Taroborah Coal Project

Appendix 13 – Surface Water Management Plan

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Shenhuo International Group Pty Ltd.

Taroborah Coal Project

Surface Water Management Plan

November 2014

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LIST OF ABBREVIATIONS

AARC	AustralAsian Resource Consultants Pty Ltd
AEP	Annual Exceedance Probabilities
AHD	Australian Height Datum
ARI's	Annual Reccurrence Intervals
ATCW	ATC Williams Pty Ltd
CHPP	Coal Handling and Preparation Plant
CPPWRD	Mine Wastewater Dam MWD and CPP Water Recycle Dam
DEHP	Department of Environmental and Heritage Protection
DNRM	Department of Natural Resources and Mines
EPP Water	Environmental Protection (Water) Policy 2009
EV	Environmental Values
GSDM	Australian Generalised Short Duration Method
IFD	Intensity-Frequency-Duration
IMC	IMC Mining Group Pty Ltd
MDL	Mineral Development Licence
Mtpa	Million tonnes per annum
QWQG	Queensland Water Quality Guidelines
SWMP	Surface Water Management Plan
WQO	Water Quality Objectives

1 INTRODUCTION

1.1 Background

Shenhuo International Group Pty Ltd. (Shenhuo) is proposing to develop the Taroborah Coal Project, which is located within the western edge of the Bowen Basin and is expected to commence construction works during the fourth quarter of 2017. Shenhuo has engaged IMC Mining Pty. Ltd. (IMC) as the Project managers for the Taroborah works. A site locality plan showing the geographical project location is provided in **Figure 1**.

This report provides an assessment of the surface water resources of the proposed Project in the context of environmental values as defined by the Environmental Protection (Water) Policy 1997 (EPP (Water)). ATC Williams Pty Ltd (ATCW) has been commissioned by AustralAsian Resource Consultants (AARC) on behalf of Shenhuo to develop a Surface Water Management Plan (SWMP) for their operations.

1.2 Site Description

The Taroborah Coal Project is located approximately 22 km west of Emerald in Central Queensland extending north and south of the Capricorn Highway and Central West rail line which transect the Project in an east-west direction. It is located in the Central Highlands Regional Council area on the Mineral Development Licence (MDL) 467, which encompasses an area of 7,966 hectares (ha).

The land within MDL467 is predominantly used for low intensity cattle grazing and cropping and includes an area mapped as potential Strategic Cropping Land. It is advised by AARC that an assessment of strategic cropping land in accordance with the *Strategic Cropping Land Act 2011* has been undertaken as part of the Environmental Impact Statement (EIS) assessment process.

1.3 Scope and Report Structure

The scopes of works for the SWMP are as follows:

- Data review, definition of design criteria and confirmation of site layout options for water management structures;
- Conduct a flood study to identify areas of the Taroborah Coal Project site that could be impacted by flooding with any infrastructure and activities that can potentially influence flood levels;
- Prepare a site water management strategy and water balance model for the site which reflects proposed development conditions, identifying potential shortcomings and additional works required to achieve current and/or proposed environmental requirements; and
- Prepare documentation to support the engineering assessment process incorporating the design and analyses for site water management components as outlined above.

The structure of this report, to address the above scope, is as follows:

Section 2.0 - Outlines the key components of the proposed development. Provides descriptions of the Taroborah Coal Project and site setting covering climatic and hydrological conditions.

Section 3.0	-	Presents the flood modelling component of the study. Outlines the hydrological and hydraulic descriptions of the flood study.
Section 4.0	-	Outlines the philosophy of water management for the Taroborah Coal Project site, and justifies key performance/design criteria for the water management system.
Section 5.0	-	Presents details of site water balance modelling carried out in relation to the Taroborah Coal Project site and to review overall hydrological performance based on the adopted water management layout.
Section 6.0	-	Presents design of clean water diversion drains and site water collection drains including hydrological analyses undertaken for sizing.
Section 7.0		Describes the outcomes related to surface runoff based on subsidence impact during post-mining conditions.

A series of plates and figures are also included to present the results of modelling and analysis, and to show engineering concepts.

2 PROJECT SITE SETTING

2.1 Key Elements of the Project

The Taroborah Coal Project site concerns the development of a mine for the extraction processing and export of thermal coal including the development of an onsite Coal Handling and Preparation Plant (CHPP). The site involves the mining of a total determined resource of 200 Mt, at a rate of up to approximately 2.3 Million tonnes per annum (Mtpa) run of mine (ROM) for the open-cut operation and up to 5.8 Mtpa for the underground operation.

An overview of the Taroborah Coal Project site layout is shown in **Figure 2**. The key elements of the site in relation to site water management are outlined below.

- Three out of pit spoil dumps are prepared in the western, south western and south eastern areas of the mining area. Once there is sufficient space for in pit dumping, the pits will be progressively backfilled with spoil (in pit spoil dumps);
- A mine water management system to be constructed which diverts clean water, stores and manages mine area runoff and pit water for reuse;
- Mine haul roads will connect open cut pits to a new CHPP and associated storage and loading facilities for ROM coal;
- A conveyor will be constructed to transfer product coal from the CHPP product stockpile and thence to the train load out facility;
- Light vehicle access roads will be constructed to and around the CHPP; and
- Process waste comprising both coarse and fine rejects from the CPP will be returned by truck and disposed of in the Project's spoil dumps.

2.2 Proposed Operations

Open-cut mining will be carried out using conventional hydraulic excavators and a fleet of dump trucks to remove overburden and extract the coal resource in the southern portion of the proposed mining area. Underground mining will be undertaken by longwall pillar extraction techniques in the northern portion of the proposed mining area. ROM coal will be transported by truck to the CHPP for on-site for processing. Product coal will be transported from the Project site via the Central West and Blackwater rail systems to the Port of Gladstone for export. The Project's preferred coal transport option will require the construction of a new on-site rail-loading facility and train loop, as well as an upgrade of the Central West railway line.

Coarse and fine rejects from the CHPP will be deposited on-site within both Out of Pit and In Pit soil dumps Waste rock from the open-cut pit will be deposited on-site in Out of Pit and In Pit spoil dumps.

Site access will be via the Capricorn Highway, which passes through the middle of MDL467 in an east–west direction.

The major activities proposed for the Project have been summarised as follows:

- Open-cut mining, via hydraulic excavators and dump trucks, in the southern part of the proposed mining area;
- Underground mining, via longwall mining extraction techniques, in the northern part of the proposed mining area;

- Processing of mined coal at a CHPP, including coal sizing, handling and washing; and
- Transport of the coal to the port of Gladstone via the Central West and Blackwater rail systems.

2.3 Hydrological Characteristics and Topography

2.3.1 Regional

Regionally, the Project site is located within the Nagoa River Basin which is a sub-basin of the Fitzroy River Basin (refer **Plates 1** and **2**). The Fitzroy River catchment covers an area of 142,665 square kilometres, making it the largest river catchment flowing to the eastern coast of Australia. The river is formed by the joining of the Mackenzie and Dawson rivers at Duaringa with the Mackenzie River formed by the joining of the Nago River and Comet River. The catchment stretches from the Carnarvon Ranges in the west to the river mouth in Keppel Bay, near Rockhampton. It is bounded to the north by the Burdekin River catchment area and to the south by the Burnett River catchment area. The Fitzroy River originates in southeast Queensland at an elevation of 58.4m RL and drops around 59m over its 335km length before it reaches Keppel Bay.

The Nogoa River falls from the Carnarvon Range in the Carnarvon National Park in Central Queensland and flows in a north easterly direction. The river joins with the Comet River north of Comet, from which the river is called the Mackenzie River. The Nogoa River in south Queensland originates at an elevation of RL 501m and drops around RL 361m over its 569km length.

Plate 1
Queensland River Basins Showing Project Site Location
(Source: Bureau of Meteorology (BOM))

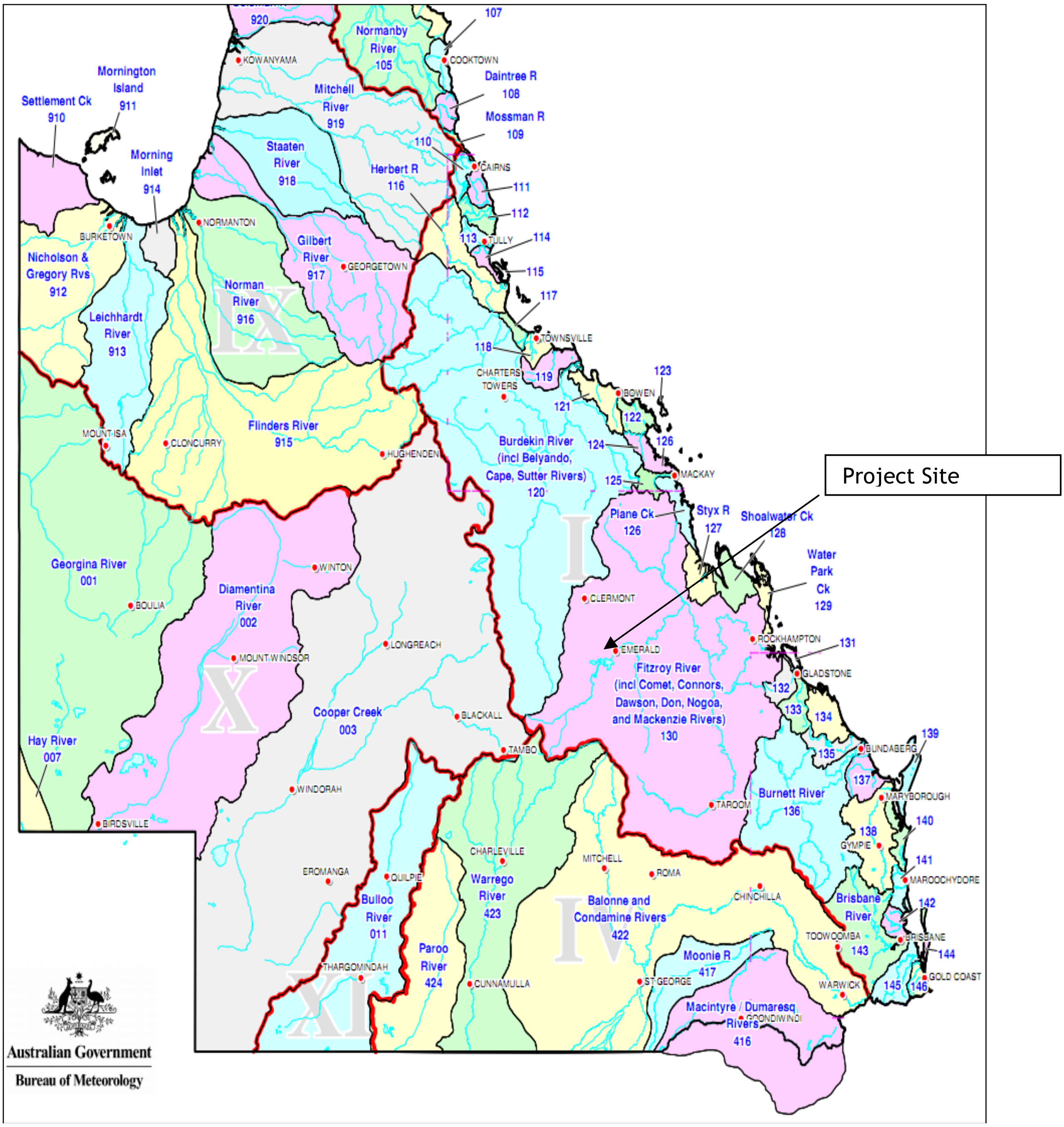
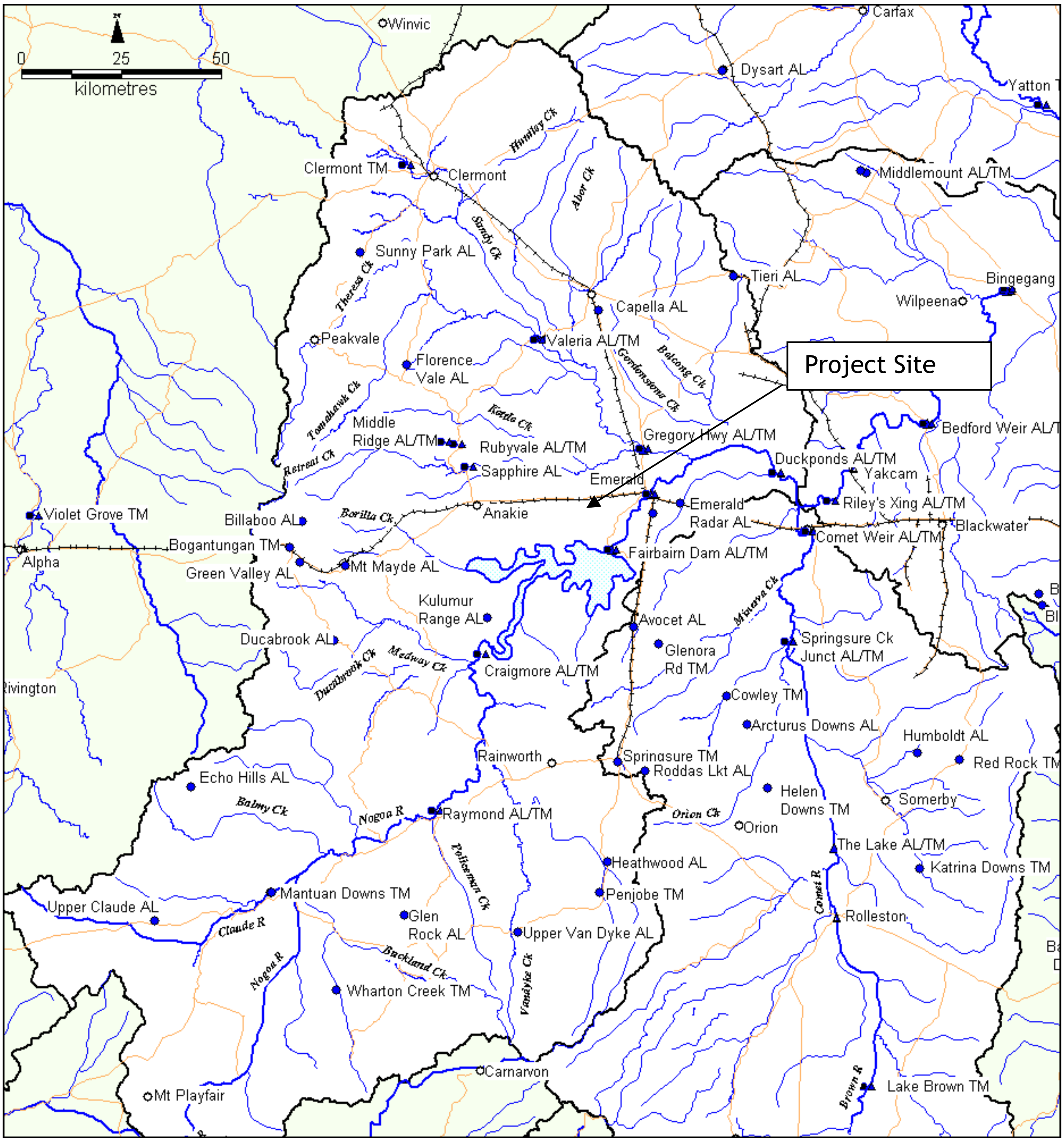


Plate 2
Regional Hydrological Setting within Fitzroy River Basin
(Source: Bureau of Meterology(BOM))

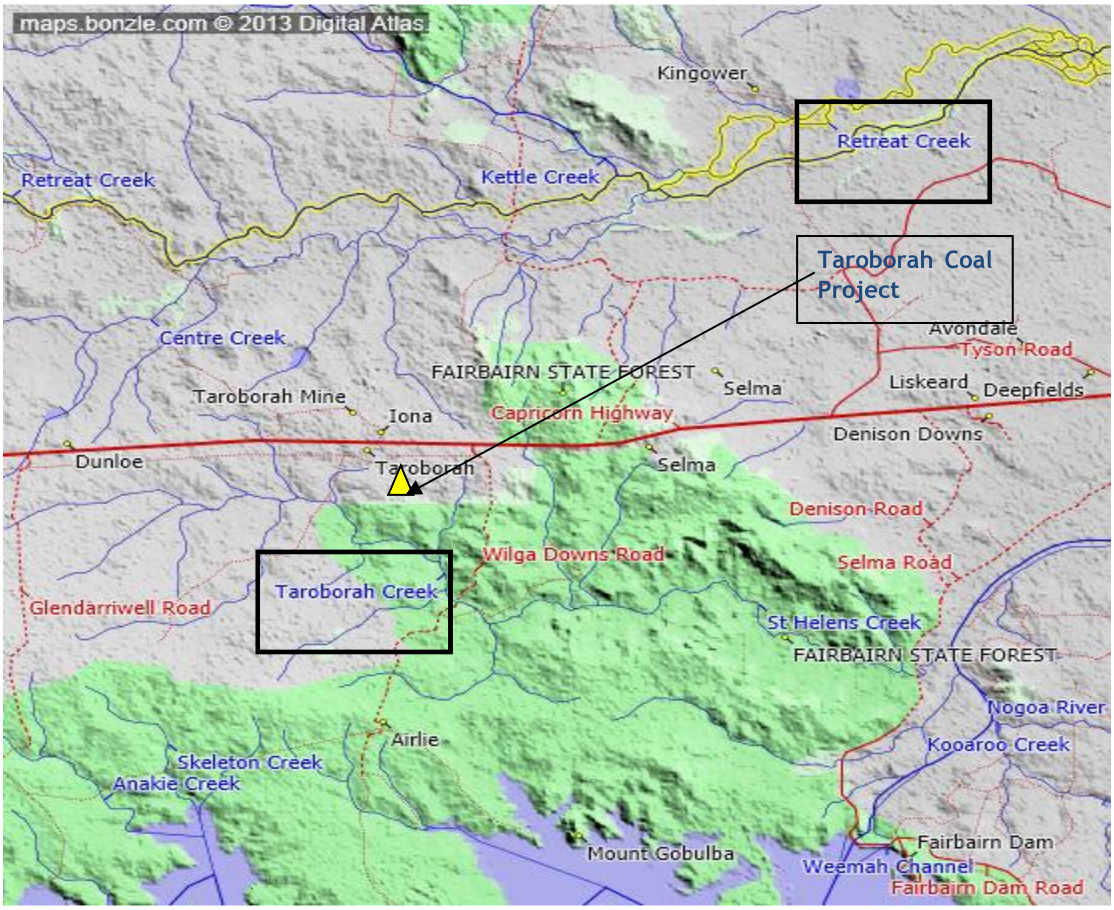


2.3.2 Local Context

The primary drainage lines occurring within the Project site and the surrounding areas are Taroborah Creek, Retreat Creek and Centre Creek which are located south and north of MDL467. The alignment of the creeks in relation to the site is shown on **Figure 2**. Taroborah Creek flows in a south easterly direction and flows into the St Helens creek which then flows into Nogoa River approximately 18 km from the site. Centre Creek flows in a north easterly direction and flows into Retreat creek which then flows into Theresa's Creek before joining the Nogoa River.

Topographically, the Project site catchment is gently undulating and varies from 200 m above Australian Height Datum (AHD) to 280 m AHD. Lake Maraboon, Queensland's second largest lake is located approximately 5 km south of the Project boundary. The lake was created following construction of the Fairbairn Dam in 1972 and currently provides water to about 300 Irrigators within the Emerald Region. The Fairbairn Dam discharges to the Nogoa River with flow maintained to supply a consistent water supply to the downstream Irrigators. **Plate 3** shows the Taroborah Coal Project location in relation to Taroborah Creek and Retreat Creek.

Plate 3
Retreat Creek, Taroborah Creek Catchment and Project Location
(Source: Bonzle Digital Atlas of Australia)



Runoff generated from surface areas disturbed by the Project will be retained on site (excluding extreme events), with the open cut mining clean water flows draining south to Taroborah Creek. The runoff from the area over the underground mine flows north to Retreat Creek.

2.3.3 Irrigation System

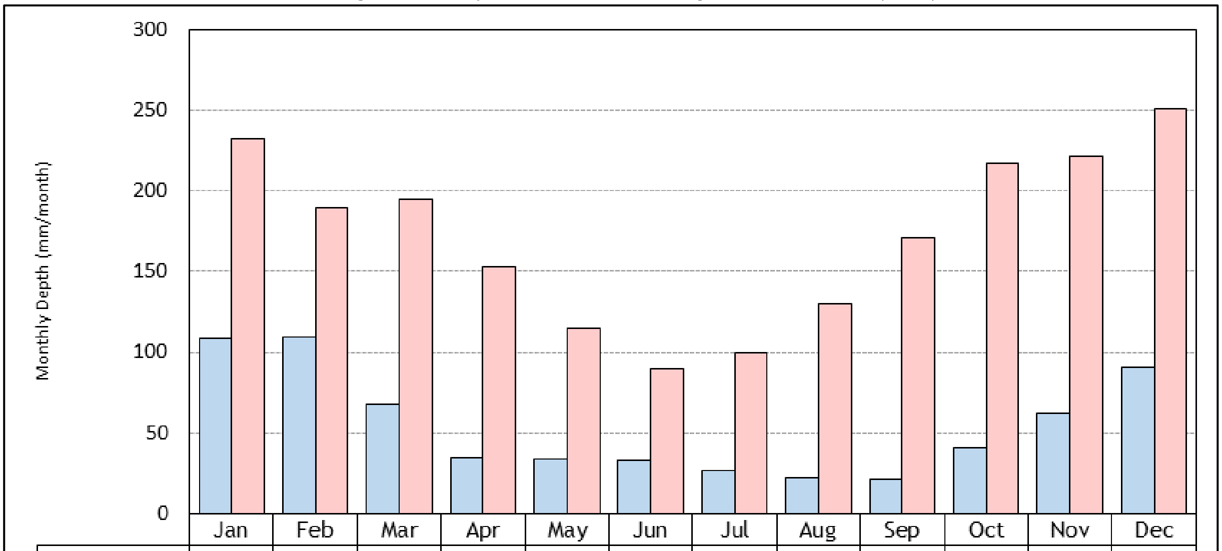
The Taroborah Creek headwaters is located nearby Glendarriwell, located 9km west of the Taroborah Coal Project site. The Taroborah Creek extends some 17km easterly flowing into St Helen's Creek, which then flows into Nogoa River some 8km downstream of the Fairbairn Dam. The Fairbairn Dam, which creates Lake Maraboon, lies approximately 15km to the southeast of the Taroborah Coal Project site boundary.

Water stored within Lake Maraboon and restrained by the Fairbairn Dam supplies two major irrigation channels for the agricultural areas located on either side of the Nogoa River. The water in Lake Maraboon is also released to the Nogoa River for consumers located further downstream. The Selma Channel, which services the agricultural area located to the north and west of the Nogoa River is proposed to be the Taroborah Coal Project site's release location for excess water, as required.

2.4 Climate

The Project site is subject to a semi-arid climate with highly variable rainfall conditions. The monthly rainfall is shown on **Plate 4**, with a seasonal pattern of lower rainfall conditions during the winter months, the peak rainfall occurring during December and January and the mean annual rainfall is 651.9 mm (Bureau of Meteorology, 2013). The nearest meteorological station to the site is Emerald Station (No. 035264). This station does not have long term evaporation data – a significant parameter in the assessment of surface water management. Therefore, evaporation data from the meteorological station at the Clermont Post Office (No. 035019 approximately 63km to the north-west) has been adopted.

Plate 4
Average Monthly Rainfall and Evaporation Data (mm)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	108.7	109.4	67.9	34.9	34	32.8	26.3	22.4	21.1	41.2	62.4	90.8
Evaporation	232.5	189.275	195.3	153	114.7	90	99.2	130.2	171	217	222	251.1

2.5 Environmental Values and Beneficial Uses

Schedule 1 of the Environmental Protection (Water) Policy 2009 (EPP Water), subordinate legislation to the Environmental Protection Act 1994 (EP Act), documents the waters for which the legislation applies that are to be enhanced or protected and specifies relevant environmental values (EV's) and water quality objectives (WQO's). Review of Schedule 1 indicates that the

Project lies within the Environmental Protection (Water) Policy 2009 Nogoa River Sub-basin Environmental Values and Water Quality Objectives and as such EV's and WQO's have been pre-determined and listed in Section 1.2 of Schedule 1.

The Project site is situated in a rural landscape where agriculture (in the form of low-intensity cattle grazing and cropping). Water for agricultural use (stock water) is predominantly sourced from groundwater. The area has been largely cleared of native vegetation except along watercourses, where some remnant riparian vegetation exists. The Fairburn State Forest is located immediately adjacent to the eastern and south-eastern Project boundary and is used for forestry purposes. Historically, the Retreat Creek alluvium located west (upstream) of the Project area has been mined for gravel and gemstones.

Using Schedule 1 of the EPP Water, EV's can be characterised as slightly disturbed waters, consistent with the Project site which can be defined as a slightly to moderately disturbed ecosystem.

Schedule 1 of the EPP (Water) includes the water quality objectives to protect aquatic ecosystem EV's and is detailed in the Nogoa River Sub-basin Environmental Values and Water Quality Objectives. The following water quality objectives are based on Queensland Water Quality Guidelines (QWQG) Central Coast regional water quality guidelines.

Table 1
Lower Nogoa/Theresa Creek Water Quality Objectives

Parameter	Water Quality Objectives to Protect Aquatic Ecosystem EV
Ammonia (N)	<10 µg/L[a]
Oxidised (N)	<60 µg/L[a]
Organic(N)	<420 µg/L[a]
Total Nitrogen(TN)	<500 µg/L[a]
Filterable Reactive Phosphorus (FRP)	<20 µg/L[a]
Total Phosphorus(TP)	<50 µg/L[a]
Chlorophyll a	<5.0 µg/L[a]
Dissolved Oxygen	85%-110% saturation
Turbidity	<50 NTUa
Suspended Solids	<10 mg/L[b]
pH	6.5-8.5 [b]
Conductivity (EC) baseflow	<720 µS/cm (Theresa Creek)
	<340 µS/cm (Lower Nogoa)
Conductivity (EC) high flow	<250 µS/cm[b]
Sulfate	<25 mg/L[b]

Note: As per Table 2 in the EPP (WATER) 2009 for the Nogoa River WQO's

2.5.1 Background Water Quality -Groundwater

A groundwater impact assessment was conducted by AGE to develop a conceptual understanding of the local groundwater level and water quality of the site. The assessment was carried out using groundwater quality conditions that is currently being monitored from 19 groundwater monitoring boreholes located at 16 separate sites as shown on **Plate 5**. AGE (2014) reported that the monitoring boreholes within the project area intersects three major aquifers as described below.

Aldebaran Sandstone

- The main source of groundwater within the Project area is from the Aldebaran Sandstone. Ten bores inferred to be screened across Aldebaran Sandstone are located either within the Project area, or immediately to the east of the Project boundary (**Plate 5**). Observations have shown groundwater to be present under confined conditions throughout a number of different horizons within the Aldebaran Sandstone including:
    - A and B coal seams;
    - pebbly coarse-grained sandstone unit directly overlying A Seam;
    - shallower, predominantly fine-grained, sandstones.

