RED HILL
MINING LEASE

ENVIRONMENTAL IMPACT STATEMENT

Appendix Q3
Independent Expert Scientific Committee Report

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Abbreviations and Units

Abbreviation	Definition
AEP	annual exceedence probability
AHD	Australian Height Datum
AWBM	Australian Water Balance Model
BMA	BHP Billiton Mitsubishi Alliance
BRM	Broadmeadow Underground Mine
CHPP	coal handling and preparation plant
CSG	coal seam gas
EA	environmental authority
EC	electrical conductivity
EIS	environmental impact statement
EP Act	*Environmental Protection Act 1994*
EPP (Water)	Environmental Protection (Water) Policy 2009
GIS	Geographic Information System
GLS	Goonyella Lower Seam
GMA	Groundwater Management Area
GMS	Goonyella Middle Seam
GPR	Ground Penetrating Radar
GRB	Goonyella, Riverside and Broadmeadow
GRM	Goonyella Riverside Mine
GUS	Goonyella Upper Seam
IMG	incidental mine gas
IQQM	Integrated Quantity and Quality Models
IRCIA	Isaac River Cumulative Impact Assessment
JORC	Joint Ore Reserves Committee
MIA	mine industrial area
ML	mine lease
MLA	mine lease application
NRM	Department of Natural Resources and Mines
QWQG	Queensland Water Quality Guidelines
PHA	preliminary hazard analysis
RHM	Red Hill Mine
ROM	run-of-mine
TDS	total dissolved solids
TEP	Transitional Environmental Programs
WQO	Water Quality Objectives

Unit	Definition
km^2	square kilometres
L/s	litres per second
m^3/t	cubic metres per tonne
mbgl	metres below ground level
ML	megalitres
ML/day	megalitres per day
ML/year	megalitres per year
mg/L	milligrams per litre
µg/L	micrograms per litre
µS/cm	microSiemens per centimetre
mtpa	million tonnes per annum
tph	tonnes per hour

Section 01 Summary Details

Table 1-1 Project Summary Details

Project Title	Red Hill Mining Lease EIS
Date of Request	17 October 2013
Requesting Organisation	Department of the Environment
EPBC Act Referral	2013/6865
Advice Stage	EIS being prepared by proponent
Request Details	The proposed action requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999*
Proponent Details	BM Coal Alliance Operations Pty Ltd
Website Links	metcoalinfo@bhpbilliton.com
Public Submissions	Not Applicable

On the 21st June 2013, the EPBC Act was amended to include an additional controlling provision relating to 'protection of water resources'. On the 17th October 2013, the Minister determined that the Red Hill Mining Lease Project, under item 23 of Schedule 1 to the *Environment Protection and Biodiversity Conservation Amendment Act 2013* (the EPBC Amendment Act), that Sections 24D and 24E of the EPBC Act are controlling provisions for the proposed action. The consequence of this decision is that the proposed action must be approved for the purposes of this controlling provision before it can proceed.

Section 02 Project Description

BHP Billiton Mitsubishi Alliance (BMA), through its joint venture manager, BM Alliance Coal Operations Pty Ltd, proposes to convert the existing Red Hill mining lease application (MLA) 70421 to enable the continuation of existing mining operations associated with the Goonyella Riverside and Broadmeadow (GRB) mine complex. Specifically, the mining lease conversion will allow for:

- An extension of three longwall panels (14, 15 and 16) of the existing Broadmeadow Underground Mine (BRM).
- Future incremental expansion of the existing Goonyella Riverside Mine (GRM).
- Future Red Hill Mine (RHM) underground expansion option located to the east of the GRB mine complex.

The three project elements described above are collectively referred to as 'the project' and a detailed description of each element is provided in **Section 2.2.2.**

2.1 Project Location

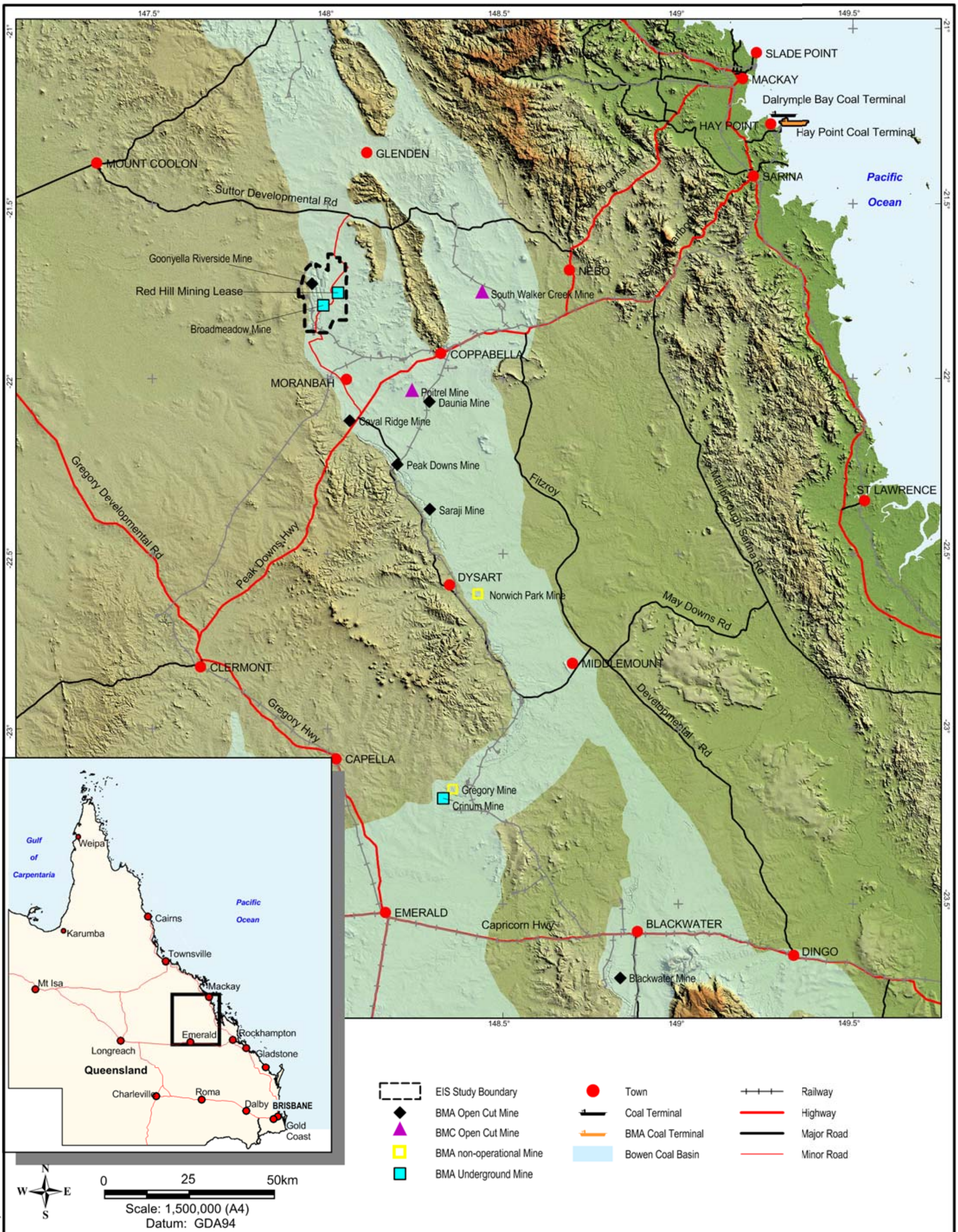
The Red Hill Mining Lease (MLA70421) is located adjacent to the existing GRB mine complex in the Bowen Basin, approximately 20 kilometres north of Moranbah and 135 kilometres south-west of Mackay, Queensland (**Figure 2-1**).

2.1.1 Physical Setting

The study area (**Figure 2-2**) comprises the surface water and groundwater regions that could be affected by the proposed mine activities. The study area is located within the upper sub-catchment of the Isaac River in the northern part of the Fitzroy River Basin and is bordered by the Peak Range to the southwest, Denham Range to the northwest, and the Broadsound and Connors ranges to the east and northeast, respectively.

The study area is located within a broad valley through which the Isaac River flows, generally in a southerly direction. The northern portion of the study area is formed by a low broad ridge that defines the northern extent of the Isaac River catchment. The low hills located to the east of the Isaac River near the GRB mine complex are undulating with a well-developed system of drainage lines.

The topography of the Isaac River valley near the study area varies from approximately 250 metres Australian Height Datum (AHD) elevation along the Isaac River east of the study area to approximately 325 metres AHD elevation along portions of the Denham Range that define the western edge of the valley. The relatively steep slopes associated with the Denham Range contrast with the extensive flat areas across the base of the river corridor, where gradients are generally less than 1:100.



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REGIONAL LOCATION

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Figure: **2-1**

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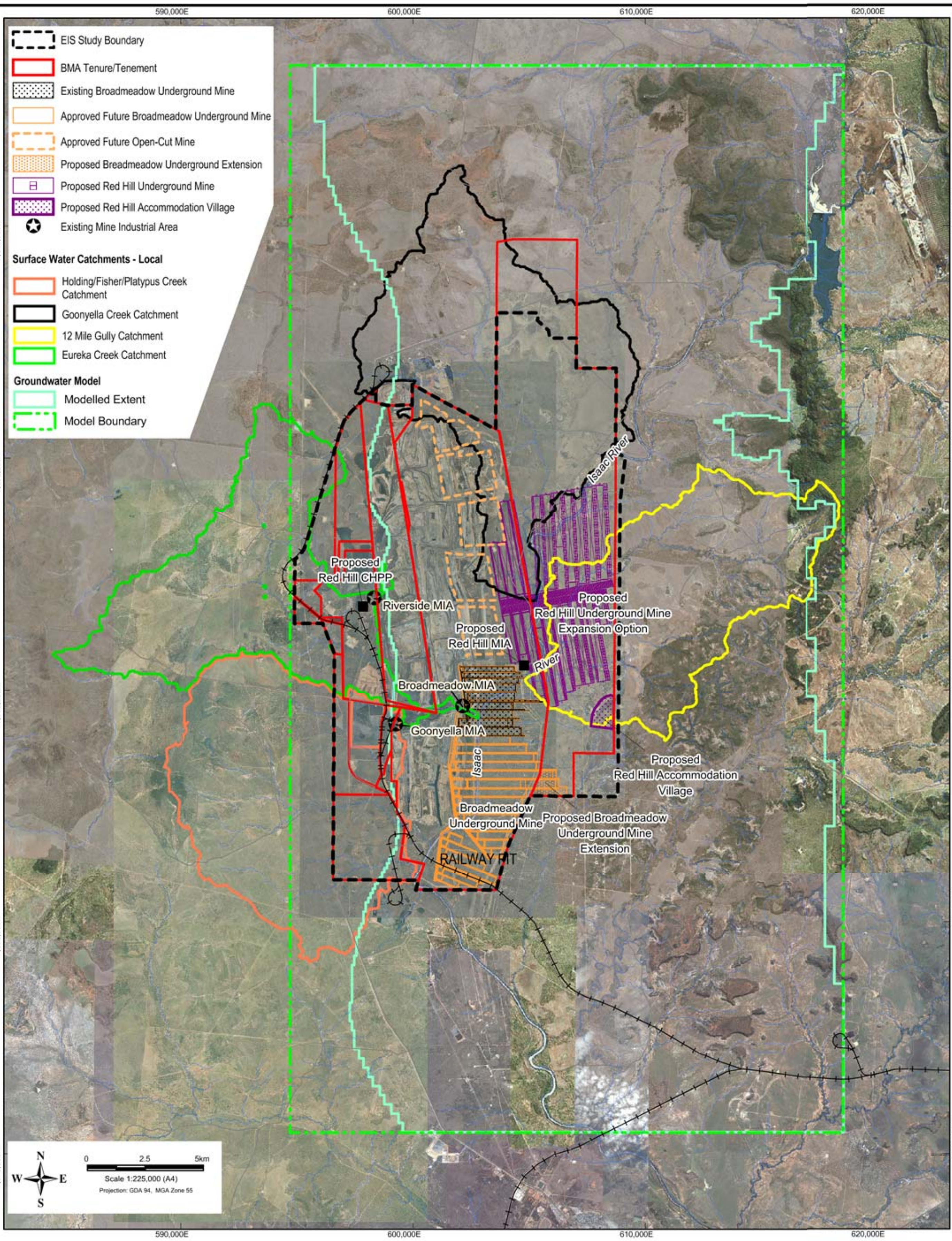

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2.1.2 Geological Overview

The study area is located within the geological Bowen Basin, an elongate north-south trending basin which extends from east-central Queensland to northern New South Wales. The major geological structure of the geological survey area is the Collinsville Shelf, a thin accumulation of sediments of the Bowen Basin that forms the boundary of the basin in the west and dips gently (two to eight degrees) and thickens to the east. The eastern boundary of the Collinsville Shelf is marked by a major thrust fault termed the Burton Range Thrust Fault, which is located approximately 10 kilometres east of MLA70421. The lack of regionally significant geological structures or fault zones distinguishes the Collinsville Shelf sediments from the tightly folded and intruded sediments to the east of the Burton Range Thrust Fault.

