground mining simulation, a slow recovery in groundwater levels in the underground and open pits commences.

It should be noted that recovery within the open pits does not assume progressive placement of spoil into the voids prior to commencement of underground mining, rather the model applies the spoil backfill at the end of the open pit mining. The implications of this are the recovery potentially taking longer within the open pits, and hence the underground mine. Hence, at the end of open pit mining the configuration of the final voids are as follows:

- The void making up the Johnson, Southern and Eastern Pits footprint with an area of approximately 131ha. The lowest point in this final void will be about RL40m, a depth of about 180m below the spill level of the void of approximately RL220m; and

- The void at the north-western edge of the Creek Pit footprint with an area of approximately 6ha. The lowest point in the final void will be RL105m, a depth of about 115m below the spill level of the void of approximately RL220m.

The locations and extent of the final voids are shown below in Figure 17.

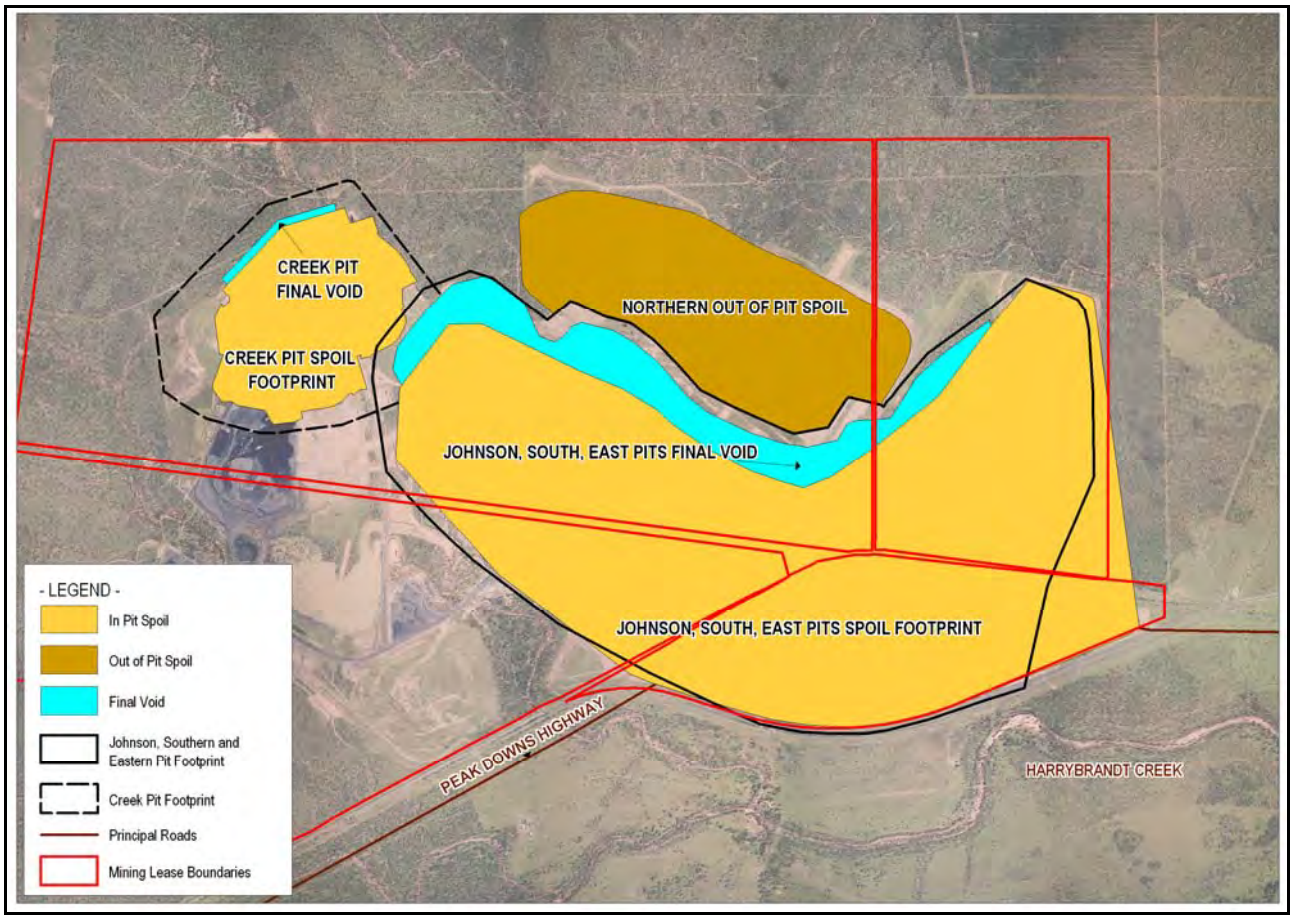


Figure 17: Locations and Extent of Final Voids and Spoil

At the cessation of mining, there will be a relatively high groundwater gradient between the underground workings and open voids in the mine areas and the surrounding coal seam aquifers which will initially result in relatively rapid inflows, followed by a declining rate of groundwater inflow as the underground mine and goaf areas fill with water and the lakes begin to form in the open pit voids.

Direct rainfall at the site will also add to the void water levels 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. Hence, the rate of recovery of groundwater levels in the aquifers will be dependent to certain extent on rainfall, with below average rainfall years extending the recovery period and wet years reducing the time for stabilization. Hydraulic interconnection between the underground working and the open pit mine areas will likely result in groundwater levels recovering below pre-mining levels as average daily evaporation from the void lakes exceeds average daily rainfall in the area by a factor of about four.

Pre-mining groundwater levels measured in 1998 in the exploration bore indicate groundwater levels ranged from RL178m to RL200m.

The water levels in the final voids were estimated by running the transient groundwater recovery model with the following modifications incorporated for model parameters. The hydraulic properties adopted for the underground workings, spoil backfilled areas in the pits, and final voids are summarised in Table 17.

Table 17: SPOIL, VOID AND UNDERGROUND WORKINGS HYDRAULIC PARAMETERS

Layer	Parameter	Value
Pits Spoil	Horizontal Hydraulic Conductivity [kh]	20m/day
	Vertical Leakance	10 x original
	Specific Yield [S_y]	0.2
	Specific Storage [$S_{s]}$]	1 x 10^{-3}
	Recharge	2.737 x 10^{-4}m/day (17% of annual rainfall)
	Evapo-Transpiration	0.0048m/day
Pits Voids	Horizontal Hydraulic Conductivity [kh]	1,000m/day
	Vertical Leakance	100,000 x original
	Specific Yield [S_y]	1
	Specific Storage [S_s]	1
	Recharge	1.288 x 10^{-3}m/day (80% of annual rainfall)
	Evaporation	0.0048m/day
Underground Workings	Vertical Leakance (within the continuous vertical cracking zone above longwall panels)	1,000 x original

For the spoil areas the evapo-transpiration rate was set with a constant extinction depth of 2m applied, whereas for the final void area 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 spoil is shown in Figure 18 and for the Underground Mine in Figure 19.

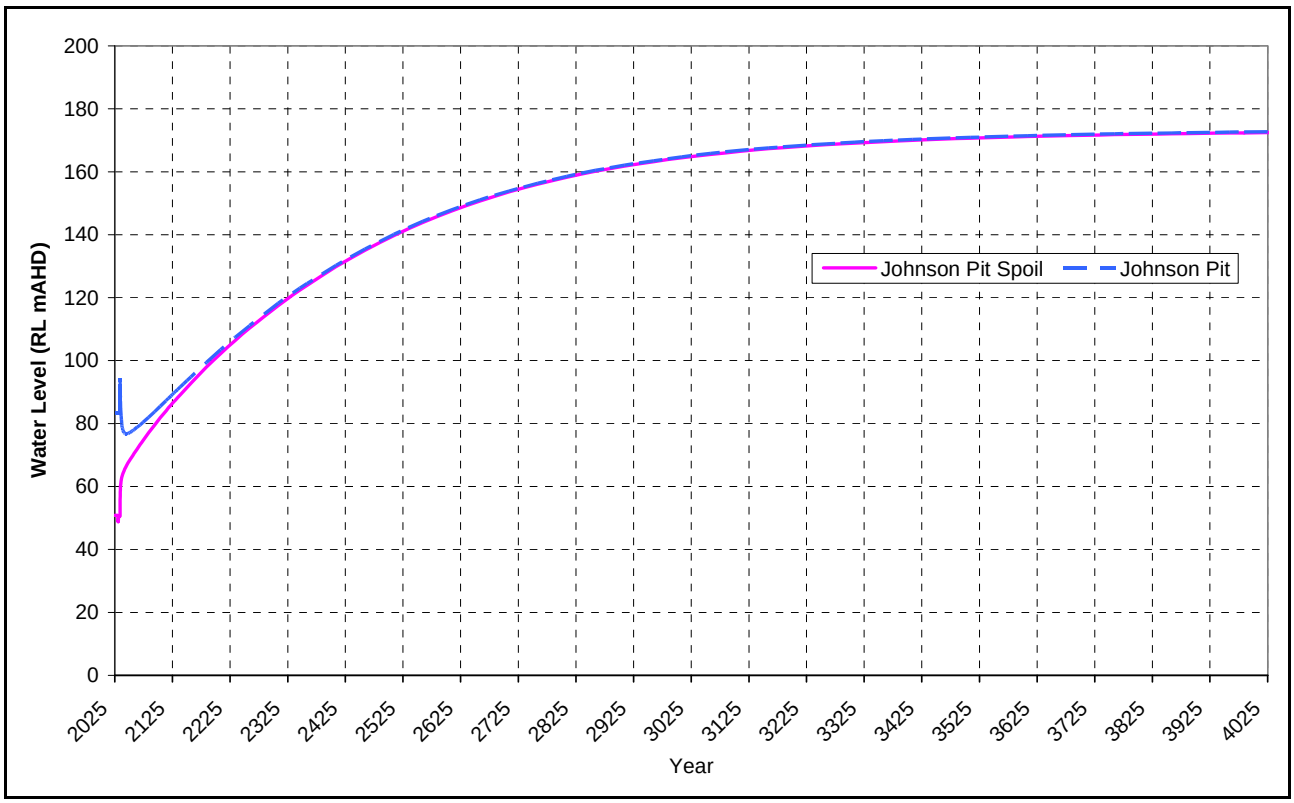


Figure 18: Simulated Water Level Recovery in Johnson Pit Final Void and Spoil

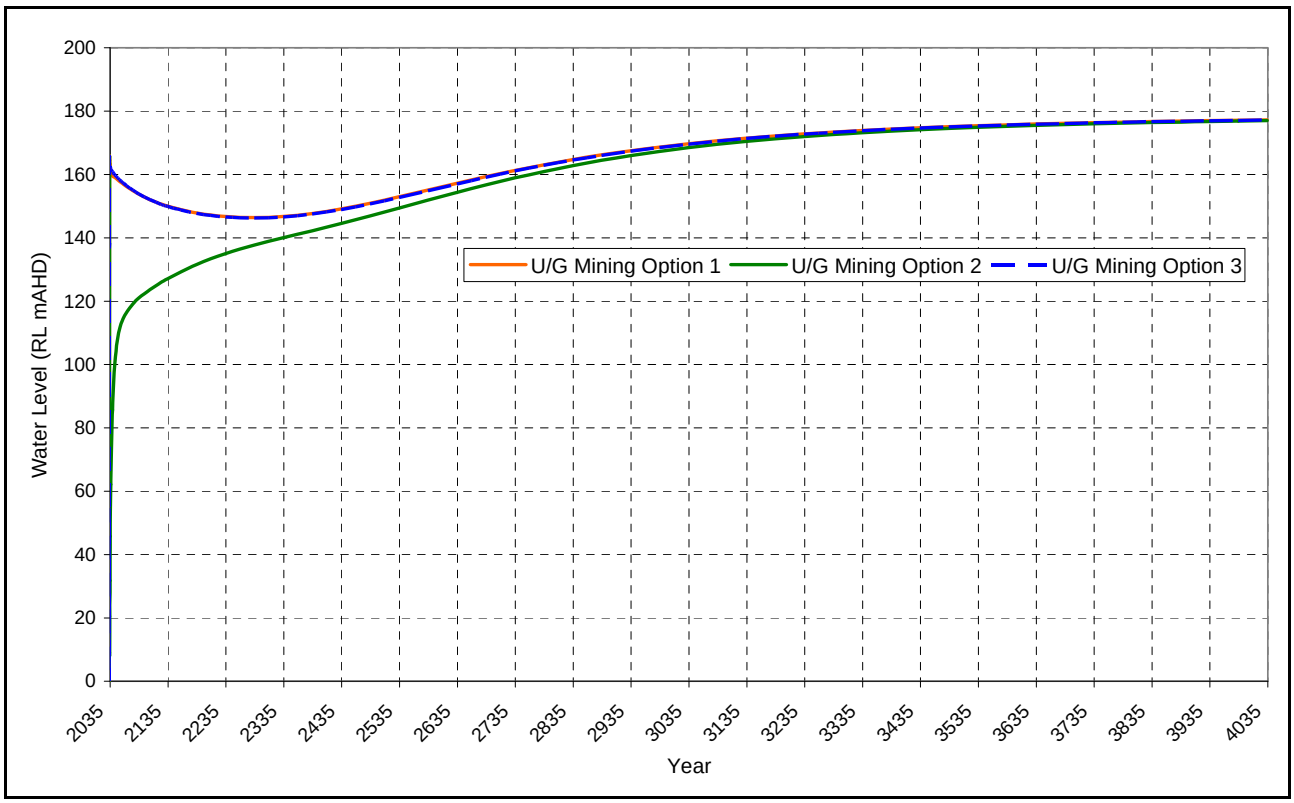


Figure 19: Simulated Water Level Recovery within the Underground Workings

The simulations show the groundwater recovery for the underground mining varies depending on the mining option adopted, with a similar groundwater recovery predicted for Options 1 and 3. However, groundwater levels for these two scenarios continue to decline for 200 years post closure which is likely to be a response to an increased storage potential produced through development of the goaf above the underground mine area. Conversely, a more pronounced drawdown response followed by a slow recovery is predicted for Option 2 due to the greater volume of groundwater removed from the system for this scenario.

The assessment indicates groundwater levels in both the open pit voids and the underground mine show a slow recovery rate with water levels rising to a pseudo-equilibrium level around RL175m, but only after an extremely protracted simulation period between 1,500 years and 2,000 years. This is considered a function of the mine's close proximity to groundwater flow barriers created by the regional faulting to the west, and the zone of Rangal Coal Measures sub-crop to the south and east, effectively terminating the extent of the aquifer in these areas. Hence, the only opportunity for water flow/seepage into mine area would be from the north and from rainfall into the open pit voids.

In summary, the voids in hydraulic connection with the flooded underground workings will act as a local sink for groundwater with 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 is 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 or Tertiary.

13.8 Model 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 during mining. 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, Quaternary, Permian interburden 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.
- The lack of historical groundwater level and baseflow records for the water courses in the area meant only limited calibration could be undertaken.

14.0 POTENTIAL IMPACT OF PROJECT ON GROUNDWATER REGIME AND MITIGATION OPTIONS

14.1 Groundwater Inflow to Mine and Control Strategies

The numerical modelling indicates inflows to the underground workings will be mainly dependent on whether dewatering/pumping of groundwater inflows takes place at the active mining area only (as simulated for Options 1 & 3), or continuously from all the mined areas for the duration of underground mining operation (as simulated for Option 2). It is noted there is little difference in groundwater inflows as to whether the coal is mined from south to north or vice versa.

Inflows into the underground mine are predicted to peak around 5.5ML/day for Options 1 & 3, and up to 17ML/day for Option 2. Total inflows from both the open pit and underground for the same periods are predicted to peak around 9.5ML/day for Options 1 and 3, and 19.5ML/day for Option 2. However, the actual volumes of water pumped from the underground 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 via the ventilation system. These losses may represent up to between 12L/s and 15L/s (1ML/day and 1.3ML/day).

Groundwater inflow at the working face within the underground working will need to be controlled by strategically located sumps, from where it can be 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.

14.2 Groundwater Levels and Regional Impact

As discussed the underground mine development and operation will depressurise the Permian and coal seam aquifers as well as the Tertiary aquifer where it exists above the underground footprint, by groundwater flow into the underground workings. This will result in a lower 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 Nos. 13 to 15. The drawdown due to mining is shown in Drawing Nos. 16 to 19.

The drawings indicate that the zone of significant drawdown at the end of mining, that is greater than 1m, is limited to the area immediately surrounding the underground and open pit mine footprints. That is, the cone of depression has a generally steep drawdown curve from between 300m and 600m in Layer 1 representing the Tertiary sediments, and up to 350m in layer 7 representing the coal seam being mined. Based on these simulated drawdown levels, the extent of impact on groundwater levels is confined to within 1km of the mine area. South Walker Creek Coal Mine, located some 10km to the north, is the nearest operational mine to the Coppabella site and is well outside the zone of impact. Hence it can be concluded that there will be no net cumulative drawdown impacts from these two mines on the regional aquifer.

14.3 Impact on Existing Farm Bores

As discussed in Section 13.6 there are no operational domestic or stock bores within or adjacent to the proposed mining lease area. The nearest water supply bores are RN81848 and RN85078 are located some 4.5km from the mine site, which is beyond the predicted zone of groundwater drawdown. To confirm the modelling predictions, it is important that a groundwater monitoring

program is implemented (refer Section 15.0) and where applicable the numerical model re-run incorporating monitoring results and operational experiences.

14.4 Impact on Environmental Values

Section 10.3 of this report indicates that there are no groundwater dependent ecosystems that are likely to be impacted by the Coppabella Underground Project.

The only environmental value for the groundwater that could be suitable for the Coppabella Underground 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. As stated in Section 10.3.6, no other obvious environmental values for groundwater were identified in the project area, due to the poor water quality and low bore yields.

14.5 Groundwater Contamination

The potential for groundwater contamination may occur from the following sources:

- rejects disposal, workshops, waste disposal – Tertiary, 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.

14.6 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.

15.0 GROUNDWATER MONITORING PLAN

The proposed plan for future monitoring of the potential impact of the Coppabella Underground Project on the groundwater resources of the area is based on the installed monitoring bores in the alluvium, Tertiary, Permian and coal seam aquifers, that is at sites MB1 to MB11. In addition to this, it is proposed that further monitoring bores also be established at the following locations:

- along Thirty Mile Creek to the south of Johnson Pit at site MB12 to monitor the potential impact on the Tertiary aquifer south of the current area of mining; and
- around the Stage 1 Co-disposal Tailings Storage Facility, at four locations (CDA-MB1 to CDA-MB4) to monitor potential impact from ongoing disposal on the uppermost aquifer.

It is acknowledged that some of the monitoring bores will be destroyed from expansion of the open cut operation prior to the underground mining commencing. Hence, it would be appropriate that further monitoring bores be established to replace those lost at alternative locations that will not be affected by future mining development. With this in mind, it is proposed that such locations be:

- Near the north-western corner of the proposed underground mine footprint at site MB13.
- Near the eastern side of the proposed underground mine footprint at site MB14.

The indicative locations for these additional monitoring bores are shown in Drawing No. 20, with the actual extent/number of bores to be confirmed prior to their installation. The final locations and number of the co-disposal monitoring bores must be such that they will provide sufficient lateral coverage to intersect potential leakage from around the Stage 1 Co-disposal Tailings Storage Facility. Timing for establishing these additional bores should be such that they provide at least 12 months of monitoring data prior to impact on groundwater in these areas from the expansion of the open pit and underground mining operations.

These bores will make up the monitoring bore network. The network will continue to monitor the effects of mining activities on the groundwater resource and on other potential users of the resource in terms of quality and quantity. The groundwater monitoring program will provide both an on-going assessment of the impact of the proposed mine and a timely indicator of potential impacts on the groundwater regime, so that remedial action can be taken if necessary.

The monitoring program is summarised in Table 18. It is recommended the data from the monitoring program be reviewed annually and the results held on site. After three years of monitoring, a review be undertaken to assess whether the frequency of monitoring should be changed to bi-annually or annually.

It is recommended that all groundwater monitoring, water level measurements and sample collection, storage and transportation be undertaken in accordance with the procedures outlined by the EPA – Water Quality Sampling Manual (Dec. 1999), and the Murray Darling Basin Commission (Aug. 1997). It is recommended that dataloggers be installed in these bores to allow for regular daily measurements of groundwater levels and salinity, and hence potential changes/ impact on the groundwater regimes.

The parameter suite for analysis for each groundwater sample should include but not necessarily be limited to following:

- pH, Electrical Conductivity, (field and laboratory determinations),
- Total Dissolved Solids (laboratory analysis),
- Anions – carbonate, bicarbonate, chloride, sulphate, bromide (laboratory analysis),
- Cations – calcium, magnesium, sodium, potassium (laboratory analysis),
- Dissolved metals – aluminium, antimony, arsenic, barium, molybdenum, strontium, selenium, silver, iron, mercury (laboratory analysis),
- Nutrients – nitrate, nitrite, phosphorus, ammonia.

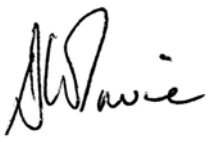
Table 18: PROPOSED GROUNDWATER MONITORING PROGRAM

Location	Parameters	Frequency	Comment
Tertiary Aquifer			
MB2, MB3B, MB6, MB8, MB9B, MB11 plus new bore south of Johnson Pit and around the proposed Co-Disposal facility	water level	Monthly (with electronic data loggers recording at least twice daily)	Assess groundwater drawdown in Tertiary overburden and changes in water quality
	pH, EC, TDS cations/anions, metals	6 monthly	
Permian Aquifer			
MB1, MB3, MB4, MB5, MB7 plus new bores to east and west of Underground Mine footprint	water level	Monthly (with electronic data loggers recording at least twice daily)	Assess groundwater drawdown in Permian and changes in water quality
	pH, EC, TDS cations/anions, metals	6 monthly	
Coal Seam Aquifer			
MB9, MB10	water level	Monthly (with electronic data loggers recording at least twice daily)	Assess groundwater drawdown in Coal Seams and changes in water quality
	pH, EC, TDS cations/anions, metals	6 monthly	

Trigger levels should be defined following C&M JV undertaking further rounds of groundwater sampling and laboratory analyses to establish a statistically representative baseline groundwater data set prior to commencing mining. A minimum of 12 rounds of monthly groundwater sampling and analysis would be required to establish the trigger levels which should preferably be collected prior to commencement of construction of the mine. Once the baseline data set has been established, the monitoring bores can be designated as either reference (background) sites or impact (down-gradient/detection) sites.

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Reviewed by:





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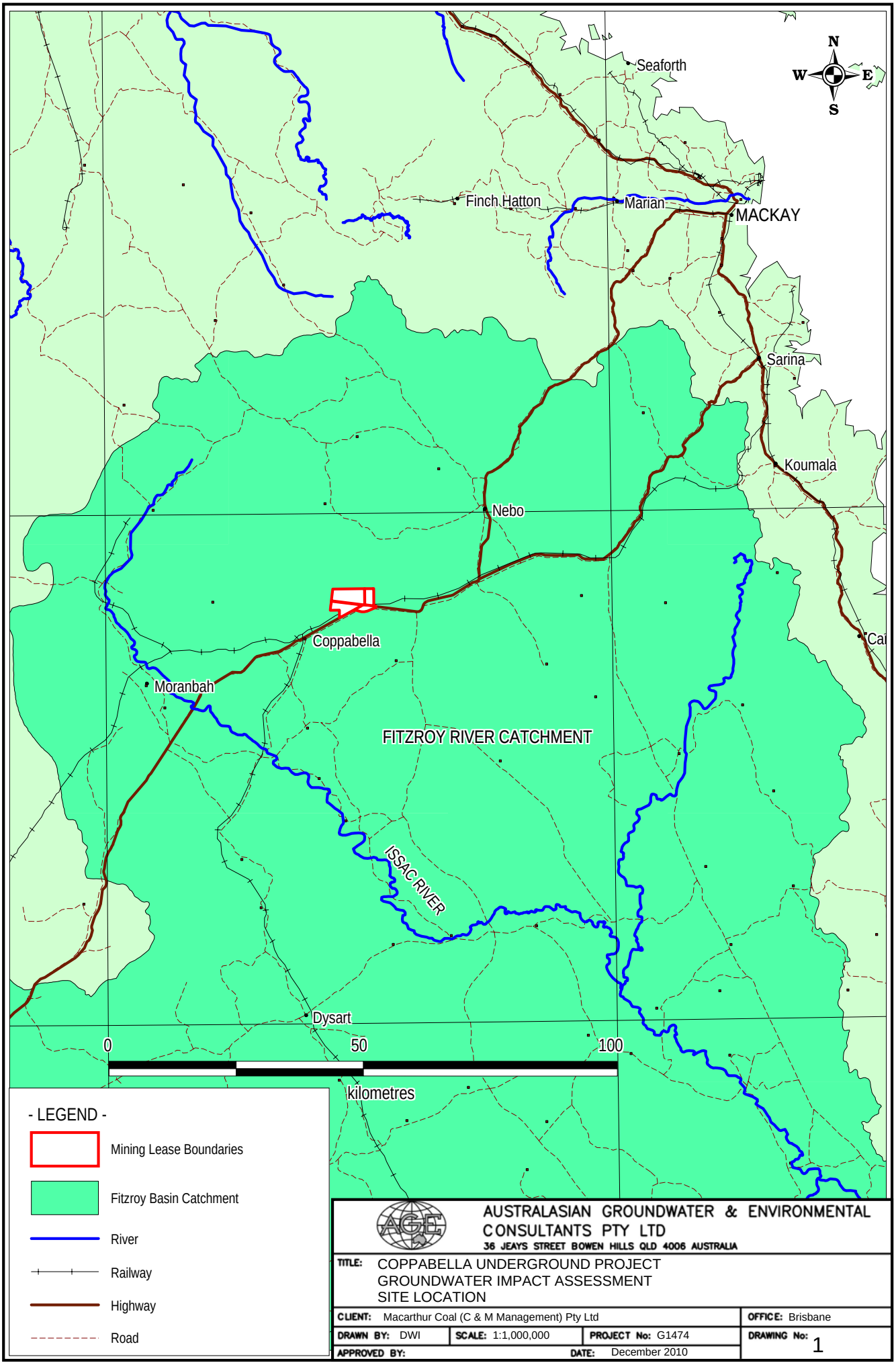
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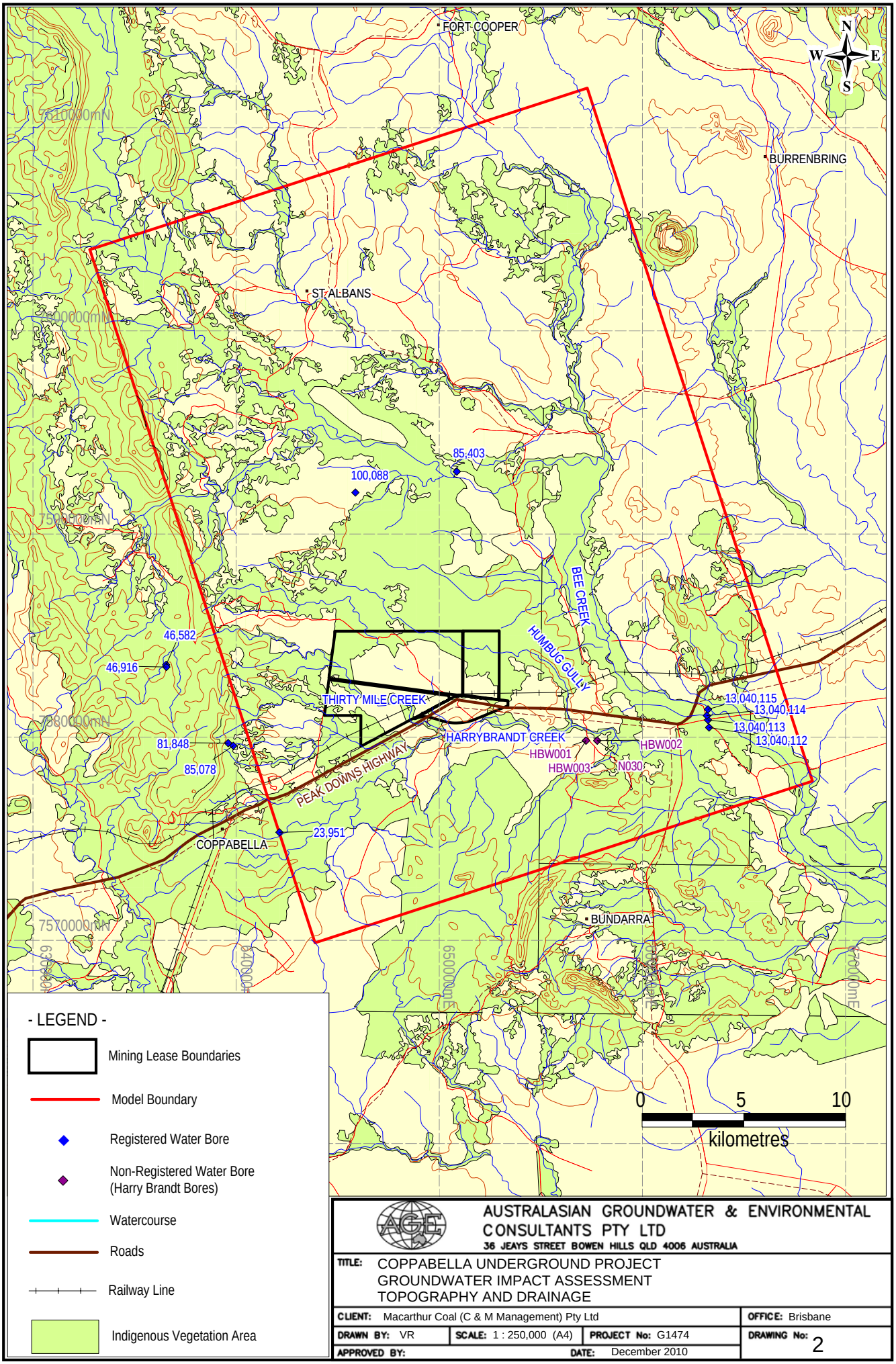
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36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

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GROUNDWATER IMPACT ASSESSMENT
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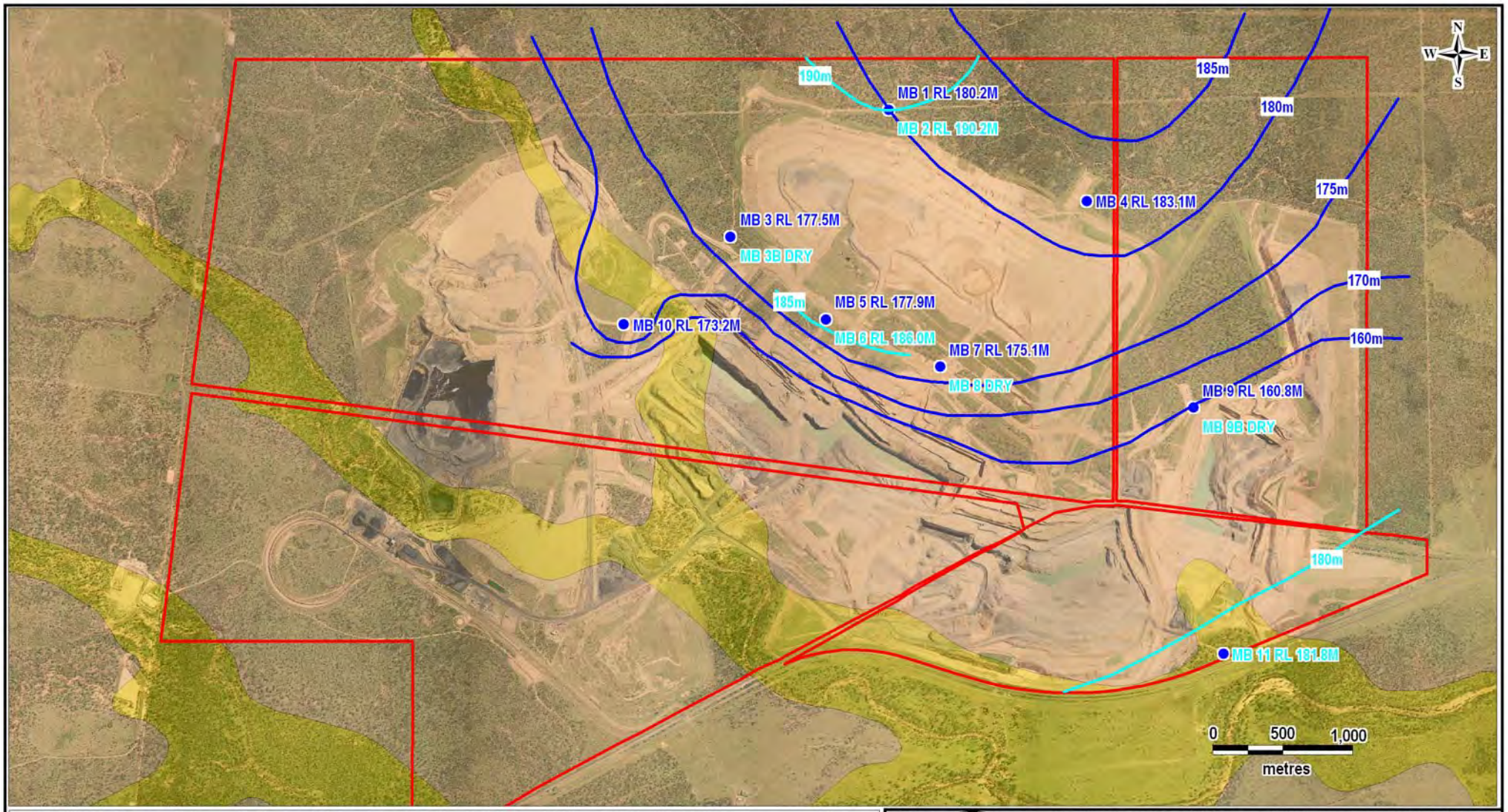
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APPROVED BY:	DATE: December 2010		



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36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
TOPOGRAPHY AND DRAINAGE

CLIENT: Macarthur Coal (C & M Management) Pty Ltd			OFFICE: Brisbane
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APPROVED BY:		DATE: December 2010	



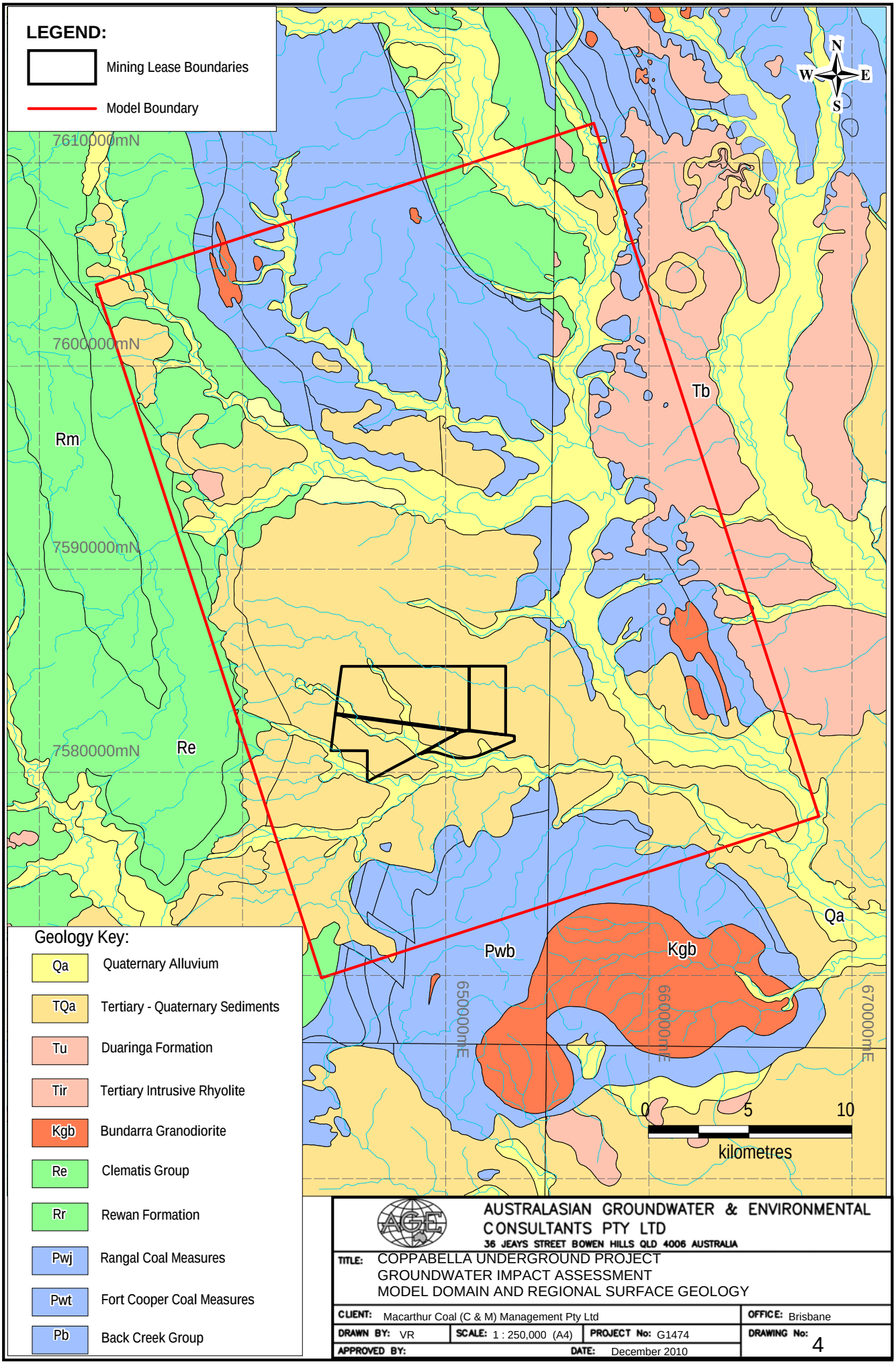
- LEGEND -

- Mining Lease Boundaries
- Quaternary Alluvium
- Tertiary Sediments
- Groundwater Contours Tertiary Aquifer
- Groundwater Contours Permian Aquifer

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TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
GROUNDWATER LEVELS AND CONTOURS

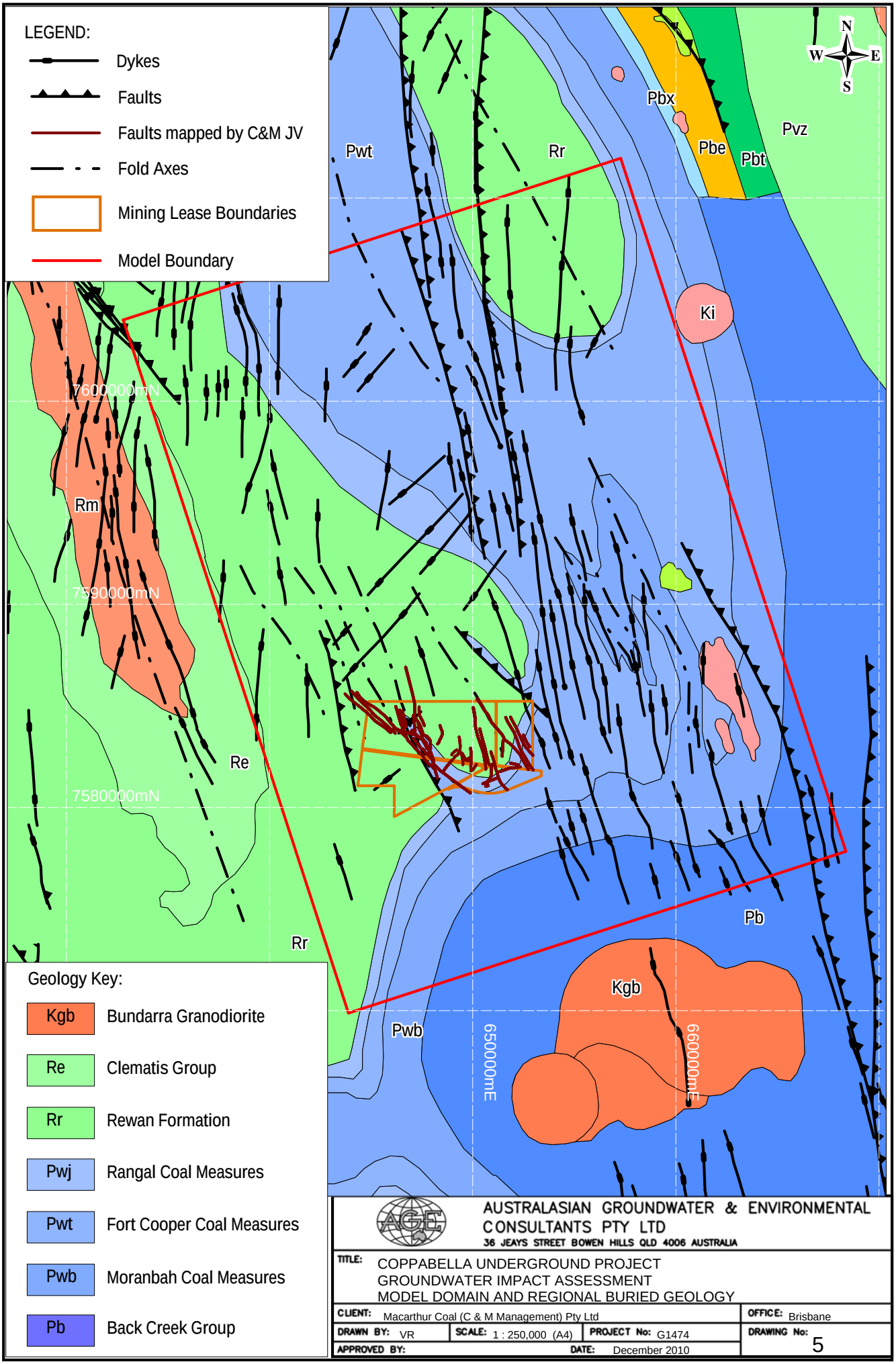
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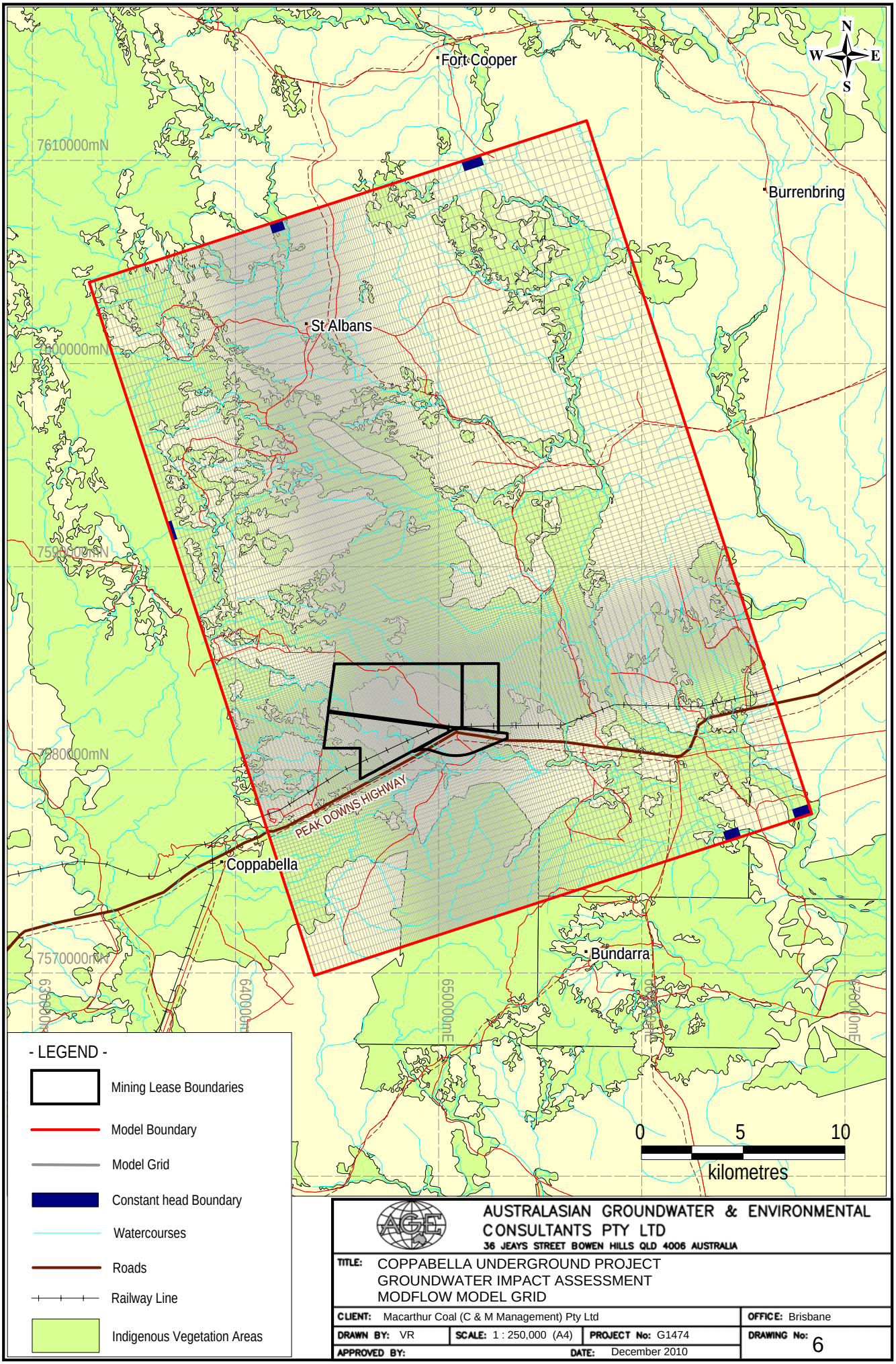


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TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
MODEL DOMAIN AND REGIONAL SURFACE GEOLOGY

CLIENT: Macarthur Coal (C & M) Management Pty Ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 250,000 (A4)	PROJECT No: G1474	DRAWING No: 4
APPROVED BY:		DATE: December 2010	


LEGEND:
Dykes
Faults
Faults mapped by C&M JV
Fold Axes
Mining Lease Boundaries
Model Boundary
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W
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S
Pwt
Rr
Pbx
Pbe
Pbt
Pvz
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Kgb Bundarra Granodiorite
Re Clematis Group
Rr Rewan Formation
Pwj Rangal Coal Measures
Pwt Fort Cooper Coal Measures
Pwb Moranbah Coal Measures
Pb Back Creek Group
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36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
MODEL DOMAIN AND REGIONAL BURIED GEOLOGY
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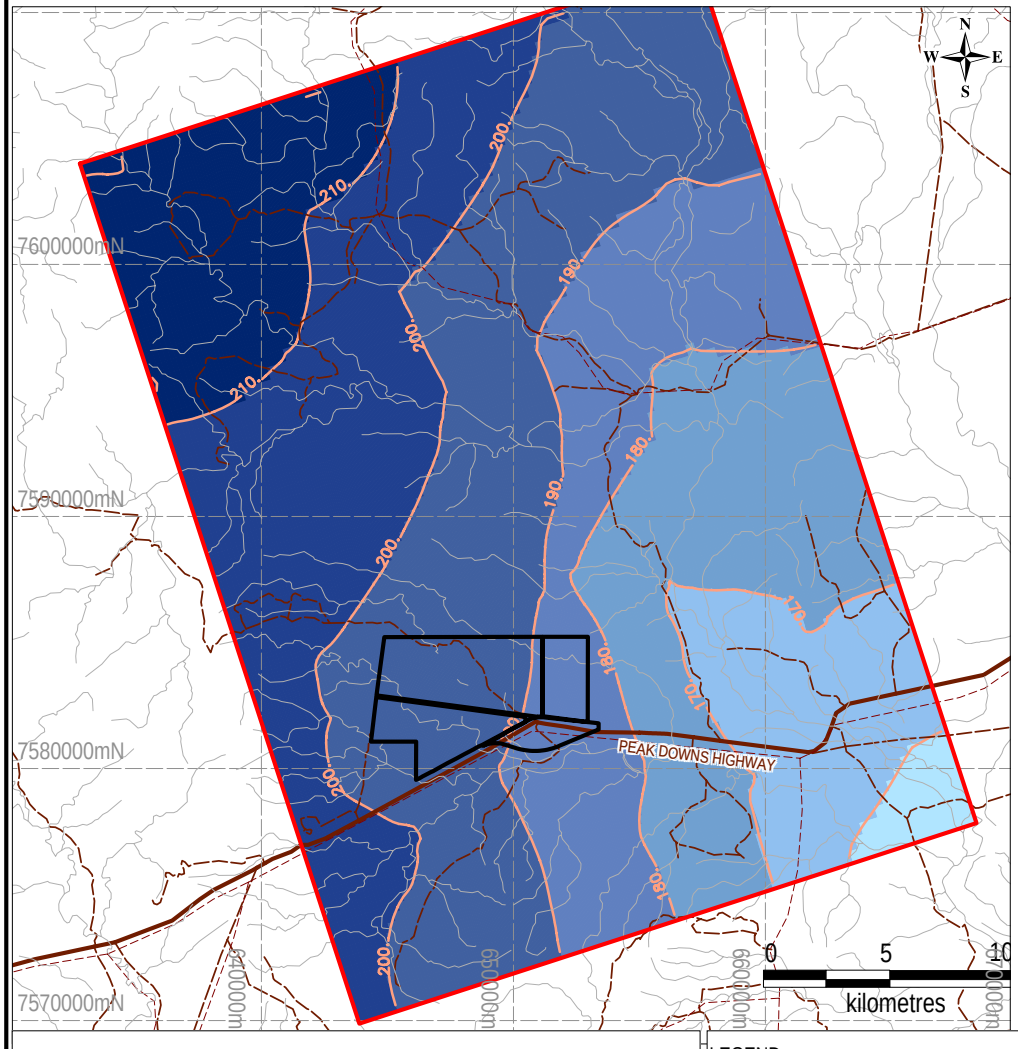


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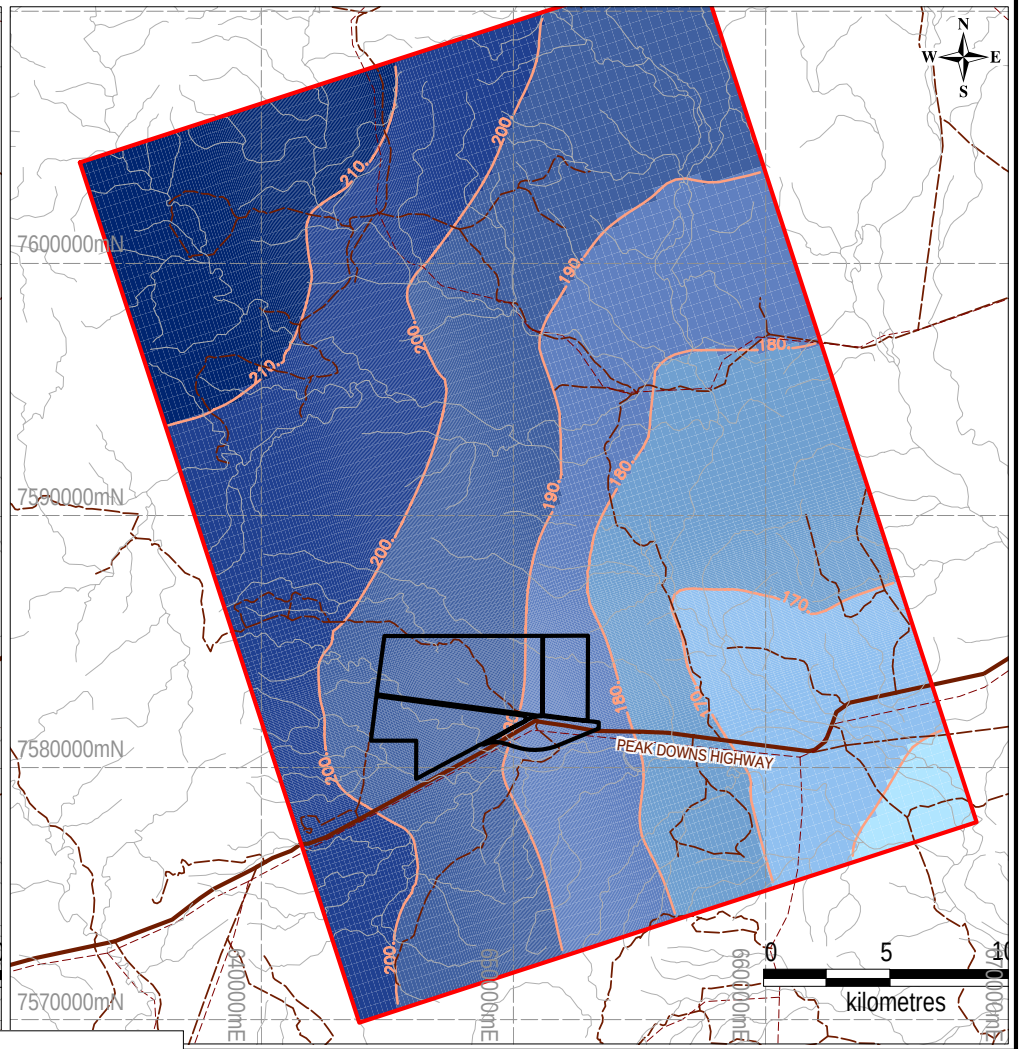
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APPROVED BY:	DATE: December 2010		

GROUNDWATER CONTOURS AT THE END OF YEAR 1997 - LAYER 1 TERTIARY AQUIFER



GROUNDWATER CONTOURS AT THE END OF YEAR 1997 - LAYER 7 PERMIAN AQUIFER



- LEGEND -

- Mining Lease Boundaries
- Model Boundary
- Principal Roads
- Unsealed Roads
- Watercourses

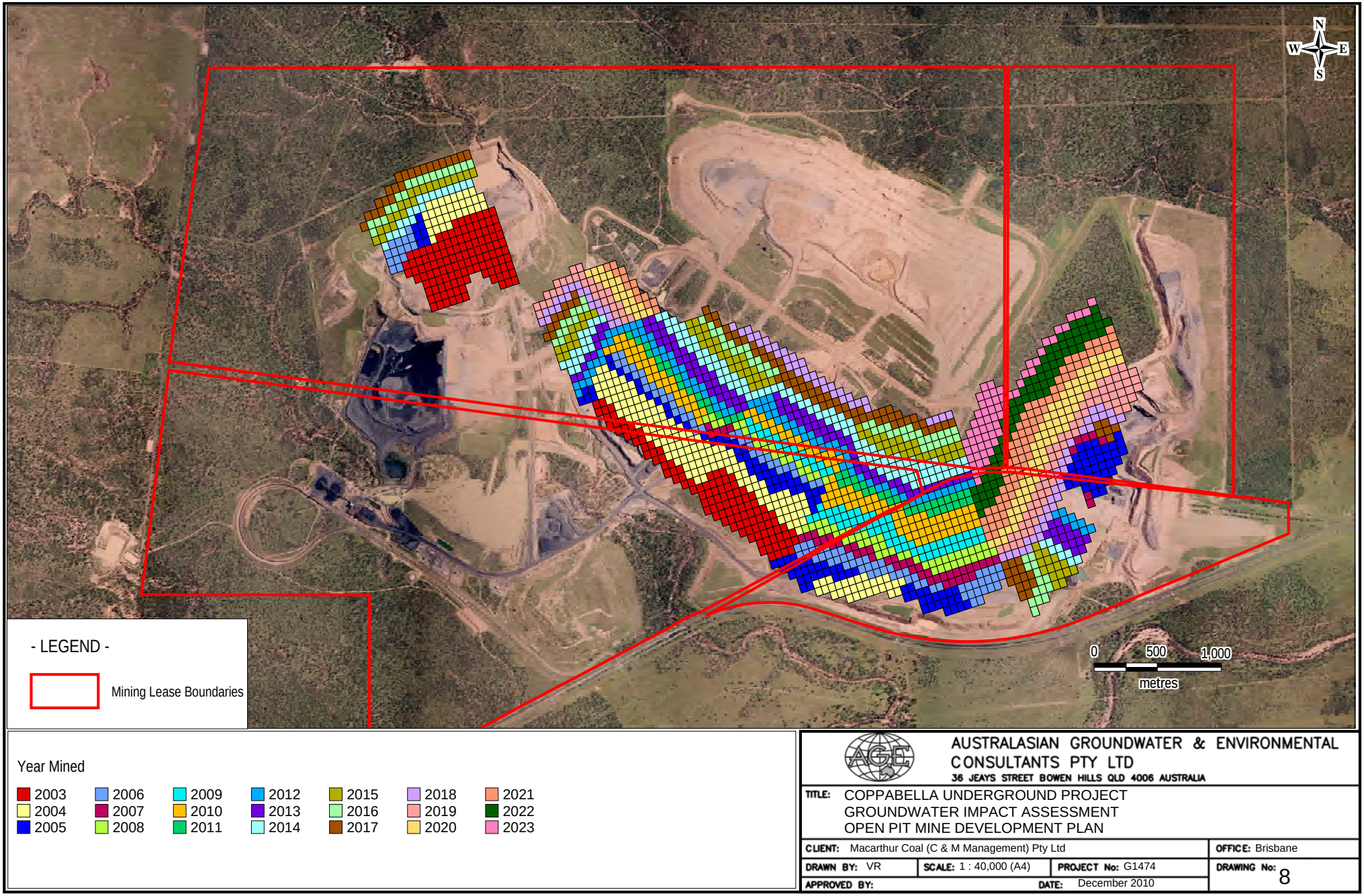
LEGEND
Contours (RLm)

- 210 to 220
- 200 to 210
- 190 to 200
- 180 to 190
- 170 to 180
- 160 to 170
- 150 to 160

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
SIMULATED PRE-MINING WATER LEVELS (1997)

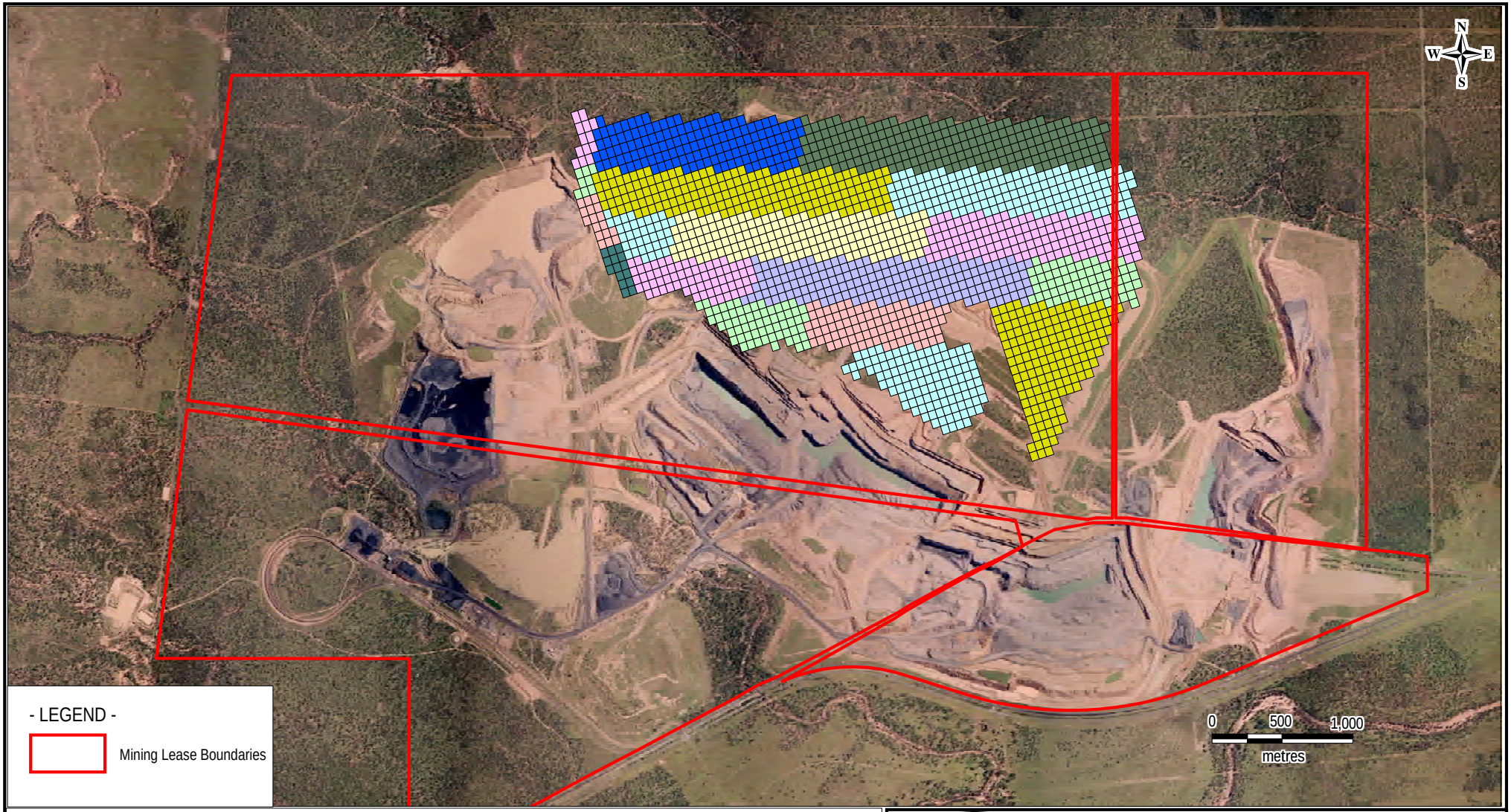
CLIENT: Macarthur Coal (C & M Management) Pty Ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 7
APPROVED BY:		DATE: December 2010	



AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
OPEN PIT MINE DEVELOPMENT PLAN

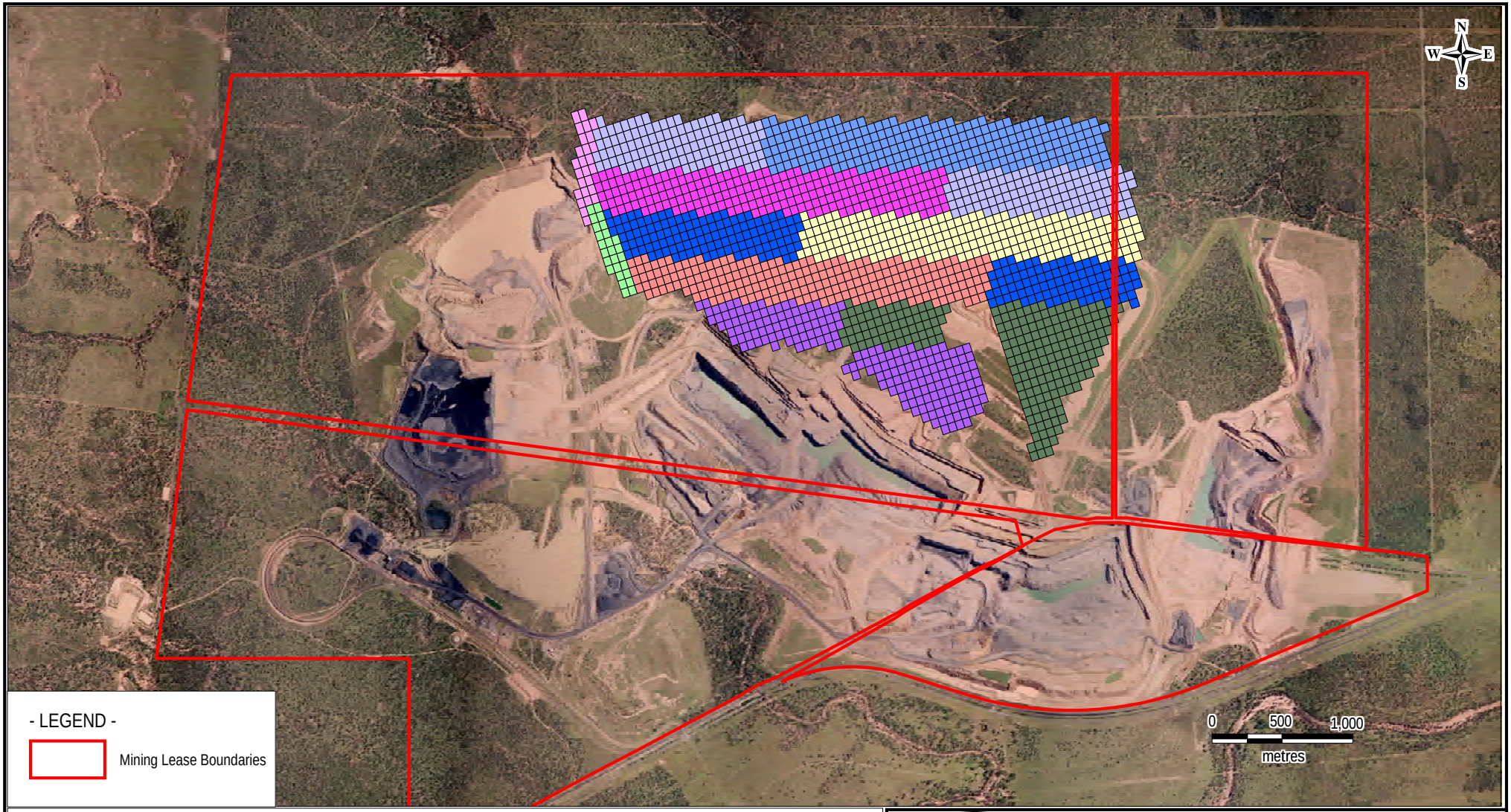
CLIENT: Macarthur Coal (C & M Management) Pty Ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 40,000 (A4)	PROJECT No: G1474	DRAWING No: 8
APPROVED BY:	DATE: December 2010		



AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
UNDERGROUND MINE DEVELOPMENT PLAN - OPTIONS 1 AND 2

CLIENT: Macarthur Coal (C & M Management) Pty Ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 40,000 (A4)	PROJECT No: G1474	DRAWING No: 9
APPROVED BY:	DATE: December 2010		



- LEGEND -

Mining Lease Boundaries

Year Mined

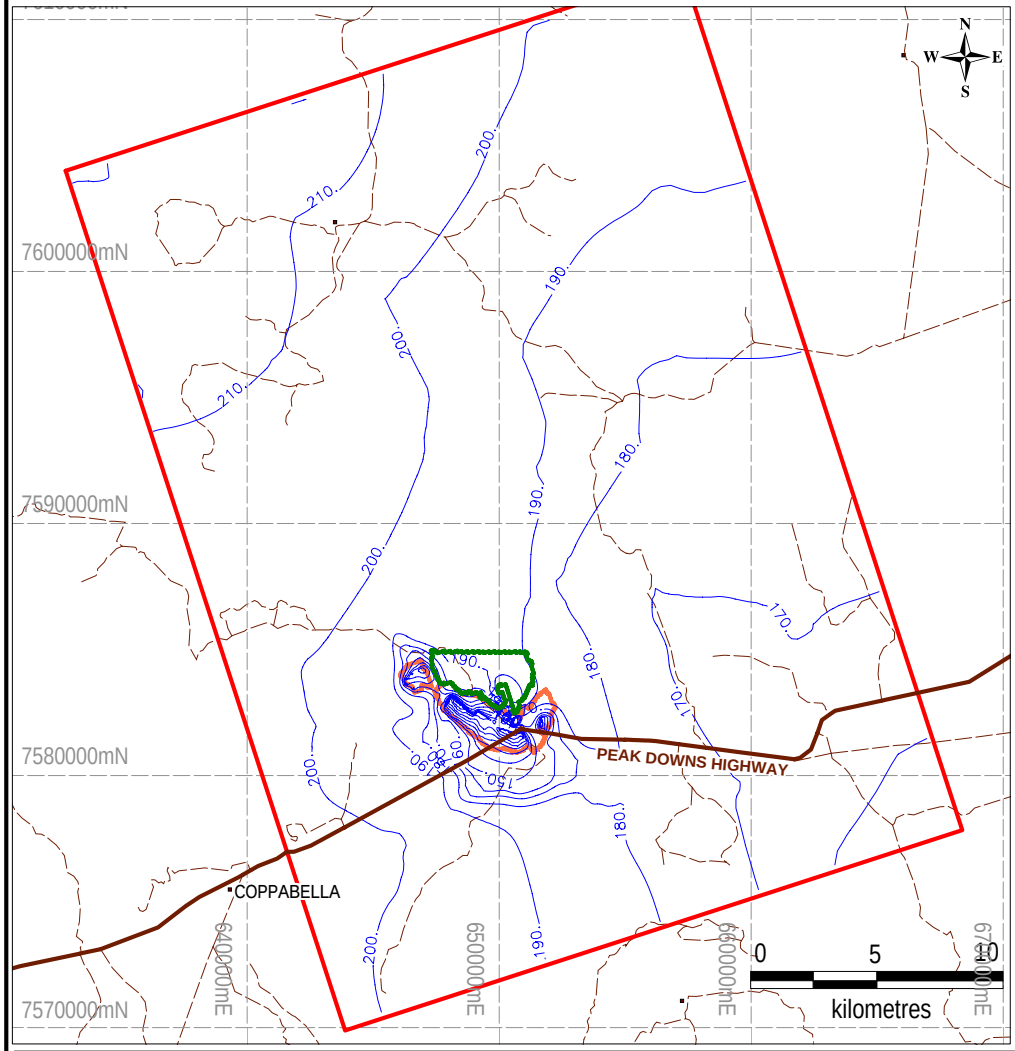
2024	2027	2030	2033
2025	2028	2031	
2026	2029	2032	

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
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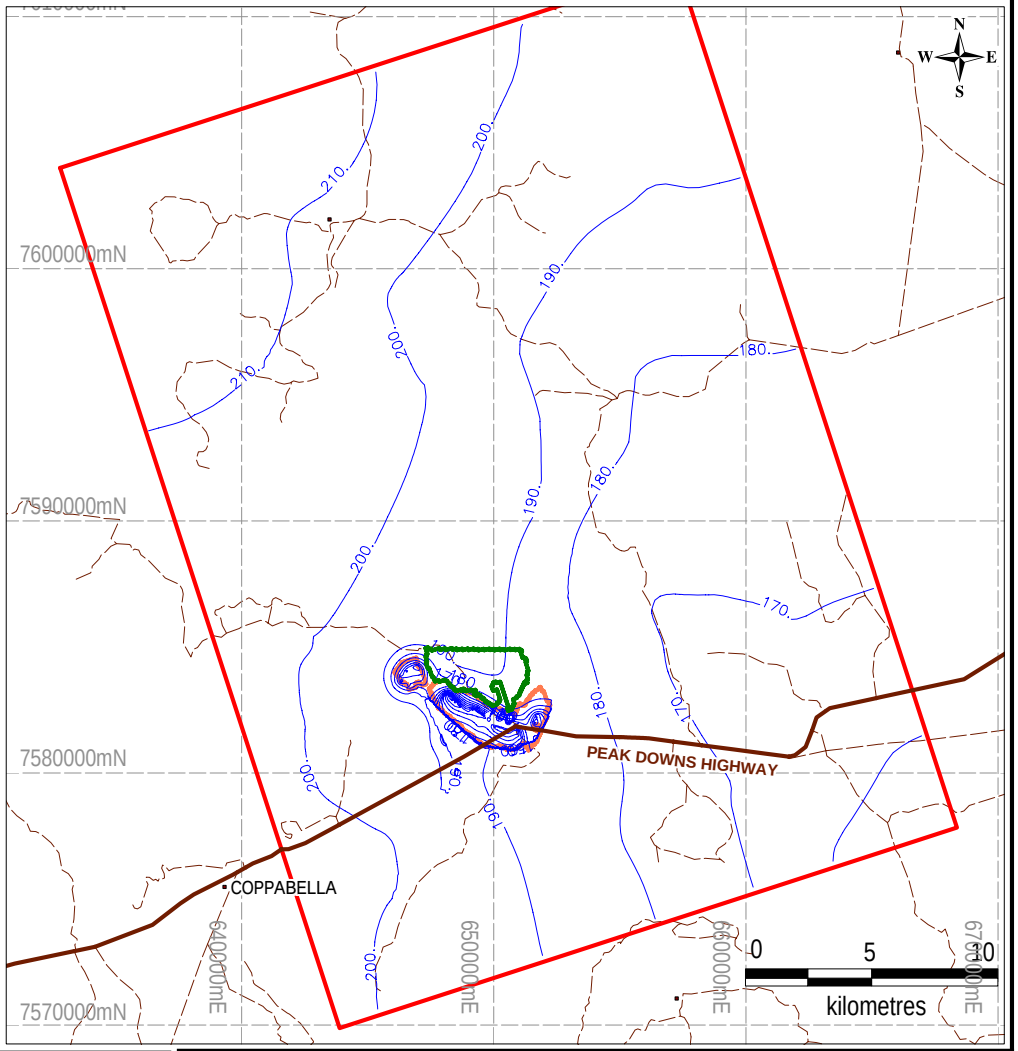
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
UNDERGROUND MINE DEVELOPMENT PLAN - OPTION 3

CLIENT: Macarthur Coal (C & M Management) Pty Ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 40,000 (A4)	PROJECT No: G1474	DRAWING No: 10
APPROVED BY:		DATE: December 2010	

GROUNDWATER CONTOURS AT THE END OF YEAR 2010 - LAYER 1 TERTIARY AQUIFER



GROUNDWATER CONTOURS AT THE END OF YEAR 2010 - LAYER 7 PERMIAN COAL MEASURES



- LEGEND -

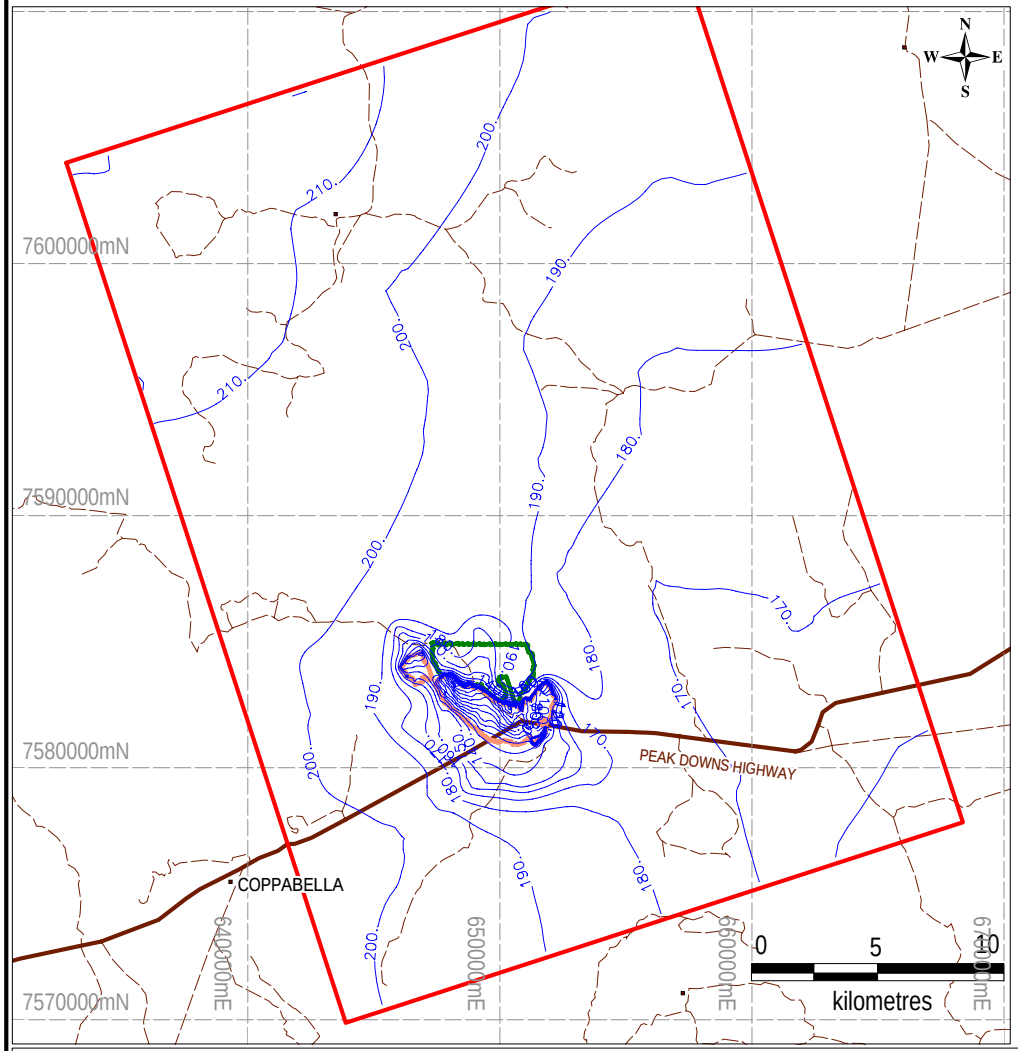
- Proposed Underground Mine Area
- Open Pit Mine Area
- Model Boundary
- Groundwater Contours (RLm)
- Principal Roads
- Unsealed Roads

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

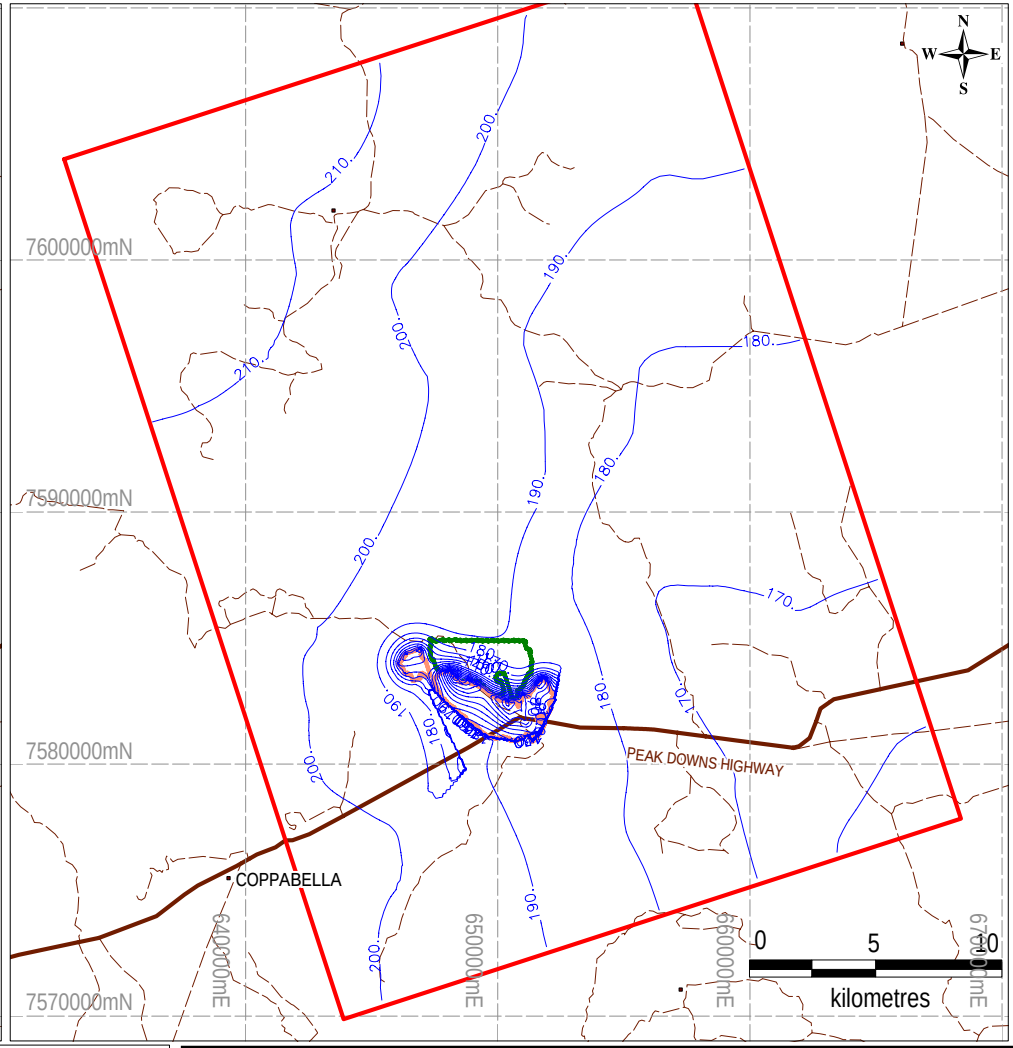
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PREDICTED GW LEVEL CONTOURS 2010 - CURRENT

CLIENT: Macarthur Coal (C & M Management) Pty ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 11
APPROVED BY:		DATE: December 2010	

GROUNDWATER CONTOURS AT THE END OF YEAR 2023 - LAYER 1 TERTIARY AQUIFER



GROUNDWATER CONTOURS AT THE END OF YEAR 2023 - LAYER 7 PERMIAN COAL MEASURES



- LEGEND -

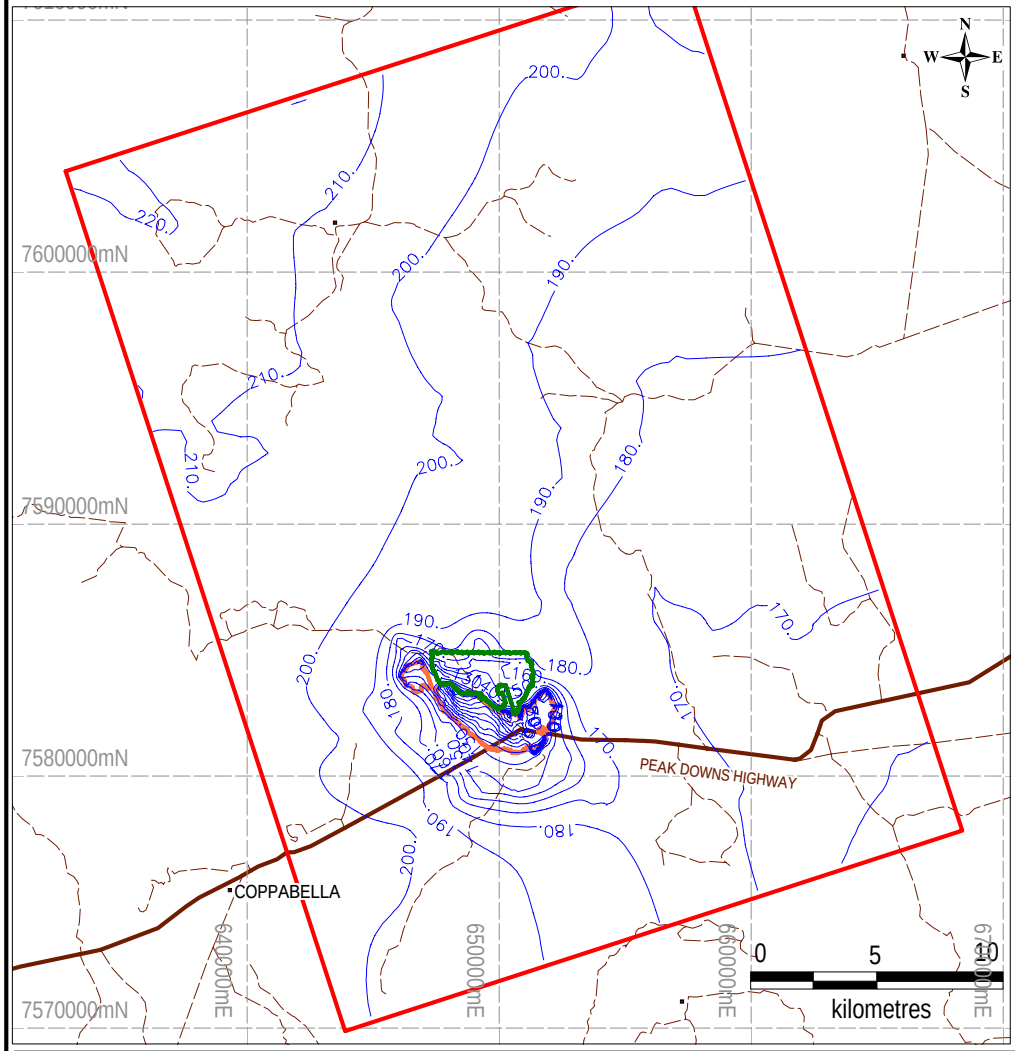
- Proposed Underground Mine Area
- Open Pit Mine Area
- Model Boundary
- Groundwater Contours (RLm)
- Principal Roads
- Unsealed Roads