Tertiary Basalt

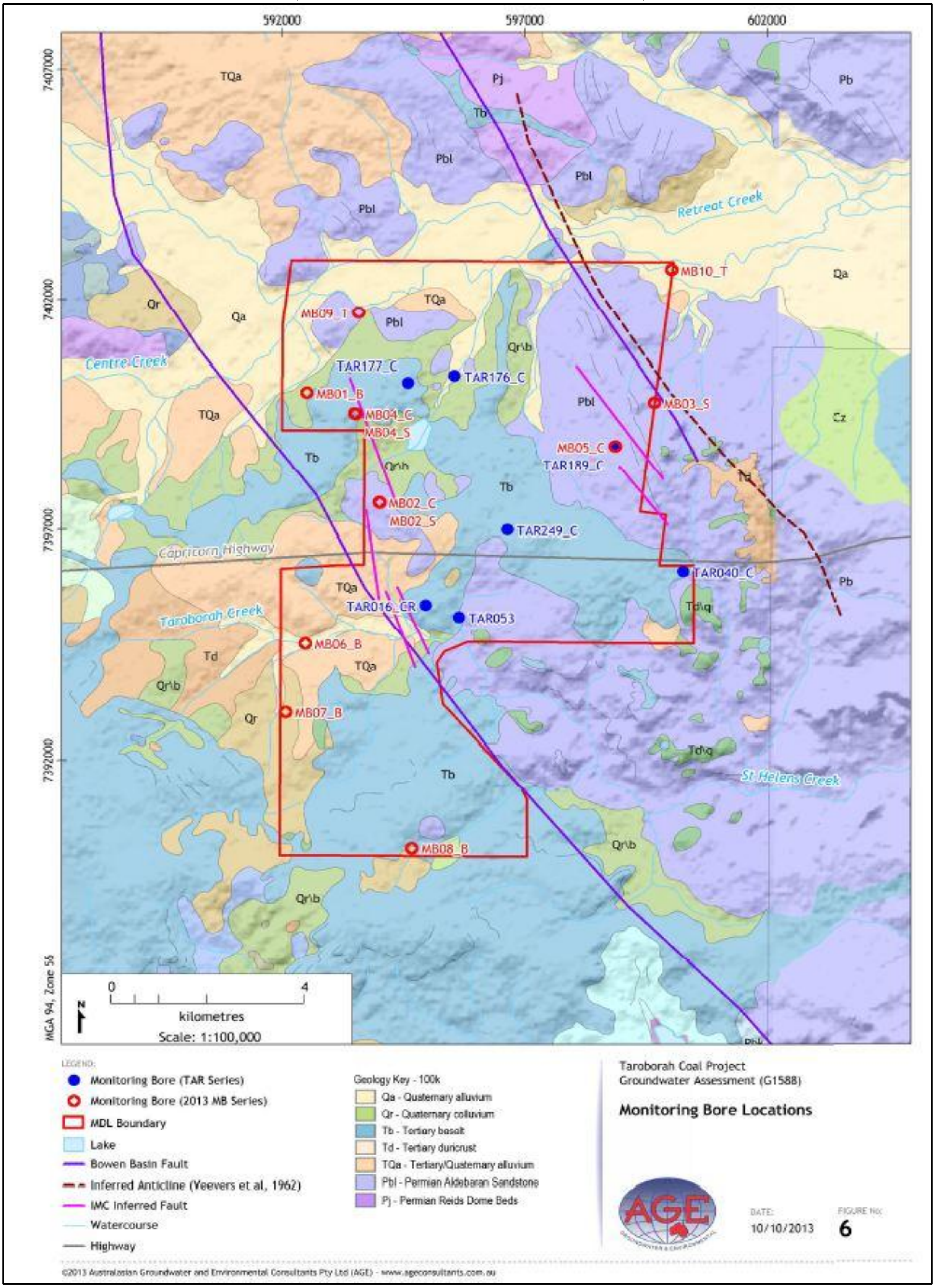
- The Tertiary basalts are commonly weathered within the Project area, with only localised, dissected areas of fresh basalt. The Tertiary basalts are relatively thin and occurs sporadically across the Project area, with thick sequences of fresh basalt mapped to the south-west of the Project area. Groundwater within basalt typically occurs within fractured and vesicular horizons. It is expected that the amount of flow within the basalts is dependent on the extent and intensity of the fractures.
- The presence of thick impermeable Tertiary clays throughout the Project area suggests the Tertiary units are likely to be confined and hydraulically disconnected from the underlying Aldebaran Sandstone. Groundwater flows were too low to be measured by air lift tests for monitoring bores

Quaternary Alluvium

- Alluvium within the Project area has limited groundwater potential, as drilling shows it is typically thin (<30 m) and has limited lateral extent. Observations during drilling of a borehole located approximately 20 m from Taroborah Creek, show that alluvial sands adjacent to the creek are dry in that location. No users of alluvium where identified within the Project area during the bore census. Where groundwater is present in the alluvium it is likely to be unconfined.

Plate 5
Monitoring Borehole Locations

(Source: G1588 Taroborah_EIS_Final)



As part of the groundwater impact assessment carried out for the EIS, three sampling events were undertaken as follows:

Event 1: Sampled on the March/April 2013;
Event 2: Sampled on the May 2014; and
Event 3 Sampled on September 2014

Water quality results from the above sampling for bores monitoring the Aldebaran Sandstone aquifer are presented in **Table 2** representing the highest parameters readings for the three events. Also included in **Table 2** are the guideline values for irrigation taken from the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000) and, commonly referred to as the ANZECC (2000) guidelines and the surface water quality objects for the Lower Nogoa River as described in **Table 1**. The above guidelines were selected for comparison to assess if groundwater released into the Selma channel from the Taroborah Coal Project site meets the regulatory guidelines for irrigation and is suitable for release into the existing environment. For the purpose of this assessment to reflect the potential dewatering water quality, 12 monitoring bores located within the Aldebaran Sandstones were considered as shown in **Table 2.**

Table 2
Groundwater Quality Results from the Aldebaran Sandstone Aquifer (Source: AGE,IMC)

Analytes	Units	Limit of Reporting (LOR)	Guideline Value - Surface Water Quality	Guideline Value - Short Term Irrigation	Groundwater Monitoring Borehole											
					MB02_C	MB02_S	MB03_S	MB04_C	MB04_S	MB05_C	TAR016_CR	TAR053	TAR176_C	TAR249_C	TAR040_C	TAR189C
Aquifer	-				Aldebaran Sandstone - B seam	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - Fine Sandstone	Aldebaran Sandstone - B seam	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - A seam	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - Fine Sandstone	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone	Aldebaran Sandstone
Date Sampled	-	-			13/03/2013	12/03/2013	13/03/2013	12/03/2013	12/03/2013	13/03/2013	23/04/2013	22/04/2013	18/04/2013	22/04/2013	15/5/2014	15/5/2014
Field - Physical Parameters																
pH Value	pH Unit		6.5-8.5	4.5-9.0	8.35	8.24	7.95	8.39	8.34	8.37	6.75	7.24	8.66	7.68	7.05	7.84
Electrical Conductivity @ 25°C	µS/cm	-	720(baseflow) 250(highflow)	1500-7700	**3180**	**1395**	**3130**	**2760**	**2570**	**1570**	**1328**	**956**	**893**	**797**	**1,194**	**2,267**
Total Dissolved Solids	mg/L	-	-	-	-	-	-	-	-	-	864	624	-	520	-	-
Temperature	°C	-	-	-	24.1	25.4	26.8	25.3	24.5	26.9	26.6	26.2	26.7	25.7	21.7	29.0
Laboratory - Physical Parameters																
pH Value	pH Unit	0.01	-	-	8.23	8.16	8.36	8.24	8.2	8.45	7.59	7.93	8.65	8.56	8.26	8.48
Electrical Conductivity @ 25°C	µS/cm	1	-	-	3070	1370	3060	2630	2440	1590	1290	980	930	783	1,050	2,150
Sodium Adsorption Ratio	-	0.01	-	9	4.5	2.7	**11.8**	6.32	8.98	3.52	1.97	1.51	3.73	3.79	1.74	6.1
Total Dissolved Solids (Calc.)	mg/L	10	-	-	2000	890	1990	1710	1590	1030	838	637	604	509	559	1,170
Total Suspended Solids	mg/L	5	10	-	**270**	**126**	**8020**	**3470**	**163**	**240**	**11**	7	<5	**85**	223	49
Total Hardness as $CaCO_3$	mg/L	1	-	-	773	446	318	583	385	348	459	371	186	137	378	439
Alkalinity																
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	<1	<1	11	<1	<1	20	<1	<1	28	14	<1	38
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	248	472	276	245	376	260	537	445	157	75	442	450
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	248	472	288	245	376	280	537	445	186	90	442	488
Major Ions																
Calcium	mg/L	1	-	-	97	60	58	77	57	39	75	58	53	17	51	29
Chloride	mg/L	1	-	30-700	**718**	154	540	594	488	291	117	48	199	179	108	501
Fluoride	mg/L	0.1	-	2	0.4	0.6	0.6	0.5	0.8	0.4	0.5	0.5	0.2	0.4	0.2	0.3
Magnesium	mg/L	1	-	-	129	72	42	95	59	61	66	55	13	23	61	89
Potassium	mg/L	1	-	-	13	5	83	18	44	12	3	5	16	10	78	294
Sodium	mg/L	1	-	-	288	131	482	351	405	151	97	67	117	102	9	10
Sulfate as SO_4	mg/L	1	25	-	**67**	**36**	**293**	**185**	**156**	**66**	22	13	**37**	**42**	12	8

1. Guideline values for irrigation beneficial use (identified as the only beneficial use for the connected groundwater aquifers.) are based on Australian and New Zealand Guidelines for Fresh & Marine Water Quality – October 2000 (ANZECC) values which are the maximum concentration (mg/L) or contaminant in the irrigation water which can be tolerated assuming 20 yrs. of irrigation.
2. Exceedences to guideline values are bolded.
3. **718** for groundwater quality criteria
4. **0.05** inidcates exceedance for surface water quality criteria

Table 2 (Cont'd)
Groundwater Quality Results from the Aldebaran Sandstone Aquifer (Source: AGE,IMC)

Analytes	Units	Limit of Reporting (LOR)	Guideline Value - Surface Water Quality	Guideline Value - Irrigation	Groundwater Monitoring Borehole											
					MB02_C	MB02_S	MB03_S	MB04_C	MB04_S	MB05_C	TAR016_CR	TAR053	TAR176_C	TAR249_C	TAR040_C	TAR189C
Dissolved Metals																
Aluminium	mg/L	0.01	-	20	0.02	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	0.02	0.01	<0.01	<0.01
Antimony	mg/L	0.001	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Arsenic	mg/L	0.001	-	-	<0.001	0.004	0.002	<0.001	0.003	0.002	0.001	0.005	0.002	<0.001	0.002	<0.001
Barium	mg/L	0.001	--	-	0.146	0.047	0.093	0.082	0.163	0.108	0.121	0.388	0.078	0.031	0.233	0.154
Beryllium	mg/L	0.001	-	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	-	0.5-6.0	0.13	0.09	0.28	0.14	0.08	0.11	0.1	0.06	0.1	0.05	0.11	0.13
Cadmium	mg/L	0.0001	-	0.05	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001		1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	-	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.003	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	-	5	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Ferrous Iron	mg/L	0.05	-	10	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.22	1.29	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	0.001	-	5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	-	10	0.022	0.008	0.029	0.016	0.01	0.017	0.051	0.029	0.001	0.003	0.102	0.017
Mercury	mg/L	0.0001	-	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	-	0.05	0.002	0.009	0.015	0.007	0.003	0.002	0.002	0.003	0.011	0.011	0.008	0.004
Nickel	mg/L	0.001	-	2	<0.001	<0.001	0.001	0.001	<0.001	0.002	0.002	0.004	<0.001	0.001	0.002	0.001
Selenium	mg/L	0.01	-	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.001	-	0.1	<0.001	0.008	0.012	0.005	<0.001	0.001	0.01	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	-	0.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	-	5	0.005	<0.005	0.006	<0.005	0.005	0.007	0.005	<0.005	<0.005	0.008	0.016	<0.005
Nutrients																
Ammonia	mg/L	0.01	0.01	-	**0.14**	0.08	**0.92**	**0.22**	**0.13**	**0.17**	0.02	**0.38**	**0.54**	**0.26**	**8.19**	**0.56**
Nitrate as N	mg/L	0.01	0.05	-	0.02	<0.01	0.02	<0.01	<0.01	0.03	0.02	<0.01	<0.01	0.02	<0.01	<0.01
Nitrite as N	mg/L	0.01	-	-	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	--	-	0.02	<0.01	0.04	<0.01	<0.01	0.03	0.02	<0.01	<0.01	0.02	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	-	-	0.4	<0.1	0.8	0.7	0.2	<0.1	0.2	0.5	0.6	1	8.3	0.6
Total Nitrogen as N	mg/L	0.1	0.5	-	0.4	<0.1	**0.8**	**0.7**	0.2	<0.1	0.2	**0.5**	**0.6**	**1**	8.3	**0.6**
Reactive Phosphorus as P	mg/L	0.01		-	0.04	0.02	<0.01	<0.01	0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.04
Total Phosphorus as P	mg/L	0.01	0.05	-	**0.44**	**0.1**	**0.42**	**0.17**	0.43	**0.63**	<0.01	0.08	<0.01	0.08	0.21	0.07
Ion Balance																
Total Anions	meq/L	0.01	-	-	26.6	14.5	27.1	25.5	24.5	15.2	14.5	10.5	10.1	7.72	12.1	24
Total Cations	meq/L	0.01	-	-	28.3	14.8	29.4	27.4	26.4	13.8	13.5	10.5	9.21	7.43	11.2	21.8
Ionic Balance	%	0.01	-	-	3.12	0.74	4.15	3.56	3.74	4.62	3.65	0.27	4.59	1.91	4.04	4.89

1. Guideline values for irrigation beneficial use (identified as the only beneficial use for the connected groundwater aquifers.) are based on Australian Water Quality Guidelines for Fresh & Marine Waters – November 1992 (ANZECC) values which are the maximum concentration (mg/L) or contaminant in the irrigation water which can be tolerated assuming 100 yrs. of irrigation.
2. Exceedences to guideline values are bolded.
3. **718** for groundwater quality criteria
4. **0.05** inidcates exceedance for surface water quality criteria

Review of the groundwater quality results in comparison to the ANZECC (2000) agricultural guidelines, indicates that:

- pH from the collected samples ranges from 6.75 to 8.6 with all results within both guidelines limits;
- The Sodium Adsorption Ratio (SAR) is used to predict the potential for sodium to accumulate in the soil, if sodic water was in constant use. Majority of the site samples shows SAR level within the range of 3-9 which is suitable for irrigation with the exception of BH MB03_S which has shown elevated levels of SAR(Sodium Absorption Ratio).This result was not replicated in the adjacent boreholes and the cause of the elevated levels is not clear;
- All total dissolved metals concentrations measured are below guideline values; and
- Salinity, being a key constraint to water management and groundwater use, and can be categorised by Electrical Conductivity (EC). The EC obtained from the laboratory and field results for the three events were compared against the ANZECC (2000) Table 4.2.5 guideline for the main irrigated crops supplied by the Nogoa Mackenzie Water Supply Scheme based on Sunwater (2014) and cereal crops as advised by IMC. It is considered that wheat, sorghum, corn (grain and sweet) are the main constituents for cereal crops based on the ANZECC (2000) Table 4.2.5 guideline. The Average Root Zone Salinity Threshold was chosen to compare against the groundwater quality results. The main irrigated crops based on Sunwater (2014) are as follows:

  - Cotton;
  - Grape; and
  - Citrus comprising
    - Mandarin and Lemon (No salinity tolerance requirement provided in Table 4.2.5 ANZECC (2000) guidelines therefore was not included);
    - Orange ; and
    - Grapefruit (Not a main crop provided by Sunwater (2014) but has been considered from Table 4.2.5 ANZECC (2000) guidelines as it being a Citrus crop as requested by IMC).

  The Average Root Zone Salinity Threshold requirements for each crop based on ANZECC (2000) Table 4.2.5 guideline is as follows:

  - Cotton 7,700 µS/cm
  - Orange 1,700 µS/cm
  - Grape 1,500 µS/cm
  - Grapefruit 1,800 µS/cm
  - Wheat 6,000 µS/cm
  - Sorghum 6,800 µS/cm
  - Corn (Grain and Sweet) 1,700 µS/cm

  The comparisons were plotted accordingly and are provided on **Plates 6-a** and **6-b**;

A summary of the groundwater salinity levels in comparison against the Average Root Zone Salinity Threshold requirements provided by the ANZECC (2000) guideline show tolerable levels for boreholes MB02_S, TAR016_CR, TAR053, TAR176_C, TAR249_C and TAR040_C for laboratory and field testing results. The remaining boreholes being MB02_C, MB03_S, MB04_C, MB04_S, MB05_C and TAR189C show tolerable levels with respect to Cotton, Wheat and Sorghum threshold requirements but exceed threshold requirements for Orange, Grape, Grapefruit and Corn (Grain and Sweet) for laboratory and field testing results.

To address the above exceeded threshold requirements, it is proposed to release the groundwater from the Taroborah Coal Project site at a maximum rate of 2ML/day and diluted with some 160ML/day (supply rate) of water from Lake Maraboon. The dilution process will reduce the groundwater's salinity levels released from the site to lower levels allowing the Selma Channel to remain within threshold requirements. This analysis however does not take into consideration the integrity of the irrigation channel or existing crops along the channel or receiving environment, nor the quality and dilution from stormwater captured in the MWD before release.

Plate 6
Groundwater Salinity Test Results

a) Laboratory Test Results: Salinity Level at Taroborah Coal Project Site

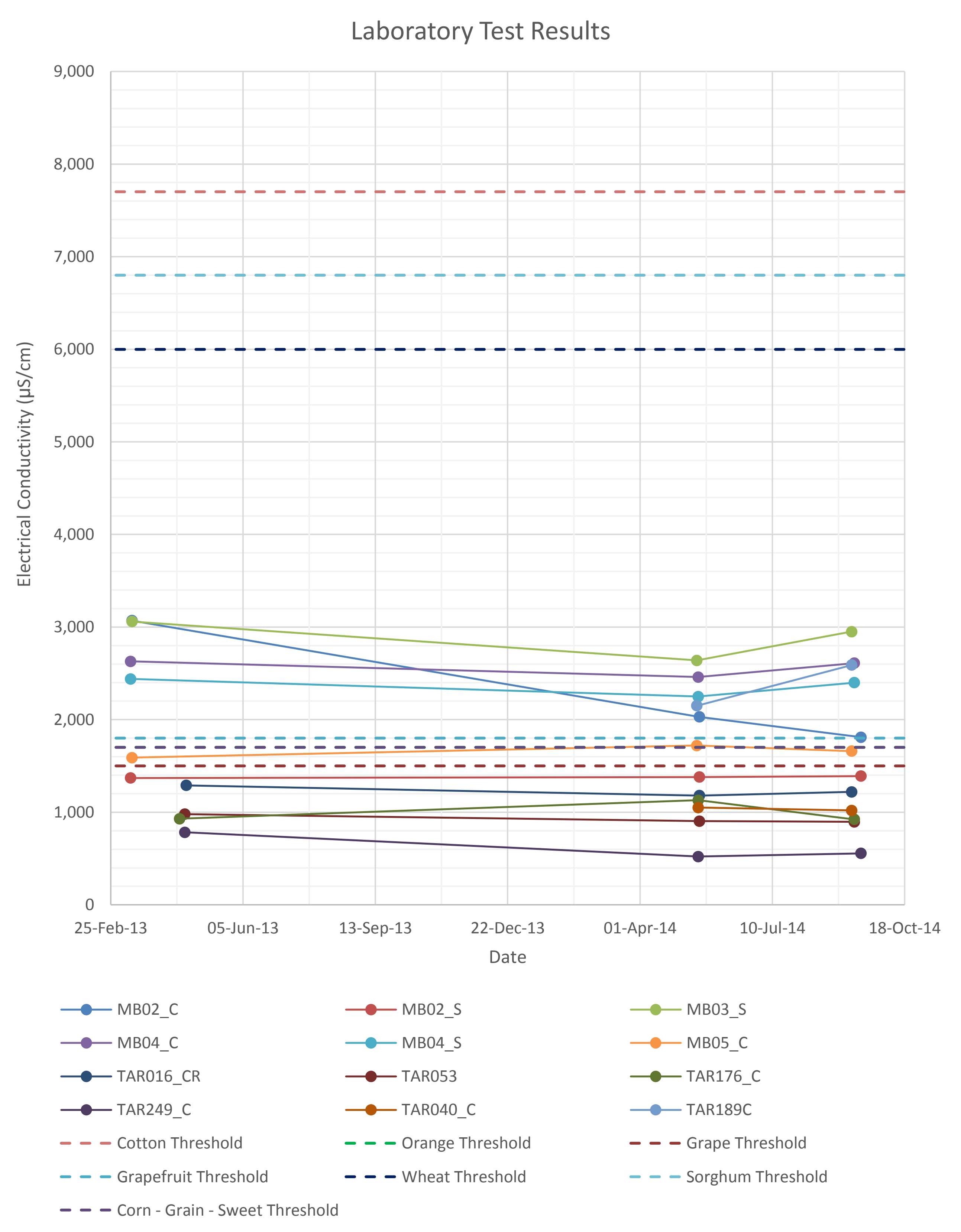
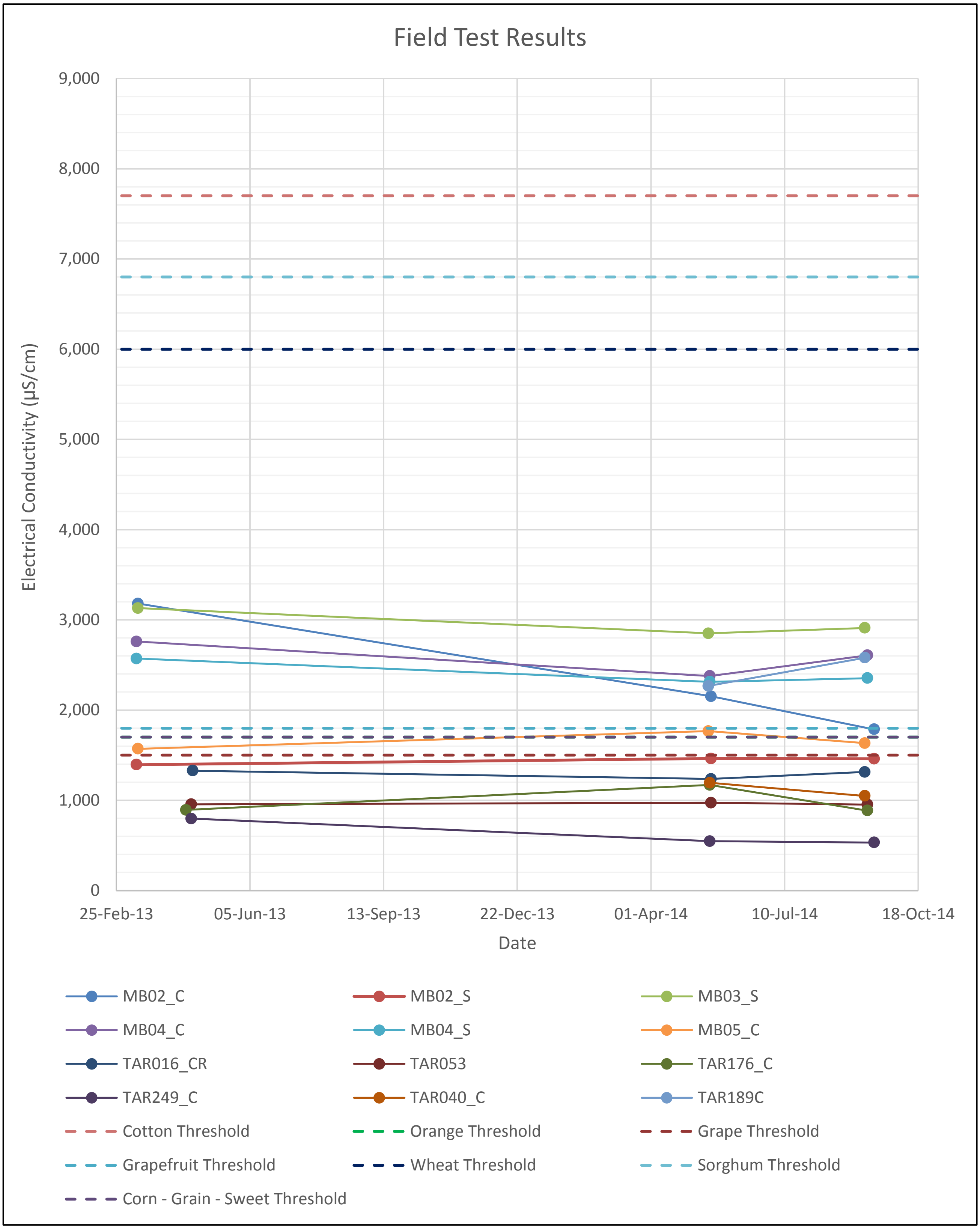


Plate 6 (Cont'd)
Groundwater Salinity Test Results

b) Field Test Results: Salinity Level at Taroborah Coal Project Site



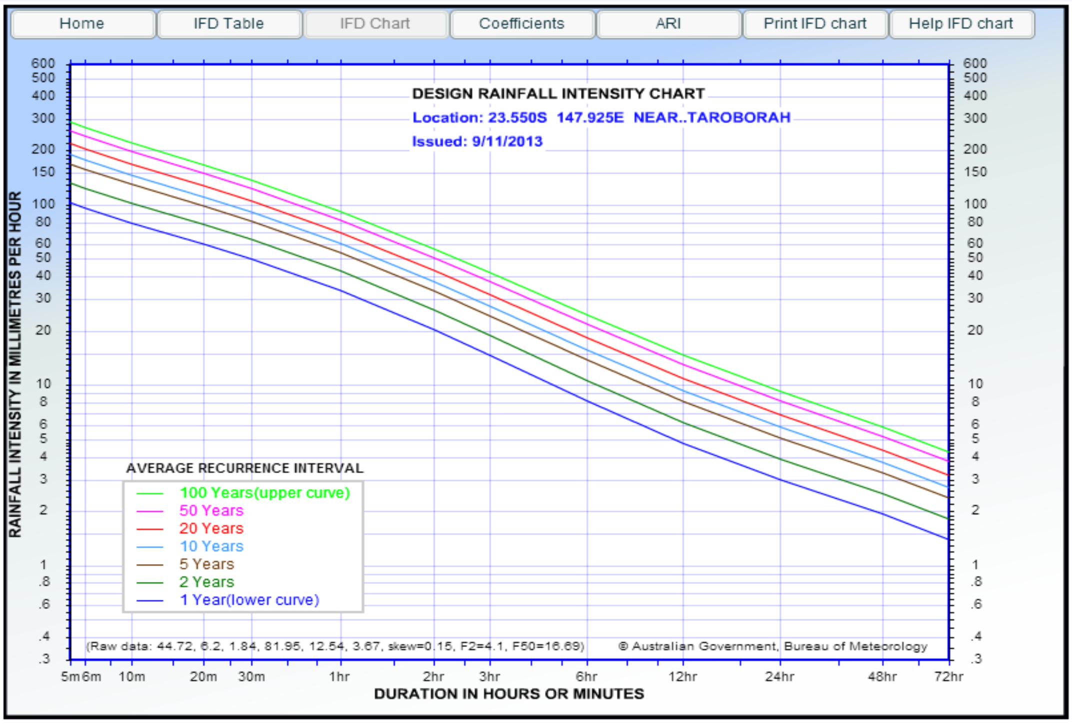
2.6 Design Rainfall Estimates

The design rainfall intensity-frequency-duration (IFD) curves for the Project are shown in **Table 3** and **Plate 7** below. The IFD curves were used to design site water collection drains for the specified locations for Annual Reccurrence Intervals (ARI's) of 100 years or less.