Regionally, the stratigraphic sequence is summarised as follows: the Early to Middle Permian age Back Creek Group is the oldest Bowen Basin succession observed. This is conformably overlain by the Late Permian Blackwater Group, which contains the coal seams of economic interest to BMA. Following deposition of the Blackwater Group was the Triassic Rewan Group. Tertiary volcanic deposits composed mostly of basaltic lava flows overlie the Bowen Basin successions. These Tertiary volcanic units occur as isolated exposures in the north of the study area. Extensive Quaternary alluvial deposits are associated with the Isaac River system.

The study area specific stratigraphy is presented in **Table 2-1** and a typical cross-section of the study area is depicted in **Figure 2-3**.

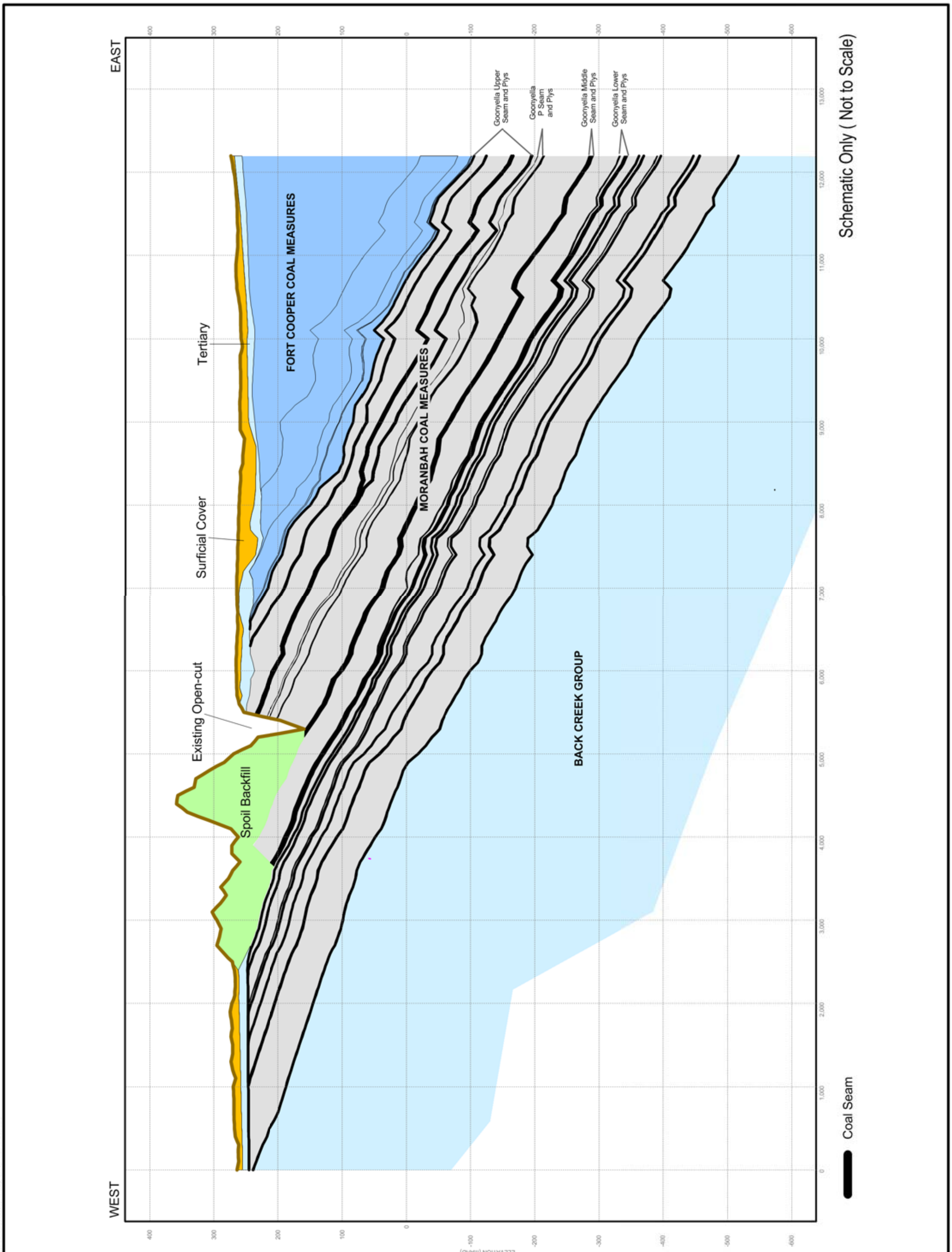
Table 2-1 Stratigraphy of the Study Area

Period		Stratigraphic Unit				Description	Max. Thickness (m)	Presence in Study Area
Cainozoic	Quaternary	Alluvium				Clay, silts, sand, gravel, floodplain alluvium	37 m in survey area	Confined to present day stream alignments and palaeochannels
	Tertiary	Basalt				Olivine basalt flows	35 m in survey area	Isolated patches in north of survey area
		Suttor Formation				Clay, silts, sand, gravel, colluviual and residual deposits, fluvial and lacustrine deposits	80 m in survey area	Most extensive in the mine areas and to the east
Triassic	Early		Rewan Group	Rewan Formation		Green lithic sandstone, pebble conglomerate, red and green mudstone	Unknown in survey area	Small area within the north-east
Permian	Late	Bowen Basin	Blackwater Group	Rangal Coal Measures		Sandstone, siltstone, mudstone, coal, tuff, sandstone	100 m	Outcrops or subcrops in the majority of the survey area
				Fort Cooper Coal Measures	Burngrove Formation	Mudstone, siltstone, sandstone, coal, tuff	400 m	
					Fair Hill Formation	Labile sandstone, quartzose sublabile sandstone, siltstone, mudstone, calcareous and tuffaceous sandstone, volcanic conglomerate, carbonaceous mudstone, coal		
				Moranbah Coal Measures		Quartzose to sublabile, locally argillaceous sandstone, siltstone, mudstone, carbonaceous mudstone and coal	250 m	
	Early to Middle		Back Creek Group			Quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite	Unknown in survey area	Outcrops west of mines and extends under mined areas to the east

2.1.3 Hydrogeological Overview

The groundwater regime in the study area is considered to include:

- Quaternary alluvial aquifers (surficial cover) associated with the creeks and Isaac River;
- Tertiary sediment aquifers;
- Tertiary basalt aquifers; and
- Permian-Triassic sedimentary fractured rock (coal seam) aquifers.



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TYPICAL GEOLOGICAL CROSS SECTION

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Figure: **2-3**

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Located within the declared Isaac Connors Groundwater Management Area (GMA), as defined in the Water Resources (Fitzroy Basin) Plan 2011, the Quaternary alluvial aquifers in the study area are known as the Isaac Connors Groundwater Unit 1, with all other aquifers grouped together as the Isaac Connors Groundwater Unit 2. The alluvium associated with the Isaac River in the study area is defined as the Isaac Connors Alluvium groundwater sub-area of the Isaac Connors GMA.

Groundwater supply is not considered to be a major water source in the study area. Based on a review of available data, the beneficial use of groundwater in the survey area is considered to be low due to low sustainable yields and poor groundwater quality.

2.2 Project Overview and Components

The proposed mining at Broadmeadow to facilitate the extension of longwall panels 14, 15 and 16 will utilise existing BRM mine infrastructure and extend the life of mine by approximately one year. No additional mining infrastructure will be required to enable the panel extensions into MLA70421. The existing BRM workforce will complete all work associated with the extensions.

The GRM incremental expansion option refers to those project activities which are located within the existing GRB mine complex and associated with the proposed RHM underground expansion option.

The future RHM underground expansion option is located on MLA70421 to the east of the existing GRB complex.

2.2.1 Operational Area

The GRB mine complex currently operates on a number of mining leases: mine lease (ML) 1763, ML1764, ML1802, ML1900, ML70038, ML70121, ML70193, ML70194, ML70287, ML70288 and ML70289.

The BRM currently operates on ML1763. The Broadmeadow extension is proposed to extend from ML1763 into the southern section of MLA70421 through the conversion to a mining lease.

2.2.2 Operation Details

The key elements of the project include:

- The extension of BRM longwall panels 14, 15, and 16 into MLA70421. Key elements include;
  - No new mining infrastructure is proposed other than infrastructure required for drainage of incidental mine gas (IMG) to enable safe and efficient mining.
  - Management of waste and water produced from drainage of IMG will be integrated with the existing BRM waste and water management systems.
  - The mining of the BRM panel extensions is to sustain existing production rates of the BRM mine and will extend the life of mine by approximately one year.
  - The existing BRM workforce will complete all work associated with the extensions.
- The incremental expansion of the GRM including:
  - underground mining associated with the RHM underground expansion option to target the Goonyella Middle Seam (GMS);
  - a new mine industrial area (MIA);

  - a coal handling and preparation plant (CHPP) adjacent to the Riverside MIA on MLA1764 and ML1900, the Red Hill CHPP will consist of up to three 1,200 tonne per hour modules;
  - construction of a drift for mine access;
  - a conveyor system linking RHM to the Red Hill CHPP;
  - associated coal handling infrastructure and stockpiles;
  - a new conveyor linking product coal stockpiles to a new rail load-out facility located on ML1900; and
  - flood protection to the mine access and MIA, potentially requiring a levee along the west bank of the Isaac River.
- A potential new Red Hill underground mine expansion option to the east of the GRB mine complex, to target the GMS on MLA70421. Key aspects of the project include:
  - The proposed mine layout consists of a main drive extending approximately west to east with longwall panels ranging to the north and south
  - A network of bores and associated surface infrastructure over the underground mine footprint for mine gas pre-drainage (IMG) and management of goaf methane drainage to enable the safe extraction of coal;
  - A ventilation system for the underground workings;
  - A bridge across the Isaac River for all-weather access. This will be located above the main headings, and will also provide a crossing point for other mine related infrastructure including water pipelines and power supply; and
  - A new accommodation village (Red Hill accommodation village) for the up to 100 per cent remote construction and operational workforces with capacity for up to 3,000 workers.

2.2.3 Project Lifetime

Indicative project timing is shown in **Table 2-2**.

Table 2-2 Indicative Project Timing

Phase	Indicative dates
Environmental impact assessment completed	November 2014
EPBC approval decision	December 2014
Land acquisition and compensation	2014
Draft EA	November 2014
Mining lease and EA issue	February 2015
Stage 1 – Broadmeadow extension panels 14 and 15 Panel 16 commencement date to be determined	2016 - 2018
Stage 2 – RHM Underground expansion option and GRM expansion option	Commencement dates not known

The proposed RHM underground expansion option will target the Goonyella Middle Seam (GMS). Depending on the rate and scale of development, the RHM underground expansion option will have an estimated life of mine of about 20 to 25 years, extracting 234 million tonnes of run-of-mine (ROM) coal which when processed will produce 190 million tonnes of product.

2.2.4 Residual Site Conditions

The main features of the final landform after mining ceases based on the proposed longwall mining technique will comprise of subsidence troughs on the surface for both the proposed Broadmeadow extensions and RHM footprint.

Rehabilitation of surface disturbance caused by mining activities will be continuous as mining progresses and will continue after mining has ceased until completion criteria have been achieved.

The proposed longwall mining will permanently alter the aquifer parameters (hydraulic conductivity and storage) in the goaf.

2.2.5 Site Rehabilitation

Current objectives in relation to post mining land use are that rehabilitation will return disturbed areas to a stable landform capable of supporting cattle grazing as per the current land use.