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

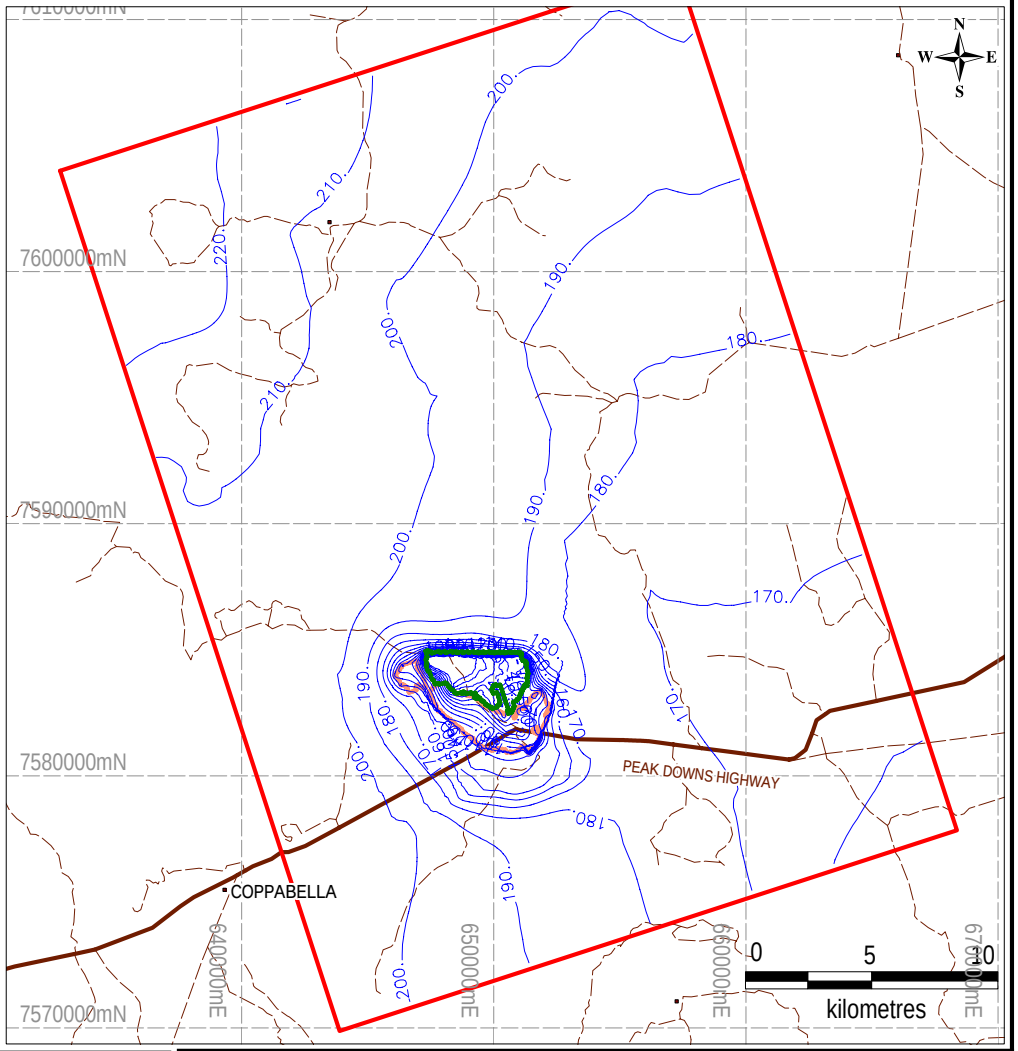
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PREDICTED GW LEVEL CONTOURS - END OF OPENCUT (2023)

CLIENT: Macarthur Coal (C & M Management) Pty ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 12
APPROVED BY:		DATE: December 2010	

GROUNDWATER CONTOURS AT THE END OF YEAR 2033 - LAYER 1 TERTIARY AQUIFER



GROUNDWATER CONTOURS AT THE END OF YEAR 2033 - LAYER 7 PERMIAN COAL MEASURES



- LEGEND -

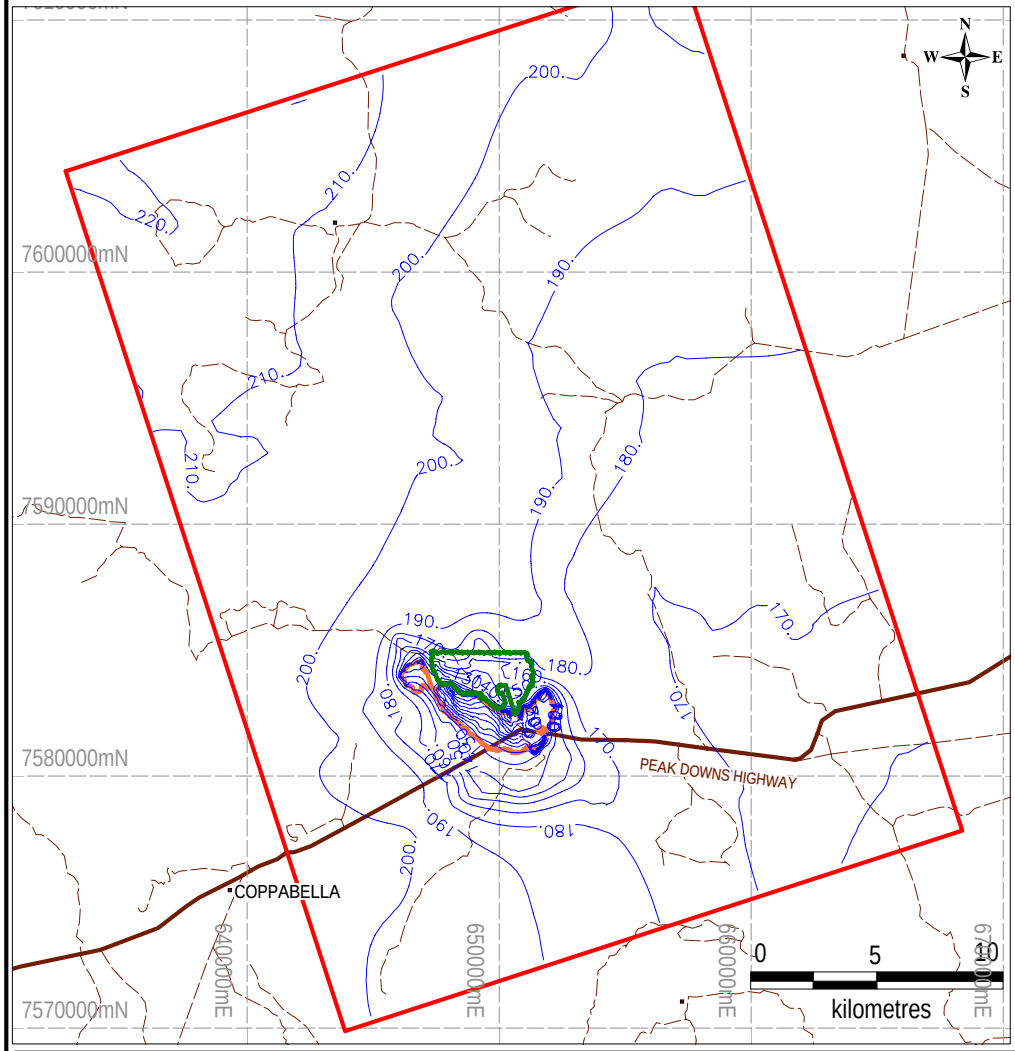
- Proposed Underground Mine Area
- Open Pit Mine Area
- Model Boundary
- Groundwater Contours (RLm)
- Principal Roads
- Unsealed roads

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

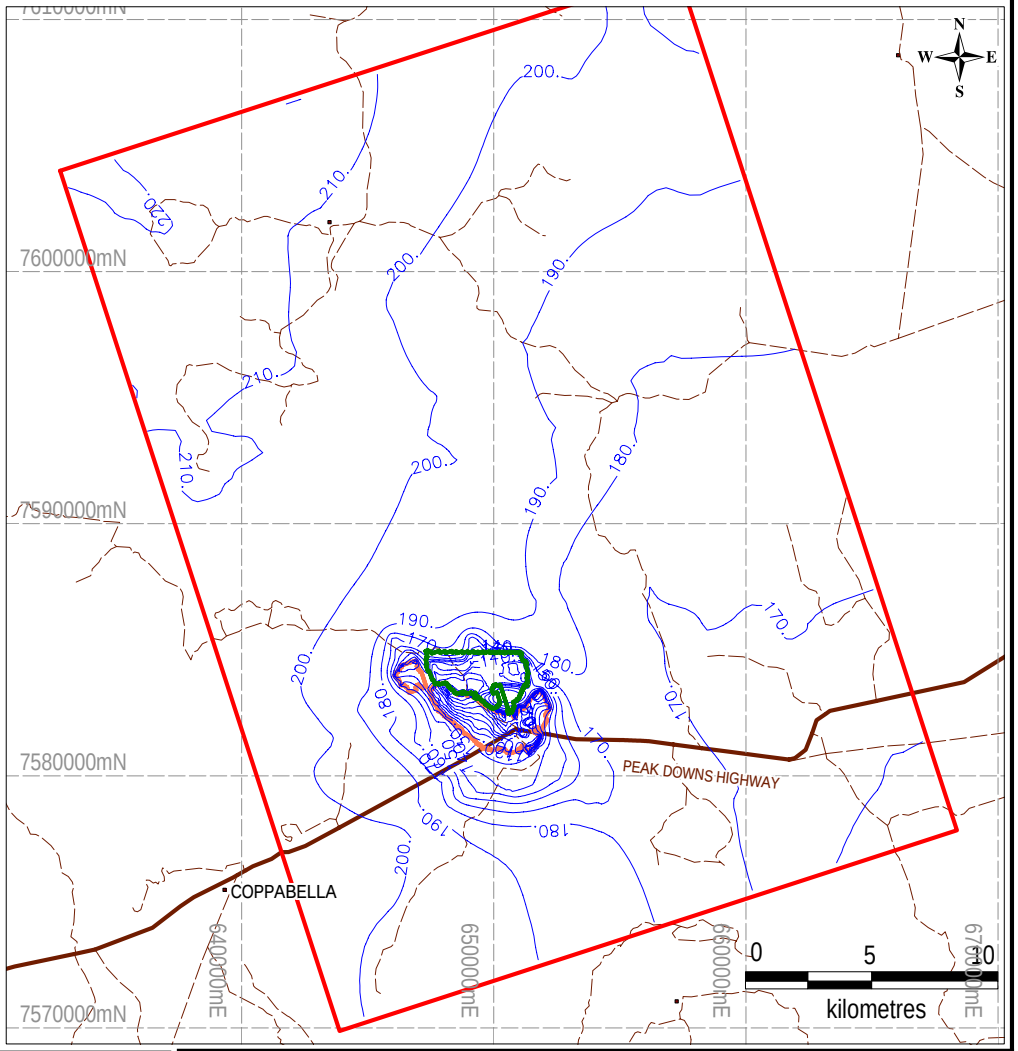
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PREDICTED GW LEVEL CONTOURS 2033 - UNDERGROUND OPTION 1

CLIENT: Macarthur Coal (C & M Management) Pty ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 13
APPROVED BY:		DATE: December 2010	

GROUNDWATER CONTOURS AT THE END OF YEAR 2033 - LAYER 1 TERTIARY AQUIFER



GROUNDWATER CONTOURS AT THE END OF YEAR 2033 - LAYER 7 PERMIAN COAL MEASURES



- LEGEND -

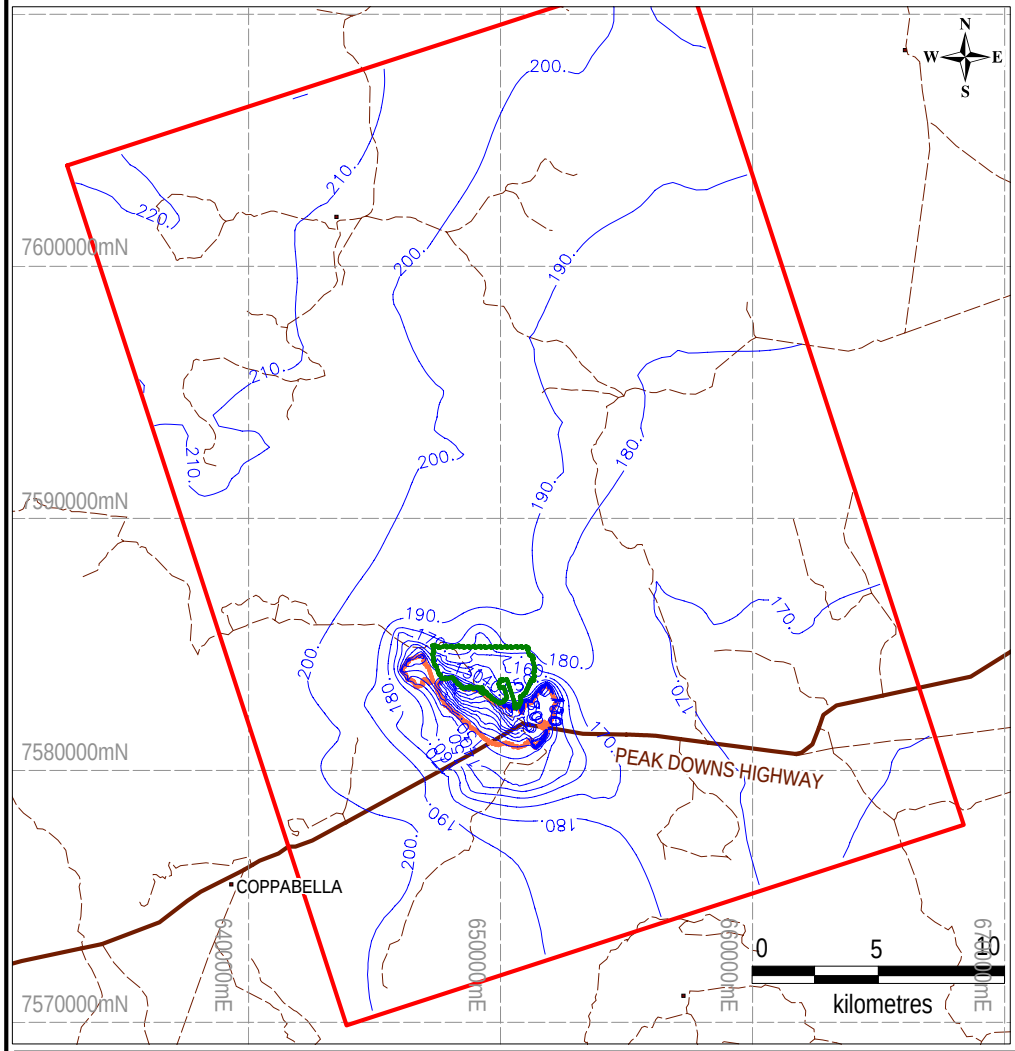
- Proposed Underground Mine Area
- Open Pit Mine Area
- Model Boundary
- Groundwater Contours (RLm)
- Principal Roads
- Unsealed Roads

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

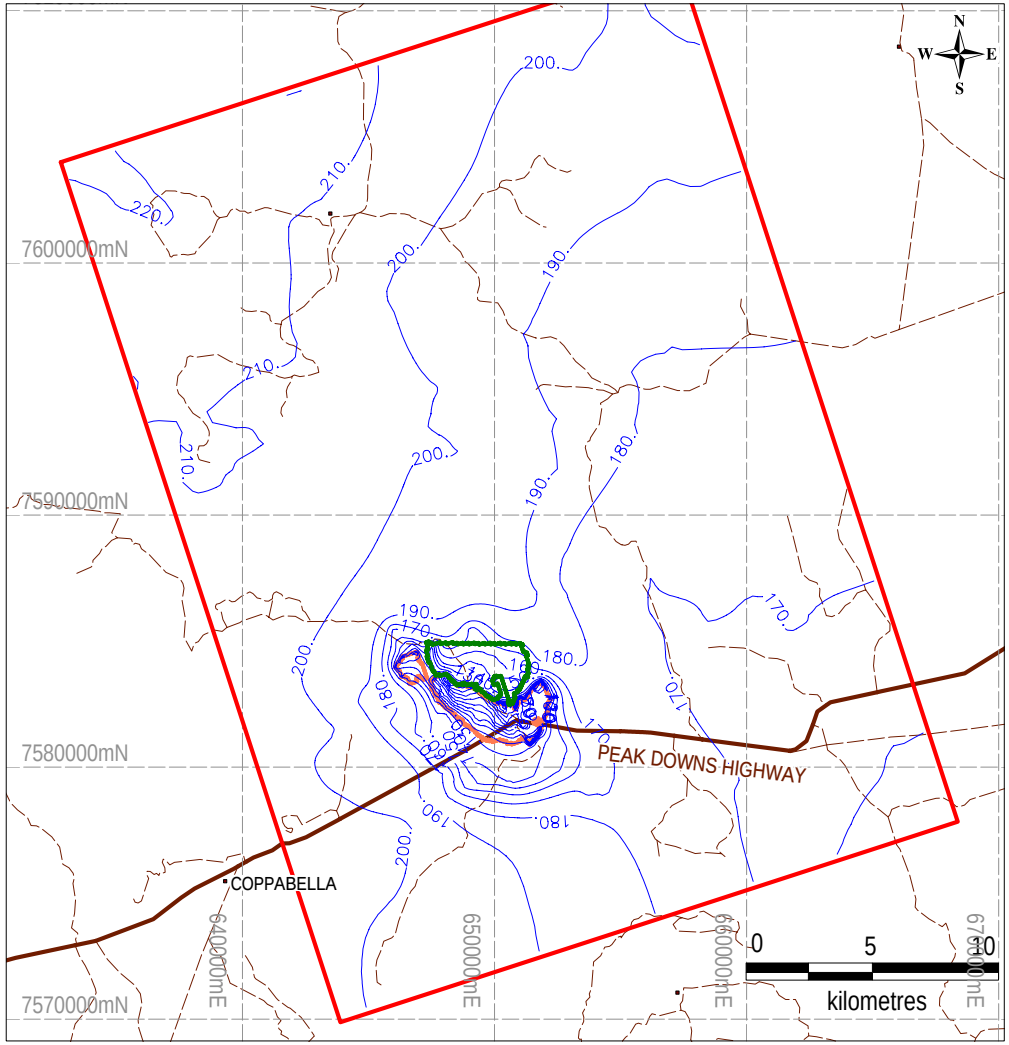
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PREDICTED GW LEVEL CONTOURS 2033 - UNDERGROUND OPTION 2

CLIENT: Macarthur Coal (C & M Management) Pty ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 14
APPROVED BY:		DATE: December 2010	

GROUNDWATER CONTOURS AT THE END OF YEAR 2033 - LAYER 1 TERTIARY AQUIFER



GROUNDWATER CONTOURS AT THE END OF YEAR 2033 - LAYER 7 PERMIAN COAL MEASURES



- LEGEND -

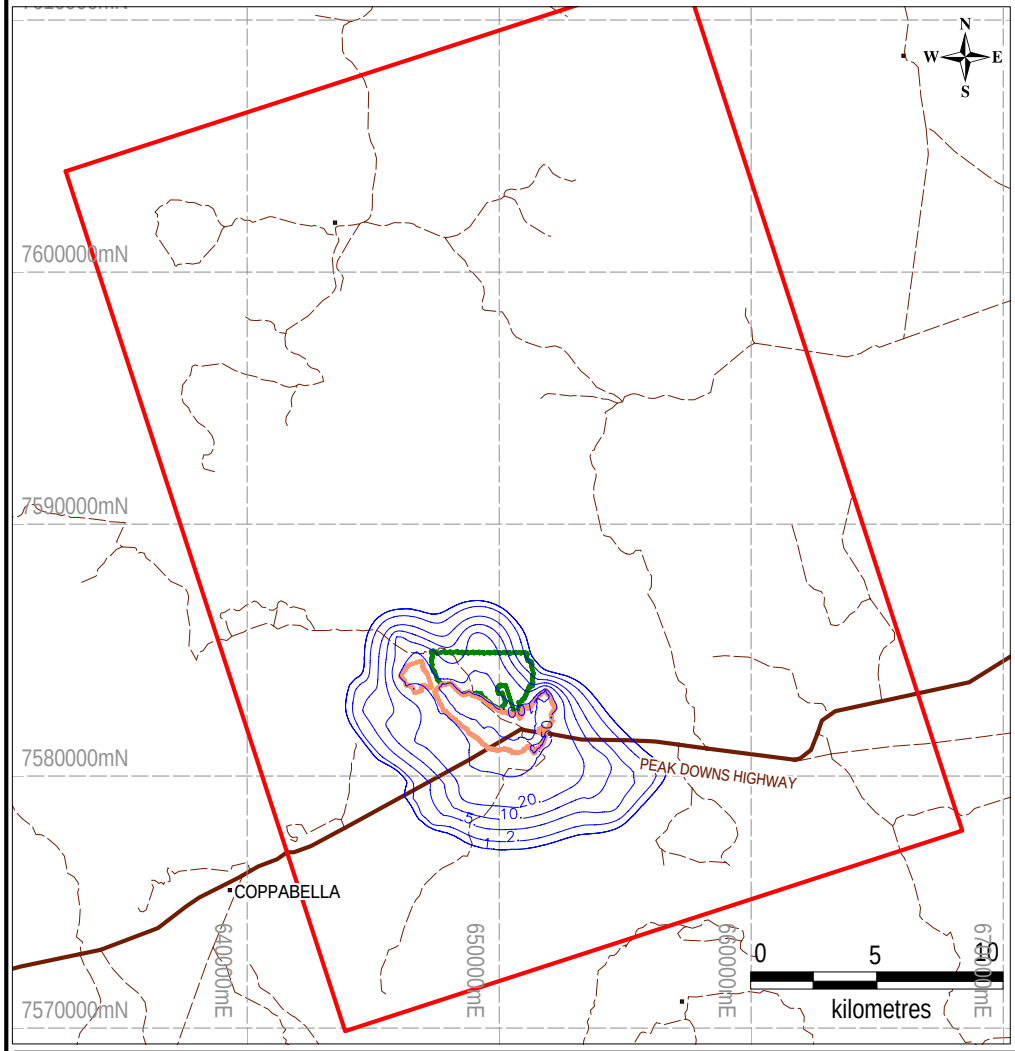
- Proposed Underground mine Area
- Open Pit Mine Area
- Model Boundary
- Groundwater Contours (RLm)
- Principal Roads
- Unsealed Roads

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

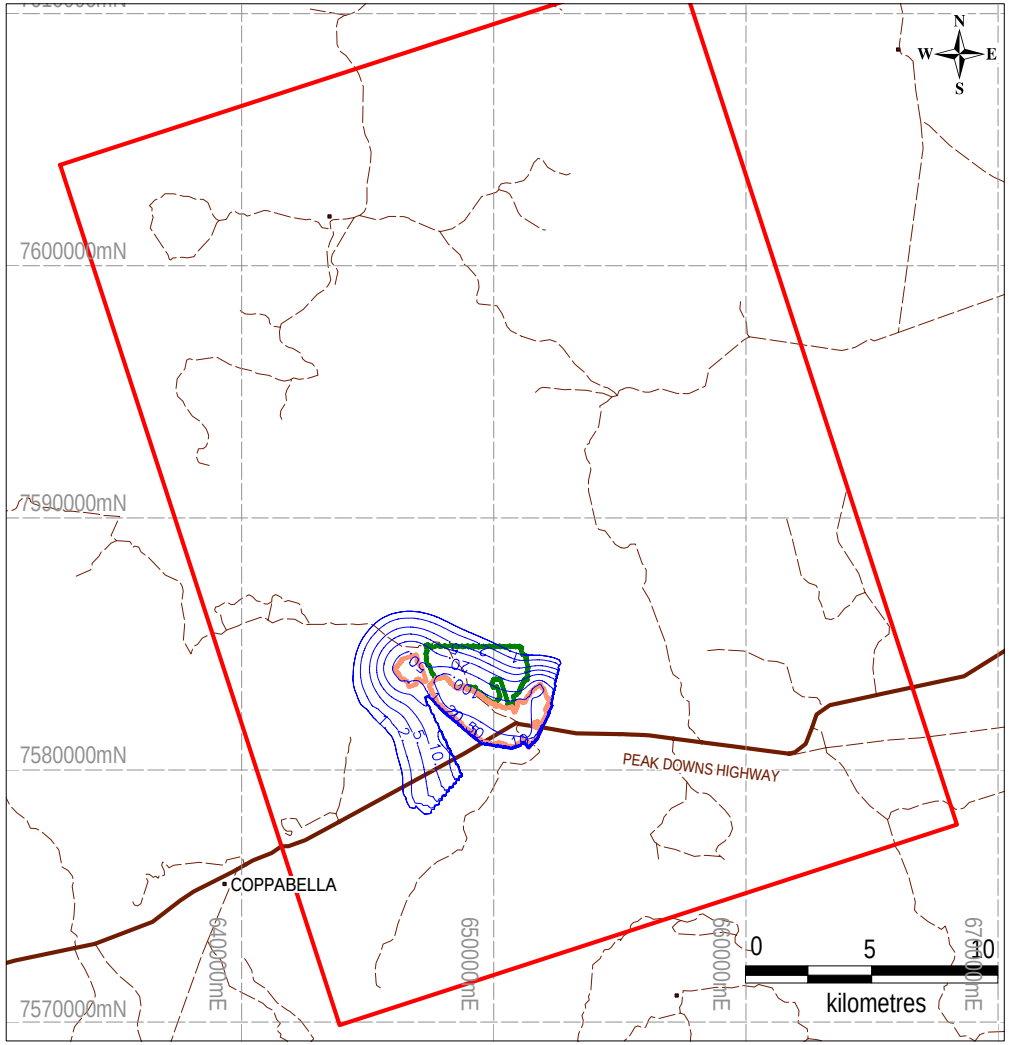
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PREDICTED GW LEVEL CONTOURS 2033 - UNDERGROUND OPTION 3

CLIENT: Macarthur Coal (C & M Management) Pty ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 15
APPROVED BY:		DATE: December 2010	

DRAWDOWN CONTOURS AT THE END OF YEAR 2023 - LAYER 1 TERTIARY AQUIFER



DRAWDOWN CONTOURS AT THE END OF YEAR 2023 - LAYER 7 PERMIAN COAL MEASURES



- LEGEND -

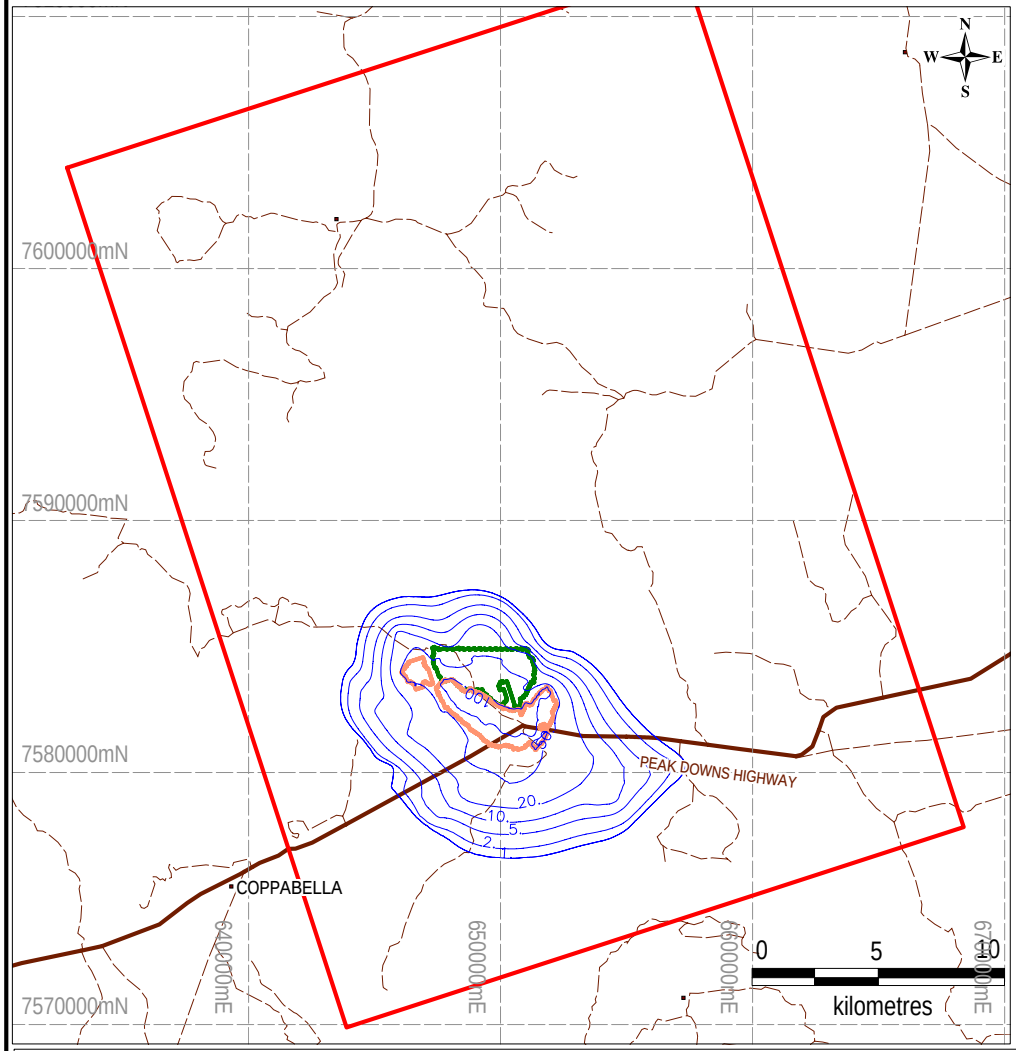
- Proposed Underground Mine Area
- Open Pit Mine Area
- Model Boundary
- Drawdown Contours (m)
- Principal Roads
- Unsealed Roads

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

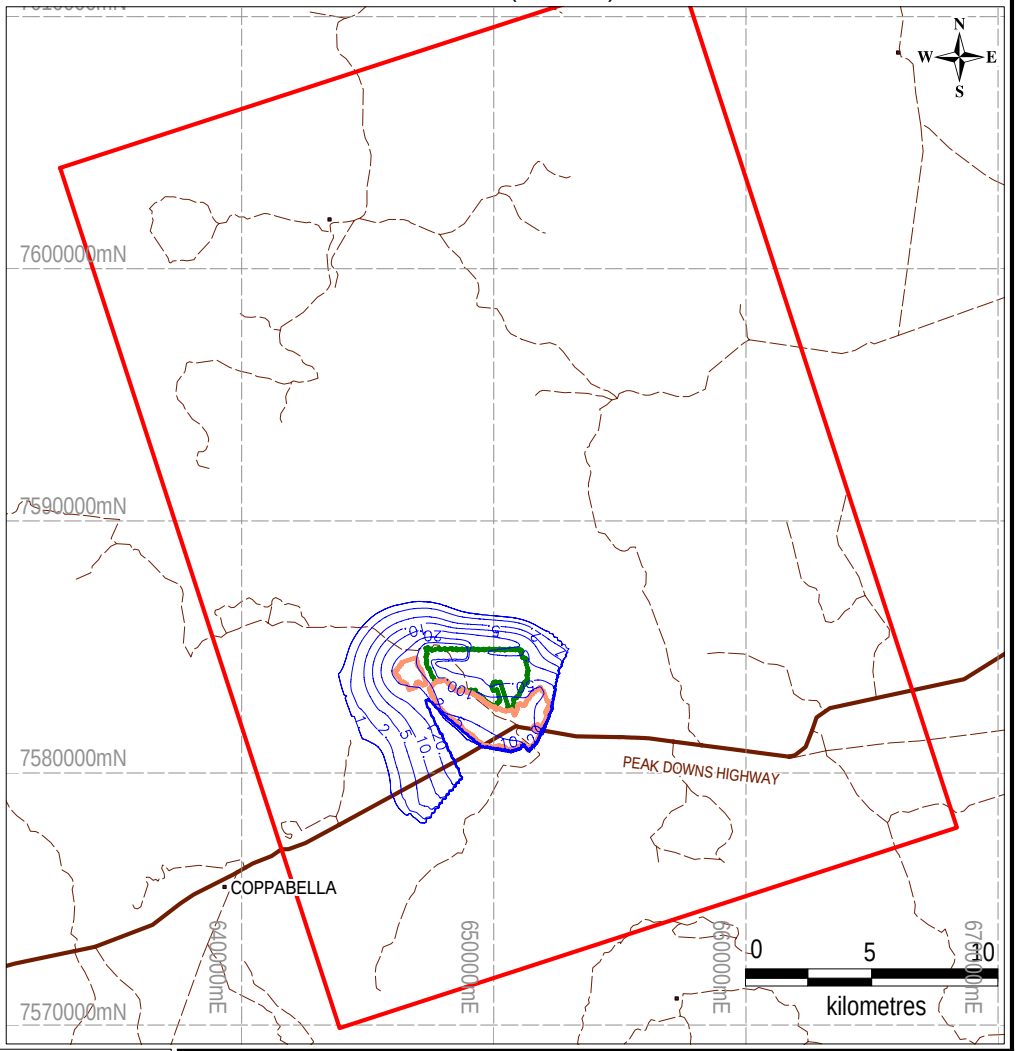
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PREDICTED DRAWDOWN - END OF OPEN CUT (2023)

CLIENT: Macarthur Coal (C & M Management) Pty ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 16
APPROVED BY:		DATE: December 2010	

DRAWDOWN CONTOURS AT THE END OF YEAR 2033 (OPTION 1) - LAYER 1 TERTIARY AQUIFER



DRAWDOWN CONTOURS AT THE END OF YEAR 2033 (OPTION 1) - LAYER 7 PERMIAN COAL MEASURES



- LEGEND -

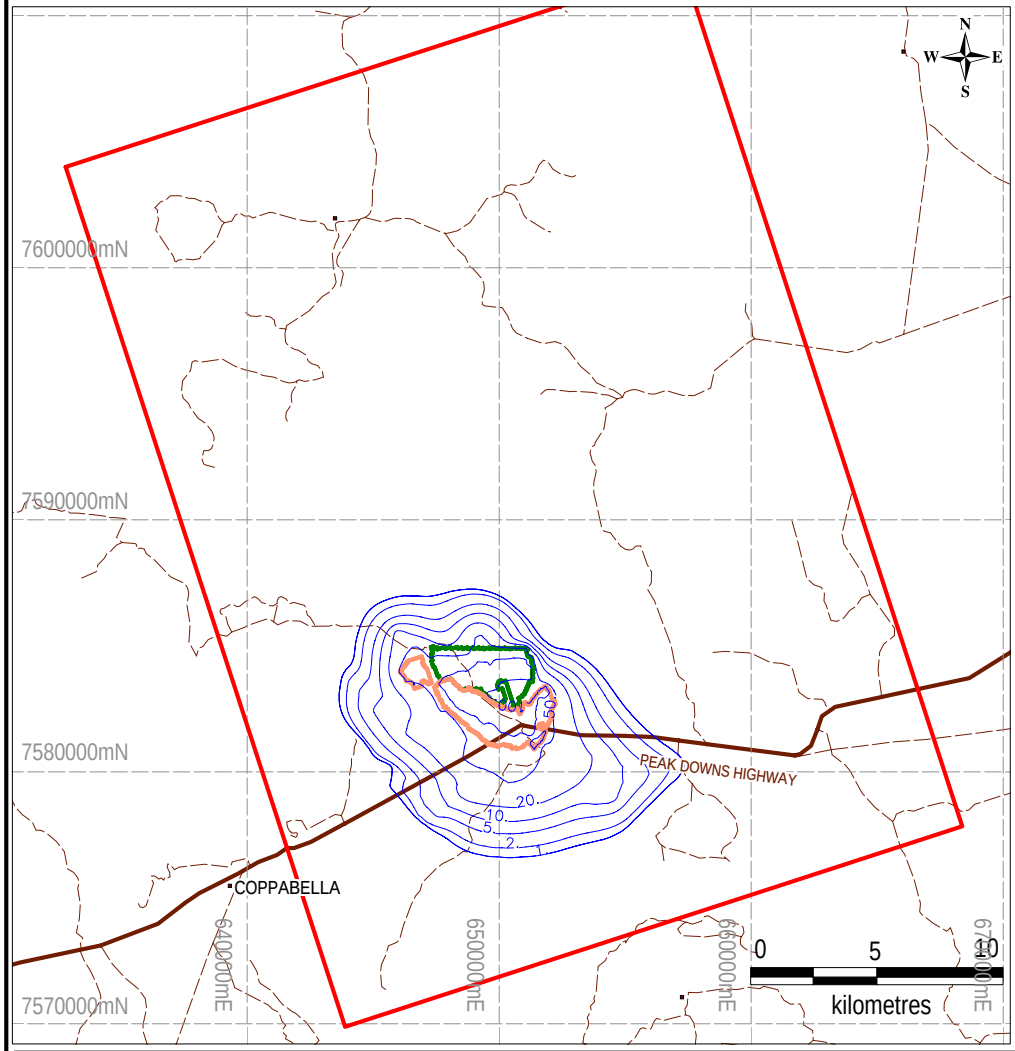
- Proposed Underground Mine Area
- Open Pit Mine Area
- Model Boundary
- Drawdown Contours (m)
- Principal Roads
- Unsealed Roads

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

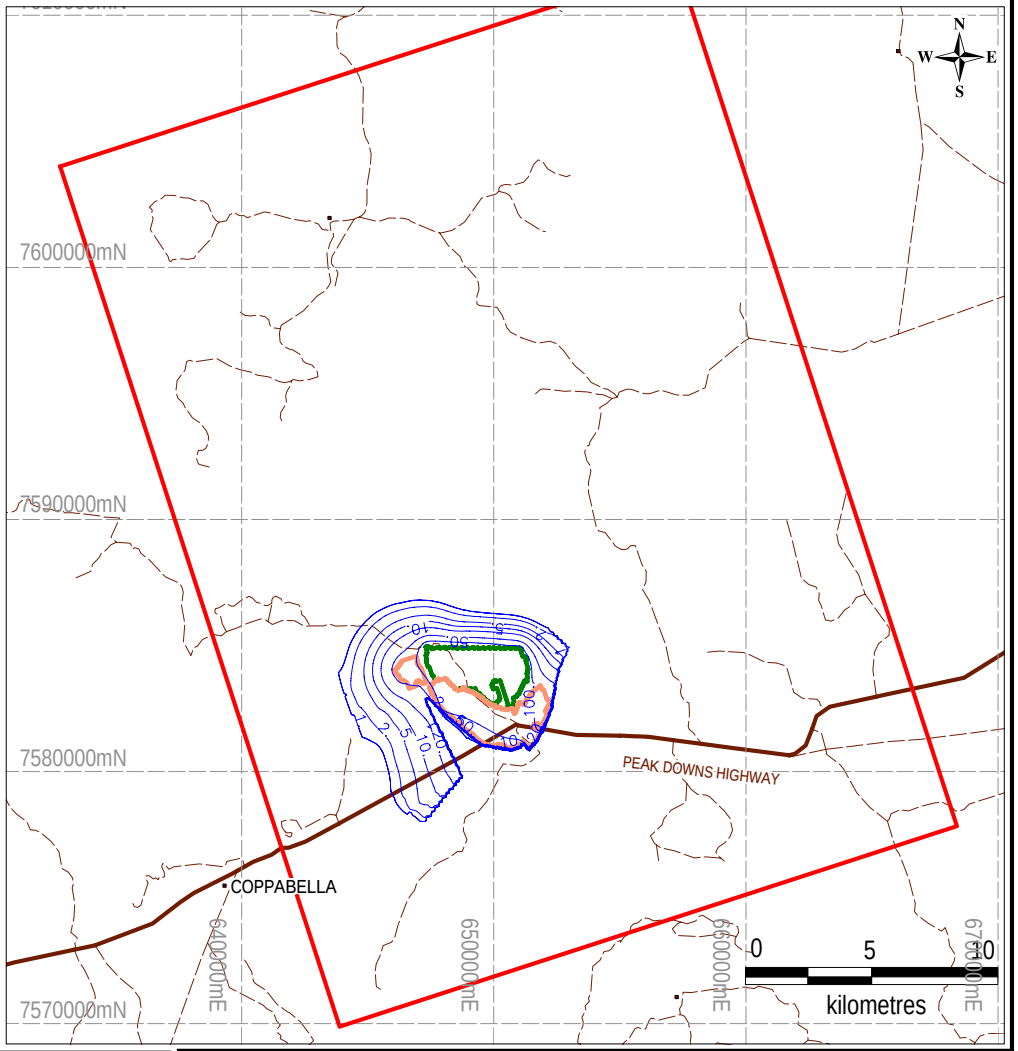
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PREDICTED DRAWDOWN - END OF UNDERGROUND OPTION 1 (2033)

CLIENT: Macarthur Coal (C & M Management) Pty ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 17
APPROVED BY:		DATE: December 2010	

DRAWDOWN CONTOURS AT THE END OF YEAR 2033 (OPTION 2) - LAYER 1 TERTIARY AQUIFER



DRAWDOWN CONTOURS AT THE END OF YEAR 2033 (OPTION 2) - LAYER 7 PERMIAN COAL MEASURES



- LEGEND -

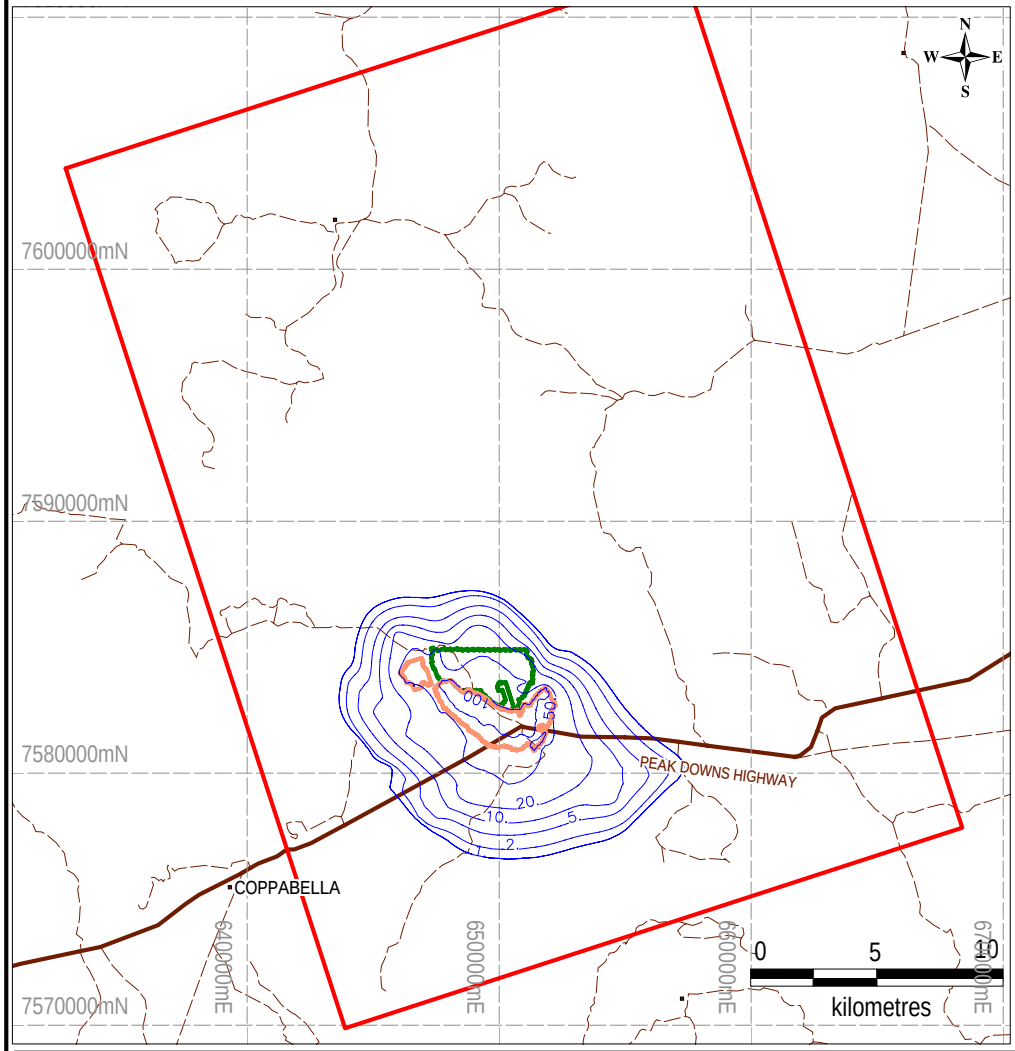
- Proposed Underground Mine Area
- Open Pit Mine Area
- Model Boundary
- Drawdown Contours (m)
- Principal Roads
- Unsealed Roads

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

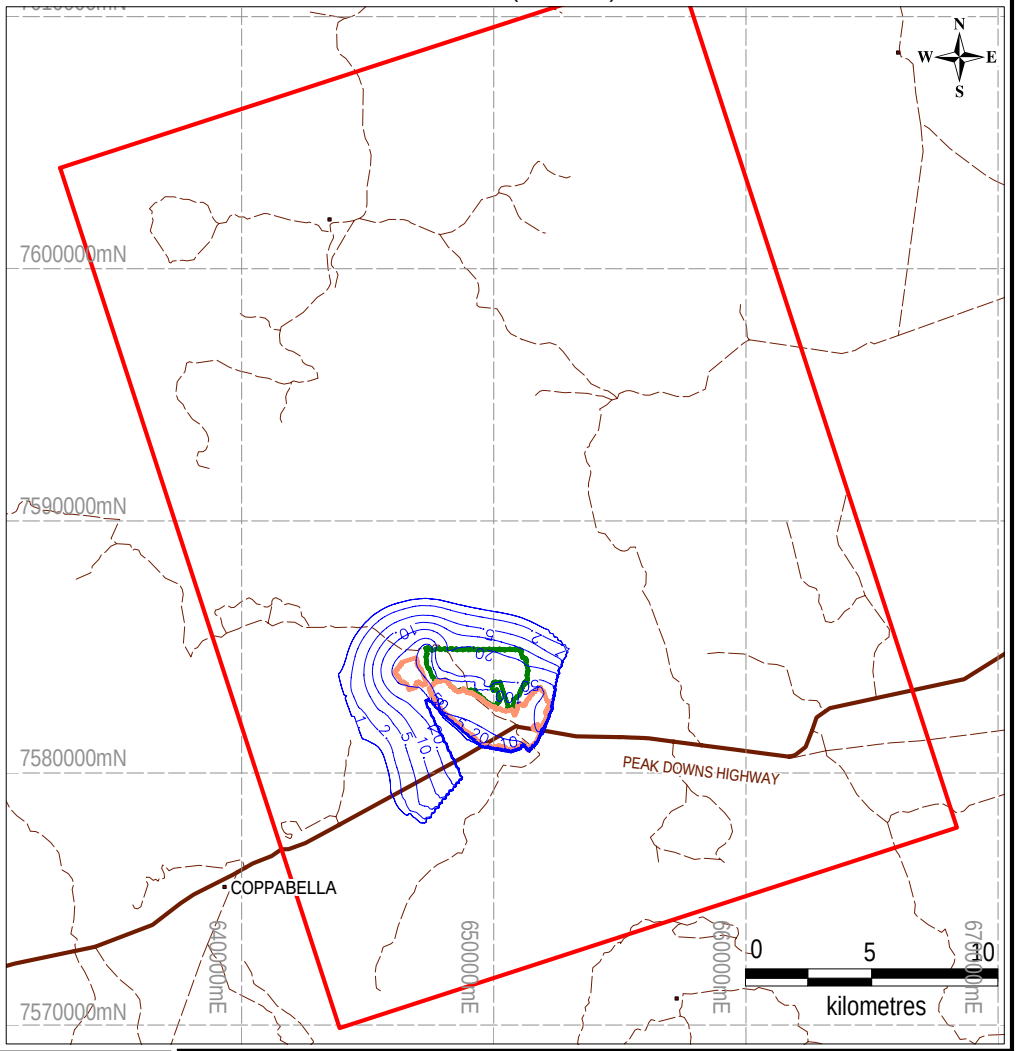
TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PREDICTED DRAWDOWN - END OF UNDERGROUND OPTION 2 (2033)

CLIENT: Macarthur Coal (C & M Management) Pty ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 18
APPROVED BY:		DATE: December 2010	

DRAWDOWN CONTOURS AT THE END OF YEAR 2033 (OPTION 3) - LAYER 1 TERTIARY AQUIFER



DRAWDOWN CONTOURS AT THE END OF YEAR 2033 (OPTION 3) - LAYER 7 PERMIAN COAL MEASURES



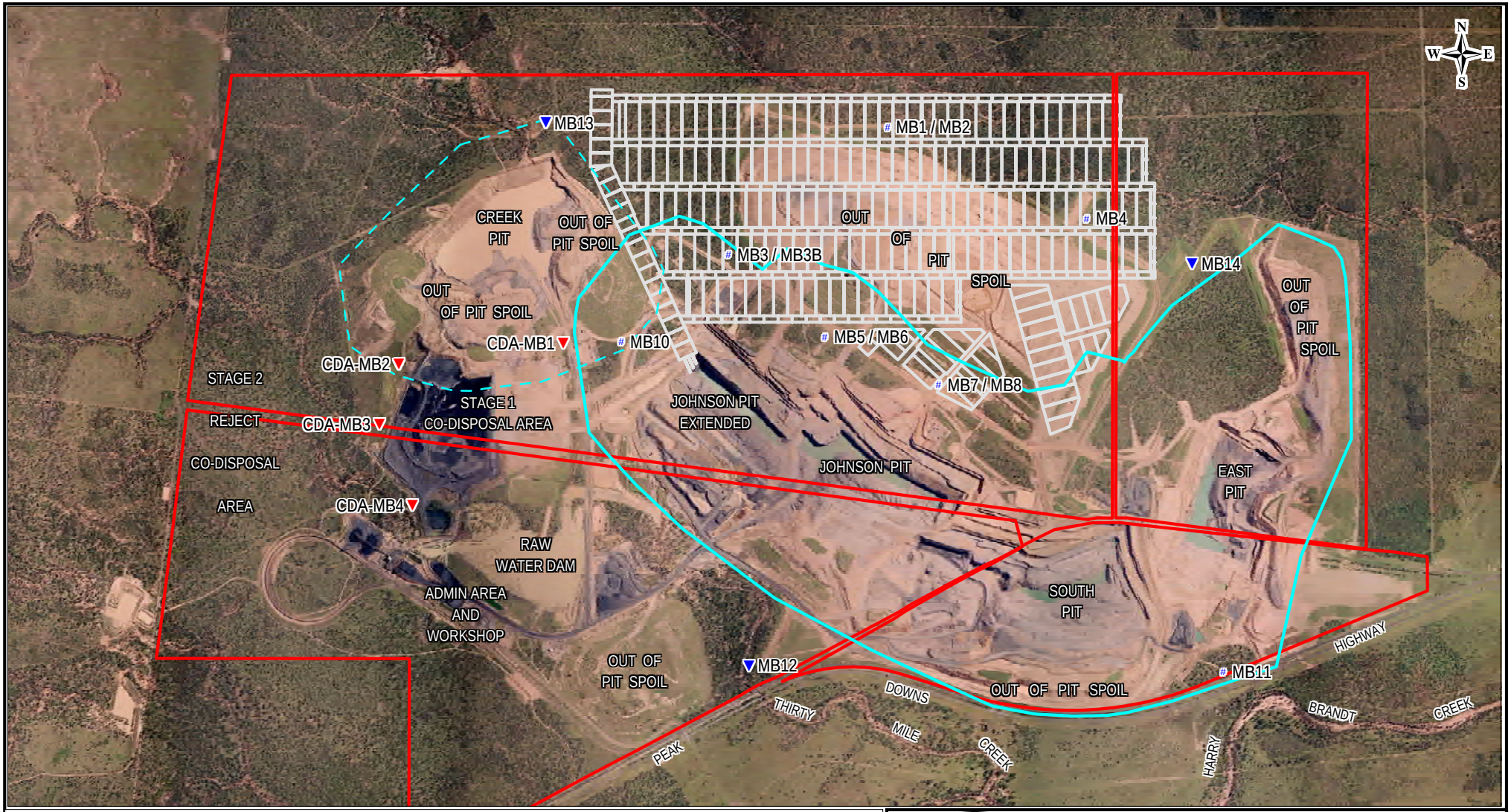
- LEGEND -

- Proposed Underground Mine Area
- Open Pit Mine Area
- Model Boundary
- Drawdown Contours (m)
- Principal Roads
- Unsealed Roads

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PREDICTED DRAWDOWN - END OF UNDERGROUND OPTION 3 (2033)

CLIENT: Macarthur Coal (C & M Management) Pty ltd			OFFICE: Brisbane
DRAWN BY: VR	SCALE: 1 : 300,000 (A4)	PROJECT No: G1474	DRAWING No: 19
APPROVED BY:		DATE: December 2010	



- LEGEND -

- Mining Lease Boundary
- # Existing Monitoring Bore - Mining Area
- ▼ Proposed Monitoring Bore - Mining Area
- ▼ Proposed Monitoring Bore - Co-Disposal Area
- Extents of Future Johnson, South and East Pits Footprint
- Extents of Future Creek Pit Footprint
- Proposed Underground Mine Footprint

AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA

TITLE: COPPABELLA UNDERGROUND PROJECT
GROUNDWATER IMPACT ASSESSMENT
PROPOSED GROUNDWATER MONITORING NETWORK

CLIENT: Macarthur Coal (C & M Management) Pty Ltd			OFFICE: Brisbane
DRAWN BY: TM	SCALE: 1 : 40,000 (A4)	PROJECT No: G1474	DRAWING No: 20
APPROVED BY:		DATE: December 2010	

Appendix A

BORELOGS

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **MB 1**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**228.42 mAHD**
DATE:	**Sep/Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**229.28 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**649432.91 mE, 7584687.81 mN**	LOGGED BY:	**DWI**

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0		SANDY CLAY: medium to high plasticity, brown to orange brown, medium to coarse sand, firm, dry to slightly moist.			Grout
220		CLAYEY SAND: medium to coarse grained, orange brown, low plasticity clay, slightly moist.			
10		SANDY CLAY: medium to high plasticity, grey with yellow brown mottling, fine to medium sand, firm, dry to slightly moist.			
		CLAYEY SAND: medium grained, brown to yellow brown, low plasticity clay, dry to slightly moist.			Backfill
210		SANDY CLAY: high plasticity, grey to brown with red and yellow mottling, fine to medium sand, stiff, dry to slightly moist. Slightly gravelly 20m-23m.			
20		CLAYEY GRAVELLY SAND: medium to coarse grained, light brown to orange brown, low plasticity clay, medium rounded sandstone gravel, dry to slightly moist.			
200		SANDY GRAVELLY CLAY: high plasticity, grey to yellow brown, fine to medium sand, minor medium rounded sandstone gravel, firm to stiff, dry to slightly moist.			Hole diameter 171mm
30		CLAYEY SAND: fine to medium grained, yellow brown to orange brown, low plasticity clay, dry to slightly moist.			
		SILTY CLAY: high plasticity, light grey to grey with yellow brown mottling, stiff to very stiff, dry to slightly moist. With minor sandstone gravel bands.			
190		CLAYEY SAND: fine grained, yellow brown, medium plasticity clay, moist.			
40		SANDY GRAVELLY CLAY: medium to high plasticity, brown to grey brown, fine sand, minor medium rounded sandstone gravel, firm to stiff, moist to wet - minor groundwater inflow at 36m.	SWL 49.11 mbTOC at 08/11/2009		50mm PVC casing
180		SANDY GRAVELLY CLAY: medium to high plasticity, light grey with yellow mottling, fine to coarse sand, fine rounded quartz and sandstone gravel, firm to stiff, wet.			
50		BASE OF TERTIARY SEDIMENTS			
		SILTSTONE: highly weathered, brown to red brown with yellow brown limonite staining, medium stength, dry to slightly moist.			
		INTERBEDDED SILTSTONE/SANDSTONE: highly weathered to fresh, grey to dark grey, medium stength to hard, dry to moist. 70% siltstone / 30% sandstone. Slightly weathered to fresh at 58m. Fresh from 59m.			
170		SANDSTONE: fresh, grey, fine grained, medium stength to hard, moist.			Hole diameter 120mm
60		SILTSTONE: fresh, dark grey, medium stength to hard, dry to slightly moist. Sandstone interbeds at 63m, 70m, 72m-74m.			
160					
70					

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **MB 1**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**228.42 mAHD**
DATE:	**Sep/Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**229.28 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**649432.91 mE, 7584687.81 mN**	LOGGED BY:	**DWI**

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
150 / 80		SILTSTONE: fresh, dark grey, medium stength to hard, dry to slightly moist. Sandstone interbeds at 63m, 70m, 72m-74m.			Backfill
140 / 90					Bentonite pellets
		SANDSTONE: fresh, grey, fine grained, medium stength to hard, slightly moist to wet. White calcite veining at 92m, with siltstone interbeds at 96m, 97-98m, 102m, 103-104m groundwater inflow at 92m,			50mm PVC screen
130 / 100		groundwater inflow at 101m: 0.2L/sec (V-notch weir)			Gravel
		groundwater inflow at 104m: 0.6L/sec (V-notch weir)			50mm PVC screen Bore depth 104m
120 / 110					
110 / 120					
100 / 130					
90 / 140					
80 / 150					

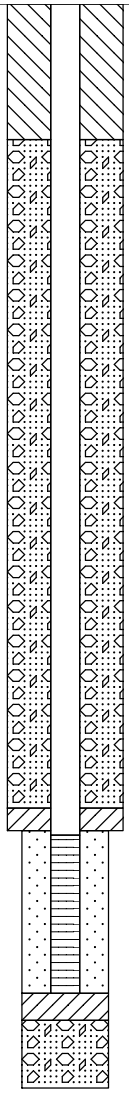
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BOREHOLE LOG

BOREHOLE ID: **MB 2** Page 1 of 1

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**228.50 mAHD**
DATE:	**Sep/Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**229.30 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**649436.78 mE, 7584687.51 mN**	LOGGED BY:	**DWI**

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 / 225		SANDY CLAY: medium to high plasticity, brown to orange brown, medium to coarse sand, firm, dry to slightly moist.			Grout
5 / 220		CLAYEY SAND: medium to coarse grained, orange brown, low plasticity clay, slightly moist.			
10 / 215		SANDY CLAY: medium to high plasticity, grey with yellow brown mottling, fine to medium sand, firm, dry to slightly moist.			
15 / 210		CLAYEY SAND: medium grained, brown to yellow brown, low plasticity clay, dry to slightly moist.			Backfill
20 / 205		SANDY CLAY: high plasticity, grey to brown with red and yellow mottling, fine to medium sand, stiff, dry to slightly moist. Becoming slightly gravelly between 20m and 23m.			
25 / 200		CLAYEY GRAVELLY SAND: medium to coarse grained, light brown to orange brown, low plasticity clay, medium rounded sandstone gravel, dry to slightly moist.	SWL 39.08 mbTOC at 07/11/2009		50mm PVC casing
30 / 195		SANDY GRAVELLY CLAY: high plasticity, grey to yellow brown, fine to medium sand, minor medium rounded sandstone gravel, firm to stiff, dry to slightly moist.			
35 / 190		CLAYEY SAND: fine to medium grained, yellow brown to orange brown, low plasticity clay, dry to slightly moist.			
40 / 185		SILTY CLAY: high plasticity, light grey to grey with yellow brown mottling, stiff to very stiff, dry to slightly moist. With minor sandstone gravel bands.			Bentonite pellets
45 / 180		CLAYEY SAND: fine grained, yellow brown, medium plasticity clay, moist.			Gravel
50 / 175		SANDY GRAVELLY CLAY: medium to high plasticity, brown to grey brown, fine sand, minor medium rounded sandstone gravel, firm to stiff, moist to wet - minor groundwater inflow at 36m.			50mm PVC screen
55 / 170		SANDY GRAVELLY CLAY: medium to high plasticity, light grey with yellow mottling, fine to coarse sand, fine rounded quartz and sandstone gravel, firm to stiff, wet.			Bore depth 43.8m
60 / 165		BASE OF TERTIARY SEDIMENTS			Bentonite pellets
65 / 160		SILTSTONE: highly weathered, brown to red brown with yellow brown limonite staining, medium stength, dry to slightly moist.			Backfill
70 / 155					
75					

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BOREHOLE LOG

BOREHOLE ID: **MB 3**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**225.25 mAHD**
DATE:	**8 Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**226.25 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**648300.70 mE, 7583783.19 mN**	LOGGED BY:	**DWI**

Depth	Elevation	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0			SANDY CLAY: high plasticity, red brown / yellow brown to grey with red brown mottling, medium to coarse sand, firm to stiff, dry to slightly moist.			Grout
	220					
10			SAND/SANDY CLAY: fine to coarse grained, brown to yellow brown, low plasticity clay, dry to slightly moist. Some fine rounded gravel at 9m.			
	210		SANDY CLAY: medium to high plasticity, grey with strong yellow brown mottling, fine to medium sand, firm to stiff, dry to slightly moist.			Hole Diameter 171mm
20			CLAYEY SAND: fine to medium grained, brown to yellow brown, low plasticity clay, dry to slightly moist.			
			SANDY CLAY: medium to high plasticity, yellow brown, medium sand, firm to stiff, dry to slightly moist.			Backfill
	200		BASE OF TERTIARY SEDIMENTS			
			SILTSTONE: highly weathered to fresh, light brown to grey (with pervasive red brown mottling in the weathered zone), soft to hard, dry. Highly to moderately weathered to 34m. Moderately to slightly weathered to 42m. Slightly weathered to fresh to 43m. Fresh from 44m.	SWL 48.80 mbTOC at 08/11/2009		
30						
	190					
40						
	180					Hole Diameter 120mm
50						
			SANDSTONE: fresh, grey, fine to medium grained, medium stength to hard, dry.			
	170		SILTSTONE: fresh, grey to dark grey, medium stength to hard, dry.			
			SANDSTONE: fresh, grey, fine to medium grained, medium stength to hard, dry.			50mm PVC casing
60			SILTSTONE: fresh, grey to dark grey, medium stength to hard, dry to moist. Minor seepage at 66m to 67m.			
	160					
			SANDSTONE: fresh, grey, fine to medium grained, medium stength to hard, moist.			
70						
			SILTSTONE: fresh, grey to dark grey, medium stength to hard, dry to moist.			

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BOREHOLE LOG

BOREHOLE ID: **MB 3**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**225.25 mAHD**
DATE:	**8 Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**226.25 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**648300.70 mE, 7583783.19 mN**	LOGGED BY:	**DWI**

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
150 / 80		SILTSTONE: fresh, grey to dark grey, medium stength to hard, dry to moist.			
		INTERBEDDED SILTSTONE/SANDSTONE: fresh, grey to dark grey, fine grained sandstone, medium stength to hard, moist. 50% siltstone / 50% sandstone.			
140 / 90		SILTSTONE: fresh, grey to dark grey, medium stength to hard, dry to moist.			Backfill
130 / 100		Interbedded siltstone/sandstone at 96m, 101m, 103m, 105m, 107m, 108m.			Bentonite pellets
120 / 110		SANDSTONE: fresh, grey, fine to coarse grained, medium stength to hard, moist to wet.			Gravel
110 / 120		Groundwater inflow at 114m: 0.8L/sec (V-notch weir)			50mm PVC screen
		Groundwater inflow at 119m: 1.0L/sec (V-notch weir)			Bore depth 119m
100 / 130					
90 / 140					
80 / 150					

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BOREHOLE LOG

BOREHOLE ID: **MB 3B**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**225.33 mAHD**
DATE:	**9 Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**226.33 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**648302.19 mE, 7583786.14 mN**	LOGGED BY:	**DWI**

Depth	Elevation	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0	220		SANDY CLAY: high plasticity, red brown / yellow brown to grey with red brown mottling, medium to coarse sand, firm to stiff, dry to slightly moist.	DRY at 04/11/2009		Grout
10	210		SAND/SANDY CLAY: fine to coarse grained, brown to yellow brown, low plasticity clay, dry to slightly moist. Some fine rounded gravel at 9m.			Bentonite pellets Gravel 50mm PVC screen
20	200		SANDY CLAY: medium to high plasticity, grey with strong yellow brown mottling, fine to medium sand, firm to stiff, dry to slightly moist.			50mm PVC casing
30	190		CLAYEY SAND: fine to medium grained, brown to yellow brown, low plasticity clay, dry to slightly moist.			50mm PVC screen Bore depth 21m
40	180		SANDY CLAY: medium to high plasticity, yellow brown, medium sand, firm to stiff, dry to slightly moist. BASE OF TERTIARY SEDIMENTS			
50	170					
60	160					
70						

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BOREHOLE LOG

BOREHOLE ID: **MB 4**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**220.09 mAHD**
DATE:	**27 Sep 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**221.09 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**650847.43 mE, 7584037.57 mN**	LOGGED BY:	**DWI**

Depth	Elevation	Lithologic Description	SWL	Bore Description
0	220	CLAYEY SAND: medium to coarse grained, yellow brown, low plasticity clay, slightly moist.		Grout
		SANDY CLAY: medium to high plasticity, yellow brown, medium sand, firm, slightly moist.		Hole diameter 171mm
		CLAYEY SAND: medium to coarse grained, red brown to yellow brown, low plasticity clay, slightly moist.		
10	210	SANDY CLAY: medium to high plasticity, yellow brown, fine to medium sand, firm to stiff, dry to slightly moist.		
		CLAYEY SAND/SANDY CLAY: medium to coarse grained, yellow brown, low to medium plasticity clay, dry to slightly moist. Becoming more clayey from 15m-18m.		
		BASE OF TERTIARY SEDIMENTS		
20	200	SILTSTONE: highly to moderately weathered, purple brown to dark brown (with strong pervasive red mottling), soft to medium strength, dry. Some fine grained sandstone at 24m.		Hole diameter 120mm
30	190	SANDSTONE: moderately weathered to fresh, brown to grey, medium to coarse grained, medium stength to hard, dry. Slightly weathered to fresh at 29m. Fresh from 32m.	SWL 37.99 mbtoc at 08/11/2009	
40	180	SILTSTONE: fresh, grey, medium stength to hard, dry. With fine grained sandstone interbeds from 43m to 44m, 49m to 50m, and 52m to 54m.		50mm PVC casing
50	170			
		INTERBEDDED SANDSTONE/SILTSTONE: fresh, grey to dark grey, fine grained sandstone, medium stength to hard, dry. 70% sandstone / 30% siltstone.		Backfill
60	160	SILTSTONE: fresh, grey to dark grey, medium stength to hard, dry. Some very fine sandstone (10%) at 60m, (50%) at 61m to 62m, (10%) at 64m.		
		SANDSTONE: fresh, grey, fine to medium grained, hard, dry to moist - slightly damp returns at 65m. Some dark grey siltstone (10%-20%).		
70	150	SILTSTONE: fresh, grey to dark grey, medium stength to hard, dry to moist. Some very fine sandstone (20%-30%).		

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BOREHOLE LOG

BOREHOLE ID: **MB 4**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**220.09 mAHD**
DATE:	**27 Sep 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**221.09 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**650847.43 mE, 7584037.57 mN**	LOGGED BY:	**DWI**

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
80 — 140		SANDSTONE: fresh, grey, fine to medium grained, hard, moist. With some dark grey siltstone.			Backfill
		SILTSTONE: fresh, grey to dark grey, medium stength to hard, dry to moist. Some very fine sandstone (20%-40%).			Bentonite pellets
		SANDSTONE: fresh, grey, fine to medium grained, hard, moist. With some dark grey siltstone (20%).			
90 — 130		SILTSTONE: fresh, grey to dark grey, medium stength to hard, dry to moist. Some very fine sandstone (20%-50%).			Gravel
		SANDSTONE: fresh, grey, fine to medium grained, hard, wet.			
100 — 120					50mm PVC screen
110 — 110		minor groundwater inflow at 112m at <0.1L/sec.			50mm PVC screen
					Bore depth 112m
120 — 100					
130 — 90					
140 — 80					
150					

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BOREHOLE LOG

BOREHOLE ID: **MB 5**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**225.32 mAHD**
DATE:	**28 Sep 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**226.32 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**648986.25 mE, 7583194.42 mN**	LOGGED BY:	**DWI**

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 / 225		SAND: medium to coarse grained, light grey, loose, dry.			Grout
		SANDY CLAY: medium to high plasticity, yellow brown to red brown, medium sand, firm to stiff, dry.			
220		CLAYEY SAND: medium to coarse grained, grey to red brown, low plasticity clay, dry.			
10		SANDY CLAY: medium plasticity, yellow brown to red brown mottling, medium sand, firm, dry.			
		CLAYEY SAND: medium to coarse grained, yellow brown, low plasticity clay, dry.			
210		SANDY CLAY: medium to high plasticity, yellow brown, medium to coarse sand, firm to stiff, dry.			Hole diameter 171mm
20		SANDY CLAY: medium to high plasticity, grey brown with yellow brown mottling, fine to medium sand, firm to stiff, dry to slightly moist. Clayey sand lens at 20m. Becoming more yellow brown, medium plasticity sandy clay from 22m. Slightly moist at 25m.			
200					
		SILTY CLAY: high plasticity, dark brown to purple brown, stiff to very stiff, moist.			50mm PVC casing
30		CLAYEY SAND: medium grained, dark brown, low plasticity clay, moist.			
190		SANDY CLAY: medium to high plasticity, grey with yellow brown mottling, medium to coarse sand, stiff, moist to wet. Groundwater seepage from 40m in a coarse clayey sand layer.	SWL 48.40 mbtoc at 08/11/2009		
40		BASE OF TERTIARY SEDIMENTS			Backfill
180		SILTSTONE: highly to moderately weathered, brown, medium strength, dry.			
50		SANDSTONE: moderately to slightly weathered, brown to grey with strong pervasive red staining, medium grained, soft to medium stength, dry.			
170		SILTSTONE: moderately weathered to fresh, yellow brown to grey, medium stength to hard, dry to wet. Fracture zone with groundwater inlfow at 63.5m (rods dropped 50mm). Slightly weathered at 56m. Fresh from 58m.			Hole diameter 120mm
60					Bentonite pellets
160					Gravel
		SANDSTONE: fresh, grey, medium grained, medium stength to hard, fractured, wet. groundwater inflow: 2.2L/sec (V-notch weir)			50mm PVC screen
70		SILTSTONE: fresh, dk. grey, med. stength to hard, wet.			50mm PVC screen
150		SANDSTONE: fresh, grey, medium grained, med. stength to hard, wet groundwater inflow: 2.2L/sec (V-notch weir)			End of hole 76m

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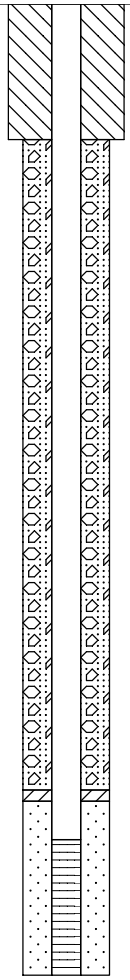
BOREHOLE LOG

BOREHOLE ID: **MB 6**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**225.25 mAHD**
DATE:	**27 Sep 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**226.25 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**648989.32 mE, 7583194.02 mN**	LOGGED BY:	**DWI**

Depth	Elevation	Lithologic Description
0		SAND: medium to coarse grained, light grey, loose, dry.
	220	SANDY CLAY: medium to high plasticity, yellow brown to red brown, medium sand, firm to stiff, dry.
		CLAYEY SAND: medium to coarse grained, grey to red brown, low plasticity clay, dry.
10		SANDY CLAY: medium plasticity, yellow brown to red brown mottling, medium sand, firm, dry.
		CLAYEY SAND: medium to coarse grained, yellow brown, low plasticity clay, dry.
	210	SANDY CLAY: medium to high plasticity, yellow brown, medium to coarse sand, firm to stiff, dry.
20		SANDY CLAY: medium to high plasticity, grey brown with yellow brown mottling, fine to medium sand, firm to stiff, dry to slightly moist. Clayey sand lens at 20m. Becoming more yellow brown, medium plasticity sandy clay from 22m. Slightly moist at 25m.
	200	
		SILTY CLAY: high plasticity, dark brown to purple brown, stiff to very stiff, moist.
30		CLAYEY SAND: medium grained, dark brown, low plasticity clay, moist.
	190	SANDY CLAY: medium to high plasticity, grey with yellow brown mottling, medium to coarse sand, stiff, moist to wet. Groundwater seepage from 40m in a coarse clayey sand layer.
40		BASE OF TERTIARY SEDIMENTS
	180	
50		
	170	
60		
	160	
70		

SWL 40.29 mbtoc at 07/11/2009



Grout

Hole Diameter 171mm

Hole Diameter 120mm

50mm PVC casing

Backfill

Bentonite pellets

Gravel

50mm PVC screen

End of hole 43m

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BOREHOLE LOG

BOREHOLE ID: **MB 7**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**229.61 mAHD**
DATE:	**12 Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**230.61 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**649797.64 mE, 7582857.64 mN**	LOGGED BY:	**DWI**

Depth	Elevation	Lithologic Description	SWL	Bore Construction	Bore Description
0		SANDY CLAY: high plasticity, dark brown, medium to coarse sand, firm to stiff, slightly moist.			Grout
		SAND: fine to coarse grained, grey brown, dry.			
		GRAVELLY SAND: fine to coarse sand with rounded to sub-angular fine to medium gravel, brown, dry.			
10	220	SANDY GRAVELLY CLAY: medium plasticity, brown, fine to coarse sand with rounded to sub-angular fine to medium gravel, firm, dry.			
		SANDY CLAY: medium to high plasticity, yellow brown, medium to coarse sand, firm to stiff, dry.			
		SANDY CLAY: medium to high plasticity, grey, strong red brown mottling, medium to coarse sand, firm to stiff, dry.			Hole diameter 171mm
20	210	SANDY CLAY: medium to high plasticity, brown to yellow brown, fine to medium sand, firm to stiff, dry to slightly moist.			
		CLAYEY SAND: medium grained, yellow brown, low plasticity clay, slightly moist.			
		SANDY CLAY: medium to high plasticity, brown to dark brown, medium sand, firm to stiff, slightly moist.			
30	200	SAND/SANDY CLAY: medium grained, grey to brown, low plasticity clay, slightly moist.			Backfill
		SANDY CLAY: medium to high plasticity, grey, strong yellow brown mottling, medium sand, firm to stiff, slightly moist			
		CLAYEY SAND: medium to coarse grained, yellow brown, low plasticity clay, slightly moist to moist (at 35m).			
40	190	SANDY CLAY: medium to high plasticity, grey to grey brown, medium to coarse sand, firm to stiff, moist. BASE OF TERTIARY SEDIMENTS			
		SILTSTONE: highly weathered to fresh, brown to grey/dark grey (with yellow brown mottling in the weathered zone), soft to hard, dry. Highly to moderately weathered to 51m. Moderately to slightly weathered to 52m. Slightly weathered to fresh to 54m. Fresh from 55m.	SWL 55.45 mbtoc at 04/11/2009		
50	180				Hole diameter 120mm
60	170	Minor seepage after rod change at 60m.			
		INTERBEDDED SILTSTONE/SANDSTONE: fresh, grey to dark grey, fine grained sandstone, medium stength to hard, dry to moist. 50% siltstone / 50% sandstone.			50mm PVC casing
		Minor seepage after rod change at 66m.			
70	160				

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BOREHOLE LOG

BOREHOLE ID: **MB 7**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**229.61 mAHD**
DATE:	**12 Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**230.61 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**649797.64 mE, 7582857.64 mN**	LOGGED BY:	**DWI**

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
80 — 150		SILTSTONE: fresh, grey to dark grey, medium stength to hard, moist.			Backfill
		INTERBEDDED SILTSTONE/SANDSTONE: fresh, grey to dark grey, fine grained sandstone, medium stength to hard, moist. 40% siltstone / 60% sandstone. Slightly increased groundwater seepage at 77m.			
		SANDSTONE: fresh, grey, fine grained, medium stength to hard, moist. Minor groundwater seepage.			Bentonite pellets
		SILTSTONE: fresh, grey to dark grey, medium stength to hard, moist.			
90 — 140		SANDSTONE: fresh, dark grey to grey, fine grained, medium stength to hard, moist to wet. Minor groundwater inflow at 83m.			50mm PVC screen
		SILTSTONE: fresh, grey to dark grey, medium stength to hard, moist to slightly wet (dust suppression).			Gravel
		INTERBEDDED SILTSTONE/SANDSTONE: fresh, grey to dark grey, fine grained sandstone, medium stength to hard, moist to slightly wet. 40% siltstone / 60% sandstone.			50mm PVC screen
100 — 130		SILTSTONE: fresh, dark grey, medium stength to hard, wet.			Bore depth 101m
		SANDSTONE: fresh, grey, medium grained, medium stength to hard, wet. groundwater inflow: <0.1L/sec. (V-notch weir)			
110 — 120					
120 — 110					
130 — 100					
140 — 90					
150 — 80					

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BOREHOLE LOG

BOREHOLE ID: **MB 8**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**229.66 mAHD**
DATE:	**13 Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**230.51 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**649794.97 mE, 7582855.25 mN**	LOGGED BY:	**DWI**

Depth	Elevation	Lithologic Description	SWL	Bore Construction	Bore Description
0		SANDY CLAY: high plasticity, dark brown, medium to coarse sand, firm to stiff, slightly moist.			Grout
		SAND: fine to coarse grained, grey brown, dry.			Hole Diameter 171mm
		GRAVELLY SAND: fine to coarse sand with rounded to sub-angular fine to medium gravel, brown, dry.			
10	220	SANDY GRAVELLY CLAY: medium plasticity, brown, fine to coarse sand with rounded to sub-angular fine to medium gravel, firm, dry.			Hole Diameter 120mm
		SANDY CLAY: medium to high plasticity, yellow brown, medium to coarse sand, firm to stiff, dry.			50mm PVC casing
		SANDY CLAY: medium to high plasticity, grey with strong red brown mottling, medium to coarse sand, firm to stiff, dry.			
20	210	SANDY CLAY: medium to high plasticity, brown to yellow brown, fine to medium sand, firm to stiff, dry to slightly moist.			Backfill
		CLAYEY SAND: medium grained, yellow brown, low plasticity clay, slightly moist.			Bentonite pellets
		SANDY CLAY: medium to high plasticity, brown to dark brown, medium sand, firm to stiff, slightly moist.	DRY at 04/11/2009		
30	200	SAND/SANDY CLAY: medium grained, grey to brown, low placsicity clay, slightly moist.			Gravel
		SANDY CLAY: medium to high plasticity, grey with strong yellow brown mottling, medium sand, firm to stiff, slightly moist.			
		CLAYEY SAND: medium to coarse grained, yellow brown, low plasticity clay, slightly moist to moist (at 35m).			50mm PVC screen
40	190	SANDY CLAY: medium to high plasticity, grey to grey brown, medium to coarse sand, firm to stiff, moist.			Bore depth 39m
		BASE OF TERTIARY SEDIMENTS			
50	180				
60	170				
70	160				

Australasian Groundwater & Environmental Consultants Pty Ltd

36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **MB 9**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**224.69 mAHD**
DATE:	**25 Sep 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**225.69 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**651604.14 mE, 7582566.03 mN**	LOGGED BY:	**DWI**

Depth	Elevation	Lithologic Description	Bore Construction
0	220	SANDY CLAY: medium to high plasticity, yellow brown to grey with yellow mottling, medium to coarse sand, firm to stiff, dry.	Grout Hole diameter 171mm
		SANDY CLAY: low to medium plasticity, red brown, medium to coarse sand, firm to stiff, dry.	
10		SANDY CLAY: high plasticity, grey to red brown, medium to coarse sand, firm, dry.	
	210	SANDY CLAY: high plasticity, yellow to red brown (becoming grey at 16m), medium to coarse sand, firm to stiff, dry.	
20		SILTY SAND: medium to coarse grained, yellow brown, dry to slightly moist.	Hole diameter 120mm
	200	SANDY CLAY: high plasticity, yellow to grey brown, medium sand, firm to stiff, dry to slightly moist.	
		BASE OF SEDIMENTARY SEDIMENTS	
30		SILTSTONE: highly weathered, brown to grey, soft to hard, dry. Limonite staining.	
	190	SANDSTONE: highly weathered, yellow brown, fine grained, soft to medium stength, dry.	
		SILTSTONE: highly weathered to fresh, brown to grey, soft to hard, dry. Slightly weathered at 40m. Fresh from 44m.	50mm PVC casing
40			
	180	SILTSTONE/CARBONACEOUS SHALE: fresh, grey to dark grey/black, medium stength to hard, dry.	
50		SILTSTONE: fresh, dark grey, medium stength to hard, dry.	
		SILTSTONE/CARBONACEOUS SHALE: fresh, grey to dark grey/black, medium stength to hard, dry.	
	170	SILTSTONE: fresh, dark grey, medium stength to hard, dry.	Backfill
60		INTERBEDDED SILTSTONE/SANDSTONE: fresh, grey to dark grey, fine grained sandstone, medium stength to hard, dry to slightly moist. 80% siltstone / 20% sandstone.	
	160	SILTSTONE: fresh, dark grey, medium stength to hard, moist.	
70		INTERBEDDED SILTSTONE/SANDSTONE: fresh, grey to dark grey, fine grained sandstone, medium stength to hard, dry to slightly moist. 90% siltstone / 10% sandstone.	
	150	SILTSTONE: fresh, dark grey, medium stength to hard, moist from 76m with dust suppression from 79m.	