Table 3
Point Rainfall Intensities (mm/hr)
(Australian Rainfall Runoff(AR&R) - derived from BOM)

Duration	1 Year	2 years	5 years	10 years	20 years`	50 years	100 years
5 Mins	103	132	168	190	219	257	288
6 Mins	95.7	123	157	177	204	240	268
10 Mins	79.2	102	130	146	168	198	221
20 Mins	60.4	77.5	98.2	110	127	149	166
30 Mins	50	64.2	81	91	105	123	137
1 Hr	33.5	43	54.3	61	70.1	82.3	91.7
2 Hrs	20.3	26.1	33.2	37.4	43.2	50.8	56.8
3 Hrs	14.6	18.8	24.1	27.3	31.6	37.4	41.9
6 Hrs	8.17	10.6	13.8	15.7	18.3	21.8	24.5
12 Hrs	4.75	6.19	8.12	9.31	10.9	13	14.7
24 Hrs	2.99	3.89	5.09	5.85	6.84	8.18	9.24
48 Hrs	1.93	2.5	3.26	3.73	4.35	5.19	5.85
72 Hrs	1.39	1.81	2.37	2.71	3.16	3.78	4.26

Plate 7
Intensity Frequency Duration Curve For Taroborah Site



Additionally, the CRCFORGE method was used to determine the rainfall intensity of the catchments for storms with an ARI greater than 100 years. CRCFORGE is a regional analytical method for developing point rainfall estimates for Annual Exceedance Probabilities (AEP) less than 1%. CRCFORGE incorporates areal reduction factors to convert point rainfall estimates to catchment rainfall estimates. Output from the CRCFORGE (Queensland) Program is reproduced in **Table 4**.

Table 4
Point Rainfall Intensities (mm/hr)
(CRCFORGE)

Duration	200 years	500 years	1,000 years	2,000 years
15 min	223.6	257.2	283.9	311.8
30 min	161	185.2	204.5	224.6
1 hour	111.7	128.6	141.9	155.8
3 hours	49.09	56.48	62.34	68.46
6 hours	28.93	33.28	36.74	40.34
12 hours	17.09	19.66	21.7	23.83
18 hours	13.1	15.07	16.64	18.27
24 hours	10.83	12.45	13.75	15.1
48 hours	6.741	7.657	8.358	9.079
72 hours	4.919	5.595	6.107	6.633
96 hours	3.933	4.453	4.849	5.25
120 hours	3.322	3.748	4.072	4.394

3 FLOOD ASSESMENT

The proposed mine infrastructure is located in proximity to the Taroborah Creek floodplain and therefore a flood assessment was required to assess the impact of flooding of Taroborah Creek on the proposed infrastructure and mine plan. The flooding assessment can also be used as the basis for detailed design of site water management infrastructure. Results of the baseline flooding assessment were used to:

- locate site infrastructure areas and assess potential flood risks;
- determine flood bunds required to protect the mine pit; and
- identify any potential flood risk issues associated with site access or the transportation of coal across the site

3.1 Available Data

Sources of data that were used in this study include:

(a) Topographic maps
(b) Aerial photography
(c) Aerial survey (digital terrain model)

In 2008 and 2013, IMC commissioned Fugro Spatial Solutions Pty Ltd to conduct Aerial Photography, Digital Mapping and Orthoimagery surveys with ground control of a specified area around the Project site with an accuracy of +/- 30cm. The survey specification was to provide 1:25,000 scale colour aerial photography over the area, that were then used to produce digital topographic mapping and digital orthophotos.

The supplied survey data was used to generate a cross section representing the Taroborah Creek for input into the hydraulic modelling.

3.2 Watercourse Determination

A desktop assessment was completed on behalf of Shenhuo for three water features (Retreat Creek, Centre Creek and Taroborah Creek) within MDL467. The objective of the assessment was to determine which waterways within MDL 467 are considered watercourses as defined under the *Water Act 2000* (the Water Act).

Department of Natural Resources and Mines (DNRM) states that a watercourse as defined under the Water Act must have certain characteristics of a channel of a river, creek or other stream between the outer banks laterally and between upstream and downstream limits longitudinally. It does not include a drainage feature and must have flow that persists after rain has ceased. The determination has been made in accordance with current legislation and DNRM guidelines

Following this desktop assessment, the Department of Environmental and Heritage Protection (DEHP) has identified that Retreat Creek, Centre Creek and Taroborah Creek are the only features within MDL 467 that exhibit the characteristics of a watercourse as defined in the Water Act.

3.3 Catchment Hydrology

3.3.1 General

A hydrological model was developed to estimate peak flows and hydrographs for the streams in the Taroborah Creek catchment. Typically flow estimates require flood frequency analysis, regional regression analysis, or rainfall/runoff modelling. As there were no stream gauges located within the site and the catchment area is relatively large (i.e. approximately 160 km^2), rainfall/runoff modelling was undertaken to determine flows within the catchment. Rainfall/runoff modelling also permits the model to be modified to include mine infrastructure (dams, drains, increased impervious area, etc.) to demonstrate the impact of mine development on flood events within the catchment and assess the effectiveness of mitigation measures.

3.3.2 Methodology

XP-RAFTS software was selected to undertake the rainfall/runoff modelling. XP-RAFTS is a rainfall runoff model which determines catchment flows based on Laurenson's non-linear reservoir routing method. XP-RAFTS is similar to other commercially available programs such as URBS and RORB, and is widely used for catchments of this nature. The catchment delineation for XP-RAFTS was determined from a review of available survey data and aerial photography.

Sub-catchments within the XP-RAFTS model are described by specifying values for the following:

- Size and slope of the catchments;
- Catchment roughness (PERN value); and
- Level of development (fraction impervious).

XP-RAFTS utilises a graphical interface in which sub-catchments and creeks and drains are interconnected to represent the catchment and stream network. Input parameters are separated into catchment specific data and global parameters. Global parameters were populated in conjunction with AR&R, Institute of Engineers, 2013. These parameters include initial and continual rainfall loss, and Manning's roughness coefficient (n). Individual sub-catchment specific parameters were determined using GIS tools and include catchment size, vectored slope and fraction impervious. The model was verified with Rational Method and the results summarised for input into the hydraulic model.

3.3.3 Selection of Design Rainfall Condition

The adopted design rainfall condition utilised in the flood assessment is the 1,000 year ARI flood event chosen based on DEHP (2012) design criteria and the (Probable Maximum Precipitation) PMP event was selected for the flood protection design of the final void.

The method of locating major infrastructure that was considered to influence/impact flood flows (ie out of pit spoil dumps and final void/s) for the project was such that they were located outside the inundation area of the 1,000 year flood. As the layout of the out of pit spoil dumps and final void were configured to not impact on the 1 in 1,000 year flood event, additional analysis of design events less than 1,000 year ARI were not included as a part of this flood study.

The Generalised Short Duration Method (GSDM) was used to determine the rainfall depth for the 0.5 hr, 1.0 hr, 3.0 hr, 4.5 hr. and 6.0 hr. durations.

The 1,000 year ARI rainfall depth was adopted based on DEHP (2012), with rainfall data sourced from CRCFORGE and used to determine peak discharges for the design event. The critical duration was determined to be 1.5 hours for the site and was used to provide the peak discharge for the 1,000 year ARI. The flow from this event was compared to the Rational Method for verification.

The 1,000 year rainfall depth and the PMP depths for the Taroborah catchment are shown below in **Table 5**.

Table 5
Rainfall Depth (mm)

Rainfall Event	1,000 year ARI (mm)	PMP (mm)
0.5 hr	102	190
1.0 hr	142	280
3.0 hr	187	410
4.0 hr	n/a	470
6.0 hr	220	530

3.3.4 Temporal Patterns for Design Rainfalls

Temporal distributions for each model were derived using pluviograph traces recorded for major Australian storms as referenced from the Estimation of Maximum Probable Precipitation as described in Australian Generalised Short Duration Method (GSDM). GSDM offers guidance in estimating probable maximum precipitation for durations up to three or six hours in Australia for large or extreme events.

3.3.5 Design Rainfall Loss Rate (Infiltration)

Selection of design loss rate has a significant impact on the estimation of the final design flood. XP-RAFTS include a loss model to account for rainfall losses as an initial loss followed by continuing loss. The loss parameters for events with recurrence interval greater than 1 in 500 years were derived from AR&R (2013) Book IV: *Estimation of Large and Extreme Floods*. An initial loss of 1 mm and continuing loss of 0 mm were adopted in the model.

3.3.6 Design Flow

The 1,000 year ARI rainfall depth was adopted based on DEHP (2012), with rainfall data sourced from CRCFORGE and used to determine peak discharges for the design event. The critical duration was determined to be 1.5 hours for the site and was used to provide the peak discharge for the 1,000 year ARI. The flow from this event was compared to the Rational Method for verification.

3.4 Hydraulics

Hydraulic modelling was undertaken in order to assess hydraulic properties and characteristics of Taroborah Creek. HEC-RAS (USACE, 2011) was selected to complete the hydraulic modelling. HEC-RAS is a one-dimensional steady state hydraulic model capable of analysing natural channels and hydraulic structures such as culverts. Hydraulic modelling was performed for the “existing” case.

3.4.1 Roughness

Roughness values were defined across the HEC-RAS grid based on land use identified from aerial photography and site assessment. The applied Manning's n values are shown in **Table 6.**

Table 6
Roughness Values

Description	Range of Roughness Values (Manning's 'n')
Channel	0.03 - 0.035
Riparian Zone	0.04 - 0.08

3.4.2 Boundary Conditions

To define the boundary conditions, it was assumed that the river flows under "uniform flow" conditions at the downstream boundary i.e. an energy slope. This assumption was necessary to allow HEC-RAS to calculate the flow depth using Manning's Equation.

3.5 Baseline Flooding Results

3.5.1 Flood Extents

The estimated flood extent and depths for the 1,000 year ARI, 90 minutes critical and the PMP (determined to have an AEP of 10^{-7}) based on AR&R (2013) duration flood events are shown in **Figure 3** and **Figure 3A** respectively.

3.5.2 1,000 Year Flood Extent

The 1,000 year ARI flood extents of the Taroborah Creek are largely uncontained, overflowing to the high flow creek channel running east to west through the MDL area. Taroborah Creek overflows to the north-east towards the proposed open-cut mine pit. The flood extents are shown in **Figure 3**.

As described in Section 3.3.1, the existing scenario for the 1,000 year ARI flood extents was used to relocate the major infrastructure of the site away from the inundation area. This approach met the DEHP guideline (2012) criteria and therefore the post development scenario and design events less than the 1,000 year ARI were considered unnecessary as a part of this study as these conditions were not impacted by the proposed development.

3.5.3 PMP Flood Extent

The PMP flood modelling indicates that the inundation level near the void entrance/ramp is at RL 220 m. Assessed against the void entrance level at approximately RL 224 m, as shown on **Figure 3A,** demonstrates that the final void will not be inundated subject to the PMP flood event as modelled and therefore it is considered that no additional flood mitigation measures will be required around the void entrance.

4 STORMWATER MANAGEMENT SYSTEM STRATEGY PROPOSAL AND DESIGN CRITERIA

The key objective with respect to stormwater management is to limit release of impacted water from the site to the extent that the historical users and environmental values of the receiving environment are not detrimentally impacted. Stream flows likely to be encountered in conjunction with the Project can be characterised as follows:

Clean Water - Stormwater occurring around the Project area, but not contacting active mining/operating areas.

Site Water - All water generated from disturbed site areas and associated operating surfaces within the Project area. This includes groundwater that reports to the mine pits.

Typical sources and characteristics, and the philosophy for handling these water types in the context of a stormwater management strategy for the Project are as follows:

- Clean water is to be diverted around mining/operating areas for discharge via effective hydraulic controls directly to receiving waters. It was assumed that the management objective for the Project does not include capture or harvest of clean water.

- Site water is to be managed in relation to the condition of the surface or source from which the water is generated. Several site water sources will typically exist as described below:

  (i) Site water runoff from infrastructure areas (such as power facilities, benign bare earth surfaces, workshops, hydrocarbon storages or exposed engineered surfaces). The management objective for this water type is containment at site using storage dams.

  (ii) Site water runoff from mining areas including non-acid forming (NAF) waste rock material and groundwater inflows. This runoff stream is to be managed such that it is captured in the first instance and subject to long term water quality testing, subsequent release to the receiving environment may occur, with the expected water quality issue related to suspended sediment.

4.1 Water Management Strategy

The water management strategy with respect to both clean water and site water is as follows:

(i) Clean Water Management

Diversion drains are proposed around the site infrastructure area to intercept and transport the clean water away from the disturbed areas of the Project site. The clean water catchment will not be harvested and will be diverted away from the Project site, connecting to the natural downstream tributaries.

(ii) Site Water Management

The water management objective relating to the proposed infrastructure and mining areas which include the ROM pad, CHPP, Mine Infrastructure Area (MIA), out of pit waste rock dump area and open cut pit, is for the capture and containment of runoff from these surfaces. It is proposed to contain this stormwater in a storage dam or a sediment pond and reuse this stored water as part of the mining and processing water circuits. The outflow from the sediments dams are pumped into the CPPWRD

4.2 Proposed Water Management Infrastructure Requirements

Based on the proposed site layout and in accordance with the objectives outlined in **Section 4.1**, with particular consideration to separating clean water from mine-impacted water, the following infrastructure requirements are proposed:

- Clean water drains and protection bunds along the north of the site adjacent to Capricorn Highway and to the east of the site;
- Two sumps, east sump and west sump to capture clean water and pump the clean water downstream of the Project site into Taroborah Creek system;
- Site water collection drains around the perimeter of the Project site;
- Infrastructure area which discharges to a sediment dam;
- A discharge pump and sump system in each pit which transfers water from each pit to the Mine Wastewater Dam (as required);and
- Site water collection drains around the perimeter of the out of pit spoil dumps with flow discharged into associated sediment dams.
- CPP Water Recycle Dam

The conceptual layouts and locations of each of these storm water management components (subject to the development timeline of the Project) are shown on **Figures 4** to **7**.

4.3 Design Criteria for Clean Water Management

4.3.1 Clean Water Drains and Protection Bunds

A key element of the proposed water management system is the separation of runoff from undisturbed and disturbed areas.

Clean water diversion drains and bunds capture runoff from undisturbed land and divert the flow around mining operations to minimise mixing with any mine impacted water, thereby reducing the total amount of runoff requiring containment within the site water management system.

Although not considered as regulated structures, clean water diversion drains and bunds are designed to accommodate a 1 in 1,000 year peak flow event. This criterion has been adopted as clean water diversion drains are required to protect the open pit and associated underground mine works from local overland flow inundation.

The natural stormwater runoff from catchment areas located adjacently to the north of the Capricorn Highway and flowing southerly to the Taroborah Coal Project site via culverts beneath the highway and railway line will be diverted around the mine site area by protection bunds located south of the railway line. The protection bunds' base surface is to be graded at a suitable topographical grade to avoid ponding areas or potential back water flow to the culverts located upstream. The diversion bunds are to be constructed to flow to the western side of the MIA area and into the existing drainage line to Taroborah Creek.

4.3.2 Pump and Sump Sizing

Temporary bunds, sump and pump arrangements are proposed as interim/temporary measures to capture and divert clean water which would otherwise enter the pit during the initial years of pit development, as shown on **Figures 4** to **6.** The capacity of the pump is proposed to be 100 l/s and shall be discharged into the proposed clean water drains and subsequently flow into existing natural watercourses. Using pump capacity, the sump capacity can be sized to achieve the appropriate spill/containment risk.

4.4 Design Criteria for Site Water

4.4.1 Performance Criteria for Site Water Management System

The performance of the stormwater management system identified above is based on the capacity of the proposed water dams Mine Wastewater Dam (MWD), CPP Water Recycle Dam (CPPWRD) and 7 sediment dams to contain site water with minimal discharge to the environment. Containment criteria for the storages are detailed below.

4.4.2 Performance criteria

According to the DEHP *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (2013)* as well as the EA, key criteria relevant to regulated structures relates to accommodating a design storage (wet season containment) allowance, being referred to as DSA. The DSA is to be available for each storage as at 1st November of each year. Containment criteria for the structures identified in **Section 4**, are as follows:

High Consequence	-	accommodate a 1 in 100 AEP event (wet season) as a minimum requirement, equivalent to a 1% spill probability.
Significant Consequence	-	accommodate a 1 in 20 AEP event (wet season) as a minimum requirement, equivalent to a 5% spill probability.

Conservatively, containment criteria related to 'Significant' regulated structures in the Taroborah Coal Project site was based on the following design criterion:

Significant Consequence	-	accommodate a 1 in 100 AEP event (wet season) as a minimum requirement, equivalent to a 1% spill probability.

4.4.3 Regulatory Context

The basis for the determination of performance criteria for the Taroborah water management structures has been adopted from the DEHP guidelines: *Manual for Assessing Consequence Categories and Hydraulic Performance of Structure*s (2013). The purpose of the consequence assessment as detailed in DEHP (2013) is to assign to all structures a "consequence category" based on three failure scenarios, as follows:

- *Failure to contain - overtopping scenario,*
- *Failure to contain – seepage scenario (it is noted that this scenario assessment is not relevant in the consequences assessment for the flood bunds/levees.*
- *Dam-Break scenario.*

The consequence assessment based on DEHP (2013), provides an assessment category of High, Significant or Low for the scenarios identified above. An assessed category of High or Significant for a structure will result in the structure being classified as 'Regulated' with applicable performance criteria applied based on DEHP (2013).

4.4.4 Consequence Category Criteria

Based on the failure scenarios as outlined in **Section 4.4.3**, several modes of failure are possible and each failure mode has been considered separately. The scenarios and failure modes are discussed in greater detail in **Appendix B**.

A failure to contain scenario means a release from the structure that result from loss of containment due to excessive seepage, overtopping of the structure and/or other deficiencies in water management of the structure. Although they are typically non-flood producing, failure to contain events may involve the release of contaminants, which could endanger environmental values or human life.

A dam break scenario encompasses the collapse of a dam due to any possible cause. A dam break is typically flood producing, involving the rapid release of significant volumes of contaminants, which could endanger environmental values or human life. An embankment dam break could take place via the following failure modes:

- Spillway failure;
- Erosion-induced stability failure of embankment from flooding;
- Piping failure of embankment; and
- Static or seismic stability failure.

The consequence category to be applied for a structure is the highest category determined under the failure event assessments. The consequence categories for the storage structures at Taroborah was assessed to be of 'High' and 'Low' consequence in accordance with the criteria outlined in DEHP (2013).

4.4.5 Consequence Assessment

A brief review of the potential harm, associated with failure-to-contain or dam break scenarios, for each of the proposed storage structures, has been assessed based on assumed/expected water quality conditions as advised by IMC , and summarised as follows:

- The MWD assessment was based on storage of groundwater inflows and in-pit spoil run-off pumped from the open-cut and underground mines, with major deterioration of the receiving environment expected to occur, subject to a release of contained site water runoff generated from the MWD.
- Waters stored in the CPPWRD are expected to comprise recovered process water from the CPP and site water runoff stored at sediment basins, with the release of contained site water from WRD having the potential to cause major deterioration of the receiving environment. The CPPWRD dam will also store site water transferred from the MWD (as capacity allows).
- Sediment Dam 1 (SED 01) is expected to receive runoff from the Product Coal stockpile area and some upstream catchment runoff. Sediment Dam 2 is located to the east of Sediment Dam 1 and is expected to receive runoff from the CPP area and OM coal pad which is expected to contain PAF material (EGI, 2012). Both dams will operate with continuous pumping into the CPPWRD and is expected to cause minor deterioration with the release of contained site water due to the minor storage volume contained.
- Storage in Sediment Dam 3 (SED 03) is expected to comprise surface runoff from the Mine Infrastructure Area (MIA), fuel bay and maintenance wash bay with continuous pumping for release into CPPWRD is expected to cause minor deterioration with the release of contained site water due to the minor storage volume contained.
- Sediment Dam 4 (SED 04), Sediment Dam 6 (SED 06) and Sediment Dam 7 (SED 07) are expected to comprise surface runoff from the out-of-pit spoil dumps at the Project site. These dams are expected to cause minor deterioration with the release of contained site water due indication that most of the overburden and interburden tested to date at Taroborah is likely to be NAF.(EGI,2013)
- Storage in Sediment Dam 5 (SED 05) is expected to comprise Underground ROM Stockpiles, fuel stores and wash down bay with continuous pumping to CPPWRD is expected to cause minor deterioration with the release of contained site water due to the minor storage volume contained.

Based on the above information, each proposed containment structure has therefore been assigned a consequence category as tabulated in **Table 7**. The detailed assessment for the storage dams, as per the DEHP guidelines (2013), is attached in **Appendix B**.

Table 7
Consequence Assessment Summary

Structure	Assigned Consequence			Containment Criteria (based on overtopping consequence category)	Regulated Dam(Y/N)
	Failure To Contain-Seepage	Overtopping	Dambreak		
MWD	LOW	HIGH	SIGNIFICANT	1 in 100 year AEP	Y
CPPWRD	LOW	HIGH	HIGH	1 in 100 YEAR AEP	Y
Sediment Dam 1	LOW	LOW	LOW	N/A	N
Sediment Dam 2	LOW	LOW	LOW	N/A	N
Sediment Dam 3	LOW	LOW	LOW	N/A	N
Sediment Dam 4	LOW	LOW	LOW	N/A	N
Sediment Dam 5	LOW	LOW	LOW	N/A	N
Sediment Dam 6	LOW	LOW	LOW	N/A	N
Sediment Dam 7	LOW	LOW	LOW	N/A	N

4.4.6 Water Management Sizing/Containment Criteria

Based on the above assessment and in accordance with DEHP (2013), the determination of a Design Storage Allowance (DSA) is required for all regulated structures. Storage analysis based on 'high' consequence was adopted to calculate an approximate storage at site for containment to minimise the impact on the operations and environment to an acceptable risk as discussed with Shenhuo. In addition, and based on ANCOLD (DEHP, 2013), the considered appropriate design capacity for the emergency spillway is to pass a peak flood from the 1 in 1,000 year Annual Exceedance Probability (AEP).

4.4.7 Site Water Collection Drains

Site water collection drains/bunds will be formed to intercept site water generated from disturbed surfaces and facilitate their drainage to containment structures such that the risk of discharge to receiving water is minimal. As such, the design of all site water collection drains and bunds should be to accommodate a 100 year ARI event of critical duration. Site water drains are to be located around the perimeter of possible contaminant spillage (such as hydrocarbons), with effective capture and transport of site water to the proposed collection points required.

The target maximum flow velocity within bunds and channels of 1 m/s is proposed to minimise drain/bund armouring requirements.

5 SITE WATER MANAGEMENT

5.1 Initial Storage Sizing

Initial storage requirements were assessed based on the consequence assessment criteria in **Section 4.4,** using the Method of Deciles inclusive of mean groundwater inflow and higher risks sediment dam inflows to the CPPWRD. The DSAs for each regulated structure are outlined in **Table 8**.

Table 8
Minimum Design Storage Requirement for Regulated Structures

Regulated Structure	Containment Criteria	Equivalent Rainfall(mm)	Contributing Catchment (ha)	Minimum Design Storage Allowance (ML)
MWD	1 in 100 year AEP	1,200	22.1	577#
CPPWRD	1 in 100 year AEP	1,200	32.7	392*

This value includes 312 ML of groundwater inflow that will be concurrently transferred to this dam from mine workings.
* The direct contributing catchment for the CPPWRD is 11.9 ha. The proposed DSA for CPPWRD includes the process plant catchment area of 20.8 ha which is proposed to be captured within SED01 and SED02 and subsequently pumped into CPPWRD to ensure full containment of contaminated water.

The adopted storage sizing for the non-regulated structures was based on a 1 in 10 Year AEP, 72 hour duration design criteria. The evaluated storage requirements for the non-regulated structures are outlined in **Table 9**.

Table 9
Minimum Design Storage Requirement for Non-Regulated Structures

Structure	Adopted Storage Criteria	Equivalent Rainfall (mm)	Contributing Catchment (ha)	Proposed Storage (ML)
SED 01	1 in 10 year AEP, 72 Hour	142.9	3.9	6 ML
SED 02	1 in 10 year AEP, 72 Hour	142.9	16.9	24 ML
SED 03	1 in 10 year AEP, 72 Hour	142.9	18.9	27 ML
SED 04	1 in 10 year AEP, 72 Hour	142.9	40.3	58 ML
SED 05	1 in 10 year AEP, 72 Hour	142.9	7.6	11 ML
SED 06	1 in 10 year AEP, 72 Hour	142.9	16.9	24 ML
SED 07	1 in 10 year AEP, 72 Hour	142.9	38.6	55 ML

5.2 Water Balance Model

5.2.1 Preface

The specific objective of the modelling was to assess containment capacity and minimise release of potentially mine-impacted site water, complying with the criteria as outlined in **Section 4.0,** by the appropriate sizing of site water management elements, as well as to manage the quantity of water captured on the project site. Additionally, water balance modelling was conducted to estimate the extent to which the required mine dewatering and the capture of overland flow

from related catchments can meet construction and operational water demands for the Taroborah Coal Project site.

5.2.2 Site Water Requirements

Water requirements on the mine site will vary over the life of the operation. Water use during construction and for open-cut operations will mainly comprise dust suppression and coal preparation. Ablutions will be produced from a potable water treatment plant. Climatic factors will also play a significant role in water requirements for dust suppression and will be assessed on a year to year basis. Water use for underground operations will mainly comprise equipment operational needs and dust suppression. Operational water needs will be preferentially sourced from the on-site storages (dirty), as well as surface and groundwater flows reporting to the open cut pit and underground workings. Groundwater inflow based on the groundwater report by AGE (AGE, 2014), dust suppression demand and operation water input is shown in **Appendix A**, Table 2. A 200 kL water storage tank and Potable Water Treatment Plant for the generation of potable water on site has been included in this assessment.