Rehabilitation will occur progressively throughout the mining activity as disturbed areas become available. Final rehabilitation and closure activities will commence once mining activity has ceased. As actual mine closure will not take place for an estimated 25 years, it is likely that accepted strategies and practices for rehabilitation and closure will have changed and, hence, rehabilitation and closure planning is a dynamic process.

BMA will prepare a rehabilitation management plan at the commencement of operations and will then prepare a closure plan five years prior to the anticipated closure. In addition, BMA will prepare a subsidence management plan at the commencement of construction which sets out the adaptive management approach for subsidence of the Isaac River. The plan will be developed in association with the existing Broadmeadow Subsidence Management Plan.

It should be noted that rehabilitation of waste disposal areas for mineral wastes (rejects and dewatered tailings) will be undertaken in accordance with the existing Goonyella Riverside Broadmeadow Rehabilitation Management Plan (BMA 2011).

2.3 Mineral Resources

Three major coal bearing geological formations of Permian age occur in the study area, these include the Rangal Coal Measures, the Fort Cooper Coal Measures, and the Moranbah Coal Measures.

The Rangal Coal Measures outcrop in the far eastern corner of the mining tenements, on mineral development license (MDL) 358 (Red Hill East). The Fort Cooper Coal Measures contain thick, stone banded, poor quality coal seams, which are not considered economic under current circumstances. These in turn overlie the Moranbah Coal Measures which are the productive units targeted by the RHM. The Moranbah Coal Measures typically contain up to seven coal seams, which are separated by inter-banded sandstone, siltstone and claystone and include several tuff units. The main tuff unit, the ‘‘P’’ Tuff, is recognisable across the area and is a useful correlation marker within the formation.

Three focal coal seams are present in the current and proposed mining areas: the Goonyella Upper Seam (GUS), the GMS and the Goonyella Lower Seam (GLS). These seams split and coalesce across the mining tenements and various combinations are mined in the adjacent open-cut mines to the west of the proposed RHM. The proposed RHM will only target the GMS which yields high quality coking coal. The GMS is between 5 and 10.5 metres thick within the target mining area and there are known areas of faulting. The GMS coal is the target of the Broadmeadow extension.

Section 03 Regional Water Balance Model

To assess the potential impacts of the proposed RHM Lease Project and associated infrastructure on the regional water resources, predictive modelling was undertaken.

All creeks and the Isaac River within the study area are ephemeral and there are no perennial water holes or groundwater dependant environments present. Under dry season conditions, groundwater does not contribute or have any hydraulic connection with surface water resources within these drainages. In exceptionally wet years it is possible that the Quaternary alluvium and shallow Tertiary aquifers may contribute some groundwater to the surface water system along water courses for a short duration after rain events. Due to the limited surface water – groundwater interaction within the study area, the surface water and groundwater resources were considered separately.

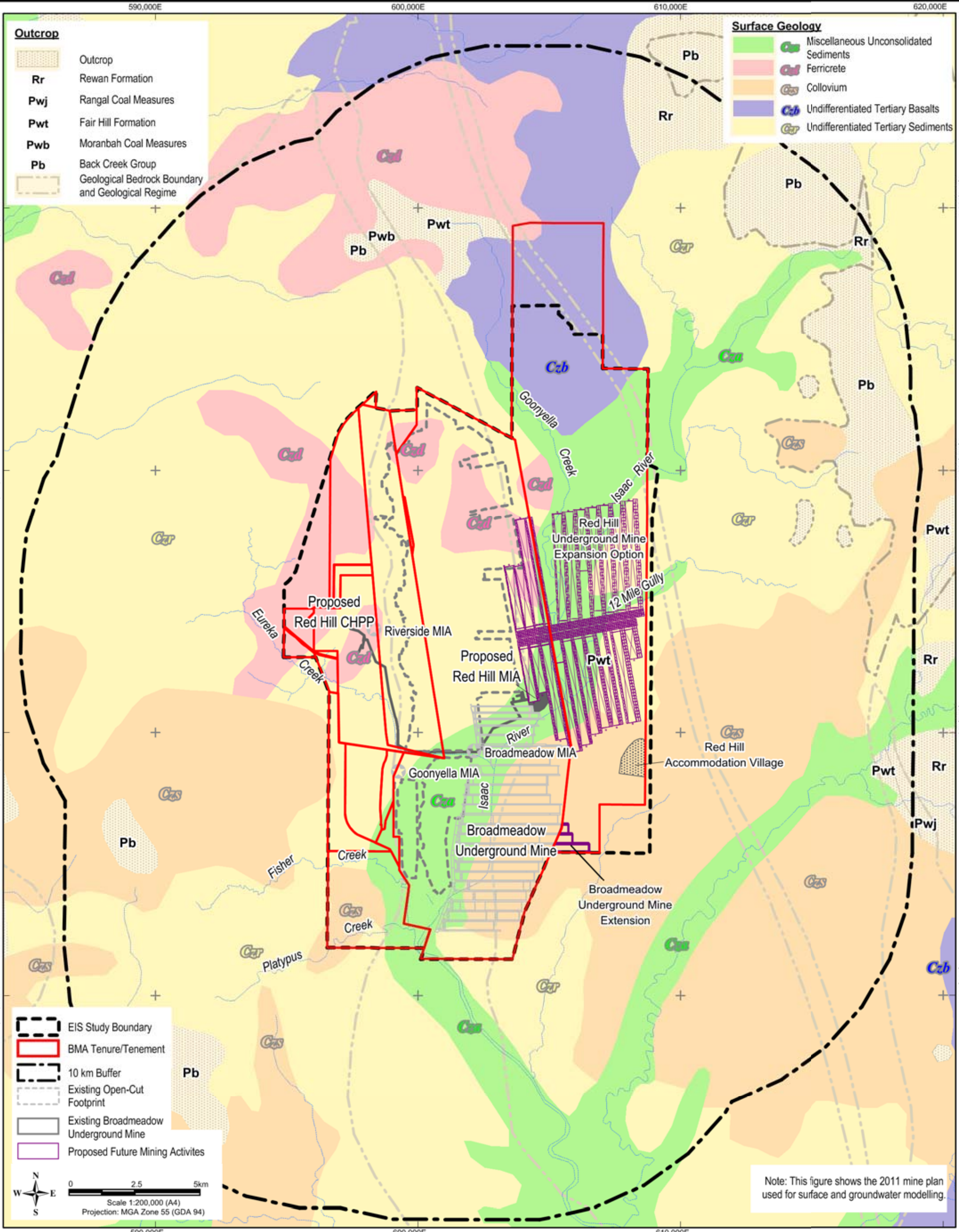
The groundwater predictive modelling was developed from regional and site specific groundwater/ aquifer data. The surface water predictive modelling was developed from regional and site specific surface water data (i.e. catchment characteristics); both models incorporated the proposed project activities.

The regional data is presented in this section.

3.1 Regional Geology

The geological Bowen Basin is an elongated, north-south trending basin, which extends from east-central Queensland to northern New South Wales. The basin covers an area of approximately 200,000 square kilometres, and is exposed over 600 kilometres from Collinsville in the north to Rolleston in the south. It contains a sedimentary sequence of Permo-Triassic clastics, which attain a maximum thickness of 9,000 metres in the depocentre of the Taroom Trough.

Regionally, the stratigraphic sequence is summarised as follows: the Early to Middle Permian Back Creek Group is the oldest Bowen Basin succession observed. This is conformably overlain by the Late Permian Blackwater Group, which contains the coal seams of economic interest to BMA. Following deposition of the Blackwater Group was the Triassic Rewan Group. Tertiary volcanic deposits composed mostly of basaltic lava flows overlie the Bowen Basin successions. These Tertiary volcanic units occur as isolated exposures in the north of the survey area. Extensive Quaternary alluvial deposits are associated with the Isaac River system. A summary of the stratigraphy from the study area is presented in **Table 2-1** and the local geology is shown in **Figure 3-1**.



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SURFACE GEOLOGY OF THE STUDY AREA

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3.2 Regional Groundwater Description

The study area is situated on the interior plains of the Bowen Basin and oriented north-south and parallel with the ancient drainage pattern and greatest thickness of sediment successions.

The Back Creek Group comprises sandstone, siltstone, shale, and minor coal and is considered a semi-pervious lower boundary for groundwater flow to the overlying Blackwater Group coal measures. The Blackwater Group is overlain by the Rewan Group of which only the Rewan Formation occurs extensively in the middle of the basin. The thickness of the Rewan Formation ranges across the Bowen Basin up to 800 metres thick (in the depocentre of the basin) but has a limited thickness within the study area and is only found within the northeast portion of the study area. The Rewan Formation is a semi-pervious barrier to vertical groundwater flow and acts as a confining unit. The Triassic and Permian sedimentary successions are overlain by isolated basaltic lava (Tertiary) outcrops, remnants of Suttor Formation (Tertiary), and undifferentiated sediments (Tertiary). Extensive alluvial deposits (Quaternary) occur along the Isaac River and creeks and floodplains within the study area.

3.2.1 Quaternary Alluvial Aquifers

Quaternary alluvial deposits in the region occur predominantly within the Isaac River floodplains. Along the Isaac River these deposits consist of clay, sandy clay, and sand and gravel with varying proportions of clay, to a depth of ~ 40 metres. Regional investigations along the Isaac River, including at the Moranbah North mine (located immediately south of GRB mine complex), indicated that the thickness of bed sands in the Isaac River was two to three metres (JBT Consulting 2010).

The sand and gravel deposits are recognised within the creek beds with the overbank deposits being silty and clayey with minor sand. In the upper catchments of the smaller creeks rock bars are evident. Sand and gravel deposits tend to accumulate behind such rock bars, where the thickness of the alluvial sediments is considered thicker than elsewhere along the creeks.

Alluvial aquifers within these deposits are recharged during flow events by surface water (SKM 2009). Available hydrologic data suggest that these units also receive rainfall recharge, as water infiltrates / drains to the base of the alluvium relatively quickly after rainfall events where more permeable units are at surface. Such saturation is sporadic, producing semi-permanent, localised, thin, aquifers.

During a ground penetrating radar (GPR) survey of the Isaac River at Moranbah North mine, accessible during the dry season, it was noted that all test pits dug for the GPR survey within the bed sands were dry, or only damp in the base layer. This indicates that the Isaac River alluvium has limited effective storage, providing only limited volumes of baseflow during and immediately after the wet season, and does not contain groundwater all year round. Limited groundwater resources may, however, occur in the deeper and relatively narrow parts of the channel.

Owing to the paucity of data for the Quaternary alluvium, limited information exists regarding groundwater flow, however regionally groundwater flow within the aquifer is expected to follow topography and drainage patterns.

Due to the generally shallow saturated thickness and the lack of continuity of the more permeable gravel and sand sections, the Quaternary alluvium is not considered a significant aquifer as it has limited sustainable yield. However, during periods of creek or river flow, the alluvium may become fully saturated and discharge to sub-cropping coal seams.

3.2.2 Tertiary Sediment Aquifers

The undifferentiated Tertiary sediments and Suttor Formation occurs extensively throughout the region, though outcrops are not always continuous, as much of the Tertiary sequence is concealed by younger alluvium and colluvium. The Tertiary sediments generally consist of lenses of palaeochannel gravels and sands separated by sandy silts, sandy clays and clays. The Tertiary sediments vary in thickness up to approximately 80 metres with a typical thickness of 15 metres in the area of the RHM. The thickness and extent of these Tertiary sediments are variable and for the most part, groundwater resources are limited and typically have poor quality. These Tertiary sediments have limited groundwater environmental values.

Most of the clean sand and gravel lenses in the Tertiary sediments are permeable but are of limited lateral and vertical extent. These permeable sections of the Tertiary sediments represent an unconfined to confined aquifer dependent on location, degree of weathering, the nature of the overlying alluvium / colluvium, and clay content. Thus the volume of groundwater stored and the ability to transmit groundwater depends on the particle size of the material and the saturated thickness of the sediments.

3.2.3 Tertiary Basalt Aquifers

An aeromagnetic geophysical survey has been undertaken over the Bowen Basin by the then Department of Natural Resources and Water. The resultant magnetic data indicates that Tertiary basalt exists as small discontinuous remnants to the south and in the west of the study area, with a larger continuous unit to the north.

Commonly, this basalt is highly to extremely weathered, clayey and does not contain groundwater. The distribution of less-weathered, fractured and vesicular water-bearing basalt is variable. Where groundwater is present in the Tertiary basalt (secondary porosity aquifer), it is contained in joints, fractures, and vesicles either confined by low permeability layers or as an unconfined (perched) water table. Groundwater is principally stored and transmitted in the fractures, joints and other discontinuities within the rock mass.