SWL

SWL 64.94 mbTOC at 08/11/2009

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36 Jeays St, Bowen Hills, Queensland 4006

BOREHOLE LOG

BOREHOLE ID: **MB 9**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**224.69 mAHD**
DATE:	**25 Sep 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**225.69 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**651604.14 mE, 7582566.03 mN**	LOGGED BY:	**DWI**

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
80 / 140		SILTSTONE: fresh, dark grey, medium stength to hard, moist from 76m with dust suppression from 79m.			
90 / 130		SILTSTONE/CARBONACEOUS SHALE: fresh, grey to dark grey/black, medium stength to hard, moist to wet. minor groundwater inflow after rod change at 90m			
100 / 120		INTERBEDDED SILTSTONE/SANDSTONE: fresh, grey to dark grey, fine grained sandstone, medium stength to hard, moist to wet. 60% siltstone / 40% sandstone.			Backfill
110 / 110		SILTSTONE: fresh, dark grey, medium stength to hard, slightly wet.			Bentonite pellets
120 / 100		INTERBEDDED SILTSTONE/SANDSTONE: fresh, grey to dark grey, fine grained sandstone, medium strength to hard, moist to wet. 60% siltstone / 40% sandstone.			Gravel
130 / 90		SILTSTONE/CARBONACEOUS SHALE: fresh, grey to dark grey/black, medium stength to hard, slightly wet.			50mm PVC screen
140 / 80		COAL: fresh, black, wet. Groundwater inflow: 0.1L/sec (V-notch weir)			Bore depth 118m
150		CARBONACEOUS SHALE/SILTSTONE: fresh, grey to dark grey/black, medium stength to hard, wet.			

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BOREHOLE LOG

BOREHOLE ID: **MB 9B**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**224.72 mAHD**
DATE:	**26 Sep 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**225.72 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**65160588 mE, 7582565.40 mN**	LOGGED BY:	**DWI**

Depth / Elevation	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0 / 220		SANDY CLAY: medium to high plasticity, yellow brown to grey with yellow mottling, medium to coarse sand, firm to stiff, dry.	DRY at 04/11/2009		Grout
		SANDY CLAY: low to medium plasticity, red brown, medium to coarse sand, firm to stiff, dry.			Hole Diameter 171mm
10		SANDY CLAY: high plasticity, grey to red brown, medium to coarse sand, firm, dry.			Hole Diameter 120mm
210		SANDY CLAY: high plasticity, yellow to red brown (becoming grey at 16m), medium to coarse sand, firm to stiff, dry.			50mm PVC casing
					Backfill
20		SILTY SAND: medium to coarse grained, yellow brown, dry to slightly moist.			Bentonite pellets
200		SANDY CLAY: high plasticity, yellow to grey brown, medium sand, firm to stiff, dry to slightly moist.			Gravel
		BASE OF TERTIARY SEDIMENTS			50mm PVC screen
					Bore depth 27m
30 / 190					
40 / 180					
50 / 170					
60 / 160					
70 / 150					

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BOREHOLE LOG

BOREHOLE ID: **MB 10**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**220.19**
DATE:	**7 Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**221.19**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**647539.87 mE, 7583160.33 mN**	LOGGED BY:	**DWI**

Depth	Elevation	Lithologic Description	SWL	Bore Construction	Bore Description
0	220	SANDY CLAY: medium to high plasticity, brown to yellow brown with some red mottling, medium to coarse sand, firm to stiff, dry to slightly moist.			Grout
					Hole Diameter 171mm
10	210	BASE OF TERTIARY SEDIMENTS			
		SANDSTONE: extremely to highly weathered, brown to yellow brown, medium grained, low plasticity clay matrix, soft, dry.			
20	200	SANDSTONE: highly weathered to fresh, brown to red brown, medium to coarse grained, soft to medium stength, dry.			Hole Diameter 120mm
		Petrified wood fragments at 23m.			
30	190	Slightly weathered to fresh at 30m.			
		CARBONACEOUS SHALE: fresh, dark grey to black, dry.			
		CARBONACEOUS SHALE/COAL: fresh, dark grey to black, dry.			
		CARBONACEOUS SHALE/MUDSTONE: fresh, dull grey to black, soft, dry.			50mm PVC casing
40	180	MUDSTONE: fresh, dull grey, soft, dry.			
		SILTSTONE: fresh, dark grey, medium stength to hard, dry.			
			SWL 47.97 mbTOC at 04/11/2009		
		CARBONACEOUS SHALE/COAL: fresh, dark grey to black, dry.			
50	170	SILTSTONE: fresh, dark grey, medium stength to hard, dry.			Backfill
60	160				
70	150				Bentonite pellets

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BOREHOLE LOG

BOREHOLE ID: **MB 10**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Percussion**	GROUND LEVEL:	**220.19**
DATE:	**7 Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**221.19**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**647539.87 mE, 7583160.33 mN**	LOGGED BY:	**DWI**

Elevation / Depth	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
80 — 140		SILTSTONE: fresh, dark grey, medium stength to hard, dry.		Bentonite pellets	
		CARBONACEOUS SHALE/COAL: fresh, dark grey to black, dry.			Gravel
		SILTSTONE: fresh, dark grey, medium stength to hard, dry.			
		COAL: fresh, black, wet. Minor seepage on rod change at 84m.			50mm PVC screen
90 — 130		SILTSTONE: fresh, dark grey, medium stength to hard, dry. Minor groundwater inflow <0.1L/sec			Bore depth 89m
100 — 120					
110 — 110					
120 — 100					
130 — 90					
140 — 80					
150					

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BOREHOLE LOG

BOREHOLE ID: **MB 11**

PROJECT NO.	**G1474**	DRILLER:	**Stan Baker**	DATUM:	**AGD 1966**
PROJECT NAME:	**Coppabella Underground Proj.**	DRILLING METHOD:	**Rotary Mud**	GROUND LEVEL:	**199.40 mAHD**
DATE:	**8 Oct 2009**	DRILL RIG:	**Ingersol Rand TH60**	TOP OF CASING LEVEL:	**200.40 mAHD**
CONTRACTOR:	**Tropical Water Bores**	COORDINATES:	**651818.93 mE, 7580810.09 mN**	LOGGED BY:	**DWI**

Depth	Elevation	Graphic	Lithologic Description	SWL	Bore Construction	Bore Description
0			CLAYEY GRAVELLY SAND: medium to coarse grained, light brown, low plasticity clay, fine rounded gravel, dry.			Grout
			SANDY CLAY: medium plasticity, yellow to red brown, medium to coarse sand, firm, slightly moist.			Hole Diameter 171mm
10	190		CLAYEY SAND: fine to coarse grained, light brown with yellow and red mottling, low plasticity clay, slightly moist to dry. Overall fining downwards sequences. Mud circulation drilling from 12m.	SWL 18.65 mbTOC at 08/11/2009		Hole Diameter 120mm 50mm PVC casing Backfill Bentonite pellets Gravel
20	180		GRAVELLY CLAYEY SAND: medium to coarse grained, light brown with yellow and red mottling, fine rounded gravel, low plasticity clay.			
			SANDY CLAY: high plasticity, brown, fine to medium sand, stiff.			50mm PVC screen
			SAND: medium to coarse grained, yellow brown. Significant loss (~5,000L) in drilling fluids.			Bore depth 26m
30	170		SANDY CLAY/SANDY CLAY: high plasticity, brown, fine to medium sand, stiff.			
40	160					
50	150					
60	140					
70	130					

Appendix B

ANALYTICAL LABORATORY CERTIFICATES

CERTIFICATE OF ANALYSIS

Work Order	: **EB0917737**	Page	: 1 of 7
Client	: **AUST GROUNDWATER & ENVIRO CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR DUNCAN IRVINE	Contact	: Tim Kilmister
Address	: 36 JEAYS STREET BOWEN HILLS QLD, AUSTRALIA 4006	Address	: 32 Shand Street Stafford QLD Australia 4053
E-mail	: duncan.irvine@ageconsultants.com.au	E-mail	: Services.Brisbane@alsenviro.com
Telephone	: +61 07 32572055	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 32572088	Facsimile	: +61-7-3243 7218
Project	: G1474	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 10-NOV-2009
Sampler	: DUNCAN IRVINE	Issue Date	: 20-NOV-2009
Site	: ----		
		No. of samples received	: 8
Quote number	: BN/283/09	No. of samples analysed	: 8

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
- Surrogate Control Limits

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*
Kim McCabe	Senior Inorganic Chemist	Inorganics
Sarah Ashworth	Organic Chemist	Organics

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. However it falls within ALS Static Control Limits and hence deemed acceptable.**
- **LCS recovery for EG020F (Dissolved Metals) fall outside Dynamic Control Limits for Antimony. They are however within ALS Static Control Limits and hence deemed acceptable. No further action is required.**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: MB1	MB3	MB4	MB5	MB6
				Client sampling date / time: 07-NOV-2009 15:00	06-NOV-2009 15:00	07-NOV-2009 15:00	07-NOV-2009 15:00	07-NOV-2009 15:00
				EB0917737-001	EB0917737-002	EB0917737-003	EB0917737-004	EB0917737-005
EA005: pH								
pH Value	----	0.01	pH Unit	8.06	8.03	8.27	7.93	7.83
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	13600	12600	13300	13700	12400
EA015: Total Dissolved Solids								
^ Total Dissolved Solids @180°C	GIS-210-010	1	mg/L	9600	8020	9580	9360	8540
EA025: Suspended Solids								
^ Suspended Solids (SS)	----	1	mg/L	4	7	26	14	8500
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	135	179	163	608	694
Total Alkalinity as CaCO3	----	1	mg/L	135	179	163	608	694
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	2	2	2	583	793
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	4960	4360	4760	4660	4590
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	270	165	266	165	148
Magnesium	7439-95-4	1	mg/L	113	49	70	248	310
Sodium	7440-23-5	1	mg/L	2620	2580	2640	2790	2870
Potassium	7440-09-7	1	mg/L	27	16	18	73	94
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.01	0.02	0.10
Antimony	7440-36-0	0.001	mg/L	0.007	<0.001	<0.001	0.005	<0.001
Arsenic	7440-38-2	0.001	mg/L	0.005	0.003	0.001	0.014	0.002
Molybdenum	7439-98-7	0.001	mg/L	<0.001	<0.001	0.002	0.004	0.002
Selenium	7782-49-2	0.01	mg/L	0.02	0.02	0.02	0.02	0.02
Silver	7440-22-4	0.001	mg/L	0.004	0.002	0.002	0.002	0.001
Iron	7439-89-6	0.05	mg/L	0.57	0.27	0.43	0.40	0.40
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EN055: Ionic Balance								
^ Total Anions	----	0.01	meq/L	143	126	138	156	160
^ Total Cations	----	0.01	meq/L	137	125	134	152	160
^ Ionic Balance	----	0.01	%	1.86	0.74	1.26	1.30	0.13
EP080/071: Total Petroleum Hydrocarbons								

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: MB1	MB3	MB4	MB5	MB6
				Client sampling date / time: 07-NOV-2009 15:00	06-NOV-2009 15:00	07-NOV-2009 15:00	07-NOV-2009 15:00	07-NOV-2009 15:00
				EB0917737-001	EB0917737-002	EB0917737-003	EB0917737-004	EB0917737-005
EP080/071: Total Petroleum Hydrocarbons - Continued								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	**330**
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	**220**
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	**550**
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	**101**	**98.8**	**98.5**	**99.2**	**101**
Toluene-D8	2037-26-5	0.1	%	**101**	**102**	**99.9**	**101**	**101**
4-Bromofluorobenzene	460-00-4	0.1	%	**102**	**101**	**98.9**	**98.8**	**99.4**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: MB7	MB9	MB10	----	----
				Client sampling date / time: 06-NOV-2009 15:00	07-NOV-2009 15:00	06-NOV-2009 15:00	----	----
				EB0917737-006	EB0917737-007	EB0917737-008	----	----
EA005: pH								
pH Value	----	0.01	pH Unit	**8.12**	**7.71**	**8.37**	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**16000**	**16400**	**13800**	----	----
EA015: Total Dissolved Solids								
^ Total Dissolved Solids @180°C	GIS-210-010	1	mg/L	**16200**	**17500**	**10600**	----	----
EA025: Suspended Solids								
^ Suspended Solids (SS)	----	1	mg/L	**46**	**770**	**440**	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**175**	**133**	**302**	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**175**	**133**	**302**	----	----
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**4**	**49**	**2**	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**6970**	**7650**	**5610**	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**524**	**580**	**150**	----	----
Magnesium	7439-95-4	1	mg/L	**331**	**214**	**150**	----	----
Sodium	7440-23-5	1	mg/L	**3520**	**3690**	**3330**	----	----
Potassium	7440-09-7	1	mg/L	**67**	**27**	**45**	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**0.01**	**0.01**	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.001**	**0.003**	**0.008**	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	**0.002**	**0.001**	----	----
Selenium	7782-49-2	0.01	mg/L	**0.02**	**0.02**	**0.02**	----	----
Silver	7440-22-4	0.001	mg/L	**0.002**	**0.002**	**0.001**	----	----
Iron	7439-89-6	0.05	mg/L	**0.80**	**1.05**	**0.27**	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EN055: Ionic Balance								
^ Total Anions	----	0.01	meq/L	**200**	**219**	**164**	----	----
^ Total Cations	----	0.01	meq/L	**208**	**208**	**166**	----	----
^ Ionic Balance	----	0.01	%	**1.91**	**2.74**	**0.40**	----	----
EP080/071: Total Petroleum Hydrocarbons								

Analytical Results

Sub-Matrix: WATER				Client sample ID	MB7	MB9	MB10	----	----
				Client sampling date / time	06-NOV-2009 15:00	07-NOV-2009 15:00	06-NOV-2009 15:00	----	----
Compound	CAS Number	LOR	Unit		EB0917737-006	EB0917737-007	EB0917737-008	----	----
EP080/071: Total Petroleum Hydrocarbons - Continued									
C6 - C9 Fraction	----	20	µg/L		<20	**20**	<20	----	----
C10 - C14 Fraction	----	50	µg/L		<50	<50	<50	----	----
C15 - C28 Fraction	----	100	µg/L		<100	<100	<100	----	----
C29 - C36 Fraction	----	50	µg/L		<50	**70**	<50	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L		<50	**70**	<50	----	----
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		**97.1**	**99.0**	**109**	----	----
Toluene-D8	2037-26-5	0.1	%		**98.4**	**99.8**	**102**	----	----
4-Bromofluorobenzene	460-00-4	0.1	%		**98.4**	**103**	**102**	----	----

Surrogate Control Limits

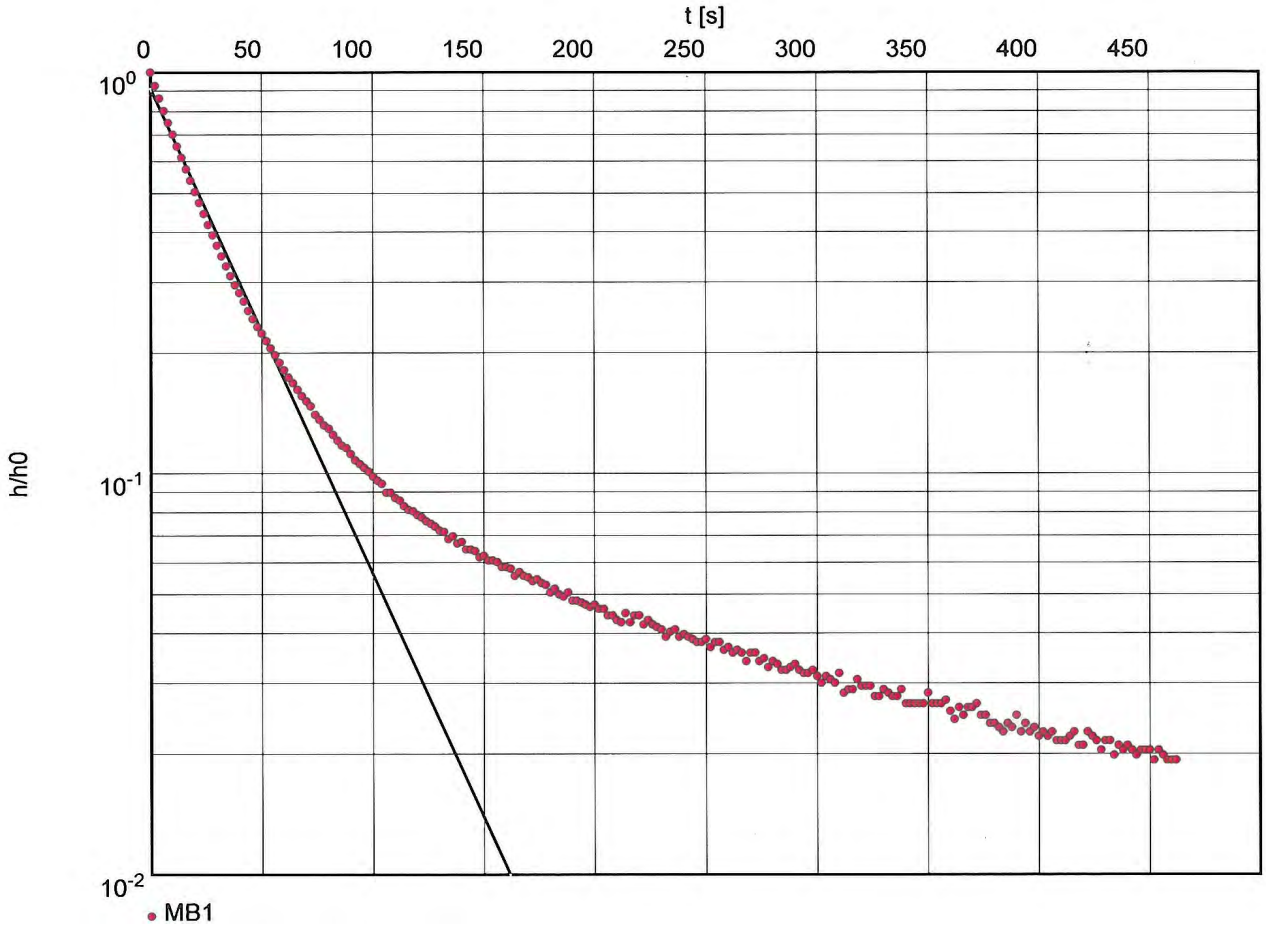
Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	80	120
Toluene-D8	2037-26-5	88	110
4-Bromofluorobenzene	460-00-4	86	115

Appendix C

PERMEABILITY TEST DATA

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009	Page 1
		Project: Coppabella Underground Project	
		Evaluated by: DWI	

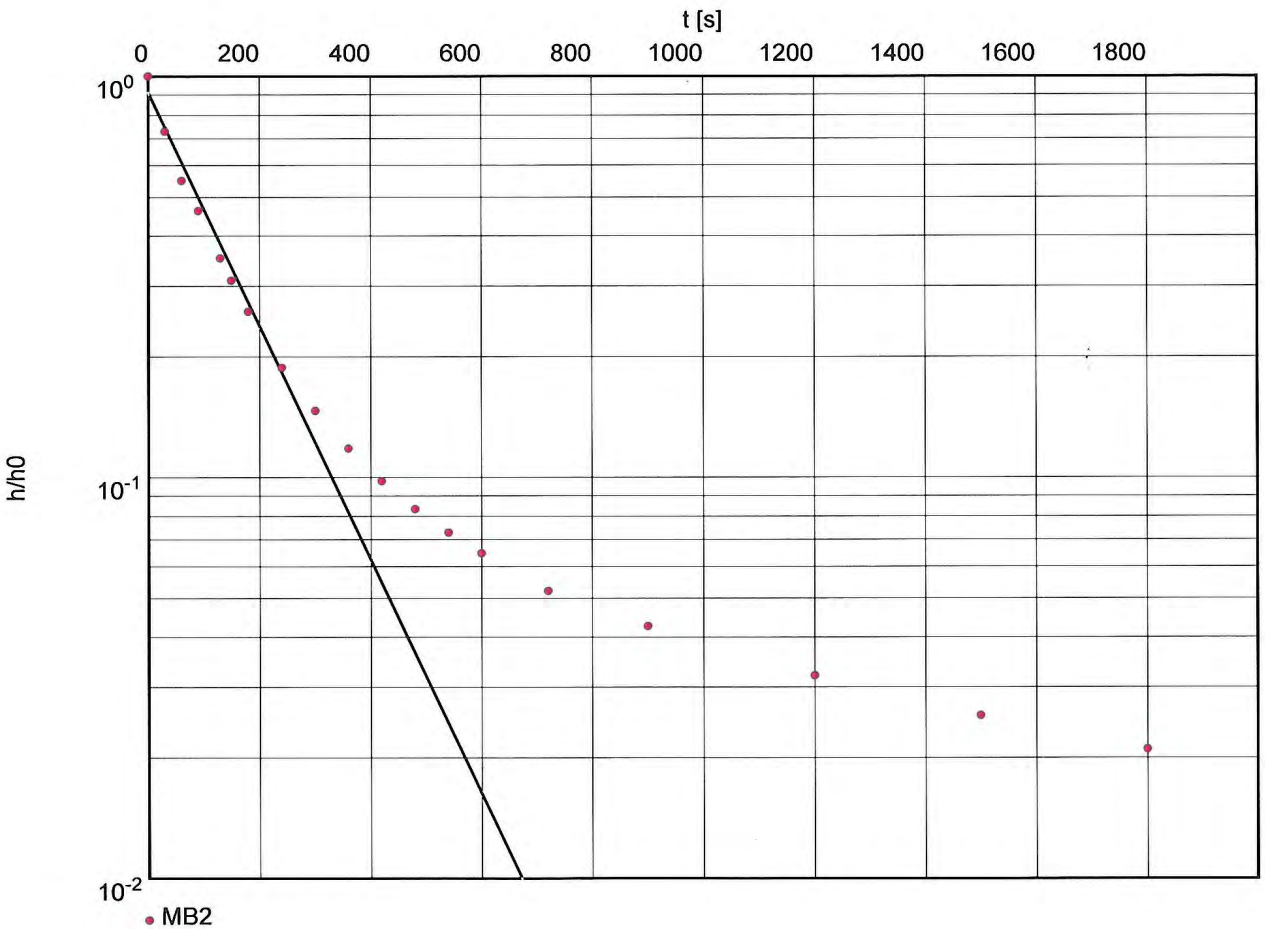
Slug Test No. 1	Test conducted on: 8/11/09
MB1	



Hydraulic conductivity [m/s]: 3.22×10^{-6}

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009 | Page 1 Project: Coppabella Underground Project Evaluated by: DWI

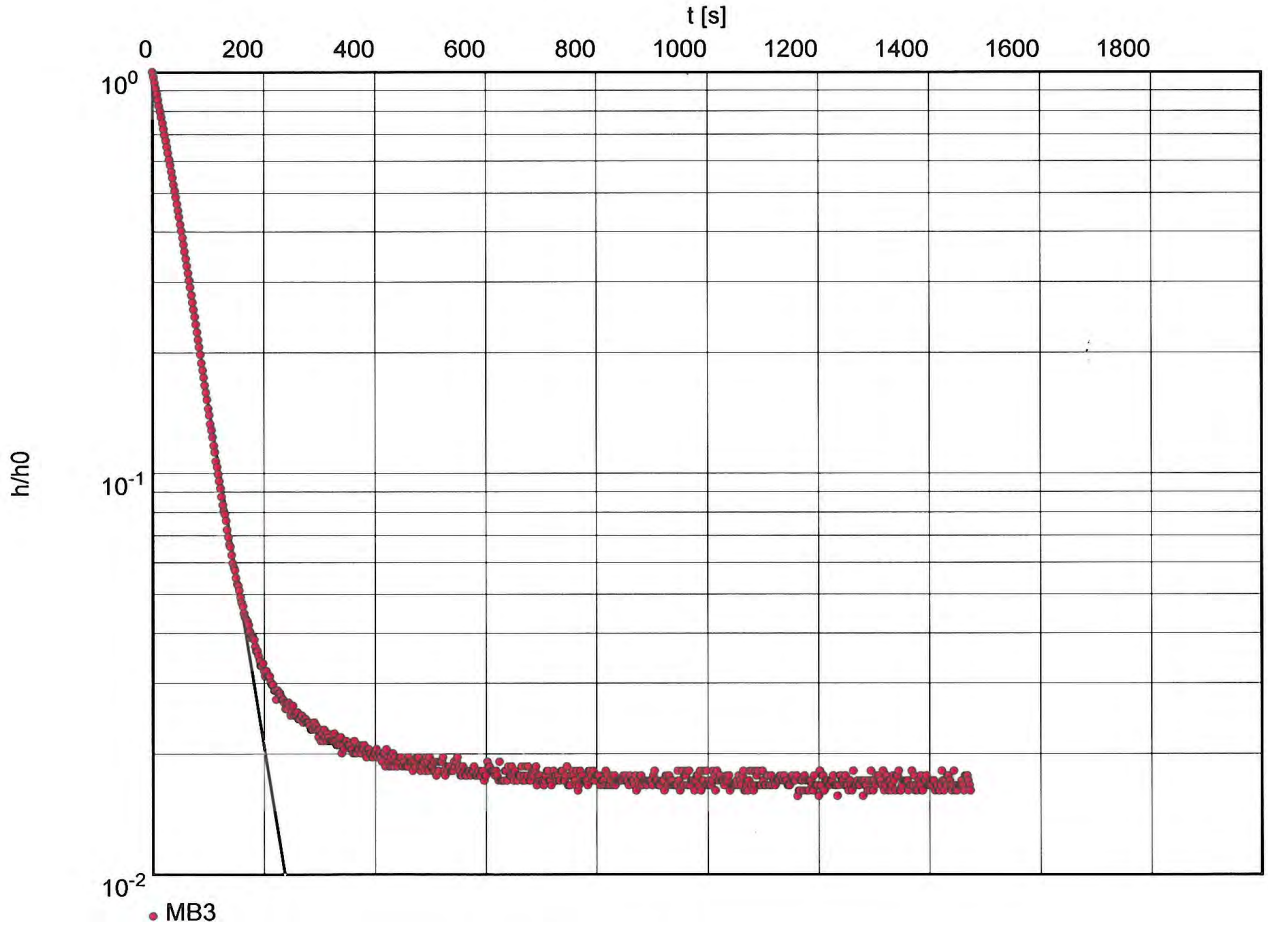
Slug Test No. 1	Test conducted on: 7/11/09
MB2	



Hydraulic conductivity [m/s]: 1.40×10^{-6}

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009	Page 1
		Project: Coppabella Underground Project	
		Evaluated by: DWI	

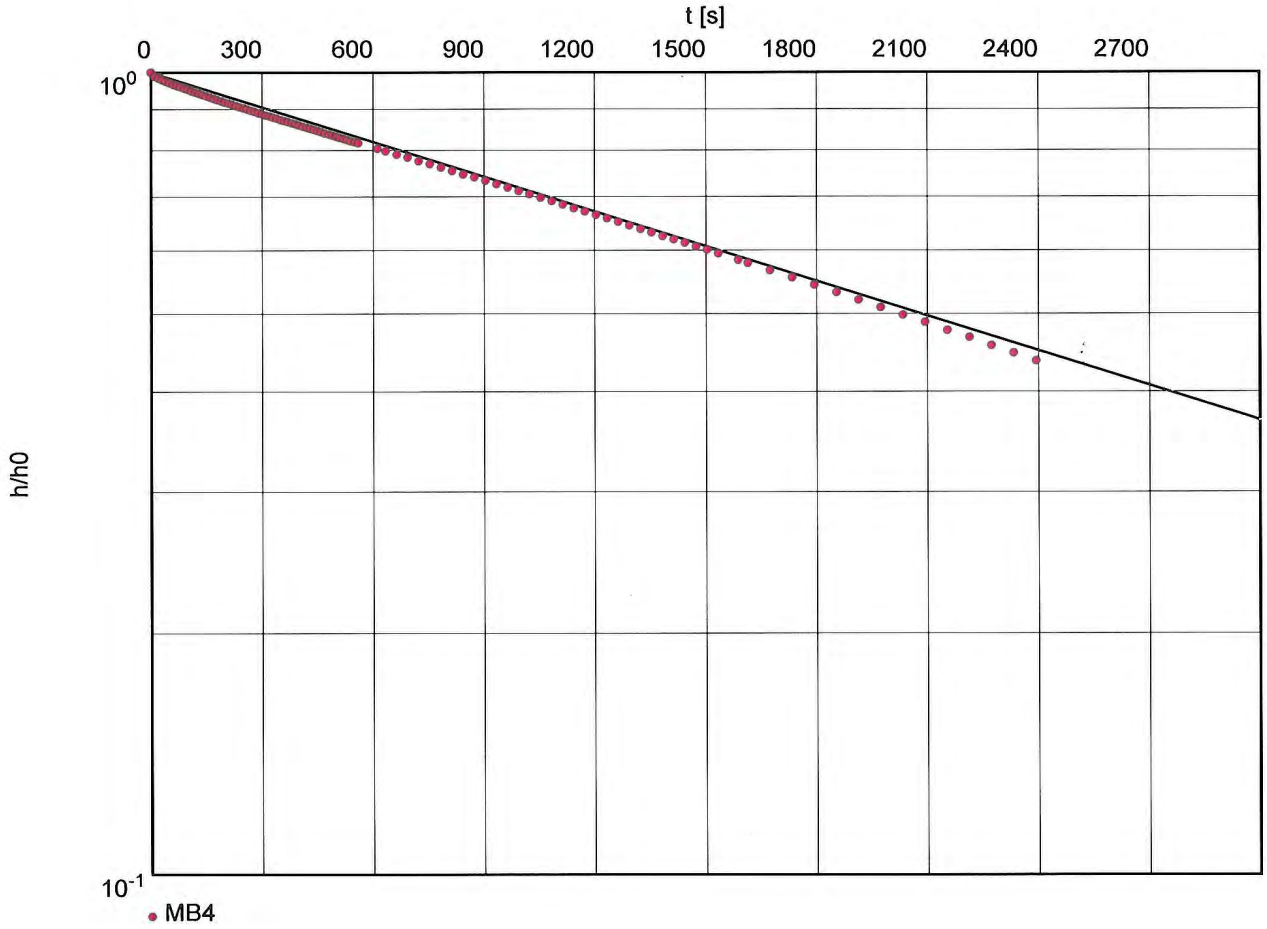
Slug Test No. 1	Test conducted on: 8/11/09
MB3	



Hydraulic conductivity [m/s]: 2.05×10^{-6}

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009	Page 1
		Project: Coppabella Underground Project	
		Evaluated by: DWI	

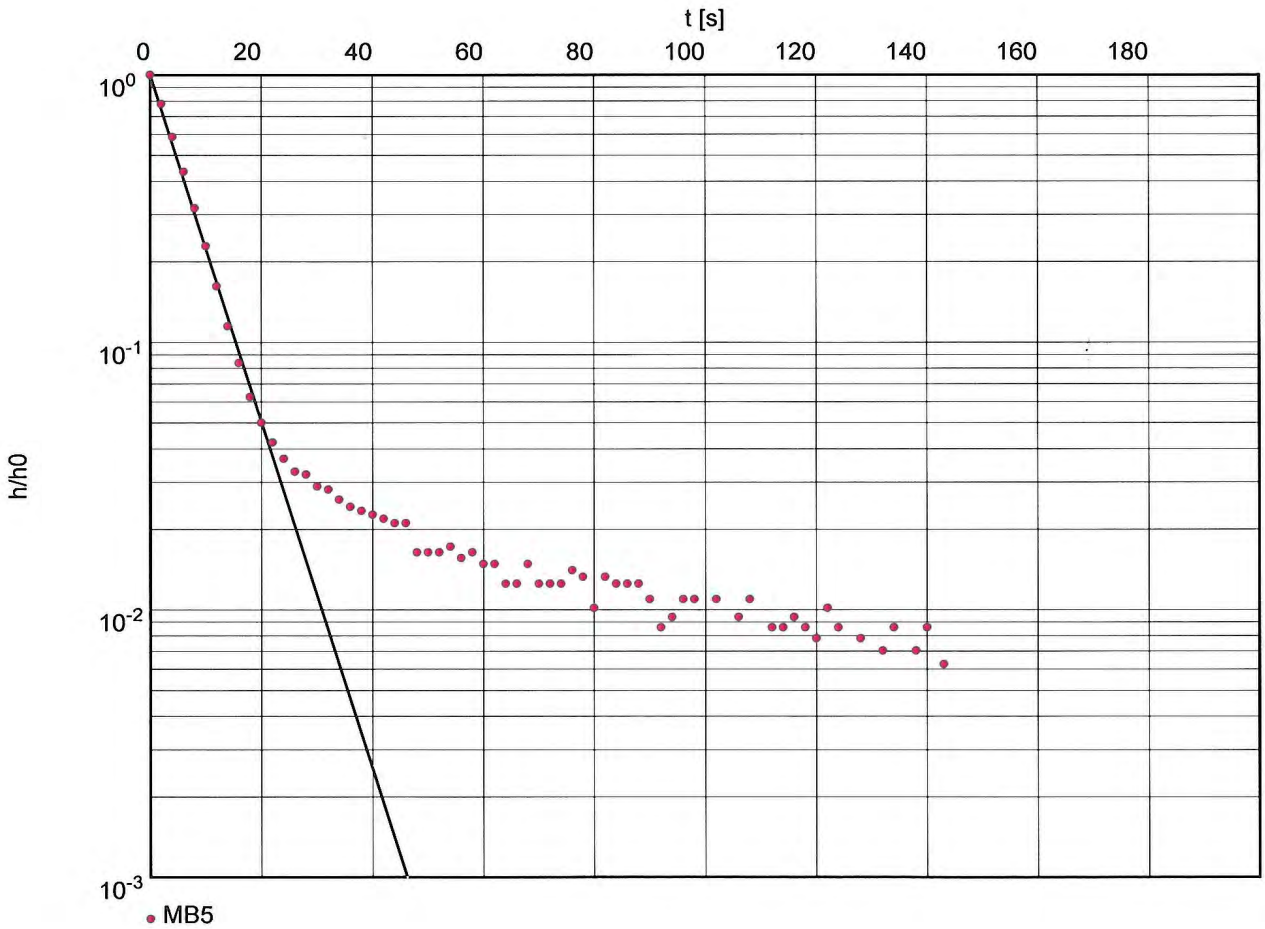
Slug Test No. 1	Test conducted on: 8/11/09
MB4	



Hydraulic conductivity [m/s]: 3.10×10^{-8}

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009	Page 1
		Project: Coppabella Underground Project	
		Evaluated by: DWI	

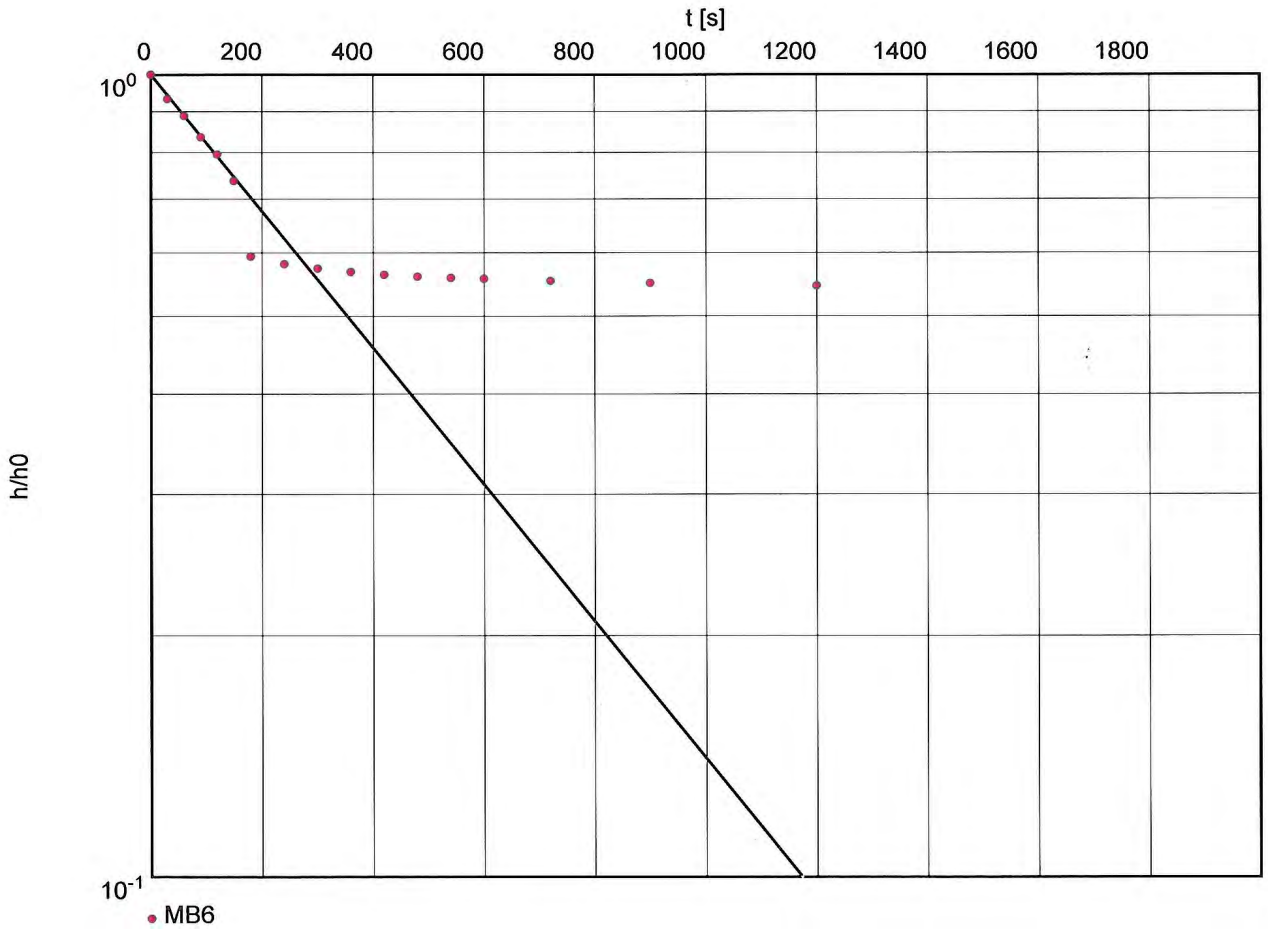
Slug Test No. 1	Test conducted on: 8/11/09
MB5	



Hydraulic conductivity [m/s]: 1.82×10^{-5}

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009	Page 1
		Project: Coppabella Underground Project	
		Evaluated by: DWI	

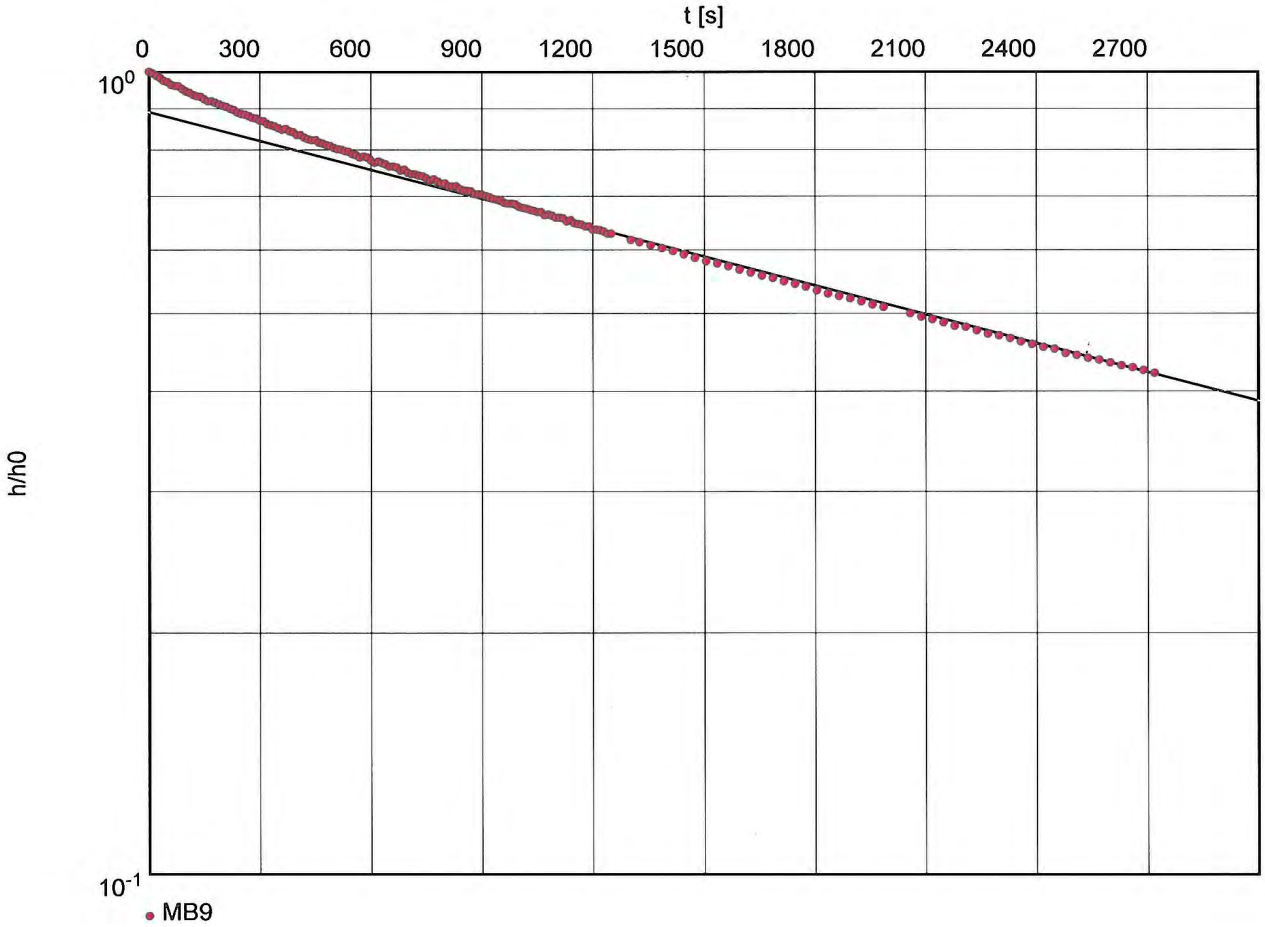
Slug Test No. 1	Test conducted on: 7/11/09
MB6	



Hydraulic conductivity [m/s]: 3.75×10^{-7}

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009 | Page 1 Project: Coppabella Underground Project Evaluated by: DWI

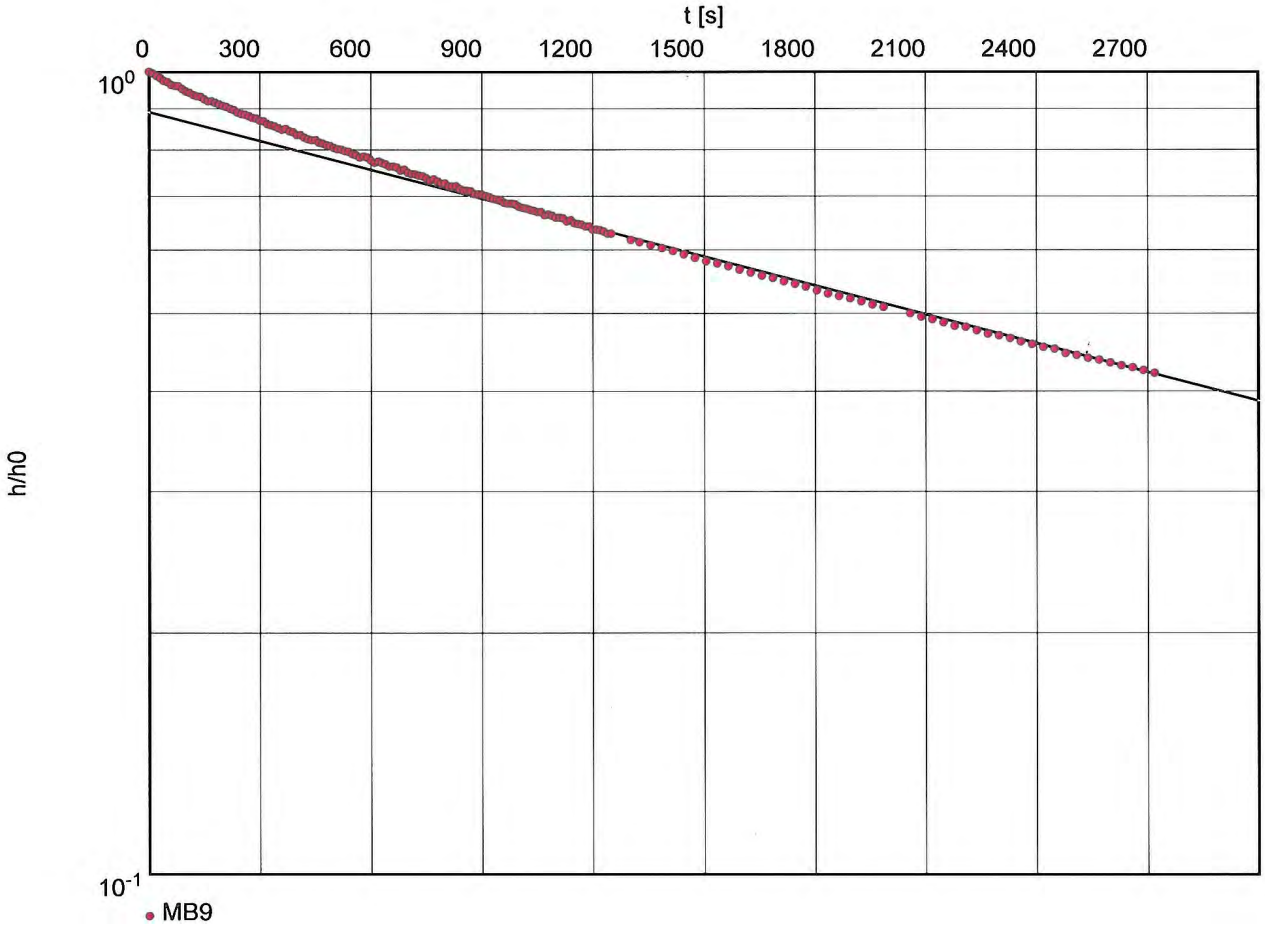
Slug Test No. 1	Test conducted on: 8/11/09
MB9	



Hydraulic conductivity [m/s]: 3.71×10^{-8}

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009 | Page 1 Project: Coppabella Underground Project Evaluated by: DWI

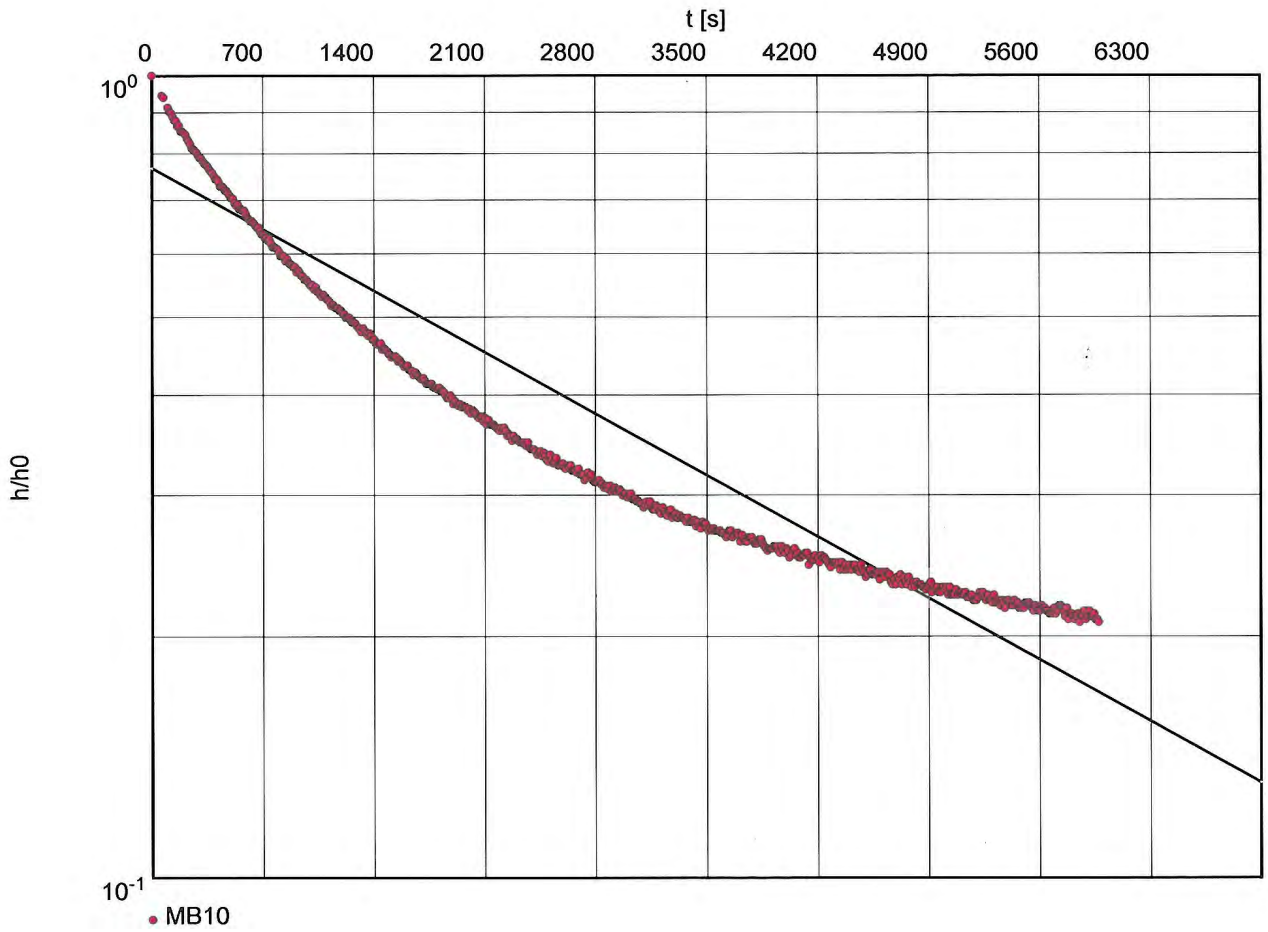
Slug Test No. 1	Test conducted on: 8/11/09
MB9	



Hydraulic conductivity [m/s]: 3.71×10^{-8}

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009	Page 1
		Project: Coppabella Underground Project	
		Evaluated by: DWI	

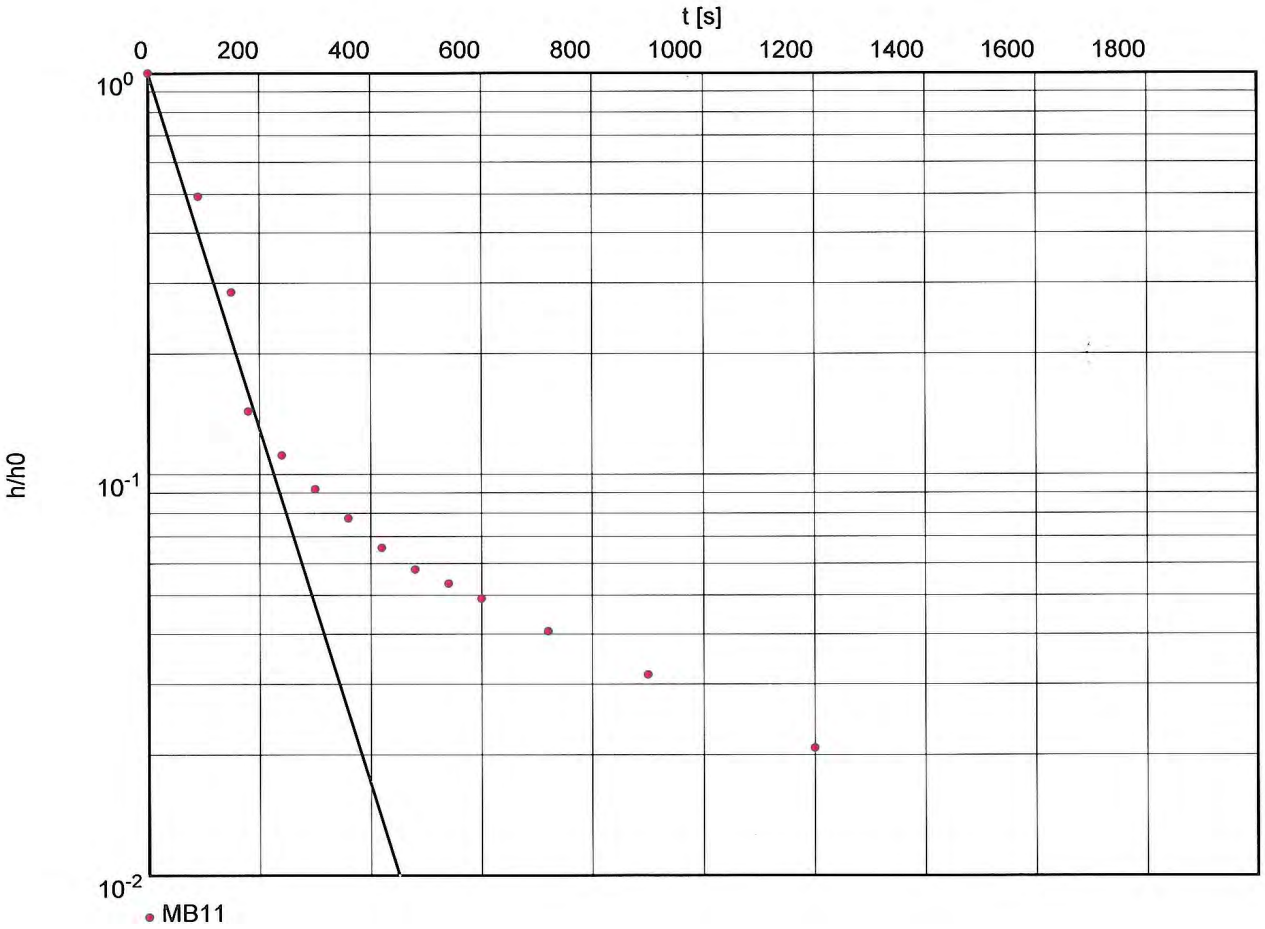
Slug Test No. 1	Test conducted on: 9/11/09
MB10	



Hydraulic conductivity [m/s]: 3.14×10^{-8}

AGE Consultants 36 Jeays Street BOWEN HILLS, QLD, 4006 AUSTRALIA	slug/bail test analysis HVORSLEV's method	Date: 18.11.2009	Page 1
		Project: Coppabella Underground Project	
		Evaluated by: DWI	

Slug Test No. 1	Test conducted on: 8/11/09
MB11	



Hydraulic conductivity [m/s]: 1.65×10^{-6}

Appendix D

SUMMARY OF REGISTERED BORE DETAILS

Appendix D - Summary of Registered and Unregistered Bore Details

Registered Number	Easting	Northing	Lot & Plan Number	Original Bore Name	Status	Depth (m)	Geology	Standing Water Level (mbGL)[1]	Bore Yield (L/sec)	Date Drilled	Water Quality[2]	Geological Stratigraphic Unit
23951	642,130	7,575,318	Lot 1 on SP158697	NQE Harrybrandt 1	Existing	-	-	-	-	2/02/1990	-	Blackwater Group
46582	636,558	7,583,562	Lot 61 on CP881527	-	Existing	250	Sandstone	-	-	20/12/1978	1,300	-
46916	636,566	7,583,454	Lot 61 on CP881527	-	Existing	58.2	Sandstone	3	<0.1	1/09/1980	-	Clematis Snadstone
81848	639,608	7,579,708	Lot 131 on RP881524	-	Existing	170	SandstoneShale	-	-	16/02/1998	-	-
85078	639,863	7,579,576	Lot 131 on RP881524	-	Existing	45	Sandstone/Ironstone	29.3	3.2	2/04/1987	-	Upper Bowen Coal
85403	650,860	7,593,075	Lot 3 on WHS16	-	Existing	3.6	Clay and Sand	0.6	0.5	10/09/1992	-	Bee Creek alluvium
100088	645,871	7,592,045	Lot 4 on WHS118	MGC Strathfield 1	Existing	1,103	-	-	-	7/11/1991	-	Moranbah Coal Measures
13040112	663,278	7,580,477	Lot 9 on CP864632	B3S3	Existing	33.5	Gravel/Carbonaceous Shale	14.08	-	3/03/1967	15,600	Bee Creek alluvium
13040113	663,225	7,580,847	Lot 9 on CP864632	B2S2	Abandoned	28.95	Clayey Sand/Grey Shale	-	-	-	-	Bee Creek alluvium
13040114	663,170	7,581,063	Lot 9 on CP864632	B1S1	Abandoned	28.95	Sandy Clay/Carbonaceous Shale	-	0.8	-	-	Bee Creek alluvium
13040115	663,230	7,581,370	Lot 9 on CP864632	B4S4	Abandoned	19.8	Gravel/Shale	-	1.0	-	-	Bee Creek alluvium

Note: - no details available

1: metres below ground/reference level

2: as electrical conductivity (μs/cm)

Datum - MGA94 Zone 55

Appendix E

OBSERVED VS SIMULATED GROUNDWATER LEVEL MODEL CALIBRATION RESULTS

Appendix E: OBSERVED AND SIMULATED GROUNDWATER LEVELS					
Bore ID	**Bore No**	**Weighting**	**Observed Head (m)**	**Simulated Head (m)**	**Residual (m)**
CP020	1	0.50	199.84	196.25	3.60
CP021C	2	0.44	190.66	194.57	-3.91
CP038	3	0.50	198.68	196.84	1.84
CP044	4	0.50	193.13	196.69	-3.56
CP051	5	0.50	186.52	189.32	-2.80
CP054	6	0.50	186.77	188.54	-1.76
CP056	7	0.50	187.73	189.86	-2.13
CP065	8	0.50	188.16	189.96	-1.80
CP067	9	0.50	188.27	190.30	-2.03
CP071	10	0.25	194.70	195.50	-0.80
CP072	11	0.50	198.54	194.87	3.67
CP075C	12	0.37	186.74	188.18	-1.44
CP078	13	0.50	188.45	190.95	-2.50
CP082L	14	0.50	188.05	190.48	-2.43
CP085C	15	0.36	189.92	191.29	-1.37
CP086	16	0.50	189.90	192.22	-2.32
CP087C	17	0.47	190.28	191.99	-1.71
CP091	18	0.50	190.38	192.50	-2.12
CP100	19	0.38	189.76	191.22	-1.46
CP102	20	0.50	188.53	190.48	-1.94
CP105	21	0.31	190.89	192.05	-1.16
CP106	22	0.34	190.88	192.18	-1.30
CP109	23	0.38	186.88	190.98	-4.10
CP111	24	0.32	190.35	191.56	-1.21
CP112	25	0.45	190.24	191.90	-1.66
CP113	26	0.38	191.14	192.61	-1.47
CP114	27	0.50	190.34	192.38	-2.04
CP115	28	0.20	191.91	192.23	-0.32
CP116	29	0.50	190.07	192.08	-2.01
CP117	30	0.32	190.72	191.95	-1.23
CP120	31	0.50	188.95	191.32	-2.37
CP121	32	0.50	189.37	191.57	-2.20
CP124	33	0.35	189.16	190.50	-1.34
CP125	34	0.50	189.66	191.59	-1.93
CP127	35	0.50	188.81	190.84	-2.03
CP128	36	0.50	188.28	190.30	-2.02
CP129	37	0.40	188.67	190.21	-1.54
CP131	38	0.50	188.90	191.88	-2.98
CP132	39	0.50	188.78	191.29	-2.51
CP134C	40	0.38	189.53	190.98	-1.45
CP135C	41	0.45	189.95	191.61	-1.66
CP136C	42	0.34	189.15	190.44	-1.29
CP137C	43	0.50	187.55	189.86	-2.31
CP138	44	0.50	189.94	192.22	-2.28
CP140	45	0.50	188.66	190.61	-1.94

Appendix E: OBSERVED AND SIMULATED GROUNDWATER LEVELS					
Bore ID	**Bore No**	**Weighting**	**Observed Head (m)**	**Simulated Head (m)**	**Residual (m)**
CP141	46	0.50	188.43	190.77	-2.34
CP147	47	0.50	188.83	190.83	-2.00
CP149	48	0.33	186.40	190.71	-4.31
CP150	49	0.50	188.35	190.56	-2.21
CP153	50	0.50	189.70	191.52	-1.82
CP154	51	0.50	189.03	191.75	-2.72
CP155	52	0.50	189.26	191.81	-2.55
CP158	53	0.45	191.05	192.73	-1.67
CP159	54	0.48	191.16	192.90	-1.74
CP160C	55	0.50	190.09	192.34	-2.25
CP161C	56	0.50	189.97	192.58	-2.61
CP162C	57	0.50	189.69	191.81	-2.12
CP163C	58	0.50	188.47	191.15	-2.68
CP164	59	0.50	190.84	192.92	-2.08
CP165C	60	0.50	187.19	190.09	-2.90
CP168L	61	0.36	189.31	190.69	-1.38
CP169	62	0.50	190.88	192.92	-2.04
CP172	63	0.41	191.00	192.55	-1.55
CP174	64	0.50	190.24	192.17	-1.93
CP177	65	0.05	178.68	191.13	-12.45
CP178	66	0.50	190.11	192.50	-2.38
CP179	67	0.50	190.51	192.63	-2.12
CP180	68	0.34	192.08	193.40	-1.32
CP187	69	0.50	190.97	193.31	-2.34
CP189	70	0.39	191.48	192.98	-1.50
CP192	71	0.30	184.27	185.39	-1.12
CP194	72	0.47	190.77	186.94	3.83
CP195	73	0.21	185.24	185.67	-0.43
CP200	74	0.41	192.96	194.52	-1.56
CP203	75	0.24	184.32	185.03	-0.71
CP210	76	0.20	185.76	185.49	0.27
CP215	77	0.26	185.02	185.87	-0.85
CP219	78	0.50	190.80	192.95	-2.15
CP220C	79	0.28	182.85	187.40	-4.55
CP221C	80	0.50	186.17	188.48	-2.31
CP224C	81	0.24	187.79	188.52	-0.73
CP225C	82	0.30	186.08	187.22	-1.13
CP226	83	0.50	185.39	187.58	-2.19
CP231	84	0.31	186.65	187.81	-1.16
CP232	85	0.33	185.79	187.04	-1.25
CP234	86	0.25	184.75	185.49	-0.74
CP237	87	0.32	192.84	194.06	-1.22
CP238	88	0.50	191.58	193.35	-1.77
CP239	89	0.44	191.18	192.82	-1.64
CP242	90	0.50	192.19	194.32	-2.13

Appendix E: OBSERVED AND SIMULATED GROUNDWATER LEVELS					
Bore ID	**Bore No**	**Weighting**	**Observed Head (m)**	**Simulated Head (m)**	**Residual (m)**
CP243	91	0.50	189.92	193.18	-3.26
CP244	92	0.36	192.98	194.38	-1.40
CP247	93	0.38	189.88	193.97	-4.09
CP250C	94	0.50	185.30	187.89	-2.59
CP251	95	0.15	182.56	188.60	-6.04
CP252	96	0.50	186.33	189.56	-3.23
CP253	97	0.26	187.00	191.70	-4.70
CP254	98	0.24	187.53	192.38	-4.85
CP261	99	0.45	193.11	194.77	-1.66
CP262	100	0.45	193.32	194.99	-1.67
CP263	101	0.23	194.44	195.04	-0.60
CP266C	102	0.38	191.30	192.76	-1.46
CP268C	103	0.50	190.82	193.28	-2.46
CP273	104	0.37	187.93	189.35	-1.42
CP276	105	0.41	188.73	190.28	-1.55
CP287	106	0.42	190.19	191.77	-1.58
CP288	107	0.50	189.85	191.92	-2.07
CP294	108	0.24	186.18	186.88	-0.70
CP296	109	0.29	185.32	186.34	-1.02
CP297	110	0.21	185.83	186.24	-0.41
CP299C	111	0.50	186.75	188.54	-1.79
CP301	112	0.50	187.43	189.23	-1.80
CP304	113	0.41	187.36	188.92	-1.56
CP305	114	0.35	186.96	188.31	-1.35
CP310	115	0.42	190.95	192.52	-1.57
CP311	116	0.31	191.16	192.33	-1.17
CP317	117	0.50	189.67	193.40	-3.73
CP324	118	0.42	189.67	193.65	-3.98
CP327	119	0.45	190.40	194.28	-3.88
CP337	120	0.29	193.08	194.14	-1.06
CP339	121	0.32	193.27	194.48	-1.21
CP341	122	0.50	192.38	194.90	-2.52
CP344	123	0.20	195.84	195.54	0.30
CP346	124	0.25	196.92	196.11	0.81
CP350	125	0.38	191.95	193.42	-1.47
CP351	126	0.50	193.44	195.35	-1.91
CP354	127	0.50	193.67	195.71	-2.04
CP356	128	0.50	193.72	195.86	-2.14
CP358	129	0.50	194.23	196.08	-1.85
CP374	130	0.28	194.64	195.61	-0.97
CP379C	131	0.50	198.20	195.76	2.44
CP383C	132	0.40	185.50	189.54	-4.04
CP384C	133	0.26	188.60	189.44	-0.84
CP385C	134	0.23	189.41	190.05	-0.64
CP385R	135	0.24	189.42	190.12	-0.70

Appendix E: OBSERVED AND SIMULATED GROUNDWATER LEVELS					
Bore ID	**Bore No**	**Weighting**	**Observed Head (m)**	**Simulated Head (m)**	**Residual (m)**
CP386C	136	0.50	188.27	190.78	-2.51
CP387C	137	0.50	190.45	192.58	-2.13
CP389C	138	0.21	191.80	191.46	0.34
CP390	139	0.21	195.42	195.81	-0.39
CP392	140	0.05	183.96	196.24	-12.28
CP394	141	0.31	197.97	196.78	1.19
CP020	142	0.01	161.72	196.21	-34.49
CP021C	143	0.19	190.66	194.47	-3.81
CP044	144	0.20	193.13	196.58	-3.45
CP072	145	0.19	198.54	194.73	3.81
CP100	146	0.02	177.56	191.20	-13.64
CP100	147	0.02	177.56	191.20	-13.64
CP106	148	0.13	190.88	192.13	-1.25
CP109	149	0.08	185.28	190.71	-5.43
CP109	150	0.08	185.28	190.71	-5.43
CP111	151	0.20	189.35	191.49	-2.14
CP111	152	0.20	189.35	191.49	-2.14
CP112	153	0.16	190.24	191.80	-1.55
CP113	154	0.14	191.14	192.44	-1.30
CP114	155	0.15	190.84	192.28	-1.44
CP114	156	0.15	190.84	192.28	-1.44
CP115	157	0.08	191.91	192.17	-0.26
CP116	158	0.11	191.17	192.06	-0.89
CP116	159	0.11	191.17	192.06	-0.89
CP117	160	0.11	190.72	191.69	-0.97
CP120	161	0.03	182.35	191.23	-8.88
CP120	162	0.03	182.35	191.23	-8.88
CP121	163	0.12	190.27	191.41	-1.14
CP121	164	0.12	190.27	191.41	-1.14
CP136C	165	0.20	186.95	190.38	-3.43
CP136C	166	0.20	186.95	190.38	-3.43
CP138	167	0.15	190.74	192.16	-1.42
CP138	168	0.15	190.74	192.16	-1.42
CP138	169	0.15	190.74	192.16	-1.42
CP138	170	0.16	190.64	192.19	-1.55
CP138	171	0.16	190.64	192.19	-1.55
CP138	172	0.16	190.64	192.19	-1.55
CP158	173	0.15	191.05	192.53	-1.48
CP160C	174	0.16	190.69	192.24	-1.55
CP160C	175	0.16	190.69	192.24	-1.55
CP161C	176	0.20	190.67	192.42	-1.75
CP161C	177	0.20	190.67	192.42	-1.75
CP169	178	0.20	190.88	192.67	-1.79
CP177	179	0.02	178.68	191.09	-12.41
CP178	180	0.18	190.71	192.36	-1.65

Appendix E: OBSERVED AND SIMULATED GROUNDWATER LEVELS					
Bore ID	**Bore No**	**Weighting**	**Observed Head (m)**	**Simulated Head (m)**	**Residual (m)**
CP178	181	0.18	190.71	192.36	-1.65
CP178	182	0.18	190.71	192.36	-1.65
CP178	183	0.20	190.51	192.44	-1.93
CP178	184	0.20	190.51	192.44	-1.93
CP178	185	0.20	190.51	192.44	-1.93
CP179	186	0.14	191.11	192.45	-1.34
CP179	187	0.14	191.11	192.45	-1.34
CP179	188	0.14	191.11	192.45	-1.34
CP179	189	0.18	190.91	192.55	-1.64
CP179	190	0.18	190.91	192.55	-1.64
CP179	191	0.18	190.91	192.55	-1.64
CP180	192	0.13	192.08	193.29	-1.21
CP187	193	0.20	190.97	193.22	-2.25
CP189	194	0.13	191.48	192.71	-1.23
CP210	195	0.08	185.76	185.43	0.33
CP219	196	0.20	190.80	192.69	-1.89
CP225C	197	0.12	185.98	187.15	-1.17
CP225C	198	0.12	185.98	187.15	-1.17
CP225C	199	0.12	185.98	187.15	-1.17
CP225C	200	0.11	186.28	187.19	-0.91
CP225C	201	0.11	186.28	187.19	-0.91
CP225C	202	0.11	186.28	187.19	-0.91
CP231	203	0.11	186.65	187.59	-0.94
CP243	204	0.20	191.22	193.13	-1.91
CP243	205	0.20	191.22	193.13	-1.91
CP266C	206	0.13	191.30	192.55	-1.25
CP268C	207	0.20	190.82	193.20	-2.38
CP287	208	0.14	190.19	191.56	-1.37
CP301	209	0.19	187.43	189.17	-1.73
CP310	210	0.15	190.95	192.38	-1.43
CP311	211	0.12	191.16	192.24	-1.08
CP317	212	0.20	189.67	193.29	-3.62
CP384C	213	0.10	188.60	189.39	-0.79
CP385C	214	0.09	189.41	190.04	-0.63
CP386C	215	0.16	189.17	190.68	-1.51
CP386C	216	0.16	189.17	190.68	-1.51
CP387C	217	0.20	190.45	192.51	-2.06
CP389C	218	0.09	190.90	191.33	-0.43
CP389C	219	0.09	190.90	191.33	-0.43
CP510	220	0.20	186.22	188.22	-2.00
CP511	221	0.12	186.36	187.51	-1.15
CP512	222	0.20	186.09	188.06	-1.97
CP513	223	0.20	186.33	188.19	-1.86
CP514	224	0.14	185.77	187.07	-1.30
CP516	225	0.18	185.97	187.64	-1.67

Appendix E: OBSERVED AND SIMULATED GROUNDWATER LEVELS					
Bore ID	**Bore No**	**Weighting**	**Observed Head (m)**	**Simulated Head (m)**	**Residual (m)**
CP518	226	0.20	186.25	188.10	-1.85
CP519	227	0.16	185.97	187.49	-1.52
CP520	228	0.19	185.93	187.65	-1.72
CP521	229	0.20	186.26	188.07	-1.81
CP521	230	0.20	186.26	188.07	-1.81
CP521	231	0.16	186.56	188.09	-1.53
CP521	232	0.16	186.56	188.09	-1.53
CP522	233	0.09	186.20	186.65	-0.45
CP525F	234	0.09	186.97	187.63	-0.66
CP526	235	0.15	186.64	188.04	-1.40
CP528	236	0.16	188.25	186.70	1.55
CP529	237	0.20	190.63	187.39	3.24
CP530	238	0.14	186.26	187.59	-1.33
CP531	239	0.11	187.20	188.11	-0.91
CP532	240	0.10	185.83	186.61	-0.78
CP534	241	0.14	186.16	187.46	-1.30
CP536	242	0.14	186.36	187.66	-1.30
CP538	243	0.10	185.22	186.01	-0.79
CP539	244	0.15	185.93	187.38	-1.45
CP540	245	0.11	186.54	187.51	-0.97
CP541	246	0.13	186.44	187.66	-1.22
CP542	247	0.08	187.87	188.01	-0.14
CP544	248	0.20	184.01	186.58	-2.57
CP546	249	0.03	197.48	187.44	10.04
CP548	250	0.18	185.95	187.59	-1.64
CP550	251	0.17	185.66	187.23	-1.57
CP551	252	0.20	185.67	187.53	-1.86
CP575	253	0.20	186.93	189.43	-2.50
CP575	254	0.20	186.93	189.43	-2.50
CP575	255	0.07	189.43	189.53	-0.10
CP575	256	0.07	189.43	189.53	-0.10
CP576C	257	0.09	188.21	188.67	-0.46
CP577	258	0.12	189.06	190.16	-1.10
CP578	259	0.12	187.47	188.64	-1.17
CP579	260	0.20	187.15	189.38	-2.23
CP581	261	0.09	190.52	191.09	-0.57
CP582C	262	0.09	188.24	188.69	-0.45
CP583	263	0.12	190.18	191.32	-1.14
CP583	264	0.12	190.18	191.32	-1.14
CP583	265	0.15	189.98	191.38	-1.40
CP583	266	0.15	189.98	191.38	-1.40
CP584	267	0.10	190.71	191.55	-0.84
CP585	268	0.11	187.72	188.69	-0.97
CP586	269	0.20	192.13	189.25	2.88
CP587	270	0.09	188.90	189.49	-0.59

Appendix E: OBSERVED AND SIMULATED GROUNDWATER LEVELS					
Bore ID	**Bore No**	**Weighting**	**Observed Head (m)**	**Simulated Head (m)**	**Residual (m)**
CP588	271	0.20	188.18	190.03	-1.85
CP589	272	0.07	195.77	190.27	5.50
CP590	273	0.09	190.03	190.53	-0.50
CP591	274	0.07	191.03	191.04	-0.01
CP592	275	0.13	190.31	191.54	-1.22
CP597	276	0.08	190.93	191.30	-0.36
CP598	277	0.07	191.98	192.07	-0.09
CP599	278	0.08	191.22	191.46	-0.24
CP647C	279	0.01	173.10	191.27	-18.17
CP648C	280	0.01	169.30	191.16	-21.86
CP649C	281	0.01	166.40	191.17	-24.77
CP650C	282	0.01	164.90	191.13	-26.23
CP651C	283	0.01	159.10	191.08	-31.98
CP653C	284	0.04	184.30	191.54	-7.24
CP654C	285	0.04	183.40	191.42	-8.01
CP658C	286	0.03	182.10	191.29	-9.19
CP659C	287	0.02	177.20	191.32	-14.12
CQ132	288	0.09	179.96	179.37	0.59
CQ133	289	0.20	181.36	179.32	2.04
CQ134	290	0.04	181.91	190.05	-8.14
CQ135	291	0.20	182.77	180.41	2.36
CQ136	292	0.20	183.35	180.35	3.00
CQ137	293	0.20	183.97	180.45	3.52
CQ138	294	0.09	186.18	181.18	5.00
CQ139	295	0.08	185.94	180.71	5.23
CQ140	296	0.08	186.11	180.71	5.40
CQ141	297	0.08	186.00	180.71	5.29
CQ142	298	0.07	180.05	174.36	5.69
CQ143	299	0.04	181.86	174.33	7.54
CQ144	300	0.20	186.30	189.36	-3.06
CQ145	301	0.11	186.20	181.60	4.60
CQ146	302	0.16	185.57	181.57	4.00
CQ147	303	0.20	185.45	181.74	3.71
CQ148	304	0.02	176.26	189.28	-13.02
CQ149	305	0.20	183.80	181.74	2.06
CQ150	306	0.20	187.11	184.36	2.75
CQ151	307	0.18	187.56	189.24	-1.68
CQ152	308	0.13	181.09	185.35	-4.26
CQ153	309	0.13	186.51	185.26	1.25
CQ154	310	0.20	187.42	185.24	2.18
CQ159C	311	0.19	177.19	175.44	1.75
CQ160C	312	0.15	183.70	182.25	1.45
CQ161C	313	0.20	182.92	179.31	3.61
MB1	314	15.00	180.43	191.51	-11.08
MB10	315	15.00	173.72	166.47	7.25

Appendix E: OBSERVED AND SIMULATED GROUNDWATER LEVELS					
Bore ID	**Bore No**	**Weighting**	**Observed Head (m)**	**Simulated Head (m)**	**Residual (m)**
MB11	316	15.00	182.04	186.39	-4.35
MB2	317	15.00	190.47	192.85	-2.38
MB3	318	15.00	177.75	192.56	-14.81
MB4	319	15.00	183.39	189.26	-5.87
MB5	320	15.00	178.28	187.45	-9.17
MB6	321	15.00	186.29	173.77	12.52
MB7	322	15.00	175.51	189.28	-13.77
MB9	323	15.00	161.05	167.92	-6.87
RN13040112_1	324	1.00	162.72	163.19	-0.47
RN13040112_2	325	1.00	162.71	163.11	-0.40
RN13040112_3	326	1.00	162.72	163.08	-0.36
RN13040112_4	327	1.00	162.67	163.05	-0.38
RN13040112_5	328	1.00	162.62	163.03	-0.41
RN13040112_6	329	1.00	162.70	163.14	-0.44
RN13040112_7	330	1.00	162.59	163.12	-0.53
RN13040112_8	331	1.00	162.48	163.03	-0.55
RN13040112_9	332	1.00	162.44	163.11	-0.67
RN13040112_10	333	1.00	162.45	163.08	-0.63
RN13040112_11	334	1.00	162.36	163.18	-0.82
RN13040112_12	335	1.00	162.35	163.18	-0.83
RN13040112_13	336	1.00	162.24	163.09	-0.84
RN13040112_14	337	1.00	162.20	163.16	-0.96
RN13040112_15	338	1.00	162.20	163.02	-0.82
RN13040112_16	339	1.00	162.16	163.01	-0.84
RN13040112_17	340	1.00	162.12	163.03	-0.91
RN13040112_18	341	1.00	162.09	163.12	-1.03
RN13040112_19	342	1.00	162.07	163.17	-1.10
RN13040112_20	343	1.00	162.05	163.03	-0.98
RN13040112_21	344	1.00	162.04	163.02	-0.97
RN13040112_22	345	1.00	162.01	163.03	-1.02
RN13040112_23	346	1.00	161.95	163.14	-1.19
RN13040112_24	347	1.00	161.93	163.08	-1.14
RN13040112_25	348	1.00	161.90	163.17	-1.27
RN13040112_26	349	1.00	161.91	163.13	-1.22
RN13040112_27	350	1.00	161.97	163.12	-1.15
RN13040112_28	351	1.00	162.04	163.05	-1.01
RN13040112_29	352	1.00	162.05	163.01	-0.96
RN13040112_30	353	1.00	162.14	163.06	-0.92

Appendix E
Environmental Management Plan (Peabody 2014)



ENVIRONMENTAL MANAGEMENT PLAN
JOHNSON EXTENDED PROJECT

CB02-1000-EV-MPL-0001
April 2014

Peabody Coppabella Pty Ltd
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C	07/04/2014	Issued for Review	Jason Martin	Bob Gallagher	Bob Gallagher
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1. Introduction

This Environmental Management Plan (EM Plan) has been developed in support of the Environmental Authority (EA) application for the Johnson Extended Project submitted by the Proponent in 2007 under the *Environmental Protection Act 1994* (EP Act). In compliance with decision made by the Department of Environment and Heritage (DEHP) on 5 November 2013, this EM Plan has been prepared in accordance with the previous (i.e. prior to 31 March 2013 amendments) section 203 of the EP Act, while accounting for the current requirements of the EP Act, as detailed in the following Guidelines:

- *Application requirements for activities with impacts to water, Version 1A*
- *Application requirements for activities with impacts to air, Version 1*
- *Application requirements for activities with impacts to land, Version 1*
- *Application requirements for activities with noise impacts, Version 1*
- *Application requirements for activities with waste impacts, Version 1*

As per the previous section 202 of the EP Act the purpose of the submitted EM plan is to propose environmental protection commitments to assist the administering authority in preparing the draft environmental authority for the application.

1.1 Environmental Management Plan Outline

This Environmental Management Plan (EM Plan) has been prepared to address the content requirements of the previous section 203 of the EP Act, with consideration of the content requirements for EA applications under the current EP Act along with the abovementioned guidelines developed under the EP Act.

Section 1.0 provides an overview of the Johnson Extended Project activities for which approval is sought and the relationship with existing and adjacent projects, and sets out the background to the EA application and studies undertaken previously in support of the application.

Section 2.0 provides a detailed description of the project components, including the land on which the activities are proposed.

Section 3.0 includes an assessment of the likely impact of each relevant activity on the environmental values, including:

a. a description of the environmental values likely to be affected by each relevant activity;
b. details of any emissions or releases likely to be generated by each relevant activity;
c. a description of the risk and likely magnitude of impacts on the environmental values;
d. details of the management practices proposed to be implemented to prevent or minimise adverse impacts; and
e. details of how the land the subject of the application will be rehabilitated after each relevant activity ceases.

This section also describes the proposed measures for minimising and managing waste generated by each relevant activity, and details relevant to site management plans that relate to the subject land. Section 3 further describes codes of environmental compliance applicable to the activities and proposes draft conditions to include in the EA.

Section 4.0 describes the framework for implementation of the EM Plan and processes for the engenderment of continuous improvement in its application including training, non-conformity and emergency management, communications management, measuring, monitoring, reporting, auditing and review.

1.2 The Proponent

The Proponent of the Johnson Extended Project comprising mining lease applications numbered 70384, 70385, 70386 and 70387 (the Johnson Extended Project MLAs), also referred to as Johnson Extended #3, #4, #5 and #6, until recently was Peabody Coppabella Pty Ltd. On 4 March 2014 the Johnson Extended Project MLAs were approved and transferred to the Coppabella and Moorvale Joint Venture (CMJV) participants. Peabody Coppabella Pty Ltd is the Principal Holder. The CMJV participants own the adjacent Coppabella Coal Mine. The participants in the CMJV and their respective interest are as follows:

Peabody Coppabella Pty Ltd	73.3%
CITIC Australia Coppabella Pty Ltd	14.0%
Mapella Pty Ltd	7.0%
KC Resources Pty Ltd	3.7%
NS Coal Pty Ltd	2.0%

The correspondence address for the Johnson Extended Project MLAs is:

Peabody Coppabella Pty Ltd
c/-Tenement Manager
Level 3
100 Melbourne Street
SOUTH BRISBANE QLD 4101

1.3 Johnson Extended Project Scope

The Johnson Extended Project is situated in the northern section of the Bowen Basin in Central Queensland, directly adjoining to the north-north-east of the existing Coppabella Coal Mine which is operated under EA Permit Number EPML00579213 (previously MIN100555707).