5.2.3 Pit Water Management

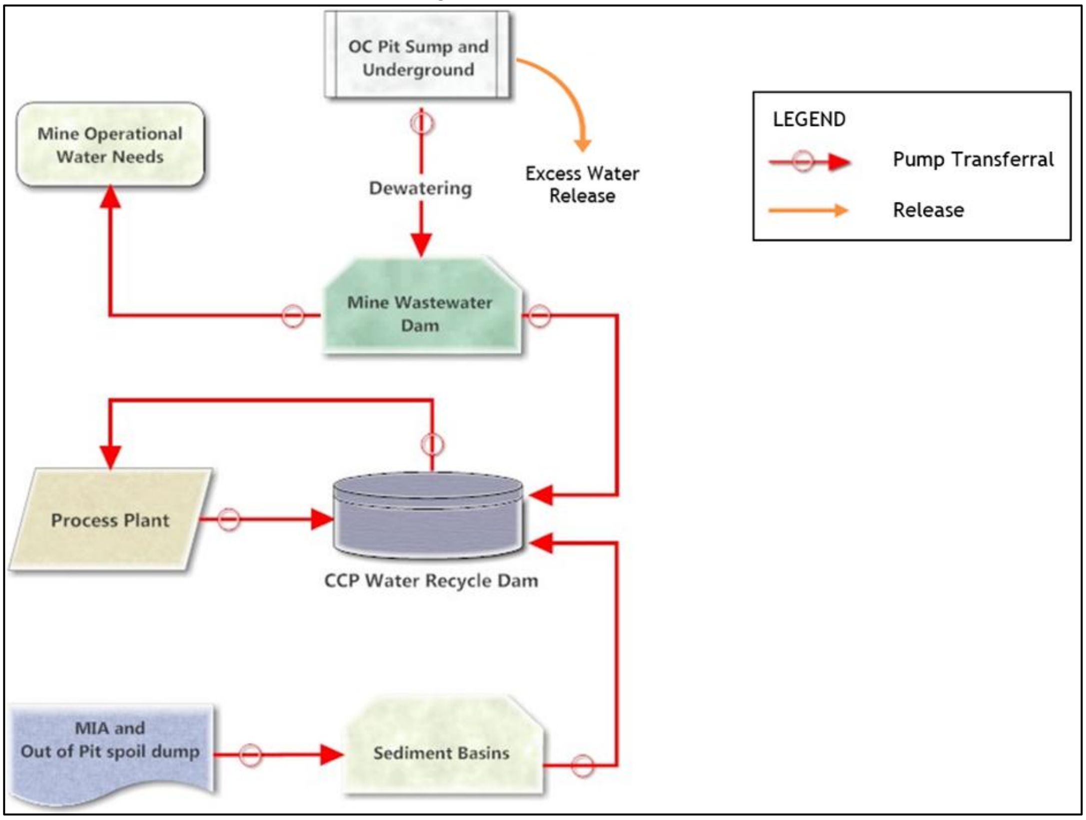
Pit inflow water which is the accumulation of both rainfall and groundwater inflow will be pumped to the MWD constructed to the west of the pit. The water contained within the MWD will be used primarily for dust suppression around the Project site or further pumped to the CPPWRD to be used for process water.

5.2.4 Model Structure

A dynamic probabilistic simulation modelling approach, utilising the program Goldsim Pro, was adopted for the water balance model based on a daily climatic record for the site. An integrated catchment yield analysis for the site water catchments was also coupled with the water balance model.

The key elements of the site water balance model are described in **Section 4**, with a process flow diagram representing the model shown in **Plate 8**.

Plate 8
Process Flow Diagram for Site Water Balance Model



The water balance model extends from July 2018 to December 2038 to incorporate the 21 year project life. Rainfall sequences adopted for model ling therefore comprised a 192-month window extracted for the 123 years of available data to generate 102 iterations.

5.2.5 Model Data Input

Data inputs for the Project water balance model are summarised below.

5.2.5.1 Climate Data Inputs

Input data adopted for the water balance model are summarised in **Table 10**. Rainfall and evaporation data input were sourced from SILO data drill from the period of 1889 to 2013. The water balance model is modelled for all climatic conditions ranging from minimum, mean and maximum climatic conditions in the form or percentiles ranging from 5% to 95 % of the WMP. The 20th percentile year represents a dry year, the 50th an average year and the 80th a wet year. The graphs presenting the maximum daily rainfall of 5%, 20%, 50%, 80% and 100% percentile that has been applied to the Water Balance Model is shown in **Appendix A**.

Table 10
Site Water Balance - Base Data

Model Parameter	Available Data	Data Source	Comments
CLIMATE DATA			
• Rainfall	Daily rainfall for period 1889 to 2013	SILO Data drill for Emerald site location.	
• Evaporation	Average monthly Class A Pan evaporation data.	SILO Data drill for Emerald site location.	Evapotranspiration data based on Class A Pan. Evaporation data, taken as representative of open-water evaporation.

5.2.5.2 *Catchment Elements Input*

Modelling conditions applying to key elements are detailed in **Table 11**, based on conditions described in **Section 4.**

Table 11
Summary of Modelling Conditions

Proposed Site Water Management Elements	Component	Adopted Modelling Condition
Mine Wastewater Dam (MWD)	Full Supply Level Storage (ML)	1,077 *
	Contributing Catchment(ha)	22
Water Recycle Dam (CPPWRD)	Full Supply Level Storage (ML)	832 *
	Contributing Catchment(ha)	11.9
• Pit Sump(UG MINE Portal)	Full Supply Level Storage (ML)	20
• Void Sump(Final Pit)	Contributing Catchment(ha)	*varies based on mine development
SED 01	Full Supply Level Storage (ML)	6
	Contributing Catchment(ha)	3.9
SED 02	Full Supply Level Storage (ML)	24
	Contributing Catchment(ha)	16.9
SED 03	Full Supply Level Storage (ML)	27
	Contributing Catchment(ha)	18.9
SED 04	Full Supply Level Storage (ML)	58
	Contributing Catchment(ha)	40.3
SED 05	Full Supply Level Storage (ML)	11
	Contributing Catchment(ha)	7.6
SED 06	Full Supply Level Storage (ML)	55
	Contributing Catchment(ha)	38.6
SED 07	Full Supply Level Storage (ML)	24
	Contributing Catchment(ha)	16.9

Table 11 (Cont'd)
Summary of Modelling Conditions

Proposed Site Water Management Elements	Component	Adopted Modelling Condition
Transfer Systems		
Open Cut Pit to MWD	Transfer Capacity	100 l/s
SED 01 to CPPWRD	Transfer Capacity	10 l/s
SED 02 to CPPWRD	Transfer Capacity	50 l/s
SED 03 to CPPWRD	Transfer Capacity	30 l/s
SED 04 to CPPWRD	Transfer Capacity	10 l/s
SED 05 to CPPWRD	Transfer Capacity	20 l/s
SED 06 to CPPWRD	Transfer Capacity	10 l/s
SED 07 to CPPWRD	Transfer Capacity	10 l/s
MWD to CPPWRD	Transfer Capacity	50 l/s
Average Mine Operational Requirements		As provided in **Appendix A**
Mean Groundwater Inflow		As provided in **Appendix A**
Potable water		200Kl/day

*The storage capacity for the dams were derived as part of the modelling process to achieve an acceptable spill risk in consultation with IMC.

5.2.5.3 Operating Priorities

The water balance model process is based on "priorities" assigned to each make-up water supply source, with these priorities identifying the sequence by which site water is recovered from specific storages and diverted into the operating system.

Priority 1 CPP-Water Recycle Dam

Priority 2 Mine Wastewater Dam

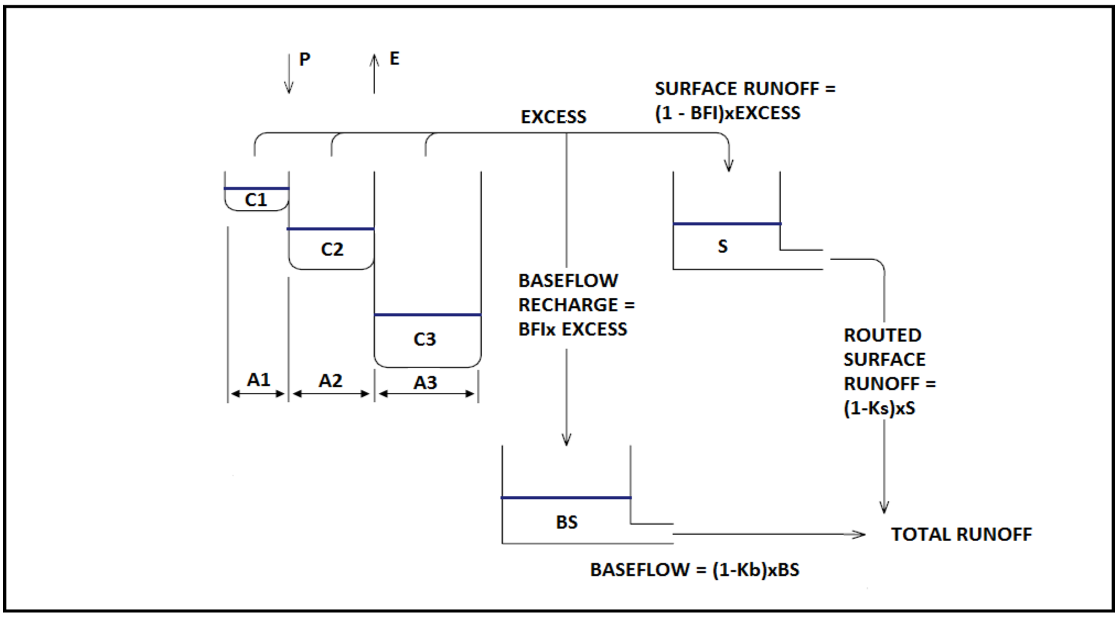
Assumptions made in the Goldsim model are as follows:

- All sediments dams are designed to hold a 10 year 72 hour ARI design criteria,
- All storage dams are assumed to be empty at the commencement of the model.
- For the conceptual water balance model, a pit sump with a total (minimum) storage capacity of 20ML is proposed at site, notwithstanding that two or more sumps will be built at different locations with reduced capacity during operation. The inflow into the proposed sump will be pit groundwater flow and catchment runoff from the pit area and in-pit spoil dump face.
- The in-pit-spoil in the open-cut and the out of pit spoils dump is assumed to be progressively rehabilitated and re-vegetated with the runoff allowed to flow naturally toward Taroborah Creek when the spoil dumps and the in pit spoil is fully rehabilitated (assumed 1 year to full rehabilitation).

5.2.6 Catchment Runoff Estimation

The Australian Water Balance Model (AWBM) was utilised to simulate daily runoff from rainfall generated within the various sub-catchment types that are present on the Project site. **Plate 9** represents a schematic of the AWBM model, reproduced from Boughton (2009).

Plate 9
Schematic of AWBM Rainfall-Runoff Model



Where:
P = Precipitation
E = Evapotranspiration
C1 - C3 = Surface Storage Capacities
A1 - A3 = Partial Areas Represented by Surface Storages
BFI = Baseflow Index
K_b = Daily Baseflow Recession Constant
BS = Current Volume in Baseflow Store
K_S = Daily Surface Flow Recession Constant
S = Current Volume in Surface Store Routing

The catchment types and AWBM model parameters used to simulate these different catchment types and the average yields from these catchment areas are summarized in **Table 12.** Model parameters have been selected based on experience with similar water balance model studies, and are considered to be conservative in the context of this un-calibrated model.

Table 12
AWBM Model Parameters

AWBM Parameters	Split Areas (sum=1.0)			Storage Capacities (mm)			Ks (day-1)	BFI	Kb (day-1)
	A1	A2	A3	C1	C2	C3			
Natural	0.134	0.433	0.433	12	120	250	0.2	0.1	1
Hardstand	1	0	0	5	5	5	0.1	0	1
Waste	0.2	0.8	0	10	150	150	0.2	0.1	1
Open Cut	0.1	0.9	0	5	20	20	0.2	0.1	1
Stockpiles	0.1	0.9	0	5	50	50	0.2	0.1	1

5.3 Water Balance Modelling Results and Interpretation

5.3.1 Model Output

Outputs from the water balance model are summarised in **Plate 10** for the MWD and **Plate 11** for the CPPWRD in the form of storage volume percentiles, over the respective modelling period, with the maximum, mean and minimum conditions also shown.

Plate 10
MWD Water Balance Model Output
(Storage Capacity by Volume)

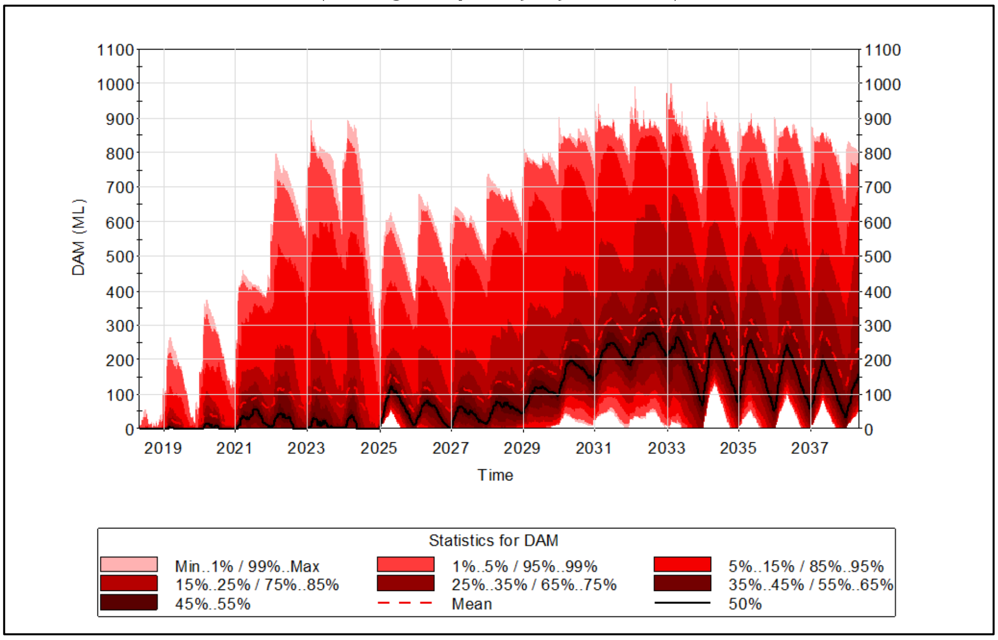


Plate 11
CPPWRD Water Balance Model Output
(Storage Capacity by Volume)

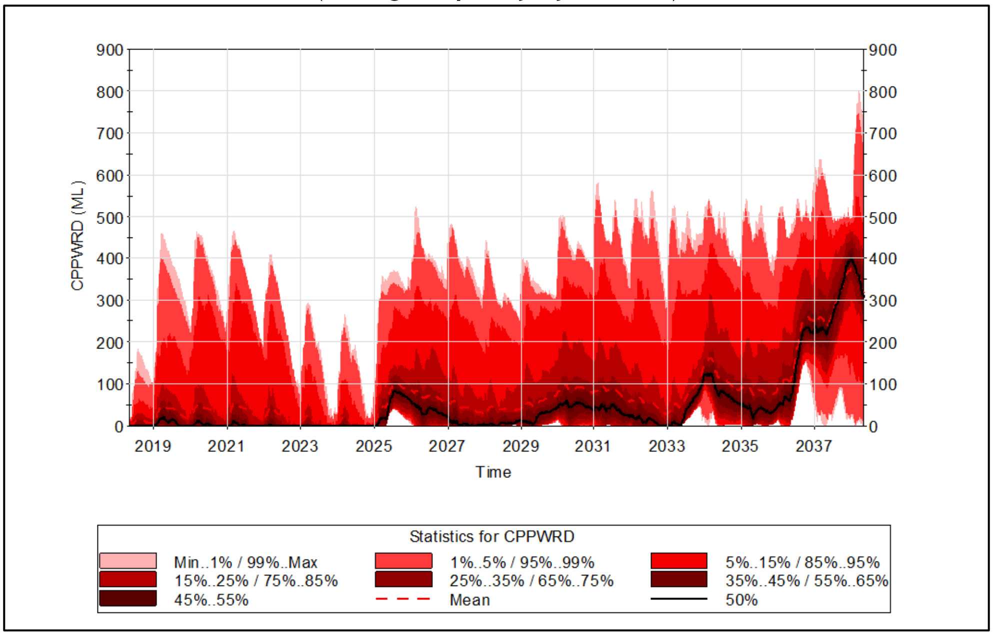
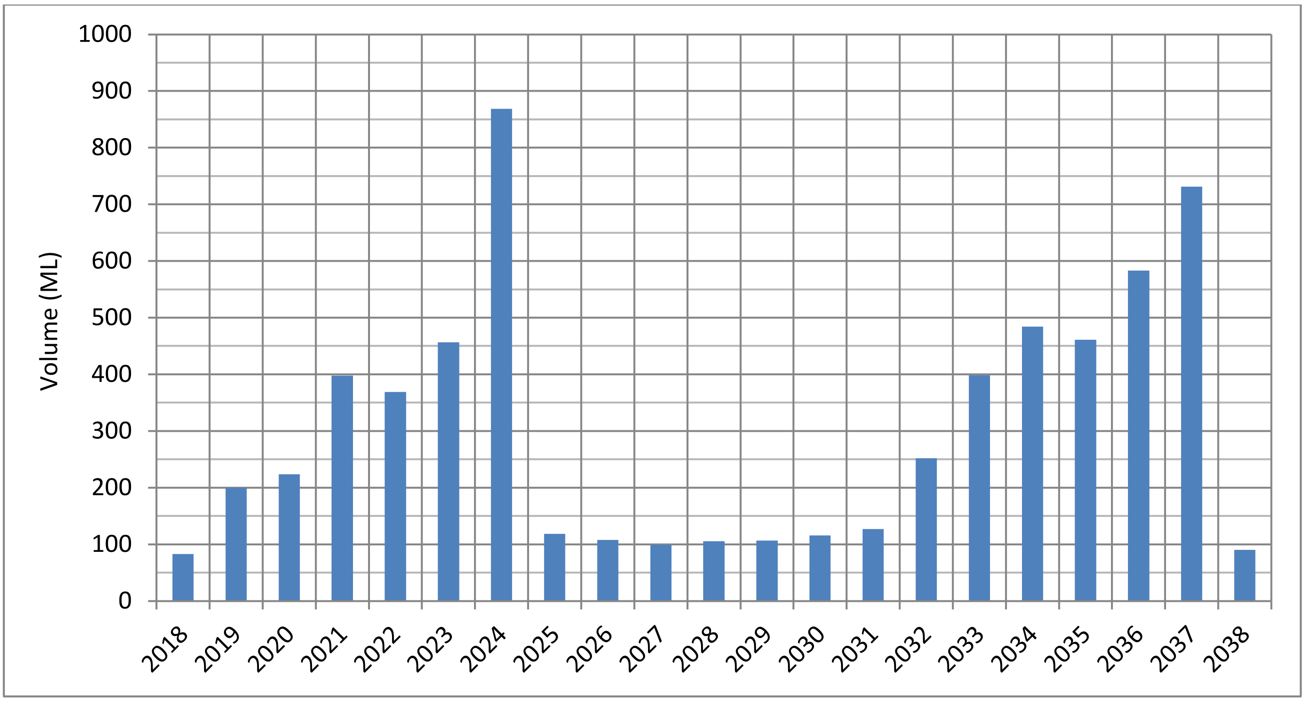


Plate 12 shows the excess ground water discharged when the MWD had a storage volume greater than 900ML.

Plate 12
Mean Excess Water at Site



5.3.2 Model Results Interpretat.ion

5.3.2.1 Mine Wastewater Dam

Plate 10 in **Section 5.3.1** indicates maximum accumulation within the MWD based on the simulated 123 year rainfall record of 1077ML, with a spill risk of less than 1% using a full storage capacity of 1,077ML and with the operational conditions in place. Plate 12 shows that the groundwater excess from dewatering will range on average between 80ML to 880 ML per annum.

As the water balance model indicates excess of groundwater inflow at site, it is proposed (by Shenhuo) to perform controlled releases of the excess water from the MWD subject to testing and necessary treatment into the irrigation system downstream of Fairbairn Dam for beneficial use. Additional monitoring and testing is proposed as necessary before release. The modelled spill risk for the MWD is less than 1% under proposed operational conditions which achieves the spill risk criteria of less than 1% for High consequence structure.

5.3.2.2 CPP Water Recycle Dam

Plate 11 in **Section 5.3.1** indicates accumulation within the CPPWRD based on the simulated 123 year rainfall record exceeds the full supply capacity of 832ML only for the final year being less than 1% of modelled conditions. The mean storage volume ranges from 50ML during the dry season to 400ML in the wet season with the higher storage levels occurring in the final 3 years of operation. The modelled spill risks for the CPPWRD is less than 0.5% which is less and achieves the spill risk criteria of less than 1% for a High consequence structure.

5.3.3 Additional Operational Conditions

For the purposes of conceptual modelling, a pit sump capacity of some 20 ML was adopted based on consultation with IMC, notwithstanding that the pit sumps will be designed based on the requirement of the site during the operational period.

5.4 Proposed Operational Conditions

The proposed regulated structures' storage capacities were selected based on the larger capacity evaluated based on the Method of Deciles method and the Operational Simulation Un-calibrated method. The proposed storage capacity for each regulated structure is outlined in **Table 13**.

Table 13
Proposed Storage Capacities for Regulated Structures

Regulated Structure	Design Storage Allowance (ML)	Operational Simulation Un-calibrated (ML)	Proposed Storage Capacity (ML)
MWD	522	1,077	1,077
CPPWRD	392	832	832

As shown above, the proposed storage from the Method of Deciles (including average groundwater inflow and excluding inflows from most sediment dams) is lower than the Operational Simulation results for the MWD and CPPWRD. The difference in the proposed storage volume estimation for the CPPWRD is due to the exclusion of all the sediment dam inflows except SED 01 and SED 02, as the inflows to the other sediment dams which have been shown in the water balance model to be highly variable inputs in terms of quantity and potential deteriorated water quality. The difference in storage volume estimation for the MWD is due to the variability of the captured groundwater inflow volumes with time, which will vary the DSA volume calculated using the Method of Deciles for each year of the project.

Therefore the mean groundwater inflow volume of 312ML per annum has been used in the Method of Deciles DSA estimation, noting that for maximum modelled groundwater inflow volumes, the Method of Deciles volume increases to approximately 900ML.

To provide the most conservative estimate for the volume requirements for the two regulated storages, the Operational Simulation results have been selected. Therefore, the proposed storages for the MWD and the CPPWRD are 1,077 ML and 832 ML, respectively.

As a contingency in the event of no groundwater release scenario, where the excess water needs to be contained and managed within the site, additional storage of 250 ML was modelled with three operating evaporators, and demonstrated that the spill risk of the additional storage to contain the excess groundwater was less than 1%.

The proposed non-regulated structures' storage capacities were based on a 1 in 10 Year, 72 hour duration requirement with respect to their equivalent rainfall and related catchment areas (refer **Table 11** in **Section 5.2.5.2**). The proposed storage capacity for each non-regulated structure is outlined in **Table 14**.

Table 14
Proposed Storages for Non-Regulated Structures

Regulated Structure	Proposed Storage Capacity (ML)
SED 01	6
SED 02	24
SED 03	27
SED 04	58
SED 05	11
SED 06	55
SED 07	24

The proposed storages are applicable with functioning pump and pipe system as outlined in **Tables 11 and **15 in Sections 5.2.5.2** and **5.4**, respectively*

Based on the water balance model results, it is anticipated that additional water sources is not proposed at site throughout the operating years. Any deficits or shortages in the system is to be managed by using water from the CPPWRD for other than coal preparation as a first recourse.

The pump transferral rates outlined in **Table 15** are proposed during the operational phase to limit the risk of unplanned release of mine affected water.

Table 15
Proposed Pumping Requirement

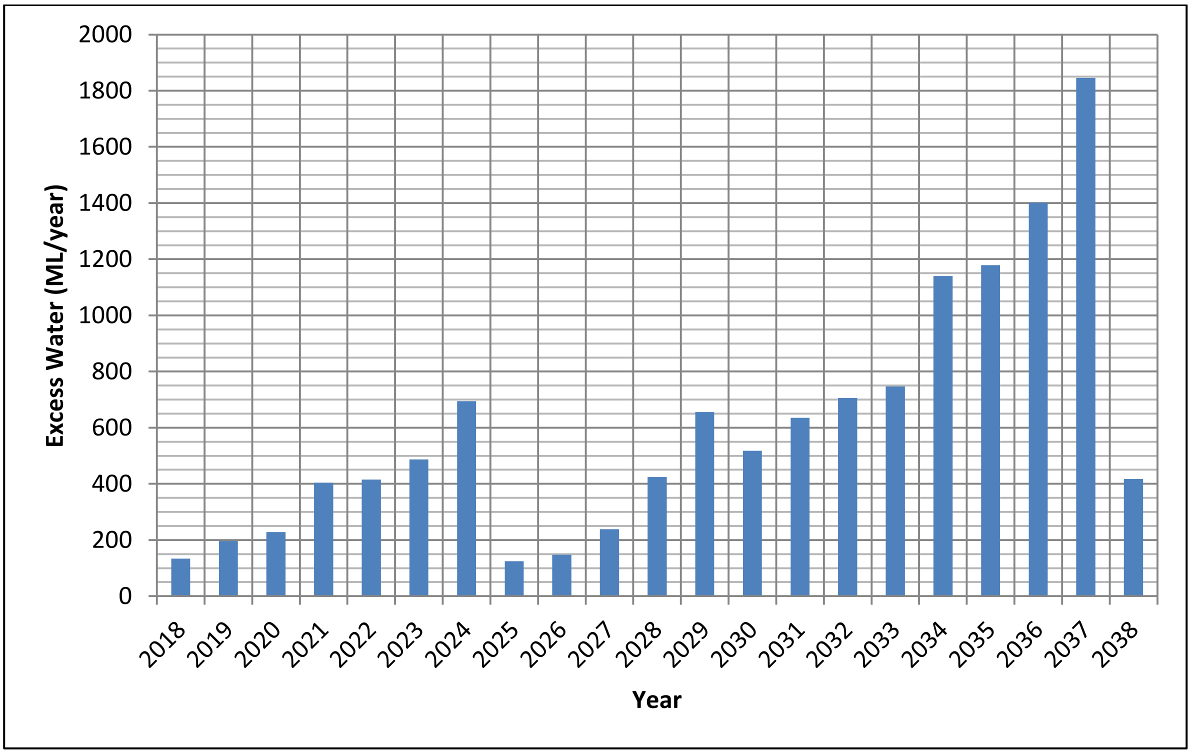
Transfer System	Pump Transferral Rate
Open Cut Pit to MWD	100 l/s
MWD to CPPWRD	50 l/s
SED 01 to CPPWRD	10 l/s
SED 02 to CPPWRD	50 l/s
SED 03 to CPPWRD	50 l/s
SED 04 to CPPWRD	10 l/s
SED 05 to CPPWRD	20 l/s
SED 06 to CPPWRD	10 l/s
SED 07 to CPPWRD	10 l/s

These pump sizes are indicative and are based on daily time step model and subject to final detail design of the pump and pipe system.

5.4.1 Sensitivity Analysis

A sensitivity analysis was conducted to determine the effects of increased groundwater inflow of some 20-50% to the Taroborah Coal Project site. Results of excess groundwater is presented on **Plate 13** and shows the annual excess varies from 110 ML/year to 1850 ML/year. The groundwater inflow was provided by AGE as shown in **Appendix A** as an input into the water balance model. Management of the groundwater inflow was varied to achieve a spill risk of less than 1 % for the MWD and the CPPWRD.

Plate 13
Excess Water at Site under Predicted Maximum Groundwater Inflow Conditions



6 SUMMARY SIZING OF STORMWATER MANAGEMENT COMPONENTS AND ENGINEERING ASPECTS

6.1 Clean Water Diversion Drains

Clean water drains or bunds will be constructed along the perimeter boundary of the proposed infrastructure to divert the upslope natural catchment. A description of the contributing catchments and relevant engineering aspects are provided below.