The depth of the basalt and the generally clayey nature of the weathered upper basalt and the Tertiary sediments associated with the basalt, results in low rainfall recharge to this unit. The nature of the Tertiary basalt, and hence its groundwater potential (permeability and porosity), is highly variable, depending on the degree of weathering and the intensity and interconnectedness of jointing and/or fracturing. Where the basalt is less weathered and more fractured or vesicular, the unit may have local (discrete) zones of moderate to high hydraulic conductivity.

3.2.4 Permian - Triassic Strata Aquifers

The Permian-Triassic formations constitute the Permian age Blackwater Group and the Back Creek Group, and the Triassic age Rewan Formation. As with the rest of the Bowen Basin, the coal seams have the highest groundwater potential within the Permian sequences. Groundwater occurs and moves within the coal seam cleats and fissures and within open fractures that intersect the seams. The mudstone and claystone of the Rewan Formation and the Permian interburden are considered aquitards.

The coal seam aquifers are confined above and below by very low permeability (either due to high clay content or significant cementing) overburden and interburden rocks. These overburden and interburden units, in most mines within the Bowen Basin, are described as essentially impervious.

The confining units also have very low vertical hydraulic conductivity (leakance), such that the rate at which water flows into the aquifer (recharge) is limited.

Evidence from piezometeric observations for the coal seam aquifers during previous investigations (environmental impact studies conducted for other regional coal mines) suggests the groundwater levels were slightly different for each seam, with the GUS seam being one to two metres higher than the GMS seam, and the GLS seam being up to 14 metres lower than the GMS seam at the same location. This variation in hydraulic heads between coal seams indicates the aquitard nature of the interburden and the limited potential for induced flow. The potentiometric surface, for these studies, varied from 15 to 50 metres below ground level (mbgl).

Prior to development of the GRB mine complex operations, groundwater flow direction in the coal seam aquifers appears to have been from the north and west to the south and east across the site. This flow direction is consistent with recharge to the coal seams occurring at the subcrops in the west of the site and discharge occurring down gradient in the Isaac River sub-catchment in the Bowen Basin. The current groundwater flow pattern has been altered locally with groundwater flow towards the existing mine pits and underground workings due to mine dewatering and depressurisation. Groundwater modelling (AGE 2002) and groundwater level measurements indicate that groundwater levels are affected by mining induced drawdown up to 2.7 kilometres from the mine workings.

3.2.5 Groundwater Quality

Groundwater samples were collected for chemical analysis from piezometers installed around the site during previous site investigations and for this groundwater study.

The physico-chemical results obtained during groundwater sampling within the survey area, which have been summarised and presented in **Table 3-1**, indicate the groundwater chemistry is typically neutral to weakly alkaline (pH) for all formations. The Tertiary and Permian formations have variable salinity (measured as electrical conductivity (EC)), ranging from brackish to saline, while the groundwater quality within the alluvium is fresh.

It should be noted that the depth of the aquifer and its distance from the area of recharge are likely to influence the result at a given sample point, as salinity appears to increase with depth and the distance from the area of recharge. Based on ANZECC (2000) guideline values, the groundwater may be suitable for livestock drinking water and irrigation of salt tolerant crops. However, the low yield typical of the aquifers precludes use for large scale irrigation. Median groundwater salinity values were greater than the 50th percentile water quality objective (WQO) nominated in the Environmental Protection (Water) Policy 2009 (EPP (Water)) for groundwater in the Isaac River Sub-basin (zone 34, which covers part of the study area). The limited dataset does, however, indicate that groundwater results cover a wide range for each unit (due to depth, distance from recharge, and age of water). The lower end of the range results are within the WQO.

Table 3-1 Summary of Regional Groundwater Quality

Aquifer Unit	Regional Description	Parameter	Min.	Max.	Mean	Count
River Alluvium	Groundwater quality is highly variable ranging from fresh to very saline but is typically slightly saline. In the Isaac River sub-catchment there is no apparent spatial pattern.	TDS (mg/L)	93	27,352	1,751	111
		EC (µS/cm)	122	36,800	2,253	171
		pH (pH units)	6.3	9	7.53	166
Tertiary Basalt	Groundwater quality is variable ranging from fresh to moderately saline. The larger less weathered basalt masses yield better quality groundwater than in smaller more heavily weathered basalt masses. Groundwater is marginally more alkaline than other aquifers.	TDS (mg/L)	436	6,824	2,254	11
		EC (µS/cm)	635	13,500	3,562	13
		pH (pH units)	6.9	8.8	8.04	11
Tertiary Sediments	Groundwater quality is variable ranging from fresh to very saline with no specific pattern to the distribution of good or poor quality groundwater.	TDS (mg/L)	256	10,971	4,206	20
		EC (µS/cm)	505	18,876	6,965	22
		pH (pH units)	6.9	8.3	7.86	22
Blackwater Group and Back Creek Group	Groundwater quality is variable ranging from fresh to very saline with no specific pattern to the distribution of good or poor quality groundwater.	TDS (mg/L)	400	13,835	3,456	57
		EC (µS/cm)	650	23,000	5,799	62
		pH (pH units)	7	8.9	7.86	57

Note: The data analysed by Pearce and Hansen (2006) include all registered Department of Natural Resources and Mines (NRM) monitoring bores in the Isaac-Connors and Mackenzie sub-catchments.

Note 2: TDS – Total dissolved solids; EC – electrical conductivity; mg/L – milligrams per litre; µS/cm – microSiemens per centimetre

3.2.6 Groundwater Use

The survey area is located within the declared Isaac Connors Groundwater Management Area, as defined under Section 6, Schedule 3 and Schedule 4 of the Water Resources (Fitzroy Basin) Plan 2011. Within the declared management area, water licenses and/or development permits are not required for stock or domestic bores, and the Department of Natural Resources and Mines (NRM) also generally excludes groundwater monitoring bores from the requirement for development permits. In Queensland, all wells deeper than six metres, including monitoring wells, must be constructed by, or under the supervision of, a licensed water bore driller who has the correct endorsements on their licence for the type of activity being performed. It is a requirement of the *Water Act 2000* that a licensed water bore driller submit the records of the drilling and installation of a water well to NRM within 30 days of completion of the well. These records are entered in the NRM groundwater bore database.

From a search of the NRM groundwater database, 31 bores are registered within 10 kilometres of the study area boundary. Of the 31 bores reported, 27 have been installed for private use, and four have been installed by NRM for groundwater monitoring and assessment (three of which have been abandoned and destroyed). Of the 27 bores installed for private use, 16 were installed for coal seam gas (CSG) exploration in the Moranbah or Fort Cooper Coal Measures, with four of the seven other private bores in these formations being abandoned and destroyed. No stratigraphic or casing description information has been included in the NRM database for the three remaining non-CSG bores and accordingly it is not certain from which aquifer these bores extract groundwater. The current use of the bores is not specified in the NRM groundwater database; however, typical groundwater use in the area is typically expected to be for stock watering owing to the variable salinity levels and generally low yields. No dewatering for CSG extraction is currently undertaken within the study area, however CSG exploration has been undertaken in the area and producing CSG wells are located to the south east of the project.

3.2.7 Data Limitations

The data collation and literature review found a reasonable amount of publically available hydrogeological information for areas within and adjacent to the study area.

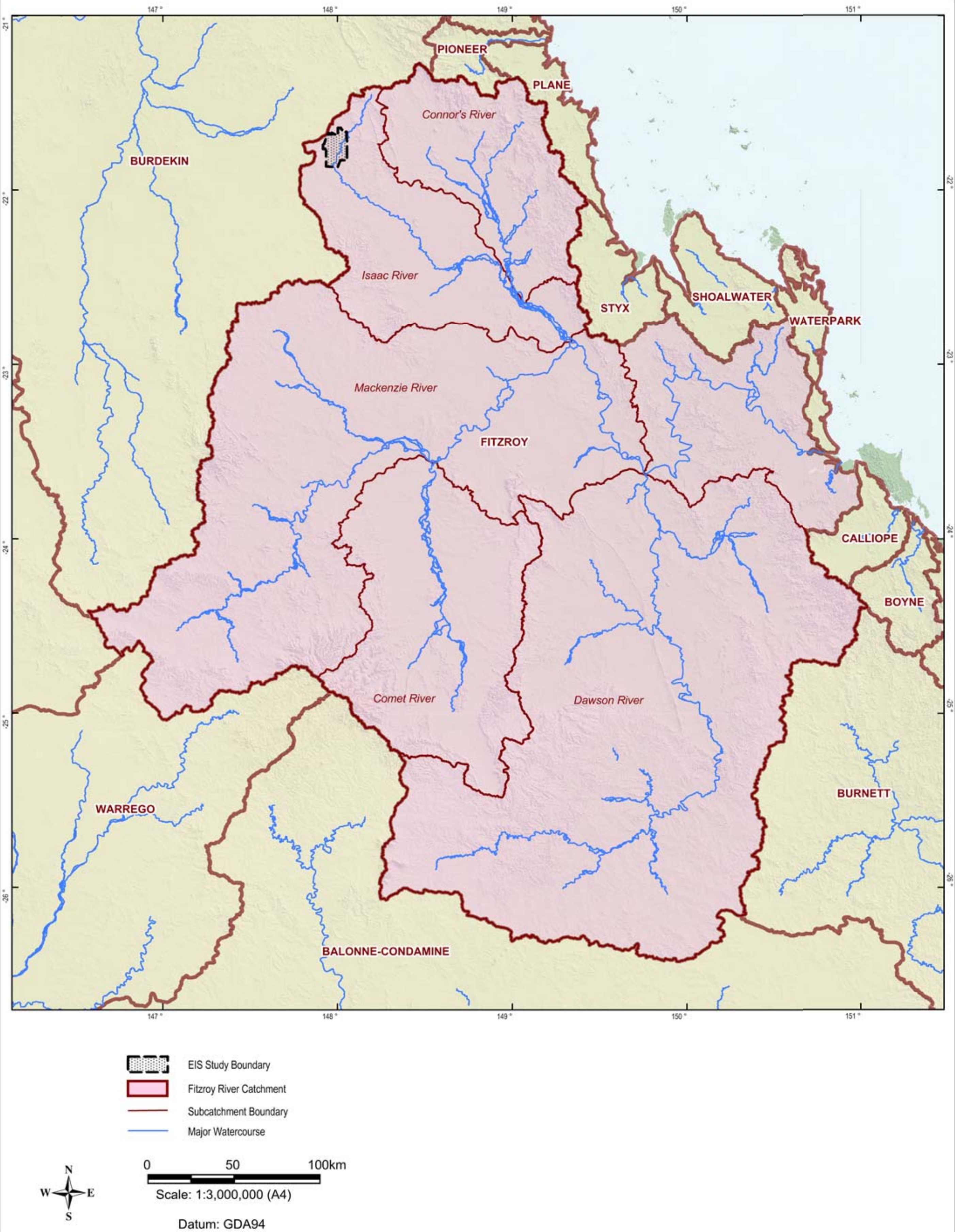
Groundwater level data from studies in the Moranbah area indicate that groundwater within the alluvium can be perched (i.e. based on groundwater level differences within confined and unconfined aquifers). Limited information exists regarding groundwater flow in the alluvium; however, at a regional scale groundwater flow within the aquifer is expected to follow topography and drainage patterns.

Information on faulting, folding, and alignment of strata was limited to regional-scale Geographic Information System (GIS) maps. Limited site-specific information on possible structural geological features is available within MLA70421. Additional data, derived from exploration drilling and geophysical surveys, can provide additional information regarding possible local-scale hydrogeological effects on groundwater flow and levels.

3.3 Regional Surface Water Description

The project is located within the headwaters of the Isaac-Connors sub-catchment of the greater Fitzroy catchment (refer to **Figure 3-2**). The Isaac River is the main watercourse draining the study area and flows south through the site, past Moranbah, and converges with the Connors and then Mackenzie Rivers. The Mackenzie River joins the Fitzroy River, which flows initially north and then east towards the east coast of Queensland. The Fitzroy River flows into the Coral Sea south-east of Rockhampton near Port Alma.