The Johnson Extended Project MLAs cover a total area of 179ha in an approximately 0.45km wide by 4.7 km long strip to the immediate north east of the existing Coppabella Coal Mine.

It is proposed that the Johnson Extended Project development be an underground Longwall Top Coal Caving (LTCC) operation, with underground access to be provided via the Coppabella Coal Mine commencing once the underground component of the Coppabella Coal Mine has been developed within the area of its existing mining leases (Coppabella Coal Underground Project).

Studies for progressing licensing and exploitation of the underground resource area of the Coppabella Coal Mine (Coppabella Coal Underground Project) are continuing, which, in time, would provide underground access to the Johnson Extended Project. On that basis, the Proponent has developed underground mining layouts and production scheduling to assist in defining a viable mine plan, production scheduling and definition of timing of access to the Johnson Extended Project.

It is proposed that the existing facilities of the Coppabella Coal Mine will be used for transport, storage and processing of material extracted from the Johnson Extended Project. It is proposed that these facilities would continue operation under the existing EA (EPML00579213, previously MIN100555707).

It is proposed that the EA for the Johnson Extended Project be applied to exploration and other mining and associated activities undertaken on the Johnson Extended Project ML areas or impacts directly associated with such activities. Potential impacts associated with services provided by the Coppabella Coal Mine would be managed under that existing EA as part of the existing Coppabella Coal Mine.

This EM Plan has been structured based on this proposed separation of environmental compliance responsibility, with the following categories of potentially impacting activities applied (where relevant) in the assessment of impacts and identification of management impacts in **Section 3**:

- **Johnson Extended Project exploration activities** including exploration activities (e.g. access, drilling and seismic survey) undertaken on the Johnson Extended Project MLAs. Further description of these activities is provided in **Section 2**.

- **Johnson Extended Project underground mining activities** including surface activities undertaken within the area of the Johnson Extended Project MLAs and directly related to the construction, operation and rehabilitation activities for underground mining, such as subsidence management and service provision (e.g. gas drainage, ventilation and dewatering). Further description of these activities is provided in **Section 2**.

Activities proposed to be undertaken under the existing EA EPML00579213 (previously MIN100555707), the Coppabella Coal Mine activities, are described and assessed in **Section 3**, however management strategies are deferred to the existing approved *Coppabella Environmental Management Plan*, and proposed conditions relevant to these activities are deferred to the existing EA.

1.4 Previous Studies

To support an understanding of potential environmental issues and impacts of underground mining for the Johnson Extended Project, a range of environmental background modelling and impact assessment studies and evaluation have been conducted during the period 2009 to 2012. These studies were targeted at understanding the impacts of the Johnson Extended Project and potential cumulative impacts as a result of transition from open cut to underground mining as part of the potential Coppabella Coal Underground Project and the impacts of accessing and mining the Johnson Extended Project.

The scope a number of completed studies is different from that of the Johnson Extended Project area, including and extending onto the adjacent Coppabella Coal Underground Project, area. Some of the studies have been completed to draft level only and remain to be finalised in regard to impact assessment. Nonetheless the studies provide an excellent basis for understanding the existing environment and potential impacts associated with the Johnson Extended Project. These studies have been relied upon where relevant in the development of this EM Plan.

The following studies will be provided upon request:

- Coppabella Underground Project: Terrestrial Ecology Baseline Assessment (August 2011). Prepared by Ecological Survey & Management.
- Coppabella Underground Project: Aquatic Ecology (June 2011). Prepared by FRC Environmental.
- Coppabella Underground Mine: Hydraulic Report (April 2011). Prepared by Cardno LawsonTreloar.
- Coppabella Underground Project: Groundwater Impact Assessment (December 2010). Prepared by Australasian Groundwater & Environmental Consultants Pty Ltd.
- Coppabella Underground Coal Mine: Air Quality Impact Assessment (January 2012). Prepared by ASK Consulting Engineers.
- Coppabella Underground Coal Mine: Noise Impact Assessment (January 2012). Prepared by ASK Consulting Engineers.
- Coppabella Underground Mine Project: Soil Survey and Land Resource Assessment (March 2010). Prepared by GSS Environmental.
- Modelling and Assessment Report: Coppabella Underground Mine Flood Modelling (January 2014). Prepared by Alluvium.

2. Project Description

2.1 Project Area

The Johnson Extended Project is situated within the Isaac Regional Council area, in Central Queensland. The area is a well-established grazing, farming and coal mining region within the Bowen Basin. The local region surrounding the Johnson Extended Project contains a number of existing open cut and underground coal mines. South Walker Creek, Moorvale, Carborough Downs, Millennium, Poitrel and Burton Coal Mines are all within 25km of the proposed Johnson Extended Project.

The Johnson Extended Project area is defined by the limits of the four MLA areas (MLAs 70384, 70385, 70386 & 70387) in which the subject exploration, underground coal mining activities and supporting surface activities are proposed to occur. The Project area is shown in **Figure 1**.

The study area used for the purposes of technical studies supporting this EM Plan (as described at Section 1) in most cases had a larger footprint than the Project Area and extended onto the existing Coppabella Coal mining leases (ML70161, ML70163, ML70164, ML70236 and ML70237) with sufficient area coverage such that environmental baseline data, modeling, evaluation and impact assessment and management strategies could be developed. Specific details of the study area are contained in each of the technical reports which will be made available upon request.

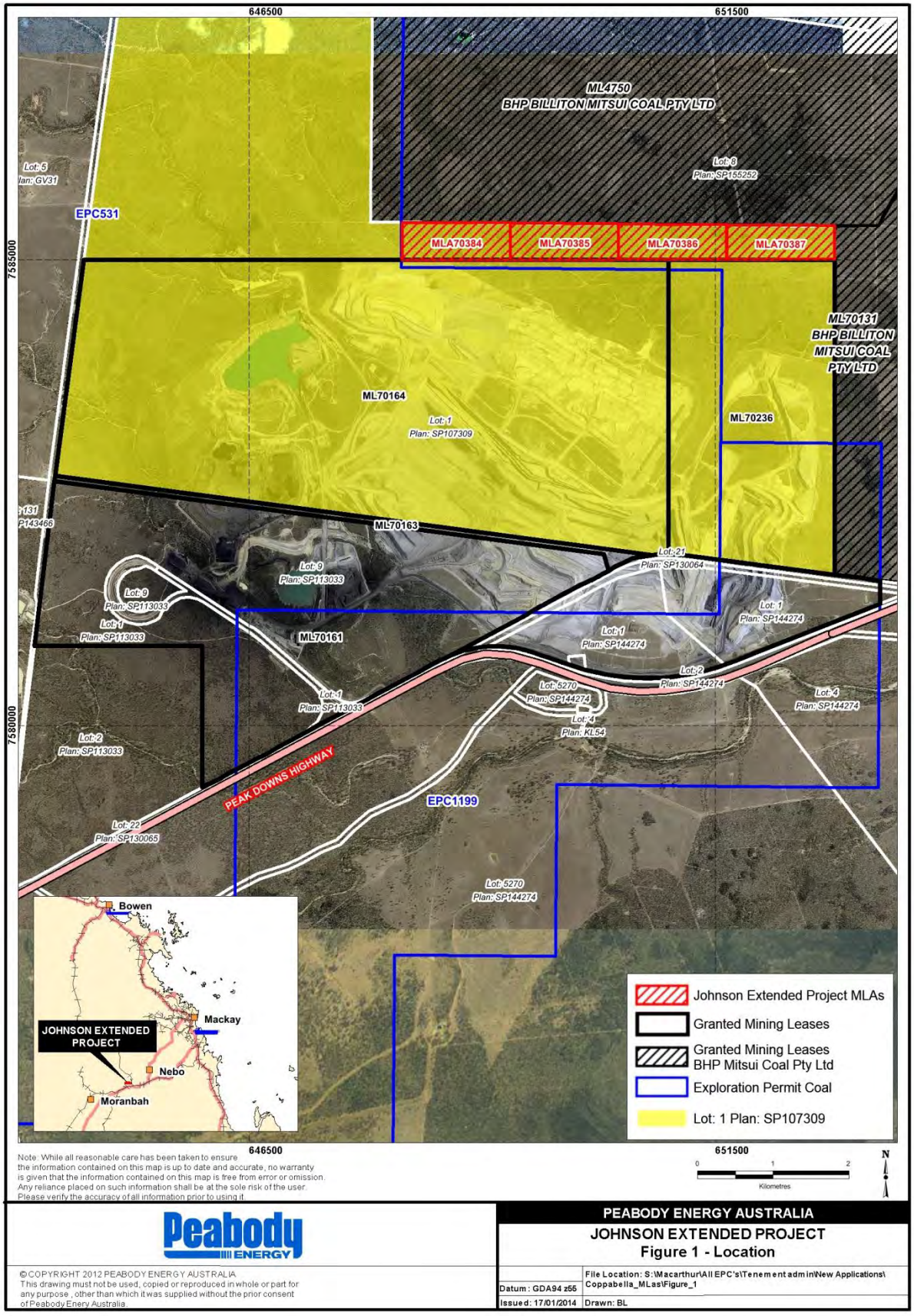
2.2 Project Location

The Johnson Extended Project is located largely to the northeast of Humbug Gully in the upper Isaac River catchment, approximately 10km east of the Coppabella Township in Central Queensland, approximately 150km southwest of Mackay and 45km east of Moranbah. The Project is bordered to the south by MLs for the current Coppabella Coal Mine and adjoins the South Walker Creek Mine and associated tenements, owned by BHP Mitsui Coal Pty Ltd, to the east (ML 70131) and north (ML 4750). (refer to **Figure 1**).

The Johnson Extended Project is close to major infrastructure including the Peak Downs Highway, the Goonyella-Hay point rail line and the regional raw water supply infrastructure.

As shown on **Figure 1** the Johnson Extended Project MLA area is contained entirely within Lot 1 on SP107309, which is within the County of Wodehouse and Parish of Kemmis.
The land over which the Johnson Extended Project MLAs is located is held as freehold and owned by Peabody Bistrotel Pty Ltd, which is owned by the participants in the CMJV. The Proponent of the Johnson Extended Project has negotiated a compensation agreement with Peabody Bistrotel Pty Ltd to allow the grant of the Johnson Extended Project MLAs.

Figure 1: Johnson Extended Project - Location



2.3 Coal Resource

The Johnson Extended Project targets the Leichhardt Lower Coal Seam with access provided via the adjacent Coppabella Coal Mine as part of the Coppabella Coal Underground Project. The geological model for the Coppabella Coal Underground Project has included the extent of the Johnson Extended Project area and both are described below.

2.3.1 Johnson Extended Project

The Leichardt Lower Seam within the area of the Johnson Extended Project MLAs typically has 60 to 260m depth of cover and is between 7m and 12m in thickness, providing a potential mineable coal target (non- Joint Ore Reserves Committee (JORC)) of up to 8.0 million tonnes of in-situ coal. Through the application of Longwall Top Coal Caving (LTCC) mining, coal recovery will be maximised.

Annual production is expected at a rate of 3.5 Mtpa of ROM coal, however this may be increased subject to further exploration, technical studies, and evolving operational experience with LTCC faces in Queensland. Based on the expected available in-situ coal tonnage and timing of access availability from the Coppabella Coal Underground Project, gas drainage and underground roadway development activities are expected to commence in 2024, with the longwall extraction life for the Johnson Extended Project expected to be approximately two and a half years (2027-2030). Decommissioning of infrastructure and rehabilitation of the Johnson Extended Project is expected to be complete by the end of 2032.

Coal mined in the Johnson Extended Project area will be conveyed through the Coppabella Coal Mine to a ROM stockpile, and then loaded to trucks for transport to the Coppabella Coal Mine CHPP area. It is proposed that coal stockpiling, processing and process waste disposal will utilise the existing Coppabella Coal Mine facilities.

A JORC Resource estimate is not yet available for the Johnson Extended Project. The grant of the MLAs is required to facilitate further exploration and modeling work. Subject to grant of the Johnson Extended Project MLAs, the Proponent proposes initial exploration activities of close spaced drilling and 3D seismic investigation (see Section 2.4.1) to improve definition of geological structure, seam thickness and location, depth of cover, coal quality and washability, gas drainage parameters, overburden properties and geotechnical environment to the extent required to support JORC Resource and Reserve definition and estimation.

2.3.2 Coppabella Coal Underground Project

The existing Coppabella Coal Mine open-cut operation targets the Leichhardt Seam within the Rangal Coal Measures. Extensive exploration drilling and 2D seismic investigations undertaken on the existing Coppabella Coal Mine to explore underground coal resource (excluding the Johnson Extended Project area) has enabled the development of a Resource estimate prepared in accordance with the JORC Code. A substantial underground JORC Resource estimate sufficient to support underground mining has been demonstrated within the area covered by the existing Coppabella Coal Mine.

2.4 Project Activities

2.4.1 Johnson Extended Project Exploration Activities

The key exploration activities proposed to be undertaken that have the potential to impact on the environmental values of the area are seismic surveying and drilling. The indicative location of proposed exploration activities is shown on **Figure 2**.

Prior to these activities being undertaken, mapping of the proposed exploration areas is planned. This will initially be through aerial photography and subsequently through ground truthing and field mapping. Ground truthing will be undertaken on foot and in 4WD vehicles using existing tracks. Mapping will seek to enable the utilisation of existing pre-cleared areas (such as for tracks and fences).

Access to the Johnson Extended Project area for mapping, ground-truthing and drilling will initially be either via an existing exploration track from the west (from the adjoining EPC tenure) or via the Coppabella Mine Site from the south, as shown in **Figure 2**.

2.4.1.1. Seismic Survey

Seismic surveying will be conducted using light trucks (10 tonne), light vehicles (4WD), and a whacker packer or self-propelled envirovibe buggy. The whacker packer is walked, or mounted on front of a vehicle, and driven along the seismic line while geophones placed along the line receive reflected seismic waves which are in turn transferred to data logging equipment contained in one of the light trucks. The envirovibe buggy is similarly driven along the seismic survey path with periodic stops to hydraulically lower a plate to the ground and generate a seismic source through a range of frequencies prior to lifting and driving to the next location, along with the supporting vehicles.

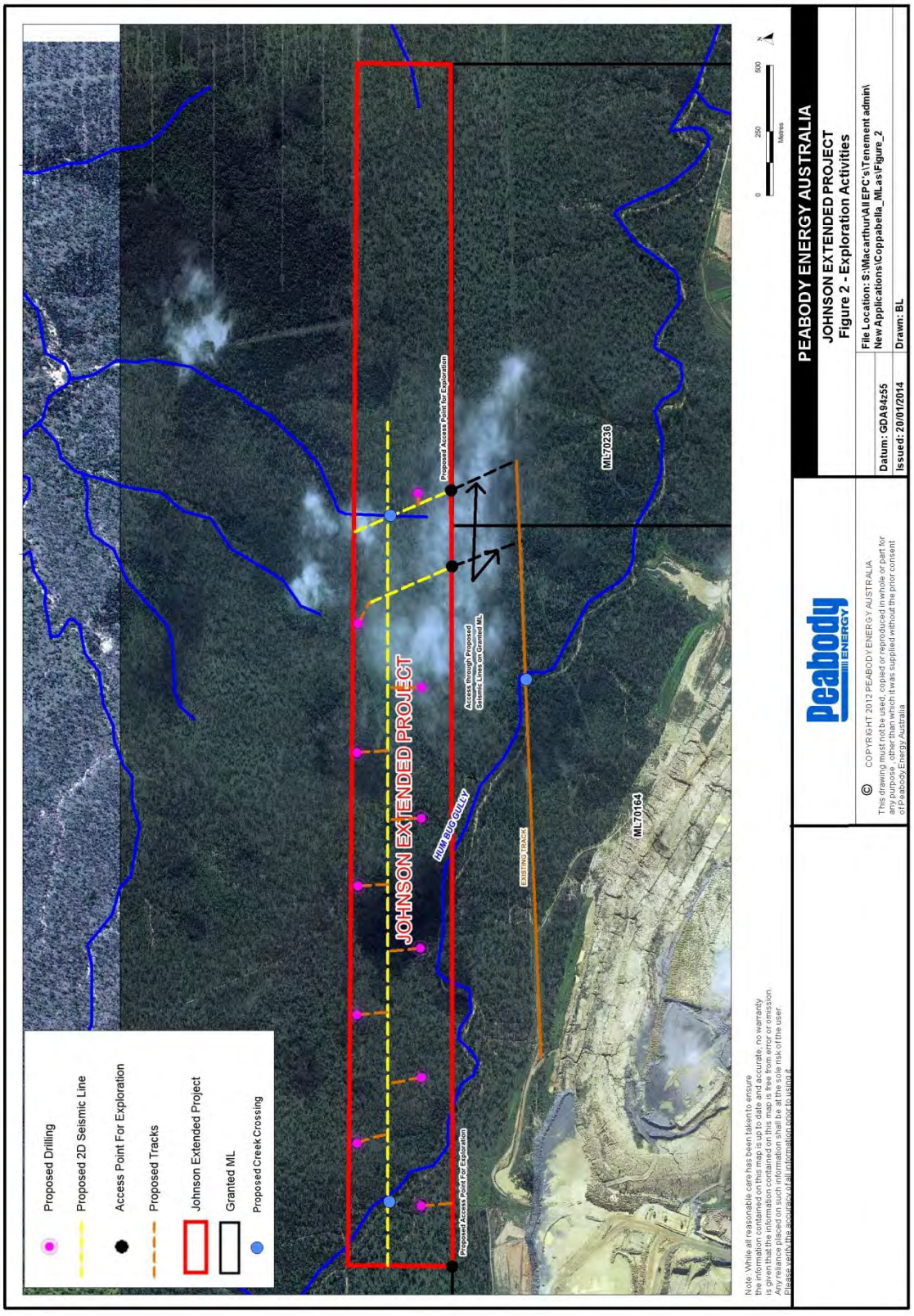
Where possible, existing tracks and fence lines will be utilised in seismic line pattern design. Where use of existing tracks and fence lines is not possible, active vegetation clearing may be required. Clearing of a seismic line involves slashing of grass or grading of a track (at surface level) for whacker packer or envirovibe buggy and vehicular access. Generally a tractor and slasher are preferred for line preparation; however, if ground conditions dictate, a backhoe loader or small grader is used instead to push or remove logs and small shrubs from the line. Should clearing of larger vegetation be required a small dozer (D6) would be used. Seismic lines are rehabilitated as per the *Code of Environmental Compliance Exploration and Mineral Development Projects*.

2.4.1.2. Drilling

Equipment used in the drilling program will likely involve a truck (approximately 15 tonne flatbed) mounted drill rig, a water and compressor truck (approximately 10 tonne flatbed), light vehicles (4WD) and a backhoe for sump development.

Where possible, access to selected drill sites will be via existing tracks, fence lines and clearings. Where it is not possible, clearing of access to the selected drill sites may be required, which will be undertaken in the same manner as the seismic lines described above. Sumps are typically constructed using a backhoe and dimensions are in the order of 8 to 10m^2 and 2.5m deep. A drill pad will be constructed with sufficient area for operations. Clearing for access and the drill pad will be undertaken utilising the same machinery hierarchy as for the seismic lines described above. Drill sites are rehabilitated as per the *Code of Environmental Compliance Exploration and Mineral Development Projects*.

Figure 2: Johnson Extended Project – Exploration Activities



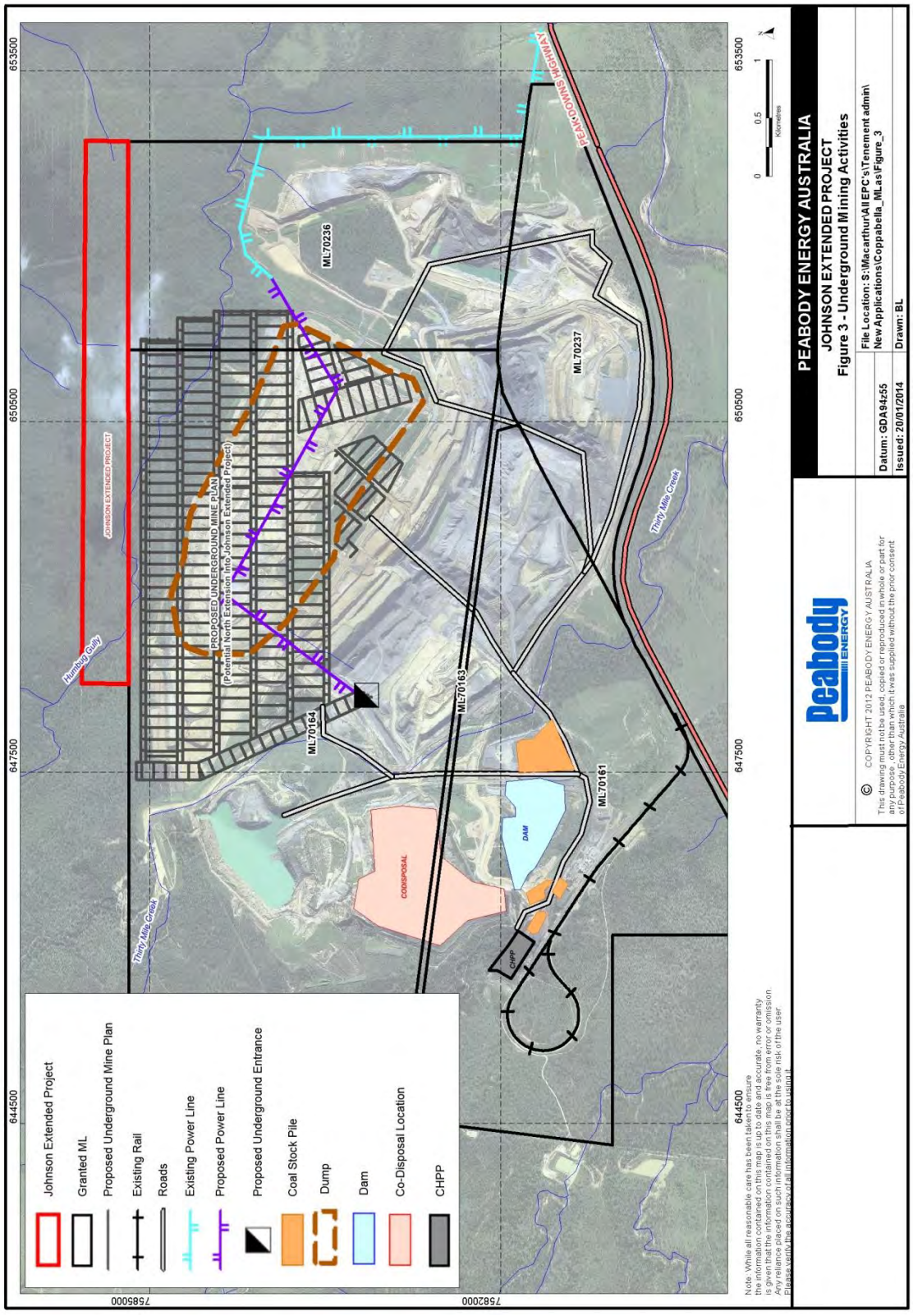
2.4.2 Johnson Extended Project Underground Mining Activities

The key activities that will be undertaken as part of the Johnson Extended Project underground mining activities will include:

- Undertaking of gas pre and post drainage and gas flaring activities
- Coal mining including development of roadways and bulk extraction utilising LTCC technology;
- Provision of services (including boreholes as required) and supporting infrastructure at the surface of the Johnson Extended Project area to enable coal mining to occur;
- Management of subsidence at the surface within the Johnson Extended Project area.

Figure 3 illustrates the indicative extent of the proposed underground mining activities (i.e. activities will be undertaken within the full extent of the Johnson Extended Project area comprising the 4 MLas).

Figure 3: Johnson Extended Project - Underground Mining Activities



2.4.2.1. Underground Mining

The Johnson Extended Project underground mining, targets the Leichardt Lower Seam which is typically between 7m and 12m in thickness in the Project area. Subject to commercial agreement with the CMJV, the mined coal and any associated waste rock will be transported to the surface via the Coppabella Coal Underground Project to the facilities of the Coppabella Coal Mine.

2.4.2.2. Services and Supporting Infrastructure

Services and supporting infrastructure that may be located on the Johnson Extended Project area to support coal mining may include:

- Gas drainage and flaring facilities;
- Ventilation, communication and emergency shafts;
- Services and pipelines (e.g. power, water, compressed air, ballast and concrete drop holes); and
- Potential groundwater monitoring and extraction bores and associated infrastructure to dewater any aquifer ahead of mining operations and handle underground water make, with connection to surface and pipeline / pumping facilities of the Coppabella Coal Mine.

Whilst existing cleared areas will be used where possible, vegetation clearing may be required to enable development, provision and access to services and supporting infrastructure. Clearing would be undertaken using similar equipment as described previously for exploration activity clearing.

Decommissioning and rehabilitation of sites of installed supporting infrastructure on the Johnson Extended project MLAs will be undertaken.

2.4.2.3. Subsidence Management

Subsidence management activities will be guided by a Subsidence Management Plan to be developed to specifically address the subsidence impacts and remediation of Humbug Gully.

Subsidence management activities may include:

- Installation of temporary sediment run off / erosion control measures or minor works;
- Deep ripping, backfilling or other reshaping of the ground surface in the areas of greatest surface cracking;
- Minor earthworks to reduce sudden elevation changes and minimise slope angles within the final land surface, especially within the vicinity of drainage lines;
- For drainage lines, re-contouring if and as required to ensure no interruption to flows; and
- Measures to exclude livestock, and other surface traffic, from disturbed areas until adequately rehabilitated.

Further discussion of subsidence management and rehabilitation is provided at **section 2.4.4**.

2.4.3 Coppabella Coal Mine Activities

Subject to conclusion of commercial negotiations, the Johnson Extended Project is expected to utilise the following services provided by the CMJV:

- Conveyance of Johnson Extended mined coal via Coppabella Coal Underground roadways to the surface within the Coppabella Coal Mine;
- Stockpiling of ROM coal at the Coppabella Coal Mine and transfer by trucking via existing Coppabella Coal Mine haul roads to the existing Coppabella Coal Mine processing facilities;
- Processing of Johnson Extended Project ROM coal at the existing Coppabella Coal Mine CHPP facility and disposal of rejects, and rejects storage rehabilitation and the conclusion of operations;
- Use of existing Coppabella Coal Mine water management infrastructure for recycling of pit water, with the addition of supplementary sumps and water flooding / inrush control in relevant areas.
- Provision, operation and establishment of support infrastructure facilities including offices, workshops, power and water supplies and rail loading facilities.

Processed coal will be loaded to trains using existing facilities and transported by existing rail facilities to the Dalrymple Bay Coal Terminal (DBCT).

The CMJV is progressing licensing and evaluation for transition to underground mining from existing open cut operations. It is expected that underground access via the Coppabella Coal Underground Project to the Johnson Extended Project area for purposes of underground gas drainage and roadway development requirements will be available from 2024.

It is proposed that the abovementioned activities be undertaken under the existing (or then superseded) EA, with management strategies deferred to the *Coppabella Environmental Management Plan*.

2.4.4 Rehabilitation Methods

The following management and mitigation strategies are a summarised description of the rehabilitation methods intended to be implemented during mining in order to reduce the potential for land degradation within the project sites and adjoining areas.

2.4.4.1. Topsoil Stripping And Handling

Where topsoil stripping and transportation is required, the following topsoil handling techniques will be used to prevent excessive soil deterioration.

Topsoil will be stripped to pre-determined depths appropriate for each soil type.

The surface of soil stockpiles will 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.

If long-term stockpiling is planned (i.e. greater than 12 months), stockpiles will be seeded and fertilised using annual cover crop species that produce sterile florets or seeds. A rapid growing and healthy annual pasture sward provides sufficient competition to minimise the emergence of undesirable weed species.

2.4.4.2. Topsoil Respreading

The following methods will be used as required to ensure the effective spreading of topsoil:

- Sampling and analysis of topsoil resources to assist in identifying potential soil deficiencies and estimating required rates of fertiliser or ameliorant (i.e. gypsum or lime) application;
- Topsoil spreading, treatment with fertiliser or ameliorants (if required) and seeding in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion; and
- Application of herbicide or weed "scalping" prior to spreading stockpiled topsoil in cases of weed infestation

2.4.4.3. Landform Design And Erosion Control

Post disturbance reshaping will be carried out where required with the aim 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.

A variety of erosion and sediment control methods will be used, the main ones being the following:

- Contour banks at intervals down slopes in order to divide a long slope into a series of short slopes that prevent runoff from reaching a depth of flow or velocity that would cause erosion;
- Contour ripping across the grade, achieving erosion control while cultivating the surface in readiness for sowing;
- Engineered waterways intercepting and diverting runoff down slope, using erosion blankets, ground-cover vegetation and/or rip rap; and
- Sediment control dams for the purpose of capturing sediment laden runoff prior to off-site release and providing semi-permanent water storages that enhance the ecological diversity of the area.

Thorough seedbed preparation will be undertaken to ensure optimum establishment and growth of vegetation. All top soiled areas will be contour ripped. Best results are usually obtained by ripping when soil is moist and when undertaken immediately prior to sowing. The re-spread topsoil will be scarified prior to, or during seeding, to reduce run-off and increase infiltration.

2.4.4.4. Revegetation Methods

Re-vegetation methods will comprise:

- Sowing of seed of pasture grasses and legumes, trees or shrub species appropriate to the desired land use, generally in the October to February period depending on seasonal conditions and operational requirements;
- Planting of selected native trees and shrubs where required. The details on the selection of the type and rate of fertiliser and seed will depend on the physical and chemical properties of the surface being treated, the season, prevailing climatic conditions and the available machinery. The mine flora and fauna studies will be used in selecting plant species for rehabilitation;
- Annual monitoring of rehabilitated areas; and
- Maintenance work to promote acceptable cover or to repair failed areas.

2.5 Project Timeframes

Pre-development activities will be completed in the period from grant of the MLAs to 2024. The holder will commence further exploration activities for the Johnson Extended Project following grant of the MLAs. This exploration information is essential for proving JORC Resource and in order to support completion of a Feasibility Study and estimation of JORC Reserves during this period.

Exploration and studies activities to be completed in the period to 2024 include:

- Conducting of field exploration;
- Exploration information assessment, geological modeling and preparation of JORC Resource and Reserve estimates;
- Detailed dewatering and water handling studies;
- Further geotechnical modeling and assessment;
- Coal quality and washability testing;
- Overburden modeling and subsidence profiling;
- Gas content, composition, permeability and porosity determination;
- Gas drainage trials;
- Finalising the mine layout, production methods and productivity estimates, and confirming the annual production target; and
- Completing supporting infrastructure studies.

Subject to availability of access via Coppabella Coal Underground Project activities, gas drainage and underground roadway development activities for the Johnson Extended Project will commence from 2024, with first longwall coal in 2027 and completion of underground mining in 2030. Mine site rehabilitation activities are expected to be conducted during the course of mining (subsidence impacts) with infrastructure decommissioning and removal after completion of mining through to the end of 2032.

The holder is not aware of any alternative logical development scenario for the Johnson Extended Project. Should the Johnson Extended Project not be accessed via the Coppabella Coal Underground Project main headings in conjunction with this timing, access via surface drifts and/or shafts would be required and impose a large capital imposition for any party seeking to extract the coal within the MLAs, almost certainly rendering the coal uneconomic.

Further, it would result in sterilisation of boundary coal on the Coppabella Coal Mine MLs in the order of magnitude of 3,500 m length x 50m assumed barrier pillar width x 7.5m average seam thickness x 90% average mining recovery x 1.5 t/m3 assumed density = 1.8 Mt ROM.

2.6 Environmentally Relevant Activities

The EP Act (s18) defines an environmentally relevant activity (ERA) as:

a. an agricultural ERA as defined under section 75; or
b. a resource activity as defined under section 107; or
c. another activity prescribed under section 19 as an environmentally relevant activity.

A mining activity being identified as a resource activity (s107 EP Act), execution of the Johnson Extended Project will include the undertaking of a resource activity ERA (ERA 5 – Mining Black Coal). No other ERAs are proposed to be undertaken or authorised under the EA for the Johnson Extended Project.

As part of the support activities related to the Johnson Extended Project (but to be undertaken by the CMJV and located on the existing Coppabella Coal Mine MLs), the following ERAs will be undertaken:

- ERA 8 - Chemical Storage;
- ERA 31 – Mineral Processing;
- ERA 33 – Crushing, milling, grinding or screening; and
- ERA 63 - Sewage Treatment.

3. Environmental Values, Impacts, Commitments and Draft Conditions

3.1 Risk Assessment

This Section includes an assessment of the likely impact of each of the relevant activities proposed as part of the Johnson Extended Project on the environmental values of the project area. The identification and management of these impacts may be undertaken through a risk assessment.

Peabody Energy has developed a hazard identification and risk management standard (Peabody Energy (2012)) in order that a consistent hazard identification and risk analysis framework is applied across all Peabody Energy owner operated mine sites and projects. This standard, which accords with the Australian standard (AS/NZS ISO 31000-2009 Risk management – Principles and guidelines) has been applied to the Johnson Extended Project. The risk assessment process includes a number of steps which include:

- Establishing the context;
- Risk identification;
- Risk analysis;
- Risk evaluation; and
- Risk treatment.

The risk assessment process used evaluated the likelihood and consequences of positive and negative environmental effects occurring as a result of exposure to one or more hazards. A number of tools were used to identify and assess the risks as part of semi-quantitative analysis. Table 3-1 is the risk matrix that was applied to quantify the level of risk for each relevant event as low, moderate, high or extreme, whilst Table 3-2 and Table 3-3 provide guidance descriptors for likelihood and consequence respectively.

Table 3-1 Risk Matrix

L - Likelihood	C - Consequence				
	1	2	3	4	5
A (Very likely)	Low	Moderate	High	Extreme	Extreme
B (Likely)	Low	Moderate	High	High	Extreme
C (Possible)	Low	Moderate	Moderate	High	Extreme
D (Unlikely)	Low	Low	Moderate	Moderate	High
E (Highly Unlikely)	Low	Low	Low	Low	Moderate

Table 3-2 Likelihood Matrix

Category	Likelihood	Descriptor
A	Very Likely	Assessed that this consequence from the hazard has occurred several times on this site or is very likely to occur at some time on this site
B	Likely	Assessed that this consequence from the hazard has occurred on this site previously or is assessed to be likely to occur at some time on this site
C	Possible	Assessed as possible that this consequence from the hazard could occur on this site at some time
D	Unlikely	Assessed as unlikely that this consequence from the hazard will occur on this site / enterprise at any time
E	Highly Unlikely	Assessed that there is no practical possibility that this consequence from the hazard would ever occur on this site / enterprise

Table 3-3 Consequence Matrix

Area of effect	Estimated level of consequence				
	1	2	3	4	5
E - Environmental Impact	Environmental nuisance. Limited damage to minimal area of low significance	Minor short to medium term material environmental harm to small area(s) of limited significance	Serious short to medium term environmental harm with widespread impacts	Major environmental harm. Relatively wide spread medium to long term impacts	Extreme environmental harm. Long term wide spread effects on environment
R - Impact on reputation	Slight impact Public aware but no public concern	Limited impact Some local public concern	Considerable impact with potential for wider public concern	National impact with potential for wider public concern	International impact. International public attention

For each aspect of the environment the relevant environmental values were identified along with potential impacting events. Standard controls were identified and the risk analysis was undertaken, identifying likelihood, consequence and level of risk using the aforementioned tables. Further controls were applied (if required) and a residual risk ranking was derived. For each aspect, a risk assessment table, similar to that provided in Table 3-4 was developed.

Table 3-4 Example Risk Assessment Table

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R

For the purpose of setting “acceptable limits” for impact, Peabody Energy (2012) notes it can normally be taken that risks ranked as Low and Moderate from this procedure are at an acceptable level, whereas risks ranked as High or Extreme require further controls.

3.2 Preliminary - Proposed General EA Conditions

Schedule A – General

A1 This environmental authority authorises environmental harm referred to in the conditions. Where there is no condition or this environmental authority is silent on a matter, the lack of a condition or silence does not authorise environmental harm.

A4 The holder of this environmental authority must:

a) install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority

b) maintain such measures, plant and equipment in a proper and efficient condition

c) operate such measures, plant and equipment in a proper and efficient manner

d) ensure all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority are properly calibrated.

Monitoring
A5 Except where specified otherwise in another condition of this environmental authority, all monitoring records or reports required by this environmental authority must be kept for a period of not less than 5 years.

Financial assurance
A6 The activity must not be carried out until the environmental authority holder has given financial assurance to the administering authority as security for compliance with this environmental authority and any costs or expenses, or likely costs or expenses, mentioned in section 298 of the Act.

A7 The amount of financial assurance must be reviewed by the holder of this environmental authority when a plan of operations is amended or replaced or the authority is amended.

Notification of emergencies, incidents and exceptions
A9 The holder of this environmental authority must notify the administering authority by written notification within 24 hours, after becoming aware of any 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.

A10 Within 10 business days following the initial notification of an emergency or incident, or receipt of monitoring results, whichever is the latter, further written advice must be provided to the administering authority, including the following:

a) results and interpretation of any samples taken and analysed

b) outcomes of actions taken at the time to prevent or minimise unlawful environmental harm

c) proposed actions to prevent a recurrence of the emergency or incident.

Complaints
A11 The holder of this environmental authority must record all environmental complaints received about the mining activities including:

a) name, address and contact number for of the complainant

b) time and date of complaint

c) reasons for the complaint

d) investigations undertaken

e) conclusions formed

f) actions taken to resolve the complaint

g) any abatement measures implemented

h) person responsible for resolving the complaint.

A12 The holder of this environmental authority must, when requested by the administering authority, undertake relevant specified monitoring within a reasonable timeframe nominated or agreed to by the administering authority to investigate any complaint of environmental harm. The results of the investigation (including an analysis and interpretation of the monitoring results) and abatement measures, where implemented, must be provided to the administering authority within 10 business days of completion of the investigation, or no later than 10 business days after the end of the timeframe nominated by the administering authority to undertake the investigation.

3.3 Air Quality

3.3.1 Description Of Surrounding Environment

The local airshed is typically rural, of reasonably good quality and with acceptable levels of pollutant concentrations.

The prevailing winds are predominantly from the east ranging from the north east to the south east. Winds during the morning are predominantly from the southeast. Winds during the afternoon are predominantly from the east and east-southeast. Highest speeds are normally associated with winds from the southeast. Wind speeds generally decrease during the night.

Dust constitutes the main pollutant, originating from exposed soils in dry conditions. At times, local bushfires or controlled burning also affect the quality of the regional airshed.
Existing air pollution is mostly caused by dust generating activities. The main sources of particulate emissions include:

- Traffic on unsealed roads;
- Farming activities: traffic, cattle movements;
- Smoke from occasional grass/bush fires; and
- Activities at the surrounding mines including rail traffic

3.3.2 Environmental Values and Sensitive Receptors

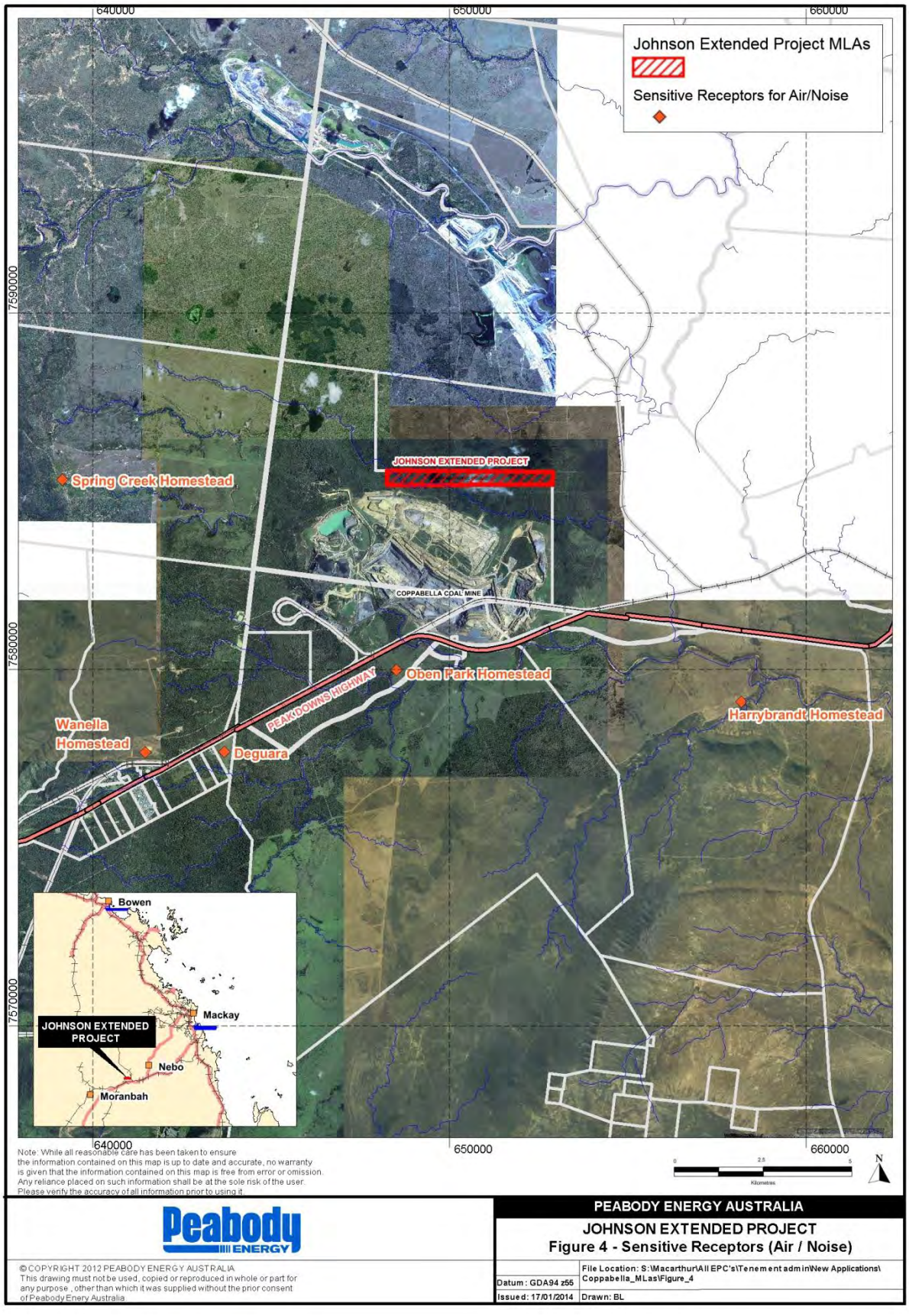
The environmental values (EVs) to be enhanced or protected listed under the *Environmental Protection (Air) Policy 2008* (EPP(Air)) that are of particular relevance to the project area are the qualities of the air environment that are conducive to human health and wellbeing, including its social and economic amenity.

Identified sensitive receptors are rural residences located in proximity to the existing Coppabella Coal mine, which are listed below and depicted in **Figure 4**: Location Of Sensitive Receptors – Air And Noise:

- Oben Park – about 2.5 km south east of south pit
- Harrybrandt residence - about 8km east of the mining lease boundary
- Wanella residence – about 5kms south west of the washplant
- Spring Creek residence - about 8km north west of the Creek Pit
- Deguara property – located towards eastern limit of the township of Coppabella and some 5 km to the south-west of Oben Park

The closest of the above Coppabella Coal Mine sensitive receptors to the Johnson Extended Project is the Oben Park homestead, at a distance some 5.3 km, followed by Harrybrandt residence and Spring Creek Homestead, respectively some 8.0 and 8.7 km distant. Based on the risk assessment conducted as part of evaluation and completion of development of this EM Plan, it is expected that both exploration and underground mining activities specific to the Johnson Extended Project MLAs will have negligible to no impact on air EVs and sensitive receptors.

Figure 4: Location Of Sensitive Receptors – Air And Noise



3.3.3 Assessment Of Potential Impacts On Environmental Values

3.3.3.1. Johnson Extended Project Exploration Activities

Activities and associated potential impacts

Dust-emitting activities during exploration will include the following:

- Vegetation clearing and associated soil disturbance;
- Vehicle traffic on unsealed roads;
- Wind erosion of cleared and unsealed areas (e.g. drill pads, tracks); and
- Exhaust emissions from mobile plant.

The use of diesel vehicles and plant during exploration activities will also generate gaseous emissions such as carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and Volatile Organic Compounds (VOC).

Potential impacts of the above activities consist of nuisance to sensitive receptors from excessive dust deposition. The quantities of gaseous emissions will be minor and will not have any impact on EVs and sensitive receptors.

Impact assessment

Table 3-5 presents the outcomes of the risk assessment of potential impacts from exploration activities on air quality.

Considering their small magnitude, short-term and temporary nature, combined with the proposed control measures in this EM Plan, exploration activities on the Johnson Extended MLAs are expected to have negligible impact on air quality EVs at the identified sensitive receptors.

Table 3-5 Risk Assessment Of Potential Impacts From Johnson Extended Project Exploration Activities On Air Quality

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Air quality	Human health, aesthetics, ecological health, agricultural use	Construction of tracks for 2D seismic survey and drill site access, along with drill pad development and drilling generating dust that causes air quality impacts to sensitive receptors	• Advise landholder of proposed activities • Obtain Landholder consent for any drill site located < 500m from a dam, stockyard, watering point or residence • Minimising areas of disturbance • Altering work practices to avoid or minimise the generation of dust; • Scheduling activities for times when they will have least impact; • Watering unsealed roads and tracks at >2L/m2/hour (as per current practices); • Limit vehicle speed limits to 30km/hr on property tracks and 10km/hr when near a residence • Rehabilitating and revegetating disturbed areas in a progressive manner and as soon as practicable (rehabilitate access tracks in consultation with landholder) • Leaving or creating wind breaks or screening; • Topsoil stripping limited to sump area and areas required for access track construction;	1	C	Low	Investigation and implementation of soil consolidation measures for dust producing areas (if required)	1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			• Clearing of mature trees avoided as far as practicable; • Existing access and fence line tracks used where possible • Regular maintenance of all machinery • Record any complaints received regarding the release of dust and implement any practicable corrective action.							

3.3.3.2. Johnson Extended Project Underground Mining Activities

Activities and associated potential impacts

Dust emissions

Potentially dust-emitting activities to be carried out within the Johnson Extended Project leases during underground mining operations are:

- construction of tracks to access and develop services and supporting infrastructure;
- vehicle traffic on unsealed roads/tracks for monitoring and maintenance purposes; and
- earthworks carried out for remediation of any subsidence impacts

The use of diesel vehicles and plant for the purpose of monitoring and maintenance as well as earthworks will also generate gaseous emissions such as carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and Volatile Organic Compounds (VOC).

Gas vents to be installed at the ground surface will drain mostly methane gas (CH_4) from the coal seam to make it safer to mine.

Potential impacts of the above activities on EVs and sensitive receptors are expected to be negligible considering their relatively small magnitude. Vehicle traffic for monitoring and maintenance will only be occasional and will only involve one or two vehicles at a time. Earthworks for subsidence remediation will be restricted to the particular affected areas and are not anticipated to generate impacting levels of dust. The quantities of gaseous emissions will be minor.

Impact assessment

Table 3-6 presents the outcomes of the risk assessment of potential impacts from underground mining activities on air quality.

Mining activities will be carried out underground and the mine exhaust system is planned to be located outside the Johnson Extended Project MLAs. Air contaminant emissions will therefore not be released from within the Johnson Extended Project Area. Refer to section 3.3.3.3 covering Coppabella Coal Mine activities for provisions relevant to the management of such emissions.

Table 3-6 Risk Assessment Of Potential Impacts From Johnson Extended Project Underground Mining Activities On Air Quality

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Air quality values	Human health, aesthetics, ecological health, agricultural use	Construction of tracks for access to gas drainage facilities, pumps, monitoring bores and subsidence impacted areas, along with the undertaking of subsidence management activities (reprofiling land) causing air quality impacts (particulate matter) to sensitive receptors.	• Altering work practices to avoid or minimise the generation of dust; • Scheduling activities for times when they will have least impact; • Watering unsealed roads and tracks at >2L/m2/hour (as per current practices); • Revegetating disturbed areas as soon as practicable; • Leaving or creating wind breaks or screening; • Clearing of mature trees avoided as far as practicable; • Cleared vegetation to be placed back into rehabilitation as habitat where practicable and appropriate (rather than burnt); • Existing access and fence line tracks used where possible; • Fitting and maintenance of appropriate exhaust systems on all equipment utilised within the Johnson Extended Project MLs to minimise diesel particulate emissions.	1	C	Low		1	C	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		Gas drainage, vehicle and equipment emissions, causing air quality impacts (gaseous emissions) to sensitive receptors	• Use and maintenance of appropriate equipment within the Johnson Extended Project MLs to minimise emissions. • Flaring of drained gas (predominantly methane)	1	D	Low	• Where necessary monitoring of air quality at sensitive receptors	1	D	Low
		Activities undertaken on the MLAs, particularly coal extraction and fuel usage causing greenhouse gas emissions, increasing the risk of climate change impacts	• Improving the efficiency of site transport, procuring fuel efficient equipment and maintaining equipment in good working order to minimise fuel usage • Reducing fugitive methane emissions by adopting proven and economically viable technologies to reduce the discharge of methane • Adopting appropriate land use strategies on site, where appropriate, to develop carbon sinks through revegetation	1	C	Low	• Investigate gas drainage techniques so that a higher proportion of the coal seam methane may be converted to carbon dioxide.	1	C	Low

3.3.3.3. Coppabella Coal Mine Activities

Activities and associated potential impacts

Dust emissions

An Air Quality Impact Assessment was carried out for the proposed underground mining at Coppabella Mine as part of the Coppabella Coal Underground Project[1]. It identified the dust-emitting activities to be carried out outside the Johnson Extended Project leases during underground mining operations as being:

- Loading to trucks with coal;
- Bulldozing coal;
- Bulldozers on overburden;
- Truck unloading coal;
- Vehicle traffic on unsealed roads;
- Use of grader;
- Plant activities;
- Wind erosion of areas left free of vegetation and unsealed; and
- Mine ventilation.

The Air Quality Impact Assessment provides annual particulate emissions estimates for each activity, assuming no dust control measures are applied.

The use of diesel vehicles and plant during exploration activities will also generate gaseous emissions such as carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and Volatile Organic Compounds (VOC).

Potential impacts of the above activities are as follows:

- Nuisance to sensitive receptors from excessive dust deposition; and
- Cause a visibility hazard for nearby road users.

The quantities of gaseous emissions will be minor and will therefore not have any impact on EVs and sensitive receptors.

Odour and Air Toxics

No potential sources of odours exist at the Coppabella Coal Mine.

Spontaneous Combustion

The propensity for spontaneous combustion of Coppabella coal is assessed as being very low due to the coal's low inherent moisture and very low sulphur content. The Coppabella Coal Mine has had over the past twelve years no heating or spontaneous combustion of coal or waste materials and based on current coal quality drilling results, it is not expected that spontaneous combustion will become an issue in future.

[1] Coppabella Underground Mine, Air Quality Impact Assessment, ASK Consulting Engineers, 25 January 2012, prepared for Macarthur Coal Pty Ltd

Impact Assessment

The Air Quality Impact Assessment uses air quality limits set out in the EPP(Air) that are similar to those used in the current Coppabella Coal Mine EA EPML00579213 (previously MIN100555707).

Modelling of air quality undertaken for underground mining operations indicates that the underground mining operations are not expected to exceed the air quality criteria at any of the sensitive receptors.

3.3.4 Objectives

The primary objectives for air quality are:

- To ensure that there is no unreasonable release (as defined in the EPP (Air)) of contaminants to air impacting sensitive receptors attributable to any activities within the Johnson Extended Project area and at the Coppabella Coal Mine
- To control potential sources of air contaminants at the site to enable achievement of the statutory environmental protection objectives
- Control dust and odour sources at the site to enable achievement of the statutory environmental protection objectives
- To minimise greenhouse gas emissions where practical to do so.

3.3.5 Control Strategies

3.3.5.1. Johnson Extended Project Exploration & Underground Mining Activities

The control measures identified in Table 3-7 are deemed appropriate to meet air quality criteria at each sensitive receptor and keep impact risks low during the exploration and mining phases.

Table 3-7 Control Strategies: Air

Control Strategies	Explor.	Mining
Advise landholder of proposed activities	✓	
Obtain landholder consent for any drill site located < 500m from a dam, stockyard, watering point or residence	✓	
Minimising areas of disturbance	✓	
Topsoil stripping limited to sump area and areas required for access track construction	✓	
Limit vehicle speed limits to 30km/hr on property tracks and 10km/hr when near a residence	✓	✓
Altering work practices to avoid or minimise the generation of dust	✓	✓
Scheduling activities for times when they will have least impact	✓	✓
Watering unsealed roads and tracks (as per current practices)		✓
Rehabilitating and revegetating disturbed areas in a progressive manner and as soon as practicable (rehabilitate access tracks in consultation with Landholder)	✓	✓
Leaving or creating wind breaks or screening	✓	✓
Clearing of mature trees avoided as far as practicable	✓	✓
Existing access and fence line tracks used where possible	✓	✓
Fitting and maintenance of appropriate exhaust systems on all equipment utilised within the Johnson Extended Project MLs to	✓	✓

Control Strategies	Explor.	Mining
minimise diesel particulate emissions		
Use and maintenance of appropriate equipment within the Johnson Extended Project MLs to minimise emissions		✓
Improving the efficiency of site transport, procuring fuel efficient equipment and maintaining equipment in good working order to minimise fuel usage	✓	✓
Reducing fugitive methane emissions by adopting proven and economically viable technologies to reduce the discharge of methane		✓
Adopting appropriate land use strategies on site, where appropriate		✓
Record any complaints received regarding the release of dust and implement any practicable corrective action.	✓	✓

3.3.6 Proposed EA Conditions

3.3.6.1. Johnson Extended Project Exploration Activities

It is expected that environmental values relating to air quality will be adequately protected and managed through implementation of the conditions of the *Code of environmental compliance for exploration and mineral development projects, DEHP, Version 1* (or later version).

3.3.6.2. Johnson Extended Project Underground Mining Activities

It is proposed to apply similar EA conditions as those applicable under the adjacent Coppabella Mine EA EPML00579213 (previously MIN100555707), as follows:

Schedule B – Air

B1 Subject to conditions B2 and B3 the release of dust or particulate matter or both resulting from the mining activity must not cause an environmental nuisance, at any sensitive or commercial place.

B2 When requested by the administering authority, dust and particulate 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 14 days to the administering authority following completion of monitoring.

B3 If the environmental authority holder can provide evidence through monitoring that the following limits are not being exceeded then the holder is not in breach of B1:

a. dust deposition of 120 milligrams per square metre per day, averaged over one month, when monitored in accordance with *AS 3580.10.1 Methods for sampling and analysis of ambient air – Determination of particulates - Deposited matter- Gravimetric method of 1991* (or more recent editions), or
b. a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometre (µm) (PM10) suspended in the atmosphere of 50 micrograms per cubic metre over a 24 hour averaging time, at a sensitive or commercial place downwind of the operational land, when monitored in accordance with:

    i. particulate matter- Determination of suspended particulate PM10 high-volume sampler with size-selective inlet- Gravimetric method, when monitored in accordance with *AS 3580.9.6 Methods for sampling and analysis of ambient air- Determination of suspended particulate matter- PM (sub) 10 high volume sampler with size-selective inlet- Gravimetric method of 1990* (or more recent editions), and
    ii. any alternative method of sampling PM10, which may be permitted by the *Air Quality Sampling Manual* as published from time to time by the administering authority.

B4 If monitoring indicates exceedence of the relevant limits in condition B3, then the environmental authority holder must:

a. Address the complaint including the use of appropriate dispute resolution if required; and

b. Immediately implement dust abatement measures so that emissions of dust from the activity do not result in further environmental nuisance.

3.4 Land

3.4.1 Strategic Cropping Land

There is no Strategic Cropping Land on the MLAs.

3.4.2 Description Of Surrounding Environment

A Soil Survey and Land Resource Assessment[2] carried out in the vicinity of the Johnson Extended Project area identified the following soil units as being present:

- Brown Duplex Sandy Loam
- Yellow Duplex Sand; and
- Yellow Duplex Sandy Loam.

Brown Duplex Sandy Loam (Brown Chromosol)

Description: This soil unit is characterised by an abrupt change between the light pale brown sandy loam surface soil and the light brown clay subsurface soil. These moderately structured soils range from slightly acidic to strongly alkaline at depth. The soils are non-saline to moderately saline at depth. The topsoils are generally non-sodic whilst the subsoils exhibit moderately sodic characteristics.

Land use: The land overlying these soils is dominated by open forest and grazing farmland. Farm tracks and remnant vegetation and sparse low lying shrubs transect the area.

Management: The top 0.12 m of this soil is marginally 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 strong 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. This soil requires only the standard erosion and sediment control measures if disturbed.

Yellow Duplex Sand (Yellow Sodosol)

Description: This soil unit is characterised by an abrupt change between the yellowish brown sandy surface soil and the brownish yellow sandy clay subsurface soil. These weakly to moderately structured soils range from slightly acidic

[2] Coppabella Underground Mine Project, Soil Survey and Land Resource Assessment, Preliminary Draft, GSS Environmental for McCollum Environmental Management Services, March 2010.

to strongly alkaline at depth. The topsoil's are generally non-sodic whilst the subsoil's exhibit moderate sodicity.

Land use: The land overlying these soils is dominated by open forest and grazing farmland. Farm tracks transect the area with remnant vegetation and sparse low lying shrubs.

Management: The 0.35 m of this soil is considered marginally suitable for stripping and reuse as a topdressing medium in rehabilitation due to high sand content in the topsoil layer and massive structure at depth. 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.

Yellow Duplex Sandy Loam (Yellow Sodosol)

Description: This soil unit generally consists of light brown to pale brown sandy loams surface soils which overlie a texture contrast to brownish yellow sandy clay and clayey subsurface soil's. These moderately structured soils range from slight acidity to neutral in the upper surface layers to slight to moderately alkaline in the subsurface layers. The soils are non-saline and generally non-sodic in the surface layers to moderately sodic in the subsurface layers.

Land use: The land overlying these soils is dominated by open forest and open grazing farmland. Farm tracks with sections of remnant vegetation and low lying shrubs traverse the area.

Management: The 0.30 m of this soil is considered marginally suitable for stripping and reuse as a topdressing medium in rehabilitation due to high sand content in the topsoil layer. The lower layers are generally unsuitable due to the limiting factors of massive structure (at increased depth) moderate 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.

3.4.3 Environmental Values

The primary recent use of land in the proposed Johnson Extended Project area has been low intensity cattle grazing within remnant vegetation on native pasture.

All soil units have been assessed as not suitable for Rainfed Cropping and as marginally suitable for grazing. They have been classified as Agricultural Land Class C3 (low quality grazing, grazing of native pastures with limited suitability for pasture improvement) or Land Suitability Class 4.

The Yellow Duplex Sand has high Plant Available Water Capacity (PAWC) limitations, low fertility and its topsoil is susceptible to erosion due to its texture. In addition, the subsoil is sodic and high in clay content which may restrict plant rooting depth and growth.

The Yellow Duplex Sandy Loam has marginal topsoil texture as it is easily erodible, it has low fertility and high PAWC limitations. Subsoils within this unit are generally sodic and high in clay content which may restrict plant rooting depth and growth.

The Brown Duplex Sandy Loam has marginal topsoil texture as it is easily erodible, has low fertility and high PAWC limitations. Subsoils within this unit are generally sodic and high in clay content which may restrict plant rooting depth and growth

All three soil units should be able to support intermittent low-quality grazing of native pastures with no pasture improvement.

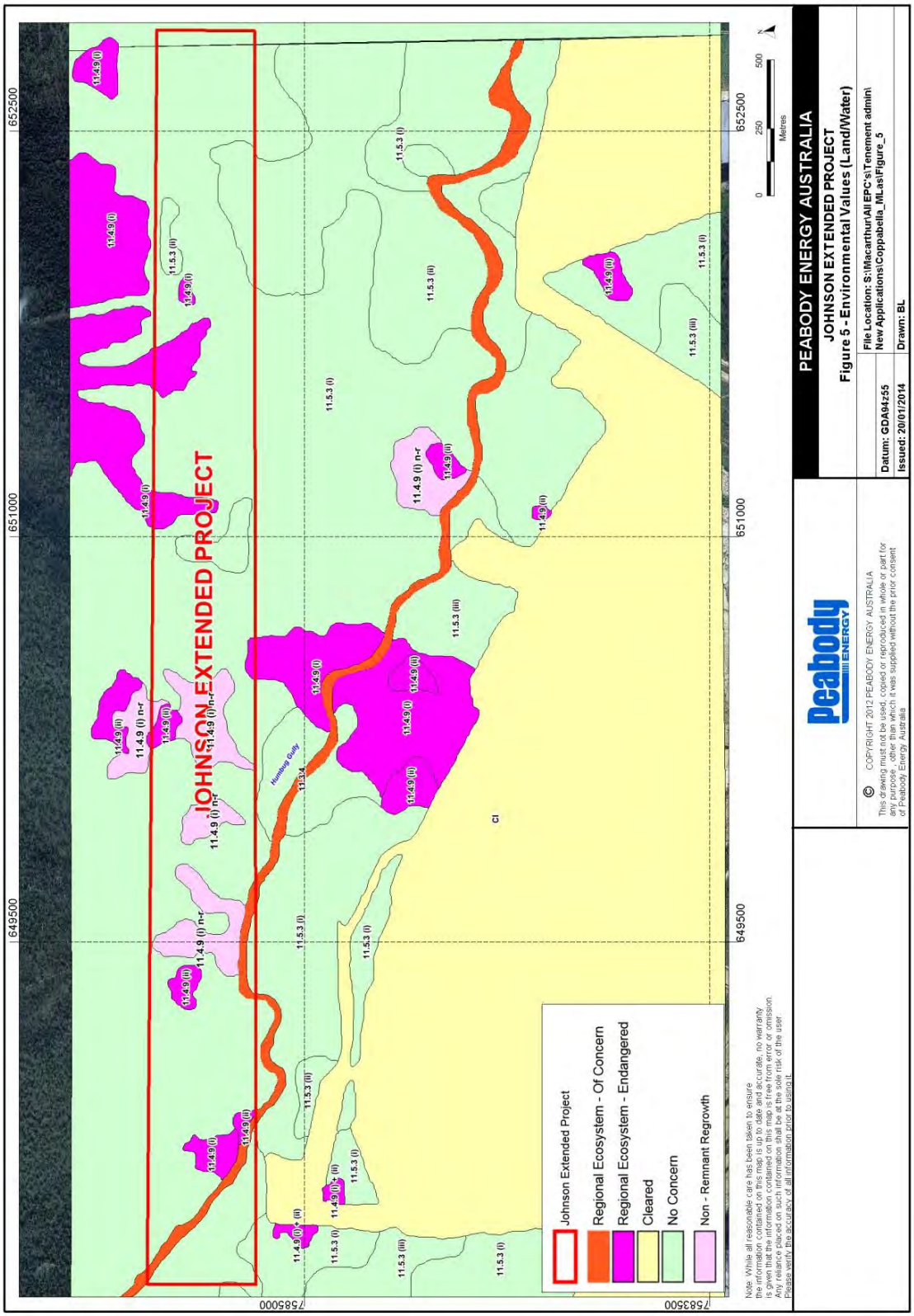
Native vegetation found on all three soil units consists of open sclerophyll forest disturbed by grazing activities. The Regional Ecosystems (REs) identified in the project areas are as follows:

- RE 11.3.4: Eucalyptus tereticornis and/or Eucalyptus spp. tall woodland on alluvial plains
- RE 11.4.9: Acacia harpophylla shrubby open forest to woodland with Terminalia oblongata on Cainozoic clay plains
- RE 11.5.3: Eucalyptus populnea and/or Eucalyptus melanophloia and/or Corymbia clarksoniana woodland on Cainozoic sand plains/remnant surfaces.

Figure 5 shows land and water EVs relevant to the Johnson Extended Project.

Post-closure land use will be determined as part of a mine closure strategy, which will be determined with appropriate stakeholders prior to closure, and considering the above potential use assessment.

Figure 5: Johnson Extended Project – Environmental Values (Land / Water)



3.4.4 Assessment Of Potential Impacts On Environmental Values

3.4.4.1. Johnson Extended Project Exploration Activities

Soil disturbing activities during exploration will include the following:

- Soil disturbance associated with vegetation clearing;
- Topsoil stripping to form tracks and drill pads;
- Drilling of boreholes;
- Vehicle traffic on unsealed roads; and
- Erosion of areas left free of vegetation and unsealed (e.g. drill pads, tracks).

Potential impacts of the above activities include degradation of land resource and receiving waters due to erosion, sediment runoff, loss of topsoils and decline in soil fertility.
Release or leaks of hazardous substances used for exploration activities may also cause degradation of the land resource.

Impact assessment

No changes to land suitability are expected to result from exploration activities. It is expected that less than 8 hectares will be required to be cleared of vegetation and disturbed as a result of surface activities, estimated as shown below (see also **Figure 2**).

Exploration Activity Type	Length Of Concern (m)	Length Endangered (m)	Length Non Remnant Regrowth Endangered (m)	No Concern (m)	Total Length (m)	Width (m)		Area Of Concern (m2)	Area Endangered (m2)	Area Non Remnant Regrowth Endangered (m2)	Area No Concern (m2)
Sesimic	42	467	568	14,923	16,000	4		168	1,868	2,272	59,692
Drilling			3 Holes	8 Holes						2,700	7,200
Tracks		21	217	975	1,213	4			84	868	3,900
Total Category Disturbance (m2)			900 m2/hole					**168**	**1,952**	**5,840**	**70,792**
									Total Disturbance (m2)		78,752
									Total Disturbance (Ha)		7.9

Table 3-8 presents the outcomes of the risk assessment of potential impacts on land from exploration activities.

Considering their small magnitude, short-term and temporary nature, combined with the proposed control measures in this EM Plan, exploration activities on the Johnson Extended Project MLAs are expected to have negligible impact on the identified land EVs.

Table 3-8 Risk Assessment Of Potential Impacts On Land From Johnson Extended Project Exploration Activities

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Land – Soils and landform	Land suitability for grazing or native biodiversity, habitat integrity	Landform modification through vegetation clearing, earthworks and stormwater diversion potentially causing degradation of land resource and receiving waters due to erosion, sediment runoff, loss of topsoils and decline in soil fertility.	• Limit extent of soil disturbance. • Consider seasonal influences, such as rainfall before establishing a drill site • Clearing will only commence when suitable erosion control measures are in place. • Topsoils managed in accordance with site specific procedures and management plans • Topsoil stockpiles will be located away from drainage paths and would be reused within 3-6 months where practical. • Effective erosion and sediment controls will be utilised where necessary to prevent erosion of disturbed areas and from soil stockpiles causing sedimentation of Humbug Gully • Avoid or minimise crossings of Humbug Gully and 'wet' areas. Any crossings would be constructed in a stable section of the bed and not running straight down the bank • Crossings would be positioned to prevent flow being directed towards the banks and provide erosion resistance to the bed and banks downstream of a crossing for a distance equal to the width of the normal flow channel; • Drilling, excavation or clearing will avoided, minimised and mitigated in Humbug Gully	1	C	Low		1	C	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		Degradation of habitat, loss of species diversity due to accidental release / leaks of hazardous substances used for exploration activities	• Storage and handling of flammable and combustible liquids will be in accordance with *AS 1940- Storage and Handling of Flammable and Combustible Liquids*. • Drill water will be contained within a sump located at drill site • All drilling fluids and muds will be captured and prevented from release from the drill site to land and waterways. Muds will be allowed to dry via natural evaporation prior to rehabilitation activities • All spills or hazardous contaminant will be cleaned up. • All excavations and sumps will be backfilled and shaped to a stable landform similar to that of surrounding undisturbed areas. • The conditions of the Code of Environmental Compliance for Exploration and Mineral Development Projects will be applied. • Topsoil and subsoil will be stockpiled separately.	1	D	Low		1	D	Low

3.4.4.2. Johnson Extended Project Underground Mining Activities

Activities and associated potential impacts

Potentially soil-disturbing activities to be carried out within the Johnson Extended Project leases during underground mining operations are:

- Underground mining;
- Earthworks carried out for remediation of any subsidence impacts;
- Vehicle traffic on unsealed roads/tracks for monitoring and maintenance purposes; and
- Erosion of areas left free of vegetation and unsealed (e.g. tracks).

Potential impacts from the above activities include the following:

- topsoil loss or degradation due to surface cracking and erosion;
- exposure of unstable (sodic or saline) subsoils, resulting in increased erosion potential;
- increased potential for surface erosion due to localised changes in topography and surface hydrology; and
- reduction in potential productivity of the land due to topsoil loss and modification of surface topography/hydrology.

These impacts may be magnified where subsidence occurs in areas of concentrated surface flow, such as creeks and drainage lines.

Impact assessment

Table 3-9 presents the outcomes of the risk assessment of potential impacts on land from underground mining activities.

Risk associated with potential impacts to land associated with subsidence was initially considered to be high; however with the development and implementation of a subsidence management plan and the rehabilitation of disturbed areas the residual risk level associated with potential subsidence impacts is reduced to moderate.

The subsidence management plan will identify and describe options for mitigating and managing subsidence impacts. The plan will address; the physical condition of surface drainage including erosion, incision processes, stream widening, tension cracking, lowering of bed and banks, creation of in-stream waterholes, changes to local drainage patterns and areas susceptible to high levels of erosion such as watercourse confluences. The plan will also address overland flow, capture of overland flow by subsided long-wall panels, increased overbank flows due to lowering of high bank watercourses and the portion of local and large scale catchment likely to be captured by subsided long-wall panels and the associated impacts on downstream users. The plan will address land condition and future suitability.

Most of the topsoil and subsoil material within the study area is considered to be relatively stable. If topsoil and surface vegetation cover are maintained, subsidence impacts when managed should not cause a significant increase in erosion potential. If the subsoil is exposed, measures outlined in this EM Plan will enable the effective prevention and mitigation of impacts.

Disturbed areas will be rehabilitated in accordance with the provisions detailed in the Code of Environmental Compliance for Mining lease projects and Guideline for rehabilitation requirements for mining projects.

Release or leaks of hazardous substances used for support and service activities associated with the underground mining may also cause degradation of the land resource; however this is assessed as a low risk.

Table 3-9 Risk Assessment Of Potential Impacts On Land From Johnson Extended Project Underground Mining Activities

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Soils and land-form	Land suitability for grazing or native biodiversity, habitat integrity	Landform modification through subsidence and vegetation clearing, earthworks and stormwater diversion associated with surface activities and subsidence management activities potentially causing degradation of land resource and receiving waters due to erosion, sediment runoff, loss of topsoils and decline in soil fertility.	• Site-specific topsoils assessment will be undertaken • Limit extent of soil disturbance. • Topsoils managed in accordance with site specific procedures and management plans • Soils stripped will be separately stored in accordance with soil properties • The height of topsoil stockpiles be minimized as far as practicable • Topsoil stockpiles would be reused as soon as practicable • A temporary cover crop may be established on the stockpiles where necessary • Effective erosion and sediment controls will be utilised where necessary to prevent erosion of disturbed areas and from soil stockpiles causing sedimentation of Humbug Gully • Avoid or minimise crossings of Humbug Gully and 'wet' areas. Any crossings will be constructed using generally accepted industry practices	3	A	High	• A subsidence management plan will be developed and implemented. • Development of an erosion and sediment control plan for other areas of disturbance • Disturbed areas will be rehabilitated in accordance with the provisions detailed in the *Code of Environmental Compliance for Mining Lease Projects, Version 1* (or more recent version). For areas in Humbug Gully, rehabilitation will be undertaken as soon as practicable and prior to the onset of the wet season.	2	A	Moderate

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		Degradation of habitat, loss of species diversity due to accidental release / leaks of hazardous substances used for surface activities	• Storage and handling of flammable and combustible liquids must be in accordance with *AS 1940- Storage and Handling of Flammable and Combustible Liquids.*	1	D	Low		1	D	Low

3.4.5 Objectives

The objectives with regards to land management are:

- To achieve a stable final land profile which is adequately vegetated and drained and does not cause soil loss or degradation and vegetation loss. The land profile achieved is to enable the protection and enhancement of potential sustainable environmental values identified, namely cattle grazing and native biodiversity life.
- To prevent or reduce the amount of soil loss from the Johnson Extended Project area during the exploration and mining phases.

3.4.6 Control Strategies

3.4.6.1. Johnson Extended Project Exploration And Underground Mining

The control strategies identified in Table 3-10 are considered appropriate to protect the identified environmental values by preventing and mitigating loss of soil quality during the exploration and underground mining phases. Further details regarding these control strategies can be found in the Soil Survey and Land Resource Assessment.

Table 3-10 Control Strategies: Land

Control Strategies	Explor.	Mining
Limit the extent of soil disturbance to what is only necessary for the operations.	✓	✓
Consider seasonal influences, such as rainfall before establishing a drill site	✓	
Clearing will only commence when suitable erosion control measures are in place.	✓	✓
Topsoils managed in accordance with site specific procedures and management plans	✓	✓
Topsoil stockpiles will be located away from drainage paths and will be reused within 3-6 months where practical.	✓	✓
Effective erosion and sediment controls will be utilised where necessary to prevent erosion of disturbed areas and from soil stockpiles causing sedimentation of Humbug Gully	✓	✓
Avoid or minimise crossings of Humbug Gully and 'wet' areas. Any crossings would be constructed in a stable section of the bed and not running straight down the bank	✓	✓
Crossings would be positioned to prevent flow being directed towards the banks and provide erosion resistance to the bed and banks downstream of a crossing for a distance equal to the width of the normal flow channel;	✓	✓
Drilling, excavation or clearing will be avoided, minimised and mitigated in Humbug Gully.	✓	
Storage and handling of flammable and combustible liquids must be in accordance with *AS 1940- Storage and Handling of Flammable and Combustible Liquids*.	✓	✓

Control Strategies	Explor.	Mining
Drill water is to be contained within sump located at drill site	✓	
All drilling fluids and muds must be captured and prevented from release from the drill site to land and waterways. Drilling fluids must be removed via a sucker truck and disposed of at a designated waste disposal area.	✓	
Hydrocarbon spill controls must be in place and used appropriately (bunded pallets, covered to prevent rainwater accumulating, sealed containers etc.)	✓	
All spills or hazardous contaminant must be cleaned up.	✓	✓
All excavations and sumps must be backfilled and shaped to a stable landform similar to that of surrounding undisturbed areas.	✓	
The conditions of the Code of Environmental Compliance for Exploration and Mineral Development Projects must be applied.	✓	
Soils stripped will be separately stored in accordance with soil properties	✓	✓
Topsoils will be managed in accordance with site specific procedures and management plans	✓	✓
The height of topsoil stockpiles will be limited as far as practicable	✓	✓
Topsoil stockpiles will be reused as soon as possible	✓	✓
A temporary cover crop will be established on the stockpiles where required	✓	✓
A subsidence management plan will be developed and implemented		✓
Disturbed areas will be rehabilitated in accordance with the provisions detailed in the *Code of Environmental Compliance for Mining Lease Projects, Version 1* (or more recent version). For areas in Humbug Gully, rehabilitation will be undertaken as soon as practicable and prior to the onset of the wet season (~April).	✓	✓

3.4.7 Proposed EA Conditions

3.4.7.1. Johnson Extended Project Exploration Activities

It is expected that environmental values relating to land quality will be adequately protected and managed through implementation of the conditions of the *Code of environmental compliance for exploration and mineral development projects, DEHP, Version 1* (or later version).

Specific conditions relating to terrestrial ecology can be found at section 3.5.6.1.

3.4.7.2. Johnson Extended Project Underground Mining Activities

Schedule H - Land and rehabilitation

H1 Land disturbed by mining must be rehabilitated in accordance with Table H1 - Rehabilitation Requirements. Table H1 is to be provided to the administering authority prior to the commencement of underground mining activities.

Table H1 – Final land use and rehabilitation approval schedule

Mine Domain	Mine Feature Name	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
Infrastructure					
Roads and tracks					
Subsidence panels					

H2 Rehabilitation must commence progressively in accordance with the plan of operations.

H3 Before applying for surrender of a mining lease, the holder must (if applicable) provide to the administering authority a site investigation report under the Act, in relation to any part of the mining lease which has been used for notifiable activities or which the holder is aware is likely to be contaminated land, and also carry out any further work that is required as a result of that report to ensure that the land is suitable for its final land use.

H4 Before applying for progressive rehabilitation certification for an area, the holder must (if applicable) provide to the administering authority a site investigation report under the Act, in relation to any part of the area the subject of the application which has been used for notifiable activities or which the holder is aware is likely to be contaminated land, and also carry out any further work that is required as a result of that report to ensure that the land is suitable for its final land use under condition H1.

H5 Minimise the potential for contamination of land by hazardous contaminants.

Schedule F – Subsidence

F17 A Subsidence Management Strategy must be developed by an appropriately qualified person(s) and implemented by the holder of this environmental authority prior to the commencement of activities that result in subsidence.

F18 The Subsidence Management Strategy must:

a) provide for the proper and effective management of the actual and potential environmental impacts resulting from the mining activity and to ensure compliance with the conditions of this environmental authority;

c) describe the proposed impacts of subsidence on any land, watercourse and floodplain including but not limited to:

i. physical condition of surface drainage:

- erosion;
- areas susceptible to higher levels of erosion such as watercourse confluences;
- incision processes;
- stream widening;
- tension cracking;
- lowering of bed and banks;
- creation of instream waterholes;
- changes to local drainage patterns;

ii. overland flow:

- capture of overland flow by subsided long-wall panels;
- increased overbank flows due to lowering of high bank of watercourses;
- the portion of local and large scale catchment likely to be captured by subsided long-wall panels and the associated impacts on downstream users;

iii. surface water quality:

iv. land condition: current land condition to be impacted by subsidence;

v. infrastructure: detail of existing infrastructure (pipelines, railway, powerlines and haul roads) should be identified where there is a potential impact from effects of land subsidence;

d) propose options for mitigating any impacts associated with subsidence and how these mitigation methods will be implemented;

e) describe cumulative impacts on watercourses or catchments;

i) include a program for monitoring and review of the effectiveness of the Subsidence Management Plan

F19 A Subsidence Panel Plan will be developed for each longwall panel by a suitably qualified and experienced person, prior to longwall mining occurring in that panel.

The Subsidence Panel Plan must:

a) assess the plan against the requirements under condition F18;

b) include recommended actions to ensure actual and potential environmental impacts are effectively managed for the longwall panel; and

c) assess the condition of the previous longwall panel, including the structural, geotechnical and hydraulic adequacy of the subsided longwall panel and the adequacy of the works with respect to the Subsidence Panel Plan, as far as data relating to the previous panel is available at the time of assessment.

F20 The holder of this environmental authority must attach to the review report required by condition F19, a written response to the report and recommended actions, detailing the actions taken or to be taken by the environmental authority on stated dates:

a) to ensure compliance with this environmental authority; and

b) to prevent a recurrence of any non-compliance issues identified.

F21 The review report required by condition F19 and the written response to the review report required by condition F20 must be submitted to the administering authority upon request.

3.5 Terrestrial Ecology

3.5.1 Description Of Surrounding Environment

Various terrestrial ecology investigations have been previously undertaken over or adjacent to the Johnson Extended Project area, including:

- *Coppabella Underground Project: Terrestrial Ecology Baseline Assessment* (Draft), Ecological Survey and Management, 2011;
- *Flora and Fauna Assessment – Coppabella Mine,* Ison Environmental Planners, 1997,; and,
- *Flora and fauna habitat assessment for the Peak Downs Highway Diversion at Coppabella,* WBM Oceanics Australia, 2000.

Ecological Survey and Management (2011) is the most relevant assessment, given that it includes the most recent survey of the Project area and is targeted specifically at the Johnson Extended Project. A copy of this assessment is provided in Appendix 1.
The majority of the project area and areas immediately to the North, East and West supports native remnant vegetation with varying levels of disturbance due to cattle grazing activities. Areas to the south are largely cleared of remnant vegetation due to the operations of the Coppabella Coal Mine. Areas further north have been cleared due to the operations of the South Walker Creek Mine.

The topography of the Project Area is very gently undulating with Humbug Gully dissecting the western quarter of the Project Area in a north-west to south-east direction. There are a number of other ephemeral drainage lines present throughout the Project Area. Gilgais or 'melon holes' have developed within many of the small Brigalow patches present within the central portion of the Project Area. Gilgai are small undulations in the soil surface that create depressions (typically less than a metre deep and less than 10 m across) that can hold water for a considerable period during and following the wet season.

3.5.2 Environmental Values And Sensitive Receptors

Environmental values relevant to the terrestrial ecology of the project area are associated with the native biodiversity and habitat integrity, along with usability for agricultural purposes.

The environmental values of the area in relation to flora and fauna habitat has been diminished over time due to historic grazing, along with pest species incursions in the remnant vegetation.

3.5.2.1. Regional Ecosystems

Ecological Survey and Management (2011) confirmed the presence of remnant vegetation throughout the majority of the Johnson Extended Project area through detailed vegetation mapping which identified communities analogous with three distinct Regional Ecosystems (RE). The location of these three ecosystems across the Johnson Extended Project area is identified in **Figure 5** and the ecosystems including their *Vegetation Management Act 1999* (VMA) and Biodiversity status are described in **Table 3-11**.

Table 3-11 Regional Ecosystems Identified Across The Johnson Extended Project Area

REID	Description	VMA class	Biodiversity status
11.5.3	Eucalyptus populnea +/- E. melanophloia +/- Corymbia clarksoniana on Cainozoic sand plains/remnant surfaces	Least concern	No concern at present
11.3.4	Eucalyptus tereticornis and/or Eucalyptus spp. woodland on alluvial plains	Of concern	Of concern
11.4.9	Acacia harpophylla shrubby woodland with Terminalia oblongata on Cainozoic clay plains	Endangered	Endangered

The predominant vegetative cover in the area is analogous with RE 11.5.3, with variations identified within and adjacent to the project area. The *Eucalyptus populnea* (Poplar Box) complex is the most common variation within the project area. The presence of RE 11.3.4 within the project area is associated with Humbug Gully, which dissects the western quarter of the project area in a north-west to south-east direction. The community is relatively narrow (less than 40 metres in width) sitting along the banks and associated narrow terraces of this drainage line. The community possesses a relatively consistent canopy composition and distribution, and is dominated by *Eucalyptus tereticornis* (Queensland Blue Gum).