Amenity Bund	Proposed to extend along northern margin of the open-cut site, the drain and bund will be formed by excavation on a bench into basement sequences. An area of 343 ha drains towards the west portion of the bund to the tributary of Taroborah Creek and subsequently to Taroborah Creek itself.
Pit	The clean water diversion will be formed along the eastern portion of the pit to divert clean catchment into the proposed pump and sump arrangement as shown on Figure 4, 5 and 6 and subsequently transferred to the existing tributary of Taroborah Creek.

The locations of these features are shown conceptually on **Figure 4, 5, 6** and **7**.

6.1.1 Sizing of Clean Water Drains

The criteria for sizing of clean water diversion drains and bunds, as outlined in **Section 4.3.1**, has been to contain a 1 in 1,000 year peak flow event. The basic performance criteria adopted to define drain configurations was to limit flow velocity, where possible, to 1m/s, with areas of higher velocity due to topographical constraints, a need for founding drains. Areas which exhibit higher velocities due to topographical constraints will require founding drain invert surfaces within competent sequences (such as strong basement rock), or armouring.

6.1.2 Roughness

Manning's roughness (n) is an estimate of channel roughness, used in the calculation of flow velocity and discharge. The value of n is typically between 0.01 and 0.1 and varies with channel slope, bed material composition (sand, gravel, cobble etc.), in-stream vegetation and sinuosity. A roughness coefficient of 0.03 was used in the calculation for all drains as suggested by Ven Te Chow (1995).

6.1.3 Drain Design

Drain designs were carried out using Manning's equation for uniform flow:

$$Q = \frac{1.486 \times A \times R^{2/3} \times S^{1/2}}{n}$$

- Q = Discharge (m^3/s)
-
- A = Cross-sectional area of flow (m^2)
- n = Coefficient of roughness
- R = Hydraulic radius (m)

- S = Slope of Pipe (m/m)

Rainfall intensity from CRC-FORGE for the Project was used to calculate the design storms to size the drain. Hydrological conditions upstream of the drain were assessed using the Rational Method (AR&R, 2013), with the critical duration determined using the Bransby-Williams formula. The result of this analysis then formed the input for hydraulic design of the structure using the Manning's formula for uniform flow. Where required, armouring of drain surfaces will comprise placement of durable, benign waste rock as rock armouring. Rock armouring will also be placed at drain discharge areas, extending over a sufficient drain length to dissipate flows such that potential scouring can be minimised.

A summary of hydrology and design requirements for the clean water drains are shown in **Table 16**.

Table 16
Clean Water Drain-(Designed for 1 in 1,000 year peak flow event)

Drain	Catchment Area (km^2)	Peak Flow (m^3/s)	Drain Width (m)	Drain Slope Max (m/m)	Flow Depth Max (m)	Velocity Max (m/s)
CWD1	3.43	88.09	5.00	0.0036	2.77	*3.05
CWD2	0.07	0.57	5.00	0.0034	1.20	*1.86

*Drain with flow velocity higher than 1m/s will be armoured with suitable material

The following drains do not directly receive runoff reporting from upstream catchments, and it is considered that they are included as Pit Protection Bunds only, with a nominal height of 0.5m (refer **Table 17**):

- CWDS1A (Stage 1)
- CWDS1A (Stage 2)
- CWDS1D (Stage 2)

Table 17
Clean Water Drain-at Pit

Mine Operational Year	Drain	Catchment Area ha	Peak Flow m^3/s	Drain Width m	Nominal Drain Slope m/m	Flow Depth Max m	Velocity Max m/s**
Year 1	CWDS1B	24.4	13.13	6	0.5%*	0.95	2.00
	CWDS1C	26.3	14.91	7	1.8%	1.00	3.20
	CWDS1D	31.9	12.64	10	1.0%	1.00	2.25
Year 3	CWDS1B	16.7	9.13	2	0.8%	1.00	2.33
	CWDS1C	3.1	1.79	1	1.6%	0.50	2.00
Year 5	CWDS1D	29.0	14.65	4	1.0%	1.00	2.75

*It should be noted that pit excavation activities may necessitate a re-assessment of these bunds as diversion drainage devices should the grading of catchments near the pit be affected by on-going development of the site.
** Drains with flow velocity higher than 1m/s will be armoured with suitable material
*** It also noted that Stage 4 does not have any proposed site water drains

6.2 Site Water Collection Drains

Site water collection drains will be formed around the infrastructure area to capture site water. The locations of these are shown on **Figure 4, 5, 6** and **7**.A description of these drains, drain sizes and relevant construction/engineering aspects, is provided below:

Out of Pit Spoil Dump	The site water drains extend around the perimeter of the out of pit spoil dumps on each side and are designed to report towards the sediments basin which is then pumped into CPPWRD. A total catchment of approximately 95.8 ha is estimated for the three out of pit spoil dumps. These drains are to be formed by excavation.
Pit	Drainage lines are proposed along the northern and eastern boundary of the pit based on the pit sequencing. The contributing catchment runoff will be captured and subsequently flow into the sump and pump arrangement and discharged into the MWD. These drains are to be formed by excavation.
Infrastructure area	Extending around the perimeter of the infrastructure area with discharge to Sediment Basins 1, 2, 3 and 5 which are then pumped into CPPWRD. These drains are to be formed by excavation.

Site water collection drains have been designed to contain a 100 year ARI, critical duration event (refer **Section 4.3.2**). Where required, armouring of drain surfaces will comprise placement of durable, benign waste rock as rock armouring. Rock armouring will also be placed at drain discharge areas and extended over a sufficient drain length to dissipate flows such that scouring potential can be minimised. A target minimum velocity of 1m/s is the minimum requirement to limit rock armouring. The dimensions selected in **Table 18** are the most suited to the site conditions at Taroborah mine although the minimum velocity is not met. **Table 18** depicts the results of hydrological and hydraulic design of these structures.

Table 18
Site Water Collection Drain Design

Drain	Catchment Area km^2	Peak Flow m^3/s	Drain Width m	Drain Slope Max m/m	Flow Depth Max m	Velocity Max m/s*
SWD1A	0.14	3.73	5.00	0.01	0.43	1.48
SWD1B	0.17	4.24	5.00	0.01	0.45	1.82
SWD2A	0.13	3.49	5.00	0.01	0.33	1.52
SWD2B	0.23	4.81	5.00	0.01	0.48	1.91
SWD3A	0.04	1.77	5.00	0.01	0.07	2.84
SWD3B	0.081	2.37	5.00	0.01	0.32	1.20

* Drains with flow velocity higher than 1m/s will be armoured with suitable material

7 SUBSIDENCE IMPACT ASSESSMENT ON SURFACE HYDROLOGY

7.1 Preface

Surface subsidence due to the mining activities at the Taroborah Coal Project site has been identified as potentially impacting the broader catchment hydrology and water resources availability in Retreat Creek and subsequently into Theresa Creek and Nogoa River. Water that has previously drained freely from the Project site catchment and contributed to the downstream river flow may be lost now due to the subsidence of the surface above the extracted panels. To this end, this assessment has been prepared to determine the change in surface hydrology from existing conditions due to the predicted subsidence over the Project site underground mine area.

The basis of the hydrology assessment for existing and post-mining conditions is summarised as follows:

Existing Condition: Water largely drains freely from the catchment with the drainages having limited pooling/ponding of water.

Post-Mining Condition: Due to the subsidence of the long-wall panel which transect across the site drainages, a number of pools/ponds will be formed within the drainages that will cause retention of runoff and subsequent open water evaporation and percolation.

Details of the hydrology assessment for the two conditions outlined above and results are provided below.

7.2 Methodology

The methodology and approach to assess the hydrological impacts and significance of potential ponding in subsidence involved the following steps:

(i) Review of available surface water data and previous modelling studies based on the Fitzroy River Basin Water Resource Plan, 2011 to assess and quantify baseline hydrology at local and regional scale. The baseline water resources hydrology characterisation considered mean annual flow volumes and flow duration as a measure of flow variability.

(ii) The post subsidence topography was then used to identify possible drainage patterns and potential ponding areas due to subsidence, and the storage-elevation-area characteristics of the subsidence troughs were determined.

(iii) A hydrological simulation model for the Taroborah Coal Project catchment was developed based on the subsidence troughs using a Goldsim model taking into account a series of daily time-step water balance calculations for each void. The model was developed to simulate runoff, estimate losses due to subsidence troughs, losses in the troughs, and thereby calculate overflows and net stream flows reaching the Retreat Creek.

In general, the water balance model will account for the net sum for each daily time step being added to the previous day pond volume. Overflow volume will be calculated when the total inflows exceed the total loses and the remaining available storage capacity.

7.3 Baseline Hydrology

7.3.1 Fitzroy River Basin

The baseline hydrology of the Project area catchment is important to establish reference information for impact assessment. Reviews of available data and previous catchment stream flow modelling were undertaken to characterise the baseline stream flow hydrology.

As part of the Fitzroy River Basin Water Resource Plan, hydrologic modelling representing the modelled stream flow data was developed. The report indicates that the major river systems and waterways contained within the Fitzroy Basin include the Fitzroy, Isaac, Connors, Mackenzie, Comet, Brown, Nogoa, Kroombit, Dawson, and the Don (Callide Creek) rivers. The Theresa, Retreat and Kettle Creek system that flows into the Nogoa River is also considered a major watercourse of the basin.

These rivers all have their headwaters within the Fitzroy Basin and create an estimated mean annual discharge of 7,130,000 megalitres (ML) as they flow toward the Fitzroy River and their ending point at the Coral Sea (Baxter 1992, FBA 1998). While this may seem a large amount of water in general terms, it equates to only 50 ML per plan square kilometer of land, or around 40 ML in total per km^2 after evaporation rates set at an arbitrary figure of 20% are taken into consideration (Adam J. Loch and John C. Rolfe).

7.3.2 Recorded Stream Flow Information

The Department of Environment and Natural Resources (DNRM) does not operate a stream gauging station on Retreat Creek. Based on the available data, the following summary has been obtained on the Kettle Creek Stream Gauge at Fork Lagoon, north of Retreat Creek. The Kettle Creek Stream Gauge Station (Station No. 130214A) was selected due to proximity of the location to Retreat Creek and also similar ground conditions of both catchments. The location of Kettle Creek is shown on **Plate 14** with evaluated mean annual rainfall for the Taroborah Coal Project site based on Kettle Creek Stream Gauge Station data and the Retreat Creek and Taroborah Coal Project site characteristics is outlined in **Table 19**.

Plate 14
Location of Kettle Creek
(Source: Google Map)

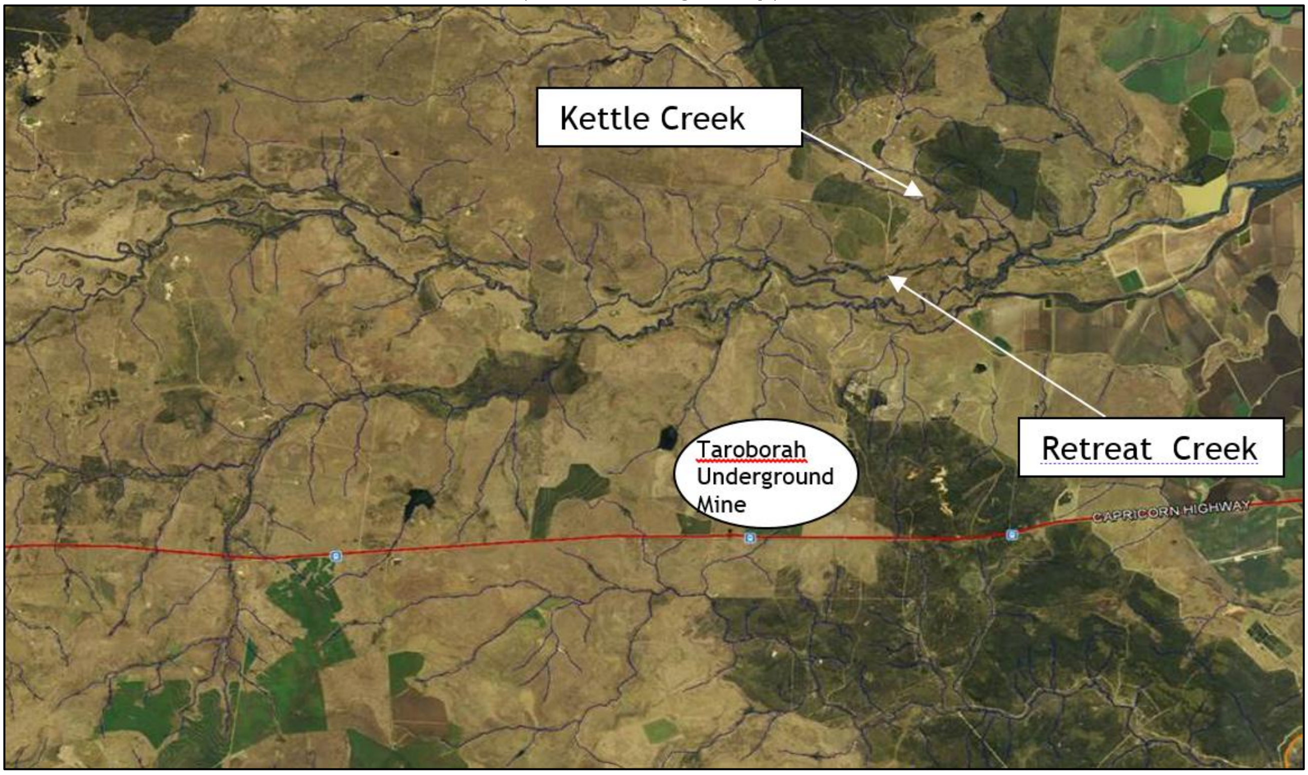


Table 19
Estimation for Retreat Creek and Taroborah Coal Project Site
(Source: Bureau of Meteorology)

Gauging Station/ Study Location	Stream Gauge 130214A (Kettle Creek)	Retreat Creek Catchment	Project Site/ Taroborah Catchment (subsidence impacted area and contributing catchment)
Station Name	Kettle Creek at Fork Lagoon	N/A	N/A
AMTD	17.742	N/A	N/A
Catchment(km^2)	401	735 (based on Google map imaging)	21 (based on survey provided by IMC)
Start of records	21/10/1972- 03/11/1988	N/A	N/A
Mean Flow(ML/day) per km^2	56 ML/day	56 ML/day (assumed based on Kettle Ck)	56 ML/day (assumed based on Kettle Ck)
Mean Flow(ML/year)	22524 ML/year	41233 ML/year	1178 ML/year
Mean Annual Runoff(mm/year)	56mm/year	56mm/year	56 mm/year

The data obtained from the Kettle Creek station indicates that the Kettle Creek catchment generates 56 ML of runoff per square kilometre which is approximate to the value detailed in the Fitzroy Basin Draft Resource Operations Plan (October, 2013) of 50 ML (before evaporation). The 56ML/km^2 per year was used to estimate the mean annual flow in Retreat Creek. The predicted

mean annual flow based on the Kettle Creek catchment for Retreat Creek is 41,233 ML/year and 1,178 ML/year for Project site catchment.

7.4 Summary of Subsidence Troughs Mapping

The level of subsidence and the post-mining topography within the Project extent were provided by IMC. The subsided topography contours received from IMC were reviewed to identify ponding locations. This review revealed that, because of the orientation of the extracted panels being roughly perpendicular to the slope of the land, the two major drainage lines were the only areas where significant ponding would occur. Cross sections along these drainage lines were then prepared to estimate ponding locations, pond geometry and the storage capacity of the ponds to the level at which the ponds would overflow.

The mapping of potential subsidence ponding extents and volumes within the proposed Taroborah underground mine area identified 10 ponding areas. The subsidence pond volumes are estimated to range between 3 ML and 12.5 ML. The average capacity would be approximately 7.1 ML. The total identified ponding area is some 28.2 hectares. The two drainage line's long sections in comparison of existing topography against post-mining topography is illustrated on **Plate 15** with the identified ponding areas shown on **Plate 16**.

Plate 15
Subsidence Impact at Taroborah Coal Project Site

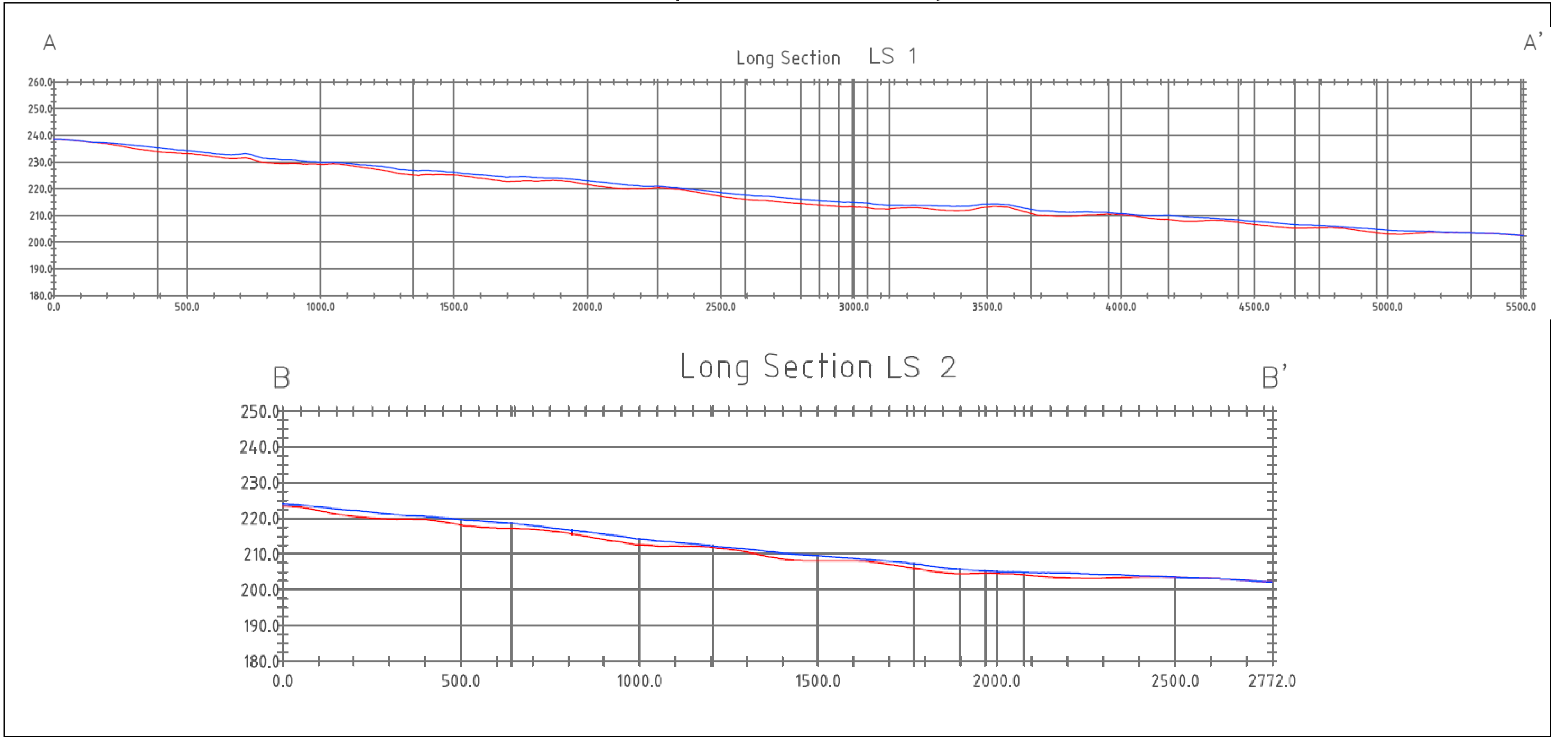
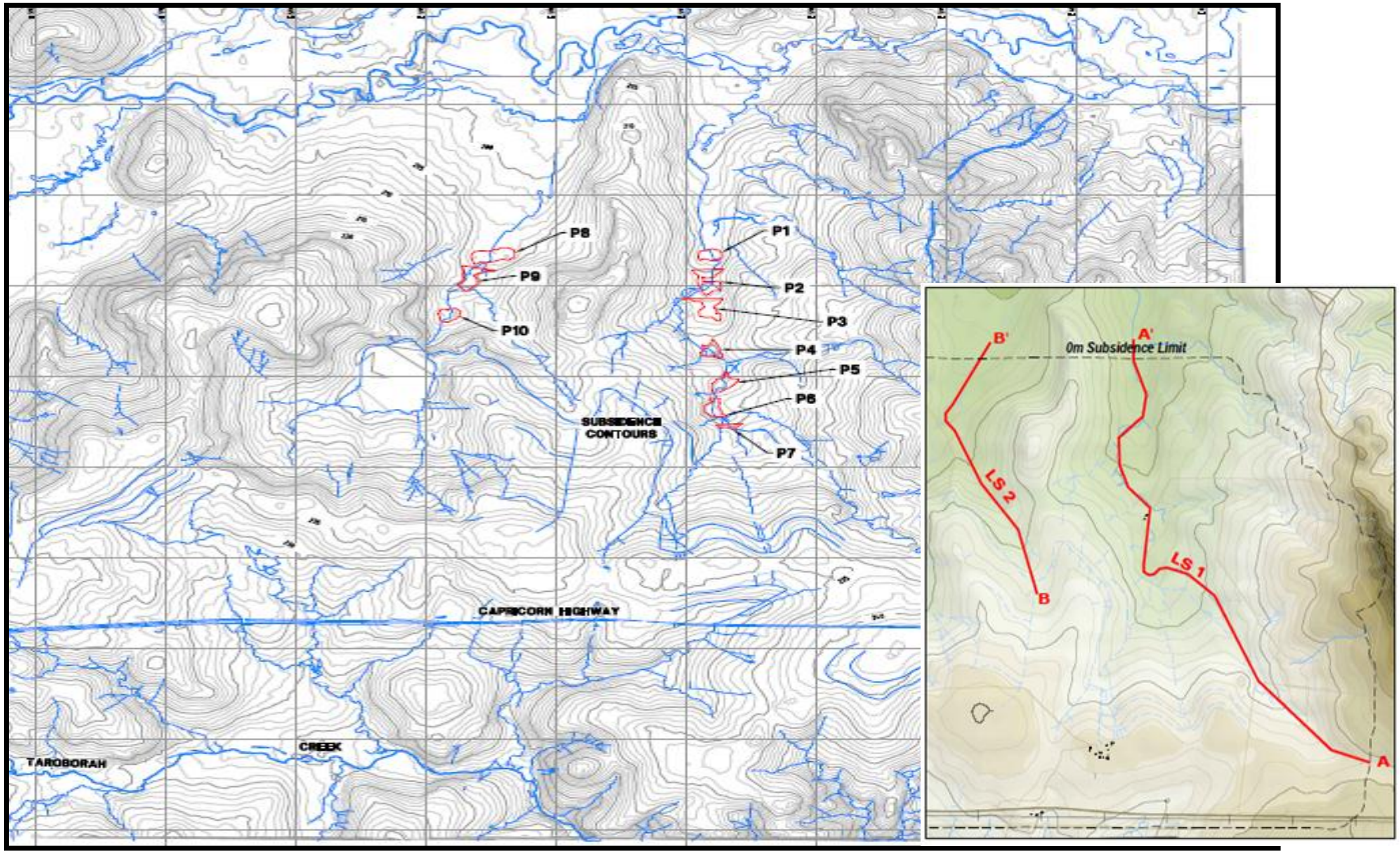


Plate 16
Potential Ponding Areas at Taroborah Coal Project Site



The key characteristics of the identified ponding locations is outlined in **Table 20** below.

Table 20
Ponding Location Characteristics

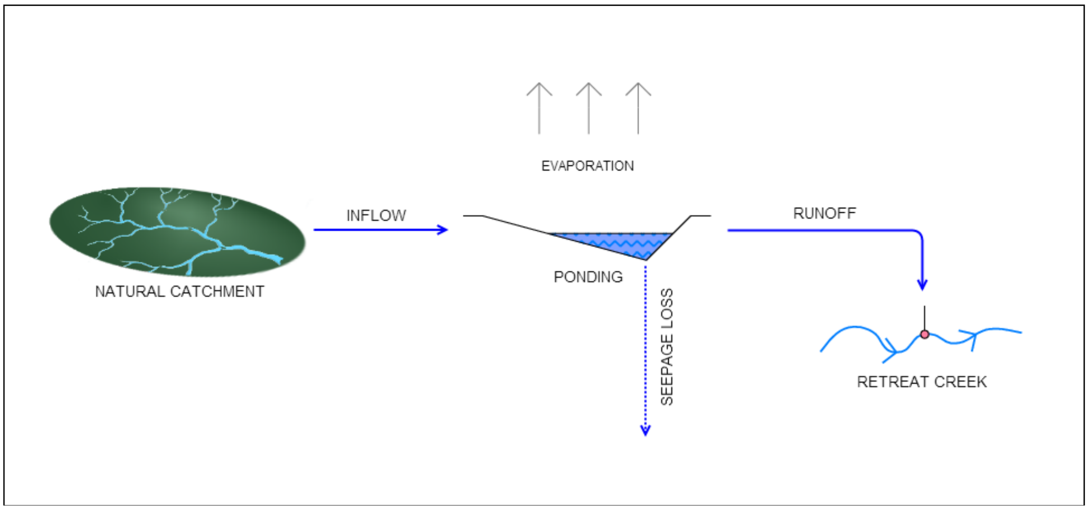
Void ID (Refer Plate 13)	Level (Overflow - m AHD)	Maximum depth when full (m)	Maximum volume when full (ML)	Maximum Area when full (ha)
P1	203.4	0.4	3.6	1.9
P2	205.6	1	10.2	3.6
P3	207.3	1	2.9	1.6
P4	210.1	1	6.9	2.8
P5	212.2	1	6.2	2.5
P6	213.3	1	9.6	2.1
P7	215.5	1	2.5	0.7
P8	203.4	0.5	12.5	6.7
P9	204.8	1	8.2	2.9
P10	206.4	1	8.3	3.3

7.5 Hydrological Simulation of Subsidence Area

7.5.1 Model Structure

A hydrological simulation model using Goldsim was developed using a series of daily time step. The hydrological model simulations were undertaken using SILO climate data drill with historical rainfall and evaporation data available from January 1889. The nets sum of the water balance model components described for each daily time step was added to the previous day pond volume. A seepage rate of 1mm/day was utilised in the model and was considered conservative and relatively insignificant. The simulated model was structured as shown on **Plate 17**.

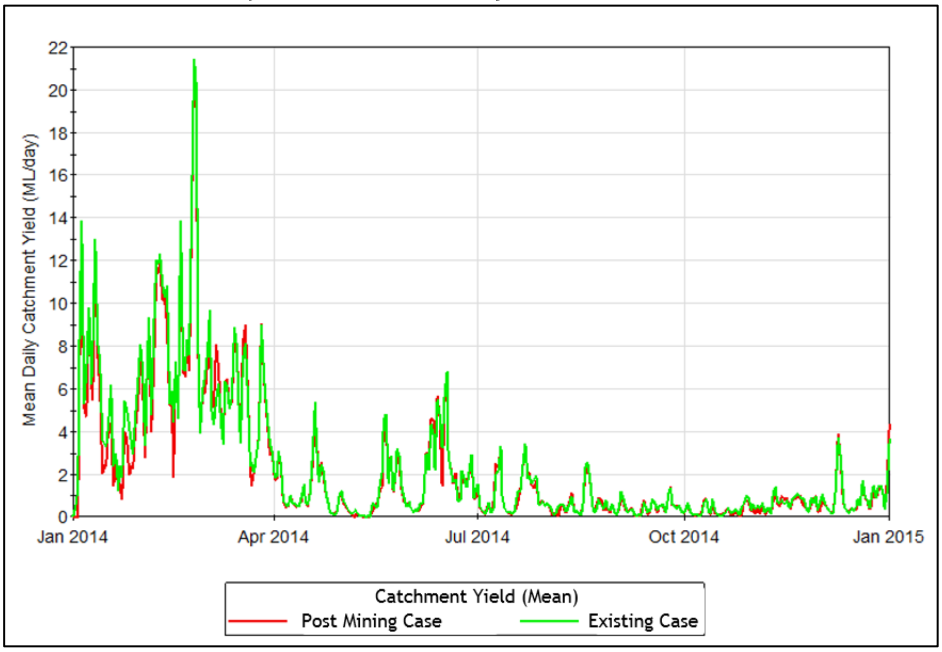
Plate 17
Flow Simulation Model



7.5.2 Model Results

Based on the model as described above, the results presented as mean daily runoff for the existing and post mining conditions are presented in **Plate 18**.