The Isaac River has a catchment area of approximately 1,215 square kilometres (km^2) at the Goonyella stream gauge located upstream of the existing rail crossing. At a broader regional scale, the greater Isaac-Connors sub-catchment area (at the confluence with the Mackenzie River) is approximately 22,000 km^2 and the total Fitzroy River catchment area to the coast is approximately 140,000 km^2. From a broad regional context, the study area represents a very small part of greater Fitzroy River catchment and is located in the headwaters of the sub-catchment. The elevation of the Isaac River channel bed in the study area and through the existing GRB mine complex is approximately 230 to 240 metres above sea level.



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REGIONAL CATCHMENT CONTEXT

3.4 Regional Surface Water Quality

The Isaac River catchment is classified as 'upland freshwater' within the Queensland Water Quality Guidelines (QWQG) (DERM 2009b, Appendix B2.2.1). The QWQG provide the following definition for upland freshwater streams:

> *Small (first, second and third order) upland streams. Moderate to fast flowing due to steep gradients. Substrate usually cobbles, gravel or sand – rarely mud.* (DIBM 2001 in DERM 2009b).

In addition, it is stated that the classification is relevant for all freshwater streams or stream sections above 150 metres elevation, although it is accepted that this may not apply in some areas (ANZECC 2000, in DERM 2009b).

The headwaters of the Isaac River catchment are elevated above the 150 metre limit (between lowland/upland classifications) but substrate is sand, and/or mud. The main channel of Isaac River shows characteristics of an upland river. Tributaries to the west are at even higher elevations, with steeper gradients, therefore Goonyella Creek, Eureka Creek and other, smaller tributaries are also upland freshwater streams.

The project activities will occur completely within the broader Isaac River catchment, and span across the tributary catchments of Goonyella Creek and 12 Mile Gully. Other nearby tributaries including Eureka Creek, Fisher Creek, and Platypus Creek are also located within the study area as shown in **Figure 3–1**.

All streams within or adjacent to the study area were identified as upland freshwater streams, which are defined as (freshwater) streams or stream sections above 150 metres in elevation (ANZECC 2000). The EPP (Water) designates waters within the study area as Isaac River main channel and Isaac northern tributaries.

Environmental values that have been identified for the study area are provided in **Table 3-2**.

Table 3-2 Environmental Values for the Receiving Environment

Environmental Values	Local Scale	Isaac River main channel	Isaac Northern tributaries – developed areas
Aquatic Ecosystem Environmental Values			
Protection of high ecological value aquatic habitat	x	x	x
Protection of slightly to moderately disturbed aquatic habitat	✓	✓	✓
Protection of highly disturbed aquatic habitat	x	x	x
Human Use Environmental Values			
Suitability for crop irrigation	x	x	✓
Suitability for farm use	x	✓	✓
Suitability for stock watering	✓	✓	✓

Environmental Values	Local Scale	Isaac River main channel	Isaac Northern tributaries – developed areas
Suitability for aquaculture	x	x	x
Suitability for human consumers of aquatic food	x	x	✓
Suitability for primary contact recreation (e.g. swimming)	x	✓	✓
Suitability for secondary contact recreation (e.g. boating)	x	✓	✓
Suitability for visual (no contact) recreation	✓	✓	✓
Suitability for drinking water supply	x	x	✓
Suitability for industrial use (including manufacturing plants, power generation)	x	✓	✓
Protection of cultural and spiritual values	✓	✓	✓

3.4.1 Aquatic Ecosystem Environmental Values

The watercourses within the study area are ephemeral in nature and provide seasonal habitat for aquatic fauna and flora.

The aquatic ecosystems are considered to be slightly to moderately disturbed from current mining and grazing activities and are classified accordingly in the EPP (Water). The disturbed status of aquatic habit values of the Isaac River is also influenced by impacts from the Burton Gorge Dam on low flow hydrology in the Isaac River.

The stream biological health for the various rivers and creeks within the study area was assessed and the results indicated a general improvement in the biological health of the sites monitored during previous monitoring events (2004, 2005, and 2009). Analysis of macroinvertebrate communities (including consideration of Stream Invertebrate Grade Number – Average Level 2 (SIGNAL 2, Chessman 2003) scores; *Plecoptera Ephemoptera* and *Trichoptera* (PET) scores) found that the diversity of macroinvertebrate taxa was similar across the surface water receiving environment within the study area. It was also determined that monitoring sites located downstream of mining activity (for example, along the Isaac River downstream of existing GRM operations) were significantly influenced by habitat (more so than water quality) at the time monitoring was conducted. This is largely expected to be due to an increase of the time the sites were inundated and, therefore, the time mobile species have to colonise.

The macroinvertebrate community structures were typical of seasonal streams in central Queensland. Although taxa were not identified to species level, no freshwater macroinvertebrates within the study area are listed under the EPBC Act. Additionally, no taxa are listed under the *Nature Conservation Act 1992* (NC Act) for the endangered fauna of Queensland. Neither of the two fish species listed under the EPBC Act or NC Act (*Neoceratodus forsteri* (lungfish) and *Scaturiginichthys vermeilipinnis* (Red-finned Blue Eye)) were found to be within the study area.

Surface water quality was assessed against the applicable guidelines for slightly to moderately disturbed aquatic ecosystems where site-specific guideline values were not available. The assessment was focused on determining whether the existing surface water quality would be conducive to 95th percentile aquatic ecosystem species protection. Further discussion of the relationship between the identified aquatic ecosystem values and surface water quality within the study area is provided in **Section 4.3**.

3.4.2 Human Use Environmental Values

3.4.2.1 Existing Land Use

The dominant land use upstream of the proposed mine site is beef cattle grazing. Tree clearing has occurred over time to improve pastures. There is also some mining activity upstream of the proposed mine and the Isaac River has been dammed upstream through the construction of Burton Gorge Dam. The catchments are therefore not in pristine condition and are susceptible to the impacts from existing land use activities.

Existing land uses downstream of the study area include mining, grazing (modified pastures) and dryland cropping.

3.4.2.2 Existing Water Use

The existing licensed water users downstream of the proposed mine are shown in **Table 3-3**.

3.4.2.3 Other Uses

Regionally, the Isaac-Connors River sub catchment streams also support primary and secondary contact recreational activities, aquaculture, aquatic food for human consumption and is used for drinking water. The watercourses are not generally navigable.

Table 3-3 Water Licences Downstream of the Red Hill Mine

License Number	Permit Type	Status	Authorised Purpose	Licensee	Nominal Megalitres (ML)	Location (Coordinates or Property Plan Number)	Distance in relation to existing GRM footprint
178493	Interfere by diversion (of surface water)	Under renewal	Divert the course of flow	Anglo Coal (Moranbah North Management) Pty Limited	Not recorded	1/RP904445 1/SP126833	Immediately downstream; extends for approximately 5 km across both banks of Isaac River.
43173WL	Take water (surface water)	Issued	Water harvesting	Private user	Not recorded	18/SP113322	Approximately 52 km downstream; adjacent to left bank of Isaac River.
44161U	Take water (groundwater)	Issued	Domestic supply, irrigation, stock	Private user	65	11/KL135 1/KL159 Lat -22.23833 Long 148.4303	Approximately 52 km downstream; adjacent to left bank of Isaac River.
16103F	Interfere by impounding – embankment or wall	Issued	Impound water	Namrog Investments Pty Limited	Not recorded	9/CNS98	Approximately 70 km downstream; on right bank of Isaac River.
400859	Take water (surface water)	Under replacement	Stock	Private user	10	6/CNS53 7/CNS53	Approximately 85 km downstream on Isaac River.

Source: NRM Water Entitlements System 2011

Section 04 Site Specific Water Balance Model Components

A water balance model was prepared to represent the interaction between the proposed RHM and the existing GRB mine complex. A water balance model was previously developed for the GRB mine complex operations and was utilised as the foundation to conduct predictive modelling for the proposed expansion and extension components of the project to predict potential impacts to water resources.

The existing GRB mine complex GoldSim model was refined to represent the following two prediction scenarios:

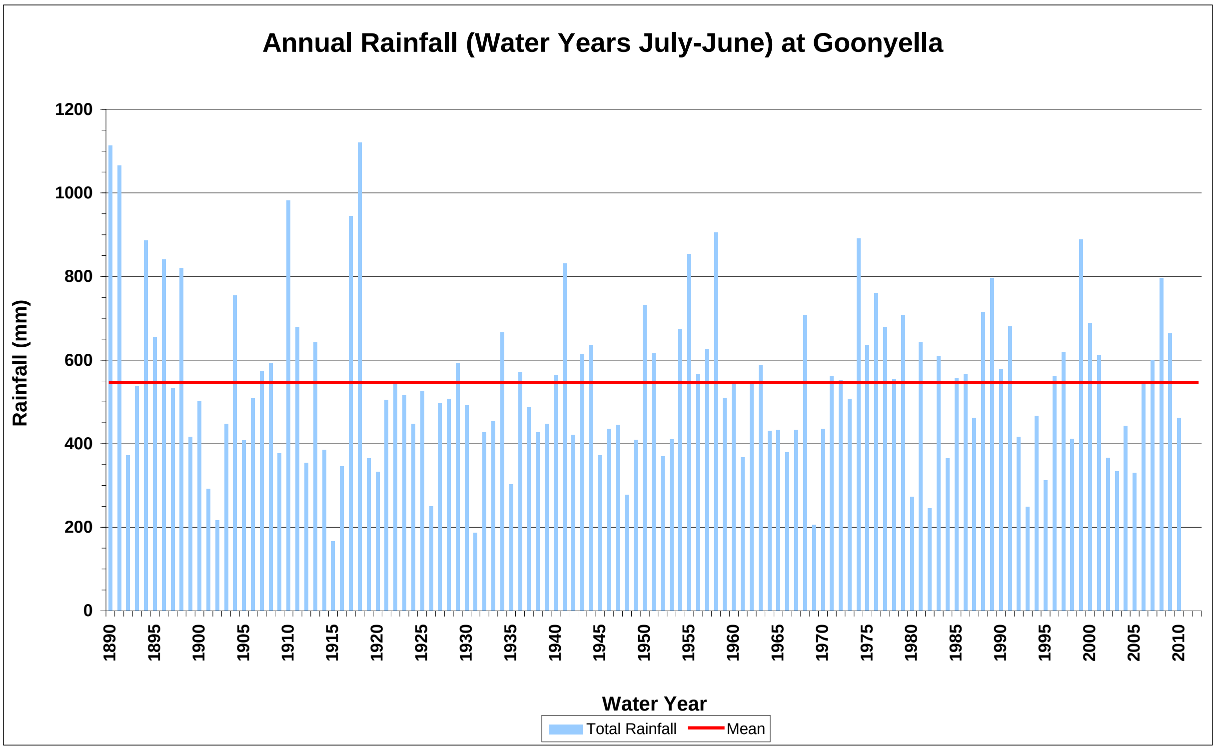
- Baseline Scenario – Model represents the mining arrangements for the GRB mine complex at 2015. The combined GRB approved coal production capacity is approximately 18.5 mtpa.
- Project Case Scenario – The Baseline scenario model is used to assess the impact of proposed RHM. This includes the addition of the new underground workings, CHPP, MIA and 50 megalitre (ML) dam. The combined site coal production approved capacity is approximately 32.5 mtpa.

The components of the site specific water balance model, compiled for the two mining scenarios, is presented below.