The balance of vegetation identified within the Project Area is representative of RE 11.4.9, with two distinct associations or cohorts of this RE identified within and immediately adjacent to the project area. These cohorts are represented by small patches of *Acacia harpophylla* (Brigalow) open forest and *Casuarina cristata* (Belah) woodland to open woodland. The small patches of *A.harpophylla* exist within broader patches of *Casuarina cristata* woodland or as isolated groves within eucalypt woodland. The *Casuarina cristata* woodland to open woodland is generally associated with narrowly incised, collapsed gullies and associated broad depressions. The overall condition of the canopy and sub-canopy layers of the *Casuarina cristata* dominated cohort is poor with a high percentage of trees found to be dead or senescing. This cohort is representative of 'Endangered' regulated regrowth.
No areas of vegetation corresponding to regrowth watercourse vegetation or essential habitat were identified within the project area.

Detailed descriptions of the vegetation communities present within the Project Area are provided in Ecological Survey and Management (2011).

3.5.2.2. Threatened Flora

Table 3-12 identifies threatened flora records returned from various database searches (undertaken for an area within 20km radius of the Coppabella Underground Project area), along with their *Nature Conservation (Wildlife) Regulation 2006* (NCR) status and the likelihood of their occurrence in the project area. These searches were undertaken and assessed by Ecological Survey and Management (2011) through desktop and field assessment.

Table 3-12 Threatened Plant Species Identified And Likelihood Of Occurrence In Project Area[3]

Scientific name	Common name	NCR status[a]	Data source[b]	Potential to occur in project area
Bertya pedicellata	-	NT	Wildlife Online	Very Low: Underlying geology and preferable habitat not present on site
Capparis humistrata	-	E	Wildlife Online	Very Low: Underlying geology and preferable habitat not present on site
Dichanthium queenslandicum	King Blue Grass	V	DSEWPaC Wildlife Online	Very Low: Underlying geology and preferable good-quality habitat not present on site
Dichanthium setosum	-	NT	DSEWPaC Wildlife Online	Low: Habitat marginally present but underlying geology not present on site
Digitaria porrecta	Jointed Fingergrass	NT	DSEWPaC	Low: Habitat marginally present but underlying geology not present on site
Eucalyptus raveritiana	Black Ironbox	V	DSEWPaC	Low: Habitat marginally present in Humbug Gully but detailed survey failed to locate this distinctive eucalypt species.
Leucopogon cuspidatus	-	V	DSEWPaC	Very Low: Underlying geology and preferable habitat not present on site
Macropteranthes leiocaulis	Southern Bonewood	NT	Wildlife Online	Very Low: Preferable habitat not present on site
Solanum adenophorum	-	E	Wildlife Online	Low: Habitat marginally present but underlying geology not present on site

a - NCR status: Conservation status of each taxon: Endangered (E), Vulnerable (V), Near Threatened (NT).
b - Source: DSEWPaC (DSEWPaC 2009b), HERBRECS (Queensland Herbarium 2009), Wildlife Online (DERM 2011a)

No species of state significance were recorded during the current field surveys. All nine species identified during the desktop review are considered to have a low or very low likelihood of occurrence within the project area based on the lack of suitable habitat (vegetative and/or underlying geology) and/or recent records from within the database search areas.

[3] Extracted and modified from Ecological Survey and Management (2011)

3.5.2.3. Weeds

Table 3-13 identifies weeds that were recorded during surveys undertaken by Ecological Survey and Management (2011), that are either classified as 'Weeds of National Significance' (WONS) or identified under the *Land Protection (Pest and Stock Route Management) Regulation 2003* (LPR).

Table 3-13 Listed Weeds Identified During Survey[4]

Botanical name	Common name	WONS	LPR	RE
Eriocereus martinii	Harissa Cactus	no	Class 2	11.5.3 & 11.4.9
Opuntia tomentosa	Velvet Prickly Pear	no	Class 2	11.5.3 & 11.4.9
Parthenium hysterophorus	Parthenium Weed	yes	Class 2	11.5.3 & 11.4.9

All three State-declared exotic species were infrequently encountered within the project area. The control and/or eradication of *Eriocereus martinii* poses the greatest management challenge and for the maintenance of the natural integrity of remnant vegetation and regulated regrowth within the project area. Currently this species occurs as isolated mature clumps (to 2m in height) and is generally associated with or located beneath shrub layer species.
Of the non-declared and exotic species recorded during surveys, most are poorly established within their suitable habitats; however, the exotic pastoral grasses of *Bothriochloa pertusa*, *Cenchrus ciliaris* and *Rhynchelytrum repens* are frequently distributed throughout the project area.

3.5.2.4. Threatened Fauna

Desktop research and targeted field survey was undertaken by Ecological Survey and Management (2011) in order to identify threated fauna potentially associated with the project area.

Ecological Survey and Management (2011) identified that the quality of the fauna habitat within the project area is moderate. While there are a number of exotic species recorded, their overall abundance was considered to be relatively low. Riparian vegetation associated with the numerous ephemeral drainages present is also considered to be relatively intact and apart from some areas that displayed some damage from grazing activities, the balance of the project area is considered to contain a reasonable cover of woody vegetation. The level of fallen timber, deep leaf litter and hollow bearing trees across the project area is considered to be below natural levels.

Table 3-14 identifies threatened fauna records returned from various data base searches (undertaken for an area within 20km radius of the project area), along with their NCR status and the likelihood of their occurrence in the project area. These searches were undertaken

[4] Extracted and modified from Ecological Survey and Management (2011)

and assessed by Ecological Survey and Management (2011) through desktop and field assessment.

Table 3-14 Threatened Plant Species Identified And Likelihood Of Occurrence In Project Area[5]

Common Name	Scientific Name	NCR Status	Potential to occur in the project area
Reptiles			
Ornamental Snake	*Denisonia maculata*	Vulnerable	Present
Striped-tailed Delma	*Delma labialis*	Vulnerable	Low
Retro Slider	*Lerista allanae*	Endangered	Low
Yakka Skink	*Egernia rugosa*	Vulnerable	Low to moderate
Brigalow Scalyfoot	*Paradelma orientalis*	Vulnerable	Low
Fitzroy River Turtle	*Rheodytes leukops*	Vulnerable	Low
Birds			
Squatter Pigeon	*Geophaps scripta scripta*	Vulnerable	High
Red Goshawk	*Erythrotriorchis radiatus*	Endangered	Low
Australian Painted Snipe	*Rostratula australis*	Vulnerable	Low to moderate
Star Finch	*Neochmia ruficauda ruficauda*	Endangered	Low
Glossy Black cockatoo	*Calyptorhynchus lathami*	Vulnerable	Low
Square-tailed Kite	*Lophoictinia isura*	Near Threatened	Moderate
Black-necked Stork	*Ephippiorhynchus asiaticus*	Near Threatened	Low to moderate
Black-chinned Honeyeater	*Melithreptus gularis*	Near Threatened	Low to moderate
Mammals			
Eastern/Greater Long-eared Bat	*Nyctophilus timoriensis / corbeni*	Vulnerable	Low to moderate
Little Pied Bat	*Chalinolobus picatus*	Near Threatened	Present

[5] Extracted and modified from Ecological Survey and Management (2011)

Of the 16 threatened or near threated species listed under the NCR that were identified through desktop research as potentially occurring within the project area, the Ornamental Snake and Little Pied Bat were confirmed as occurring. The Squatter Pigeon was identified as having a high potential to occur and the Square-tailed Kite was identified as having a moderate potential to occur in the project area. The remaining species are considered to have a low or low to moderate potential to occur.

Special least concern fauna listed under the NCR includes the Koala (*Phascolarctos cinereus*), Echidna (*Tachyglossus aculeatus*), Platypus (*Ornithorhynchus anatinus*) and certain migratory species. While none of these species were recorded from the project area by Ecological Survey and Management (2011) the Short-beaked Echidna and Koala are considered to have a high potential to occur and the Platypus is considered to have a low potential to occur due to the lack of permanent water. Database searches by Ecological Survey and Management (2011) identified a total of 10 migratory species that could potentially occur within the project area. Of these species, the Rainbow Bee-eater and Satin Flycatcher were recorded during the surveys. The White-throated needletail and Fork-tailed Swift were considered likely to overfly the project area but the existing habitats are not considered likely to be of importance for these species.

Ecological Survey and Management (2011) notes that overall, the fauna community of the project area is typical of that occurring in the broader area and there do not appear to be any sites of particular significance with respect to high biodiversity, important breeding or feeding areas, high endemism, unusual fauna assemblages, or unique habitat types or assemblages. Ecological Survey and Management (2011) notes that all of the habitats occurring within the study area are well represented throughout the broader Coppabella area and wider Central Highlands region.

Ecological Survey and Management (2011) identifies that the project area is near the southern extent of a larger patch of native vegetation that extends to the north and west to a range located approximately 10 km to the west of the project area. Ecological Survey and Management (2011) notes that although this area has been fragmented by clearing associated with agriculture and mining activities, it represents a relatively well connected landscape; however as the project area is located close to the southern limit of this area of native vegetation (with more extensive clearing to the south of the Peak Downs Highway) it is considered unlikely that the native vegetation of the project area plays an important role in maintaining landscape connectivity.

3.5.2.5. Pest Animals

During the field survey by Ecological Survey and Management (2011) feral pest species recorded were wild dogs or dingoes (*Canis lupus dingo* or *Canis familaris*) European Rabbit (*Oryctolagus cuniculus*) and Pigs (*Sus scrofa*). Each of these species is a declared pest under Queensland's *Land Protection (Pest and Stock Route Management) Act 2002*. The Cane Toad (*Rhinella marina*) is also likely to be present. Low numbers or activity of these species was observed during the field survey suggesting that the project area supports relatively small populations of these species.

3.5.3 Assessment Of Potential Impacts On Environmental Values

3.5.3.1. Johnson Extended Project Exploration Activities

Activities and associated potential impacts

Exploration activities have the potential to impact on land values associated with terrestrial ecology, including through:

- Introduction and / or spread of pests or weeds by equipment
- Fire disturbance
- removal / loss of vegetation, flora and fauna habitat due to clearing for tracks and drill pad sites and / or land degradation due sediment erosion and runoff associated with these
- Injury to fauna due to direct contact by equipment or entrapment in excavations / holes caused by activities; and
- Degradation of habitat, loss of species diversity due to accidental release / leaks of hazardous substances

Impact assessment

Table 3-15 presents the outcomes of the risk assessment of potential impacts from exploration activities on terrestrial ecology.

Considering their small magnitude, short-term and temporary nature, combined with the proposed control measures in this EMP, exploration activities on the Johnson Extended MLAs are expected to have negligible impact on environmental values for land associated with terrestrial ecology.

Table 3-15 Risk Assessment Of Potential Impacts From Exploration Activities On Land Values Associated With Terrestrial Ecology

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Terrestrial Ecology	Native biodiversity, habitat integrity and agricultural use	Introduction and / or spread of pests or weeds by equipment used for exploration activities	• Vehicles and machinery will be adequately cleaned before moving from areas containing declared plants into the project area • Weed infestated areas will be identified and effectively managed prior to commencement of and during works • Feral animal control programs will be undertaken as necessary • Effective weed and pest management will be undertaken in any areas to be rehabilitated • Induction programs will include information on nature conservation and weed control issues	1	D	Low		1	D	Low
		Fire disturbance caused by exploration activities	• All reasonable and practicable fire prevention measures will be implemented (smoking ban, collection of rubbish, etc.) • Selected personnel will be trained in the use of firefighting equipment including fire extinguishers • Fire extinguishers and / or firefighting equipment will be available to vehicles and work sites • Drill holes (apart from those to be used for monitoring purposes) will be decommissioned as soon as practical	1	C	Low		1	C	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			• Slashing in heavily grassed areas will be undertaken if necessary							
		Removal / loss of vegetation, flora and fauna habitat due to clearing for tracks and drill pad sites and / or land degradation due sediment erosion and runoff associated with these	• Clearing will be limited as far as practicable • Sensitive receiving environments identified will be taped off with danger tape • Existing access and fence line tracks will be used where possible and any new tracks constructed will link natural clearings where possible • Spacing of 2D seismic lines will not typically be less than 500 m apart, with spacings reduced to 250 m at no more than 50 points • The operational area of drill sites will be no greater than 500 square metres • Sump size will be no greater than 10 m2 • Topsoil stripping will be limited to sump areas • Clearing of mature trees will be avoided as far as practicable • Spacings between parallel tracks will not be less than 250 m • Track construction involving blade clearing of established ground cover vegetation and/or clearing of mature	2	B	Moderate	Where / if necessary an offset plan will be provided in accordance with the *Queensland Biodiversity offset Policy* to offset relevant residual impacts.	1	B	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			trees will be prevented or minimised • Line of site clearing between drill sites will be avoided • Construction of new crossings over watercourses will be avoided and only used when no reasonable alternative is available • Tracks will be constructed and maintained with adequate drainage to avoid accelerated erosion • Drill sites and sump areas will be appropriately signposted • Equipment will be used in a manner which minimises disturbance of topsoil and ground cover. • Where practical, the rootstock of existing vegetation will be left intact to promote regrowth and prevent erosion. • Drill sites will be prepared so that stormwater runoff into and from the drill site is minimised. • Disturbed areas will be rehabilitated in accordance with the provisions detailed in the *Code of Environmental Compliance for Exploration and Mineral Development Projects*.							

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		Injury to fauna due to direct contact by equipment used for exploration activities or entrapment in excavations / holes caused by activity	• Pre-clearing inspection for any clearing of remnant vegetation • Unless required for monitoring or other purposes, all excavations, drill holes or sampling sites will be backfilled as soon as practical following the completion of exploration activities • Implementation of speed limits for vehicular movements including a limit of 30km/hr on property tracks and 10km/hr when near a dam, stockyard, watering point or residence. • Rubbish and waste will be removed from the drill sites at the completion of the drilling activities (inclusive of markers and flagging tape)	1	C	Low	Use of cattle panels (around excavations) or ramps into excavations to prevent entry or enable fauna escape if fauna entrapment becomes apparent as a substantive issue	1	D	Low
		Degradation of habitat, loss of species diversity due to accidental release / leaks of hazardous substances used for exploration activities	• Storage and handling of flammable and combustible liquids will be in accordance with *AS 1940- Storage and Handling of Flammable and Combustible Liquids*. • Spillage of all flammable and combustible liquids will be contained within an on-site containment system and controlled in a manner that prevents environmental harm (other than trivial harm) • Drilling fluids and muds will be contained within sumps • Where practical, refueling and routine	1	D	Low		1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			maintenance of vehicles will be undertaken within designated service areas.							

3.5.3.2. Johnson Extended Project Underground Mining Activities

Activities and associated potential impacts

Underground mining activities proposed to be undertaken on the Johnson Extended Project area have the potential to impact on land values associated with terrestrial ecology including through:

- Introduction and / or spread of pests or weeds by equipment used for surface activities in the area of the MLAs
- Fire disturbance caused by surface activities in the area of the MLAs
- Removal / loss of vegetation, flora and fauna habitat due to clearing for tracks, subsidence related impacts and subsidence management, along with potential associated land degradation due sediment erosion and runoff
- Injury to fauna due to direct contact by equipment used for surface activities; and
- Degradation of habitat, loss of species diversity due to accidental release / leaks of hazardous substances used for surface activities.

Impact assessment

Table 3-16 presents the outcomes of the risk assessment of potential impacts from mining activities undertaken on the Johnson Extended Project area on land values associated with terrestrial ecology.

Risk associated with potential impacts to terrestrial ecology is generally considered to be low, with the risk ranking for impacts associated with subsidence identified as moderate. With the development and implementation of a subsidence management plan, the rehabilitation of disturbed areas, and the development and implementation of an offsets plan, the residual risk level associated with potential subsidence impacts is reduced to low.

The subsidence management plan will identify and describe options for mitigating and managing subsidence impacts, which will be implemented. The plan will address the physical condition of surface drainage including erosion, incision processes, stream widening, tension cracking, lowering of bed and banks, creation of in-stream waterholes, changes to local drainage patterns and areas susceptible to high levels of erosion such as watercourse confluences. The plan will also address overland flow, capture of overland flow by subsided long-wall panels, increased overbank flows due to lowering of high bank watercourses and the portion of local and large scale catchment likely to be captured by subsided long-wall panels and the associated impacts on downstream users. The plan will address land condition and future suitability.

Disturbed areas will be rehabilitated in accordance with the provisions detailed in the *Code of Environmental Compliance for Mining Lease Projects* and *Guideline for rehabilitation requirements for mining projects*

Peabody aims to minimise the environmental impacts of its operations. In the case of this project, impacts have been minimised by employing best practice. Peabody also acknowledges that while every effort is made to minimise and mitigate impacts, there are cases where a project will result in a residual unavoidable impact. In these cases environmental offsets allow for development to proceed while maintaining environmental outcomes. To this end, the Queensland Government has developed the Queensland Biodiversity Offset Policy 2011. Peabody will prepare a separate environmental offset

strategy for this project to assess the potential for unavoidable residual impacts and how these will be offset in accordance with the prevailing Biodiversity Offset Policy at the time.

Table 3-16 Risk Assessment Of Potential Impacts From Mining Activities Undertaken On The Johnson Extended Project Area On Land Values Associated With Terrestrial Ecology

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Land values	Terrestrial ecology including for native biodiversity, habitat integrity and agricultural use	Introduction and / or spread of pests or weeds by equipment used for surface activities in the area of the MLas	• Vehicles and machinery will be adequately cleaned before moving into the project area from areas containing declared plants. • Weed infestation areas will be identified and effectively managed prior to commencement of and during works • Control programs will be implemented to reduce the presence of declared and environmental weeds and feral species in accordance with the Coppabella Weed Management Plan. • Effective weed and pest management will be undertaken in any areas to be rehabilitated • Induction programs will include information on nature conservation and weed control issues	1	D	Low		1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		Fire disturbance caused by surface activities in the area of the MLas	• All reasonable and practicable fire prevention measures will be implemented (smoking ban, collection of rubbish, etc.) • Selected personnel will be trained in the use of firefighting equipment including fire extinguishers • Fire extinguishers and / or firefighting equipment will be available to vehicles and work sites • Slashing in heavily grassed areas will be undertaken if necessary	1	C	Low		1	C	Low
		Removal / loss of vegetation, flora and fauna habitat due to clearing for tracks, subsidence related impacts and subsidence management, along with potential associated land degradation due sediment erosion and runoff	• Clearing will be limited as far as practicable • Sensitive receiving environments identified will be taped off with danger tape. • Where practical, the rootstock of existing vegetation will be left intact to promote regrowth. • Topsoil stripping will be limited • Clearing of mature trees will be avoided as far as practicable • Spacing between tracks will not be less than 250m • Existing access and fence line	2	B	Moderate	• A subsidence management plan will be developed and implemented • Rehabilitation of disturbed areas • Development and implementation of an offset plan	1	B	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			tracks will be used where possible and any new tracks constructed will link natural clearings where possible; • Track construction involving blade clearing of established ground cover vegetation and/or clearing of mature trees will be prevented or minimised • Construction of new crossings over Humbug Gully will be avoided and only used when no reasonable alternative is available • Tracks will be constructed and maintained with adequate drainage to avoid accelerated erosion • Equipment used in a manner which minimises disturbance of topsoil and ground cover. • Work areas will be appropriately signposted							
		Injury to fauna due to direct contact by equipment used for	• Pre-clearing inspection will be carried out for any clearing of remnant vegetation	1	C	Low		1	C	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		surface activities	• Implementation of speed limits for vehicular movements including a limit of 30km/hr on property tracks and 10km/hr when near a dam, stockyard, watering point or residence.							
		Degradation of habitat, loss of species diversity due to accidental release / leaks of hazardous substances used for surface activities	• Storage and handling of flammable and combustible liquids will be in accordance with *AS 1940- Storage and Handling of Flammable and Combustible Liquids*. • Where practical, refueling and routine maintenance of vehicles will be undertaken within designated service areas	1	D	Low		1	D	Low

3.5.4 Objectives

The primary objective in relation to terrestrial ecology for the Johnson Extended Project during exploration, operation and post mining is to protect and ultimately enhance the ecological value of the ML areas and to not cause unnecessary adverse impacts on remnant vegetation and habitat throughout operations. The land management objectives include:

- To achieve a stable final land profile which is adequately vegetated and drained and does not cause soil loss or degradation and vegetation loss. The land profile achieved is to enable the protection and enhancement of the two environmental values identified, namely cattle grazing and native biodiversity life.
- To prevent or reduce the amount of soil loss from the Johnson Extended Project area during the exploration and mining phases.

The post mining land use proposed for the Johnson Extended Project area is a combination of grazing and nature conservation. The proposed post mining land use has been selected based on the values of each use to the region and success of similar strategies at other mines within the area.

3.5.5 Control Strategies

3.5.5.1. Johnson Extended Project Exploration And Mining Activities

Key control strategies in relation to the management of the potential impacts of exploration and mining on terrestrial ecological values are described in Table 3-17 below.

Table 3-17 Control Strategies: Terrestrial Ecology

Control Strategies	Explor.	Mining
Vehicles and machinery will be adequately cleaned before moving into the project area from areas containing declared plants	✓	✓
Weed infestation areas will be identified and effectively managed prior to commencement of and during works	✓	✓
Feral animal control programs will be undertaken as necessary	✓	✓
Effective weed and pest management will be undertaken in any areas to be rehabilitated	✓	✓
Induction programs will include information on nature conservation and weed control issues	✓	✓
All reasonable and practicable fire prevention measures will be implemented	✓	✓
Selected personnel will be trained in the use of firefighting equipment including fire extinguishers	✓	✓
Fire extinguishers and / or firefighting equipment will be available to vehicles and work sites	✓	✓
Drill holes (apart from those to be used for monitoring purposes) will be decommissioned as soon as practical	✓	
Slashing in heavily grassed areas will be undertaken if necessary	✓	✓
Clearing will be limited as far as practicable	✓	✓
Sensitive receiving environments identified will be taped off with danger tape	✓	✓
Existing access and fence line tracks will be used where possible and any new tracks constructed will link natural clearings where possible	✓	✓
Spacing of 2D seismic lines will not typically be less than 500 m apart, with spacings reduced to 250 m at no more than 50 points	✓	
The operational area of drill sites will be no greater than 500 m^2	✓	

Control Strategies	Explor.	Mining
Sump size will be no greater than 10 m^2	✓	
Topsoil stripping will be limited to sump area	✓	
Topsoil stripping will be limited		✓
Clearing of mature trees will be avoided as far as practicable	✓	✓
Spacings between tracks will not be less than 250 m	✓	✓
Track construction involving blade clearing of established ground cover vegetation and/or clearing of mature trees will be prevented or minimised	✓	✓
Line of site clearing between drill sites will be avoided	✓	✓
Construction of new crossings over watercourses will be avoided and only used when no reasonable alternative is available	✓	
Construction of new crossings over Humbug Gully will be avoided and only used when no reasonable alternative is available		✓
Tracks will be constructed and maintained with adequate drainage to avoid accelerated erosion	✓	✓
Drill site and sump area will be appropriately signposted	✓	
Work areas will be appropriately signposted		✓
Equipment will be used in a manner which minimises disturbance of topsoil and ground cover	✓	✓
Where practical, the rootstock of existing vegetation will be left intact to promote regrowth	✓	✓
Drill sites will be prepared so that stormwater runoff into and from the drill site is minimised	✓	
Disturbed areas will be rehabilitated in accordance with the provisions detailed in the *Code of Environmental Compliance for Exploration and Mineral Development Projects*	✓	
A subsidence management plan will be developed and implemented		✓
Rehabilitation of disturbed areas		✓
An offset plan will be developed and implemented	✓	✓
Pre-clearing inspection for any clearing of remnant vegetation	✓	✓
Unless required for monitoring or other purposes all excavations, drill holes or sampling sites will be backfilled as soon as practical following the completion of exploration activities	✓	
Implementation of speed limits for vehicular movements including a limit of 30km/hr on property tracks and 10km/hr when near a dam, stockyard, watering point or residence	✓	✓
Rubbish and waste will be removed from the drill site at the completion of the drilling activities (inclusive of markers and flagging tape)	✓	
Use of cattle panels (around excavations) or ramps into excavations to prevent entry or enable fauna escape if fauna entrapment becomes apparent as a substantive issue	✓	
Storage and handling of flammable and combustible liquids will be in accordance with *AS 1940- Storage and Handling of Flammable and Combustible Liquids*	✓	✓
Drilling fluids and muds will be contained within sumps	✓	
Where practical, refuelling and routine maintenance of vehicles will be undertaken within designated service areas	✓	✓

3.5.6 Proposed EA Conditions

3.5.6.1. Johnson Extended Project Exploration Activities

Exploration activities shall be carried out in compliance with the standard conditions of the *Code of environmental compliance for exploration and mineral development projects, DEHP, Version 1* (or later version), with the exception of standard Condition 13. The following alternate conditions are proposed, consistent with the EA conditions as applicable under the current Coppabella Mine EA EPML00579213 (previously MIN100555707):

X1 The environmental authority holder is authorised to carry out exploration activities in or within five hundred (500) metres of Endangered Regional Ecosystems located within ML 70384, 70385, 70386 and 70387.

X2 When carrying out exploration activities in or within five hundred (500) metres of any Endangered Regional Ecosystems, the holder of the environmental authority must do so in accordance with conditions X3 to X7.

X3 Drilling or Seismic Grid a) Spacing of grid lines or 2D seismic lines is not less than five hundred (500) metres apart; and b) Spacings may be reduced to two hundred and fifty (250) metres at no more than fifty (50) specified points; and c) seismic lines constructed within Endangered Regional Ecosystems must not exceed a total disturbance area of twenty (20) hectares.

X4 Drill Sites a) Operational area is to be no greater than nine hundred (900) square metres; and b) Sump size is to be no greater than ten (10) square metres; and c) Topsoil stripping must be limited to sump area; and d) Clearing of mature trees must be avoided as far as practicable.

X5 Tracks a) Spacings between parallel tracks must not be less than two hundred and fifty (250) metres; and b) Existing access and fence line tracks must be used where possible and any new tracks constructed must link natural clearings where possible; and c) Track construction involving blade clearing or established ground cover vegetation and/or clearing of mature trees is prevented or minimised; and d) Line of site clearing must be avoided; and e) Construction of new crossings over watercourses must be avoided and is only permitted when no reasonable alternative is available; and f) All tracks must be constructed and maintained with adequate drainage to avoid accelerated erosion.

X6 Other Land Disturbances a) Activities must not include costeaning or bulk sampling; and b) All equipment such as earthmoving and drilling equipment must be used in a manner which minimises unnecessary disturbance of topsoil and ground cover vegetation; and c) Camp sites must not be established.

X7 Disturbance due to exploration activities must be rehabilitated in accordance with provisions detailed in the *Code of Environmental Compliance for Exploration and Mineral Development Projects*.

3.5.6.2. Johnson Extended Project Underground Mining Activities

It is proposed to apply biodiversity offsets conditions extracted from the DEHP Guideline *Model mining conditions* as follows:

Biodiversity offsets

H6 The holder of this environmental authority must provide an offset for impacts on applicable state significant biodiversity values, in accordance with Queensland Biodiversity Offset Policy. The biodiversity offset must be consistent with the requirements for an offset as identified in the Biodiversity Offset Strategy (as per condition H7) and must be provided:

a) prior to impacting on state significant biodiversity values; or

b) where a land based offset is to be provided, within 12 months of the later of either of the following

1. the date of issue of this environmental authority; or
2. the relevant stage identified in the Biodiversity Offset Strategy submitted under condition H7; or

c) where an offset payment is to be provided, within 4 months of the later of either of the following

3. the date of issue of this environmental authority; or
4. the relevant stage identified in the Biodiversity Offset Strategy submitted under conditions H7.

H7 A Biodiversity Offset Strategy must be developed and submitted to the administering authority within either 30 days, or a lesser period agreed to by the administering authority, prior to impacting on the applicable state significant biodiversity values.

3.6 Noise And Vibration

3.6.1 Description Of Noise Environment

Noise levels in the area are typical of rural environments but are, for some sensitive receptors, affected by noise from existing mining operations.

A noise impact assessment was carried out for the proposed underground mining operations at Coppabella Mine[6]. For the purpose of the assessment, noise logging was carried out at the two closest sensitive receptors, homesteads Harrybrant (Lot 4 on SP144274) and Oben Park (WP156).

Table 3-18 provides a summary of the measured noise levels at both homesteads.

The noise levels are expressed in terms of the Leq, L10, and L90. The L10 and L90 are respectively the A-weighted noise levels exceeded 10%, and 90% of the time. The Leq is the A-weighted energy average noise level containing the same acoustic energy as the actual fluctuating noise level.

Background noise levels were also measured at both homesteads. Due to the likelihood that the background noise levels at Oben Park are affected by the operation of the mine, the background noise levels from Harrybrant are used as the typical background noise levels at

[6] Coppabella Underground Coal Mine, Noise Impact Assessment (draft), 25 January 2012, ASK Consulting Engineers for Macarthur Coal.

both sites, in the absence of the mine. These levels are provided in Table 3-19 Measured Background Noise Levels At Harrybrant Homestead.

The background noise levels (min L90) are calculated using the 'lowest 10th percentile' of the L90 levels in each period of the day.

Table 3-18 Summary Of Measured Noise Levels

Location	Statistic	L10,dB(A)			L90,dB(A)			Leq,dB(A)		
		Day	Even	Night	Day	Even	Night	Day	Even	Night
Harrybrant	**Max**	57	55	56	41	38	47	66	51	53
	Min	27	20	19	19	18	17	25	20	18
	90%	49	40	44	32	32	32	47	37	41
	10%	32	26	24	22	19	18	31	24	22
	Average	40	34	34	26	25	23	39	31	31
Oben Park	**Max**	85	63	66	70	46	52	77	56	58
	Min	33	34	28	29	24	24	31	29	25
	90%	51	56	59	41	41	49	46	48	52
	10%	38	41	42	32	30	30	35	36	37
	Average	44	48	51	36	37	40	40	42	45

Table 3-19 Measured Background Noise Levels At Harrybrant Homestead

Location	Background Noise Level, minL90, dB(A)		
	Day	Evening	Night
Harrybrandt	22	19	18

3.6.2 Environmental Values And Sensitive Receptors

The key environmental values for noise and vibration are outlined in the Environmental Protection (Noise) Policy 2008 (EPP Noise):

The environmental values to be enhanced or protected are the qualities of the acoustic environment that are conducive to—
(a) the wellbeing of the community or a part of the community, including its social and economic amenity; or
(b) the wellbeing of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise.

EPP(Noise) sets noise level objectives for various periods of the day. Schedule 1 of the EPP(Noise) includes the following acoustic quality objectives to be met at residential dwellings:

- Outdoors:
  - Daytime and Evening: 50 dB(A) LAeq,adj,1hr, 55 dB(A) LA10,adj,1hr and 65 dB(A) LA1,adj,1hr.

- Indoors:
  - Daytime and Evening: 35 dB(A) LAeq,adj,1hr, 40 dB(A) LA10,adj,1hr and 45 dB(A) LA1,adj,1hr.
  - Night: 30 dB(A) LAeq,adj,1hr, 35 dB(A) LA10,adj,1hr and 40 dB(A) LA1,adj,1hr.

As indicated in the Noise Impact Assessment, the EcoAccess Guideline "Noise and vibration from blasting" applies to mining activities and contains criteria applicable to noise and vibration emitted from blasting. The criteria address human comfort and are below typical limits for prevention of structural damage, as follows:

- Airblast: Airblast overpressure 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.
- Vibration: 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.

The guidelines states that:

"blasting should generally only be permitted during the hours of 9am to 3pm, Monday to Friday, and from 9am to 1pm on Saturdays. Blasting should not generally take place on Sundays or public holidays.
Blasting outside these recommended times should be approved only where:
(a) Blasting during the preferred times is clearly impracticable (in such situations blasts should be limited in number and stricter airblast overpressure and ground vibration limits should apply); or
(b) There is no likelihood of persons in a noise sensitive place being affected because of the remote location of the blast site."

The current EA EPML00579213 (previously MIN100555707) applicable to the Coppabella Mine sets the vibration limits at 10mm/s peak particle velocity at any sensitive receptor.

The Coppabella mine's sensitive noise and vibration receptors are the homesteads located in the vicinity of the mine site:

- Harrybrant: approximately 7.8 km of the Johnson Extended Project area boundary and 12 km from the coal processing facilities
- Oben Park: approximately 5.1 km of the Johnson Extended Project area boundary and 2.5 km from the coal processing facilities
- Spring Creek: approximately 8.7 km of the Johnson Extended Project area boundary and 6.8 km from the coal processing facilities
- L&G Tones: approximately 8.7 km of the Johnson Extended Project area boundary and 4.5 km from the coal processing facilities
- Wanella: approximately 10 km of the Johnson Extended Project area boundary and 5.9 km from the coal processing facilities

Figure 5 illustrates the location of each homestead in relation to the mine site, Oben Park being situated the closest to the mine.

3.6.3 Assessment of Potential Impacts on Environmental Values

3.6.3.1. Johnson Extended Project Exploration Activities

Activities and associated potential impacts

During exploration, noise generating activities will consist of:

- Operation of drill rigs; and
- Vehicle and plant movements.

Exploration activities will generate negligible levels of vibrations.

Impact assessment

The Johnson Extended Project area is located on the northern side of the Coppabella Mine site, which is situated the furthest away from all sensitive receptors, as shown on **Figure 4**. Considering the low level of noise generated by exploration activities and the distance separating the sensitive receptors from the Johnson Extend Project area, it is highly unlikely that any noise will reach a sensitive receptor.

Table 3-20 presents the outcomes of the risk assessment of potential impacts from exploration activities on the acoustic and vibration environment at sensitive receptors.

Table 3-20 Risk Assessment Of Potential Impacts From Johnson Extended Project Exploration Activities On The Acoustic And Vibration Environment

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Noise and vibration	Human health, aesthetics and ecological health.	Construction of tracks for 2D seismic survey and drill site access, along with drill pad development and drilling generating noise and vibration that causes impacts to sensitive receptors	• Use and maintain low noise equipment; • Repair or replace defective mufflers of vehicles and plant with suitable effective mufflers; • All mobile equipment to be fitted with efficient silencing equipment to current Queensland mining standards. • Existing access and fence line tracks used where possible • Leaving or creating wind breaks or screening	1	C	Low	Review of hours of operations should complaints (that are not vexatious or frivolous) be received	1	D	Low

3.6.3.2. Johnson Extended Project Underground Mining Activities

Activities and associated potential impacts

Noise and/or vibration generating mining activities will consist of:

- Surface activities:
  - Construction/installation of monitoring bores, gas drainage facilities;
  - Earthworks for subsidence management; and
  - Operation of pumps and fans for gas drainage.

- Underground activities:
  - Operation of coal mining machinery; and
  - Blasting

Impact assessment

Noise modeling was undertaken for the purpose of the Noise Impact Assessment carried out for the Coppabella Underground Mine Project. Results of the modeling and noise impact assessment on sensitive receptors indicate that the EPP(Noise) indoor noise criteria will not be exceeded at any of the sensitive receptors, whether in daytime or nighttime.

Predictive blasting noise calculations and impact assessment were undertaken under the Noise Impact Assessment. The study finds that, based on the mine's blast parameters, the 10mm/s peak particle velocity criterion would be achieved at distances greater than 1.5 km from the blast and 5mm/s peak particle velocity criterion will be achieved at distances greater than 2.3km, which is the distance separating the mine from the nearest sensitive receptor.

The Noise Impact Assessment notes that airblast and flyrock would be expected to be minimal from an underground coal mine, and as such it is not further considered.

Table 3-21 presents the outcomes of the risk assessment of potential impacts from mining activities on the acoustic and vibration environment at sensitive receptors.

Table 3-21 Risk Assessment Of Potential Impacts From Johnson Extended Project Underground Mining Activities On The Acoustic And Vibration Environment

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Noise and vibration	Human health, aesthetics and ecological health.	Construction of tracks for access to gas drainage facilities, pumps, monitoring bores and subsidence impacted areas, along with the undertaking of subsidence management activities (re-profiling land) causing noise impacts to sensitive receptors	• Provide and maintain low noise equipment; • Repair or replace defective mufflers of vehicles and plant with suitable effective mufflers; • Existing access and fence line tracks used where possible • Leave or create wind breaks or screening;	1	C	Low	Review of hours of operations for certain activities should complaints (that are not vexatious or frivolous) be received.	1	D	Low
		Gas drainage, vehicle and equipment (e.g. pumps / fans) emissions, causing noise impacts to sensitive receptors	• Provide and maintain low noise equipment; • Repair or replace defective mufflers with suitable effective mufflers; • Leaving or creating wind breaks or screening;	1	D	Low		1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		Blasting undertaken as part of underground operations causing vibration impacts to sensitive receptors	• Blast design will ensure that all relevant ground vibration criteria are complied with at the boundary of the Mining Leases. • Blasting operations at the Johnson Extended Project will be conducted in accordance with Australian Standard AS 2187.2 Explosives - Use of Explosives. • Blast design will ensure that ground vibration does not exceed any relevant statutory limits at any sensitive receptor. • Appropriate warnings will be provided prior to blasting in accordance with legislative provisions.	1	D	Low		1	D	Low

3.6.4 Objectives

The primary objectives for noise and vibration are:

- To ensure that there is no unreasonable intrusive noise or vibration attributable to the mining operation at the nearest noise sensitive locations; and
- Control noise and vibration sources at the site to enable achievement of the statutory environmental protection objectives contained in the EPP(Noise).

3.6.5 Control Strategies

3.6.5.1. Johnson Extended Project Exploration And Underground Mining Activities

The control strategies identified in Table 3-22 are deemed appropriate to meet noise and vibration criteria at each sensitive receptor and keep impact risks low during the exploration and mining phases.

Table 3-22 Control Strategies: Noise and Vibration

Control Strategies	Explor.	Mining
Advise landholder of proposed activities	✓	
Obtain Landholder consent for any drill site located < 500m from a residence	✓	
Limit vehicle speed limits to 30km/hr on property tracks and 10km/hr when near a residence	✓	
Existing access and fence line tracks used where possible	✓	
Schedule activities for times when they will have least impact	✓	✓
Use and maintain low noise equipment;	✓	✓
Repair or replace defective mufflers of vehicles and plant with suitable effective mufflers;	✓	✓
All mobile equipment to be fitted with efficient silencing equipment to current Queensland mining standards.	✓	✓
Leave or create wind breaks or screening	✓	✓
Repair or replace defective mufflers of vehicles and plant with suitable effective mufflers;	✓	✓
Blast design will ensure that all relevant ground vibration criteria are complied with at the boundary of the Mining Leases.		✓
Blasting operations at the Johnson Extended Project will be conducted in accordance with Australian Standard AS 2187.2 Explosives - Use of Explosives.		✓
Blast design will ensure that ground vibration does not exceed any relevant statutory limits at any sensitive receptor.		✓
Appropriate warnings to be provided prior to blasting in accordance with legislative provisions.		✓

3.6.6 Proposed EA Conditions

3.6.6.1. Johnson Extended Project Exploration Activities

It is expected that environmental values relating to noise and vibration will be adequately protected and managed through implementation of the conditions of the *Code of environmental compliance for exploration and mineral development projects, DEHP, Version 1* (or more recent version).

3.6.6.2. Johnson Extended Project Underground Mining Activities

It is proposed to apply the following EA conditions:

Schedule D - Noise

D1 Subject to condition D2, noise from the mining activity must not cause an environmental nuisance, at any sensitive place.

D2 When requested by the administering authority, noise 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 belied in the opinion of the authorised officer) of environmental nuisance at any sensitive place, and the results must be notified within fourteen (14) days to the administering authority following completion of monitoring.

D3 If the environmental authority holder can provide evidence through monitoring that the limits defined in Table D1- Noise Limits and Table D2- Airblast Overpressure Level- Sensitive Place inclusive are not being exceeded then the holder is not in breach of condition D1. Monitoring must include:

a. LA, max adj, T
b. The level and frequency of occurrence of impulsive or tonal noise;
c. Atmospheric conditions including wind speed and direction; and
d. Location, date and time of recording.

D4 If monitoring indicates exceedance of the limits in Table D1- Noise Limits, then the environmental authority holder must:

a. Address the complaint including the use of appropriate dispute resolution if required; or

b. Immediately implement noise abatement measures so that emissions of noise from the activity do not result in further environmental nuisance.

D5 The method of measurement and reporting of noise levels must comply with the latest edition of the administering authorities Noise Measurement Manual.

Table D1 – Noise Limits

Noise Level dB(A) measured as	**Monday to Saturday**			**Sundays and Public Holidays**		
	7pm–6pm	**6pm–10pm**	**10pm–7am**	**9am–6pm**	**6pm–10pm**	**10pm–9am**
	Noise measured at a "noise sensitive place"					
LA10,adj,10 mins	b/g+5	b/g+5	b/g+0	b/g+5	b/g+5	b/g+0
LA1,adj,10 mins	b/g+10	b/g+10	b/g+5	b/g+10	b/g+10	b/g+5

Table D2 – Airblast Overpressure Level – Sensitive Place

Noise Parameter	Monday to Saturday 6am – 7pm Noise measured at a "noise sensitive place"	Sundays and Public Holidays 9am – 7pm
Airblast overpressure level (dB linear peak)	115dB (80th percentile)	115dB (80th percentile)
Airblast overpressure level (dB linear peak)	120 dB (maximum)	120 dB (maximum)

Vibration

D6 Subject to condition D7, vibration from the mining activity must not cause an environmental nuisance, at any sensitive place.

D7 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 any mistaken belief in the opinion of the authorised officer) of environmental nuisance at any sensitive place, and the results must be notified within fourteen (14) days to the administering authority following completion of monitoring.

D8 If the environmental authority holder can provide evidence through monitoring that the limits defined in *Table D3- Vibration limits* are not being exceeded then the holder is not in breach of condition D6.
Monitoring must include:

a. Location of the blasts/s within the mining area (including which bench level); and
b. Atmospheric conditions including temperature, relative humidity and wind speed and direction; and
c. Location, date and time of recording.

Table D3 – Vibration Limits

Vibration Parameter	Vibration measured at a sensitive place	
	Monday to Saturday 6am – 7pm	Sundays and Public Holidays 9am – 7pm
Houses and low rise residential buildings and commercial building not Included below	10 mm/s peak particle velocity	10 mm/s peak particle velocity

3.7 Waste

The regulatory requirements governing waste management in Queensland are provided by the following pieces of legislation.

- *Environmental Protection Act 1994* (EP Act)
- *Environmental Protection Regulation 2008* (EP Reg)
- *Environmental Protection (Waste Management) Regulation 2000* (EP(WM) Reg)
- *Waste Reduction and Recycling Act 2011* (WRR Act)
- *Waste Reduction and Recycling Regulation 2011* (WRR Reg)

The EP Act defines waste as anything, that is:

a. Left over, or an unwanted by-product, from an industrial, commercial, domestic or other activity
b. Surplus to the industrial, commercial, domestic or other activity generating the waste.

The EP Reg identifies certain ERAs relevant to waste management (e.g. for storage, transport, recycling and treatment of waste), the undertaking of which requires a development permit and a registration certificate. As such, the EP Reg stipulates that these ERAs must only be undertaken by licensed parties at licensed facilities.

The purpose of the EP(WM) Reg is to protect the environment by:

a. Minimising the impact of waste to the environment including, in particular, the impact of waste so far as it directly affects human health
b. Establishing an integrated framework for minimising and managing waste under the principles of ecologically sustainable development.

The EP(WM) Reg provides for the reporting and tracking requirements of regulated waste.
The WRR Act defines a number of key concepts in relation to the management of waste including:

- the **waste and resource management hierarchy**, which, in the order of most preferred to least preferred waste and resource management option is:

a. Avoid unnecessary resource consumption;
b. Reduce waste generation and disposal;
c. Reuse waste resources without further manufacturing;
d. Recycle waste resources to make the same or different products;
e. Recover waste resources, including the recovery of energy;
f. Treat waste before disposal, including reducing the hazardous nature of waste; and
g. Dispose of waste only if there is no viable alternative.

- The **polluter pays principle** is the principle that all costs associated with the management of waste should be borne by the persons who generated the waste.
- The **user pays principle** is the principle that all costs associated with the use of a resource should be included in the prices of the goods and services (including government services) that result from the use.
- The **proximity principle** is the principle that waste and recovered resources should be managed as close to the source of generation as possible.

- The **product stewardship principle** is the principle that there is a shared responsibility between all persons who are involved in the life cycle of a product for managing the environmental, social and economic impact of the product.

The WRR Reg differentiates between waste types, particularly commercial and industrial waste, construction and demolition waste, and regulated waste.

3.7.1 Description Of Environment Relevant To Waste

Existing conditions in relation to waste at the location of the Johnson Extended Project reflect the existing land use of grazing i.e. the existing land use causes minimal to no waste-related impacts.
Facilities and services in the region relating to waste management include:

- Nebo Resource Recovery Centre, Nebo (Isaac Regional Council);
- General waste collection contractors;
- Hazardous waste contractors;
- Clean waste recycling facilities, (Mackay/Rockhampton); and
- Hazardous waste recycling facilities, (Mackay and Townsville).

3.7.2 Environmental Values And Sensitive Receptors

Environmental values associated with the Johnson Extended Project area that may be impacted by waste management practices associated with the project include human health, aesthetics, and ecological health and land use capability.

3.7.3 Assessment Of Potential Impacts On Environmental Values

3.7.3.1. Johnson Extended Project Exploration Activities

Activities and associated potential impacts

Waste management associated with exploration activities has the potential to impact on environmental values. Impact may be caused primarily through release of waste due inefficient use of resources or ineffective management causing contamination of land and surface water, degradation of social amenity, ecological health and land use capability. A secondary impact may be that pressure is put on municipal infrastructure due to increased peak demand on processing capacity.

Impact assessment

Table 3-23 presents the outcomes of the risk assessment of potential impacts from waste management associated with exploration activities on the aforementioned environmental values.
Considering their small magnitude, short-term and temporary nature, combined with the proposed control measures in this EMP, waste management associated with exploration activities on the Johnson Extended MLAs is expected to have negligible impact on environmental values.

Table 3-23 Risk Assessment Of Potential Impacts From Johnson Extended Project Exploration Activities' Waste Management On Environmental Values

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Waste management	Human health, aesthetics, ecological health and land use capability	Release of waste due inefficient use of resources or ineffective management causing contamination of land and surface water, degradation of social amenity and ecological health	• The waste management hierarchy (as previously described) will be employed • Waste will not be released directly or indirectly to any watercourse, waterway, groundwater, wetland or lake • Rubbish and waste will be removed from the drill site at the completion of the drilling activities (inclusive of all markers and flagging tape) • Regulated wastes will be stored in designated locations and will be removed from site by a licensed regulated waste contractor and taken to a licensed landfill that can accept regulated wastes • Drilling fluids contained within sumps will be removed via a sucker truck and disposed of at a designated waste disposal area • Waste will be segregated to maximise reuse and recycling opportunities and will be stored appropriately • Licensed contractors, transporters and disposal facilities will be used to manage waste	1	D	Low		1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			• Regulated wastes will be tracked in accordance with the EP(WM) Reg • A register of all chemicals stored on site will be developed and maintained • A register of hazardous materials and their location will be kept on site.							
		Inefficient use of resources or ineffective management causing pressure on municipal infrastructure due to increased peak demand on processing capacity.	• The waste management hierarchy (as previously described) will be employed • Effective communication will be undertaken will waste management contractors and waste recovery facility managers as necessary	1	E	Low		1	E	Low

3.7.3.2. Johnson Extended Project Underground Mining Activities

Activities and associated potential impacts

Waste management associated with mining operations in the Johnson Extended Project area has the potential to impact on environmental values. Impact may be caused primarily through release of waste due inefficient use of resources or ineffective management causing contamination of land and surface water, degradation of social amenity, ecological health and land use capability. A secondary impact may be that pressure is put on municipal infrastructure due to increased peak demand on processing capacity.

Impact assessment

Table 3-24 presents the outcomes of the risk assessment of potential impacts from waste management associated with these activities on the aforementioned environmental values. Considering their small magnitude combined with the proposed control measures in this EM Plan, waste management associated with mining activities on the Johnson Extended MLAs is expected to have negligible impact on environmental values.

Impact assessment

Table 3-25 presents the outcomes of the risk assessment of potential impacts from waste management associated with these activities on the aforementioned environmental values.

Given the proposed control measures in this EMP, waste management associated with mining activities on the Johnson Extended MLAs is expected to have a low level of impact on environmental values.

Table 3-24 Risk Assessment Of Potential Impacts From Johnson Extended Project Exploration Activities' Waste Management On Environmental Values

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Waste management	Human health, aesthetics, ecological health and land use capability	Release of waste due inefficient use of resources or ineffective management causing contamination of land and surface water, degradation of social amenity and ecological health	• The waste management hierarchy (as previously described) will be employed • Waste will not be released directly or indirectly to any watercourse, waterway, groundwater, wetland or lake • Wastes will be collected and removed from site. • Regulated wastes will be stored in designated locations and will be removed from site by a licensed regulated waste contractor and taken to a licensed landfill that can accept regulated wastes. • Waste will be segregated to maximise reuse and recycling opportunities and will be stored appropriately • Licensed contractors, transporters and disposal facilities will be used to manage waste • Regulated wastes will be tracked in accordance with the EP(WM) Reg. • A register of all chemicals stored on site will be developed and maintained • A register of hazardous materials and their location will be kept on site.	1	D	Low		1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			• Waste will be managed in accordance with the Coppabella Coal Mine waste management plan, which includes the setting of annual targets to track the generation of various categories of waste • Annual audits will report progress towards meeting targets and the effectiveness of waste reduction and recycling programs.							
		Inefficient use of resources or ineffective management causing pressure on municipal infrastructure due to increased peak demand on processing capacity.	• The waste management hierarchy (as previously described) will be employed • Effective communication will be undertaken will waste management contractors and waste recovery facility managers as necessary. • Waste will be managed in accordance with the Coppabella Coal Mine waste management plan, which includes the setting of annual targets to track the generation of various categories of waste • Annual audits will report progress towards meeting targets and the effectiveness of waste reduction and recycling programs.	1	E	Low		1	E	Low

Table 3-25 Risk Assessment Of Potential Impacts From Johnson Extended Project Mining Activities' Waste Management On Environmental Values

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Waste management	Human health, aesthetics, ecological health and land use capability	Release of waste due inefficient use of resources or ineffective management causing contamination of land and surface water, degradation of social amenity and ecological health	• The waste management hierarchy (as previously described) will be employed • Waste will not be released directly or indirectly to any watercourse, waterway, groundwater, wetland or lake • Regulated wastes will be stored in designated locations and will be removed from site by a licensed regulated waste contractor and taken to a licensed landfill that can accept regulated wastes. • Waste will be segregated to maximise reuse and recycling opportunities and will be stored appropriately • Licensed contractors, transporters and disposal facilities will be used to manage waste • Regulated wastes will be tracked in accordance with the EP(WM) Reg. • A register of all chemicals stored on site will be developed and maintained • A register of hazardous materials and their location will be kept on site. • Waste will be managed in accordance with the Coppabella Coal Mine waste	1	D	Low		1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			management plan, which includes the setting of annual targets to track the generation of various categories of waste •Annual audits will report progress towards meeting targets and the effectiveness of waste reduction and recycling programs.							
		Inefficient use of resources or ineffective management causing pressure on municipal infrastructure due to increased peak demand on processing capacity.	•The waste management hierarchy (as previously described) will be employed •Effective communication will be undertaken will waste management contractors and waste recovery facility managers as necessary. •Waste will be managed in accordance with the Coppabella Coal Mine waste management plan, which includes the setting of annual targets to track the generation of various categories of waste •Annual audits will report progress towards meeting targets and the effectiveness of waste reduction and recycling programs.	1	E	Low		1	E	Low

3.7.4 Objectives

The primary objective in relation to waste management for the Johnson Extended Project during exploration, operation and post mining is to ensure that waste is managed (including generation, transportation, reuse, recycling, recover, treatment and disposal (if necessary)) in a way that protects all environmental values.

3.7.5 Control Strategies

3.7.5.1. Johnson Extended Project Exploration And Underground Mining Activities

Key control strategies in relation to the potential impacts associated with waste management for exploration and mining on the Johnson Extended Project area are described in **Table 3-26** below.

Table 3-26 Control Strategies: Waste

Control Strategies	Explor.	Mining
The waste management hierarchy will be employed	✓	✓
Waste will not be released directly or indirectly to any watercourse, waterway, groundwater, wetland or lake	✓	✓
Rubbish and waste will be removed from the drill site at the completion of the drilling activities (inclusive of all markers and flagging tape)	✓	
Regulated wastes will be stored in designated locations and will be removed from site by a licensed regulated waste contractor and taken to a licensed landfill that can accept regulated wastes.	✓	✓
Drilling fluids contained within sumps will be removed via a sucker truck and disposed of at a designated waste disposal area	✓	
Waste will be segregated to maximise reuse and recycling opportunities and will be stored appropriately	✓	✓
Licensed contractors, transporters and disposal facilities will be used to manage waste	✓	✓
Regulated wastes will be tracked in accordance with the EP(WM) Reg.	✓	✓
A register of all chemicals stored on site will be developed and maintained	✓	
A register of hazardous materials and their location will be kept on site.	✓	✓
Effective communication will be undertaken will waste management contractors and waste recovery facility managers as necessary.	✓	✓
Wastes will be collected and removed from site.	✓	✓
Waste will be managed in accordance with the Coppabella Coal Mine waste management plan, which includes the setting of annual targets to track the generation of various categories of waste		✓
Annual audits will report progress towards meeting targets and the effectiveness of waste reduction and recycling programs.		✓

3.7.6 Proposed Environmental Authority Conditions

3.7.6.1. Exploration Activities

Exploration activities shall be carried out in compliance with the standard conditions of the *Code of environmental compliance for exploration and mineral development projects, DEHP, Version 1* (or later version).

3.7.6.2. Underground Mining Activities

It is proposed to apply the following EA conditions:

Schedule C – Waste

C2 Unless otherwise permitted by the conditions of this environmental authority or with prior approval from the administering authority and in accordance with a relevant standard operating procedure, waste must not be burnt.

C3 The holder of this environmental authority may burn vegetation cleared in the course of carrying out extraction activities provided the activity does not cause environmental harm at any sensitive place or commercial place.

3.8 Water

This section addresses both surface water and groundwater potentially affected by the proposed Johnson Extended Project. It relies on the following technical studies:

- Hydraulics study[7] undertaken for the purpose of the wider Coppabella Underground Mine project in order to assess its potential impacts on Humbug Gully.
- Flood modeling baseline study of Humbug Gully[8]
- Groundwater Impact Assessment[9] carried out for the Coppabella Underground Mine project to understand the potential impacts of the underground mine on groundwater in the area.
- Aquatic ecology assessment undertaken of Humbug Gully to understand baseline aquatic ecology values.[10]

This section uses content from both studies that is relevant to the purposes of this EMP.

3.8.1 Description of Surrounding Environment

3.8.1.1. Surface Water

The Johnson Extended Project area is in the majority located within the Humbug Gully catchment area. Humbug Gully catchment rises in the foothills of the Carborough Range, about 10 km northwest of the existing mine site. The watercourse is ephemeral and is essentially linear in shape, with only minor tributary gullies branching from the main flow path. Humbug Gully is the only watercourse present within the project area. It drains from West to East and is a tributary of Harrybrandt Creek, which runs south of the Coppabella Mine site and drains to the west and south-west into Bee Creek. Ultimately surface water runoff from the region drains into the Isaac River approximately 60km to the south-east. The location of the abovementioned creeks is shown in **Figure 5**.

The flood modelling study provides a baseline assessment of the Humbug Gully flooding regime that will be used as reference for comparison with the expected flooding regime after subsidence has occurred due to the underground mining. A flood modelling study accounting for subsidence will be included in the scope of the subsidence management plan to be prepared at a later stage.

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[7] Coppabella Underground Mine, Hydraulic Report, Cardno Lawson Treloar, April 2001, prepared for Macarthur Coal Limited.

[8] Modelling and Assessment Report: Coppabella Underground Mine Flood Modelling, Alluvium, January 2014.

[9] Coppabella Underground Project, Groundwater Impact Assessment, Australasian Groundwater and Environmental Consultants Pty Ltd, December 2010, prepared for Macarthur Coal.

[10] Coppabella Underground Project: Aquatic Ecology. Frc Environmental, 2011. Draft report. Prepared for Ecological Survey and Management.

3.8.1.2. Groundwater

Alluvial aquifers

The alluvium in the project area is typically associated with Harrybrandt Creek and its tributaries, south of the current mine area and along the southern boundary, where it is generally confined to a relatively narrow band along the creeks and tributary channels.
The alluvium consists of silty clayey sand, sand and gravel which appear to be generally not well developed and relatively thin. Review of exploration borelogs indicates an average thickness for alluvial sediments of 1.3m ranging from 0.2m to 7m.

Tertiary aquifers

During site investigations, groundwater was intersected towards the base of the Tertiary between 22m (Monitoring Bore (MB) 11) and 40m (MB6). Hence the aquifer occurs at the base of the Tertiary sediments where the sandy to gravelly sand layer is present and is sufficiently porous to host groundwater. The occurrence and depth of the aquifer is likely to be variable and depend on the depth and extent of these more porous sandy and gravelly layers.

Groundwater levels in this aquifer ranged between 17.7m (MB11) and 39.3m (MB6) below ground level. This indicates this aquifer is confined to semi-confined beneath the overlying more clayey sediments.

Water quality analyses indicate that the Tertiary groundwater has a slightly alkaline pH and is dominated by sodium and chloride with total dissolved solids (TDS) of around 8,500mg/L making it saline, exceeding the guideline level for cattle. A relatively high sulphate level was recorded; however this was still within the range for livestock. Metal concentrations for selenium meet the livestock guideline, whilst concentrations of the other metals were either below the laboratory detection limit or below the relevant guideline level.

Permian overburden aquifer

Groundwater associated with the overburden sequences that is, not related to the coal seams, was intersected at four locations across the site at varying depths, from 63m in bore MB5 to greater than 100m in bores MB3 and MB4. Similarly the extent of groundwater inflows also varied from minor inflow at bore MB7 (<0.1L/s) to 2.2L/s in bore MB5 and was mostly associated with sandstone.

Groundwater levels measured in five monitoring bores constructed in this aquifer ranged from 37.0m (bore MB4) to 54.4m (bore MB7) below ground level. This indicates this aquifer is confined beneath the overlying less permeable sedimentary layers.

Water quality analyses indicate that groundwater from this aquifer has a slightly alkaline pH and is dominated by sodium and chloride with total dissolved solids (TDS) in excess of 12,500mg/L making it saline and exceeding the guideline levels for cattle. A relatively high sulphate level was recorded in bore MB5; however this is still within the range for livestock. Levels for selenium were equivalent to the livestock threshold in each bore. 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.

Coal seam aquifers

The coal seams targeted for the underground mine are restricted to the Permian Rangal Coal Measures, which include the Macarthur Seam (average thickness of 11m), and Leichhardt Lower Seam (average thickness of 6.5m), within the Coppabella Mine area. Other Permian coal seams include the Vermont and Girrah Seams within the Fort Cooper Coal Measures which are stratigraphically lower than the Rangal Coal Measures and will not be intersected by the underground mining. The coal seams are confined aquifers which generally exhibit low transmissivity and recharge rates, that is, of low to moderately permeability. Groundwater storage and movement occurs within the coal seam cleats and fissures and within open fractures that intersect the seams. Groundwater levels measured in the two monitoring bores constructed in this aquifer ranged from 47.0m to 63.9m below ground level.

Water quality analyses indicate that the Permian coal seam aquifer groundwater has a slightly alkaline pH and is dominated by sodium and chloride with TDS levels in excess of 10,500mg/L making it saline which exceed the guideline levels for cattle. Levels for selenium were equivalent to the livestock threshold in each bore. Other metal concentrations were either below the laboratory detection limit or below the relevant livestock guideline.

3.8.2 Environmental Values

3.8.2.1. Surface Water

Environmental values and Water quality Objectives for the watercourses in the region of the Coppabella Mine are identified in Schedule 1 of the *Environmental Protection (Water) Policy 2009* (EPP (Water)), particularly in the *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), DEHP September 2011* and the associated plan *WQ1301 - Isaac River Sub-basin*. Environmental Values identified by both documents and applicable to the watercourses in the mine area are those for the Isaac fresh waters in undeveloped areas, as follows:

- Aquatic Ecosystems, defined as “a community of organisms living within or adjacent to water, including riparian or foreshore area” (EPP (Water), schedule 2).
- Stock watering, defined as “suitability of water supply for production of healthy livestock“.
- Human consumer of aquatic food, defined as “health of humans consuming aquatic foods, such as fish, crustaceans and shellfish from natural waterways”.
- Primary recreation, defined as “health of humans during recreation which involves direct contact and a high probability of water being swallowed, for example, swimming, surfing, windsurfing, diving and water-skiing”.
- Secondary recreation, defined as “health of humans during recreation which involves indirect contact and a low probability of water being swallowed, for example, wading, boating, rowing and fishing”.
- Visual recreation, defined as “amenity of waterways for recreation which does not involve any contact with water—for example, walking and picnicking adjacent to a waterway”.
- Drinking water supply, defined as “suitability of raw drinking water supply”. This assumes minimal treatment of water is required, for example, coarse screening and/or disinfection.
- Cultural and spiritual values, defined as:

- "indigenous and non-indigenous cultural heritage" (e.g. custodial, spiritual, cultural and traditional heritage, hunting, gathering and ritual responsibilities; symbols, landmarks and icons; lifestyles (such as agriculture and fishing)) and
- the water's "aesthetic, historical, scientific, social or other significance, to the present generation or past or future generations". (EPP (Water), s. 6).

30 Mile Creek, Humbug Gully and Harrybrandt Creek will be affected by the project through water discharges from existing mine water storages. Humbug Gully will be affected by the project through ground disturbance (primarily subsidence). The environmental values relevant to the three watercourses are deemed to be:

- Aquatic Ecosystems
- Stock water
- Visual recreation
- Cultural and spiritual values

The baseline aquatic ecology investigations (FRC (2011)) identified that the biological values of the aquatic ecosystems within the study area are relatively low when compared with those of the wider catchment. The report noted the ephemeral nature of Humbug Gully as a primary driver of the EVs and that historical agricultural development and mining within the region has likely influenced water quality and the physical characteristics of aquatic habitats in the study area.

FRC (2011) identified physico-chemical water quality in the study area as being poor to moderate during field survey, and being characterised by high turbidity and low dissolved oxygen levels. Biodiversity was noted as being low, with only fish and macroinvertebrate species that are tolerant of varying and often harsh conditions inhabiting the study area.

FRC (2011) noted that the creeks within the study area would provide 'upstream' dispersal habitat for the fish species that were recorded in the study area (and possibly breeding habitat for some species) and that therefore macroinvertebrate and fish communities found within the study area are likely to contribute to the success of downstream populations through movement/migration.

FRC (2011) did not identify any endangered, vulnerable, or near threatened species of aquatic flora or fauna as occurring or being likely to occur in, the waterways of the study area.

3.8.2.2. Groundwater

The Groundwater Impact Assessment reviewed all potential environmental values related to groundwater. It concluded that aquifers associated with the Tertiary, Permian and coal seam sequences are of no, or limited value for most uses, with the only value being that for industrial purposes in relation to the proposed coal mine operation. Hence the environmental values for suitability of groundwater within the Coppabella Underground Project and therefore the Johnson Extended Project area that would need to be enhanced or protected are those for industrial use only.

3.8.3 Assessment Of Potential Impacts On Environmental Values

3.8.3.1. Johnson Extended Project Exploration Activities

Activities to be carried out during exploration that have the potential to impact on surface and groundwater are as follows:

- Construction and use of tracks across Humbug Gully;
- Use of hazardous substances; and
- Clearing and soil disturbance in proximity to Humbug Gully.

Potential impacts associated with the above activities are as follows:

- Obstruction to flow paths causing changes in flood flow distributions;
- Sedimentation of watercourse; and
- Water contamination due to accidental release of hazardous substances.

Impact assessment

Considering the low magnitude and the temporary nature of the exploration activities, it is expected that such activities will have minor impacts on water quality.

Table 3-27 presents the outcomes of the risk assessment of potential impacts on water from exploration activities.

Table 3-27 Risk Assessment Of Potential Impacts On Water From Johnson Extended Project Exploration Activities

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Water	Aquatic Ecosystems Stock water Visual recreation Cultural and spiritual values	Obstruction to flow paths causing changes in flood flow distributions	•Divert water around areas of disturbance •Minimise the number of crossings of Humbug Gully and restrict the area of disturbance. •Landholder consent must be obtained for any drill site located < 500m from a stock watering point. •Water source points must be approved by the Landholder and identified with signage For any crossings: •Minimise alteration of the natural bed and bank profile •Spread material evenly within the bed and banks of the watercourse so that it does not interfere with the flow of water	1	D	Low		1	D	Low
	Aquatic Ecosystems	Degradation of water quality in Humbug Gully associated with modified stormwater flows (including sediment load) and sedimentation from disturbed areas	•Avoidance and minimisation of area of disturbance and implementation of effective sediment and erosion controls •Disturbed areas will be rehabilitated in a timely manner. •All drill sites must be prepared so that stormwater runoff into and from the drill site is minimised.	1	D	Low		1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		Degradation of aquatic habitat within Humbug Creek due to crossing activities undertaken within / adjacent the watercourse	• Drilling, excavation or clearing will be avoided, minimised and mitigated in Humbug Creek. • Minimise the number of crossings of Humbug Gully and restrict the area of disturbance. • All excavations and sumps will be backfilled and shaped to a stable landform similar to that of surrounding undisturbed areas. For any crossings: • Minimise alteration of the natural bed and bank profile • Avoid carrying out activities on the outside of the watercourse bend, on steep banks or where the soil type is prone to erosion (dispersive soils). • Spread material evenly within the bed and banks of the watercourse so that it does not interfere with the flow of water • Ensure natural stream bed controls or features that create natural waterholes are not lowered or removed. • Access tracks will not interrupt low flow along the watercourse. • Reuse existing watercourse crossings where possible and appropriate • All disturbed areas located within riverine areas will be rehabilitated prior to the onset of the wet season	1	C	Low		1	C	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		Degradation of surface or groundwater quality and associated aquatic habitat and loss of species diversity due to accidental release / leaks of hazardous substances used for exploration activities to watercourses	• Dam catchment exclusion areas must be identified and discussed at prestarts. • Storage and handling of flammable and combustible liquids must be in accordance with *AS 1940- Storage and Handling of Flammable and Combustible Liquids*. • Hydrocarbon spill controls must be in place and used appropriately (bunded pallets, covered to prevent rainwater accumulating, sealed containers etc.) • 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) • Drill water will be contained within a sump located at drill site and reused where practicable • The maintenance and cleaning of any vehicles, plant or equipment will not be carried out in areas from which contaminants can be released into any receiving waters. • Drill casings will be cut off approximately 1m below the natural surface and sealed with a cap and backfilled • All discarded core, drill chips and dried sludge will be disposed of in the drill sumps prior to backfilling • All rubbish and waste will be removed from	1	D	Low	Investigation and / or undertaking of surface water grab sampling should complaints regarding surface water quality impact (that are not vexatious or frivolous) be received	1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			the drill site at the completion of the drilling activities (inclusive of all markers and flagging tape)							

3.8.3.2. Johnson Extended Project Underground Mining Activities

Activities and associated potential impacts

Underground mining activities to be carried out within the Johnson Extended Project leases during that have the potential to impact on water quality are:

- Underground mining; and
- Earthworks and soil-disturbing activities (e.g. subsidence remediation, vehicle traffic on unsealed roads/tracks, erosion of areas left free of vegetation and unsealed).

Potential impact from the above activities includes the following:

- Water sedimentation due to soil erosion;
- Soil disturbance due to subsidence causing erosion and water sedimentation;
- Loss of groundwater causing drawdown of water table;
- Water contamination due to accidental release of hazardous substances;
- Loss of surface water due to cracks in the ground from subsidence; and
- Alteration of flood patterns at Humbug Gully due to ground subsidence.

Impact assessment

Subsidence

The Hydraulics study of Humbug Gully assessed the potential impacts of subsidence on the watercourse using broad assumptions of potential subsidence levels. The study predicted that subsidence would cause a decrease in peak water levels, with the magnitude of change being roughly equivalent to the depth of subsidence – a maximum water level decrease of 1.81 m and 2.98 m for the average and worst case simulations, respectively. Peak velocities were predicted to decrease by up to 0.65 m/s in the area affected by subsidence, due to the flatter hydraulic grade line caused by the subsidence. With regards to sediment transport, it is predicted that large bed depressions caused by mine subsidence were likely to accumulate sediment at a higher rate than other regions of the creek. Otherwise, erosion and accretion were not predicted to be severe, with the largest average change in bed level predicted to be -0.09m for the wet year, high subsidence case.

Risk associated with potential impacts to water, and particularly Humbug Gully, associated with subsidence was initially considered to be high; however with the development and implementation of a subsidence management plan and the rehabilitation of disturbed areas the residual risk level associated with potential subsidence impacts is reduced to moderate.

As previously described, the subsidence management strategy and the underlying subsidence management plan for each longwall panel will identify and describe options for mitigating and managing subsidence impacts. The plan will address; the physical condition of surface drainage including erosion, incision processes, stream widening, tension cracking, lowering of bed and banks, creation of in-stream waterholes, changes to local drainage patterns and areas susceptible to high levels of erosion such as watercourse confluences. The plan will also address overland flow, capture of overland flow by subsided long-wall panels, increased overbank flows due to lowering of high bank watercourses and the portion of local and large scale catchment likely to be captured by subsided long-wall panels and the associated impacts on downstream users. The plan will include a flood study for Humbug Gully taking into account impacts from post-mining subsidence.

Disturbed areas will be rehabilitated in accordance with the provisions detailed in the Code of Environmental Compliance for Mining lease projects and Guideline for rehabilitation requirements for mining projects.

Other surface water impacts

Release or leaks of hazardous substances used for support and service activities associated with the underground mining may also cause degradation of the land resource; however this is assessed as a low risk.

Groundwater

The Groundwater Impact Assessment carried out for the wider Coppabella Underground Mine project has assessed the potential impacts of underground mining activities on groundwater. While the study did not account specifically for mining in the Johnson Extended Project area, it considered a much larger mining area and scope. Applying the conclusions of the study to the Johnson Extended Project is therefore considered conservative.

The study found that inflows into the underground mine were predicted to peak around 5.5ML/day for Options 1 & 3[11], and up to 17ML/day for Option 2. However, it predicts that the actual volumes of water pumped from the underground mine will likely be less than the volumes predicted as some water will be removed as moisture with the coal and some will be lost via the ventilation system. These losses may represent up to between 12L/s and 15L/s (1ML/day and 1.3ML/day).

Groundwater levels and regional impact

The study predicted that the underground mine development and operation would depressurise the Permian and coal seam aquifers as well as the Tertiary aquifer where it exists above the underground footprint, by facilitating groundwater flow into the underground workings. This would result in a lower elevation of the piezometric surface of these aquifers and create a cone of depression around the mine. Based on the simulated drawdown levels, the extent of impact on groundwater levels was confined to within 1km of the mine area. South Walker Creek Coal Mine, located some 10km to the north, is the nearest operational mine to the Coppabella site and is well outside the zone of impact. The study concluded that there would be no net cumulative drawdown impacts from the two mines on the regional aquifer. The scope of mining activities in the Johnson Extended Project area being much smaller than the one assessed by the study, a similar conclusion can be drawn.

Impact on existing farm bores

There are no operational domestic or stock bores within or adjacent to the proposed mining lease area. The nearest water supply bores (RN81848 and RN85078) are located approximately 4.5km from the mine site, which is beyond the predicted zone of groundwater

[11] Option 1 considered mining advancement from south to north thereby following the coal seam down-dip, and dewatering/pumping of groundwater inflows from the active mine area only. Option 2 considered mining advancement from south to north similarly to Option 1 but assumed dewatering/pumping of groundwater inflows from all mined areas. Option 3 considered mining advancement from north to south effectively following the coal seam up-dip toward the open cut mine area.

drawdown. The technical assessment noted that to confirm the modelling predictions, it is important that a groundwater monitoring program is implemented and where applicable the numerical model re-run incorporating monitoring results and operational experiences.

Impact on environmental values

The groundwater impact assessment found that there were no groundwater dependent ecosystems likely to be impacted by the Coppabella Underground Project. The only environmental value for the groundwater that would be relevant to the Coppabella Underground Project would be industrial use. Impact on the saline aquifers will not affect this environmental value as no nearby users of this saline groundwater exist. No other environmental values for groundwater were identified in the project area, due to the poor water quality and low bore yields.

Table 3-28 presents the outcomes of the risk assessment of potential impacts on water from mining activities.

Table 3-28 Risk Assessment Of Potential Impacts On Water From Johnson Extended Project Underground Mining Activities

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Water	Aquatic Ecosystems Stock water Visual recreation Cultural & spiritual values	Modification and / or obstruction of flow paths and ponding due to subsidence and surface activities causing changes in flood flow distributions	For non subsidence-related activities: •Divert water around areas of disturbance •Avoid or minimise the number of crossings of Humbug Gully and restrict the area of disturbance. •Spread material evenly within the bed and banks of the watercourse so that it does not interfere with the flow of water •Divert water around areas of disturbance •All disturbed areas located within riverine areas will be rehabilitated prior to the onset of the wet season For any crossings: •Avoid alteration of the natural bed and bank profile •Spread material evenly within the bed and banks of the watercourse so that it does not interfere with the flow of water •Rehabilitate when no longer in use	3	A	High	A subsidence management plan will be developed and implemented Disturbed areas will be rehabilitated in accordance with the provisions detailed in the *Code of Environmental Compliance for Mining Lease Projects*.	2	A	Moderate

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
			• Access tracks will not interrupt low flow along the watercourse. • Reuse existing watercourse crossings where possible and appropriate							
	Aquatic Ecosystems Visual recreation Cultural & spiritual values Industrial use (groundwater)	Degradation of water quality in Humbug Gully associated with modified stormwater flows (including sediment load) due subsidence, subsidence management and other activities	Avoidance and minimisation of area of disturbance and implementation of effective sediment and erosion controls.	2	B	Moderate	A subsidence management plan will be developed and implemented Disturbed areas will be rehabilitated in accordance with the provisions detailed in the *Code of Environmental Compliance for Mining Lease Projects*.	1	C	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		Degradation of aquatic habitat within Humbug Gully due to crossing activities undertaken within / adjacent the watercourse and degradation of aquatic habitat in Humbug Gully and elsewhere associated with surface and / or groundwater due to coal extraction, subsidence and subsidence managemen	• Avoid or minimise the number of crossings of Humbug Gully and restrict the area of disturbance. For any crossings: • Avoid alteration of the natural bed and bank profile • Avoid carrying out activities on the outside of the watercourse bend, on steep banks or where the soil type is prone to erosion (dispersive soils). • Spread material evenly within the bed and banks of the watercourse so that it does not interfere with the flow of water • Ensure natural stream bed controls or features that create natural waterholes are not lowered or removed. • Access tracks will not interrupt low flow along the watercourse.	3	B	High	A subsidence management plan will be developed and implemented Disturbed areas will be rehabilitated in accordance with the provisions detailed in the *Code of Environmental Compliance for Mining Lease Projects*. Where / if necessary an offset plan will be provided in accordance with the Queensland Biodiversity offset Policy to offset relevant residual impacts.	1	C	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		t activities								
		Localised diminution of groundwater resources through lowering due to coal extraction, water management and subsidence		1	A	Low	Undertake baseline and ongoing monitoring of groundwater levels and water quality in order to obtain additional information on groundwater conditions. Refer to the Groundwater Impact Assessment for further details.	1	A	Low
		Degradation of surface or groundwater quality and associated aquatic habitat and loss of species diversity due to accidental release / leaks of hazardous substances used for	• Storage and handling of flammable and combustible liquids must be in accordance with *AS 1940- Storage and Handling of Flammable and Combustible Liquids*. • 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.	1	D	Low	Undertake baseline monitoring of groundwater levels and water quality in order to obtain additional information on groundwater conditions. Refer to the Groundwater Impact Assessment for further details.	1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
		surface and underground activities to watercourses								

3.8.4 Objectives

The objectives with regards to water are:

- To maintain the existing chemical, physical and biological integrity of downstream water quality within acceptable parameters, so as to minimise potential impacts to the environmental values;
- To minimise impacts on groundwater quality and quantity, so as to protect the existing and potential future environmental values;
- To manage raw water usage to minimise potential impacts on the water supply system of the area;
- Maintenance of sufficient quantity and quality of surface water and protection of existing beneficial downstream uses of those waters (including maintenance of in-stream biota and the littoral zone); and
- Minimisation of impacts on flooding levels and frequencies both upstream and downstream of the project.

3.8.5 Control Strategies

3.8.5.1. Johnson Extended Project Exploration And Underground Mining Activities

Control strategies for exploration and underground mining activities are identified in Table 3-29.

Table 3-29 Control Strategies: Water

Control Strategies	Explor.	Mining
Divert water around areas of disturbance	✓	✓
Minimise the number of crossings of Humbug Gully and restrict the area of disturbance.	✓	✓
Landholder consent must be obtained for any drill site located < 500m from a stock watering point.	✓	
Water source points must be approved by the Landholder and identified with signage	✓	✓
Drilling, excavation or clearing will be avoided, minimised and mitigated in Humbug Creek.	✓	
Minimise the number of crossings of Humbug Gully and restrict the area of disturbance.	✓	✓
All excavations and sumps will be backfilled and shaped to a stable landform similar to that of surrounding undisturbed areas.	✓	
Dam catchment exclusion areas must be identified and discussed at prestarts.	✓	
Storage and handling of flammable and combustible liquids must be in accordance with *AS 1940- Storage and Handling of Flammable and Combustible Liquids*.	✓	✓
Drill water will be contained within a sump located at drill site and reused where practicable	✓	

Control Strategies	Explor.	Mining
The maintenance and cleaning of any vehicles, plant or equipment will not be carried out in areas from which contaminants can be released into any receiving waters.	✓	✓
Drill casings will be cut off approximately 1m below the natural surface and sealed with a cap and backfilled	✓	
All discarded core, drill chips and dried sludge will be disposed of in the drill sumps prior to backfilling	✓	
All rubbish and waste will be removed from the drill site at the completion of the drilling activities (inclusive of all markers and flagging tape)	✓	
All disturbed areas located within riverine areas will be rehabilitated prior to the onset of the wet season	✓	✓
Crossings		
Minimise alteration of the natural bed and bank profile	✓	✓
Spread material evenly within the bed and banks of the watercourse so that it does not interfere with the flow of water	✓	✓
Avoidance and minimisation of area of disturbance and implementation of effective sediment and erosion controls	✓	✓
All drill sites must be prepared so that stormwater runoff into and from the drill site is minimised.	✓	
Avoid carrying out activities on the outside of the watercourse bend, on steep banks or where the soil type is prone to erosion (dispersive soils).	✓	✓
Ensure natural stream bed controls or features that create natural waterholes are not lowered or removed.	✓	✓
Access tracks will not interrupt low flow along the watercourse.	✓	✓
Reuse existing watercourse crossings where possible and appropriate	✓	✓
Disturbed areas will be rehabilitated in a timely manner.	✓	✓
A subsidence management plan will be developed and implemented.		✓
An erosion and sediment control plan will be developed for other areas of disturbance.		✓
Disturbed areas will be rehabilitated in accordance with the provisions detailed in the Code of Environmental Compliance for Mining Lease Projects, Version 1 (or more recent version). For areas in Humbug Gully, rehabilitation will be undertaken as soon as practicable and prior to the onset of the wet season (~April).		✓

3.8.6 Proposed EA Conditions

3.8.6.1. Johnson Extended Project Exploration Activities

It is expected that environmental values relating to land quality will be adequately protected and managed through implementation of the conditions of the *Code of environmental compliance for exploration and mineral development projects, DEHP, Version 1* (or later version).

3.8.6.2. Johnson Extended Project Underground Mining Activities

It is proposed to use the following conditions applying to groundwater management :

Schedule E – Groundwater

E1 The holder of the environmental authority must develop and implement a groundwater monitoring program. The program must be able to detect a significant change to groundwater quality values (consistent with the current suitability of the groundwater for industrial use) due to activities that are part of this mining project. The groundwater monitoring program must detail:

a. The location of groundwater monitoring sites and the aquifers the sites are monitoring;
b. The frequency at which sampling will be undertaken;
c. The groundwater contaminant trigger levels;
d. The groundwater monitoring reporting requirements; and
e. Management measures to effectively mitigate and manage potential impacts on aquifers and existing groundwater users.

E2 Groundwater potentially affected by the mining operations must be monitored at two different representative locations within the Johnson Extended Project area.

E3 If the groundwater contaminant trigger levels defined in Table E1 are exceeded then 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. Trigger values for table E1 are to be provided to the administering authority prior to the commencement of underground mining activities.

Table E1 - Groundwater Contaminant Trigger Values

Water Quality Indicator	Unit	Trigger Values
Electrical Conductivity	µS/cm	To be provided based on existing and planned groundwater baseline studies
pH	pH Units	To be provided based on existing and planned groundwater baseline studies
Dissolved solids (total)	mg/L	To be provided based on existing and planned groundwater baseline studies
Carbonate	mg/L	To be provided based on existing and planned

Water Quality Indicator	Unit	Trigger Values
		groundwater baseline studies
Bicarbonate	mg/L	To be provided based on existing and planned groundwater baseline studies
Total Alkalinity	mg/L	To be provided based on existing and planned groundwater baseline studies
Sulphate	mg/L	To be provided based on existing and planned groundwater baseline studies
Chloride	mg/L	To be provided based on existing and planned groundwater baseline studies
Calcium	mg/L	To be provided based on existing and planned groundwater baseline studies
Magnesium	mg/L	To be provided based on existing and planned groundwater baseline studies
Sodium	mg/L	To be provided based on existing and planned groundwater baseline studies
Potassium	mg/L	To be provided based on existing and planned groundwater baseline studies
Aluminium	mg/L	To be provided based on existing and planned groundwater baseline studies
Antimony	mg/L	To be provided based on existing and planned groundwater baseline studies
Arsenic	mg/L	To be provided based on existing and planned groundwater baseline studies
Molybdenum	mg/L	To be provided based on existing and planned groundwater baseline studies
Selenium	mg/L	To be provided based on existing and planned groundwater baseline studies
Silver	mg/L	To be provided based on existing and planned groundwater baseline studies
Iron	mg/L	To be provided based on existing and planned groundwater baseline studies
Mercury	mg/L	To be provided based on existing and planned groundwater baseline studies
Petroleum Hydrocarbons (total)		

Water Quality Indicator	Unit	Trigger Values
C_6 – C_9 Fraction	µg/L	To be provided based on existing and planned groundwater baseline studies
C_{10} – C_{14} Fraction	µg/L	To be provided based on existing and planned groundwater baseline studies
C_{15} – C_{28} Fraction	µg/L	To be provided based on existing and planned groundwater baseline studies
C_{29} – C_{36} Fraction	µg/L	To be provided based on existing and planned groundwater baseline studies
C_{10} – C_{36} Fraction (sum)	µg/L	To be provided based on existing and planned groundwater baseline studies

E4 If the groundwater contaminant trigger levels defined in the groundwater monitoring program are exceeded then 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.