Plate 18
Mean Daily Runoff for the Project Site Subsidence Area



The sum of the mean daily runoff with evaporation included as part of the water balance analysis as shown on **Plate 18** in **Section 7.5.2** indicates the following:

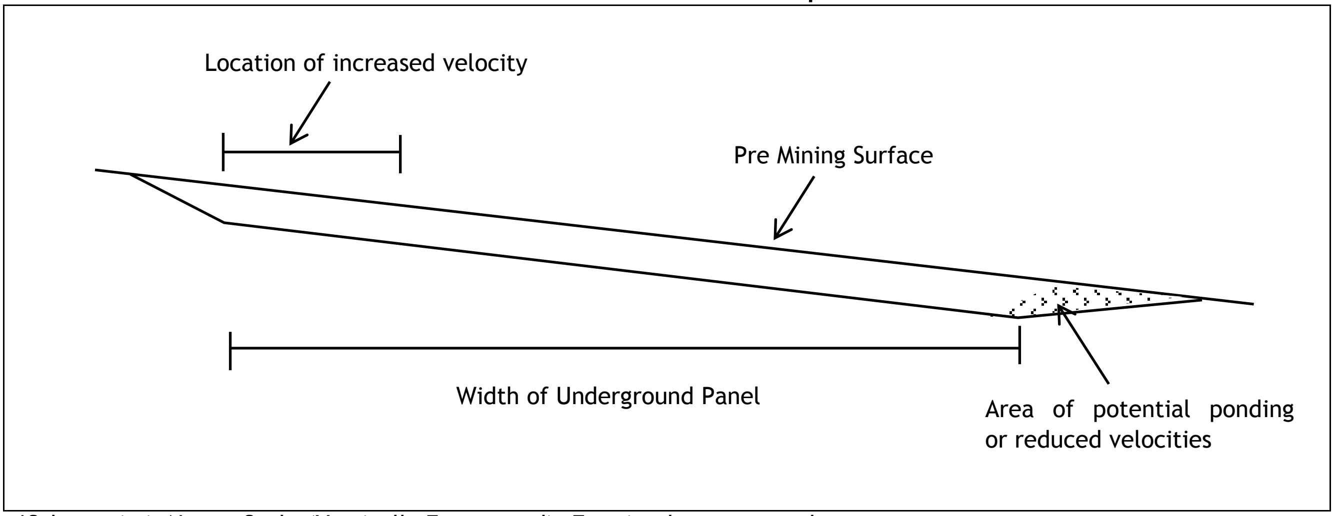
- Mean annual runoff for the existing conditions is some 852 ML/pa being equivalent to 40.5 ML/km^2;
- Mean annual runoff for post-mining conditions is some 799 ML/pa being equivalent to 38ML/km^2; and
- The difference between the existing and post-mining runoff volumes indicate that the annual average losses due to the subsidence ponds is some 53ML over 21km^2, equivalent to 2.5 ML/km^2 of the subsided impacted area and contributing catchment.

7.6 Scouring of Subsided Surface Drainage and Water Quality Impact

The subsidence model completed by IMC indicates that the changes in grade will be minor (maximum of 1.2%) when compared with the existing gradients as shown on **Plate 15** in **Section 7.4.**

The change in gradient due to subsidence will be most notable within the primary drainage paths which are represented as the long sections on **Plate 15** in **Section 7.4**. Subsidence in areas outside the drainage paths would only marginally change the overland flow direction with maximum gradients within the order of the existing topography. A schematic of the subsidence along the drainage path is provided on **Plate 19** and shows the impact of ponding due to subsidence localised to areas of the upslope associated with the chain pillars between the extraction panels.

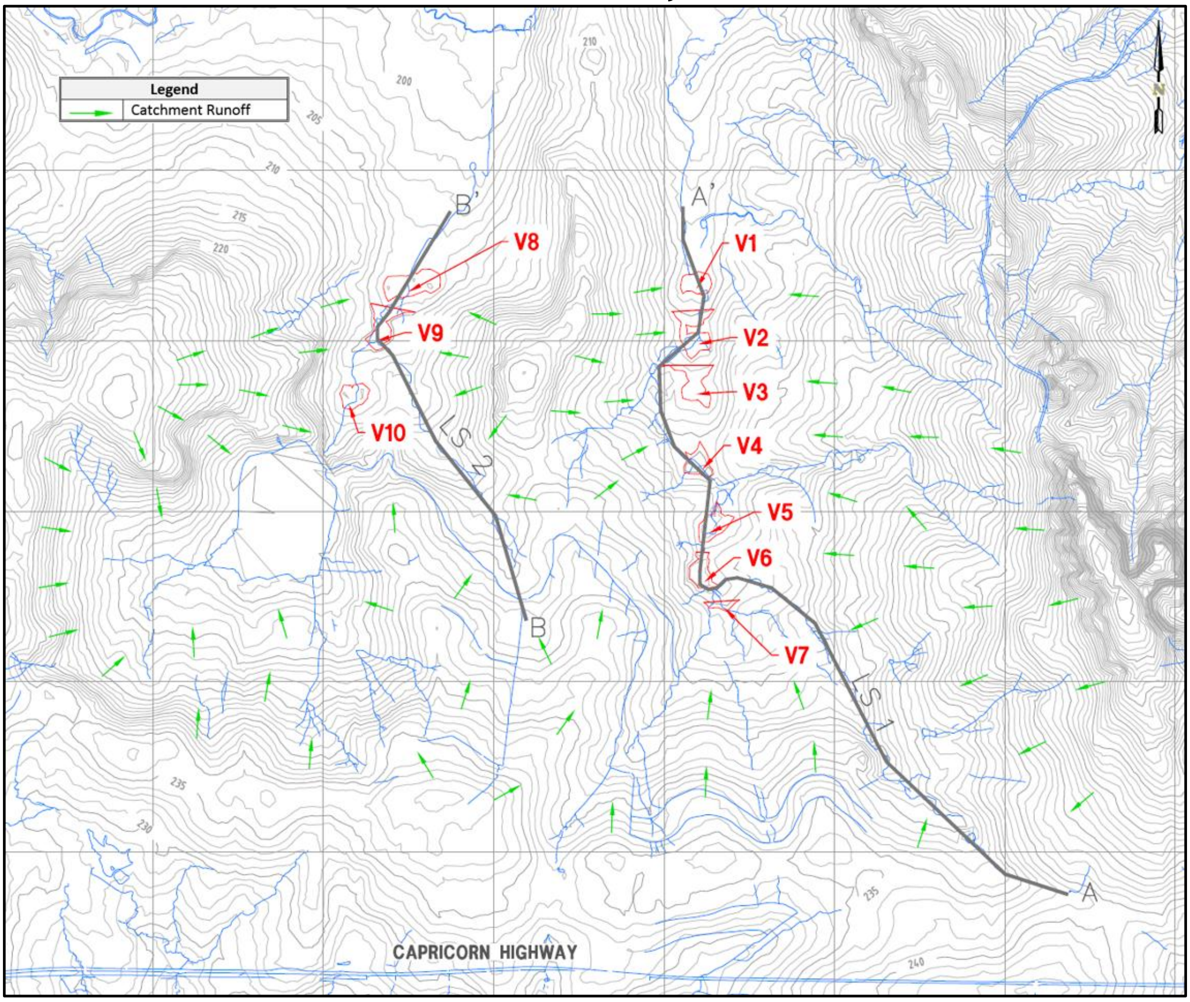
Plate 19
Schematic of Subsidence Impact*



*Schematic is Not to Scale (Vertically Exagerated). For visual purposes only.

In relation to the 10 identified ponding locations, increased velocities will be encountered. Peak velocities (namely V1 to V10) was evaluated based on the locations as shown on **Plate 20.**

Plate 20
Evaluated Peak Velocity Locations



The peak velocities was evaluated using the Rational Method to assess existing topographical conditions against post-mining topographical conditions. The evaluated peak velocities were based on critical durations using ARIs of 2 year, 10 year, 20 year and 50 year with results presented in **Table 21.**

Table 21
Flow Velocities for Existing and Post-Mining Conditions

Location	Existing Flow Velocities Flow Velocity (m/sec)				Post-Mining Flow Velocities Flow Velocity (m/sec)			
	ARI							
	2 Year	10 Year	20 Year	50 Year	2 Year	10 Year	20 Year	50 Year
P1	1.46	1.67	1.75	1.85	1.48	1.68	1.77	1.88
P2	1.45	1.64	1.72	1.83	1.46	1.67	1.75	1.85
P3	1.41	1.60	1.67	1.78	1.42	1.61	1.71	1.80
P4	1.29	1.44	1.51	1.60	1.30	1.46	1.55	1.62
P5	1.19	1.31	1.36	1.42	1.22	1.34	1.38	1.45
P6	1.19	1.31	1.35	1.42	1.22	1.33	1.38	1.44
P7	1.03	1.13	1.18	1.22	1.06	1.15	1.20	1.25
P8	1.29	1.45	1.52	1.61	1.29	1.46	1.54	1.61
P9	1.15	1.28	1.35	1.42	1.15	1.30	1.37	1.44
P10	1.53	1.69	1.76	1.84	1.54	1.71	1.78	1.87

7.7 Mitigation of Potential Water Losses

7.7.1 Surface Tension Cracks

Localised surface cracking may occur due to tensile strain on ground surface. Tension cracks are predicted on the edges of long wall panels and along the tops of topographic high points. This surface cracking will be the greatest at the start and end of each panel and most obvious on hard/brittle surfaces. The following information was provided by IMC,

- The cracks are predicted to extend approximately 35m either side of the pillars into the panels (i.e. a zone of ~100m on 300m centres);
- Cracks will be in the order of a maximum width of 0.2 - 0.3m and a maximum depth of 5m in the worst case instances; and
- In most areas, the surface cracking is anticipated to be less severe.

It is considered that most surface fractures may be temporary, with many closing during natural swelling and deposition of sediment from rainfall events. The surface soil cover will have an influence on the cracking that is actually visible at the surface. Unconsolidated deposits of alluvium, colluvium, and soil tend to obscure surface cracks. Therefore, the tension cracks will be filled over time and can be considered negligible for storage of surface runoff. In cases where the cracks remain open over time, mitigation measures such as ripping, re-grading to smooth surface profile and re-vegetating the cracked areas are proposed. With the implementation of these measures, it is anticipated that the losses of surface water through surface tension cracks will be insignificant.

7.7.2 Assessment of Hydrological Impacts

Based on the model results as presented in **Section 7.5.2**, the following comments are provided in relation to the hydrological impact of the mine subsidence:

- Existing model conditions indicates a mean annual catchment yield of some 40.5ML/km^2 being achievable when compared against the 40ML/km^2 (*after evaporation*) stated by Adam J. Loch and John C. Rolfe, quoted in **Section 7.3.1**, and therefore considered that the model suitably represents catchment yield for the purpose of this comparative assessment.
- The post-mining catchment yields of 38ML/km^2 indicates that a potential loss of the order of 2.5 ML per km^2 on average runoff which is some 6% less than the the existing condition.

7.7.3 Regional Context – Potential Loss of Flow in the Retreat Creek

Based on the statutory Water Resource (Fitzroy Basin) Plan 2011 (Queensland Parliamentary Counsel, 2014), the nearest catchment with respect to the application of Environmental Flow Objectives (EFO) for Retreat Creek is Theresa Creek (Node 14 in Schedule 5). The EFO objective at this location is not to reduce mean annual flow by less than 90 percent from pre-development mean annual flow conditions.

The potential mean annual flow loss in Retreat Creek was evaluated by related site data showing that the mean annual yield of rainfall runoff would reduce from 41,233 ML to 41,180 ML pa being some 0.1% less than the pre-development mean annual flow conditions in Retreat Creek. Therefore, the negative impacts from subsidence on annual flow volume in Retreat Creek is in accordance to the statutory Water Resource (Fitzroy Basin) Plan 2011 discussed above.

Proposed mitigation measures to reduce rainfall runoff loss to Retreat Creek during post-mining conditions are discussed below.

7.7.4 Determination of Mitigation Measures

Although the subsidence impact is expected to be significantly less at a regional scale, there is potential to mitigate the loss of flow from the Project site due to ponding in subsidence troughs by undertaking minor remedial earth works to restore drainage through the ponded areas following subsidence. As the depth of the troughs is considered shallow, the works required to restore drainage through subsidence troughs would be achievable without unnecessary damage to the environment.

7.7.5 Conclusions and Recommendations

Based on this assessment, it is considered that the hydrological impacts on Retreat Creek from the Taroborah Coal Project activities will not be significantly impacted (i.e. less than 0.1% reduction in the runoff yield from the entire catchment and less than some 6 % at the Project site). The localised impact can be mitigated with the implementation of minor remedial earthworks to restore drainage through the subsidence troughs.

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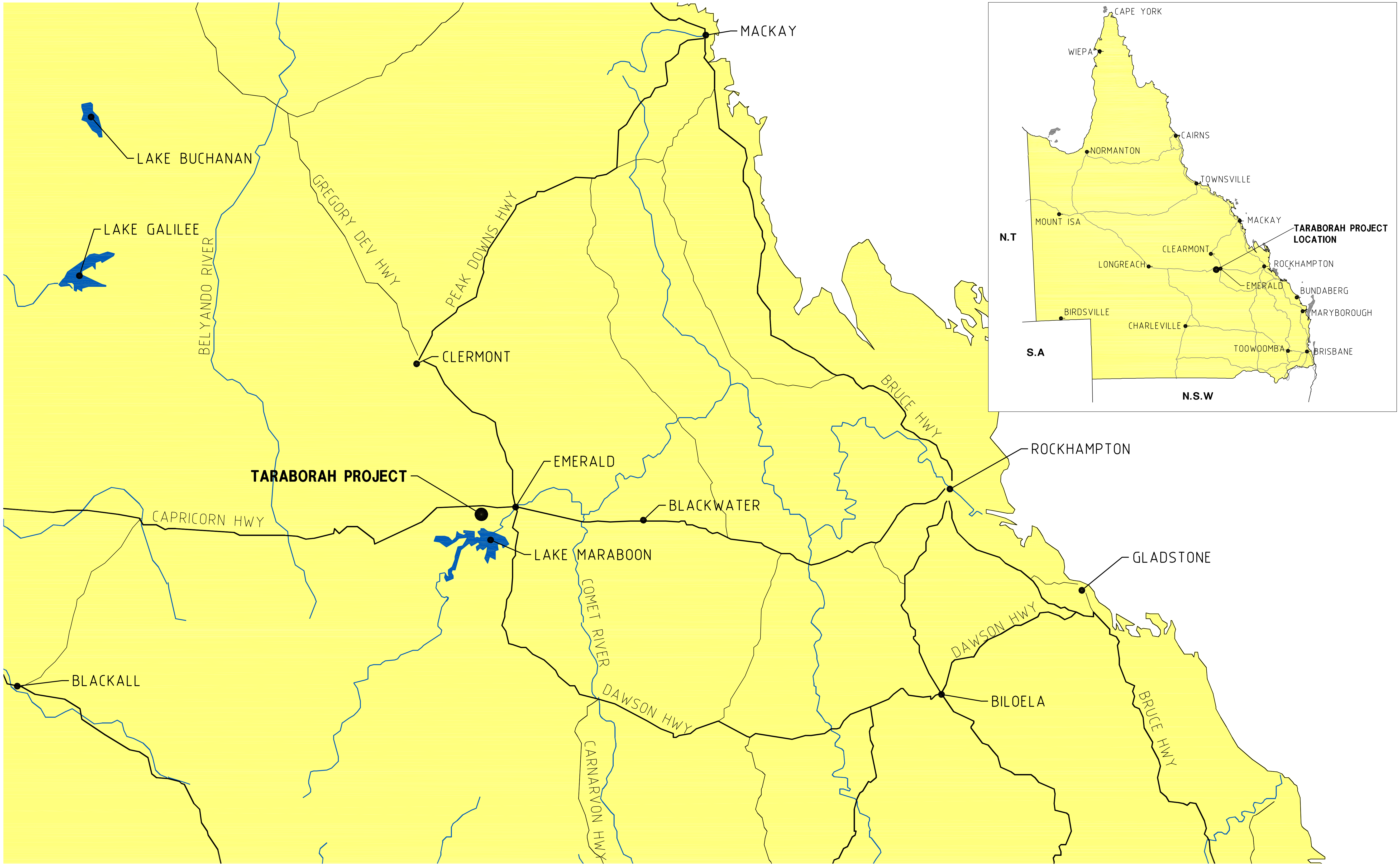
FIGURES



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AUSTRALASIAN RESOURCE CONSULTANTS
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SITE WATER MANAGMENT ASSESSMENT
LOCALITY PLAN

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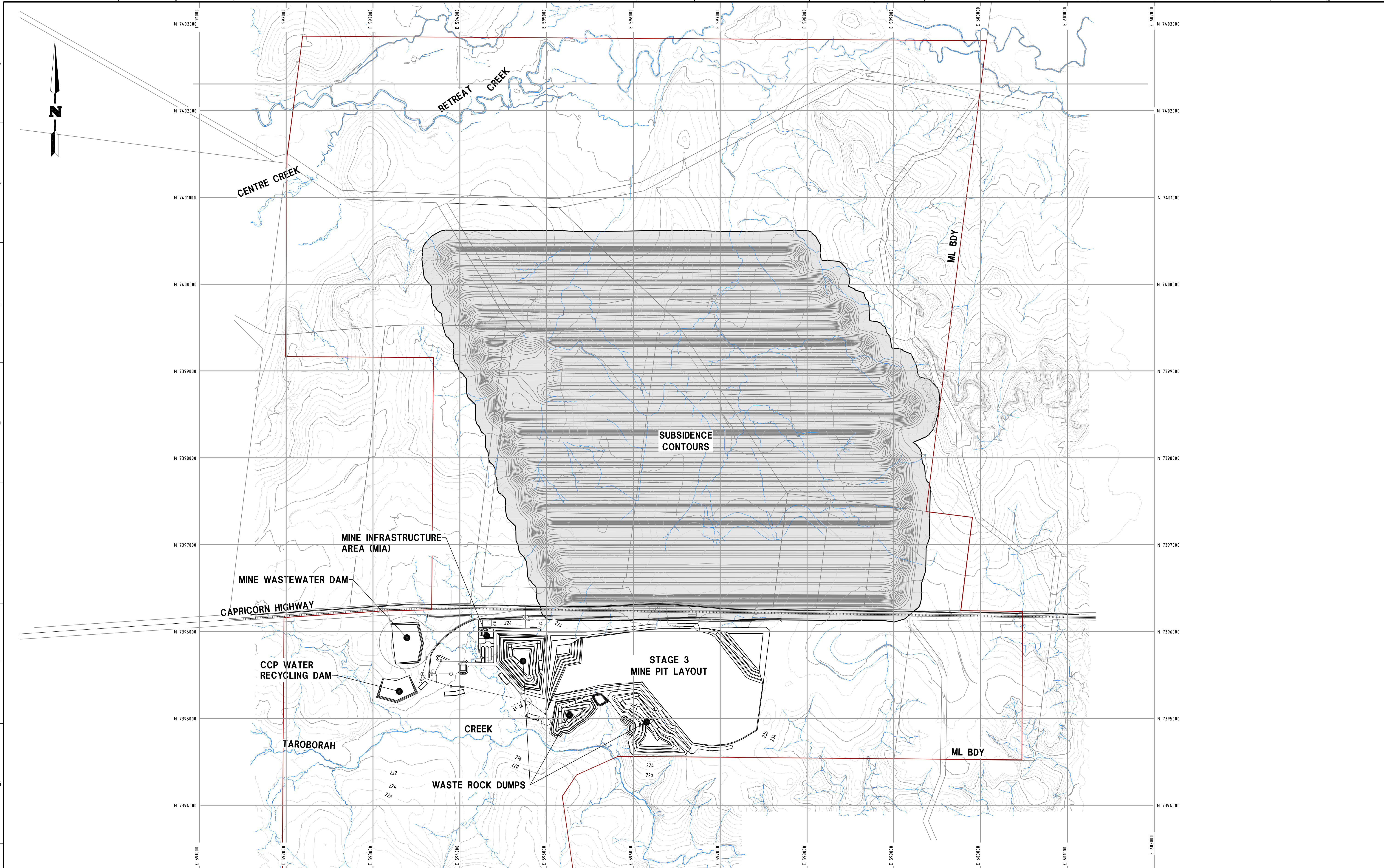

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SITE LAYOUT

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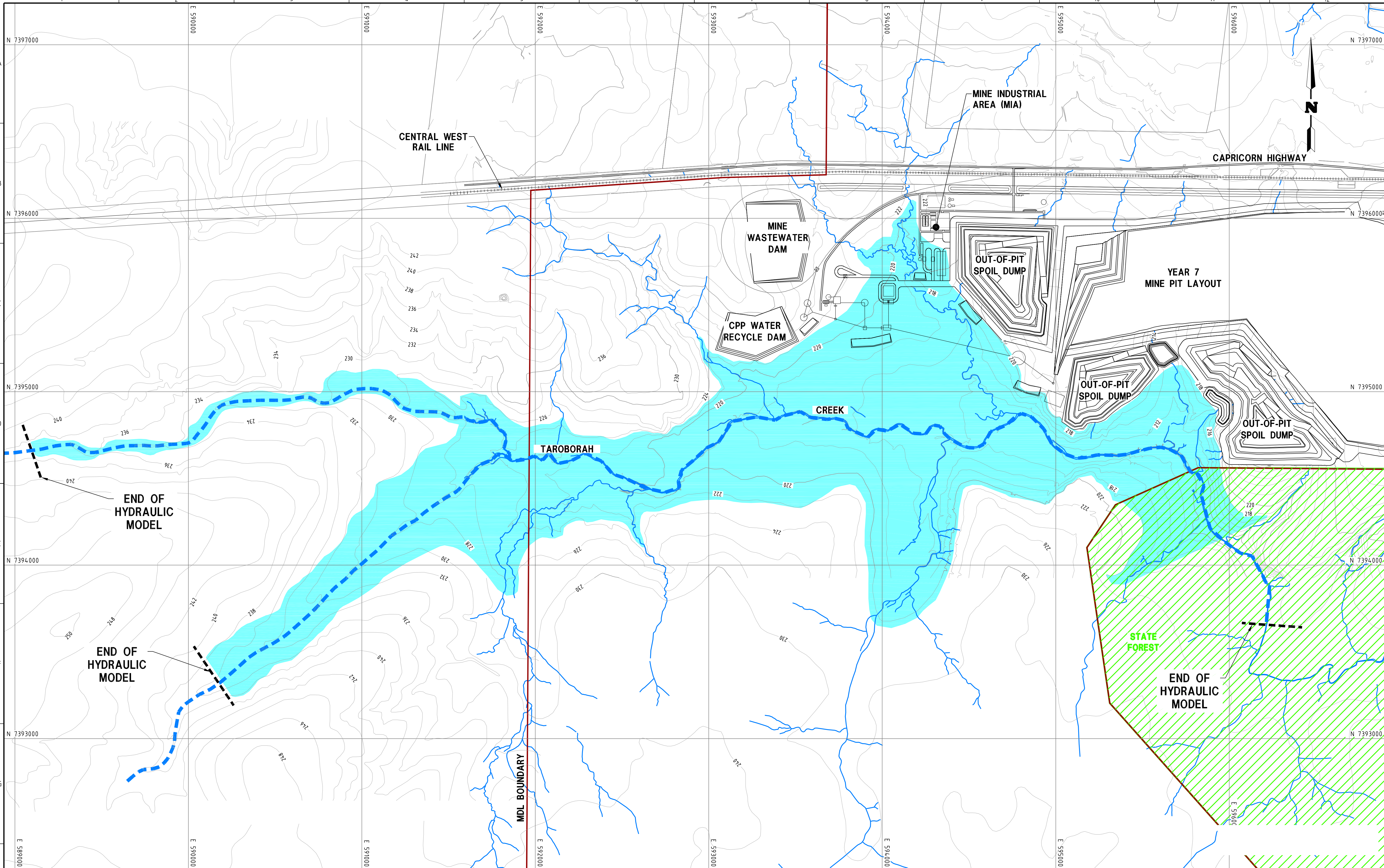

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PROBABLE MAXIMUM FLOOD EXTENT (PMF)

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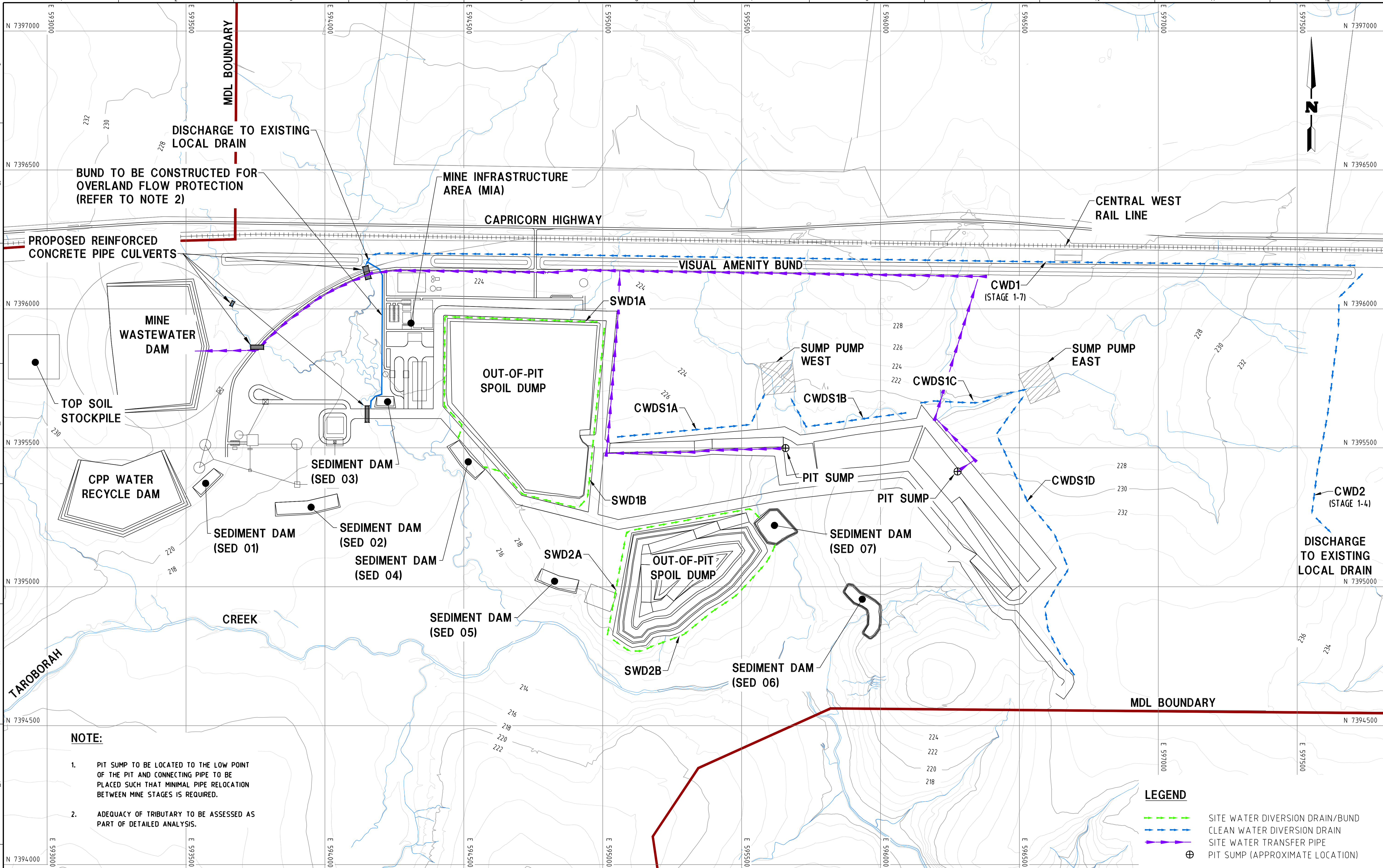