4.1 Climate

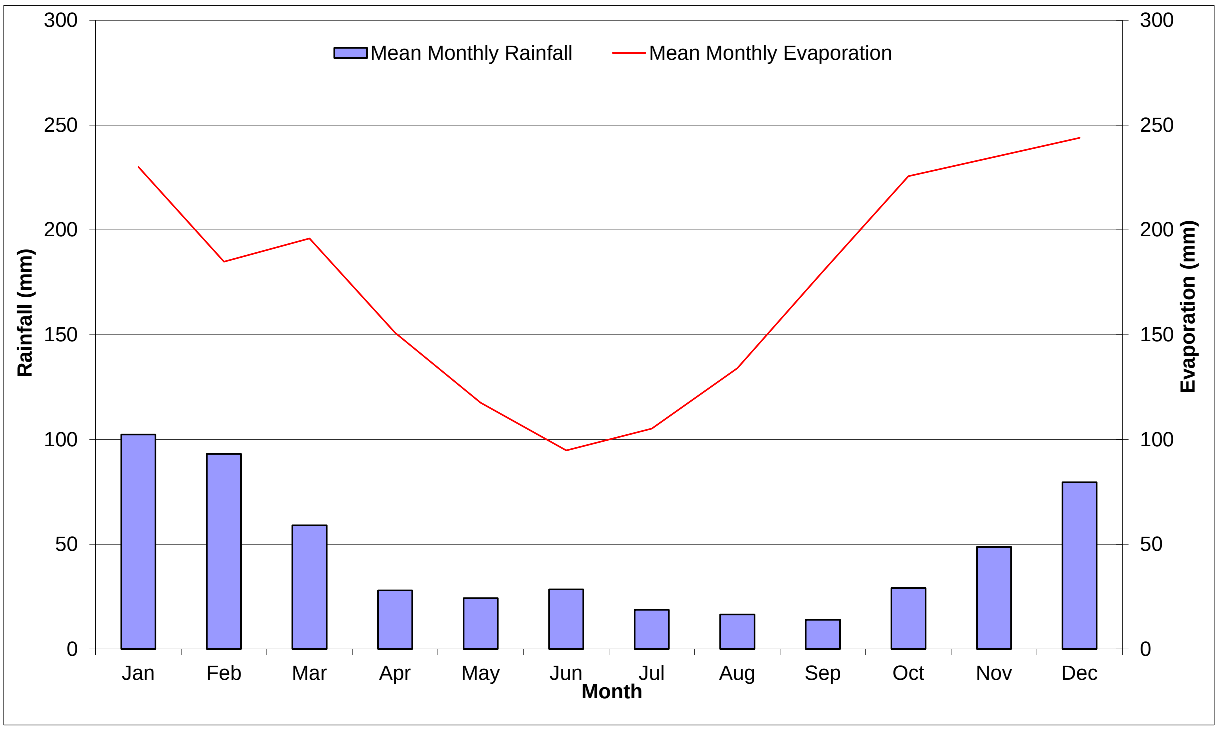
Historic climate data was sourced from the Bureau of Meteorology SILO Data Drill using 123 years of records (1889 to 2011). The data is produced by accessing grids of data derived from interpolating the bureau's records from individual weather recording stations. **Figure 4-1** shows annual water year totals for the site and **Figure 4–2** shows mean monthly rainfall and evaporation. From **Figure 4-1** it can be seen that annual rainfall at the study area is highly variable and subject to prolonged periods of above and below average rainfall. **Figure 4–2** shows a distinct seasonal rainfall distribution, with monthly rainfall totals greatest in the wet season extending from November through March, and typically peaking in January with an average of just over 100 millimetres. The average monthly evaporation exceeds the average monthly rainfall throughout the year with a maximum of around 245 millimetres average monthly evaporation in December. It is important to note that average monthly statistics are not used for the purpose of water management assessment and design, as high wet season rainfall in wetter years (which can be highly variable) can substantially exceed evaporation rates.

Figure 4-1 Annual Rainfall Totals at Goonyella



Note: data from SILO Data Drill 1889 to 2011

Figure 4-2 Mean Monthly Rainfall and Evaporation at Goonyella



Note: data from SILO Data Drill 1889 to 2011.

4.2 Groundwater Overview

4.2.1 Groundwater Occurrence

The site specific (local) groundwater regime is considered to include:

- Quaternary alluvial aquifers associated with local creeks and the Isaac River;
- Tertiary sediment aquifers;
- Tertiary basalt aquifers; and
- Permian-Triassic sedimentary fractured rock aquifers.

The study area is located within the declared Isaac Connors GMA, as defined in the Water Resources (Fitzroy Basin) Plan 2011. Within the Isaac Connors GMA, aquifers in the Quaternary alluvium are known as the Isaac Connors Groundwater Unit 1, with all other aquifers grouped together as the Isaac Connors Groundwater Unit 2.

Groundwater supply is not considered to be a major water source in the groundwater study area. Based on a review of available data, the beneficial use of groundwater in the groundwater study area is considered to be low due to low sustainable yields and poor groundwater quality.

4.2.1.1 Quaternary Alluvial Aquifers

Quaternary alluvial deposits occur predominantly within the floodplains of the Isaac River and other creeks within the study area. The sand and gravel deposits are recognised within the creek beds with the overbank deposits being silty and clayey with minor sand.

Potential for usable groundwater resources exists within the more permeable sand and gravel dominant sections of the alluvium, and represents an unconfined to semi-confined aquifer. However, drilling in the alluvium within the study area indicates variable saturated thickness and does not form a consistent interconnected aquifer. The alluvial aquifer is classed as a porous media aquifer where groundwater occurs within the voids between individual grain particles. The volume of groundwater associated with the alluvium depends on the interconnection of permeable units, saturated thickness, and the ability to store groundwater, i.e. effective storage allowing for baseflow to creeks and rivers during the dry season.

Groundwater discharge from the alluvium occurs through:

- evapotranspiration from vegetation growing in the creek beds and along the banks;
- short duration baseflow from the permeable sands and gravels within the alluvium material; and
- possible infiltration and recharge to the underlying older formations where the creeks cross more permeable zones within these units.

Drilling within the study area indicates that, where groundwater does occur, depth to groundwater in the Quaternary alluvium was approximately 11 to 13 mbgl. The groundwater level in the alluvium, measured in a study by Thatcher (1976), was about 20 metres above the piezometeric (confined) water level in the coal at the same location. These groundwater levels indicate a marked separation between the perched alluvium groundwater level and the piezometeric levels associated with the deeper coal seam aquifer groundwater. It is, thus, unlikely that changes in groundwater levels in the coal would significantly impact on the perched water table associated with the alluvium.

Aquifer hydraulic properties of Quaternary alluvium material (Isaac River bed sands) and flood plain deposits were obtained from investigations undertaken at Moranbah North mine (JBT Consulting 2010). These hydrogeological investigations determined that permeability of the alluvium ranged from 9 to > 45 metres per day. These investigations also found that the Quaternary flood deposits (river bank sediments) were generally finer grained than the bed sands, and returned permeability values between 0.01 and 10 metres per day. This testing indicated that the river bank sediments were less permeable than the bed sands, and would be regarded as being of low to moderate permeability, compared to the higher permeability of the bed sands. Onsite, hydraulic testing of the Quaternary alluvium associated with the Eureka Creek at GW08 (**Figure 4-3**) provided a hydraulic conductivity of 0.001 metres per day, typical for silty clay.

Even though the permeability of some areas of the Quaternary alluvial aquifers are high, the alluvium is not regionally extensive (continuous) and does not maintain a significant saturated thickness and hence is considered ephemeral in nature. Accordingly, groundwater extraction at high rates would not be sustainable in the long term (i.e. limited sustainable yields due to limited volumes held in storage).

4.2.1.2 Tertiary Sediment Aquifers

The Tertiary sediments generally consist of lenses of palaeochannel gravels and sands separated by sandy silts, sandy clays and clays. A review of the borehole logs within the RHM footprint showed the Tertiary sediments vary in thickness up to approximately 80 metres with a typical thickness of up to 15 metres. The thickness and extent of these Tertiary sediments are variable and for the most part, groundwater resources are limited and typically have poor quality. These Tertiary sediments have limited groundwater environmental values.

Potential for groundwater exists within the more permeable sand and gravel sections of the Tertiary sediments, and represents an unconfined to confined aquifer depending on location, degree of weathering, the nature of the overlying alluvium, and clay content.

Recharge processes in the Tertiary sediment aquifers are generally from:

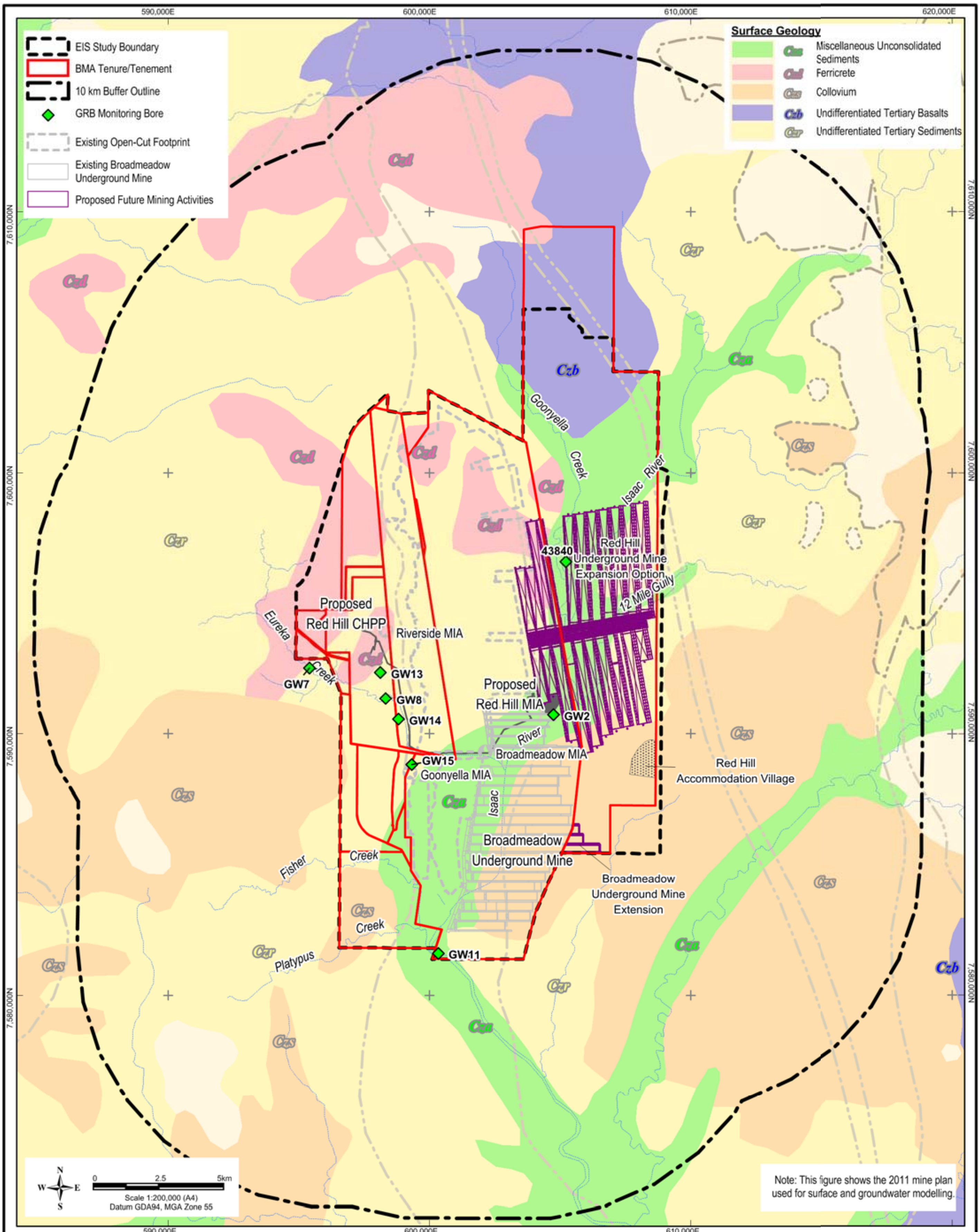
- direct infiltration of rainfall and overland flow where Tertiary sediments outcrop and no substantial clay barriers exist in the subsurface; and
- overlying Quaternary alluvial aquifers.

Primary discharge mechanisms of the Tertiary sediment aquifers are likely to be a result of:

- through flow into adjacent or underlying aquifers (outcropping or sub-cropping coal seams); evapotranspiration; and
- groundwater extraction.

The depth to groundwater in monitoring wells on site in the Tertiary sediment aquifer is typically less than 15 mbgl (IESA 2001a).

Most of the clean sand and gravel lenses in the Tertiary sediments are permeable but are of limited lateral and vertical extent. Thus the volume of groundwater stored and the ability to transmit groundwater depends on the particle size of the material and the saturated thickness of the sediments. A review of bore logs within the RHM footprint showed that the Tertiary sediments are dominated by low permeability clays and sandy clays with isolated areas of loose more permeable sand.