Annual report for groundwater

E8 All groundwater monitoring data must be reviewed on an annual basis. The review must include the assessment of groundwater levels and quality, and the suitability of the monitoring network. An annual report that assesses the impacts of mining on groundwater, and includes all groundwater monitoring results, must be forwarded to the administering authority by 30 September each year.

Temporary Interference with waterways

E26 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 Department of Natural Resources and Mines (or its successor) *Guideline – Activities in a Watercourse, Lake or Spring associated with Mining Activities.*

Stormwater and Water sediment controls

E28 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.

E29 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 E28

b) water management infrastructure that is installed and operated, in accordance with a Water Management Plan that complies with condition F27, for the purpose of ensuring water does not become mine affected water.

E32 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 (with the consent of the third party).

E37 Water General

All determinations of water quality 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 Water Quality Sampling Manual:

   Note: Condition F37 requires the Water Quality Manual to be followed and where it is not followed because of exceptional circumstances this should be explained and reported with the results.
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. laboratory testing must be undertaken using a laboratory accredited (e.g. NATA) for the method of analysis being used.

E39 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 the contaminants 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 exceedences with 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.

E41 Water Management Plan

A Water Management Plan must be developed by an appropriately qualified person and implemented.

E45 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.

E46 Acid Rock 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.

Sewage effluent
A sewage treatment plant is not currently planned so no conditions have been included.

E47 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.

Structures which are dams or levees constructed as part of environmentally relevant activities.
There are currently no dams or levees that are subject to these conditions on the MLAs.

Schedule G - Dams

G1 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. if it is an existing structure, prior to the adoption of this schedule; or
c. 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 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).

Design and construction of a regulated structure

G4 Conditions G5 to G9 inclusive do not apply to existing structures.

G5 All regulated structures must be designed by, and constructed 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 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:
c. the 'as constructed' drawings and specifications meet the original intent of the design plan for that regulated structure;
d. construction of the regulated structure is in accordance with the design plan.

G10 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 G8, and
ii. a set of 'as constructed' drawings and specifications, and
iii. certification of those 'as constructed drawings and specifications' in accordance with condition G9, 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.

G12 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.

Mandatory reporting level

G13 Conditions G14 to G17 inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain – overtopping'.

G14 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.

G15 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.

G16 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.

G17 The holder must record any changes to the MRL in the Register of Regulated Structures.

Design storage allowance

G18 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.

G19 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).

G20 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.

G21 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.

Annual inspection report

G22 Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.

G23 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.

G24 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).

G25 The holder must:

a. Within 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 10 business days6 of receipt of the request.

Decommissioning and rehabilitation

G27 Dams must not be abandoned but be either:

a. decommissioned and rehabilitated to achieve compliance with condition (G28); or
b. be left in-situ for a beneficial use(s) provided that:

i. it no longer contains contaminants that will migrate into the environment; and
ii. it contains water of a quality that is demonstrated to be suitable for its intended beneficial use(s); and
iii. the administering authority, the holder of the environmental authority and the landholder agree in writing that the dam will be used by the landholder following the cessation of the environmentally relevant activity(ies).

G28 After decommissioning, all significantly disturbed land caused by the carrying out of the environmentally relevant activity(ies) must be rehabilitated to meet the following final acceptance criteria:

a. the landform is safe for humans and fauna;
b. the landform is stable with no subsidence or erosion gullies for at least three (3) years;
c. any contaminated land (e.g. contaminated soils) is remediated and rehabilitated
d. not allowing for acid mine drainage; or
e. there is no ongoing contamination to waters (including groundwater);
f. rehabilitation is undertaken in a manner such that any actual or potential acid sulfate soils on the area of significant disturbance are treated to prevent or minimise environmental harm in accordance with the Instructions for the treatment and management of acid sulfate soils (2001)
g. all significantly disturbed land is reinstated to the pre-disturbed soil suitability class;
h. for land that is not being cultivated by the landholder:

i. groundcover, that is not a declared pest species is established and self-sustaining
ii. vegetation of similar species richness and species diversity to pre-selected analogue sites is established and self-sustaining, and

i. the maintenance requirements for rehabilitated land is no greater than that required for the land prior to its disturbance caused by carrying out the petroleum activity(ies).

i. for land that is to be cultivated by the landholder, cover crop is revegetated, unless the landholder will be preparing the site for cropping within 3 months of petroleum activities being completed.

Register of Regulated Dams

G29 A Register of Regulated Dams must be established and maintained by the holder for each regulated dam:

G30 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.

G31 The holder must make a final entry of the required information in the Register of Regulated Dams once compliance with condition (G10) and (G11) has been achieved.

G32 The holder must ensure that the information contained in the Register of Regulated Dams is current and complete on any given day.

G33 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.

G34 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.

3.9 Cultural Heritage And Native Title

3.9.1 Description Of Surrounding Environment

The Johnson Extended Project area is entirely overlapped by the Barada Barna People Native Title Claim (Claim number QC2008/011). The Johnson Extended Project ML areas (MLA 70384, 70385, 70386 and 70387) are entirely within land described as Lot 1 on SP107309. This parcel of land is held in Freehold title. Native Title has been extinguished over the area of the Johnson Extended Project area. Any Native Title issues associated with the operations of the Coppabella Coal Mine, the facilities of which will support the Johnson Extended Project, are dealt with through the normal operations of that mine. The Project proponent has a long standing relationship with the Barada Barna People and this will be continued through the execution of the Johnson Extended Project.

The Barada Barna People are the Aboriginal party under the *Aboriginal Cultural Heritage Act 2003* (ACHA) for the Johnson Extended Project and Coppabella Coal Mine areas. A Cultural Heritage Management Plan (CHMP) that covers the Johnson Extended Project and Coppabella Coal Mine areas has been entered into with the Barada Barna People. The CHMP was approved by the Queensland Government in accordance with section 107 of the ACHA in October 2010 and is designed to manage the protection of indigenous cultural heritage values as disturbance to land associated with operations occurs.

The non-indigenous cultural heritage and history of the Coppabella area is the subject of a study and report *History of Coppabella South and Moorvale Mining Leases*. The conclusion drawn from the historical study is that there will be no conflict with or impact on European cultural heritage values on the region caused by the Coppabella Mine. The conclusion is confirmed by the archaeologists conducting the field studies to identify cultural heritage values and interests.

3.9.2 Environmental Values

Places and objects in the Johnson Extended Project and Coppabella Coal Mine mining lease areas with indigenous cultural heritage significance have been identified by the relevant Aboriginal groups including through a number of surveys and are the subject of various reports submitted directly to the Queensland Government, including for the development of the CHMP.

Non-indigenous cultural heritage values may include aesthetic, architectural, historical, scientific, social, or other significance of the place. As previously noted, non-indigenous cultural heritage values and interests of the Coppabella area have been assessed. The conclusion drawn from the historical study is that there will be no conflict with or impact on European cultural heritage values on the region caused by the Coppabella Mine.

3.9.3 Assessment Of Potential Impacts on Environmental Values

3.9.3.1. Johnson Extended Project Exploration And Underground Mining Activities

Activities and associated potential impacts

Exploration and mining activities proposed to be undertaken on the Johnson Extended Project area (including Coppabella Coal Mine areas) have the potential to impact on cultural heritage values to their detriment due project personnel being unaware of or not following cultural heritage management practices.

Impact assessment

Table 3-30 presents the outcomes of the risk assessment of potential impacts from execution of the Johnson Extended Project on cultural heritage values.

The progression of the Johnson Extended Project will be undertaken in consultation with the Barada Barna in accordance with the CHMP. The CHMP includes management practices to achieve the stated objectives and comply with the ACHA. The CHMP contains detailed statements of cultural heritage values and strategies to conserve these values. The CHMP also includes strategies to manage a range of activities (including mining and pastoral activities) impacting and/or potentially impacting, on the cultural heritage values of the area. It is considered that cultural heritage materials, places and interests will be protected by effective management under the CHMP.

Given the application of the CHMP and effective control strategies, the Johnson Extended Project is expected to have a low level of impact on cultural heritage values.

Table 3-30 Risk Assessment Of Potential Impacts From Johnson Extended Project On Cultural Heritage Values

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Cultural heritage	Indigenous and non-indigenous heritage values	Harm caused to indigenous or non-indigenous cultural heritage values caused by Project personnel being unaware of or not following cultural heritage management practices	• Implementation of the CHMP including all procedures and control strategies for indigenous heritage management • Drawings are utilised to accurately identify locations of items of cultural heritage value and future ground disturbance is planned to avoid where practicable items or areas of cultural heritage value • All employees working on the Johnson Extended Project will be trained in cultural heritage awareness during the site induction process • A cultural heritage inspection will be undertaken prior to any clearing • Procedures will be implemented should discovery of non-indigenous heritage items occur during project implementation including: Ceasing work and establishing a temporary buffer Notification to site and project management Assessing significance of the site using criteria established under the *Queensland Heritage Act 1992*, to determine the appropriate protection measures for identified sites	1	D	Low		1	D	Low

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
			Liaison with regulatory authorities to implement appropriate management							

3.9.4 Objectives

The objectives with regard to cultural heritage matters include:

- Retention of the integrity of intrinsic or attributed values of cultural heritage features on the lease area
- To interact with both Aboriginal and European groups who may have an interest in the area
- No incidents which impact cultural heritage values.

CHMP objectives for management of indigenous heritage are described fully within the CHMP.

3.9.5 Control Strategies

3.9.5.1. Johnson Extended Project Exploration And Underground Mining Activities

Key control strategies in relation to the management of the potential impacts of exploration and mining on cultural heritage values are described in **Table 3-31** below.

Table 3-31 Control Strategies: Cultural Heritage

Control Strategies	Explor.	Mining
Implementation of the CHMP including all procedures and control strategies for indigenous heritage management.	✓	✓
Drawings are utilised to accurately identify locations of items of cultural heritage value and future ground disturbance is planned to avoid where practicable items or areas of cultural heritage value	✓	✓
All employees working on the Johnson Extended Project will be trained in cultural heritage awareness during the site induction process.	✓	✓
A cultural heritage inspection will be undertaken prior to any clearing.	✓	✓
Procedures will be implemented should discovery of non-indigenous heritage items occur during project implementation including: Ceasing work and establishing a temporary buffer Notification to site and project management Assessing significance of the site using criteria established under the Queensland Heritage Act 1992, to determine the appropriate protection measures for identified sites Liaison with regulatory authorities to implement appropriate management.	✓	✓

3.9.6 Proposed EA Conditions

3.9.6.1. Johnson Extended Project Exploration Activities

All exploration activities shall be carried out in compliance with the standard conditions of the *Code of environmental compliance for exploration and mineral development projects, DEHP, Version 1* (or later version).

3.9.6.2. Johnson Extended Project Underground Mining Activities

It is not proposed to apply any EA conditions specific to cultural heritage.

3.9.6.3. Coppabella Coal Mine Activities

It is not proposed to apply any EA conditions specific to cultural heritage.

3.10 Social Environment

3.10.1 Description Of Surrounding Environment

The surrounding social environment of the Johnson Extended Project is effectively as per that of the adjacent Coppabella Coal Mine which has been in operation since 1998. Since that time the operations of the mine have had limited impacts on the local townships of Nebo, Coppabella and Moranbah and have had a substantial positive impact on regional and state economies.

The Lawrence Consulting (Lawrence (2012)) report for the Queensland Resources Council (QRC) based on expenditure data provided by QRC full-member companies, indicates that the resource sector contributed an estimated $36 billion in direct spending to the Queensland economy in 2011 / 2012, with the coal industry directly contributing 52.7% of that spending (approximately $19 billion). The coal industry spend was comprised of $3.0 billion in wages and salaries and $16.0 billion in voluntary community contributions and purchases of goods and services. Lawrence (2012) reported that the total economic impact (direct and indirect) from the resources sector to the Queensland economy in 2011/12 amounted to:

- $81.2 billion in output/turnover
- $73.1 billion in value added (contribution to gross state product)
- $30.5 billion in income (wages and salaries)
- 480,013 full-time equivalent jobs

This means that the resources sector contributed 25.8% of Gross State Product ($283.6 billion) and 20.5% of total employment (2,338,160 persons) in Queensland in 2011/12.
Lawrence (2012) reported the resource sector's direct expenditure and employment for the Mackay region (amalgam of Mackay and Isaac regional council areas) in 2011/2012, which is dominated by coal sector, was $6.422 billion and 14,076 jobs respectively, with resource sector-induced value added and employment being $13.230 billion and 78,464 jobs respectively.

Rolfe, Lockie, and Franettovich (2003) prepared the report *Economic and Social Impacts of the Coppabella Mine on the Nebo Shire* for the then owner of the mine, Australian Premium Coals. The report indicated that whilst operations of the mine had contributed to the transformation of Nebo from an agricultural and administrative centre towards a more mining focus, the development and operations of the mine had not appeared to have caused major adverse economic or social impacts.

The *Coppabella Environmental Management Plan* (29 March 2011) indicated that based on annual production of 5.3M tonnes of product coal at the Coppabella Coal Mine, the Gross State Product was increased by approximately $150M per year. The approximate annual expenditure on employment at the time of development the *Coppabella Environmental Management Plan* was $25M based on 250 full-time equivalent jobs at the mine, which resulted in an employment flow on effect of 360 full time equivalent jobs per year created in the region. The benefit attributable to increased employment flowed directly into the regional economy. Furthermore the plan provided an estimate of annual income to the state during the operational phase as being approximately $50M comprising coal royalties, rail freight and taxes and other expenses.

Issues of concern previously raised by local community members during previous consultation in consideration of the Coppabella Coal Mine have included the effects on the

communities and their ability to cope with the requirements of the additional workforce. Specific areas included infrastructure such as housing and industrial areas, schools and service providers.

3.10.2 Environmental Values

Values of the social environment relevant to the project area and potential impacts are amenity and access to social, community services and infrastructure in the region surrounding the project, including economic conditions and benefits.

3.10.3 Assessment Of Potential Impacts On Environmental Values

3.10.3.1. Activities And Associated Potential Impacts

The Johnson Extended Project has the potential to impact on social environment including through:

- Requirements associated with the need to assimilate workforce required for the Project including housing pressure
- Strain on community services in the local area, such as health and education
- Strain on community infrastructure such as roads and utilities
- Impacts to amenity through emissions such as dust, noise and visual amenity through landform change

3.10.3.2. Impact Assessment

Table 3-32 presents the outcomes of the risk assessment of potential impacts from execution of the Johnson Extended Project on social environment values.

Impacts to amenity through emission such as dust, noise and visual amenity through landform change, are addressed through section 3.3, 3.6 and 3.4 respectively.

Considering that the Johnson Extended Project will likely be developed as a life extension of future underground mining activities and following the cessation of large scale production from Coppabella Coal Mine open cut activities, the impact to social values is assessed as being of low magnitude. Levels of employment associated with the Johnson Extended Project and underground mining activities generally, will likely be lower than current levels of employment at the Coppabella Mine, and will not be in addition to current employment.

As such, associated impacts such as housing pressures and strain on services and infrastructure are likely to be lesser than the levels currently experienced.

Exploration activities for the Johnson Extended Project will be undertaken in conjunction with open cut mining activities at the Coppabella Coal Mine; however resourcing requirements for the exploration phase are negligible in comparison to operations for open cut or underground mining, and as such exploration phase impacts to social environment values are expected to be negligible.

Table 3-32 Risk Assessment Of Potential Impacts From The Johnson Extended Project On Social Environment Values

Aspect	Environmental Value	Potential impacting event	Standard controls	Risk ranking			Further controls (if required)	Residual risk ranking		
				C	L	R		C	L	R
Social environment	Amenity and access to services and infrastructure	Negative impact to amenity or access to services due to the activities and requirements associated with Johnson Extended Project activities	In addition to the actions previously identified to address amenity: • Ongoing engagement with surrounding landholders • Processes implemented for public, stakeholder and regulatory consultation and notification in relation to complaints • Ongoing engagement with local infrastructure and service providers • Utilise local suppliers wherever practicable	1	D	Low		1	D	Low

3.10.4 Objectives

The objectives with regard to social environment are:

- Minimising the exposure of the general public to risks of any adverse effects arising from the project
- Maintaining access to services and infrastructure by the local community
- Reducing the number of complaints by members of the local community towards zero
- Indirectly improving the delivery of services and infrastructure to the local community by contributing to the local economy
- Contributing to and enhancing where practical the social and community amenity and self-awareness.

3.10.5 Control Strategies

3.10.5.1. Johnson Extended Project Exploration And Mining Activities

Key control strategies in relation to the management of the potential impacts of exploration and mining on social environment values (in addition to strategies previously described to manage amenity impacts) are described in **Table 3-33** below.

Table 3-33 Control Strategies: Social Environment

Control Strategies	Explor.	Mining
Ongoing engagement with surrounding landholders;	✓	✓
Processes implemented for public, stakeholder and regulatory consultation and notification in relation to complaints.	✓	✓
Ongoing engagement with local infrastructure and service providers	✓	✓
Utilise local suppliers wherever practicable.	✓	✓

3.10.5.2. Coppabella Coal Mine Activities

Control strategies for the Coppabella Coal Mine activities are consistent with those described above and are contained in the *Coppabella Environmental Management Plan*, 29 March 2011 or later revision.

3.10.6 Proposed EA Conditions

3.10.6.1. Johnson Extended Project Exploration Activities

No EA conditions relating to the social environment are proposed.

3.10.6.2. Johnson Extended Project Underground Mining Activities

No EA conditions relating to the social environment are proposed.

3.10.6.3. Coppabella Coal Mine Activities

No EA conditions relating to the social environment are proposed.

4. Overarching Strategies

4.1 Framework

4.1.1 Training

The holder will develop an environmental induction package and assessment. All staff and contractors will receive an environmental induction upon commencement of employment at the Johnson Extended Project. The Environmental Induction Package will include the below elements:

- Legislative framework including relevance to the Johnson Extended Project and employees
- Cultural heritage requirements
- Water management requirements
- Waste management practices
- Land management requirements
- Rehabilitation strategies
- Air quality
- Noise
- Social responsibilities.

The induction package will include an assessment component to verify understanding of the environmental management requirements and practices.

In addition to the Environmental Induction, refresher packages as required and general environmental awareness topics will be developed for presentation to workgroups within regular "toolbox" meetings.

Training records and relevant authorisation registers will be maintained.

4.1.2 Non-conformity, Investigation And Preventive Action

Non-conformances will be identified through a variety of processes including audits, inspections, complaints and incidents or emergencies.

All non-conformances will be recorded, assessed for significance, investigated based on significance, corrective actions established and tracked through to completion. Non-conformances include incidents and/or injury and may also include near misses, procedure breaches, deficiencies or other items. It is the significance or the potential risk of the non-compliance that drive the processes.

4.2 Emergency Preparedness

An Emergency Response plan will be developed for the Johnson Extended Project and will detail emergency response actions and responsibilities. This plan will document the responsibilities of key personnel in the event of an emergency and the contact details for appropriate emergency services.

During the conduct of the catastrophic risk reviews, identification of all potential emergency situations that could result in significant environmental impacts will be undertaken. A list of potential high risk catastrophic environmental incidents will be maintained in the site risk register. Emergency responses to these potential situations will be incorporated into subsequent reviews and updates of all emergency procedures. An appropriate level of

preparedness will be maintained relative to the level of risk for each identified potential emergency situation.

All personnel will receive an appropriate level of emergency preparedness and response training. The site will maintain a dedicated emergency response team who will undergo regular training and operational drills involving identified high risk activities. Relevant managers will consider emergency preparedness drills for such events.

Any changes to emergency procedures will be documented and communicated to all personnel.

4.3 Communications

Communications include both internal and external parties. Procedures will be developed to ensure that matters relating to the implementation of the EMP are communicated to all personnel. Differentiation of complaints relevant specifically to Johnson Extended rather than Coppabella Mine operations will be discussed with the CMJV to ensure that the appropriate site deals with the complaint as relevant. In particular, communication of complaints and environmental incidents/emergencies will be handled in the following manner.

4.3.1 Complaint Handling

The holder will investigate and resolve all complaints received at the site through development and adoption of a Complaint Management System for the Johnson Extended Project, including complaint logging and handling procedures.

Complaints will be logged as follows:

- Name, address and contact number for complainant
- Time and date of complaint
- Reasons for the complaint as stated by the complainant
- Discussions / confirmation of responsibility with CMJV
- Investigations undertaken in response to the complaint
- Conclusions formed
- Actions taken to resolve complaint
- Any abatement measures implemented to mitigate the cause of the complaint
- Name and contact details of the person responsible for resolving the complaint.

4.3.2 Environmental Incidents And Emergencies

Environmental incidents and emergencies will be reported to the appropriate regulatory agency, as required. In the event of an incident, an environmental incident report form will be completed. The report will record the following, as a minimum:

- The name and telephone number of the designated contact person
- The location of the emergency or incident
- The date and time of the release
- The time the authority holder became aware of the emergency or incident
- The estimated quantity and type of any substances involved in the incident
- The actual or potential suspected cause of the release
- A description of the effects of the incident including any environmental harm that has occurred or may occur as a result of the release

- Any sampling conducted or proposed, relevant to the emergency or incident
- Actions taken to prevent any further release and mitigate any environmental harm caused by the release

An environmental incident register will be maintained in accordance with record control procedures.

An investigation will be conducted into each environmental incident, which shall include reporting requirements and recommendations for corrective or preventative action. A review of the effectiveness of the corrective or preventative action will be undertaken within one month of the occurrence of the incident and the relevant procedures are to be updated as required.

4.4 Measuring, Monitoring And Reporting

4.4.1 Monitoring

Monitoring will occur during all stages of the Project to ensure that control strategies are being effectively implemented and that objectives are being met within each component of the EM Plan. Monitoring will be conducted by suitably qualified personnel in accordance with required sampling methodologies.

Specific monitoring requirements for the different components are detailed within each section of the management plan.

Monitoring is undertaken using standard monitoring techniques and calibrated equipment operated by trained personnel. Calibration will be undertaken in accordance with the equipment manufacturer's recommendations. Calibration records are kept of the monitoring equipment used.

Analysis of samples is to be undertaken in accordance with the environmental authority. Monitoring results are compared against environmental authority conditions, and any non-conformance recorded against the monitoring result and reported as necessary. In the event of a non-conformance, investigation of the cause of the non-conformance will be undertaken and corrective and/or preventative action recommended. The effectiveness of the corrective and/or preventative action will be assessed by analysis of the next available monitoring results.

Results from all monitoring undertaken as part of this EMP will be maintained and be available within the timeframes required under environmental licensing requirements for the Project.

4.4.2 Auditing

Auditing of the environmental compliance of the Johnson Extended Project will consist of an annual environmental audit undertaken by an independent third party.

The audits will consider compliance with environmental authority conditions, implementation of control strategies and attainment of objectives as described in this EM Plan. The results will be communicated to senior management and as necessary in accordance with conditions of environmental authority. External audits will be conducted by a suitably qualified, experienced and independent person.

This program of external audits will be supported by interim internal audits. The internal audits will be undertaken to assess whether the EM Plan has been properly implemented and maintained and that objectives have been met. The results are communicated to senior management. These will be conducted by Johnson Extended staff during the period between formal annual external audits on a regular basis. Internal auditors will be selected on the basis of their understanding of environmental management principles and mining operations.

Action plans will be developed based on the audit findings (as necessary) in order to facilitate the continuous improvement process.

4.4.3 Review

The elements of this EM Plan will be regularly reviewed and revised to reflect changes to the Johnson Extended Project and new developments. Reviews, at varying levels of detail, as appropriate, will include assessing opportunities for improvement and the need for changes to the plan and will be conducted at the following frequencies:

- No longer than at annual intervals, or at increased frequency as required to address;
- When feedback is received from regulatory agencies
- When conditions arising from the project environmental authority are issued
- When/if changes to or new operating methods are proposed.

During the review of the elements of this EM Plan the following items will be considered:

- Summary of complaints/incidents and response actions
- Summary of results of monitoring and auditing conducted under the plan
- Assessment of opportunities for improvement of environmental performance
- Suggested amendments required to the plan.

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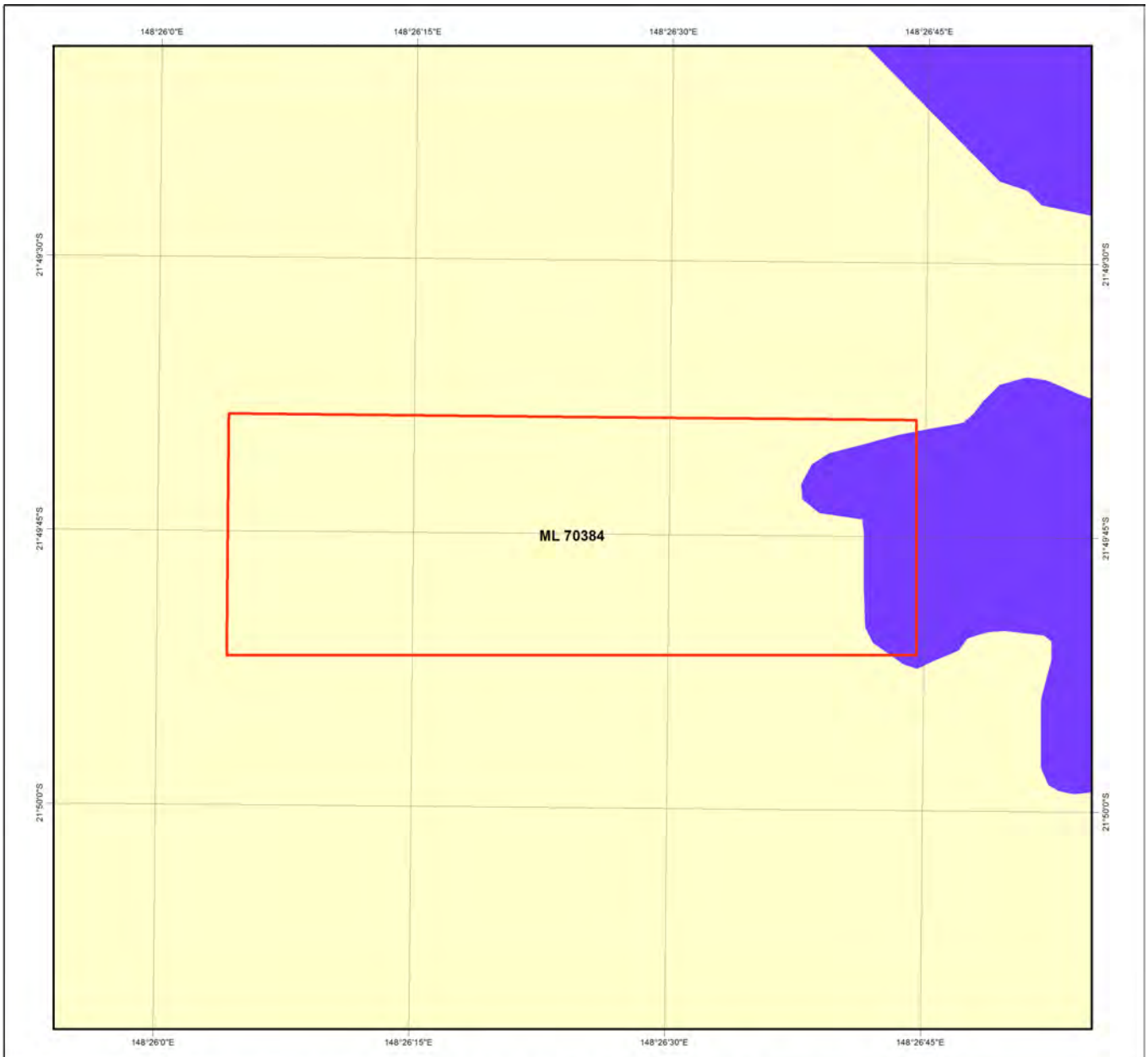
ABBREVIATIONS

Code	Department
4WD	Four Wheel Drive
ACHA	*Aboriginal Cultural Heritage Act 2003*
AS	Australian Standard
CHMP	Cultural Heritage Management Plan
CHPP	Coal Handling and Preparation Plant
CMJV	Coppabella and Moorvale Joint Venture
CH4	Methane gas
CO	Carbon Monoxide
CO2	Carbon Dioxide
DBCT	Dalrymple Bay Coal Terminal
DEHP	Department of Environment and Heritage
DERM	Department of Environment and Resource Management (Former Queensland Government Department)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Former Commonwealth Government Department)
EA	Environmental Authority
EM Plan	Environmental Management Plan
EP Act	*Environment Protection Act 1994*
EPC	Exploration Permit for Coal
EPP (Air)	*Environmental Protection (Air) Policy 2008*
EPP (Noise)	*Environmental Protection (Noise) Policy 2008*
EPP (Water)	*Environmental Protection (Water) Policy 2009*
EP Reg	*Environmental Protection Regulation 2008*
EP(WM) Reg	*Environmental Protection (Waste Management) Regulation 2000*
ERA	Environmentally Relevant Activity
ESA	Environmentally Sensitive Area
EV	Environmental Value
GED	General Environmental Duty
H Act	*Heritage Act 1992*
HERBRECS	Queensland Herbarium Records System
JORC	Joint Ore Reserves Committee
LPR	*Land Protection (Pest and Stock Route Management) Regulation 2003*
LTCC	Longwall Top Coal Caving
MB	Monitoring Bore
ML	Mining Lease
MLA	Mining Lease Application
Mtpa	Million tonnes per annum
NATA	National Association of Testing Authorities
NCR	*Nature Conservation (Wildlife) Regulation 2006*
NO2	Nitrogen Dioxide
NT Act	*Native Title (Queensland) Act 1993*
PAWC	Plant Available Water Capacity

Code	Department
PCI	Pulverized Coal Injection
PM	Particulate Matter
QRC	Queensland Resources Council
RE	Regional Ecosystem
REMP	Receiving Environment Management Program
ROM	Run-of-Mine
SO2	Sulfur Dioxide
TDS	Total Dissolved Solids
VMA	*Vegetation Management Act 1999*
VOC	Volatile Organic Compounds
WONS	Weeds of National Significance
WRR Act	*Waste Reduction and Recycling Act 2011*
WRR Reg	*Waste Reduction and Recycling Regulation 2011*

Appendix F
ESA mapping





ENVIRONMENTALLY SENSITIVE AREAS - Mining Activities

- Selected Mining Lease (ML)

CATEGORY A
- National Parks
- Conservation Parks
- Forest Reserves
- Special Wildlife Reserve
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Area
- Marine Parks other than General Use Zones

CATEGORY B
- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Seaward Side of Highest Astronomical Tide
- Fish Habitat Areas
- Coordinated Conservation Areas
- Endangered Regional Ecosystems - regrowth and remnant (Biodiversity Status)
- General Use Zones of Marine Parks
- Marine Plants

CATEGORY C
- Nature Refuges
- Resources Reserve
- State Forests
- Timber Reserves
- River Improvement Areas
- Stanbroke DLA
- Coastal Management District
- Dams and Weirs

OTHERS
- Towns
- Roads
- Repealed Wild River Nominated Waterways
- Repealed Wild River Preservation Areas
- Repealed Wild River High Preservation Areas
- Mahogany Glider Habitat
- Directory of Important Wetlands
- Queensland



N

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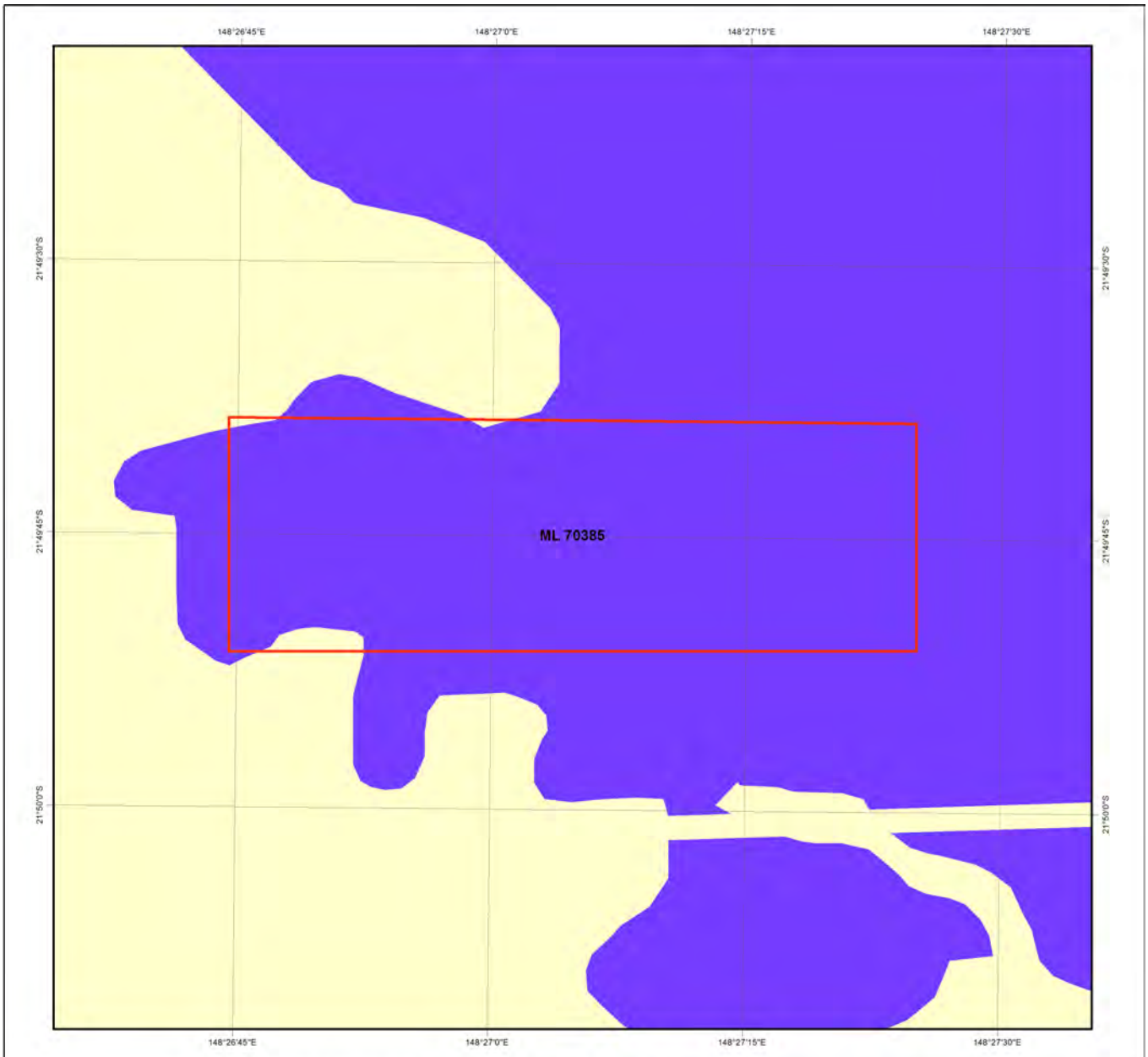
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- Selected Mining Lease (ML)

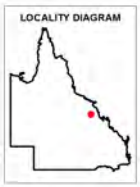
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LOCALITY DIAGRAM



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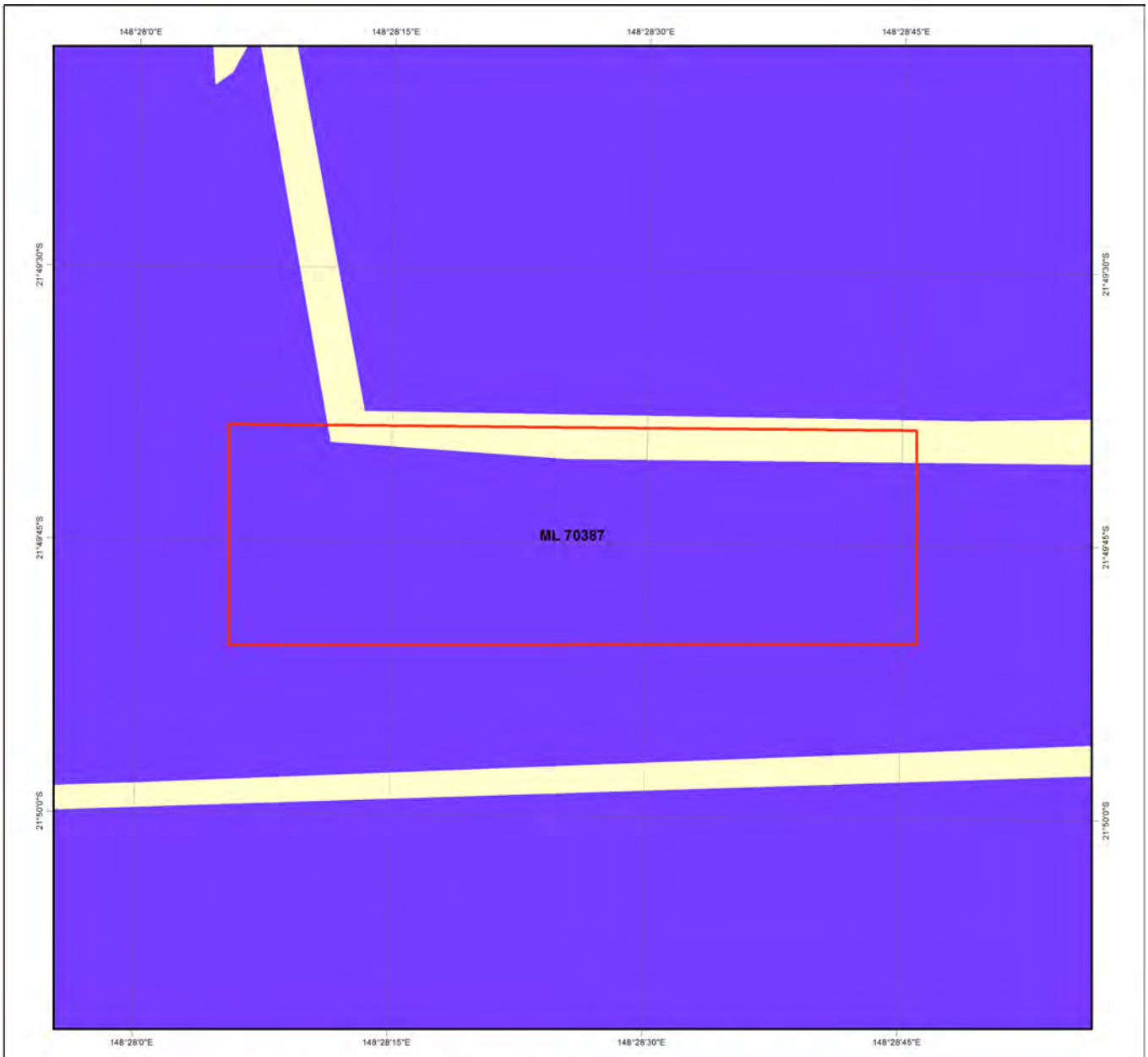
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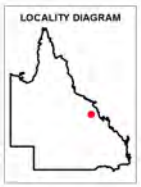
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Appendix G
Flood modelling (Alluvium 2014)



alluvium

MODELLING AND ASSESSMENT REPORT:

Coppabella Underground Mine Flood Modelling

January 2014

Peabody ENERGY

Document history

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Author/s	Alan Davidson Brett Twycross
Checked	Brett Twycross
Approved	Mark Hausfeld

Distribution:

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Acronyms and Glossary

Acronyms

AEP	Annual Exceedance Probability. The probability that a given rainfall total accumulated or peak flow rate for a given duration will be exceeded in any one year. See Table A-1 for conversion to ARI.
AHD	Australian Height Datum
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval. The average, or expected, value of the periods between exceedances of a given rainfall total accumulated or peak flow rate for a given duration. See Table A-1 below for conversion to AEP.
ARR	Australian Rainfall and Runoff
CL	Continuing Loss
CM	Coppabella Mine
CRCCH	Cooperative Research Centre - Catchment Hydrology
CRC-FORGE	Cooperative Research Centre - Focussed Rainfall Growth Estimation
CUG	Coppabella Underground Mine
DEM	Digital Elevation Model
DTM	Digital Terrain Model
DXF	Drawing Exchange Format
EY	Exceedances per Year, equal to inverse of ARI
GSDM	Generalised Short Duration Method
IFD	Intensity, Frequency, Duration
IL	Initial Loss
LiDAR	Light Detection And Ranging
PMP	Probable Maximum Precipitation, used specifically for the extreme rainfall event
PMF	Probable Maximum Flood, the flood resulting from the PMP
SRTM	Shuttle Relay Topography Mission
WRD	Waste Rock Dump

In accordance with the latest Australian Rainfall and Runoff (ARR) guidelines, the Annual Exceedance Probability (AEP) has been used throughout this report in preference to ARI. ARIs of greater than 10 years are very closely approximated by the reciprocal of the AEP. For events smaller than the 10 year ARI, the term Exceedances per Year (EY) is recommended instead and is calculated as the inverse of the ARI. While the 10 year ARI does not equate exactly to the 10% AEP it has, for the purpose of this report, been treated as though it does.

Table A-1, below, provides a summary of the conversion from ARI to EY or AEP.

Table A-1. ARI to AEP/EY conversion table

ARI (years)	EY	AEP	AEP expressed as percentage (%)
2 or Q2	0.5	0.393	39
5 or Q5	0.2	0.181	18
10 or Q10		0.095	10 (actually 9.5%)
20 or Q20		0.049	5
50 or Q50		0.020	2
100 or Q100		0.010	1
1000 or Q1000		0.001	0.1

Further information can be found here:
http://www.arr.org.au/wp-content/uploads/2013/Draft_Chapters/Book1_terminology_draft_130625.pdf

Glossary

Alluvium	Alluvium Consulting Australia
RORB	Hydrological modelling software package
TUFLOW	1D/2D Hydrodynamic modelling software package
XPSWMM	1D/2D Hydrodynamic modelling software package

1 Introduction

The proposed Coppabella Underground Mine (CUG) lies approximately 110km south west inland of Mackay, within the Fitzroy Basin and in the northern portion of the existing Coppabella Mine (CM) lease. Humbug Gully flows through the northern portion of CM mine lease, over the proposed CUG longwall panels before discharging to Harrybrandt Creek, approximately 5km downstream of the CM lease. The CUG area abuts the Carborough Range to the west and South Walker Creek open cut mine is to the north and east of CUG. The location of the project area is illustrated in Figure 1-1.

In December 2013, Peabody Energy engaged Alluvium Consulting Australia (Alluvium) to undertake a baseline flood study for the CUG project area, primarily focusing on determining the flood extents for a range of events to inform conceptual infrastructure design. The baseline results will also allow comparison with post development assessments to be undertaken in the future. This report provides a summary of the tasks that were completed and delivers recommendations where appropriate.

1.1 Scope of Works

The scope of the project is as follows:

- Derive hydrology for the Harrybrandt Creek catchment including Humbug Gully
- Develop an existing conditions hydrodynamic model for the CUG area
- Simulate a range of flood events, as follows:
    - 2 year ARI (the 0.5 EY event)
    - 10 year ARI (the 10% AEP event)
    - 20 year ARI (the 5% AEP event)
    - 50 year ARI (the 2% AEP event)
    - 100 year ARI (the 1% AEP event)
    - 1,000 year ARI (the 0.1% AEP event)
    - PMF
- Present the hydrodynamic modelling results for both flood depth and velocity, for each flood event considered.

It should be noted that the scope specifically excludes:

- Evaluation of flood impacts due to installation of new infrastructure for CUG
- Evaluation of subsidence impacts (post development assessment)

1.2 Project Objectives

The objectives of the project are as follows:

1. To provide a baseline study for the existing site, and to use as a basis of comparison for future design scenarios;
2. To inform mine planning and concept studies for infrastructure design, and;
3. To produce flood maps and extents for the range of events specified.

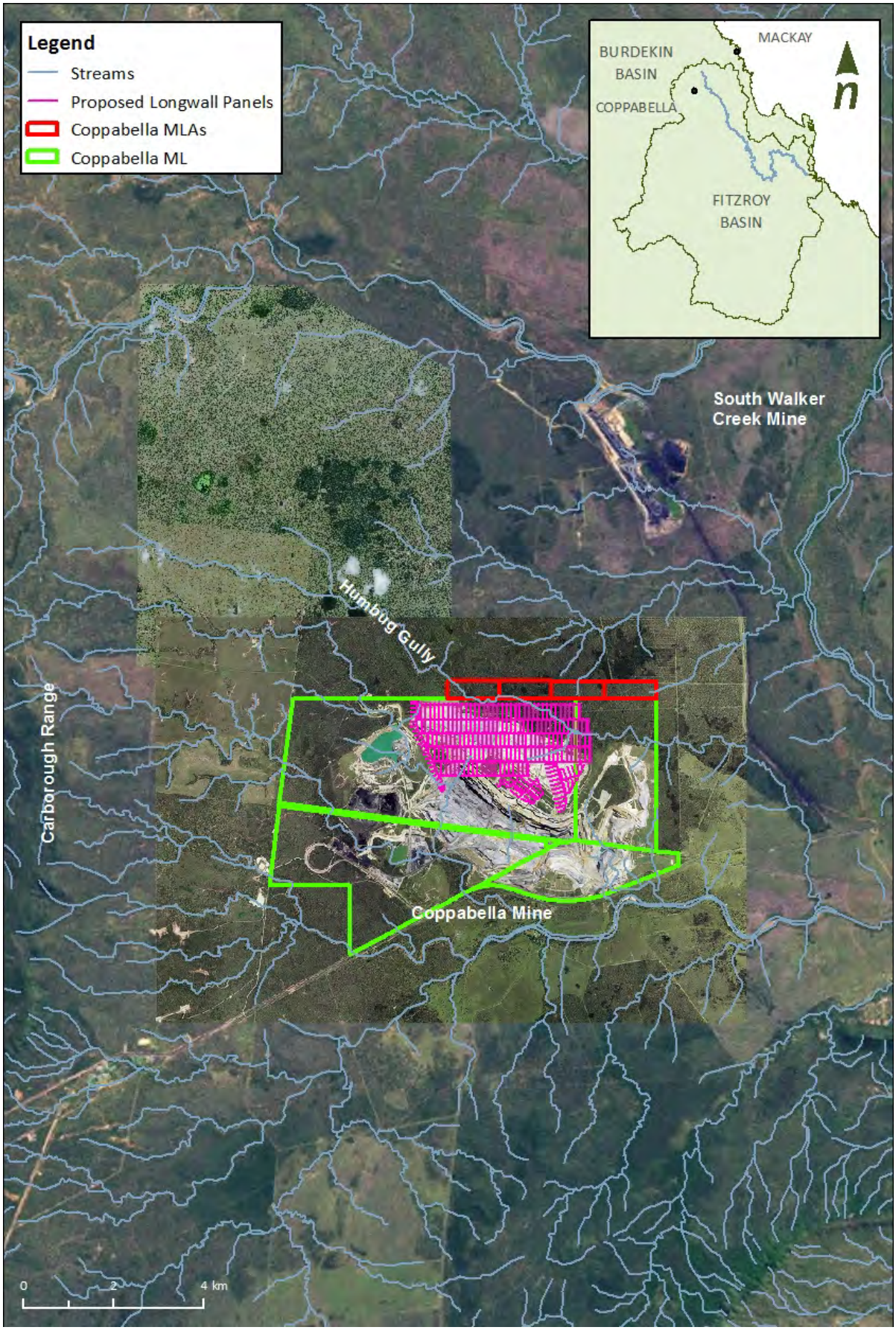


Figure 1-1. CUG location map

2 Project Outputs Summary

The sections below summarise the key findings of the study.

Refer to Attachment A for details on the development of the terrain model for this project.

2.1 Catchment hydrology

The CUG project area lies within the Fitzroy basin, near its northern boundary with the Burdekin Basin (refer to Figure 1-1). The proposed longwall panels will undermine Humbug Gully, a tributary of Harrybrandt Creek.

The Harrybrandt Creek catchment was delineated down to approximately 1km downstream of the Humbug Gully confluence, as presented in Figure 2-1. The Humbug Gully catchment area totals approximately 24km^2, 28.7km^2 and 41.8km^2 for locations at the upstream extent of CUG, the downstream extent of CUG and at the Harrybrandt Creek confluence respectively.

As per the project requirements, hydrologic information for the catchment was derived at suitable locations to provide input hydrographs to the hydrodynamic model. This will allow estimation of flood depths, extents and velocities for Humbug Gully through the project area for the range of events from the 0.5 EY up to the Probable Maximum Flood (PMF).

See Attachment B for further details on the development of the hydrology for flood modelling.

2.2 Baseline Flood Modelling

Humbug Gully is a watercourse of low sinuosity set in a confined valley with occasional floodplain pockets throughout the majority of the mine lease. Further downstream, around the north east corner of the Waste Rock Dump (WRD), Humbug Gully becomes partly confined, with discontinuous floodplain.

Flood modelling for Humbug Gully through the project area, in its existing topographic form (ie. a baseline study), was undertaken for seven events; the 0.5 EY, the 10% AEP, the 5% AEP, the 2% AEP, the 1% AEP, the 0.1% AEP and the PMF. The predicted flood extents for each event are shown in Figure 2-2.

Due to the confined nature of Humbug Gully, the flood extents through the CUG area typically vary little between the smallest 0.5 EY event and the 0.1% AEP. This indicates that for the range of events which need to be considered, it will be equally cost effective to provide mitigation (if required) for the larger event as for the smaller.

Upstream of the CUG area, floodplain pockets are engaged by the 0.1% AEP event, meaning 0.1% AEP extents are substantially wider than the more frequent events modelled, which are confined. The PMF yields a significantly larger flood extent in some areas which is to be expected given the estimated flow rates (see Table 6-6 in Attachment B).

The key outputs of this section of the project are the digital files containing the modelled flood extents which will be used to inform future mine planning.

See Attachment C for further details of the hydrodynamic modelling undertaken for the project including figures presenting the flood depths and velocities for all modelled events.

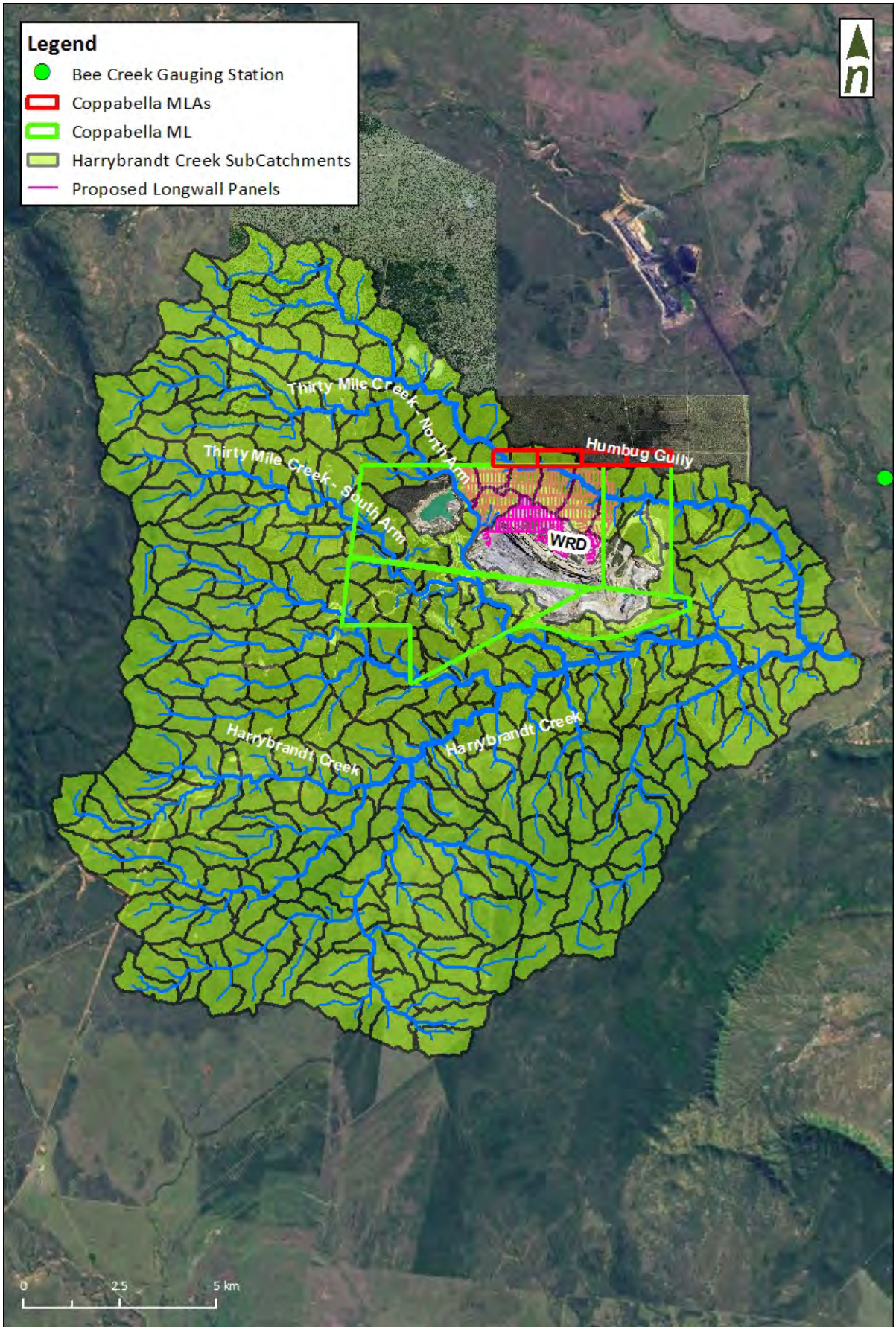


Figure 2-1. **Harrybrandt Creek catchment delineation**

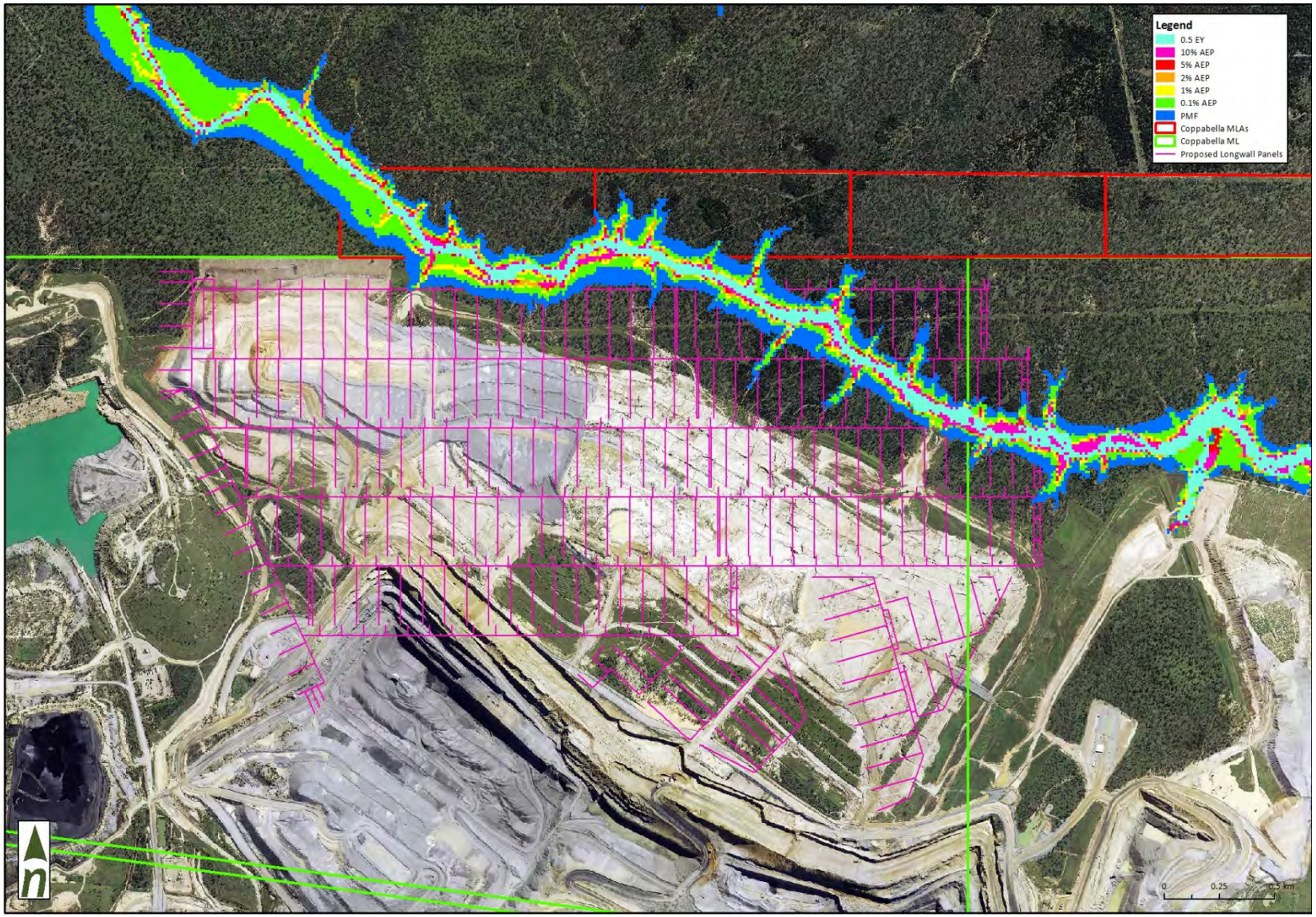


Figure 2-2. 0.5 EY to PMF baseline flood extents for the CUG project area

3 Recommendations

To provide more robust modelling outputs for future use it is recommended that the modelling and mapping of additional storm durations be considered, particularly those on either side of the hydrologic critical duration. This would confirm the absolute maximum flood extent for each event.

The following points are also suggested for further work which would add value to the project and provide additional input to inform future mine planning:

- Sediment transport modelling, especially for assessing environmental impacts of longwall mining
- Duration of inundation and hazard mapping would assist in determining the flood risks posed to the human population in the mine area and could be used to support evacuation planning. This would be most useful once the flood mitigation measures have been developed following further mine planning.

4 References

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Laurenson E.M, Mein R.G. and Nathan R.J. (2007). *RORB Version 6 Runoff Routing Program User Manual*, Monash University Department of Civil Engineering.

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Attachment A
Development of Terrain Model

5 Terrain Model Development

The proposed CUG project long wall panels cover approximately 6.5km^2, with approximately one third of this area laying within the Humbug Gully catchment, in the northern portion of the existing CM lease. In total, the area to be modelled covers approximately 138km^2, though as discussed in Section 7.1, this model was originally developed for another project for Peabody and includes an area larger than required for this study. For the purpose of this study, the reporting is restricted to the area covering Humbug Gully and its tributaries.

As shown in Figure 5-1, it was necessary to utilise survey data from a number of sources to develop a terrain model which covers the entire modelled area.

5.1 Terrain data sources

In total, four different data sources were used, as outlined below:

- Photogrammetry data collected in March 2013. This covered the area within the Coppabella Mine open cut area.
- LiDAR data collected on 9 February 2012. This data covers an area to the northwest of the existing mine lease.
- Original 2m contours from before commencement of Coppabella Mine. No details are available.
- 1 arcsecond NASA Shuttle Relay Topography Mission (SRTM) 30m Digital Elevation Model (DEM) grid tiles acquired by Alluvium late in May 2013 from Geosciences Australia. This data covers the remainder of the catchment not covered by the first three datasets and was used to fill in all the missing data required for hydrologic and hydrodynamic modelling.

Table 5-1, below, provides specific detail on each source of data.

Table 5-1. Survey data used to develop terrain model, in order of priority

Received Data	Format	Source	Date Received	File Name	Coordinate System
Photogrammetry	DXF	Peabody Energy	12/06/2013	Coppabella Mar13 MINEGRID	Coppabella
Lidar	xyz	Peabody Energy	12/06/2013	CN_e640n7584_thn to CN_e648n7592_thn	GDA94 MGA z55
Contours	DXF	Peabody Energy	12/06/2013	Coppa_original_130612	Coppabella
SRTM	GRID	Geosciences Australia	30/05/2013	SRTM_1arcsec_DEM	WGS84

5.2 Manipulation of terrain data

Table 5-2, below, provides detail on the translation required for each dataset to create an overall model in a consistent projection that ties in with the dataset for Coppabella Mine. The chosen coordinate system was GDA94 zone 55 with the Australia Height Datum (AHD).

Table 5-2. Translation of data to consistent projection

Received Data	Coordinate System Translation to GDA 94 z55	Translation Required to Join Data
Photogrammetry	x= +113.992 y= +180.200 z= -0.085, as advised by Mark Brouwer	No Change
Contours		No change
Lidar	No Change	Translated to join photogrammetry z= +0.438
SRTM	Automatic process through ArcView	Translated to join with other data sources z= -4

Figure 5-1, below, shows the fencing used for each data set.

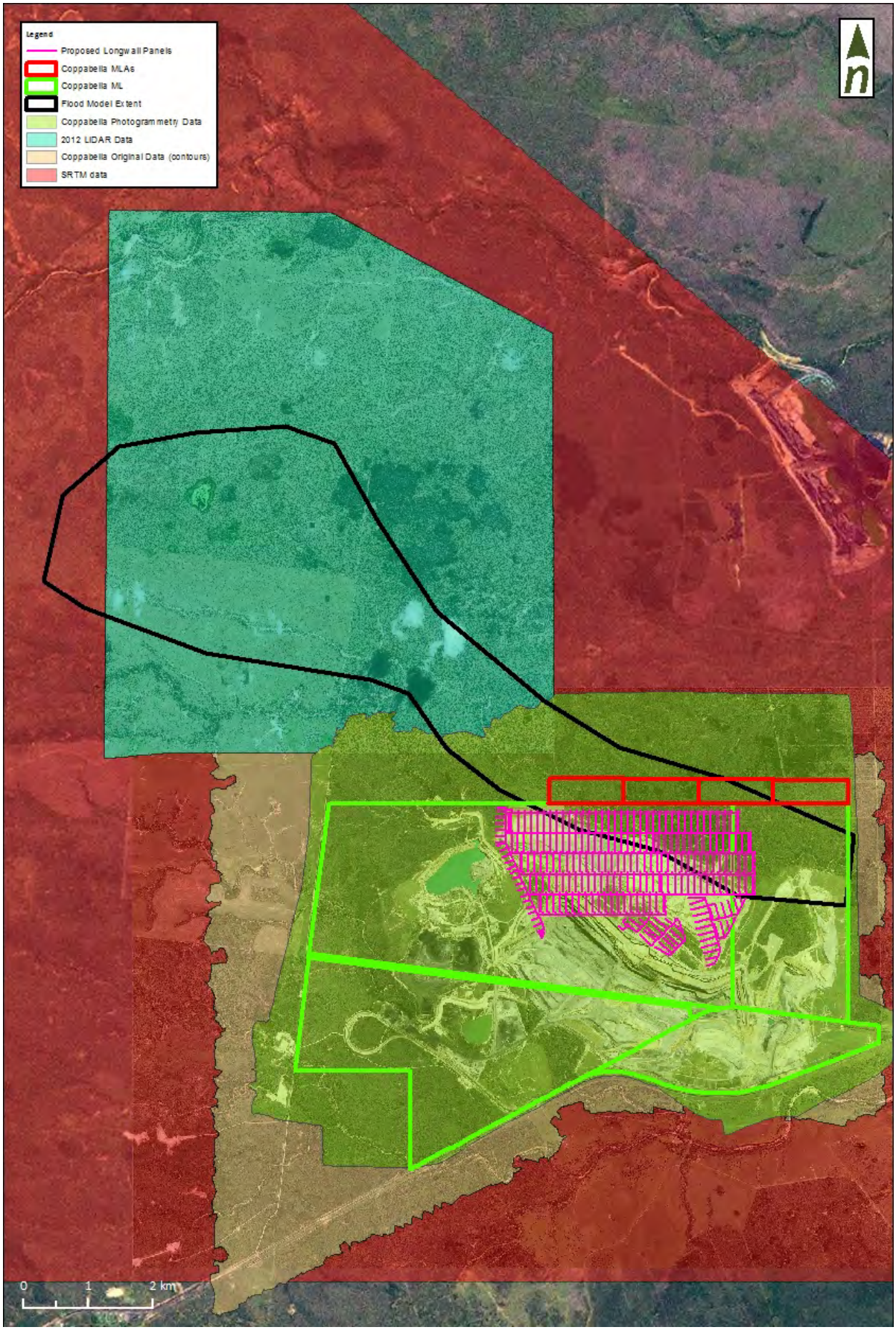


Figure 5-1. **Data and sources used for CUG flood study**

Attachment B
Hydrologic Modelling

6 Hydrologic Modelling

The CUG project area lies within the Fitzroy basin, near its northern boundary with the Burdekin Basin (refer back to Figure 1-1). The proposed longwall panels will undermine Humbug Gully, a tributary of Harrybrandt Creek.

The Harrybrandt Creek catchment was delineated to approximately 1km downstream of the Humbug Gully catchment. Details of the Harrybrandt Creek catchment, as defined for the purpose of this project, are presented in Table 6-1.

Table 6-1. Catchment details

Catchment	Catchment Area (km^2)	Catchment Outlet
Harrybrandt Creek	261.4	On Harrybrandt Creek, 1km downstream of confluence with Humbug Gully

As per the project requirements, hydrologic information for the catchment was derived at suitable locations to determine the flood envelope within the project area for the range of events from the 0.5 EY up to the PMF.

6.1 RORB model description

The hydrologic modelling software used in this study is RORBWin version 6.15, a Windows version of the industry accepted RORB program (Laurenson et al 2007).

A RORB model represents the rainfall runoff process occurring in a catchment by:

- Conceptualising the catchment as a linked series of sub-catchments represented in the model by catchment storages and river reach storages;
- Applying rainfall excess (rainfall minus losses) to each sub-catchment (rainfalls are assumed to enter the sub-catchment at its centroid);
- Calculating the resulting runoff from each sub-catchment storage;
- Routing the runoff through the catchment system, combining flows at channel junctions; and
- Outputting flow hydrographs at points of interest in the catchment.

The model represents only the rapid flow or surface runoff component of stream flow, and the slow response or base flow component has not been included in the model.

Setting up the model comprises:

- Determining the catchment boundary and dividing the catchment into sub-catchments;
- Calculating the area of each sub-catchment;
- Placing model nodes at sub-catchment inflows and junctions;
- Placing reach storages between nodes; and
- Measuring the length of reach between adjacent nodes.

The RORB model requires four parameters to be specified which include k_c, m, initial loss (IL) and continuing loss (CL). The k_c and m parameters are factors in the storage discharge relationship.

The storage discharge relationship for the reach storages in the model has the general form:

$$S = 3600k\,Q^m$$

Where:

S is the volume of water in storage (m^3);
k is related to travel time of a particular reach and the characteristics of the whole catchment;
Q is outflow rate from the reach storage; and
m is a dimensionless exponent representing the non-linearity of catchment response. m varies in the range 0.6 to 1.0 with a value of 1 representing a linear response. Many studies adopt a value of 0.8.

The relationship between k and k_c is given by the equation:

$$k = k_{ri}\,k_c$$

Where:

k_{ri} is the relative delay time of reach i; and
k_c is an empirical coefficient applicable to the catchment and is a constant for the whole catchment.

The two rainfall loss parameters of IL and CL are used in the generation of the rainfall excess hyetograph for the model. IL is the rainfall at the start of a storm event which fills soil and groundwater storage, is intercepted by vegetation, or is lost by another process and does not contribute to runoff. CL is the ongoing portion of rainfall that falls after the initial loss that does not produce surface runoff. This could be due to deep soil storage, vegetation interception or evaporation. The loss parameters used in the model can be storm and catchment specific.

6.2 Catchment delineation

Catchment delineation and subdivision was undertaken using the CatchmentSIM software program which delineates sub-catchments from a Digital Terrain Model (DTM), calculates their properties and creates output files for a range of hydrologic models including RORB.

The catchment delineation and subdivision took account of all known diversions and waterways within the project area. Following delineation of the sub-catchments, the CatchmentSIM model was exported as a RORB catchment file using a CatchmentSIM-RORB macro (6.0 v3). This automatically sets up the connections between sub-catchments and reaches and calculates and assigns the sub-catchment areas, reach lengths and slopes in the RORB catchment file. This file was then modified to specify the locations where hydrograph outputs were required.

The model for Harrybrandt Creek catchment has 227 subcatchments. The resulting layout of subcatchments and reaches are shown in Figure 6-1.

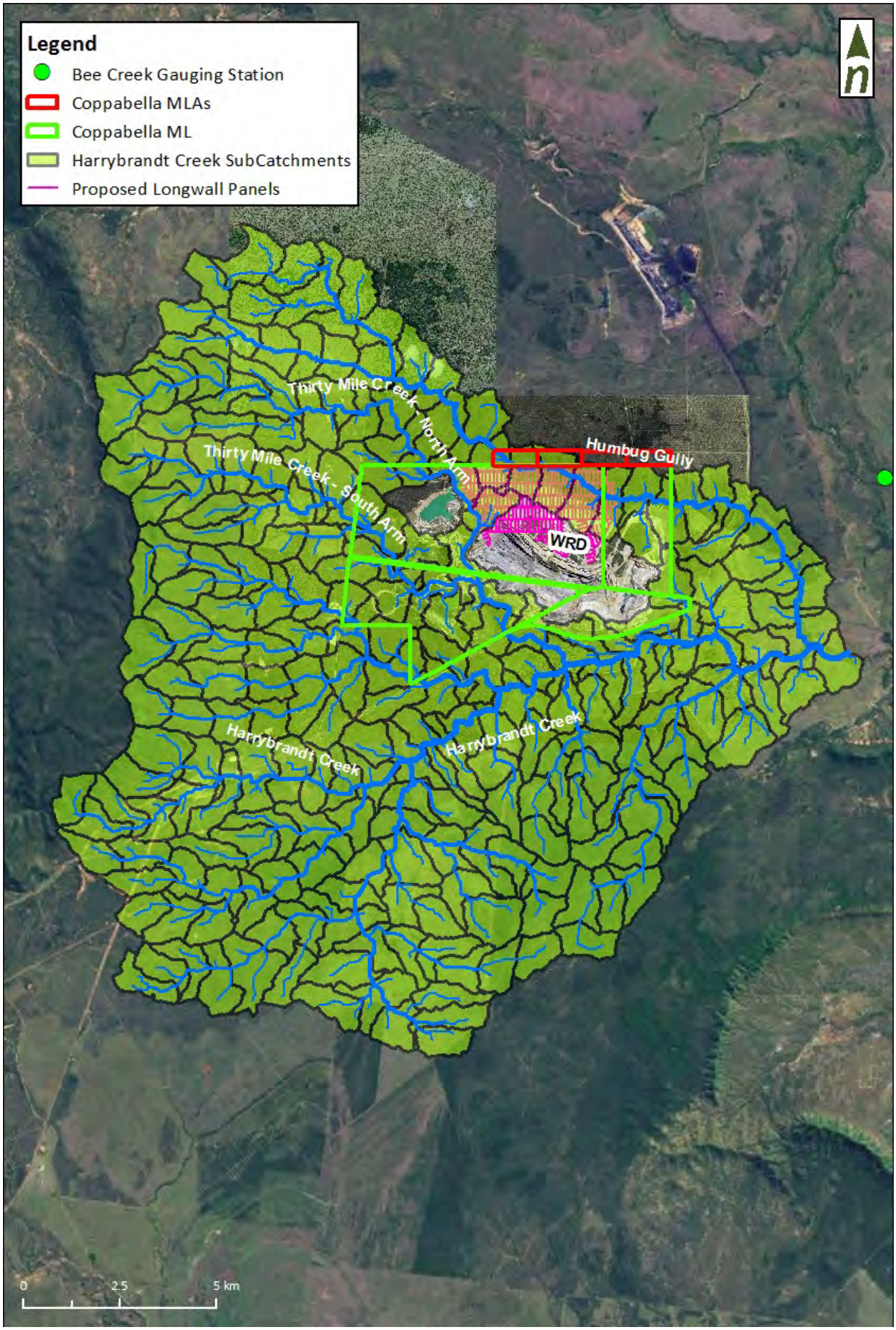


Figure 6-1. **Harrybrandt Creek catchment**

6.3 Model parameter derivation

Due to the limited stream flow data available, it was not possible to directly calibrate the hydrologic model. Therefore, it was necessary to investigate what options were available to develop the parameters required.

Bee Creek at Smiths Yard gauging station (# 130411A)

The only streamflow gauging location near to the project area is located on Bee Creek, which Harrybrandt Creek is a tributary for, and gauges an area of 1280km^2. Alluvium undertook a study of the Bee Creek catchment in 2008 (Sargent 2008) using historical data collected between 1971 and 1988 (the period the station was open for) and determined that the suitable k_c and m values were 35.15 and 0.8, respectively. Based on the catchment area, the corresponding Weeks value for k_c would be 39.0 which is slightly less conservative than that used for the study (ie. generates lower peaks).

A new catchment model was developed for the Bee Creek catchment and calibrated to the 2008 outputs. Overall the results were shown to have good agreements with using typical uncalibrated design parameters for the catchment; using the Weeks regional relationship to develop the k_c value (see the next section) and using typical ARR design losses. Therefore it was decided to use this approach for the Harrybrandt Creek catchment model. See Table 6-2, below, for a comparison between the two different model outputs.

Table 6-2. Comparison of hydrology between Alluvium 2008 and Alluvium 2013

Event	Bee Creek at Smiths yard (gauging station)	
	Alluvium 2008	**Alluvium 2013**
0.5 EY	370 (30hr)	520 (30h)
0.2 EY	790 (18hr)	980 (18h)
10% AEP	1180 (18hr)	1260 (30h)
5% AEP	1600 (12hr)	1640 (18h)
2% AEP	2400 (18hr)	2370 (12h)
1% AEP	2850 (18hr)	2960 (12h)

Weeks regional relationship method

Australian Rainfall and Runoff (ARR) outlines, in section 3.6.2, the regional relationships developed to calculate k_c for ungauged catchments. For Queensland, the relevant method was derived by Weeks and takes the form:

$$k_c = 0.88 * Area^{0.53}$$

As discussed above, it was decided to adopt the Weeks method for this project. Table 6-3, below, lists the Weeks derived k_c values for the Harrybrandt Creek catchment model.

Table 6-3. Calculated Weeks values for all catchments

Catchment	Catchment Area (km^2)	Weeks k_c Value*
Harrybrandt Creek	261.4	16.814

*Note, that the underlying assumption is that m = 0.8.

Other modelling parameters

For this project it was considered suitable to use typical Queensland design values for IL and CL for all events up to the 1% AEP. For the 0.1% AEP and PMP, the loss values recommend by the Bureau of Meteorology for the PMP were adopted. The losses are presented in Table 6-4.

Table 6-4. Adopted model parameters for initial loss and continuing loss

Parameter	0.5 EY to 1% AEP	0.1% AEP and PMP
Initial Loss	25mm	0mm
Continuing Loss	2.5mm/hr	1 mm/hr

6.4 Design rainfall

Design rainfall depths for a range of events up to the PMP events were generated for the study.

The 0.5 EY to the 2% AEP design rainfalls were determined using the ARR method inbuilt in RORB (with site parameters determined from ARR Vol 2). ARR 1987 areal reduction factors were used.

The 1% to 0.1% AEP design rainfalls were determined using DERM design rainfall data (Hargraves 2005) for Queensland. This data was based on analysis of rainfall records on a regional basis using a technique developed by the Cooperative Research Centre - Catchment Hydrology (CRCCH) known as CRC-FORGE (Hargraves 2005). CRC (ARF) areal reduction factors were used.

For the PMP, the Generalised Short Duration Method (GSDM) (BOM 2003) was used, as the initial stages of flood modelling suggested the critical durations were below the 6hr upper limit of the GSDM. The GSDM accounts for catchment area as part of the method so no additional areal reduction factors were required.

To generate appropriate design flood hydrographs for the Harrybrandt Creek catchment area it was necessary to develop Intensity, frequency, duration (IFD) data.

The IFD table for the Harrybrandt Creek catchment is presented in Table 6-5.

Table 6-5. IFD Table for Harrybrandt Creek catchment, total rainfall depth in mm (includes Areal Reduction Factors)

Event	0.5 EY	10% AEP	5% AEP	2% AEP	1% AEP	0.1% AEP	PMP (GSDM)
15 min	13.60	19.25	22.12	25.93	49.14	74.37	130
30 min	19.75	27.39	31.28	36.41	69.02	104.46	190
1 hour	33.12	44.89	50.90	58.79	93.15	140.98	290
3 hours	49.61	70.53	81.11	95.22	129.62	196.18	440
6 hours	60.79	89.12	103.43	122.68	158.21	239.45	570
12 hours	73.81	111.56	130.64	156.57	193.55	292.93	
18 hours	83.60	128.66	151.48	182.66	225.79	341.73	
24 hours	90.39	140.94	166.58	201.75	251.72	376.40	N/A
48 hours	107.59	173.37	206.90	253.38	334.28	485.29	
72 hours	115.96	190.87	229.21	282.74	384.09	563.92	

Temporal patterns

For events ranging from the 0.5 EY to 2% AEP the standard ARR zone 3 temporal patterns were utilised.

A design temporal pattern suitable for all events greater than 2% AEP (except the PMP) was derived from the 10 patterns provided in the Jordan et al. (2005) paper combined with the Bulletin 53 pattern from the Generalised Short Duration Method (GSDM) PMP. The resulting “Rare Design” temporal pattern is depicted in Figure 6-2.

For the PMP, the Bulletin 53 pattern from the Generalised Short Duration Method (GSDM) PMP was used (BOM 2003).

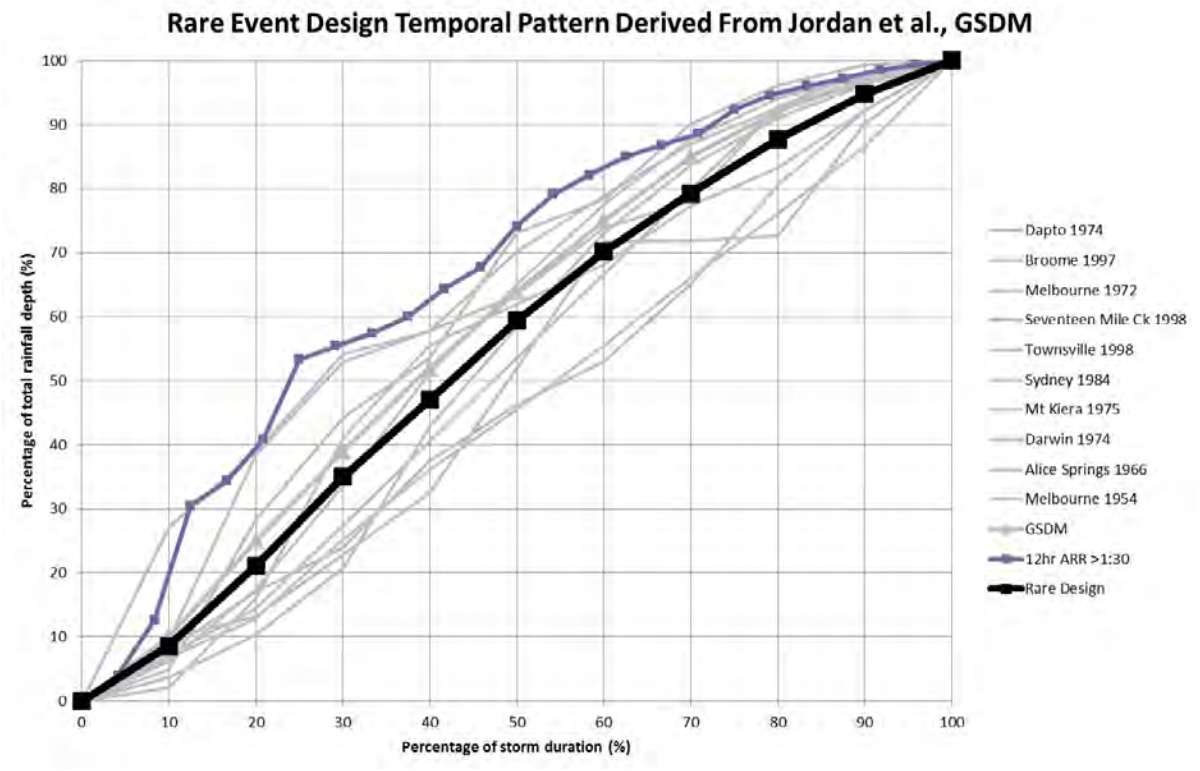


Figure 6-2. Selection of the design temporal pattern for rare events

6.5 RORB model output flow

Presented in Table 6-6 below are the RORB model outputs for existing (baseline) conditions. The output locations are depicted in Figure 6-3 and have been chosen to facilitate reporting.

Note that the peak flow rates did not all coincide on the same duration storm event – overall the critical duration varied between the 2 hour and 4.5 hour events depending on the event probability.

Table 6-6. Design discharges generated from hydrologic modelling

Locations	Upstream catchment (km^2)	0.5 EY	10% AEP	5% AEP	2% AEP	1% AEP	0.1% AEP	PMF
		Peak Discharge (m^3/s)*						
Sub40	17.6	23.3	51.1	65.8	86.2	142.1	284	662
Sub74	23.7	23.1	54.3	65.9	87.5	144.4	311	687
Sub59	28.7	22.5	53.6	64	85.1	140.7	308	673

Note that a small portion of the mine lease lies within the neighbouring catchment to the north. As these sub catchment areas are small and immediately adjacent to the catchment divide, run off rates can be considered negligible for the purposes of a flood assessment. Assessment of these catchments within the mine lease would provide little value to the project and has therefore not been included as part of this study.