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SITE WATER MANAGMENT ASSESSMENT
PROPOSED DRAINAGE WORKS
MINE STAGE PLAN YEAR 1

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SHEET 1 OF 1

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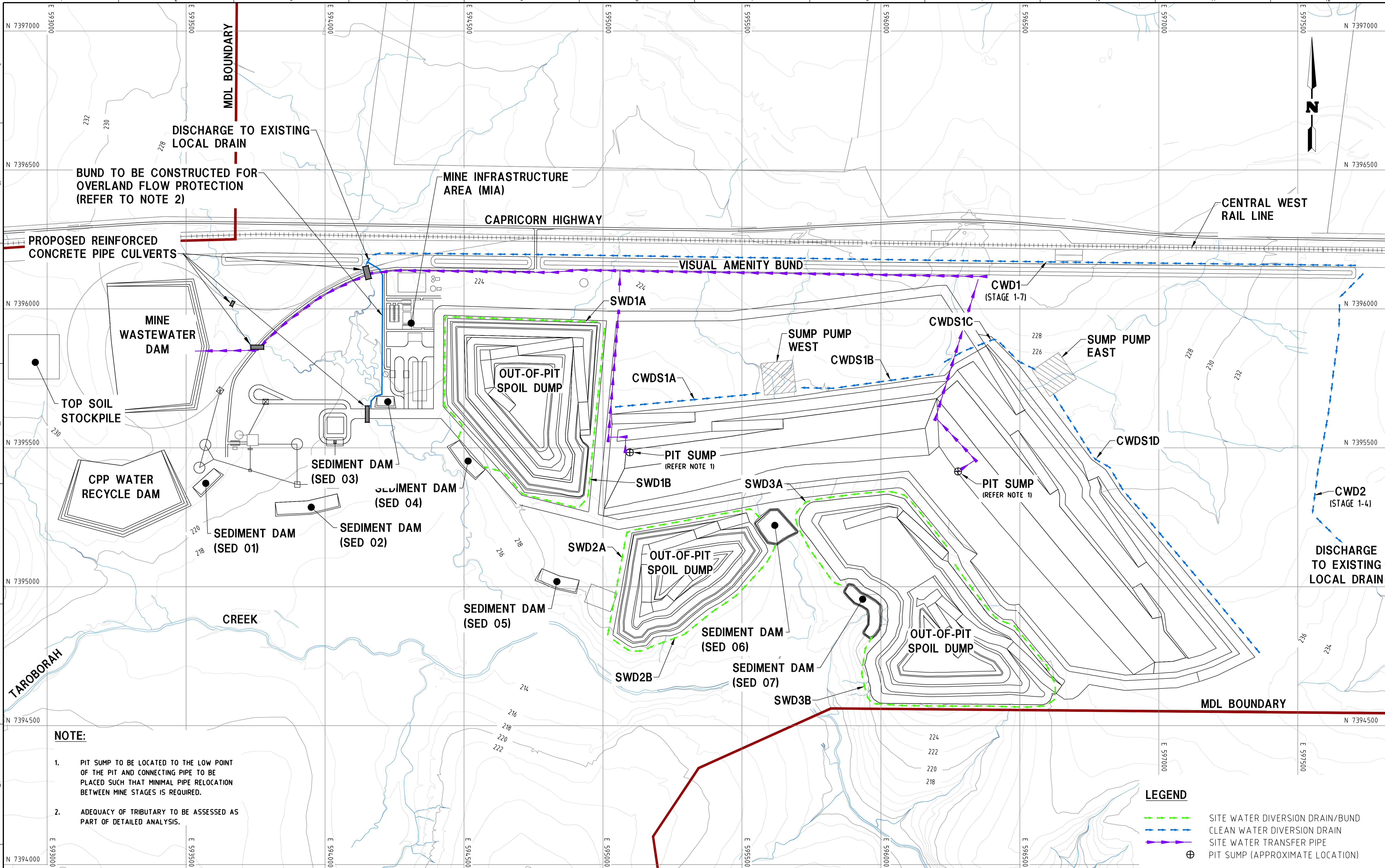

NOTE:

1. PIT SUMP TO BE LOCATED TO THE LOW POINT OF THE PIT AND CONNECTING PIPE TO BE PLACED SUCH THAT MINIMAL PIPE RELOCATION BETWEEN MINE STAGES IS REQUIRED.
2. ADEQUACY OF TRIBUTARY TO BE ASSESSED AS PART OF DETAILED ANALYSIS.

LEGEND

- SITE WATER DIVERSION DRAIN/BUND
- CLEAN WATER DIVERSION DRAIN
- SITE WATER TRANSFER PIPE
- ⊕ PIT SUMP (APPROXIMATE LOCATION)

No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
F	FINAL ISSUE	13-11-14	CMA	VV	RJH
E	ISSUED FOR REVIEW		MJC		
D	ISSUED FOR REVIEW	10-12-13	MJC	VV	RJH
C	ISSUED FOR REVIEW	08-11-13	MJC	VV	RJH
B	ISSUED FOR REVIEW	02-10-13	MJC	VV	RJH
A	ISSUED FOR REVIEW	06-09-13	CMA	VV	VV

SCALE: 1:12,500	
JOB No.	112180-01
DATE	28/08/13
DESIGN	CMA
DRAWN	CMA
CHECKED	VV
APPROVED	RJH

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AUSTRALASIAN RESOURCE CONSULTANTS
TAROBORAH PROJECT

SITE WATER MANAGMENT ASSESSMENT
PROPOSED DRAINAGE WORKS
MINE STAGE PLAN YEAR 3

DWG. No. 005

SHEET SIZE A3 | Rev. F

SHEET 1 OF 1

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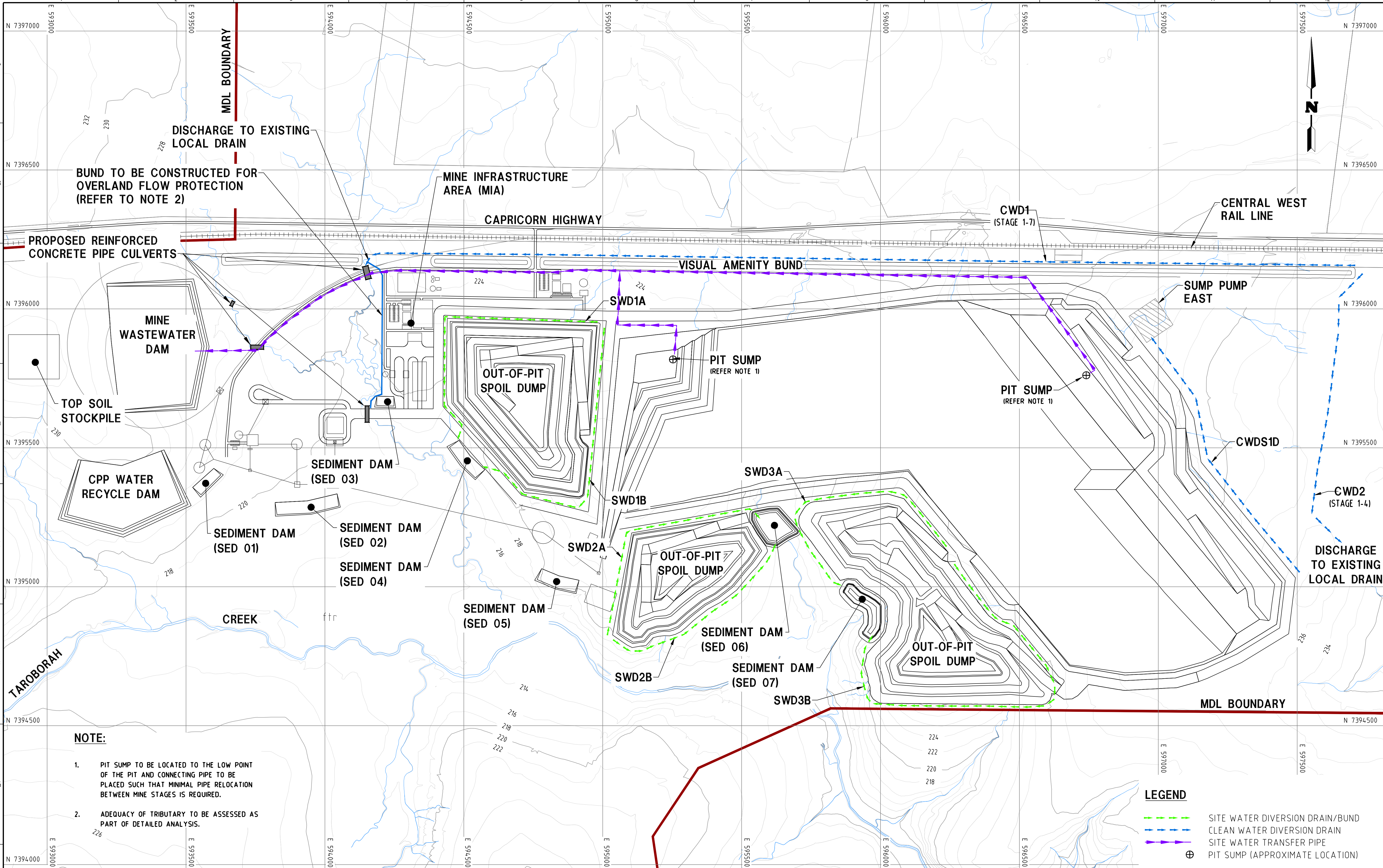

NOTE:

1. PIT SUMP TO BE LOCATED TO THE LOW POINT OF THE PIT AND CONNECTING PIPE TO BE PLACED SUCH THAT MINIMAL PIPE RELOCATION BETWEEN MINE STAGES IS REQUIRED.
2. ADEQUACY OF TRIBUTARY TO BE ASSESSED AS PART OF DETAILED ANALYSIS.

LEGEND

- SITE WATER DIVERSION DRAIN/BUND
- CLEAN WATER DIVERSION DRAIN
- SITE WATER TRANSFER PIPE
- PIT SUMP (APPROXIMATE LOCATION)

No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
F	FINAL ISSUE	13-11-14	CMA	VV	RJH
E	ISSUED FOR REVIEW		MJC		
D	ISSUED FOR REVIEW	10-12-13	MJC	VV	RJH
C	ISSUED FOR REVIEW	08-11-13	MJC	VV	RJH
B	ISSUED FOR REVIEW	02-10-13	MJC	VV	RJH
A	ISSUED FOR REVIEW	06-09-13	CMA	VV	RJH

SCALE: 1:12,500	
JOB No.	112180-01
DATE	28/08/13
DESIGN	CMA
DRAWN	CMA
CHECKED	VV
APPROVED	RJH

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AUSTRALASIAN RESOURCE CONSULTANTS
TAROBORAH PROJECT

SITE WATER MANAGMENT ASSESSMENT
PROPOSED DRAINAGE WORKS
MINE STAGE PLAN YEAR 5

DWG. No. 006
SHEET SIZE A3 Rev. F

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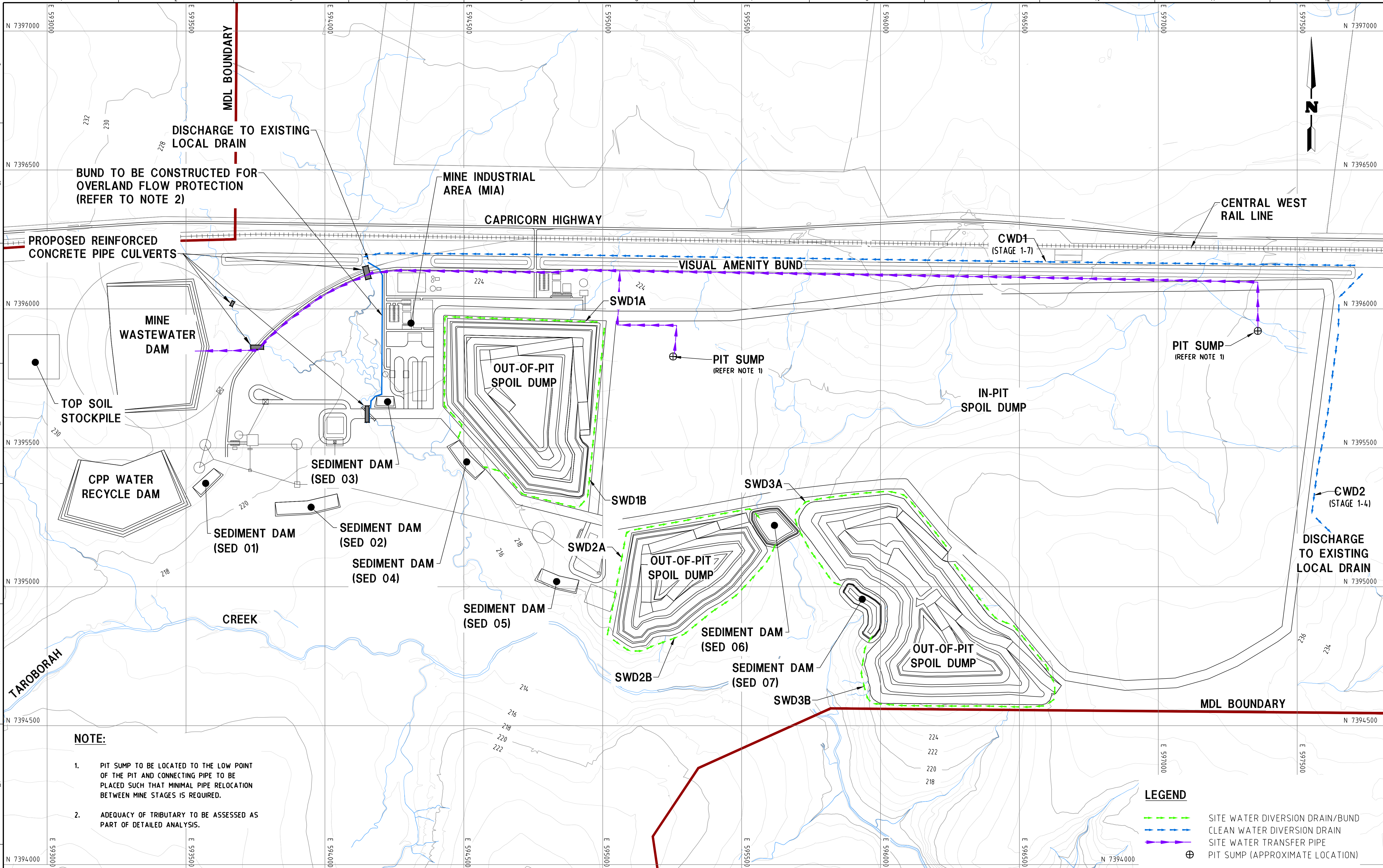

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C	ISSUED FOR REVIEW	08-11-13	MJC	VV	RJH
B	ISSUED FOR REVIEW	02-10-13	MJC	VV	RLH
A	ISSUED FOR REVIEW	06-09-13	CMA	VV	VV

SCALE:	1:12,500
JOB No.	112180-01
DATE	28/08/13
DESIGN	CMA
DRAWN	CMA
CHECKED	VV
APPROVED	RJH

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AUSTRALASIAN RESOURCE CONSULTANTS
TAROBORAH PROJECT

SITE WATER MANAGMENT ASSESSMENT
PROPOSED DRAINAGE WORKS
MINE STAGE PLAN YEAR 7

DWG. No. 007

SHEET SIZE A3 | Rev. F

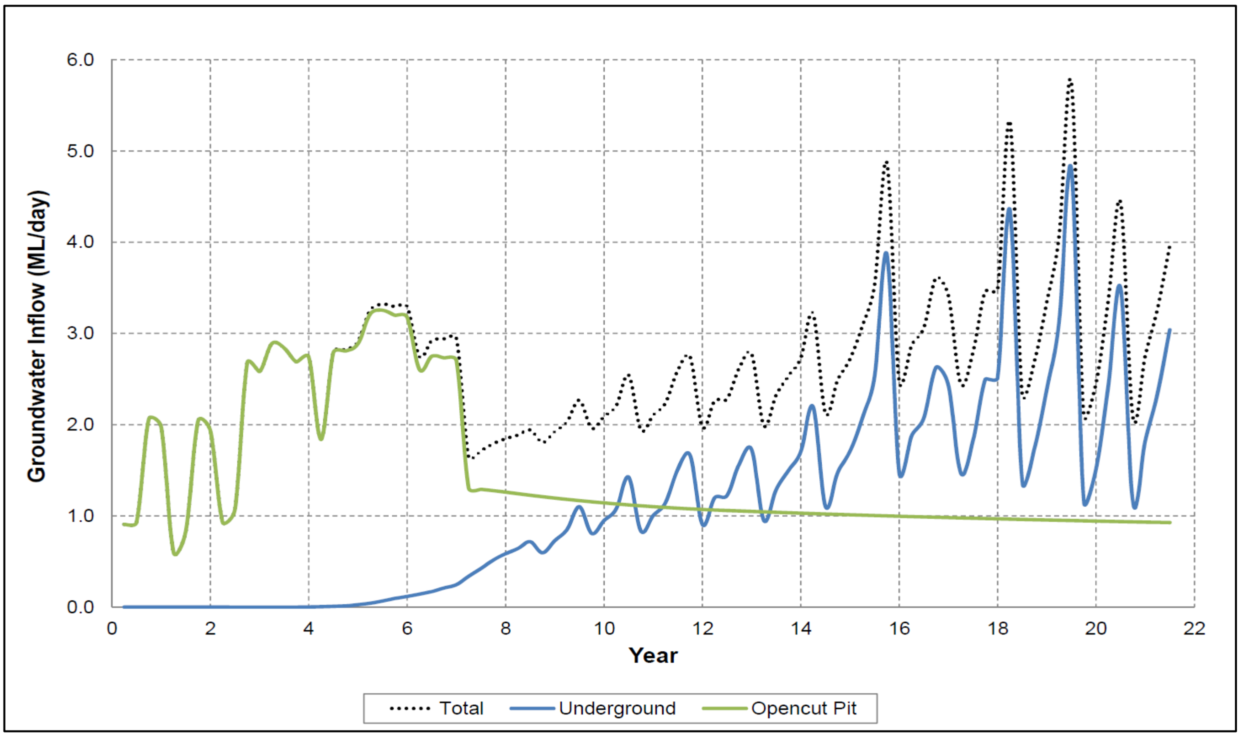
SHEET 1 OF 1

APPENDICES

APPENDIX A
INFLOW DATA INPUT

Input Data

Groundwater Inflow Rates over the mine life (provided by AGE, 2014) were used as input into the water balance.



Worst Case Scenario

Groundwater Inflow Rates for the worst case scenario over the mine life (provided by AGE, 2014) were used as input into the water balance.

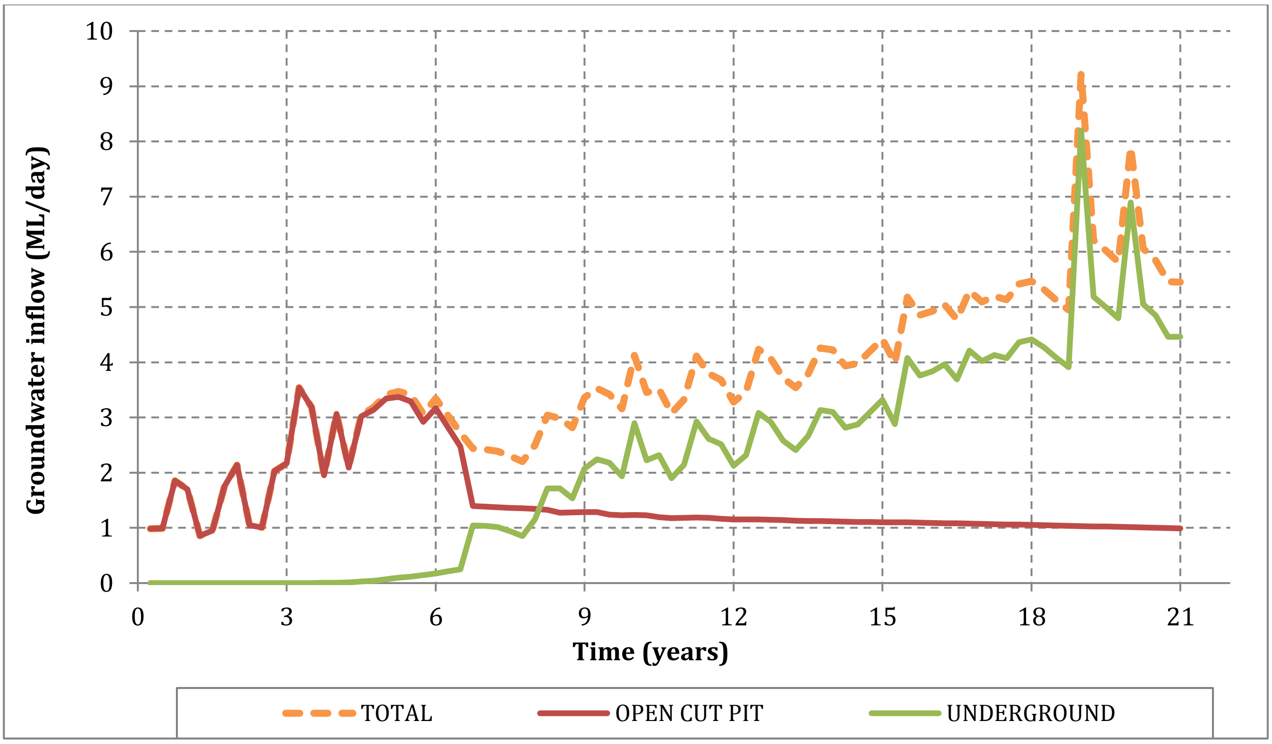
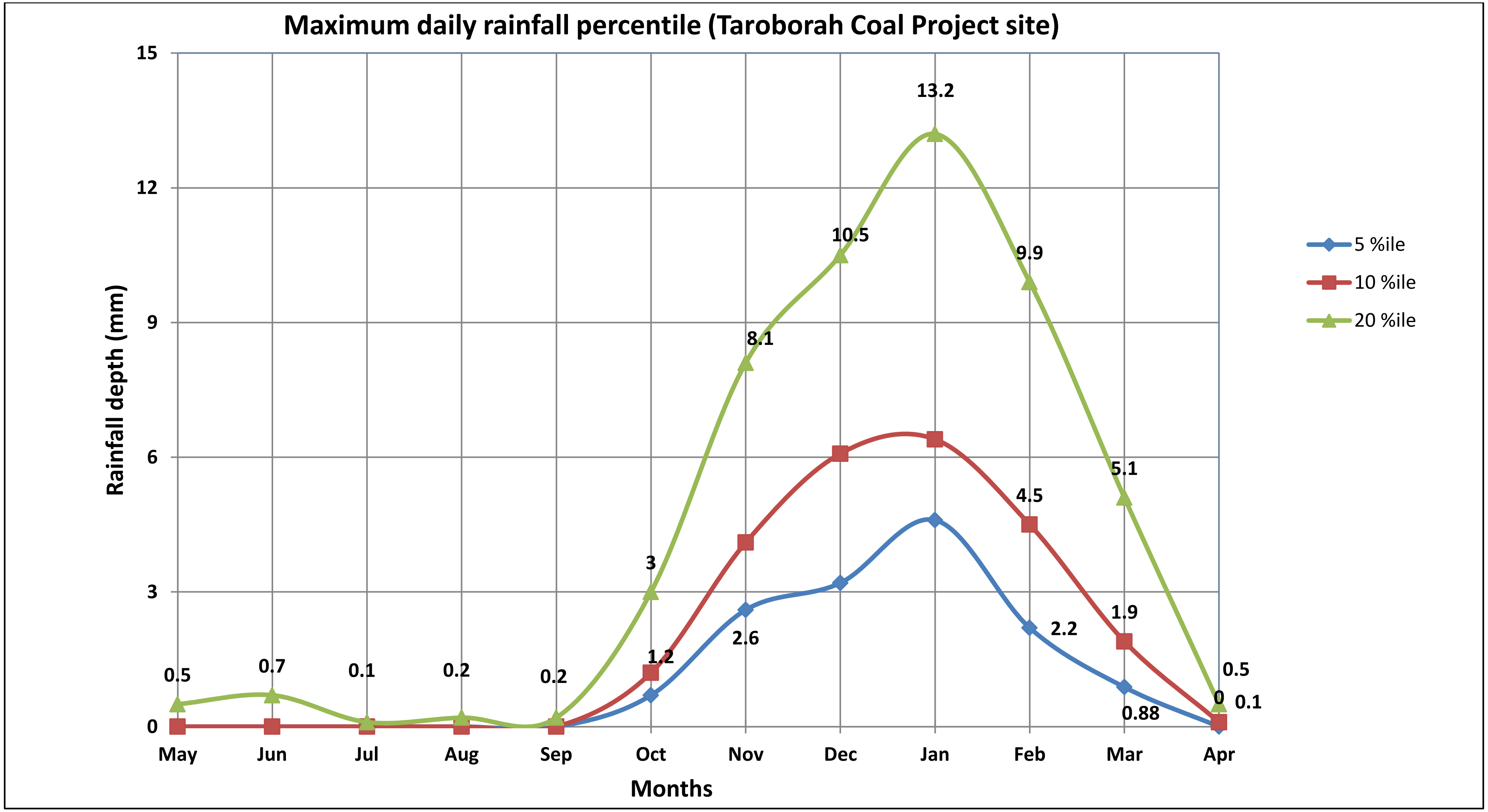
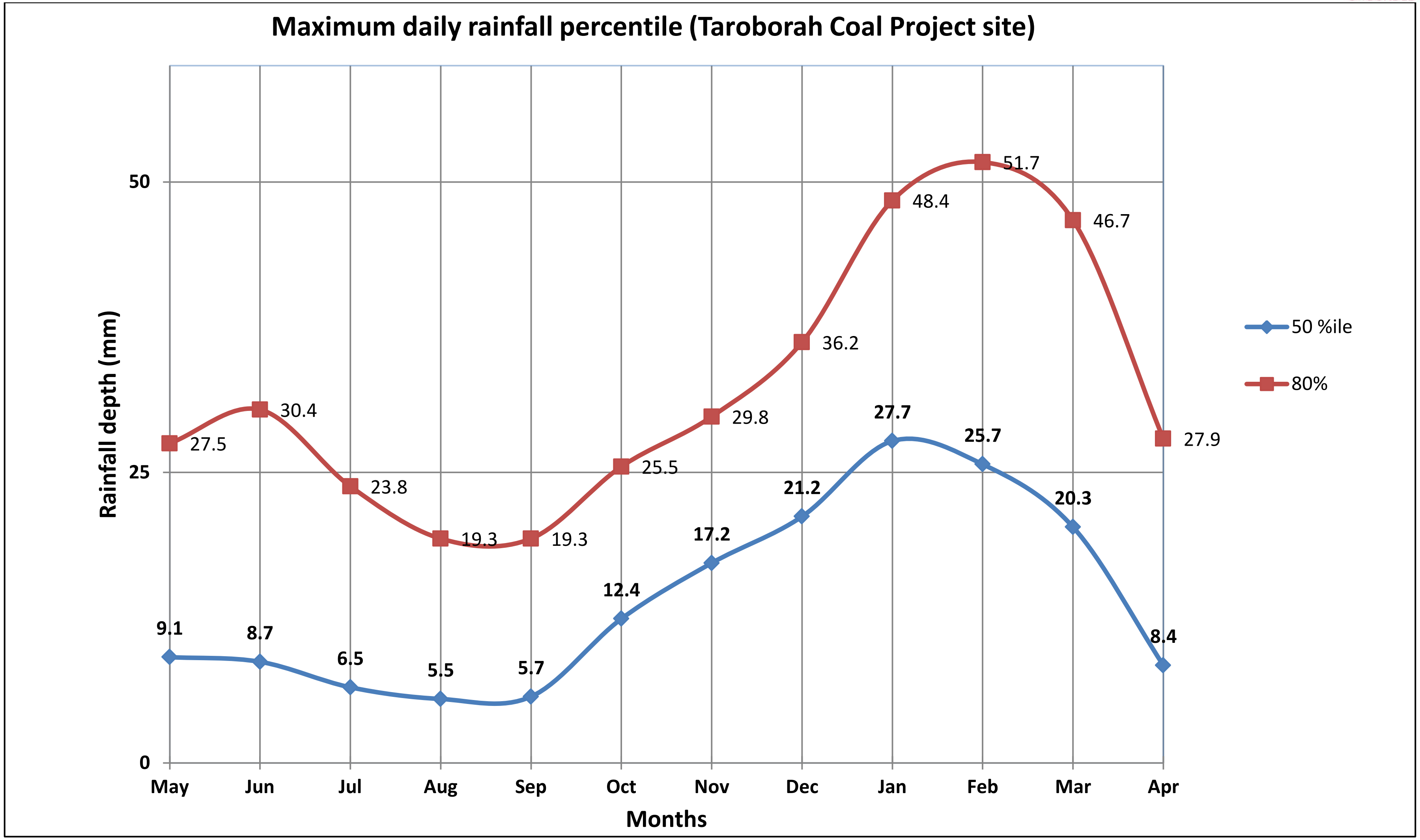
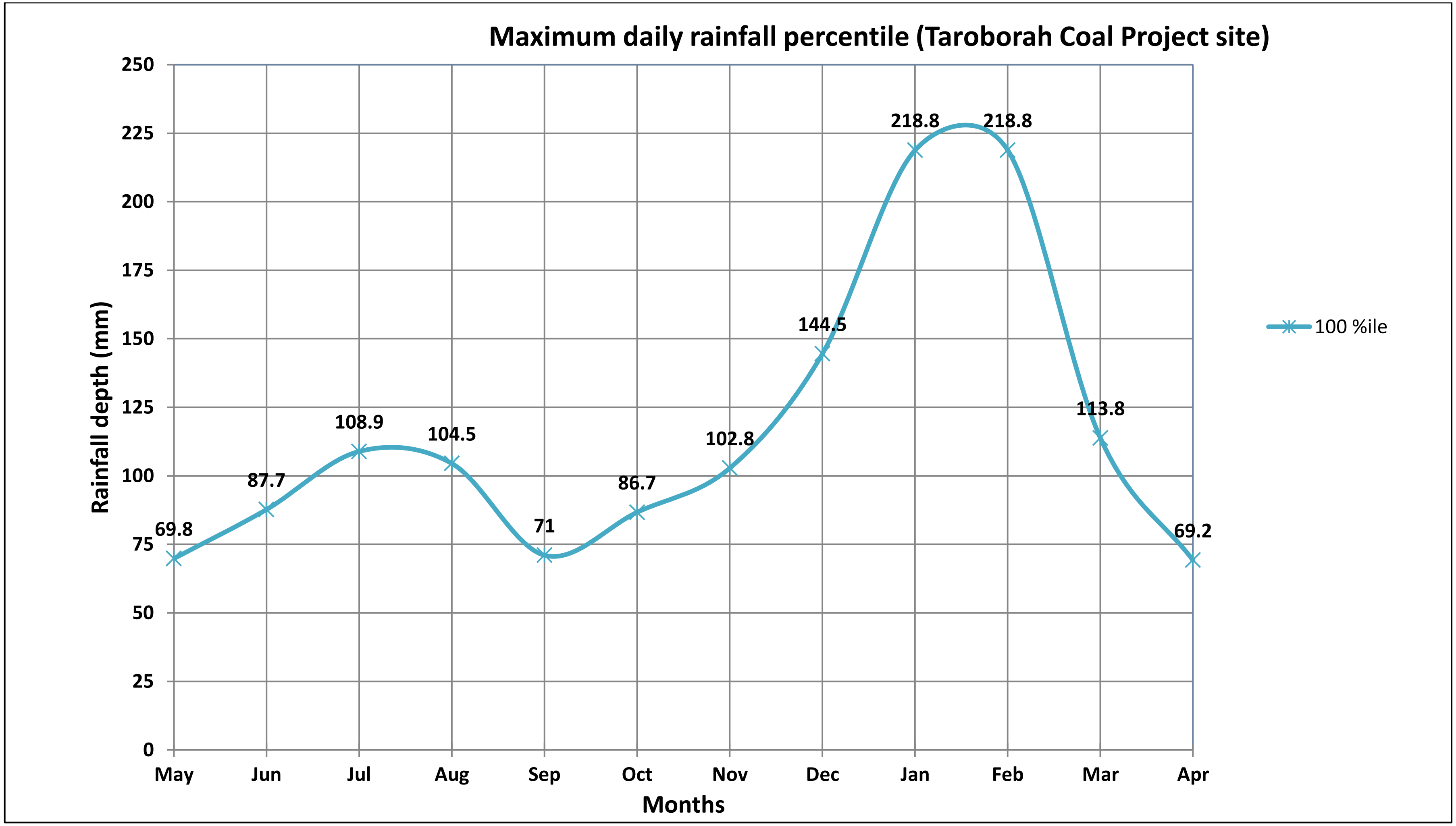