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QUATERNARY AND TERTIARY FORMATIONS WITHIN AND SURROUNDING THE EIS STUDY AREA

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Figure: 4-3

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The interpreted hydraulic conductivity value of 6.6 x 10^{-4} metres per day obtained from the variable (falling) head test for monitoring well GYTD7 during investigations for the Airstrip Pit Box cut (IESA 2001a) is very low, indicating predominantly clay intersected within this bore. No other site specific testing of hydraulic properties has been undertaken on the shallow Tertiary sediments. Installation of monitoring bores (GW1 to GW15), depicted on **Figures 4-3** and **4-4**, showed that the Tertiary sediments, where intersected, comprise predominantly of clays, containing only very minor sand lenses, and intersected little or no groundwater. Data from exploration drilling also indicates that these sediments are often dry, and occurrence of groundwater in these sediments is sparse. However, where the sediment is coarse in composition, the unit may have localised zones of enhanced hydraulic conductivity.

4.2.1.3 Tertiary Basalt Aquifers

No basalt is mapped within the footprint of the RHM.

For the majority of exploration boreholes that intersected basalt, the basalt is logged as highly to extremely weathered, clayey and dry. The distribution of less-weathered, fractured and vesicular water-bearing basalt is variable. The Tertiary basalt aquifers are classed as a secondary porosity aquifer and are expected to represent unconfined to confined aquifers depending on location. Groundwater is principally stored and transmitted in the fractures, joints and other discontinuities within the rock mass.

The depth of the basalt, and the generally clayey nature of the weathered upper basalt and the Tertiary sediments associated with the basalt, indicate that the recharge is low. Groundwater recharge in this aquifer occurs from:

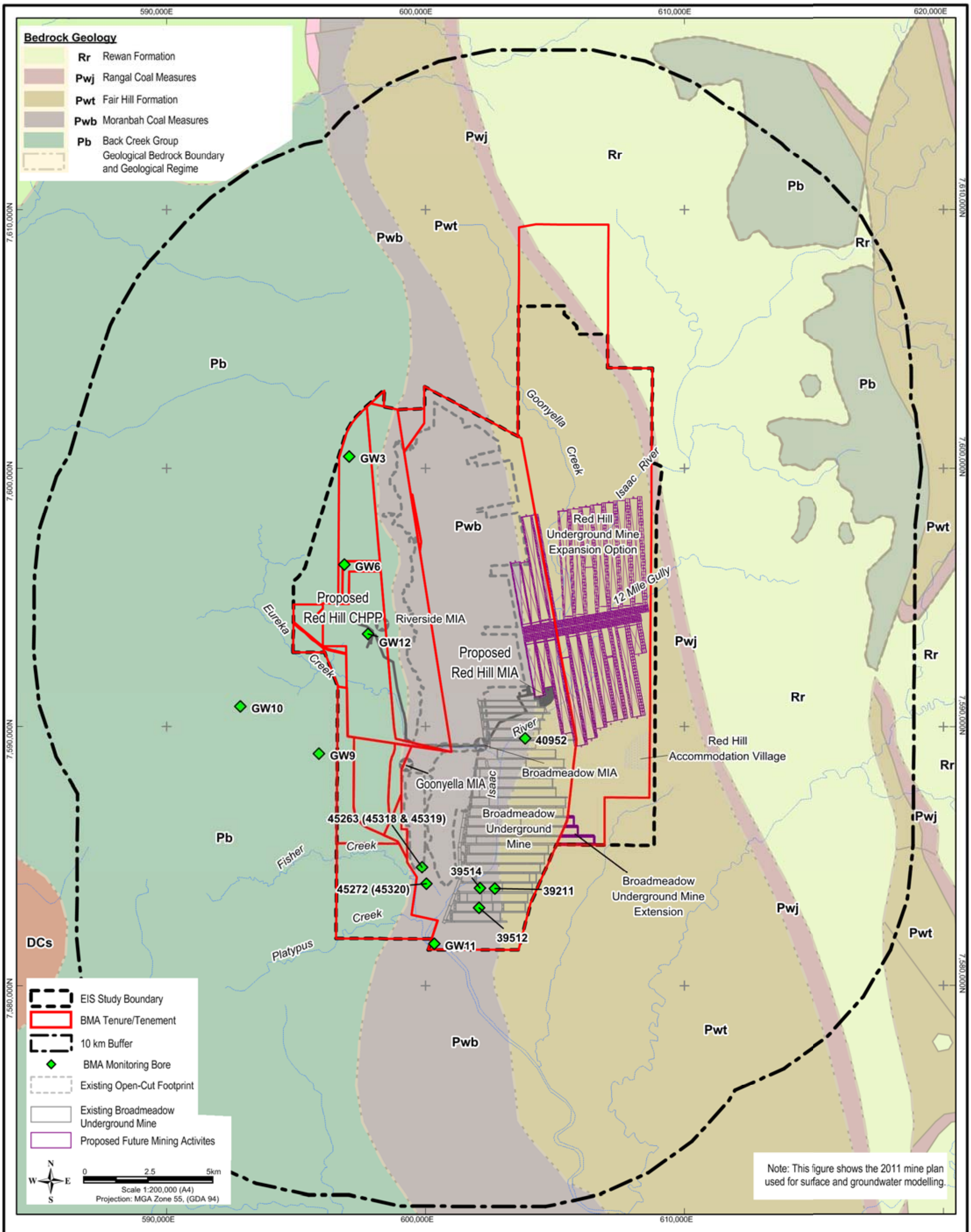
- infiltration of rainfall in rock outcrop areas where no substantial clay barriers exist in the shallow subsurface; and
- vertical seepage or through flow from overlying or adjacent alluvial or tertiary sediment aquifers.

Primary discharge mechanisms in the Tertiary basalt aquifers are likely to be:

- down gradient Tertiary basalt outcrop areas;
- through flow into adjacent or underlying aquifers (outcropping or sub-cropping coal seams); evapotranspiration; and
- groundwater extraction.

Depth to groundwater in the Tertiary basalt aquifers have historically been measured at between 23 and 34 mbgl (AGE 2004b).

The nature of the Tertiary basalt, and hence its permeability and porosity, is highly variable, depending on the degree of weathering and the intensity and interconnectedness of jointing and/or fracturing. Where the basalt is less weathered and more fractured or vesicular, the unit may have local zones of moderate to high hydraulic conductivity. Hydraulic testing at Moranbah North mine (JBT Consulting 2010) indicated the Tertiary basalt to be moderately permeable with hydraulic conductivity values ranging from one to four metres per day and storage coefficient between 1 x 10^{-2} and 1 x 10^{-4}. Onsite, interpreted hydraulic conductivity values of 1.21 and 0.48 metres per day were obtained from the variable head test for monitoring wells 45314 and 45319, respectively, during investigations for the groundwater depressurisation assessment of the southern extension of the Airstrip Pit (AGE 2004a) located in the southwest portion of the study area.



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SUB-SURFACE PERMIAN AND TRIASSIC FORMATIONS WITHIN AND SURROUNDING THE EIS STUDY AREA

The drilling program undertaken as part of this Airstrip Pit groundwater study showed that the Tertiary basalt appears to be highly heterogeneous and discontinuous locally. In the area of the Airstrip Pit, the basalt intersected during drilling was generally not water-bearing; however for the few holes that did intersect measurable groundwater flows, airlift yields were at most 1.25 litres per second (L/s).

4.2.1.4 Permian - Triassic Strata Aquifers

Within the study area, the GLS, GMS and GUS coal seams constitute the most extensive aquifers. These seams have been removed in the majority of the western extent of the study area through open cut mining. The Triassic Rewan Formation strata occur only in the very north-east of the study area.

The coal seam aquifers are confined above and below by very low permeability geological formations and movement of water through the aquifer (transmissivity) is through the more permeable (cleats) coal rather than the confining units. The confining units also have very low vertical hydraulic conductivity (leakance), such that the rate at which water flows into the aquifer (recharge) is limited. The Permian and Triassic strata may, therefore, be categorised into the following hydrogeological units:

- hydrogeologically 'tight' and hence very low yielding to essentially dry claystone, mudstone, sandstone, siltstone and shale that comprise the majority of the strata;
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence; and
- localised fracture or fault systems which are open and have not been infilled by clay/carbonate deposition.

Groundwater recharge in this aquifer occurs from:

- infiltration of rainfall and overland flow in outcrop and sub-crop areas;
- downward seepage or through flow from overlying or adjacent alluvial or Tertiary aquifers where no significant clay barriers exist; and
- leakage between aquifers by faulting and other structural discontinuities in overburden and interburden sediments.

Primary discharge mechanisms in the Permian-Triassic strata aquifers are likely to be:

- downgradient Permian-Triassic strata outcrop areas;
- through flow into adjacent (outcropping or sub-cropping coal seams) or seepage into underlying aquifers (via structural discontinuities); and
- groundwater extraction (IMG and other mine dewatering activities).

Groundwater levels in the Permian formations have been measured for hydrogeological investigations assessing potential inflows to pits and underground workings and the establishment of box cut or pit dewatering bores for mine design and production purposes. There are 41 groundwater level measurements from 32 bores installed in the Permian formations over the period from 1995 to 2009, however many of these bores have been destroyed during mining. Consequently, there are no long term hydrographs of groundwater levels available, and the groundwater level information is not evenly spatially distributed.

Evidence from piezometeric observations for the coal seam aquifers during these previous investigations suggests the groundwater levels were slightly different for each seam, with the GUS seam being one to two metres higher than the GMS seam, and the GLS seam being up to 14 metres lower than the GMS seam at the same location. This variation in hydraulic heads between coal seams indicates the aquitard nature of the interburden and the limited potential for induced flow. The phreatic surface varied from 15 to 50 mbgl. Prior to development of the GRB mine complex operations, groundwater flow direction in the coal seam aquifers appears to have been from the north and west to the south and east across the site. This flow direction is consistent with recharge to the coal seams occurring at the subcrops in the west of the site and discharge occurring down gradient in the Isaac River sub-catchment in the Bowen Basin. The current groundwater flow pattern has been altered locally with groundwater flow towards the existing mine pits and underground workings due to mine dewatering and depressurisation. Groundwater modelling (AGE 2002) and groundwater level measurements indicate that groundwater levels are affected by mining induced drawdown up to 2.7 kilometres from the mine workings.

No data exist on the seasonal fluctuations of groundwater level within the Permian-Triassic aquifers. However, due to the depth and confined nature of these aquifers, they are expected to show a subdued response to recharge or discharge.

Interpreted hydraulic conductivity values determined for the Moranbah Coal Measures in the study area are presented in **Table 4-1**. The aquifer testing results indicate that the cleats and joints of the coal are less open with depth, with a corresponding decrease in permeability. WDS (2011) conducted an engineering study for coal seam degassing required prior to mining of the RHM, using data derived from packer testing in 31 seam/site combinations in the Moranbah and Fort Cooper Coal Measures. This study found that:

- with increasing depth, effective stress increases and permeability decreases;
- with increasing ash (mineral matter), rock stress and effective stress increases and permeability decreases; and
- with increasing gas content to the east, primary permeability decreases.

A relationship was determined for permeability variation with depth, ash, and gas content as part of this study. This relationship is:

- Permeability (mD[1]) = -0.00548 x Depth (metres) - 0.2549 x Gas Content at 15 per cent ash + 4.045688.
- It applies to the GUS, GMS and GLS seams for depths of 132 to 593 metres, Gas Content at 15 per cent ash of 0.2 to 13.7 cubic metres per tonne.

Interpreted hydraulic conductivity values determined for the Back Creek Group during investigations as part of the EIS study were between 0.002 and 0.1 metres per day.

Hydraulic testing of the interburden units (AGE 2004b) and of drill core undertaken for the EIS revealed highly variable hydraulic conductivity from moderately pervious to highly impervious. This is evidence that the Permian formations are heterogeneous, having discrete zones of higher permeability over short distances and the very low hydraulic conductivity in the majority of the interburden and overburden isolate more conductive parts associated with the fracture/fault systems.