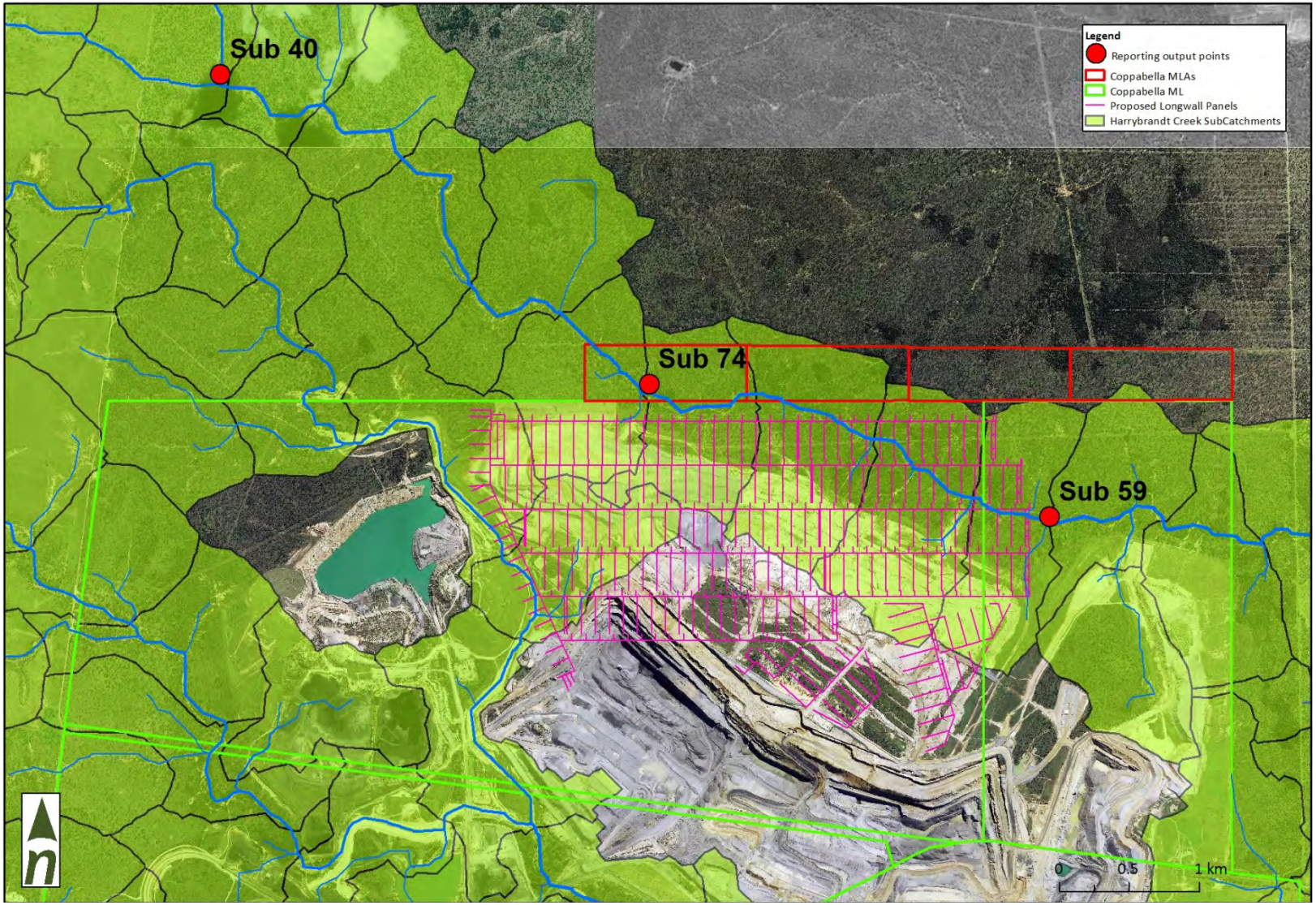


Figure 6-3. Output locations for reporting

Attachment C
Hydrodynamic Modelling

7 Hydrodynamic Modelling of Baseline Conditions

7.1 2D hydrodynamic modelling overview

Hydrodynamic modelling was undertaken to estimate the baseline flood depths, extents and velocities through the CUG project area for a range of probability events to provide an existing conditions set of results against which future post development assessments can be compared.

The model was built from aerial survey data (see Attachment A) along with design flow hydrology (Attachment B) to determine flood extents and depths associated with Humbug Gully in the CUG project area.

The model was originally built for an earlier project and is reported on separately in the EPC531 Flood Modelling Report (Alluvium 2013b). However, the area of the model relevant to this study is reported on in the section below.

7.2 2D hydrodynamic model set-up

A 2D hydrodynamic model of the catchments within and adjacent to the project area was constructed using XPSWMM, a hydrodynamic modelling software package which couples together the SWMM 1D model and the 2D finite difference model TUFLOW.

The model outfall is location on Humbug Gully, at the approximate eastern extent of the current mining activity.

The digital terrain model (DTM) used for the model consists of a processed amalgam of data sources, three of which were supplied by Peabody. Further details are provided in Attachment A.

Manning's n roughness coefficients for the model were set using polygons delineated from aerial imagery (without onsite verification). Manning's n values adopted for the different polygons are presented in Table 7-1 with the delineated Manning's n polygons shown in Figure 7-1.

Table 7-1. Manning's n roughness values for Humbug Gully 2D flood model

Land use/Vegetation Type	Roughness value
Sand bed, low density vegetation	0.040
Riparian, medium density vegetation	0.075
Riparian, dense vegetation	0.100
Floodplain, low density vegetation	0.040
Floodplain, medium density vegetation (default)	0.060
Floodplain, dense vegetation	0.090
Mining areas	0.025
Dams	0.020

The model was configured using a 12m cell size. The active area of the model is shown in Figure 7-1.

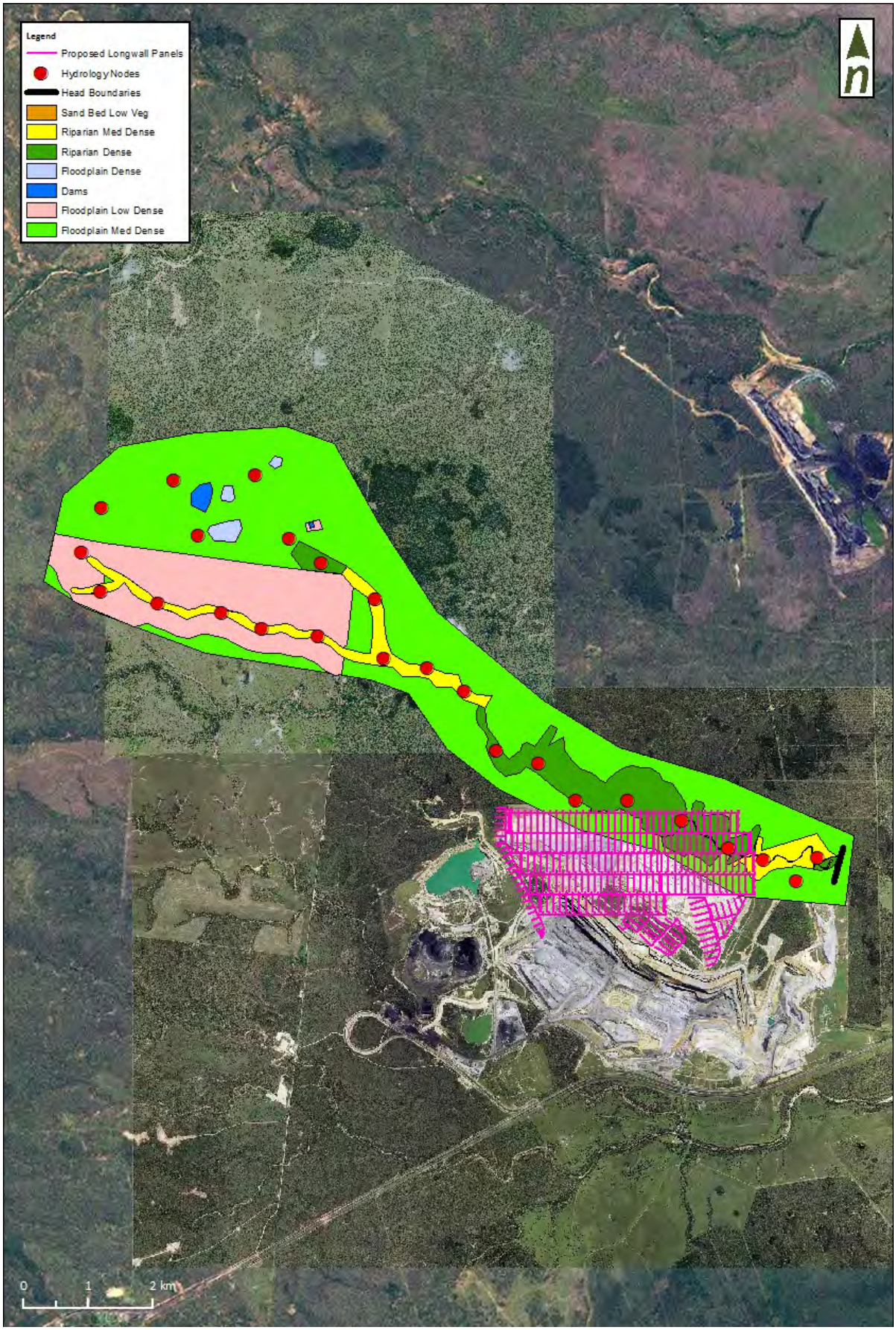


Figure 7-1. XPSWMM model set up

As discussed in Attachment B, hydrologic inputs suitable for 2D modelling were developed for the range of events from the 0.5 EY to the PMF event.

Design hydrographs were input into the hydrodynamic model at the locations shown in Figure 7-1 to represent inputs from both the catchments external to the area and runoff generated locally. The storm durations modelled for each event are presented below in Table 7-2.

Table 7-2. Event durations modelled

Catchment	0.5 EY	10% AEP	5% AEP	2% AEP	1% AEP	0.1% AEP	PMF
Coppabella Mine	4.5 hours	4.5 hours	3 hours	3 hours	3 hours	3 hours	2 hours

For more robust flood mapping, it is recommended that additional storm durations be modelled for each event, particularly on either side on the hydrologic critical duration, to confirm the greatest flood extent that could occur.

It should be noted that the XPSWMM hydrodynamic model does not predict erosion and sediment transport impacts in the 2D domain.

7.3 2D hydrodynamic modelling results

The flood extents for all the modelled events are shown below in Figure 7-2. Maximum flood depths and velocities are shown for all modelled events from Figure 7-3 to Figure 7-16.

The predicted flood extents do not vary significantly between the smallest 0.5 EY event and the 0.1% AEP primarily due to the small local catchment sizes and relatively confined channels. This suggests that for all the range of events which need to be considered, it may be just as cost effective to provide mitigation (if required) for the larger event as for the smaller.

The PMF yields a significantly larger flood extent, as shown in Figure 7-2.

It can be observed in all the velocity figures that the reach over the downstream end of the longwall panels experience velocities up to, and slightly exceeding, 3m/s. The high velocities are experienced equally for the 0.5EY as for the 0.1% (though velocities are slightly higher for the PMF), suggesting that the velocities through the reach are not a function of flowrate but of topography (ie. gradient) and the degree of incision of the channel.

Humbug Gully was the subject of a hydraulic study by Alluvium (2013a). The study identified that the subject reach has a steep gradient but that the hydraulic parameters are still within an acceptable range.

The key outputs of this section of the project are the digital files containing the modelled flood extents which will be used to inform the concept study infrastructure design. For future assessments, this study serves as a baseline which can be used for as a basis for comparison of design scenarios, changes to flow regimes, afflux and water depths.

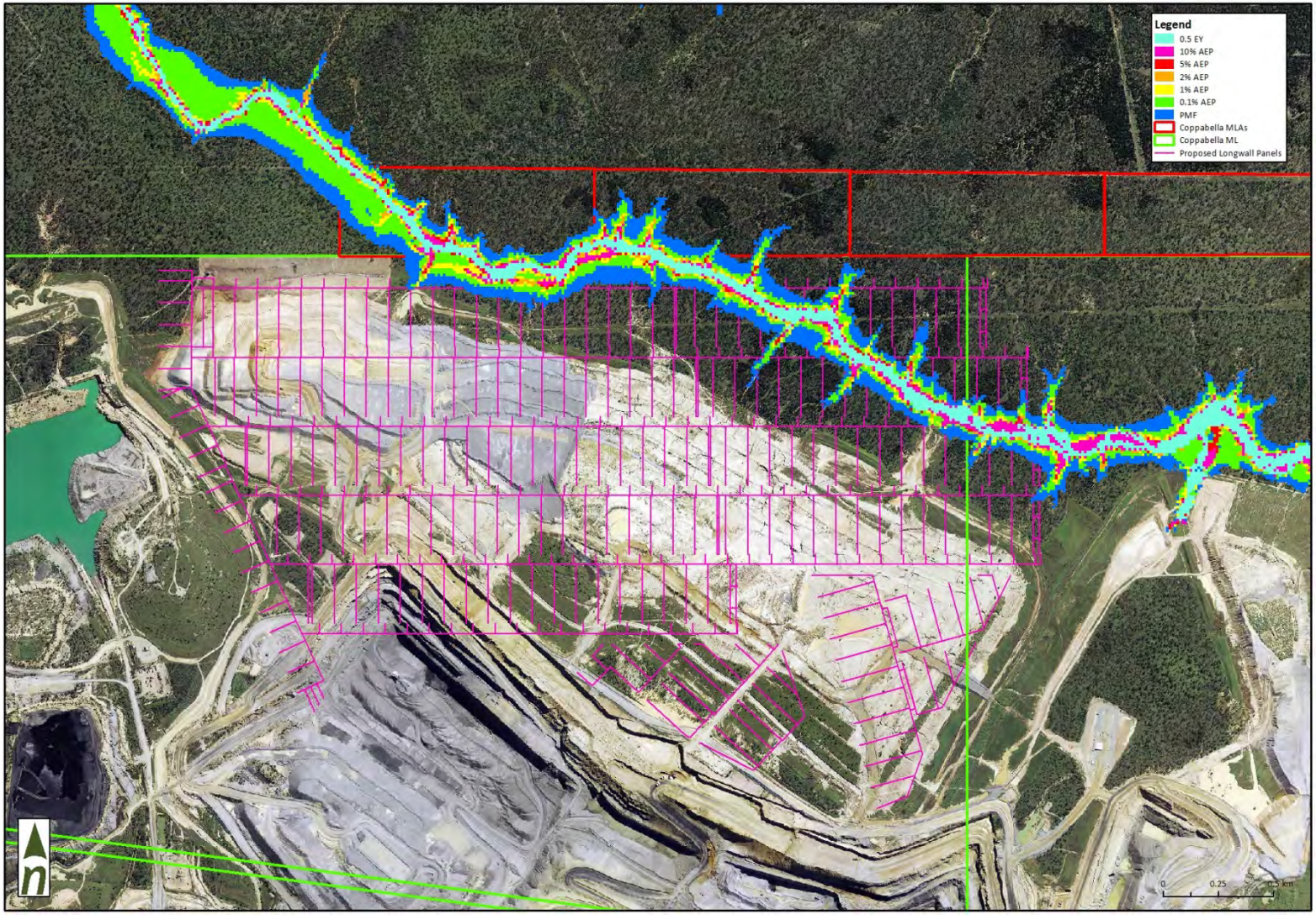


Figure 7-2. 0.5 EY to PMF flood extents for project area

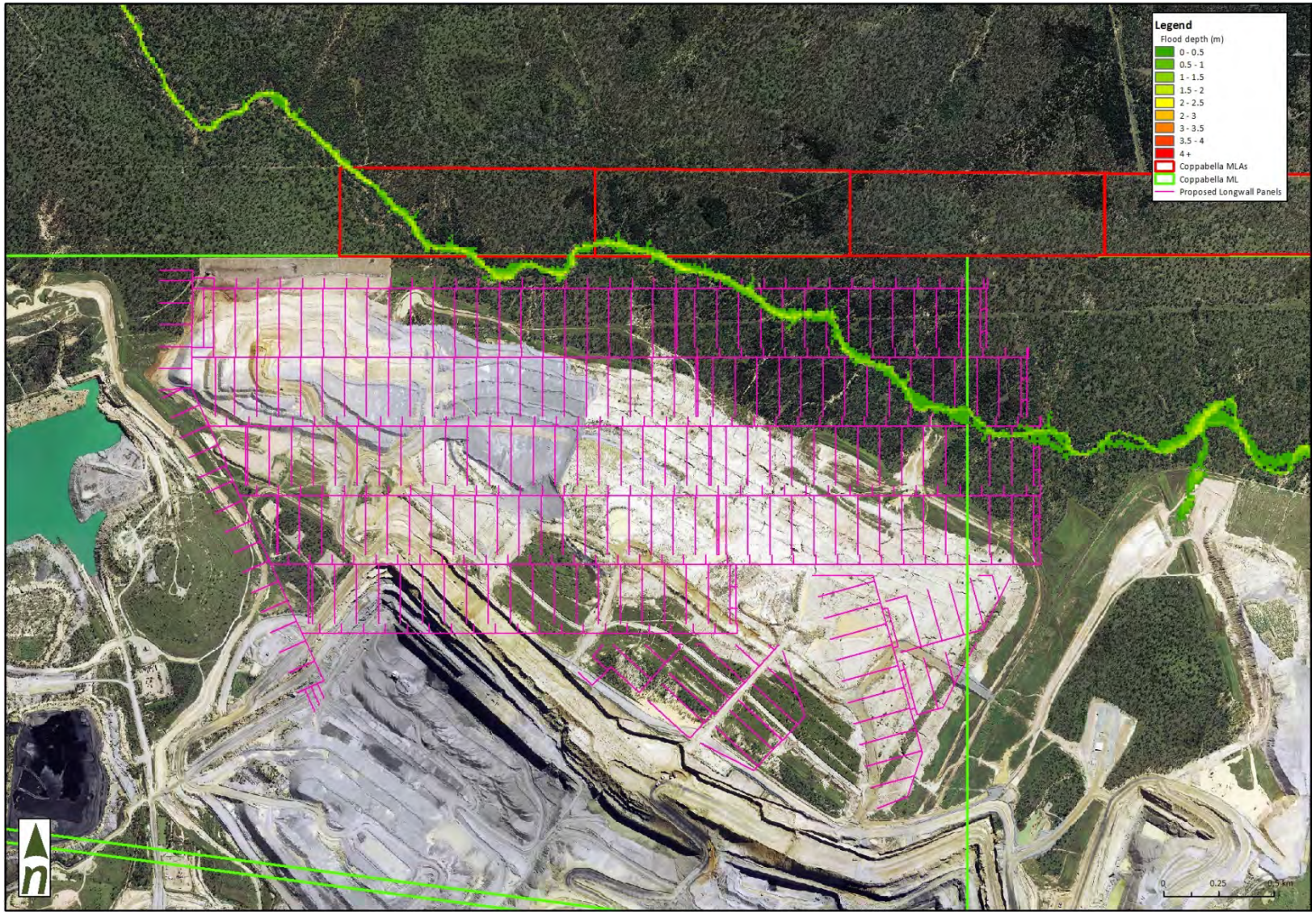


Figure 7-3. 0.5 EY flood extents and depths for project area

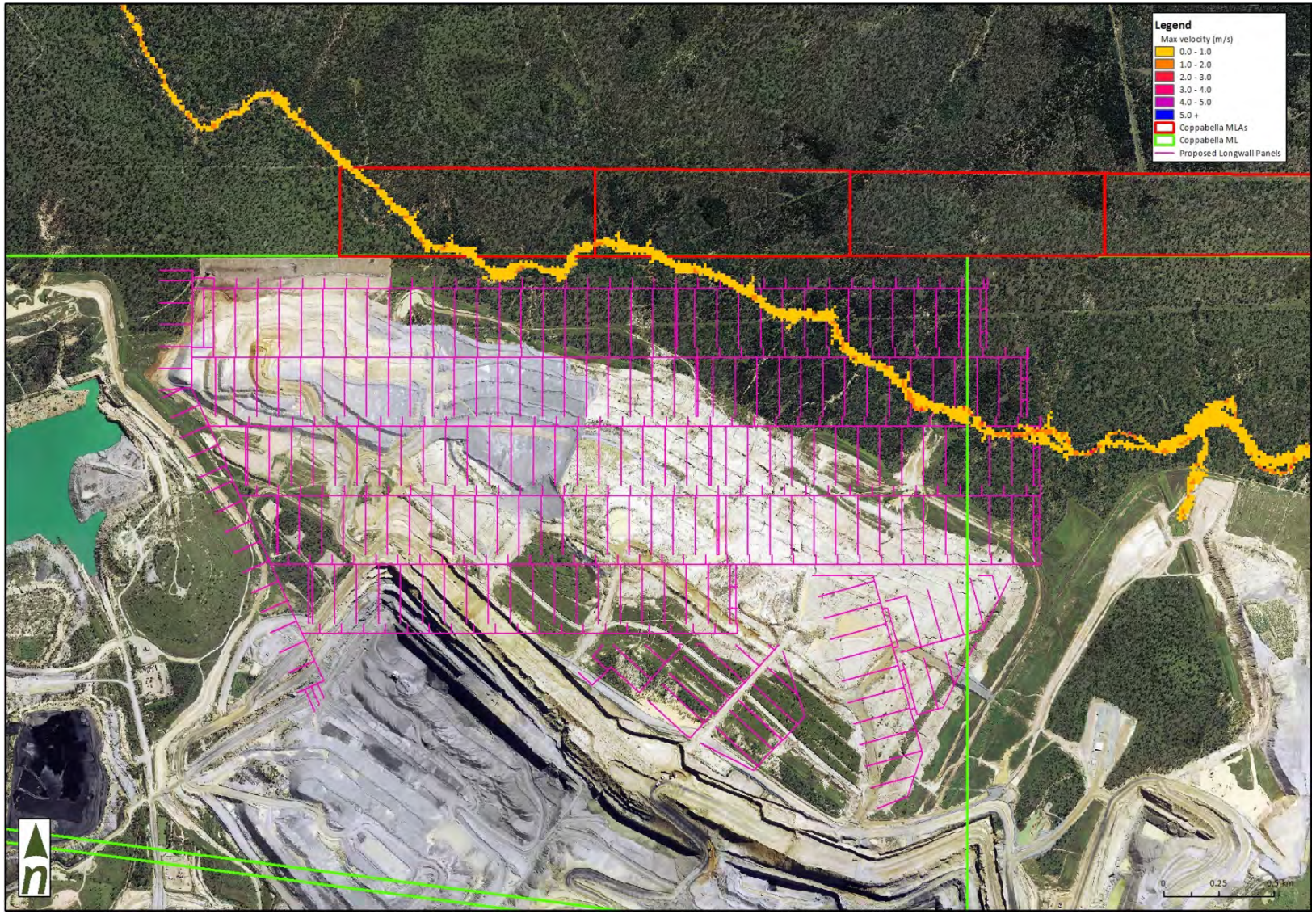


Figure 7-4. 0.5 EY peak velocities for project area

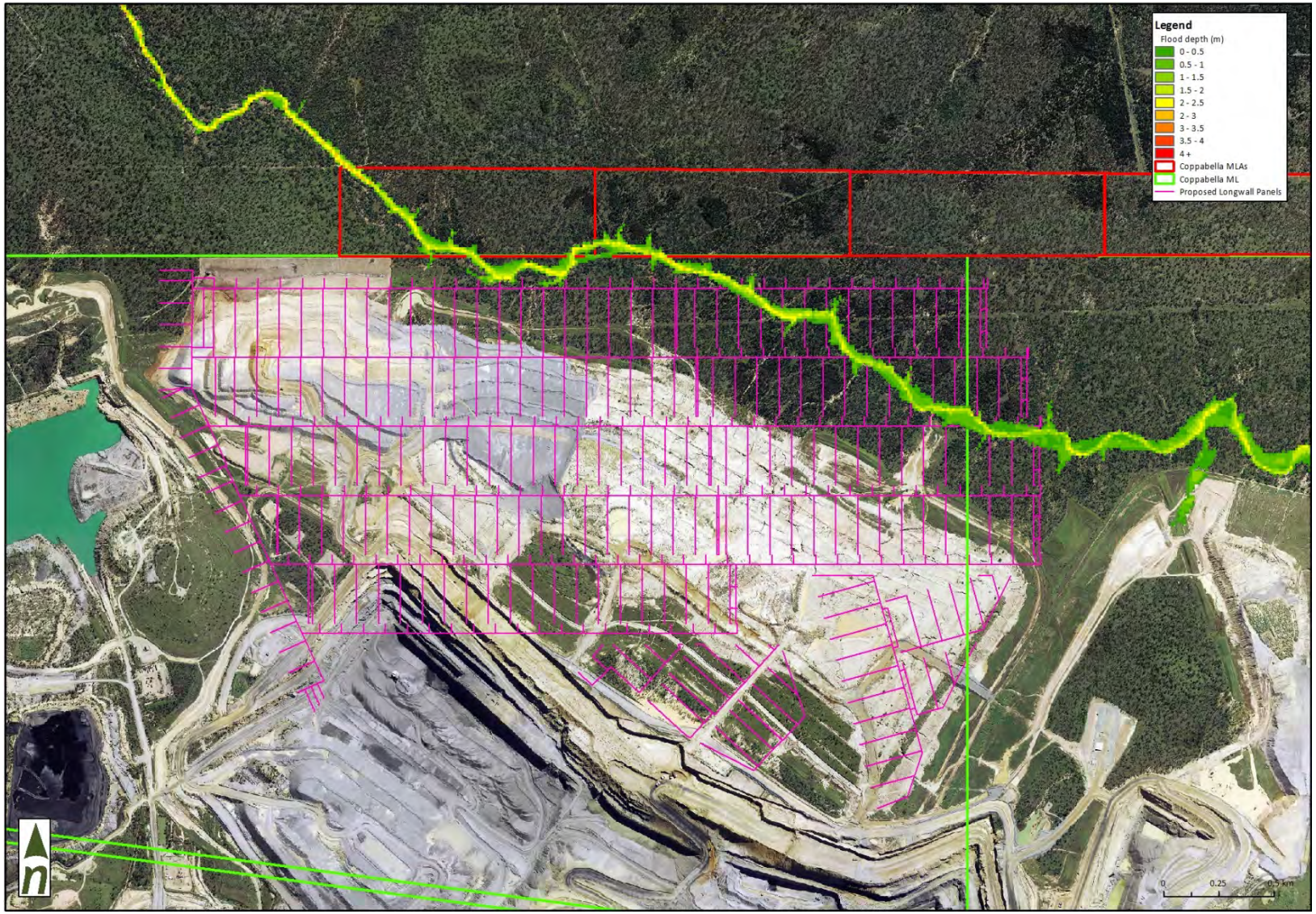


Figure 7-5. 10% AEP flood extents and depths for project area

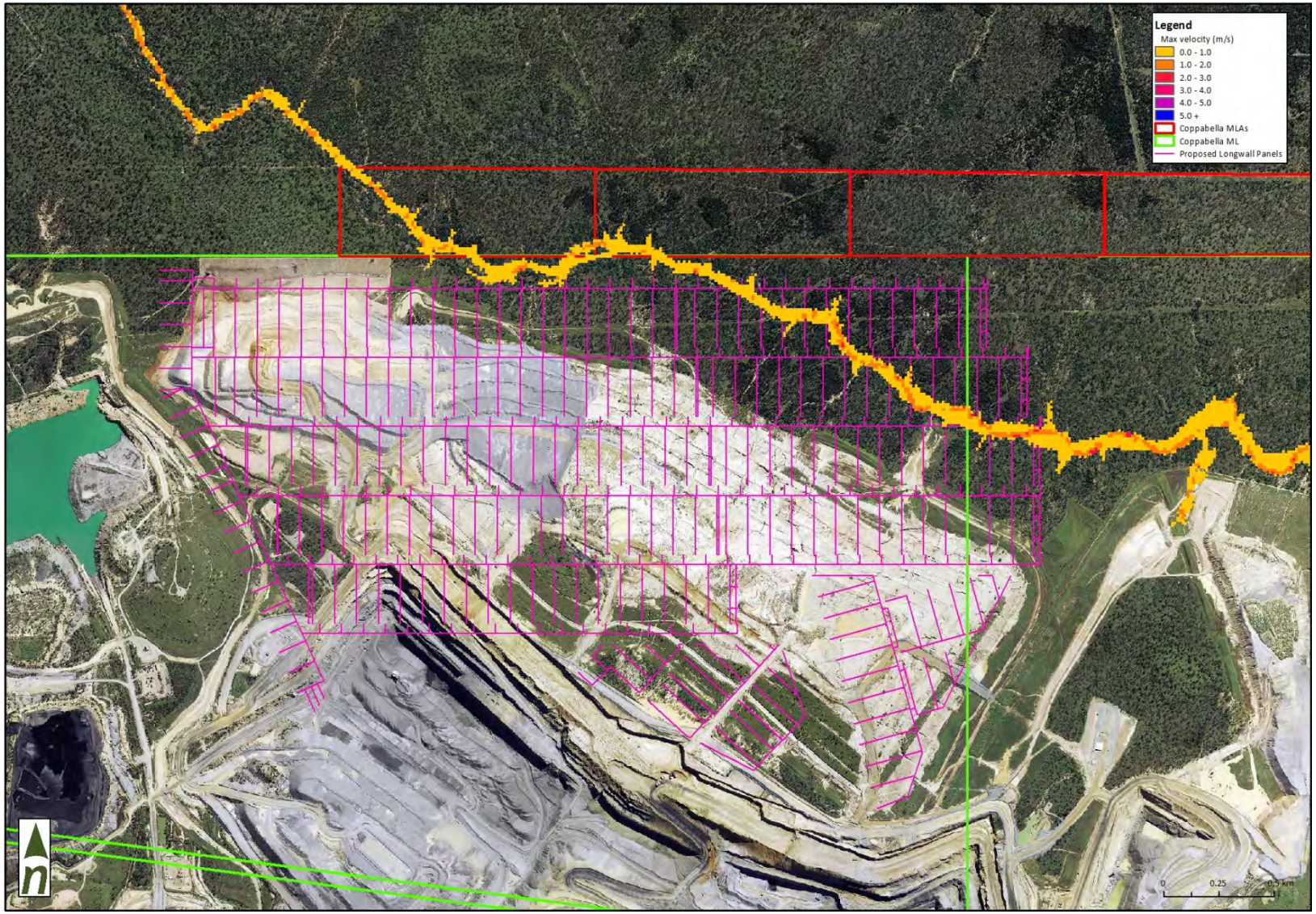


Figure 7-6. 10% AEP peak velocities for project area

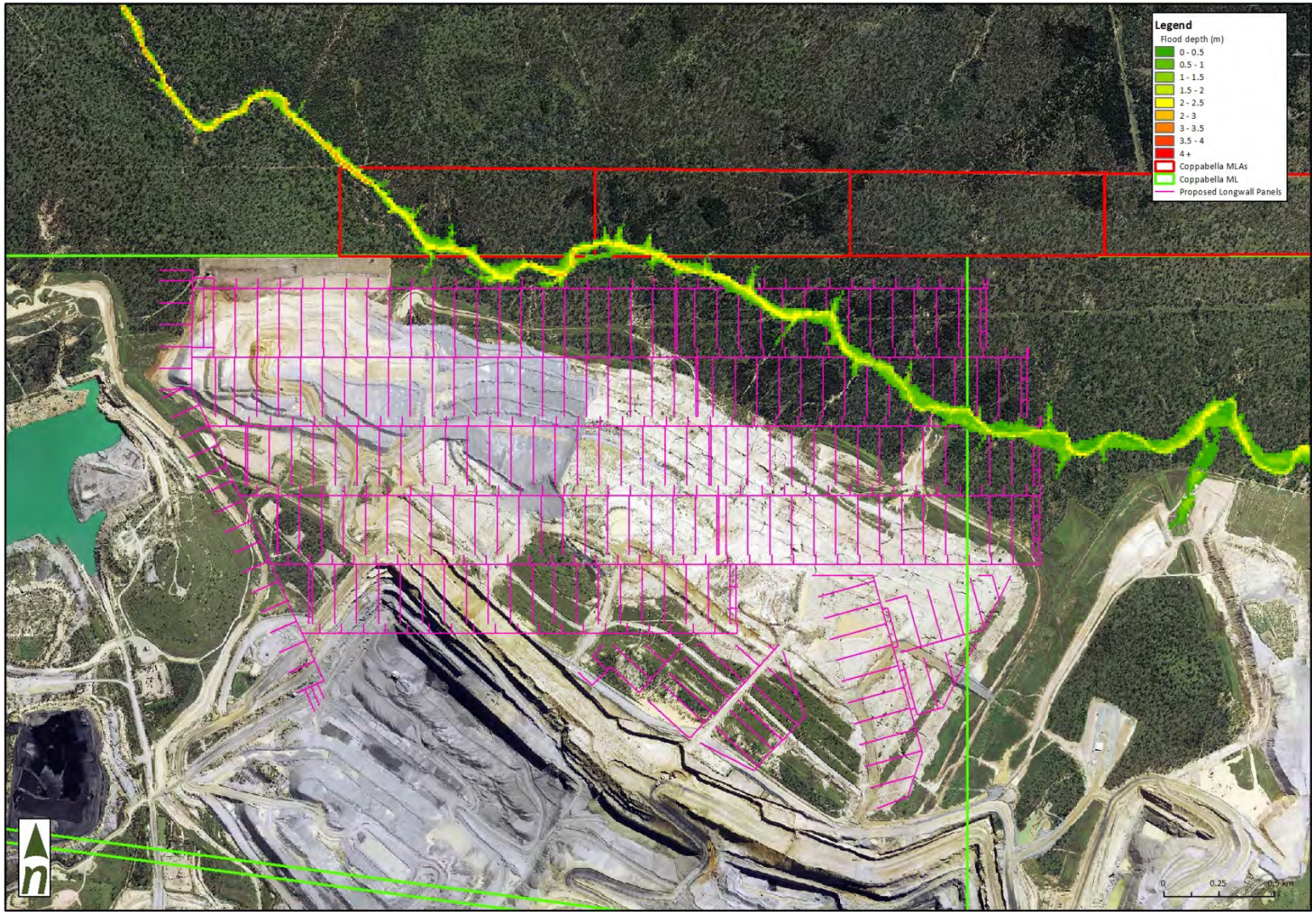


Figure 7-7. 5% AEP flood extents and depths for project area

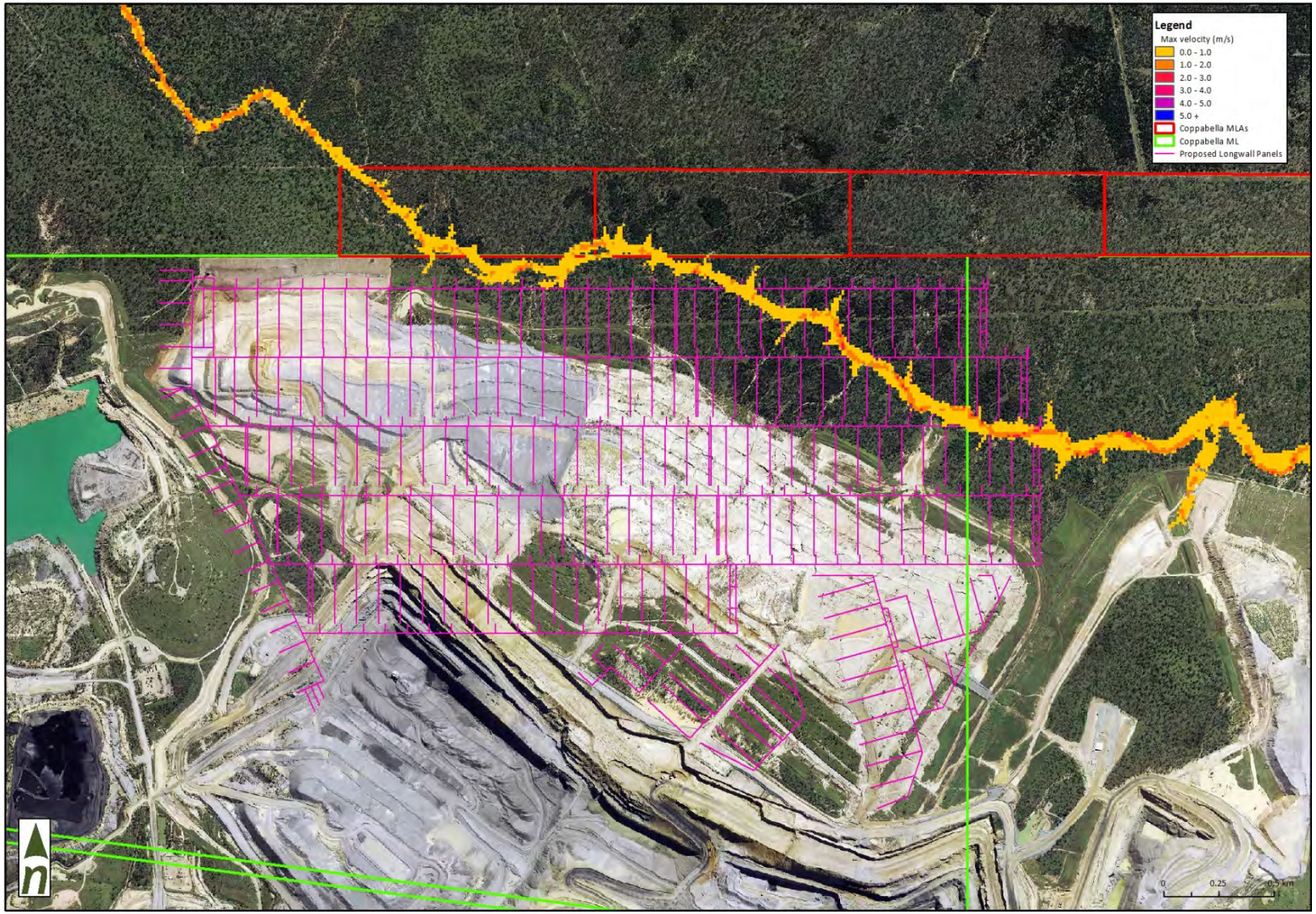


Figure 7-8. 5% AEP peak velocities for project area

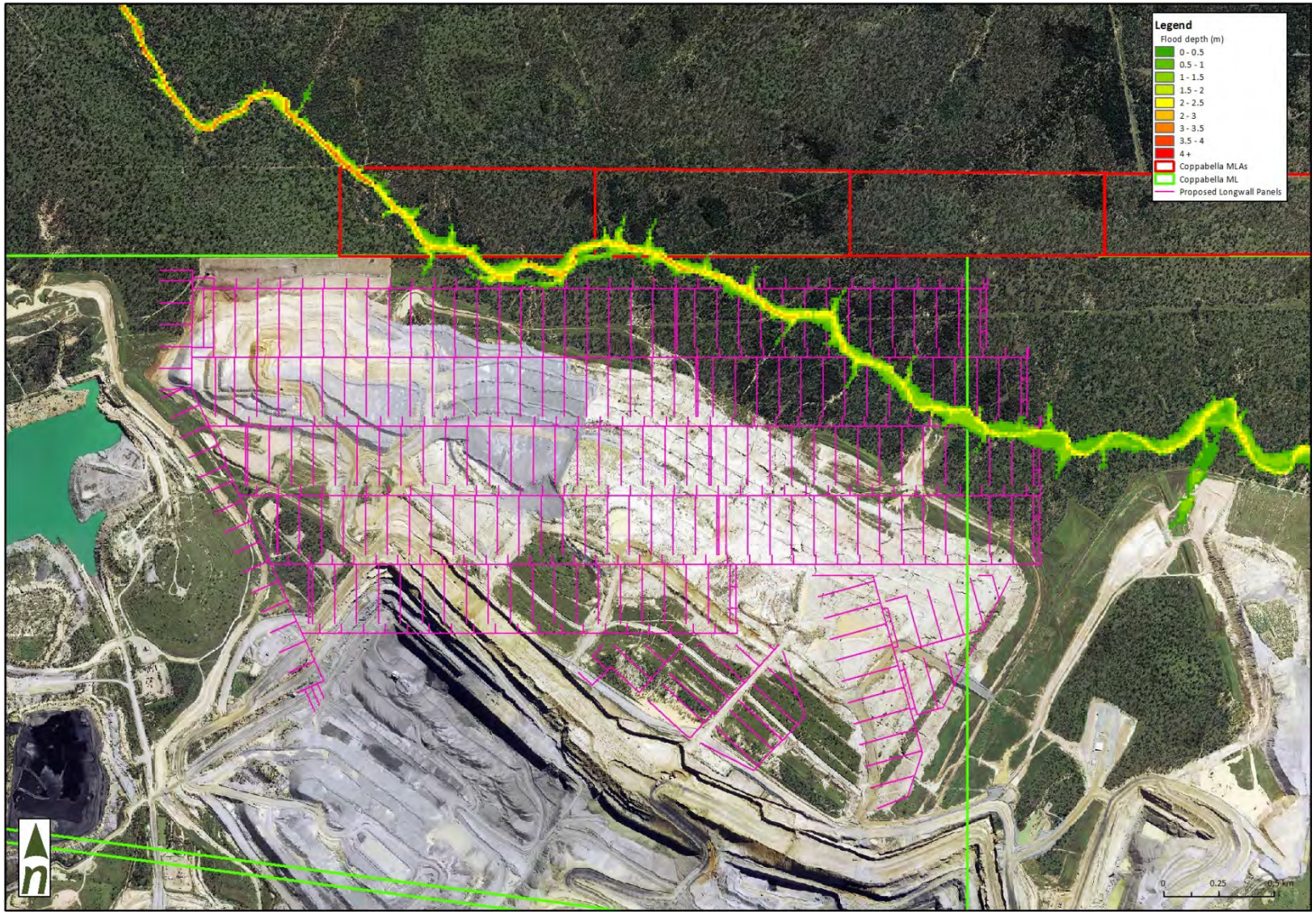


Figure 7-9. 2% AEP flood extents and depths for project area

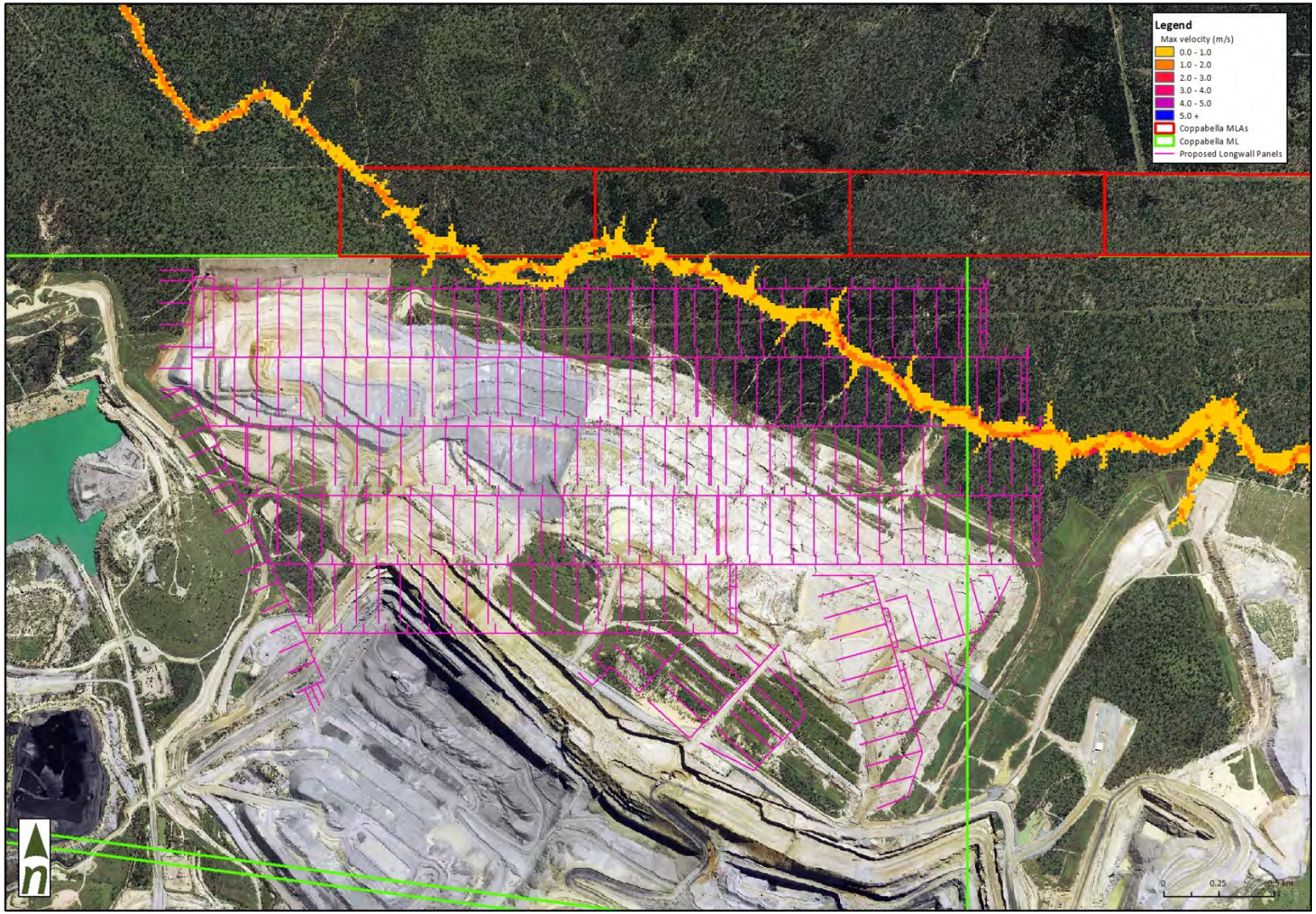


Figure 7-10. 2% AEP peak velocities for project area

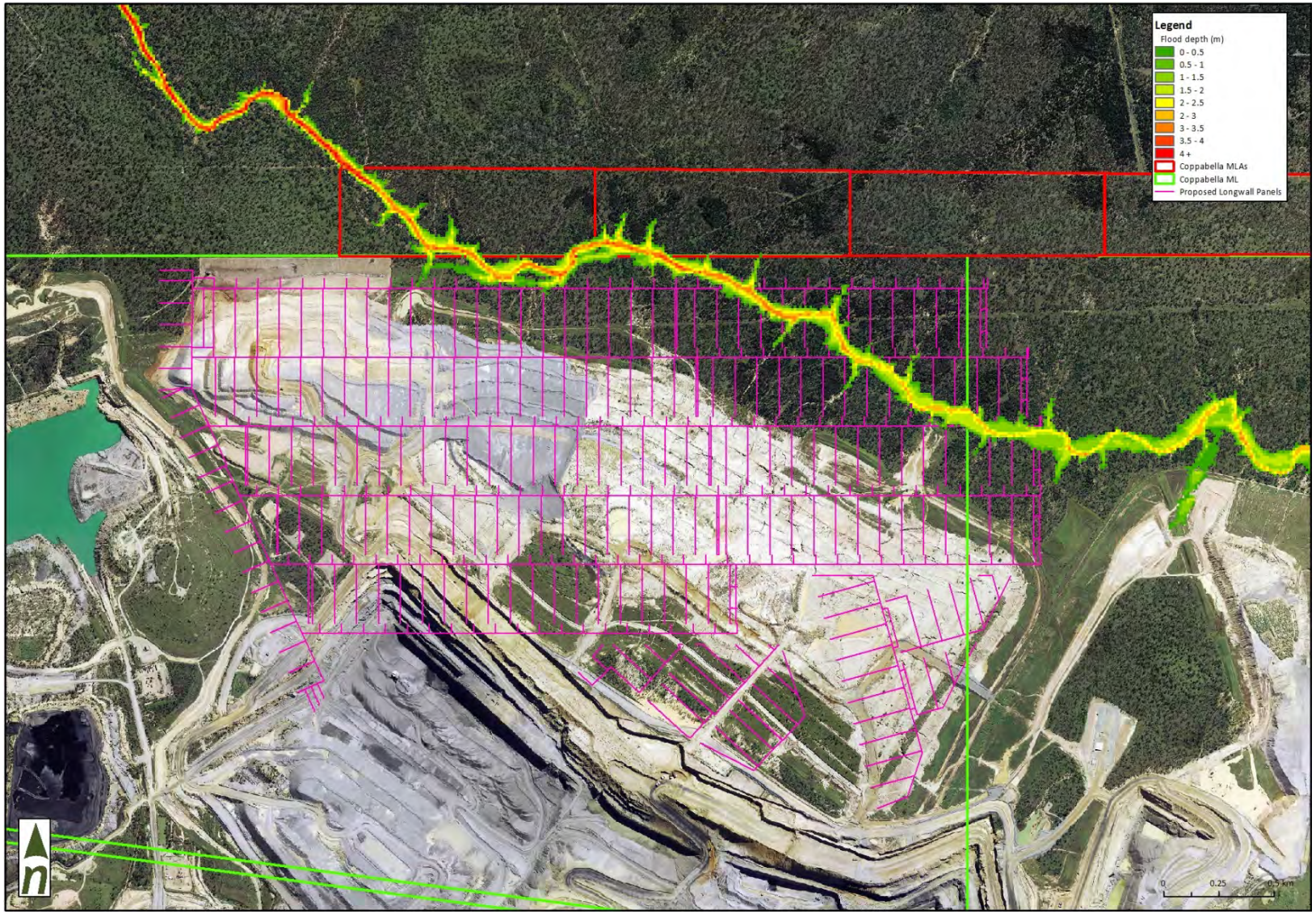


Figure 7-11. 1% AEP flood extents and depths for project area

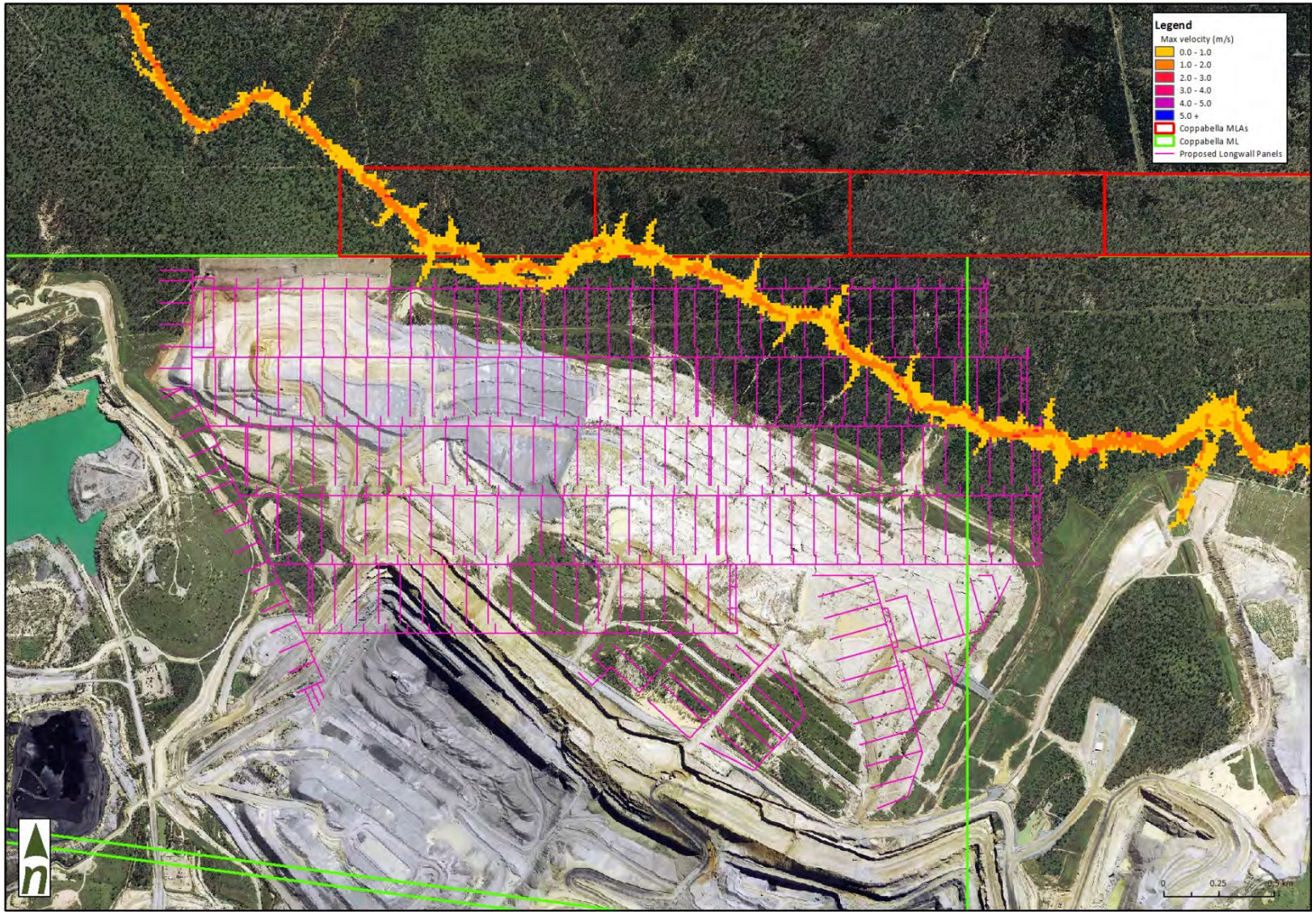


Figure 7-12. 1% AEP peak velocities for project area

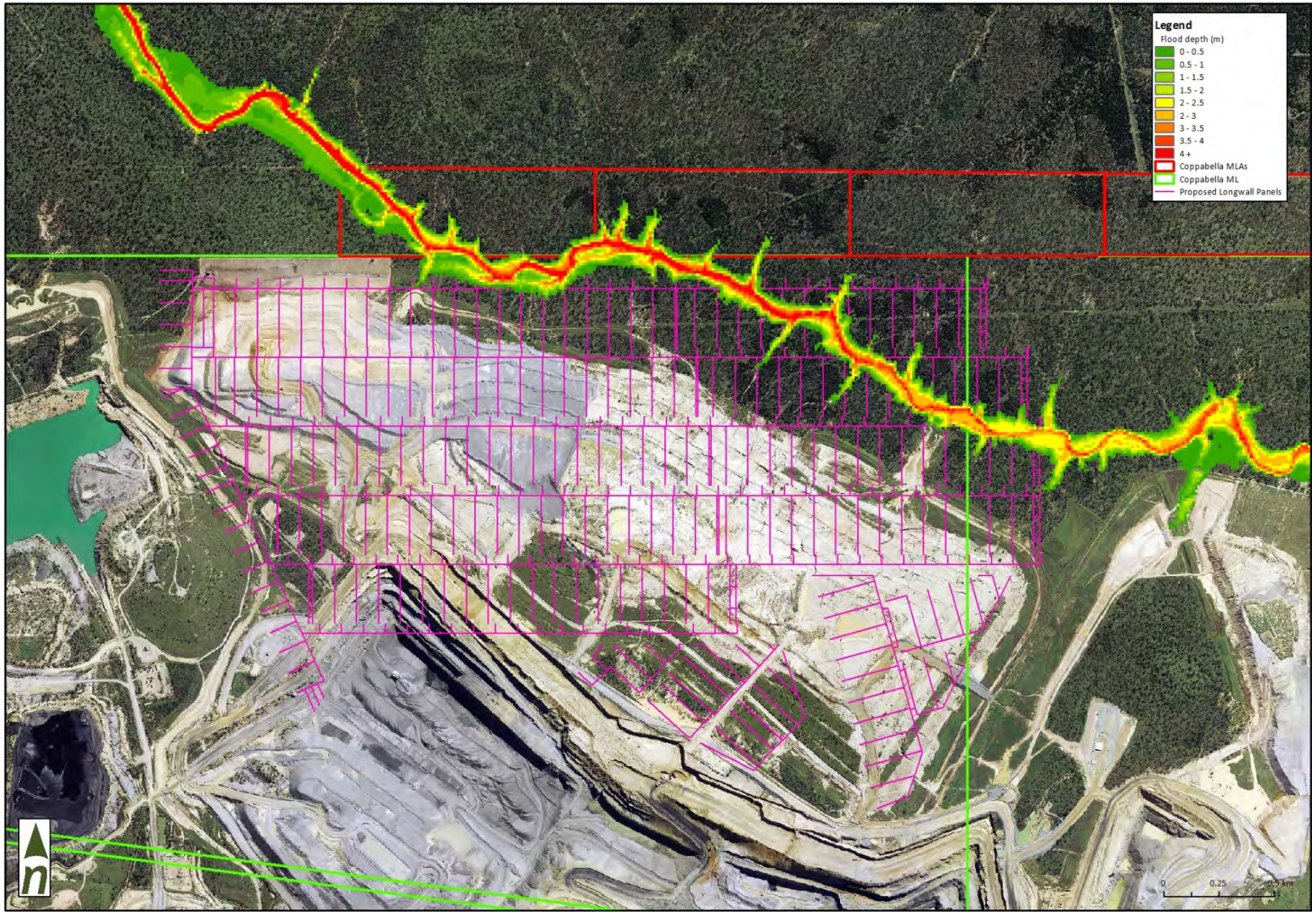


Figure 7-13. 0.1% AEP flood extents and depths for project area

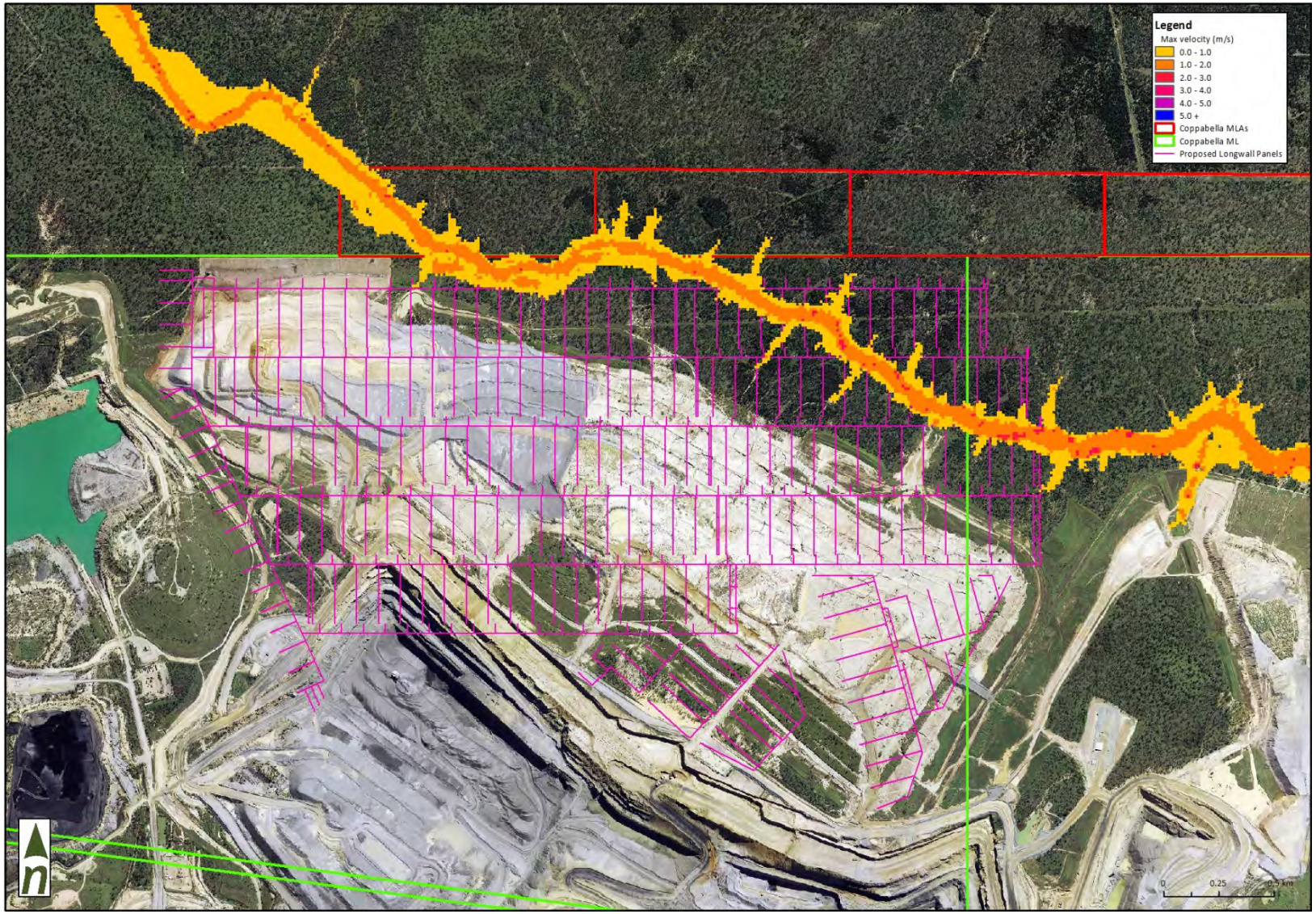


Figure 7-14. 0.1% AEP peak velocities for project area

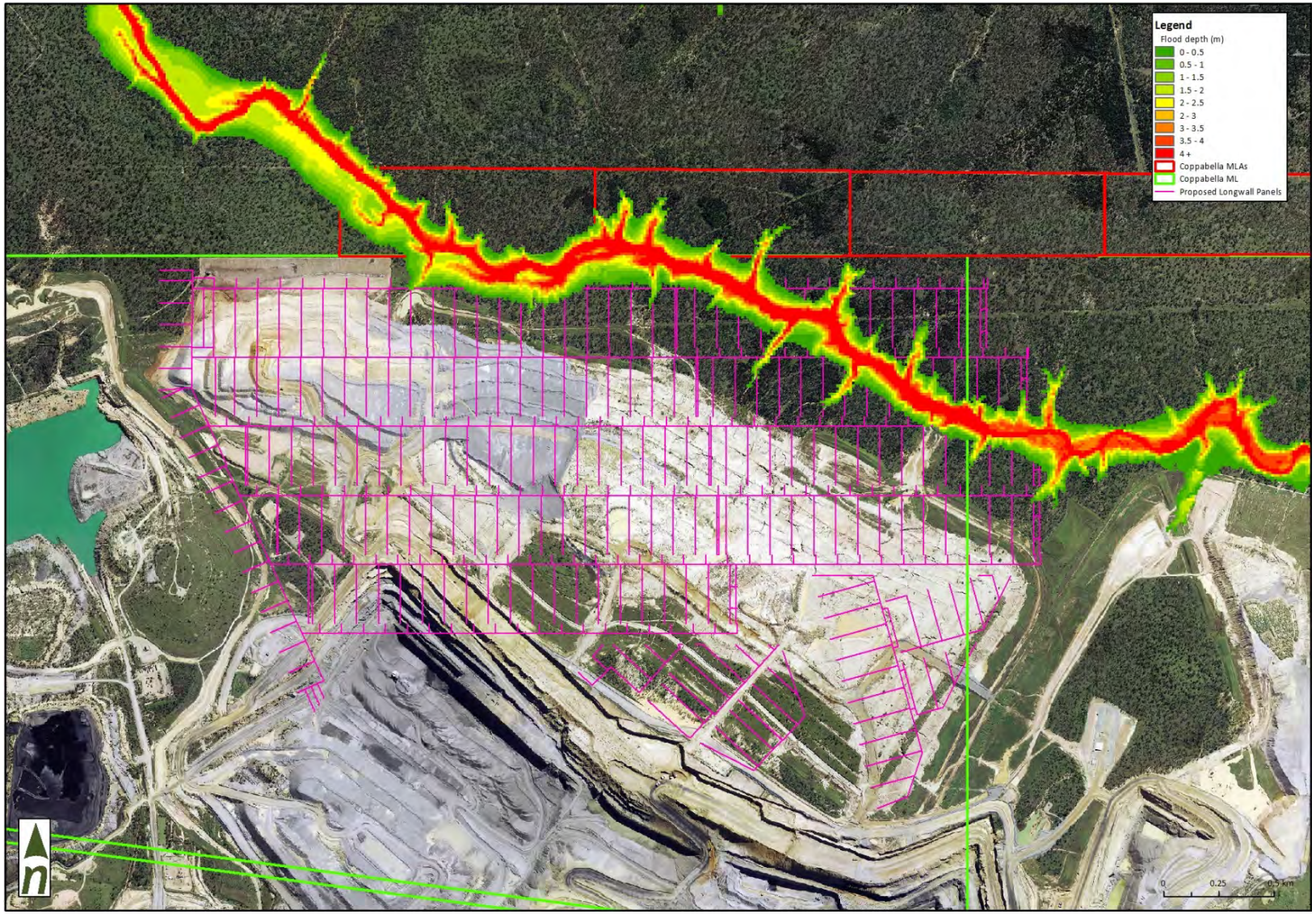


Figure 7-15. PMF flood extents and depths for project area

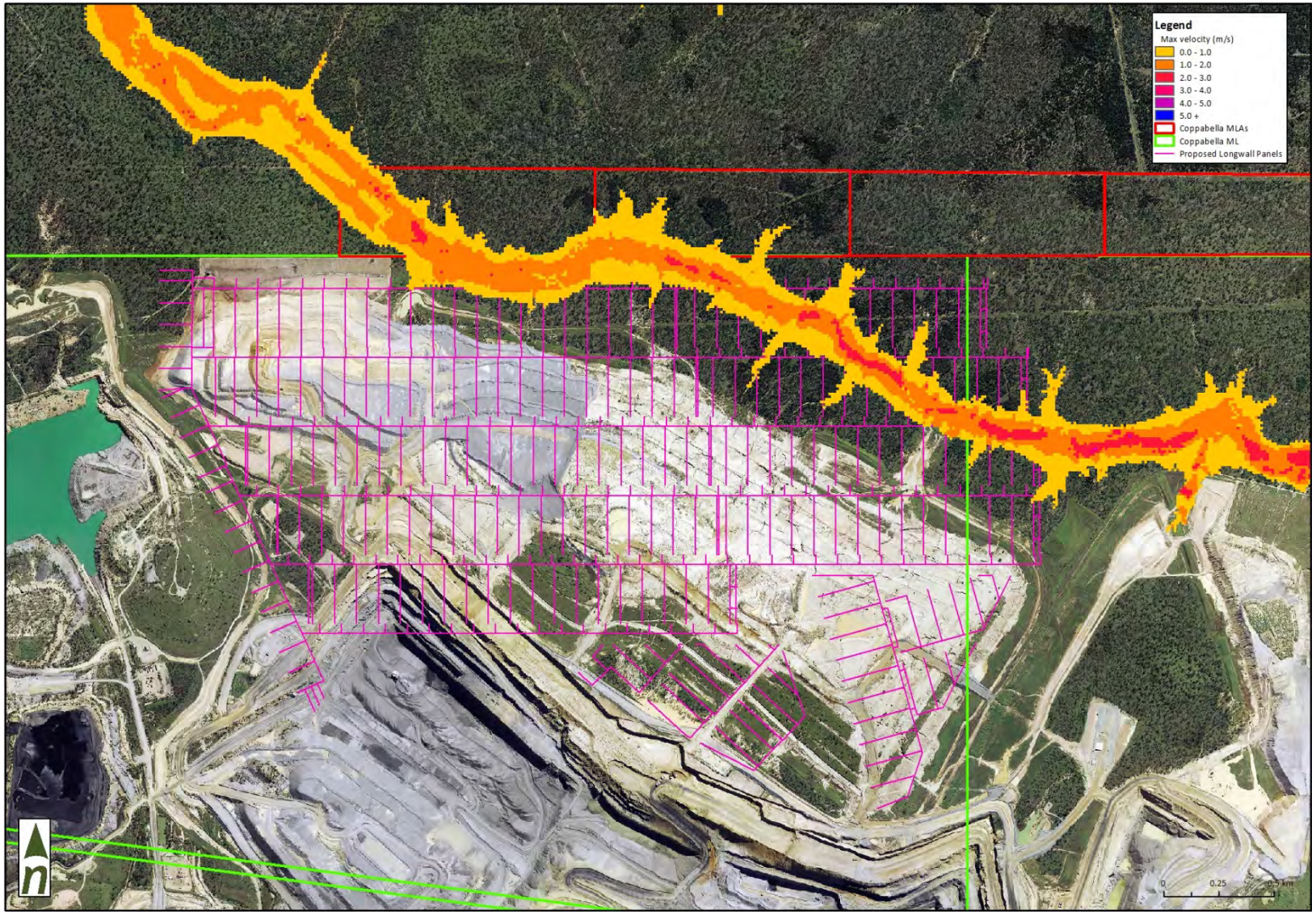


Figure 7-16. PMF peak velocities for project area

Appendix H
Geotechnical report (SCT 2023)



SCT OPERATIONS PTY LIMITED

Strata Control Technology

PEABODY – COPPABELLA JOHNSON EXTENDED PROJECT

High Level Empirical Review and Assessment of Concept Bord and Pillar Design and Subsidence

PEA5657

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REPORT TO	Brian Neilson Director Engineering – Open Cut Mining Peabody Energy 100 Melbourne Street South Brisbane QLD 4001
TITLE	High Level Empirical Review and Assessment of Concept Bord and Pillar Design and Subsidence
REPORT NO	PEA5657
PREPARED BY	Rick Lee Stuart MacGregor
DATE	25 August 2023





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Report No	Version	Date	Revisions
PEA5657	Final	25 August 2023	

EXECUTIVE SUMMARY

Peabody Energy (Peabody) are conducting concept level underground mining studies for the Johnson Extended Project (JEP) area of the Coppabella Mine. Previous underground mining assessments have considered Longwall Top Coal Caving (LTCC) methods to maximise coal recoveries of the Lower Leichardt seam. The LTCC method was subsequently modified to a Bord and Pillar layout following a recent mine planning assessment to reduce impacts of underground mining across the JEP area.

SCT Operations Pty Ltd (SCT) has been engaged to conduct and review the existing bord and pillar design to assist with a Department of Environment and Science (DES) request for information regarding a geotechnical study of pillar stability and subsidence.

The UNSW pillar strength formula has been used to evaluate the pillar Factor of Safety (FoS) of the pillars in the mine plan. The design of underground workings beneath critical surface infrastructure necessitates adherence to specific criteria. As per the UNSW formulae, a minimum w/h ratio of 5, coupled with a minimum FoS of 2.11, is recommended to protect critical surface areas. Pillars designed at a FoS below 2.11 increase the risk of subsidence but are still able to minimise subsidence subject to specific design criteria.

The existing bord and pillar panels in the JEP area are designed at supercritical widths from a subsidence perspective. Additional engineering controls including mine design incorporating subcritical panels, which act to reduce subsidence, and large barriers that isolate extraction areas would further reduce the risk of subsidence over the JEP area. Recommendations have been made for bord and pillar design based on industry practices which act to minimise subsidence including ensuring panel pillars are designed with FoS >1.6 and W/H ratio >5 following total coal extraction.

Our assessment of the mine plan indicates that the panel pillars have FoS >1.6 and W/H >5, for first pass development (3m roadway height) only. These pillars are likely to reduce the risk of and minimise subsidence over the JEP area when combined with suitable barrier pillar design.

Notably pillar height, and more specifically width-to-height ratio (w/h), has a large impact on pillar strength. The pillar stability assessment conducted as part of this review indicated that pillar FoS reduces significantly following floor coal extraction because of increased pillar height to 6m consistent with the proposed extraction height. Under these conditions most of the pillars have low to very low FoS and W/H ratios that would make many of the pillars susceptible to uncontrolled failure and collapse. These conditions would result in unsafe mining operations in some areas and would increase subsidence as a function of pillar yield and failure and resultant downwards overburden movements.

High level subsidence predictions have been provided and based on benchmarking from similar underground mining operations and empirical design charts. For the mine plan subsidence will be dependent on panel width, extraction height, coal recovery and barrier pillar design. For first workings (3m extraction height) low levels of subsidence are likely given the bord and pillar design FoS of > 1.6 and w/h >5.

Guidelines have been provided for pillars, including barrier pillars, to minimise subsidence and for where critical surface protection is required. For critical surface protection a minimum pillar FoS of 2.11 and w/h >5 is recommended consistent with industry standards. Pillar design needs to consider potential impacts on pillar strength including the lithology of the roof and floor contacts and other weak units in the pillar system.

The issue of the potential for long-term deterioration and instability of the underground workings leading to failure in the overburden and resultant subsidence has been assessed. No sink holes are expected given the proposed mining method and cover depths. Provided adequate pillar design long term subsidence can be minimised as required as part of underground mining at the JEP area. Mine sealing following closure can be completed consistent with mine design guidelines and industry best practice.

The JEP area is a concept level underground mine and requires additional data collection to improve resource confidence and geotechnical understanding. The subsidence predictions provided here are based on benchmarking and high-level assessment using empirical methods. More detailed geotechnical assessment is required on both the pillar stability and subsidence predictions as part of future and more detailed studies to improve confidence.

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1. INTRODUCTION

Peabody Energy are currently exploring options for underground mining across the Johnson Extended Project (JEP) area of the Coppabella Mine. SCT Operations Pty Ltd (SCT) has been engaged to conduct a review the existing pillar design to assist with a Department of Environment and Science (DES) request for information regarding a geotechnical study of pillar stability and subsidence.

The JEP area was previously considered as an extension to an underground mining area at Coppabella. Peabody has now determined that parts of this area will be extracted through Open Cut methods, reducing the footprint for the underground project. Notably the JEP leases offer a constrained resource footprint, as a function of geological structure and the lease boundary and are limited under the Mining Lease to underground mining methods only.

Underground mining at the JEP, as part of earlier submissions, was originally based on the Longwall Top Coal Caving (LTCC) method. The LTCC method was subsequently modified to a bord and pillar layout to reduce impacts of underground mining across the JEP area of the Coppabella Mine.

Palaris have conducted initial concept level studies for a bord and pillar underground mine as it was considered the most likely underground method to be used in the four JEP mining leases (JEP No. 3 through to JEP No. 6). The design was considered a good approach to minimise subsidence impacts relative to other underground higher recovery thick seam mining methods including those previously considered.

2. SCOPE OF WORK

A scope of work was provided by Peabody (email dated 31 July) to conduct a review of the bord and pillar design to assist with an RFI submitted by the Department of Environment and Science (DES). The initial submission was based on the original LTCC mining method.

Our work scope is to conduct a suitable empirical review of pillar design as outlined in the draft Palaris Coppabella JEP Options Study to comment on the appropriate pillar dimensions and Factor of Safety (FOS) required to achieve negligible surface subsidence for the JEP project. Our proposal did not include an assessment of surface subsidence impacts which would be required to be assessed as part of more detailed underground mining studies as the project progressed.

More detailed information was provided during our assessment and to assist with the rehabilitation planning for underground mining operations as part of the geotechnical assessment including:

- Requirements for sealing off surface openings to the underground workings.
- Geotechnical assessment of the stability of the underground openings in order to manage the potential for unplanned surface subsidence and unplanned ground collapse such as sinkholes.
- The magnitude and extend of post closure residual subsidence of underground workings.

3. BACKGROUND AND CONCEPT MINE DESIGN

Peabody Energy are currently exploring options for underground mining across the Johnson Extended Project (JEP) area of the Coppabella Mine.

Palaris has completed a draft Coppabella JEP Options Study which recommended an Ensham Mine style bord and pillar mining method (Figure 1).

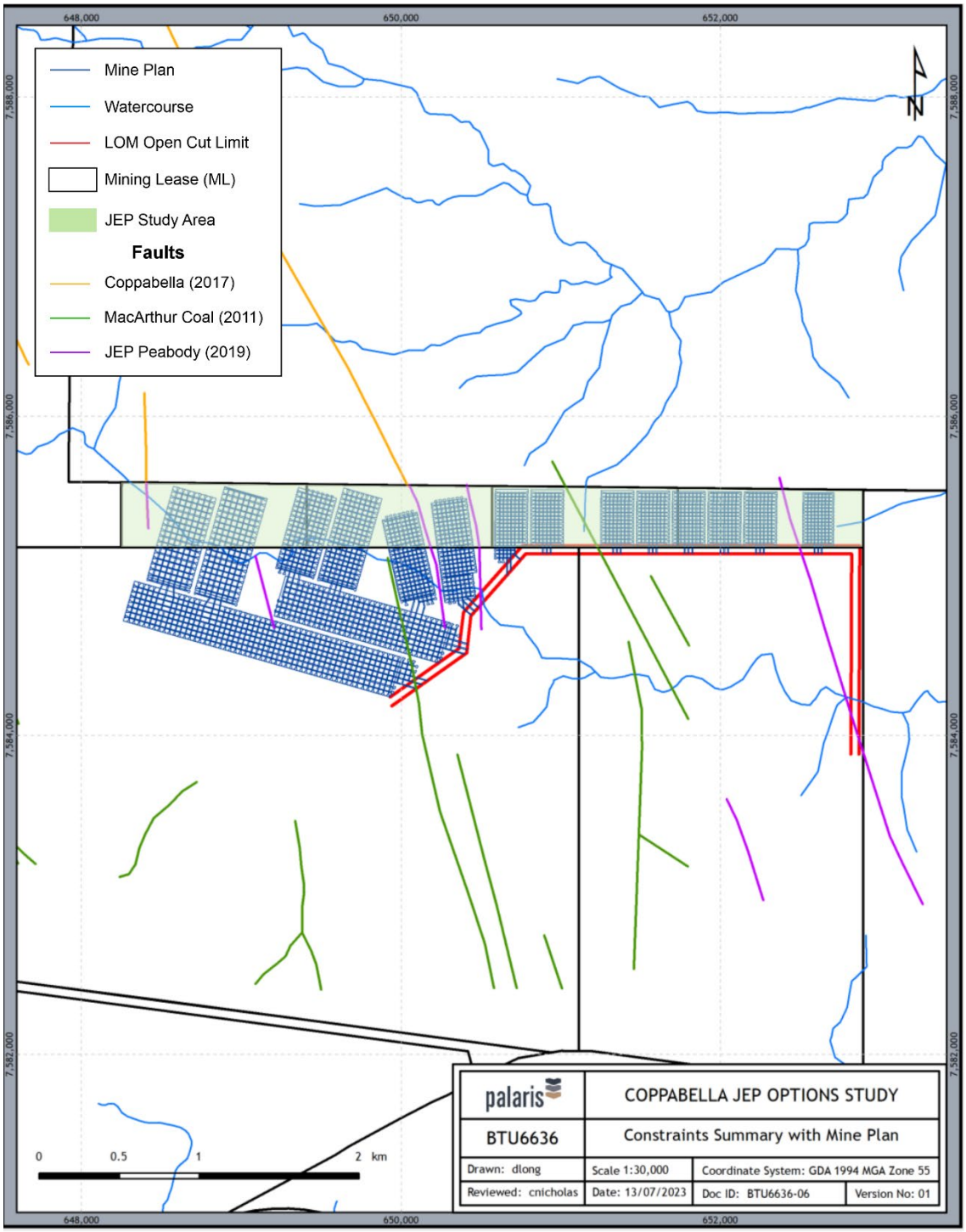


Figure 1: JEP mine plan showing proposed bord and pillar layout, surface features and LOM Open Cut Limits.

The Lower Leichardt (LL) seam was identified as the target seam for underground mining, with generally very good seam thickness and coal quality attributes. The thickness of the LL seam is noted to present future opportunities for optimisation of the working section horizon based on geotechnical and coal quality attributes as part of future studies.

The proposed mining method of Ensham Mine style bord and pillar mining was based on:

- Good resource recovery with seam thickness of the LL.
- Low to negligible subsidence design.
- Highest productivity bord and pillar method based on benchmarking databases.
- Panel orientation flexibility due to final open cut limits and geological structure constraints.

The mining method outlined comprises the Ensham style cut and flit mining method using primary development with stub bellouts and floor coal extraction as detailed below:

- 6m first pass and 5.4m second pass - additional 0.3m left on pillar to reduce rib bolt requirements and enhance pillar stability.
- First pass development cut height minimised (3m). This reduces primary support requirements and maximises floor coal.
- Floor coaling section (assumed 3m height) and bellouts to are used to maximise recovery.
- Floor coaling of panels follows primary development as a secondary process on the retreat from the panel. This coal provides low-cost production with limited to no ground support required.
- Resource recovery dependent on depth of cover as pillar size is adjusted with depth to maintain FoS. Recoveries of between 30 to 50% were estimated.

Palaris implemented the UNSW pillar design method as part of their assessment and have adopted a minimum pillar Factor of Safety (FoS) of 1.8 as part of the concept mine design. SCT have reviewed this design as part of this assessment.

The Lower Leichardt (LL) seam was identified as the target seam for underground mining, with generally very good seam thickness and coal quality attributes. The thickness of the LL seam is noted to present future opportunities for optimisation of the working section horizon based on geotechnical and coal quality attributes as part of future studies.

Palaris note that the proposed mining method offers opportunity for further expansion beyond the study area within adjoining Peabody tenements due to the structural complexity of these resources.

4. SITE LOCATION AND MINING LEASES

Coppabella Mine is operated by Peabody and located approximately 150km southwest of Mackay and 10km east of the Coppabella township in Central Queensland. The project location is shown in Figure 2.

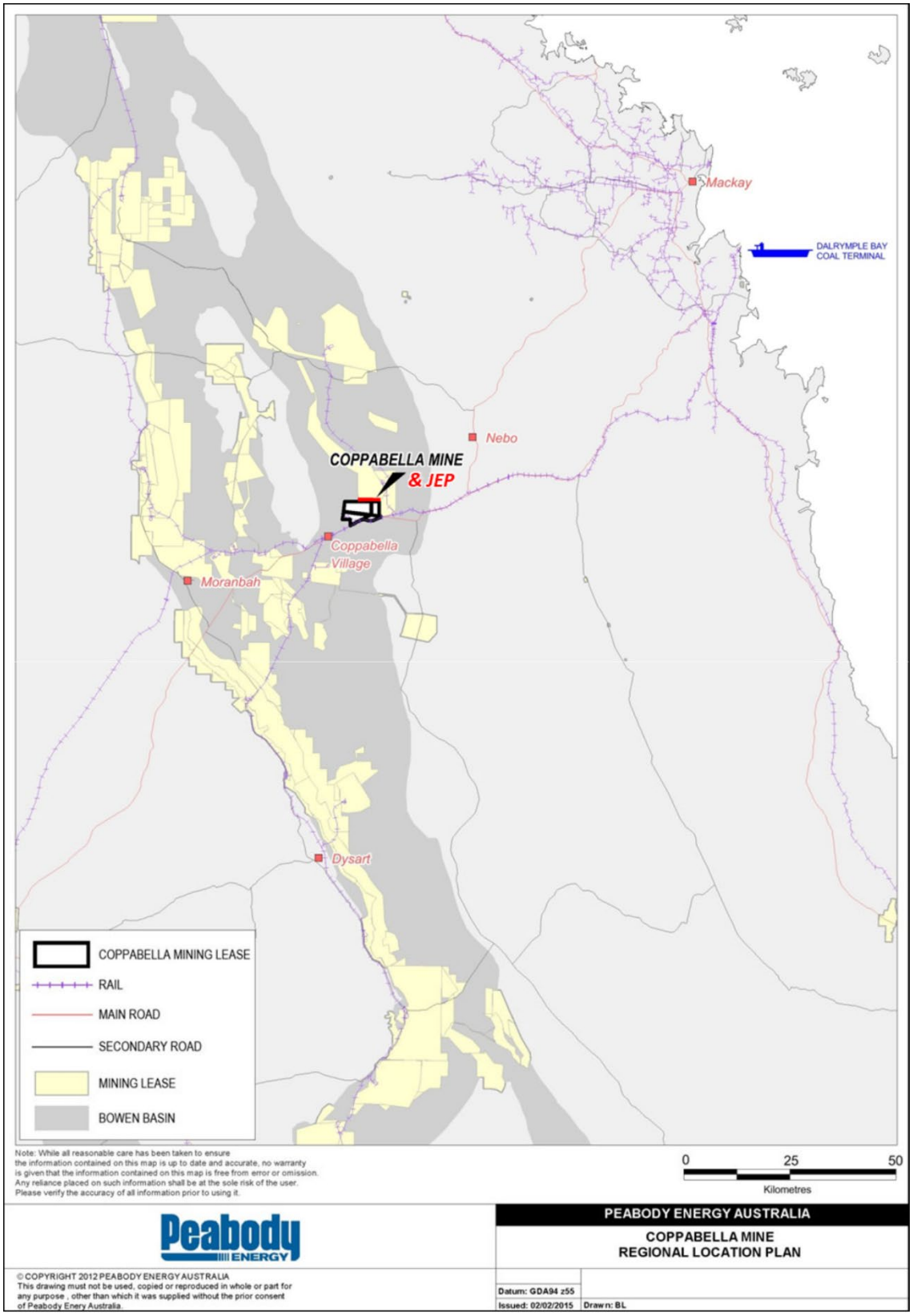


Figure 2: Location plan for the Johnson Extended Project (JEP).