Table A1
Estimated Water Usage - ML/day
Taroborah Coal Project

		Surface Dust Suppression							CHPP			
			Area for Haul Roads									
	Year	Area for MIA/Pit	Length (m)	width (m)	Area	Total Area	Usage [(1)] @ 0.33 ML/ha	Equip Washdown	ROM tonnes/ yr	Usage @ 240L/t	UG Mine	Total Water Usage
Construction	2017	10	0	35	0	10	0.33	0.03				0.33
Construction/OC Ops	2018	20	8700	35	30.45	50.45	1.66	0.03	215,314	0.15		1.81
OC Ops	2019	10	8700	35	30.45	40.45	1.33	0.03	588,506	0.40		1.74
OC Ops	2020	10	7400	35	25.9	35.9	1.18	0.03	812,142	0.56		1.74
OC Ops	2021	10	7900	35	27.65	37.65	1.24	0.03	896,461	0.61		1.86
OC Ops + UG	2022	10	8400	35	29.4	39.4	1.30	0.03	829,808	0.57	0.38	2.24
OC Ops + UG	2023	10	8900	35	31.15	41.15	1.36	0.035	831,460	0.57	0.75	2.68
OC Ops + UG	2024	10	7900	35	27.65	37.65	1.24	0.045	440,508	0.30	1.00	2.54
UG Only	2025	3	5600	35	19.6	22.6	0.34	0.015	52,378	0.04	1.20	1.57
UG Only	2026	3	5600	35	19.6	22.6	0.34	0.015	250,745	0.17	1.20	1.71
UG Only	2027	3	5600	35	19.6	22.6	0.34	0.015	614,651	0.42	1.20	1.96
UG Only	2028	3	5600	35	19.6	22.6	0.34	0.015	561,056	0.38	1.20	1.92
UG Only	2029	3	5600	35	19.6	22.6	0.34	0.015	181,038	0.12	1.20	1.66
UG Only	2030	3	5600	35	19.6	22.6	0.34	0.015	91,675	0.06	1.20	1.60
UG Only	2031	3	5600	35	19.6	22.6	0.34	0.015	371,846	0.25	1.20	1.79
UG Only	2032	3	5600	35	19.6	22.6	0.34	0.015	352,071	0.24	1.20	1.78
UG Only	2033	3	5600	35	19.6	22.6	0.34	0.015	523,314	0.36	1.10	1.80
UG Only	2034	3	5600	35	19.6	22.6	0.34	0.015	796,539	0.55	1.00	1.89
UG Only	2035	3	5600	35	19.6	22.6	0.34	0.015	778,688	0.53	1.00	1.87
UG Only	2036	3	5600	35	19.6	22.6	0.34	0.015	-	-	1.00	1.34
UG Only	2037	3	5600	35	19.6	22.6	0.34	0.01	-	-	1.00	1.34
UG Only	2038	3	5600	35	19.6	22.6	0.34	0.01	-	-	1.00	1.34


Maximum daily rainfall percentile (Taroborah Coal Project site)
Rainfall depth (mm)
15
12
9
6
3
0
13.2
10.5
9.9
8.1
5.1
4.5
3
1.9
2.2
2.6
1.2
0.5
0.7
0.1
0.2
0.2
0.5
0
0.1
0.88
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Months
5 %ile
10 %ile
20 %ile


Maximum daily rainfall percentile (Taroborah Coal Project site)
Rainfall depth (mm)
50
25
0
27.5
30.4
23.8
19.3
19.3
25.5
29.8
36.2
48.4
51.7
46.7
27.9
9.1
8.7
6.5
5.5
5.7
12.4
17.2
21.2
27.7
25.7
20.3
8.4
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Months
50 %ile
80%



Maximum daily rainfall percentile (Taroborah Coal Project site)
Rainfall depth (mm)
250
225
200
175
150
125
100
75
50
25
0
69.8
87.7
108.9
104.5
71
86.7
102.8
144.5
218.8
218.8
113.8
69.2
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Months
100 %ile

APPENDIX B

CONSEQUENCE CATEGORY ASSESSMENT

B1 Preface

The following section details the Consequence Category assessments carried out for the storage structures at the Taroborah Coal Project. These assessments have been completed in accordance with the published guideline, "Manual for Assessing Consequence Categories and Hydraulic Performance of Structures, November 2013" (Version 4).

B2 Consequence Category Assessment

In order to assess the storage structures' consequence category at the Taroborah Coal Project site, the DEHP (2013) requires the investigation of three failure event scenarios, namely:

- Failure to contain – seepage;
- Failure to contain - overtopping; and
- Dam break.

Under each of the above scenarios, several modes of failure are possible and each failure mode has been considered separately.

A failure to contain scenario means a release from the structure that result from loss of containment due to excessive seepage, overtopping of the structure and/or other deficiencies in water management of the structure. Although they are typically non-flood producing, failure to contain events may involve the release of contaminants, which could endanger environmental values or human life.

A dam break scenario encompasses the collapse of a dam due to any possible cause. A dam break is typically flood producing, involving the rapid release of significant volumes of contaminants, which could endanger environmental values or human life. An embankment dam break could take place via the following failure modes:

- Spillway failure;
- Erosion-induced stability failure of embankment from flooding;
- Piping failure of embankment; and
- Static or seismic stability failure.

The consequence category to be applied for a structure is the highest category determined under the three failure event assessments and the contaminant concentration/dam volume assessment. The consequence category selected for each storage structure is described in greater detail in the sections that follow:

<u>Mine Water Dam</u>

Consequence category for the Mine Water Dam was assessed in accordance with the criteria outlined in Table 1 of the DEHP (2013). **Table B1** is reproduced, and comments on selected categories are as follows:

Harm to humans

- The consequence category based on harm to humans based on Failure to contain due to seepage, overtopping, and dam break is 'Low' because human will not routinely be present in the failure path and human consumption is expected 20 km downstream of the Taroborah site where the health of less than 10 people being effected.

- Water released from the dams at the project site will be from the designated spillway or a structure failure would result in discharging into Taroborah creek. The nearest settlement along the Taroborah creek from the project site is almost approximately 20 km downstream, thus any contaminated waters released could result in the health of less than 10 people affected.

General environmental harm

- The Taroborah mine site is located upstream to the High Ecological Value Waters(Heva2041) wetlands as allocated in the (EPP,2009), WQ1303,Lower Nagoa River/Theresa Creek Sub-Basin. The Mine Water Dam is located approximately 10 km upstream of the Heva2041. Under a 'Failure to Contain – overtopping' scenario, these areas may cause adverse effects to the existing ecosystem and therefore the Main Dam is classified as a "HIGH" consequence category, based on general environmental harm.
- Under a 'Dam Break' scenario, these areas may undergo significant alteration to the existing ecosystem and therefore the Main Dam is classified as a "SIGNIFICANT" consequence category, based on general environmental harm.
- The release of this water through a 'Failure to Contain – Seepage' scenario, would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects. The quantity of stormwater runoff stored within the Main Dam are from groundwater inflows and in-pit spoil run-off pumped from the open-cut and underground mines, with major deterioration of the receiving environment expected to occur.

General Economic Loss

- The consequence category, based on general economic loss or property damage would be "significant" due the HEVa2041 in the potential impact area of a "Failure to Contain - overtopping" or "Dam Break" scenario and "low" for "Failure to Contain - seepage", The expected costs to third parties would be expected to cost less than $1 million in remedial works, rehabilitation, compensation and repairs.

The outcome of this assessment for the Mine water Dam under the 'Dam Break', 'Failure to Contain – seepage' scenarios, and 'Failure to Contain – overtopping' scenarios, covering the aspects as outlined above, is a "HIGH" consequence. Given the above assessment, the Mine water Dam is a "Regulated Structure" in accordance with DEHP (2013).

Table B1
Consequence Category Assessment for Mine Water Dam

Environmental Harm	Consequence Category				Overall Rating	
	High	Significant	Low	Failure to contain - Seepage	Failure to contain - Overtopping	Dam Break
Harm to Humans	Location such that people are routinely present in the failure path and if present loss of life to greater than 10 people is expected[2]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario	Location such that people are routinely present in the failure path and if present loss of life to 1 person or greater but less than 10 people is expected[2]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario	Location such that people are not routinely present in the failure path and loss of life is not expected[2]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario	**LOW**	**LOW**	**LOW**
	Location such that contamination of waters (surface and/or groundwater[3]) used for human consumption could result in the health of 20 or more people being affected[4].	Location such that contamination of waters (surface and/or groundwater[3]) used for human consumption could result in the health of 10 or more people but less than 20 people being affected[4].	Location such that contamination of waters (surface and/or groundwater[3]) used for human consumption could result in the health of less than 10 people being affected[4].	**LOW**	**LOW**	**LOW**
General Environmental Harm	Location such that: a) Contaminants may be released to areas of MNES, MSES or HEV waters that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment (Significant Values); and b) Adverse effects5 on Significant Values are likely; and c) The adverse effects are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than $50,000,000; or ii) Remediation of damage is likely to take 3 years or more; or iii) Permanent alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 5 km2.	Location such that contaminants may be released so that adverse effects (that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment) either: a) Would be likely to be caused to Significant Values but those adverse effects would not be likely to meet the thresholds for the High consequence category and instead would be likely to cause at least one of the following: i) Loss or damage or remedial costs greater than $10,000,000 but less than $50,000,000; or ii) Remediation of damage is likely to take more than 6 months but less than 3 years; or iii) Permanent alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 1 km2 but less than 5 km2. Or b) Would be likely to be caused to environmental values classed as slightly or moderately disturbed waters6, wetland of general ecological significance7, riverine areas, springs or lakes and associated flora and fauna (Moderate Values), and the adverse effects are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than $20,000,000; or ii) Remediation of damage is likely to take more than 1 year; or iii) Significant alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 2 km2.	Location such that either: a) Contaminants are unlikely to be released to areas of Significant Values or Moderate Values; or b) Contaminants are likely to be released to those areas, but would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects.	**LOW**	**HIGH**	**SIGNIFICANT**
General Economic Loss or Property Damage	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $10 million or greater in rehabilitation, compensation, repair or rectification costs[8].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $1 million and greater but less than $10 million in rehabilitation, compensation, repair or rectification costs8.	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require less than $1 million in rehabilitation, compensation, repair or rectification costs[8].	**LOW**	**LOW**	**LOW**
			OVERALL	**LOW**	**HIGH**	**SIGNIFICANT**

Sediment Dams

Consequence category for the Sediment Dams were assessed in accordance with the criteria outlined in Table 1 of the DEHP (2013). **Table B2** is reproduced, and comments on selected categories are as follows:

Harm to humans

- The consequence category based on harm to humans due Failure to contain due to seepage, overtopping, and dam break is 'Low' because human will not routinely be present in the failure path and human consumption is expected 20 km downstream of the Taroborah site where the health of less than 10 people being effected.
- Water released from the dams at the project site will be from the designated spillway or a structure failure would result in discharging into Taroborah creek. The nearest settlement along the Taroborah creek from the project site is almost approximately 20 km downstream, thus any contaminated waters released could result in the health of less than 10 people affected.

General environmental harm

- The Taroborah mine site is located immediately upstream to the High Ecological Value Waters (Heva2041) wetlands as allocated in the EPP (2009), WQ1303,Lower Nagoa River/Theresa Creek Sub-Basin. The sediment basins are located at a minimum 5 km upstream of the Heva2041. Under a 'Dam Break' scenario and 'Failure to Contain – overtopping' scenario, these areas may not undergo significant alteration to the existing ecosystem and therefore the storages are classified as a "low" consequence category, based on general environmental harm.

- The release of this water through a 'Failure to Contain – Seepage' scenario, would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects due to the distance of the sediment dams from the Heva2041.

General Economic Loss

- The consequence category, based on general economic loss or property damage would be "Low" as there are no third party assets exist in the potential impact area of a "Failure to Contain - seepage", "Failure to Contain - overtopping" or "Dam Break" scenario. The expected costs to third parties would be expected to cost less than $1 million in remedial works, rehabilitation, compensation and repairs.

The outcome of this assessment for the Sediment dams for the 'Dam Break', 'Failure to Contain – seepage' scenarios, and 'Failure to Contain – overtopping' scenarios, covering the aspects as outlined above, is of "Low" consequence. Given the above assessment, the Dams are non - regulated structure in accordance with DEHP (2013).

Table B2
Consequence Category Assessment for Sediment Dams

Environmental Harm	Consequence Category				Overall Rating	
	High	Significant	Low	Failure to contain - Seepage	Failure to contain - Overtopping	Dam Break
Harm to Humans	Location such that people are routinely present in the failure path and if present loss of life to greater than 10 people is expected[2]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario	Location such that people are routinely present in the failure path and if present loss of life to 1 person or greater but less than 10 people is expected[2]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario	Location such that people are not routinely present in the failure path and loss of life is not expected[2]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario	**LOW**	**LOW**	**LOW**
	Location such that contamination of waters (surface and/or groundwater[3]) used for human consumption could result in the health of 20 or more people being affected[4].	Location such that contamination of waters (surface and/or groundwater[3]) used for human consumption could result in the health of 10 or more people but less than 20 people being affected[4].	Location such that contamination of waters (surface and/or groundwater[3]) used for human consumption could result in the health of less than 10 people being affected[4].	**LOW**	**LOW**	**LOW**
General Environmental Harm	Location such that: a) Contaminants may be released to areas of MNES, MSES or HEV waters that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment (Significant Values); and b) Adverse effects[5] on Significant Values are likely; and c) The adverse effects are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than $50,000,000; or ii) Remediation of damage is likely to take 3 years or more; or iii) Permanent alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 5 km^2.	Location such that contaminants may be released so that adverse effects (that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment) either: a) Would be likely to be caused to Significant Values but those adverse effects would not be likely to meet the thresholds for the High consequence category and instead would be likely to cause at least one of the following: i) Loss or damage or remedial costs greater than $10,000,000 but less than $50,000,000; or ii) Remediation of damage is likely to take more than 6 months but less than 3 years; or iii) Permanent alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 1 km^2 but less than 5 km^2. Or b) Would be likely to be caused to environmental values classed as slightly or moderately disturbed waters[6], wetland of general ecological significance[7], riverine areas, springs or lakes and associated flora and fauna (Moderate Values), and the adverse effects are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than $20,000,000; or ii) Remediation of damage is likely to take more than 1 year; or iii) Significant alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 2 km^2.	Location such that either: a) Contaminants are unlikely to be released to areas of Significant Values or Moderate Values; or b) Contaminants are likely to be released to those areas, but would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects.	**LOW**	**SIGNIFICANT**	**SIGNIFICANT**
General Economic Loss or Property Damage	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $10 million or greater in rehabilitation, compensation, repair or rectification costs[8].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require $1 million and greater but less than $10 million in rehabilitation, compensation, repair or rectification costs[8].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require less than $1 million in rehabilitation, compensation, repair or rectification costs[8].	**LOW**	**LOW**	**LOW**
			OVERALL	**LOW**	**LOW**	**LOW**

CPPWRD

Consequence category for the CPPWRD was assessed in accordance with the criteria outlined in Table 1 of the DEHP (2013). **Table B3** is reproduced, and comments on selected categories are as follows:

Harm to human

- The consequence category based on harm to humans due Failure to contain due to seepage, overtopping, and dam break is 'Low' because human will not routinely be present in the failure path and human consumption is expected 20 km downstream of the Taroborah site where the health of less than 10 people being effected.
- Water released from the dam at the project site will be from the designated spillway or a structure failure would result in discharging into Taroborah creek. The nearest settlement along the Taroborah creek from the project site is almost approximately 20 km downstream, thus any contaminated waters released could result in the health of less than 10 people affected.

General environmental harm

- The Taroborah mine site is located immediately upstream to the High Ecological Value Waters (Heva2041) wetlands as allocated in the (EPP,2009), WQ1303,Lower Nagoa River/Theresa Creek Sub-Basin. The CPPWRD is expected to contain is located approximately 8 km upstream of the Heva2041. Under a 'Dam Break' scenario and 'Failure to Contain – overtopping' scenario, these areas may undergo major alteration to the existing ecosystem and therefore the CPPWRD is classified as a "HIGH" consequence category, based on general environmental harm.

- The release of this water through a 'Failure to Contain – Seepage' scenario, would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects. The quantity of stormwater runoff stored within the CPPWRD will be mainly recovered process water from the CPP and site water runoff stored at sediment basins, with the release of contained site water from CPPWRD having the potential to cause major deterioration of the receiving environment.

General Economic Loss

- The consequence category, based on general economic loss or property damage would be "Significant" due to HEVA2041 exist downstream in the potential impact area of a "Failure to Contain - seepage", "Failure to Contain - overtopping" or "Dam Break" scenario. The expected costs to third parties would be expected to cost less than $1 million in remedial works, rehabilitation, compensation and repairs.

The outcome of this assessment for the Mine water Dam under the 'Dam Break', 'Failure to Contain – seepage' scenarios, and 'Failure to Contain – overtopping' scenarios, covering the aspects as outlined above, is a "HIGH" consequence. Given the above assessment, the CPPWRD is a "Regulated Structure" in accordance with DEHP (2013).

Table B3
Consequence Category Assessment for CPPWRD

Environmental Harm	Consequence Category				Overall Rating	
	High	Significant	Low	Failure to contain - Seepage	Failure to contain - Overtopping	Dam Break
Harm to Humans	Location such that people are routinely present in the failure path and if present loss of life to greater than 10 people is expected[2]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario	Location such that people are routinely present in the failure path and if present loss of life to 1 person or greater but less than 10 people is expected[2]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario	Location such that people are not routinely present in the failure path and loss of life is not expected[2]. Note: The requirement to consider the location of people in the failure path is only relevant to the 'dam break' scenario	**LOW**	**LOW**	**LOW**
	Location such that contamination of waters (surface and/or groundwater[3]) used for human consumption could result in the health of 20 or more people being affected[4].	Location such that contamination of waters (surface and/or groundwater[3]) used for human consumption could result in the health of 10 or more people but less than 20 people being affected[4].	Location such that contamination of waters (surface and/or groundwater[3]) used for human consumption could result in the health of less than 10 people being affected[4].	**LOW**	**LOW**	**LOW**
General Environmental Harm	Location such that: a) Contaminants may be released to areas of MNES, MSES or HEV waters that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment (Significant Values); and b) Adverse effects[5] on Significant Values are likely; and c) The adverse effects are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than \$50,000,000; or ii) Remediation of damage is likely to take 3 years or more; or iii) Permanent alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 5 km^2.	Location such that contaminants may be released so that adverse effects (that are not already authorised to be disturbed to at least the same extent under other conditions of this authority subject to any applicable offset commitment) either: a) Would be likely to be caused to Significant Values but those adverse effects would not be likely to meet the thresholds for the High consequence category and instead would be likely to cause at least one of the following: i) Loss or damage or remedial costs greater than \$10,000,000 but less than \$50,000,000; or ii) Remediation of damage is likely to take more than 6 months but less than 3 years; or iii) Permanent alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 1 km^2 but less than 5 km^2. Or b) Would be likely to be caused to environmental values classed as slightly or moderately disturbed waters[6], wetland of general ecological significance[7], riverine areas, springs or lakes and associated flora and fauna (Moderate Values), and the adverse effects are likely to cause at least one of the following: i) Loss or damage or remedial costs greater than \$20,000,000; or ii) Remediation of damage is likely to take more than 1 year; or iii) Significant alteration to existing ecosystems; or iv) The area of damage (including downstream effects) is likely to be at least 2 km^2.	Location such that either: a) Contaminants are unlikely to be released to areas of Significant Values or Moderate Values; or b) Contaminants are likely to be released to those areas, but would be unlikely to meet any of the minimum thresholds specified for the Significant Consequence Category for adverse effects.	**LOW**	**HIGH**	**HIGH**
General Economic Loss or Property Damage	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require \$10 million or greater in rehabilitation, compensation, repair or rectification costs[8].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require \$1 million and greater but less than \$10 million in rehabilitation, compensation, repair or rectification costs[8].	Location such that harm (other than a different category of harm as specified above) to third party assets in the failure path would be expected to require less than \$1 million in rehabilitation, compensation, repair or rectification costs[8].	**LOW**	**LOW**	**LOW**
			OVERALL	**LOW**	**HIGH**	**HIGH**