The mine is an existing open-cut operation extracting coal from within ML70161, ML70163, ML70164, ML70236 and ML70237. Underground mining studies have identified potential underground reserves exist within an area between ML 70236 and ML 70164 and the adjacent South Walker Creek Mine on ML 4750. The underground Johnson Extended Project (JEP) area of the Coppabella Mine focuses on accessing and recovering coal from JEP No 3 through to JEP No 6. The JEP Mining Leases are ML 70384, ML 70385, ML 70386, ML 70387 as shown in Figure 3. The JEP leases offer a constrained resource footprint and are limited under the Mining Lease to underground mining methods only.

5. SUMMARY OF SITE GEOLOGY

The geology of the JEP area has been summarised as part of the Later Development Plan (Peabody Energy Australia PCI Pty Ltd, 2019).

The Coppabella coal deposit (including JEP) lies in the eastern portion of the Bowen Basin located within the Nebo Synclinorium and the south-western flank of the Carborough Syncline. The area has been uplifted by Cretaceous Bundarra Granodiorite intrusion which has slightly distorted the preexisting structure of the area.

The Permo-Triassic strata of the Coppabella deposit dips in a north-north-east orientation at between 5 to 10 degrees. Three Permo-Triassic units occur within the area - the Fort Cooper Coal Measures, Rangal Coal Measures, and the Rewan Formation. The Fort Cooper Coal Measures are approximately 350 m thick and consist of tuffaceous sediments and thick, high ash coal seams. These seams are generally considered uneconomic due to excessive high inherent ash and in seam stone bands.

The overlying Upper Permian Rangal coal measures (typically 150 m thick) contain low to moderate ash coal seams. The principal seams of the Rangal coal measures from youngest to oldest are the:

- Philips,
- Leichhardt and
- Vermont.

A summary of the stratigraphy of Coppabella Mine and the JEP area is provided in Figure 4.

In the JEP area the target mining seam is the Leichhardt Seam. Drilling is generally sparse within the JEP study area compared to the typically dense drilling coverage in ML70164 and ML70236 within the adjacent opencut areas. Some 2D seismic survey lines extend into the JEP area from the adjacent opencast exploration areas. Within the JEP the resource is classified as indicated to inferred. Further geological exploration will be needed to improve geological and resource confidence with the JEP area including the area of the proposed underground mine footprint. Additional geotechnical data is also required as part of more detailed assessments.

Within the JEP area, the Leichhardt Upper splits from the Leichhardt Lower seam, leaving the Leichardt Lower (LL) seam as the underground mining target seam. The coalesced LL seam is divided into 4 plies (LL1, LL2T, LL2B and LL3) and is composed of dull and bright coal with several stone bands. The coalesced seam is locally named the Macarthur Seam and has an average thickness of 11m.

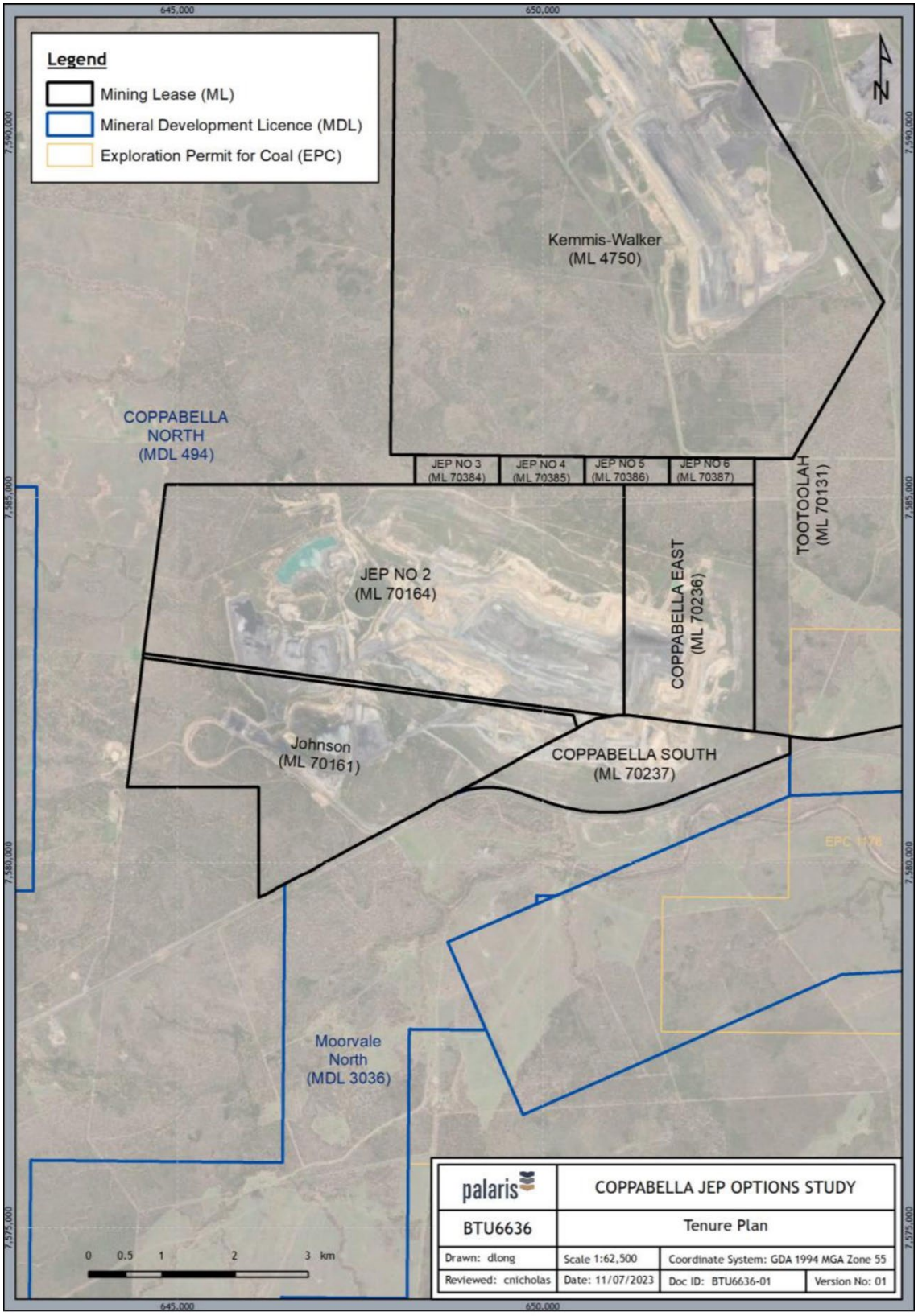
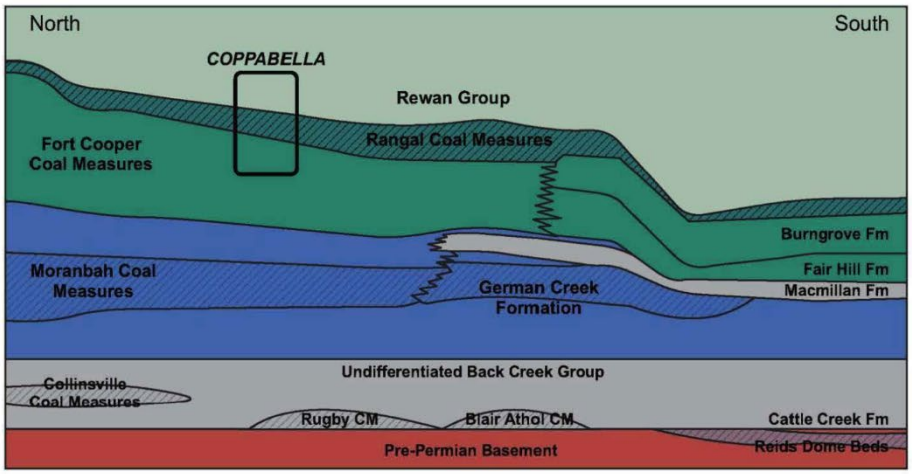
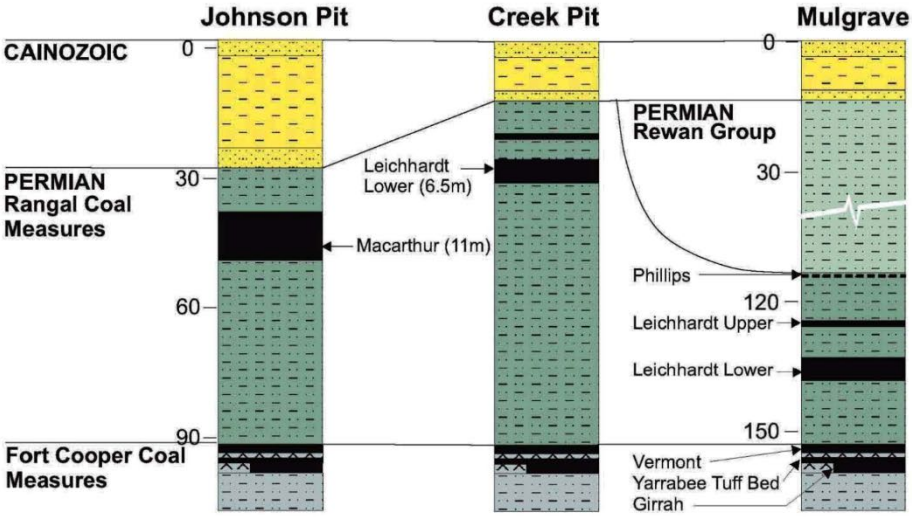


Figure 3: Coppabella Mining Leases showing area of JEP Underground Options Study.



Bowen Basin Stratigraphy



Coppabella Stratigraphy

Figure 4: Stratigraphy of the Coppabella Mine & JEP Area.

The LL seam over the JEP study area ranges in cover depth between 110m and 280m, increasing to the west, and varies primarily as a function of seam dip (Figure 5).

Palaris (2023) provide a summary of geological structure impacting the project area (Figure 6). Figure 6 shows the Leichardt seam in the JEP area is impacted by several normal faults which strike generally in an NNW orientation. Fault displacements identified from seismic and exploration drilling in the adjacent Coppabella Mine area range from negligible to a more limited number of larger structures with displacement more than 10 metres.

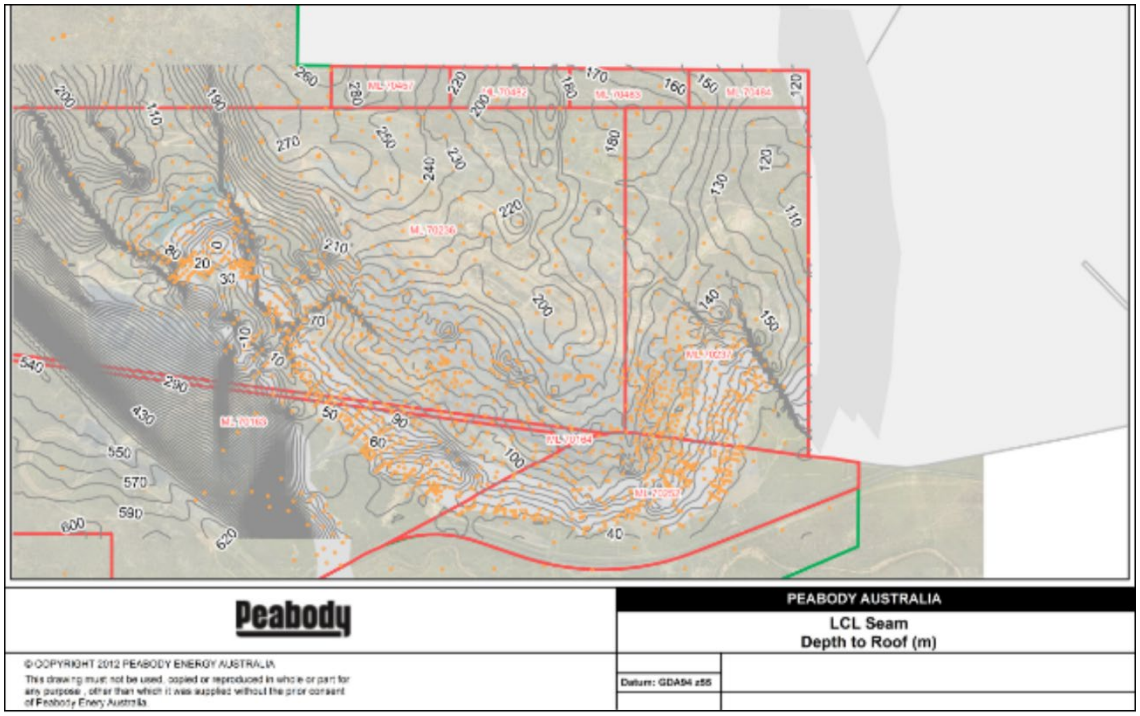


Figure 5: Depth of cover to the LL seam within the JEP and surrounding areas.

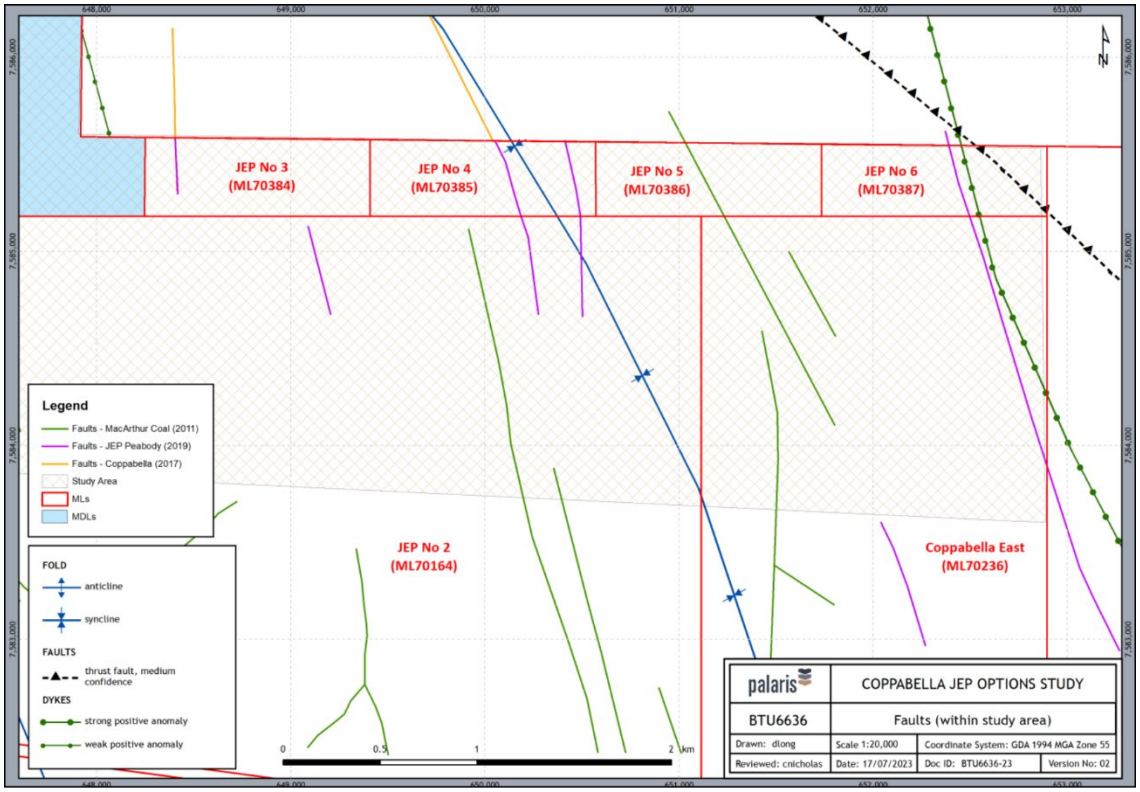


Figure 6: JEP area geological structure plan.

Faulting has potential to impact on pillar stability particularly where pillar width to height ratios is reduced. In addition, a pillars strength is proportionate to the strength of the roof and floor contacts, or any other feature or structure that acts to reduce the pillar's ability to generate confinement such as geological structure. Further assessment of pillar stability for the JEP area will need to take account of the lithology of the roof and floor contacts and any other weak units about the pillar system including within the coal pillar itself.

6. REVIEW OF THE MINE DESIGN

A concept bord and pillar design has been completed by Palaris as part of the Coppabella JEP Options Study. The JEP Options Study explored the potential underground mining methods and layout assessment for a reduced impact method of mining across the Johnson Extended Project (JEP) area of the Coppabella Mine. Previous underground mine designs for the JEP (JEP Later Development Plan, 2019) included assessment of longwall extraction using the LTCC method. This method is no longer being considered.

An Ensham style bord and pillar mining method was recommended by Palaris to allow low levels of surface impact and increased resource recovery. The proposed mining system was noted to present opportunity for further expansion beyond the study area within adjoining Peabody tenements due to the structural complexity of these resources.

Access to the underground resource would be from portals located at the final highwall of the open cut which have been used to define the potential underground footprint. Eastern and central panels are designed to have direct access from highwall with the Western panels accessed via two "mains" panels from highwall. Additional panel entries may be required for ventilation as part of further assessment. The extension of the open cut to the southern extent of JEP No 5 and No 6 significantly limits underground footprint and mine layout options as shown in Figure 7.

6.1 Mining Method and Mine Design

The underground mining method consists of Ensham style bord and pillar mining. The mining method recommended by Palaris was based on:

- Good resource recovery with seam thickness of the LL.
- Low to negligible subsidence design.
- Highest productivity bord and pillar method based on benchmarking databases.
- Panel orientation flexibility due to final open cut limits and geological structure.

The mining method outlined by Palaris comprises the Ensham style cut and flit mining method using primary development with stub bellouts and floor coal extraction. The design assumptions are detailed below:

- 6m first pass and 5.4m second pass. The second pass leaves an additional 0.3m on the pillar to reduce rib bolt requirements and enhance pillar stability.
- First pass development cut height minimised (3m). This reduces primary support requirements and maximises floor coal.

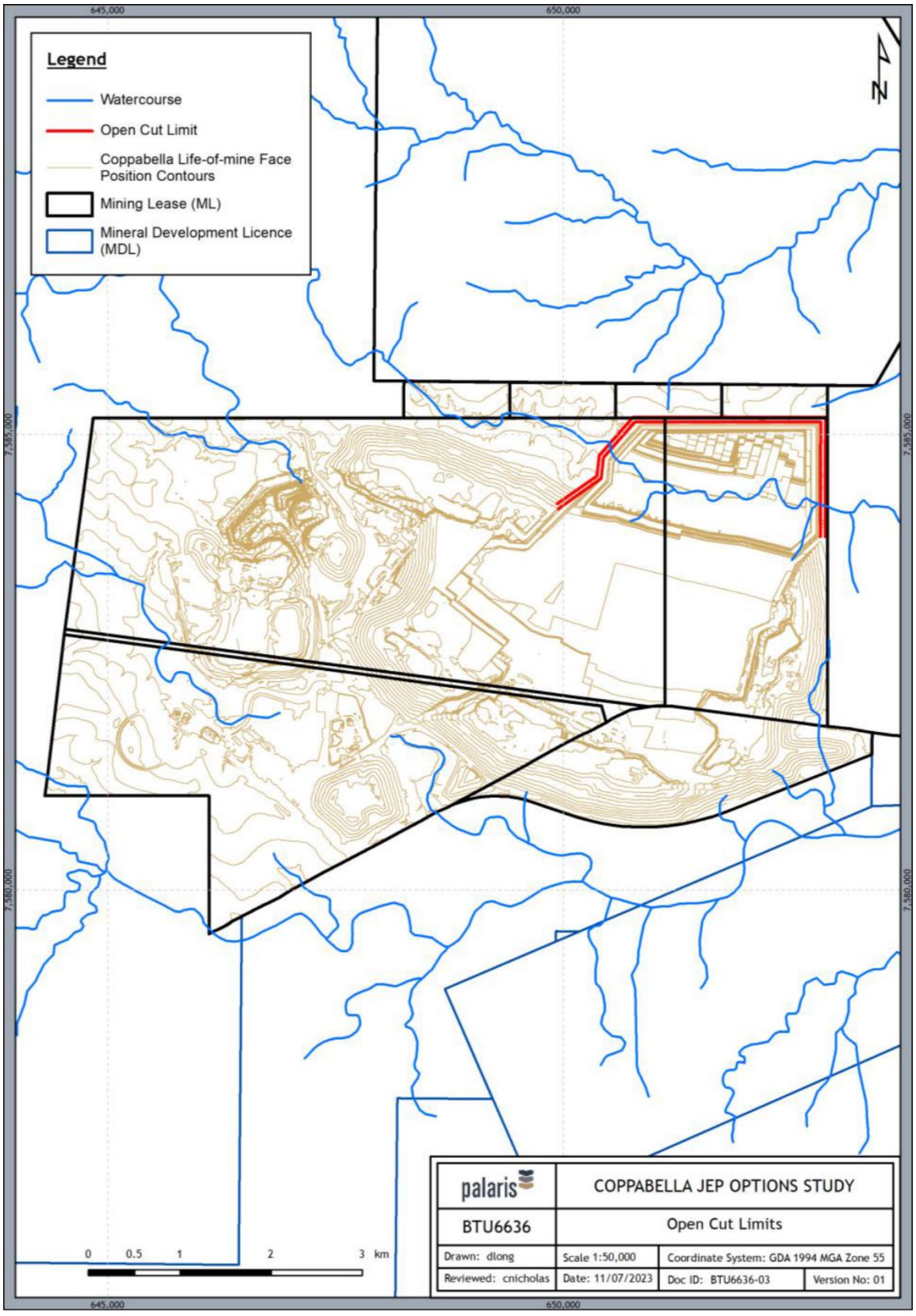


Figure 7: Opencast mining limits and highwall access (red line).

- Floor coaling section (assumed 3m height) and bellouts to are used to maximise recovery.
- Floor coaling of panels follows primary development as a secondary process on the retreat from the panel. This coal provides low-cost production with limited to no ground support requirements.
- Resource recovery dependent on depth of cover as pillar size is adjusted with depth to maintain FoS –30 to 50%.

Palaris implemented the UNSW pillar design method as part of their assessment and have adopted a minimum pillar Factor FoS of 1.8 as part of the concept underground mine design. We note that this FoS is for first pass development only and pillar FoS decrease with floor coaling and increased extraction height. Our review of the bord and pillar design is provided in Section 7 below.

7. REVIEW OF PILLAR DESIGN AND PILLAR STABILITY

Peabody supplied the concept JEP underground mine plan and depth of cover contours to the roof of the LL seam to conduct this high-level assessment of pillar stability. Importantly the pillar review and the empirical and benchmarking assessment of the likely resultant subsidence relate only to the mine design and bord and pillar panels located inside the JEP No 3 through to JEP No 6 study area only.

The mine plan inside the JEP study area consists of 14 panels with depth of cover, pillar geometry and panel widths as summarised in Table 1. The mine plan showing depth of cover contours and panels as numbered for this assessment is provided in Figure 8. Cover depths range 110m to 280m over the project area and change primarily as a function of seam dip. Panel widths range between 194m to 278m giving depth to width ratios (W/D) that range between approximately 1.0 (which generally marks the transition from sub critical to super critical) and 1.7 and are therefore considered supercritical for the mining depths assessed.

Table 1: Summary of JEP Panel Design

Panel Number	Depth Range		Design Solid Square Pillar Width	Design Panel Width	W/D Ratio
	From (m)	To (m)	(m)	(m)	
1	110	120	16.0	194	1.69
2	120	140	18.0	206	1.59
3	140	160	18.0	206	1.38
4	140	160	18.0	206	1.38
5	145	175	18.0	206	1.30
6	150	175	18.0	206	1.28
7	165	175	18.0	206	1.21
8	160	170	18.0	206	1.25
9	180	200	21.0	224	1.18
10	170	200	21.0	224	1.22
11	195	215	25.0	248	1.21
12	210	220	25.0	248	1.15
13	235	260	30.0	278	1.13
14	240	285	30.0	278	1.07

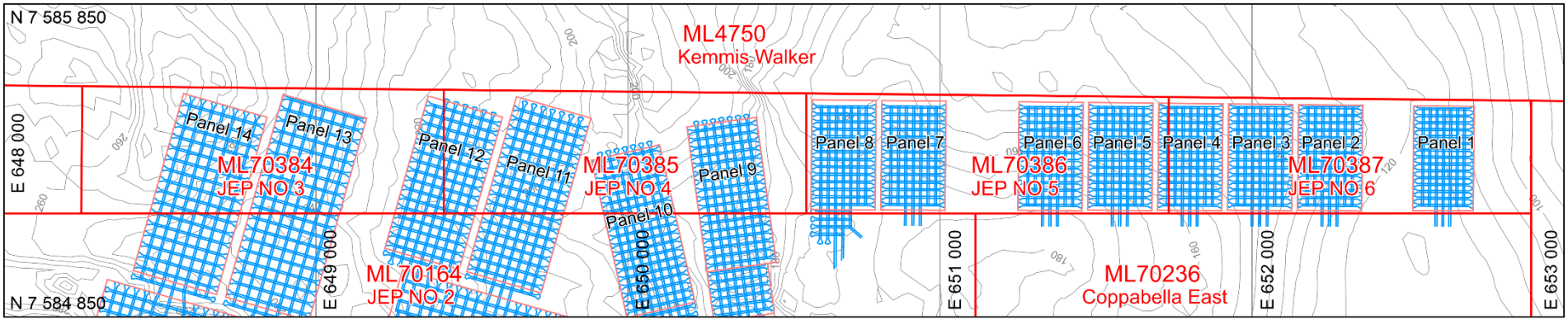


Figure 8: JEP Mine plan showing Mining Lease and depth of cover contours.

7.1 Pillar Stability Assessment

There are two general approaches for empirical pillar design:

- strength formulas and
- pillar design charts.

An empirical assessment of pillar stability typically requires an estimate of the strength of the pillar and the stresses acting on the pillar to provide the Factor of Safety (FoS). The strength of coal pillars can be estimated from experience of previous pillar instability. The UNSW pillar design approach (Galvin et al 1999) distils the experience of pillar collapses in Australia and South Africa into a pillar design approach that is broadly accepted in Australia as the benchmark for the design of small pillars. We have used the UNSW pillar design formulae as part of this assessment.

Alternately design charts are often used which link pillar stability (FoS) to pillar geometry (w/h ratios) and based on a combined database of failed South African and Australian bord and pillar panels, plus a database of highwall mining (CHM) failed pillar cases (UNSW, 1995; Madden and Hardman, 1992; Strata Engineering, 2001).

The Factor of Safety (FoS) relates average pillar strength (S) to average pillar stress (sp) as follows:

$$FOS = S / sp$$

Notably as FoS decreases, the probability of failure of the pillars can be expected to increase. The FoS derived using the UNSW formulae can be related directly to the probability of stability, as illustrated in Table 2. In Australia, long-life critical pillars (eg in main headings and for surface protection) are often designed to a minimum FoS of 2.11 which equates to a failure probability of one panel in a million.

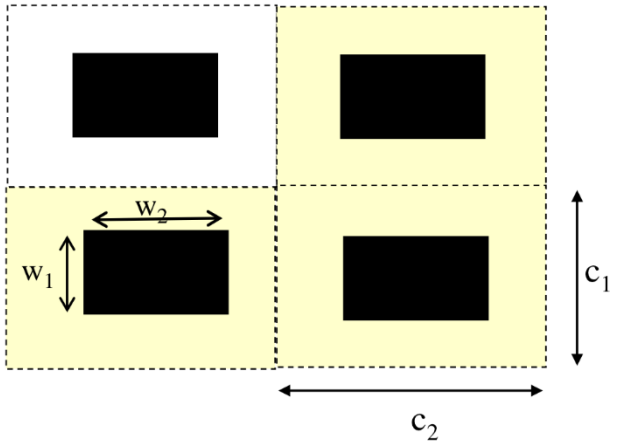
Table 2: UNSW Pillar FOS and Probability of Failure

Factor of Safety	Probability of Failure	Odds
0.87	Greater Than 0.8	Almost Certain
0.87	0.8	8 in 10
1	0.5	5 in 10
1.22	0.1	1 in 10
1.3	0.05	5 in 100
1.38	0.02	2 in 100
1.44	0.01	1 in 100
1.63	0.001	1 in 1,000
1.79	0.0001	1 in 10,000
1.95	0.00001	1 in 100,000
2.11	0.000001	1 in 1,000,000
2.12	Less than 0.000001	Less than 1 in 1,000,000

In flat terrain, the vertical load on regular pillar geometries can be estimated with reasonable confidence using the tributary area approach. With this approach, the weight of the overlying strata is apportioned to each pillar in proportion to the area contributing load to that pillar. Because the layout is regular the average pillar stress, s_p, acting on the pillars has been estimated from standard tributary area methodology for the JEP area shown in Figure 9 and given by:

$$s_p = \gamma \times H \times (c_1 \times c_2) / (w_1 \times w_2)$$

where γ is the specific weight of the overlying strata (estimated as 2.5T/m^3), H is the depth of cover, w_1 is the pillar width, w_2 is the pillar length and C_1 and C_2 are the heading and crosscut centre distances respectively. The assessment has assumed tributary loading conditions for both development (first pass 3m roadway height) and floor coaling (resultant 6m roadway height following 3m of bottom coal extraction). The stability of the pillars in the JEP area has been assessed on a panel-by-panel basis, using a conservative maximum depth of cover.



$$\sigma_p = \frac{0.025 H c_1 c_2}{w_1 w_2}$$

TRIBUTARY AREA THEORY

Figure 9: Tributary Area Theory.

Importantly close to the active extraction line, pillar load and pillar strength is constantly changing and is dependent on the rate of extraction and resultant pillar geometries. Experience suggests that the average pillar loading is typically 1.3 to 1.5 times Tributary Area Load. A Tributary Area Load multiplier, or more detailed assessment of pillar design, is often required where changing loading or pillar strength conditions are expected.

To create a long-term stable pillar geometry, an appropriate balance between pillar strength and vertical load on the remnant pillars needs to be established with enough margin to accommodate uncertainties. A further complication in panels of small pillars is that they can be vulnerable to domino collapse whereby only one pillar needs to become overloaded for the whole panel to collapse. Stability of the panel is often sensitive to the stability of the least stable pillar; typically, the most heavily loaded pillar.

Table 3 below summarises the pillar stability assessment for pillars formed during first pass development (3m height) and following floor coaling (assumed 6m total height).

Table 3: Summary of UNSW pillar stability assessment for 3m high and 6m high pillars

Panel No.	Depth of Cover Range		Pillar Height	Pillar Width	Pillar Length	Hdg width	Pillar Width Centres	Pillar Length Centres	W / H Ratio	Pillar Load	Pillar Strength	Factor of Safety
	From (m)	To (m)	(m)	(m)	(m)	(m)	(m)	(m)		(MPa)	(MPa)	
1	110	120	3.0	16.0	16.0	6.0	22.0	22.0	5.3	5.7	12.8	2.26
2	120	140	3.0	18.0	18.0	6.0	24.0	24.0	6.0	6.2	13.5	2.18
3	140	160	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.1	13.5	1.90
4	140	160	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.1	13.5	1.90
5	145	175	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.8	13.5	1.74
6	150	175	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.8	13.5	1.74
7	165	175	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.8	13.5	1.74
8	160	170	3.0	18.0	18.0	6.0	24.0	24.0	6.0	7.6	13.5	1.79
9	180	200	3.0	21.0	21.0	6.0	27.0	27.0	7.0	8.3	14.5	1.76
10	170	200	3.0	21.0	21.0	6.0	27.0	27.0	7.0	8.3	14.5	1.76
11	195	215	3.0	25.0	25.0	6.0	31.0	31.0	8.3	8.3	15.8	1.91
12	210	220	3.0	25.0	25.0	6.0	31.0	31.0	8.3	10.0	15.8	1.86
13	235	260	3.0	30.0	30.0	6.0	36.0	36.0	10.0	10.3	17.1	1.83
14	240	285	3.0	30.0	30.0	6.0	36.0	36.0	10.0	10.3	17.1	1.67
1	110	120	6.0	16.0	16.0	6.0	22.0	22.0	2.7	5.7	8.1	1.43
2	120	140	6.0	18.0	18.0	6.0	24.0	24.0	3.0	6.2	8.6	1.38
3	140	160	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.1	8.6	1.21
4	140	160	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.1	8.6	1.21
5	145	175	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.8	8.6	1.10
6	150	175	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.8	8.6	1.10
7	165	175	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.8	8.6	1.10
8	160	170	6.0	18.0	18.0	6.0	24.0	24.0	3.0	7.6	8.6	1.13
9	180	200	6.0	21.0	21.0	6.0	27.0	27.0	3.5	8.3	9.2	1.11
10	170	200	6.0	21.0	21.0	6.0	27.0	27.0	3.5	8.3	9.2	1.11
11	195	215	6.0	25.0	25.0	6.0	31.0	31.0	4.2	8.3	10.0	1.21
12	210	220	6.0	25.0	25.0	6.0	31.0	31.0	4.2	10.0	10.0	1.18
13	235	260	6.0	30.0	30.0	6.0	36.0	36.0	5.0	10.3	10.8	1.16
14	240	285	6.0	30.0	30.0	6.0	36.0	36.0	5.0	10.3	10.8	1.06

When using the UNSW method of pillar design FoS >1.6 are typically considered to be suitable for pillar panels. The minimum recommended FoS calculated for the proposed layout following taking bottoms is 1.6. The impact of pillar the width to height ratio must also be considered as part of the pillar design assessment and is discussed below.

Table 3 shows that pillars on development have a FoS of >1.6. Following floor coaling to the proposed 6m height pillar strengths are reduced and FoS range between 1.06 and 1.43. The reduced FoS are associated with decreasing pillar w/h ratios and highlight the impact of increasing pillar height during floor coal extraction on reducing pillar strength (Figure 10).

The process of taking bottoms will increase the roadway height and hence the potential for rib instability, especially in those zones that are geologically structured. Given the potential for this to occur, a retreating method of bottom coal removal would be preferred. This would allow zones of pillar side instability to be isolated in 'worked out' areas and the lengths of roadway travelled through with high ribs to get to the working face minimised. Prompt support of structured areas will be important to minimise potential for slabbing and spalling following taking bottoms.

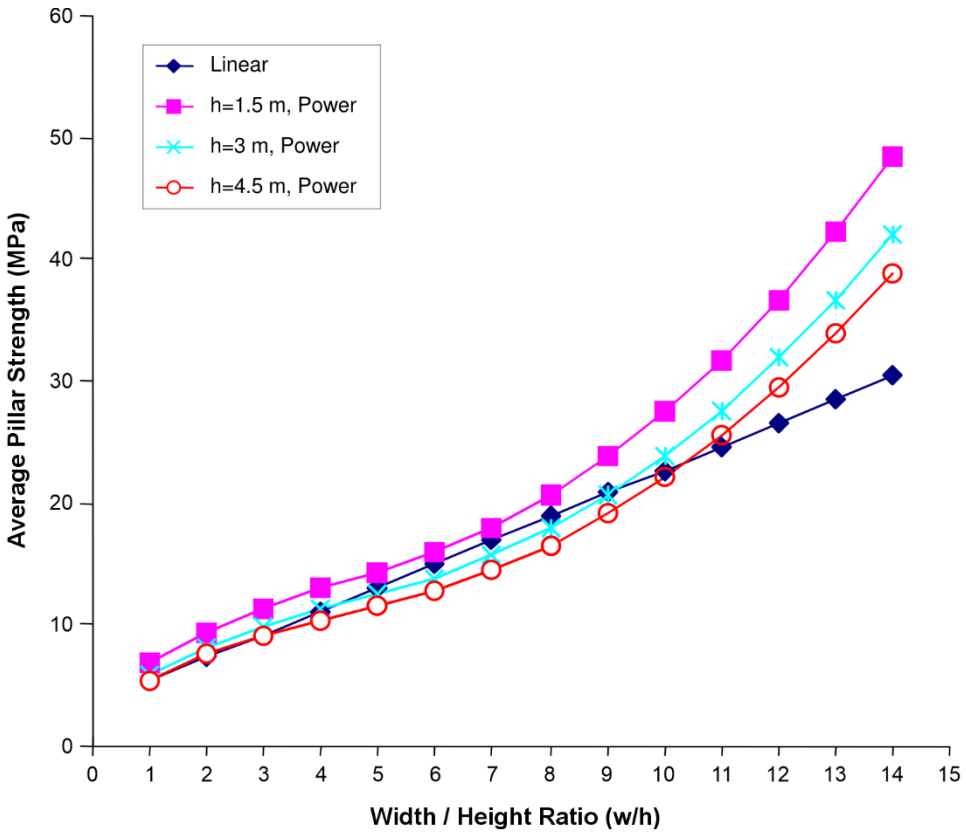


Figure 10: Impact of pillar height and W / H ratio on pillar strength using the UNSW pillar strength formulae.

7.2 Impact of Pillar Width to Height Ratio

Importantly the deformation characteristics of the pillars are controlled by their geometry, specifically their width to height ratio. The impact of pillar w/h ratio on pillar stability is well understood and is often applied in conjunction with other pillar design criteria (e.g., FoS), is a useful indicator of design reliability.

The width to height ratio is a critical parameter in determining the pillar strength for both initial bearing capacity and post failure residual strength. Tall slender pillars (low w/h ratio) will be considerably weaker than short squat pillars (high w/h ratio) of a similar size. Figure 11 shows typical strength characteristics of pillars surrounded by strong material.

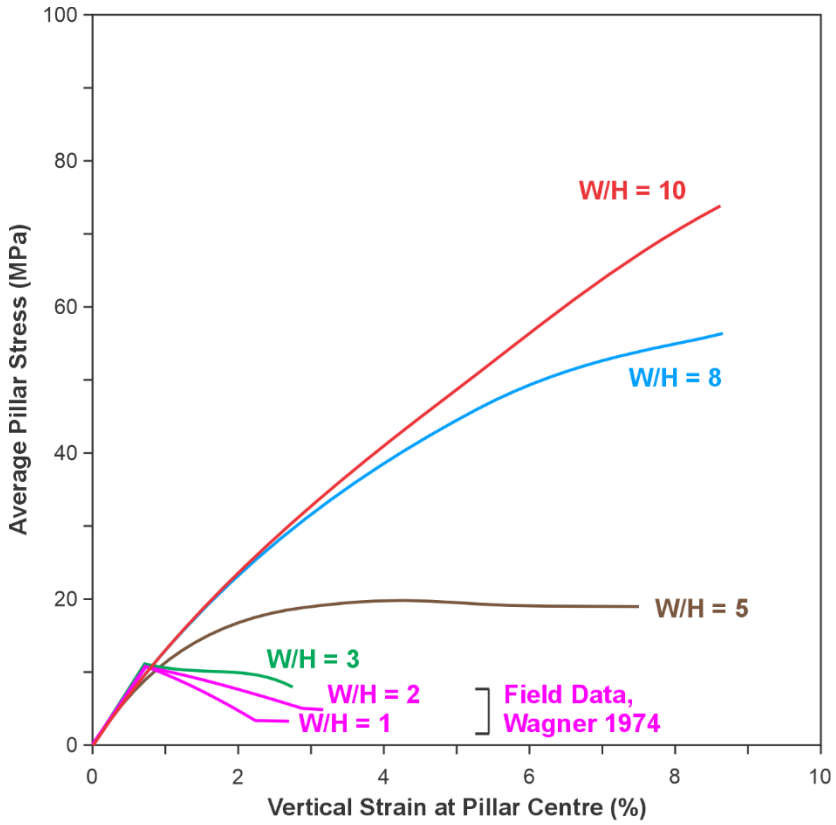


Figure 11: Pillar stress/strain relationship (Gale, 2005).

In larger pillars (w/h > 5) there is sufficient confinement maintained within the fractured coal and surrounding strata to maintain pillar load capacity. This is applicable with strong roof and floor material. If the strata about the pillars is weak with low friction, the amount of confinement maintained in the pillar system is reduced, reducing the load capacity of the pillar (Gale and Hebblewhite, 2005).

In smaller pillars (w/h < 5) the ability to develop confinement in the pillar is low and the capacity of the pillar to carry load post failure is reduced. At a ratio less than three, pillars are more likely to fail in a brittle uncontrolled manner. This process is important not only in the initial pillar assessment but becomes a key parameter when analysing behaviour in pillars that may be adjacent to failed pillars.

Pillar collapses are often associated at low w/h ratios as illustrated in Figure 12. Notably where the overburden cannot span the pillar system, post peak behaviour of the pillar system can be characterised by:

- Width to height ratio less than 3, rapid strength loss and sudden, uncontrolled collapse can occur in the pillar system.
- Width to height ratio of >5, pillar strength is maintained with increasing pillar convergence and the coal pillars demonstrate a more plastic form of deformation. Significant displacement may take place in the form of convergence of the roof and floor, as well as rib spall, but the pillar core remains confined and tends to retain its load carrying ability, generally without failing in the commonly understood sense.
- Width to height ratio greater than 8, pillar strength increases with pillar convergence.

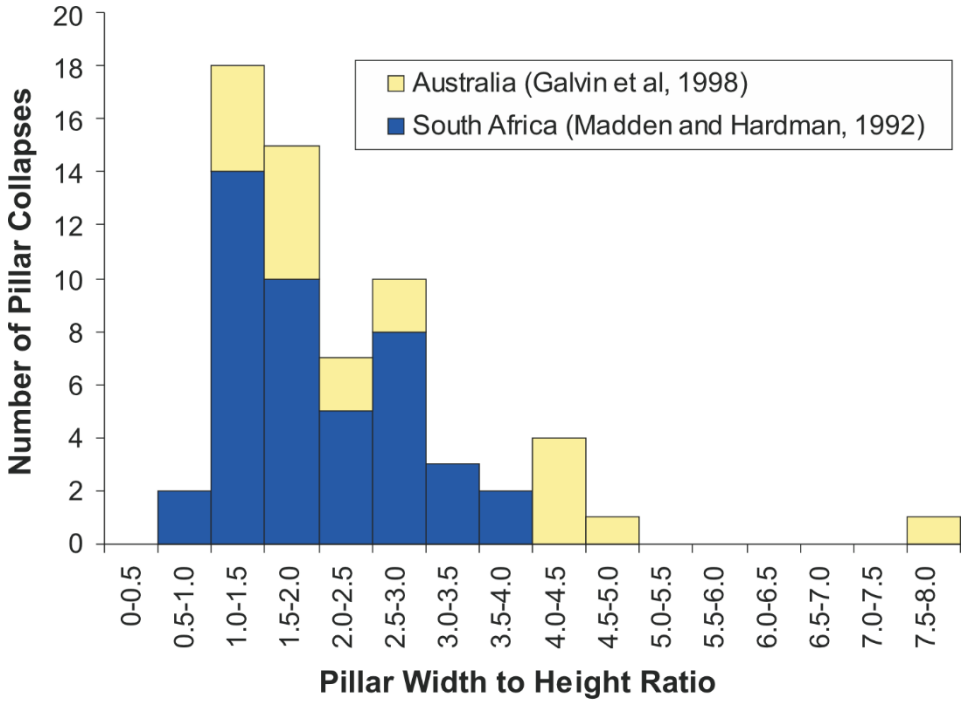


Figure 12: Frequency of pillar collapses versus width to height ratio.

As noted above, for a given pillar width to height ratio, a pillar's strength varies depending on the lithology of the roof and floor contacts. A strong contact allows a pillar to readily generate confinement by providing shear resistance to the coal that moves horizontally into the roadway due to Poisson's effect (and the increase in vertical load). A lower strength contact reduces the ability for the roof and floor to generate confinement as the weak contact provides less shear resistance to the horizontal movement.

A coal/sandstone contact generates more confinement within the pillar than a coal/clay contact. The pillar strength is therefore proportionate to the strength of the roof and floor contacts, or any other feature or structure that acts to reduce the pillar's ability to generate confinement such as geological structure. Figure 13 shows the ability for a pillar to generate strength in relation to w/h ratio and roof and floor lithology from Gale (1999).

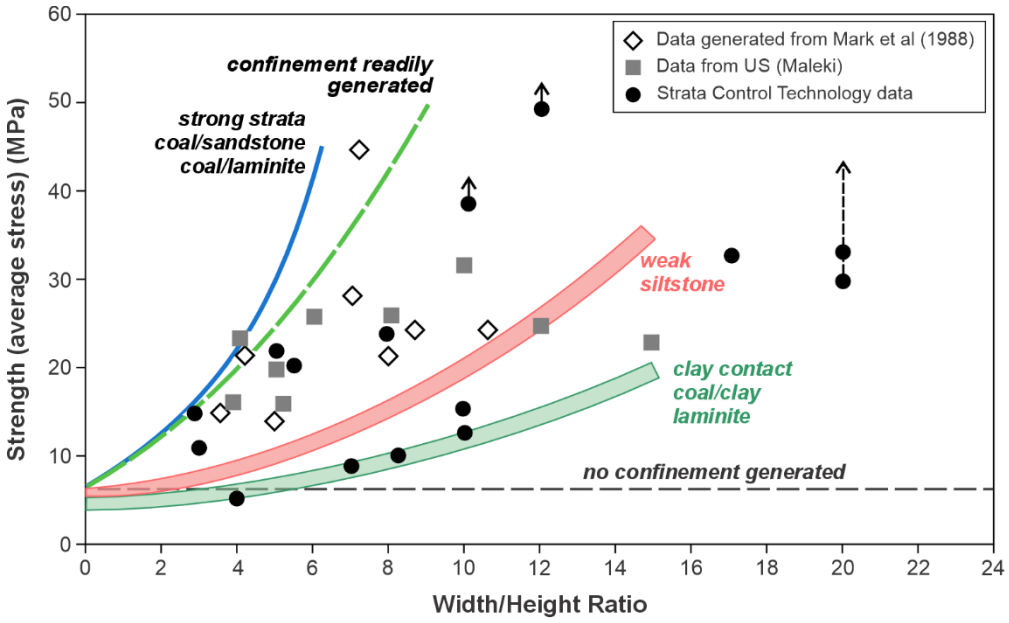


Figure 13: Strength in relation to W/H and lithology – computer model results and data (Gale, 1999).

7.3 Pillar Stability Design Charts

Pillar Stability Design Charts based on a combined database of failed South African and Australian bord and pillar collapses (Hill and Buddery, 2004), highlight the importance of combining width to height ratio and pillar FoS assessments as a useful indicator of design reliability (Figure 14).

For important long-life pillars it is considered prudent to adopt a minimum 20 per cent margin as given by the Design Envelope curve. The JEP area pillars have been plotted onto the pillar stability design chart and are shown in Figure 15.

Figure 15 highlights acceptable levels of pillar stability for first pass development. Following floor coaling pillar w/h ratios decrease and low to very low pillar FoS develop which significantly increase the probability of pillar failure. For the pillar geometries assessed here floor coaling is not recommended as the risk of uncontrolled pillar failure is very high.

Pillar strength at higher roadway heights can be increased by increasing pillar widths. Some provisional guidance for pillar design to support further concept mine design studies are provided in Section 9 below.

It is recommended more detailed assessment of pillar design is conducted as part of future studies to ensure adequate pillar stability. This is particularly relevant in cases where the design pillar FoS and w/h ratios approach critical stability values.

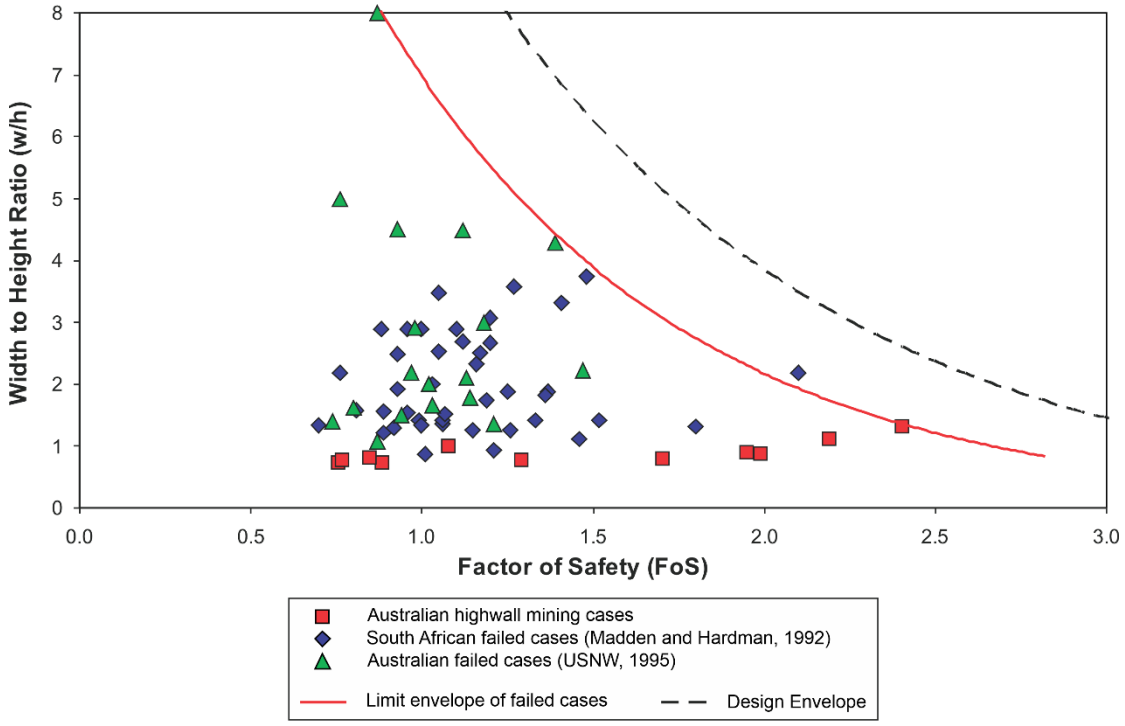


Figure 14: Database of pillar collapses – width to height ratio versus FoS.

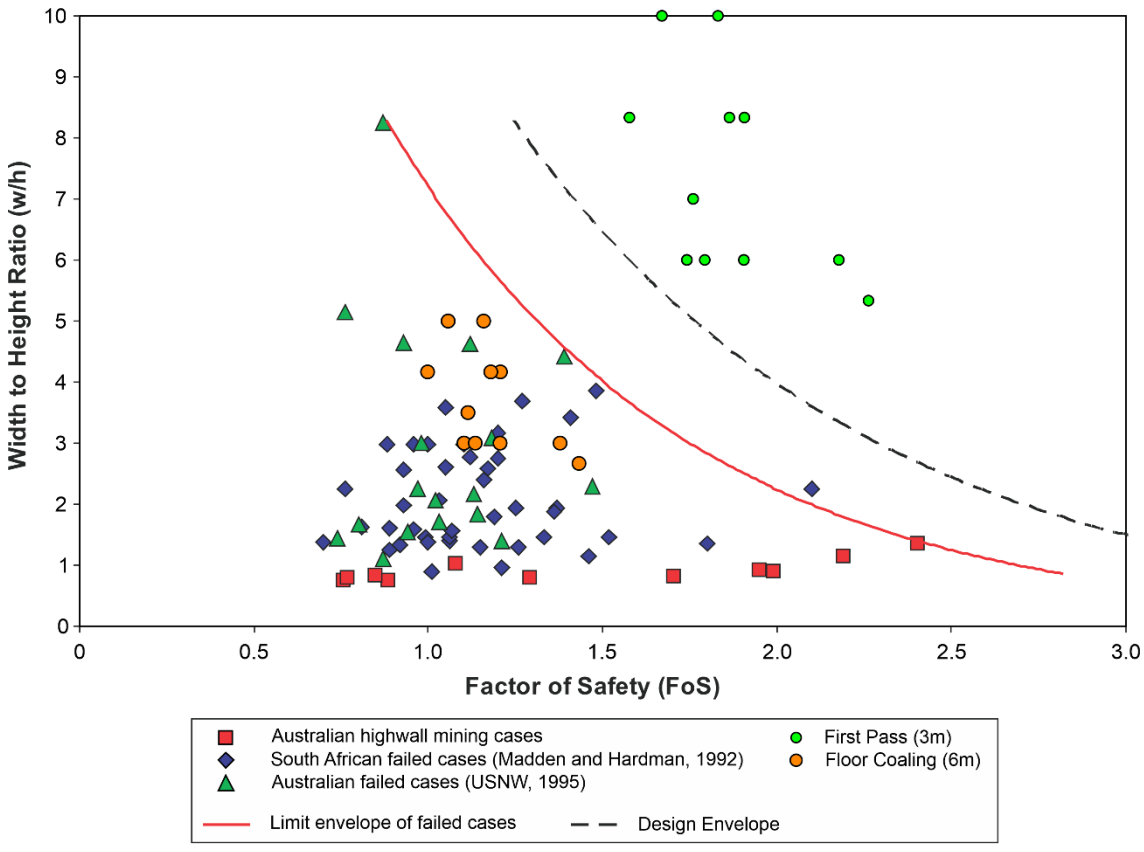


Figure 15: JEP area pillar design plotted onto pillar design chart.

8. COMMENTS ON PILLAR DESIGN AND SUBSIDENCE

8.1 Pillar Design for Surface Protection

Hill (2005) provides information on coal pillar design for surface protection including design criteria for bord and pillar workings based on factor of safety and pillar – width to height (w/h) ratio (Figure 16). As illustrated in Figure 16 in the case of pillars required for the permanent protection of critical surface features/structures (e.g., key infrastructure, such as railways/ waterways), the design criteria should be for a minimum Factor of Safety (FoS) of 2.11 equal to a failure probability of 1 in a million and combined with a minimum width to height ratio of 5 (Hill, 2005).

Figure 16 has been overlaid with the JEP area pillar design as shown in Figure 17. Figure 17 highlights inadequate levels of pillar stability following floor coaling. Whilst first pass development pillars are generally suitable for key underground workings many do not satisfy the FoS criteria of 2.11 required to ensure surface protection to critical surface features. Where surface protection is required specific pillar design with higher FoS is required.

Notably although the design barrier pillars have not been specifically assessed as part of this report many of the smaller barrier pillars (i.e., 18m width) will have low FoS in deeper areas during first pass development and in all areas following floor coaling. The existing smaller barriers will be inadequate to provide surface protection and to minimise panel interaction including subsidence. Comments on barrier design are provided below.

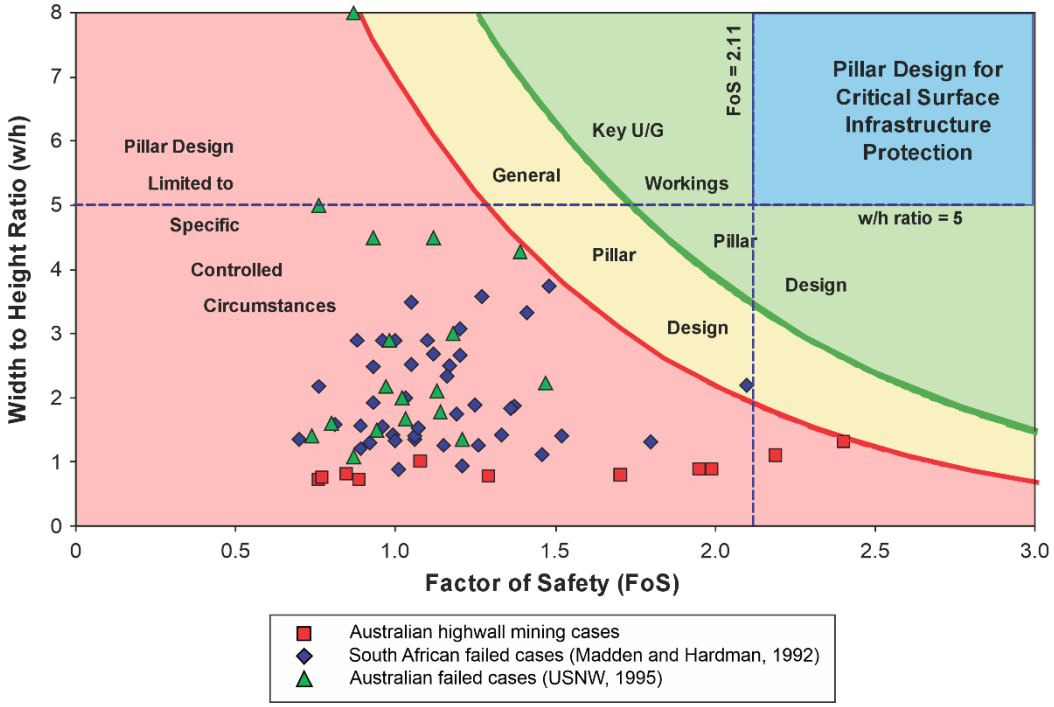


Figure 16: Design criteria for bord and pillar workings based on factor of safety and pillar – width to height ratio.

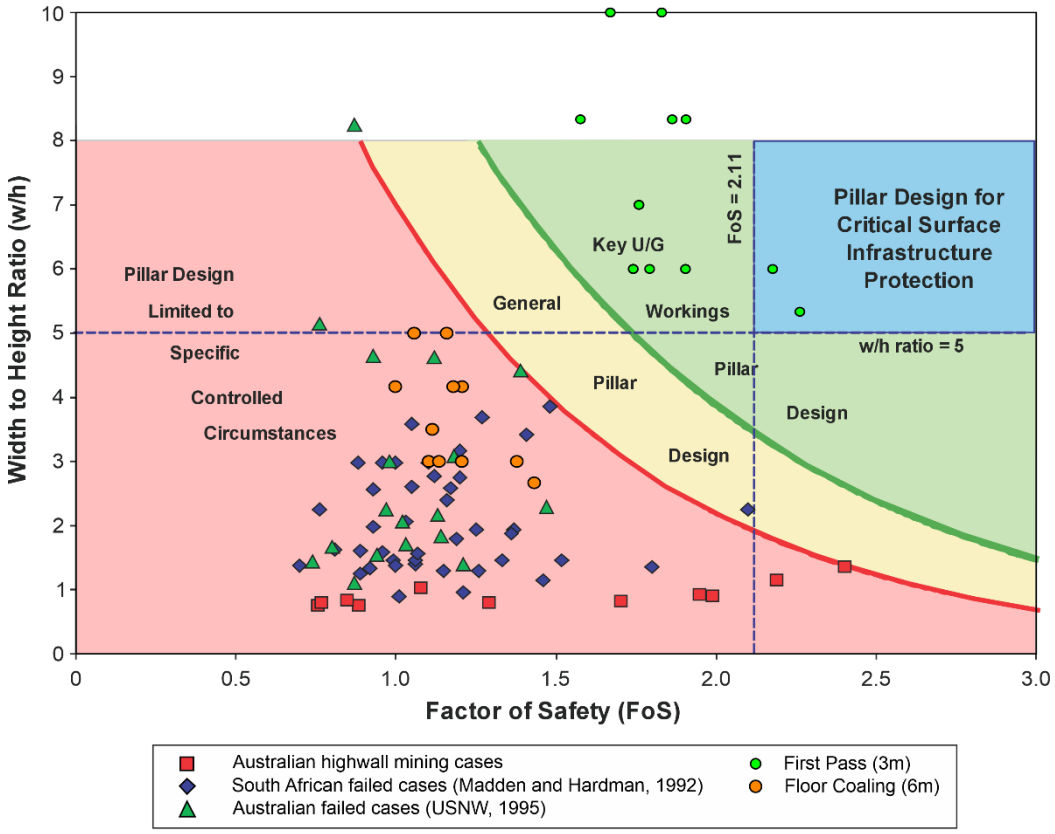


Figure 17: JEP area pillar design plotted onto pillar design chart showing pillar design criteria for surface protection.

8.2 Benchmarking of Subsidence at other Mines

8.2.1 Ensham Mine

Ensham Mine is an existing open-cut and underground bord and pillar coal mine located approximately 35 kilometres (km) east of Emerald in Queensland. Gordon (2020) prepared a subsidence report for Ensham Mine outlining the mining system that forms a regular array of stable coal pillars and roadways in each panel and does not cause large scale overburden fracturing and subsidence. The assessment of the stability of the coal pillars was conducted using the UNSW Pillar Design Procedure.

Due to the nature of the bord and pillar mining method at Ensham, subsidence is predicted to be typically less than 40mm in the Project Area. This magnitude of subsidence is less than the natural ground movements of up to 50 mm or more that can occur (IESC, 2015). The subsidence at Ensham is because of elastic compression of the strata (i.e., compression due to the additional load on the pillars after the coal is extracted) as the pillars are design for stability.

Ensham adopt a maximum mining height to achieve a pillar FoS > 1.6 for the range of depths mined which range from 80m to 210m. This 1.6 FoS value also applies below the Nogoa River where it flows across the Project Area.

At Ensham barrier pillars between panels have high FoS. For a conservative 5m mining height and minimum 50 m barrier length, the FoS of the 35 m wide barriers at 180 m depth is 2.75. This increases to 3.15 for the 40 m wide barrier pillars. Similarly, the 25 m solid barriers between the sub-panels are designed to have minimum FoS values of 2.04 at 180 m depth of cover.

Figure 18 shows a summary of Ensham pillars after secondary recovery (floor coaling) and the range of pillars adopted in the Ensham LOM project area. Pillars are designed with a minimum FoS of 1.6 following floor coaling and with w/h ratios >4. Galvin (2016) indicates that if the width to height ratio is >4, any pillar failure will be controlled and may be arrested through the application of confinement to the pillar sides.

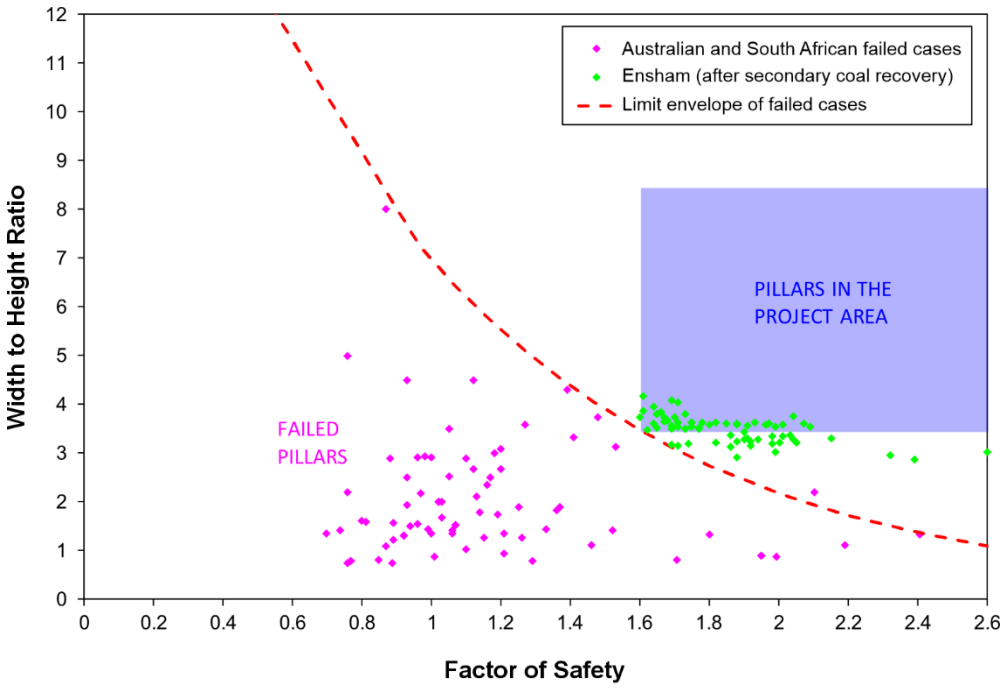


Figure 18: Summary of Pillar Design at Ensham.

8.2.2 Tasman Mine

Tasman Mine in NSW commenced the Duncan Method of partial extraction in 2008 of the 2.2-2.5 m thick Fassifern Seam, at depths up to 250 m (McTyer and Sutherland, 2011). The extraction ratios were between 67% and 82%, which are significantly higher than the recovery proposed in the JEP Area.

At Tasman Mine, subsidence control zones were established. Level 2 (<150mm subsidence) and 3 (<100mm subsidence) areas required partial pillar extraction techniques that could also support abutment loading from Level 1 areas where total extraction was allowed. Level 2 and 3 had similar subsidence constraints however, the remnant pillar FoS ranged from 1.6 to >2.11 respectively and required squat pillar geometries (i.e. width/height ratio of >5) for strain hardening response in yield (Ditton and Sutherland, 2013).

Notably in areas higher subsidence (up to 521mm and above design estimates) was recorded and inferred to be the result of weak claystone layers in the immediate 1.2m of floor below the coal pillars, which softened after mining. This softening of the floor resulted in punching of the pillar and lateral squeezing failures within the first 1.5m of floor strata. This highlights the importance of weak strata on pillar stability.

8.3 High Level Empirical Subsidence Estimates

This section provides a high-level review of likely subsidence based on the pillar stability assessment and experience of subsidence at similar bord and pillar mining operations. Notably the panels designed at JEP are supercritical (w/h >1.0) from a subsidence perspective and the pillars are required to have sufficient FoS and width-to height ratio to adequately support the overburden to minimise subsidence.

As noted above Ensham Mine subsidence was typically less than 40mm with panel pillar designed as shown in Figure 18. This subsidence is because of elastic compression of the strata (i.e., compression due to the additional load on the pillars after the coal is extracted) and is a function of the stiffness of the strata. More geotechnical data on rock properties is needed to fully assess the elastic compression mechanisms of strata at JEP.

Guidelines to achieve pillar design which would act to reduce the risk of subsidence at JEP are outlined in the section below. Importantly for the current mine plan only the first workings (3m height) satisfy this design criteria. Barrier pillars need to be assessed in more detail as part of future studies.

In areas where subsidence restrictions do not apply, and pillars are designed to yield in a controlled fashion following retreat and once in goaf, maximum subsidence can be approximately estimated for the individual panels by empirical subsidence design curves. The subsidence relationship for subcritical and supercritical panels is well understood for longwalls and is shown in Figure 19. Figure 19 can be used to estimate the likely subsidence by using the coal extraction thickness (normalised as a percentage of coal recovered over the panel extraction height) and panel width to depth (w/h) ratio.

For the supercritical panel widths assessed here (W/D range 1.0 to 1.7) maximum subsidence estimates could range up to 65% of normalised extraction thickness (based on discounted extraction / recovery values). Assuming upper bound extraction heights of 6m and 30% to 50% coal recoveries, as noted by Palaris, maximum subsidence of between approximately 1.1m and 2.0m are estimated. Table 4 provides an indication of subsidence estimates for a range of extraction heights and recovery rates assuming supercritical panel widths.

Table 4: High level subsidence estimates for various extraction heights and coal recoveries assuming supercritical panel widths

Extraction Height (m)	Coal Recovery			
	20%	30%	40%	50%
	Subsidence (m)			
3.0	0.39	0.59	0.78	0.98
4.5	0.59	0.88	1.17	1.46
6.0	0.78	1.17	1.56	1.95

Importantly as illustrated in Figure 19 panel subsidence increases and the panel W/D ratio increases. Panels that are designed as subcritical with reduced W/D ratios (<0.9) would be expected to further reduce surface subsidence and the risk of subsidence. For a subcritical panel design subsidence would depend on specific panel and barrier pillar design, extraction height and recovery rates. Engineering or mine planning controls such as subcritical panel design and large barriers that limit interaction should be considered where subsidence needs to be minimised over the JEP area.

Where subsidence is allowed panel edge subsidence would be expected to extend consistent with the of angle of draw approaching half depth or nominal 26.5° angle of draw.

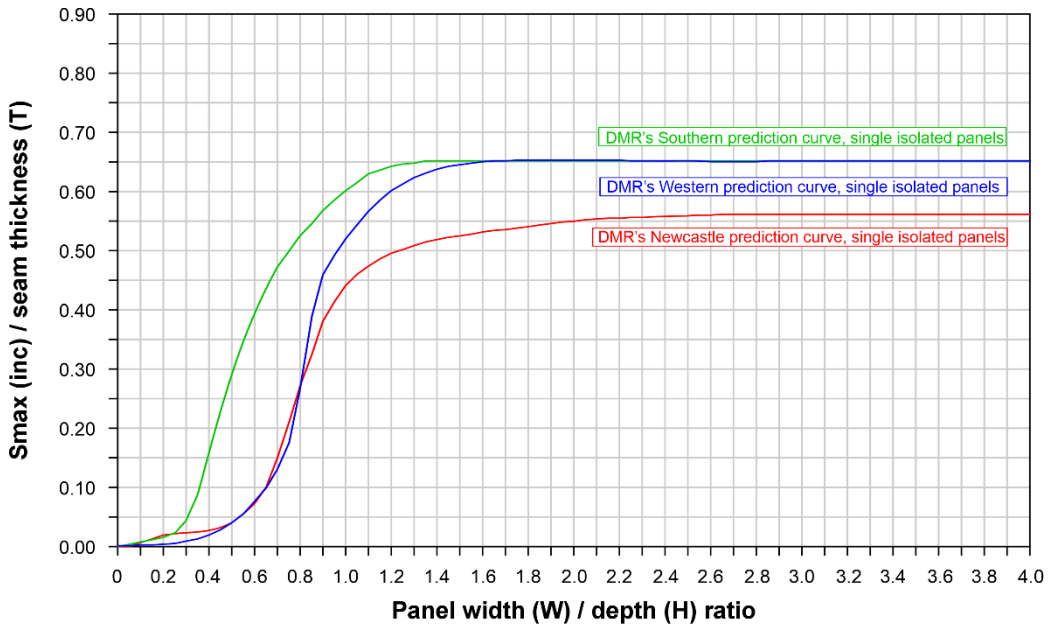


Figure 19: Prediction curves for maximum incremental subsidence. (after MSEC, 2007)

9. HIGH LEVEL PILLAR DESIGN GUIDELINES TO MINIMISE SUBSIDENCE

To support further concept bord and pillar mine design a pillar design chart has been developed using the UNSW pillar design formulae and based on various cover depths and mining heights to achieve a minimum design pillar w/h ratio of >5 and a pillar FoS >1.6 (Figure 20). Whilst these pillar guidelines do not provide protection to critical areas they reduce the risk of subsidence consistent with the Ensham Mine experience.

Figure 20 highlights the rapid increase in square pillar width needed to achieve appropriate levels of FoS with increasing mining depths and extraction height. The design chart is intended for guidance only to support further conceptual mine design and more detailed pillar design and subsidence assessment are required as part of further studies.

Panel barriers to minimise subsidence should be designed with appropriate barrier pillars to achieve minimum FoS of 2.11 accounting for all relevant loading conditions where surface subsidence impacts are critical.

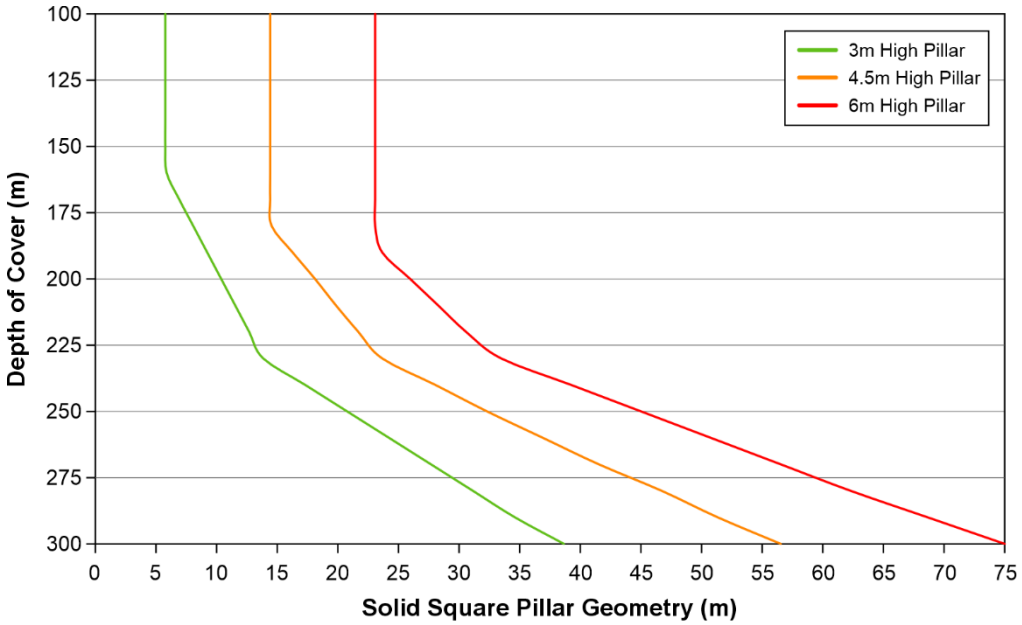


Figure 20: Concept pillar design chart for square pillars based on the UNSW pillar formulae.

Importantly tributary loading conditions on barrier pillars will only apply when the panel pillars are able support the full weight of the panel overburden. Where this does not occur, additional loading is expected from the mining panels via a side abutment and barrier pillar width will need to increase to account for these loads in accordance with best practice.

Table 5 provides barrier guidelines for a 4.5m mining height for tributary and double loading abutment conditions. The double abutment conditions are consistent with supercritical subsidence and goaf formation for a nominal 200m panel width assessed here. The double abutment pillar design is considered conservative where the mine design adopts production panel pillars designed to minimise subsidence (squat pillar with FoS >1.6) as the overburden is supported over the panel.

Table 5: Panel Barrier guideline widths for a 4.5m mining height at various cover depths to provide FoS > 2.1

Cover Depth	Loading Condition	
(m)	Tributary Load	Double Abutment Load
150	24	44
200	29	54
250	34	63
300	40	71

9.1 Protection to waterways

The main requirement for the protection of surface features at JEP is understood to be waterways. Where waterways require protection a 50m barrier located either side of the feature would provide for suitable protection to the waterway given the mining depths and mining method proposed. Refinement of barrier pillar sizing including protection barriers is recommended as part of more detailed assessments.

10. COMMENTS ON MINE SEALING

The Mine Design Guideline, MDG – 6001, provides guidelines for the permanent filling and capping of surface entries to coal seams. MDG - 6001 provides useful information for an adit which are defined in the guideline as a direct entry to a coal seam exposed at the surface either by seam outcrop or by the highwall of an opencut or excavation.

Mine sealing should be consistent with that outlined in MDG – 6001 and with industry best practice.

11. COMMENTS ON THE POTENTIAL FOR UNPLANNED POST CLOSURE SUBSIDENCE AND GROUND COLLAPSE

The issue of the potential for long-term deterioration of workings leading to failure in the overburden is an important consideration regarding surface protection.

The long-term performance of a pillar system is controlled by many factors including pillar geometry (w/h ratio), pillar stability (Pillar FoS) and on the coal pillar, roof and floor conditions. In addition, for overburden to become unstable a critical level of overburden settlement, which leads to pillar yield or collapse, is first needed to be exceeded. Hill (2005) notes that:

- key underground workings, such as main headings, with medium to long-term serviceability requirements should be designed on the basis of the limit envelope plus 20 per cent (i.e., the outer database curve in Figure 12); and

- In the case of pillars required for the permanent protection of critical surface features/structures, an ongoing broader (i.e. global) review of coal pillar behaviour suggests that even in extreme circumstances involving unusually weak floor, coal and/or roof that the potential for failure can be effectively excluded by designing to a minimum Factor of Safety of 2.11 (i.e. to a failure probability of 1 in a million), coupled to a minimum width to height ratio of 5 (i.e. 'squat' pillars).

As previously discussed where reduced subsidence is required production panel pillars should be designed with FoS >1.6 and w/h >5. Between each panel, suitable barriers should be designed. Barrier pillars are often significantly larger than the panel pillars and minimise the interaction of overburden loads between the panels.

Specific assessment of the long-term pillar stability will be required as part of more detailed studies. Where appropriate pillar design can be modified during more detailed studies to ensure the risk of long-term instability will be minimised as required.

11.1 Potential for Sink Holes

Shallow bord and pillar coal mining is often associated with extensive subsidence and/or sinkholes on the surface due to high percentage extraction from mines operating at shallow depth. Sinkholes, also referred to in the literature as potholes, chimney caves, piping or funnelling, can occur during mining or many years after mining.

A range of factors contributes to the formation of sinkholes including mining depth, mining height, the composition and properties of overburden, geological discontinuities, void space, bulking factor, the nature of overburden, presence of water and weathering.

Shallow depth of cover is identified as an important causative factor in the development of sinkholes. Sinkholes form as a result of collapse of roof strata which propagates to the surface, therefore the depth of cover needs to be sufficiently shallow to allow the progressive collapse. The arresting mechanism is bulking and the choking of roof fall progression as shown by Canbulat (2017) in Figure 21.

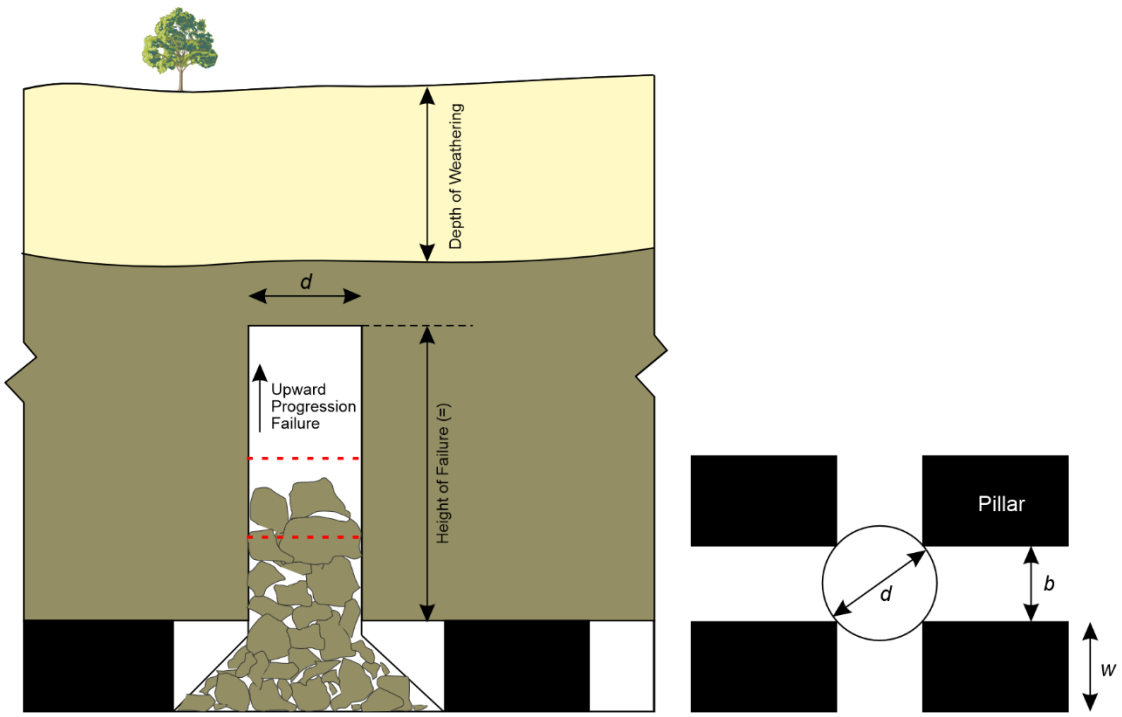


Figure 21: Sinkhole mechanism for bord and pillar workings.

Mining height does not directly affect the initial failure of a sinkhole, but it determines the height of caving before bulking arrests upward migration (Joel, 2015). Similarly, the roadway width determines the effective span affecting the roof fall characteristics, which in turn influences sinkhole formations.

Hill (1996) reviewed sinkholes in South African coalfields and concluded that sinkholes are unlikely to occur when the depth exceeds 40m. Van der Merwe and Madden (2010) stated that the formation of sinkholes appears to be especially prevalent at mining depths of less than approximately 50m.

Given the mining depths (>110m) at the JEP area, and conceptual mine plan, no sink holes or potholes are likely to form that would reach the surface for extraction heights up to 6m due to bulking.

Specific assessment of the long-term pillar stability will be required as part of more detailed studies. Where appropriate pillar design can be modified during more detailed studies to ensure the risk of long-term instability will be minimised as required.

Specific assessment of pot holing potential will be required as part of more detailed studies and would include detailed characterisation of the overburden including depth of weathering and thickness of rock head.

11.2 Comments on Long Term Pillar Behaviour and Underground Stability

The long-term performance of pillars is important to the long-term stability of the overburden and underground workings. Potential impacts on pillar stability in the longer term include:

- Changes in loading conditions.
- Changes in pillar strength (i.e., time dependant spalling or scaling of pillars).
- Materials located in the coal pillar and the immediate roof and floor including potential for water sensitive clays or other materials prone to time dependant degradation.

The impact of flooding of old panels was assessed by Galvin (2008). He notes that flooding of mine workings could influence pillar load in two ways:

- The water pressure acting on the roof of the workings would function as a hydraulic jack to unload the pillars or
- The overburden may be fully saturated over the full water head, effectively reducing the density, resulting in lower loads on the pillars.

Both these mechanisms have a positive impact on the stability of old workings. However, as noted above, effect of water on the strength of the pillar system can reduce friction on fracture planes and roof/floor interfaces. The water can also accelerate the degradation of clay rich minerals in the roof, floor and coal seam.

Additional assessment of the impacts of time dependant degradation of pillars and its impacts on the stability of the underground workings, overburden and subsidence will be required as part of more detailed assessments.

11.3 Limitations of the Subsidence Predictions

The JEP area is at a concept level of underground mine planning and requires additional data collection to improve resource confidence and geotechnical understanding. The subsidence predictions provided here are based on benchmarking and high-level assessment using empirical methods. More detailed geotechnical assessment is required on both the pillar stability and subsidence predictions as part of future and more detailed studies to improve confidence.

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