[1] milliDarcys an empirical unit of permeability

Table 4-1 Interpreted Hydraulic Conductivity of Permian Strata Aquifers

Area of Investigation	Permian Strata Investigated	Method of Determination	Hydraulic Conductivity (m/day)
Goonyella No2 (Rust PPK 1996)	GMS	Pumping test	0.003 to 0.034
	GMS	Packer test	0.009 to 0.085
Airstrip Box cut (IESA 2001a)	GLS	Falling head slug test	0.06 to 0.47
Goonyella Longwall Development (AGE 2002)	GMS	Calibration of groundwater numerical model	0.0009 to 0.1
Airstrip South Box cut (AGE 2004a)	GLS	Falling head slug test	0.06 to 0.80
		Calibration of groundwater numerical model	0.82
Ramp 8 (AGE 2004b)	GLS	Shut in pressure test	0.10
		Falling head slug test	0.01 to 0.03
	Interburden	Falling head slug test	2E-05 to 0.33
study area	Interburden	Constant head core test	Horizontal 2E-06 to 3E-05 Vertical 9E-07 to 9E-05

A review of the BMA exploration bore database was undertaken to assess airlift yields recorded during drilling. An airlift yield is the rate at which groundwater is removed from a bore during drilling with an air flushed drilling method, and is an estimate of the potential yield of a bore. Of the 659 exploration bores in the RHM area identified with recorded yield data, 440 bores (67 per cent) were identified as no recordable yield (i.e. dry), and 174 (26 per cent) had airlift yields of less than 0.5 L/s. Airlift yields recorded during drilling of the exploration bores are summarised in **Chart 4–1**. Many of the exploration bores that did not have recorded airlift yields in the exploration database may have been dry, thus the histogram may overestimate the yield from the Permian strata. The length of time for which the airlifting was conducted was not available, therefore the sustainability of these yields is not known. The airlift yields generally decrease with airlift depth, as shown in **Chart 4–2**, confirms the theory that permeability decreases with depth as a response to fractures being less open at depth.

Chart 4-1 Histogram of Airlift Yields of Exploration Bores

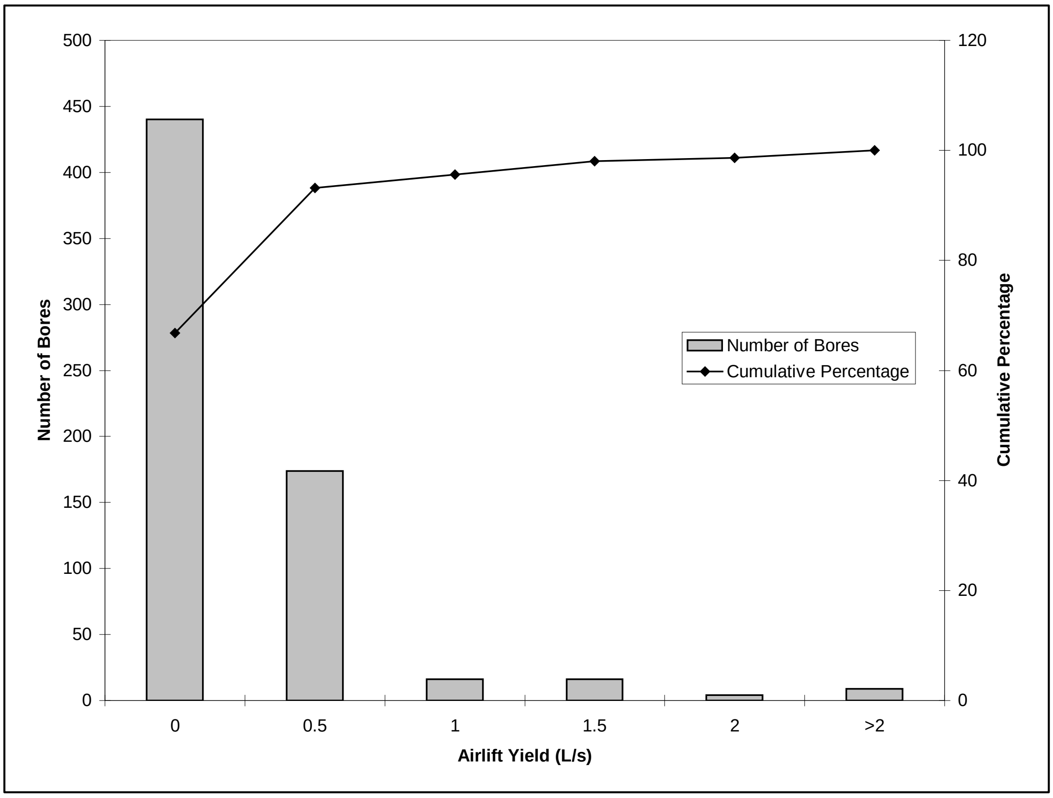
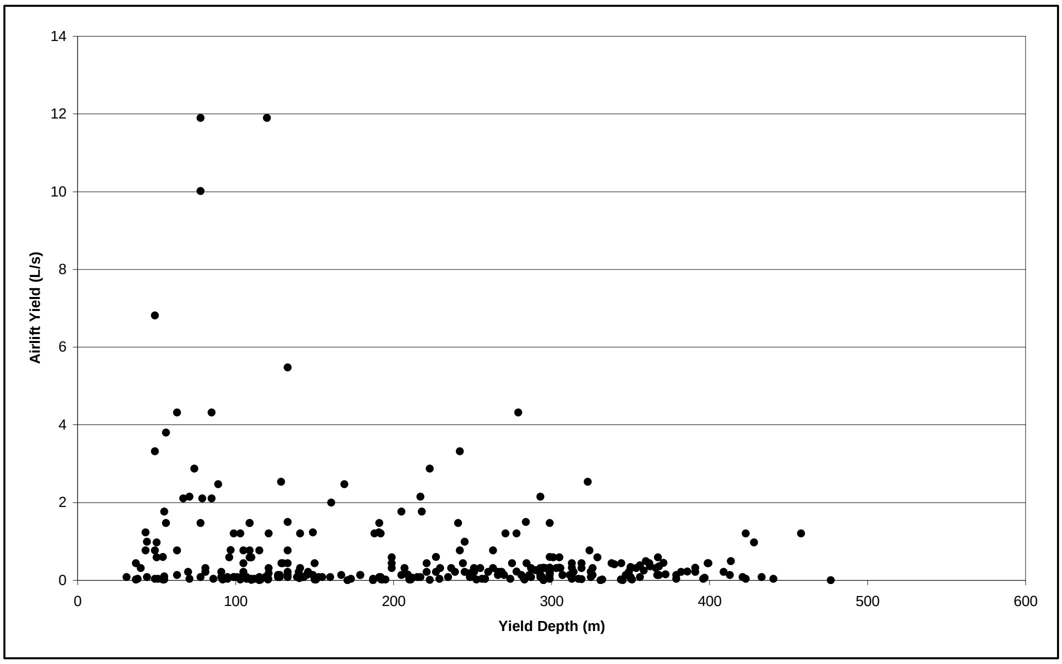


Chart 4-2 Airlift Yield versus Airlift Depth of Exploration Bores



4.2.2 Groundwater Quality

Groundwater samples were collected for chemical analysis from piezometers installed around the site during previous site investigations and for this study.

The physico-chemical results obtained during groundwater sampling within the study area for the period 2001 to 2010, which have been summarised and presented in **Table 4-2**, indicate the groundwater chemistry is typically neutral to weakly alkaline (pH) for all formations. The Tertiary and Permian formations have variable salinity (measured as EC), ranging from brackish to saline, while the groundwater quality within the alluvium is fresh.

It should be noted that the depth of the aquifer and its distance from the area of recharge are likely to influence the result at a given sample point, as salinity is highly variable, and appears to increase with depth and the distance from the area of recharge. Based on ANZECC (2000) guideline values, the groundwater may be suitable for livestock drinking water and irrigation of salt tolerant crops. However, the low yield typical of the aquifers would preclude use for large-scale irrigation.

Median groundwater salinity values were greater than the 50^{th} percentile WQO nominated in the EPP (Water) for groundwater in the Isaac River Sub-basin (zone 34, which covers part of the groundwater survey area). The limited dataset does, however, indicate that groundwater results cover a wide range for each unit (due to depth, distance from recharge, and age of water). The lower end of the range results are within the WQO.

Table 4-2 Physico- chemical Results for Aquifers in the Study Area (2001 – 2010)

Aquifer	Number of Samples	Electrical Conductivity (µS/cm)		pH	
		Range	Median	Range	Median
Quaternary Alluvium	2	521-561		6.88-7.55	
Tertiary Basalt	3	2,670-15,384	13,100	8.19-8.67	8.38
Tertiary Sediment	1	5,060		9.30	
Permian Interburden	6	7,030-18,800	12,805	7.38-8.38	8.06
GMS	5	2,450-16,127	9,110	6.65-7.90	7.12
GLS	30	387-31,300	24,050	2.71-8.76	7.99
Back Creek Group	3	4,530-24,030	22,660	5.98-6.79	6.74
Undifferentiated from airlift sampling during exploration drilling	75	100-30,000	12,593	6.89-9.18	7.68
ANZECC (2000) upper limits[1] - irrigation - livestock – cattle		2,900-5,200 8,300-16,700[2]			
EPP (Water)[3] – 50^{th} percentile - shallow groundwater (<30 m) - deep groundwater (>30 m)		2,150 6,100		7.75 7.80	

1 – ANZECC (2000) Water Quality Guidelines for livestock drinking water (cattle) and irrigation of salt tolerant crops.
2 – EC value based on TDS value for livestock (EC [µS/cm] = 1.67 × TDS [mg/L]).
3 – EPP (Water) Isaac River Sub-basin Environmental Values and Water Quality Objectives for Zone 34.

Results of the analyses of groundwater samples between 1998 and 2011 from monitoring bores installed on site are shown in **Table 4-3**. The Permian Moranbah Coal Measures and Back Creek Group has moderate to high salinity principally due to elevated levels of sodium and chloride ions. The Back Creek Group groundwater contains a relatively higher proportion of sulphate due to marine influence during deposition compared to the Moranbah Coal Measures. The groundwater from the Quaternary alluvium is dominated by sodium and bicarbonate ions, and has a lower salinity than the groundwater of the Permian formations.

Major ion concentrations for alluvial groundwater are less than the EPP (Water) 50^{th} percentile water quality objectives for shallow (<30 metre depth) groundwater, while the maximum concentration of zinc recorded is above the ANZECC (2000) water quality guideline for aquatic ecosystems.

The median concentration of sodium for groundwater from the Moranbah Coal Measures is just less than the EPP (Water) 50^{th} percentile water quality objective for deep (>30 metre depth) groundwater, while the median concentrations of chloride and bicarbonate are above the respective water quality objectives. The median concentration of manganese is also above the relevant water quality objective, while the median concentrations of nutrients (nitrate and nitrite, total phosphorous) and some dissolved metals (chromium, copper and zinc) are also above the ANZECC (2000) water quality guideline for aquatic ecosystems.

The median concentration of all major ions for groundwater from the Back Creek Group are greater than the EPP (Water) 50^{th} percentile water quality objective for deep (>30 metre depth) groundwater. The median concentration of manganese and iron are also above the relevant water quality objective, while the median concentrations of nutrients (nitrate and nitrite, total phosphorous) and some dissolved metals (boron, cadmium, chromium, copper, nickel, selenium and zinc) are above the ANZECC (2000) water quality guideline for aquatic ecosystems.

Table 4-3 Summary of Water Chemistry for Representative Bores On-Site between 1998 and 2011

Parameter	Guidelines					Moranbah Coal Measures				Back Creek Group				Quaternary Alluvium			
	EPP(Water) – 50th Percentile, Shallow (<30 m depth)[1]	EPP(Water) – 50th Percentile, Deep (>30 m depth)[1]	ANZECC (2000) and QWQG (2009) - Freshwater Ecosystems[2]	ANZECC (2000) - Livestock Drinking Water[3]	NHMRC (2011) - Human Drinking Water[4]	Count[5]	Min (mg/L)	Med (mg/L)	Max (mg/L)	Count[5]	Min (mg/L)	Med (mg/L)	Max (mg/L)	Count[5]	Min (mg/L)	Med (mg/L)	Max (mg/L)
Major Ions																	
Sodium	747	1,100	ne	ne	30[6]	13	40	1096	3560	3	824	3470	4400	2	40	-	94
Calcium	84	145	ne	1,000	ne	13	<0.01	49	469	3	34	214	422	2	13	-	39
Magnesium	108	115	ne	ne	ne	13	<0.01	25	570	3	86	542	805	2	7	-	20
Potassium	ne	ne	ne	ne	ne	13	1.4	6	28	3	29	35	38	2	3	-	3
Chloride	1,309	1,900	ne	ne	ne	13	64	2024	7510	3	1390	7000	9750	2	10	-	71
Bicarbonate	536	330	ne	ne	ne	13	85	497	5656	3	10	417	774	2	180	-	293
Sulphate	140	138	ne	1,000	200[6]	13	0.2	4	626	3	223	692	763	2	6	-	26
Fluoride	0.28	0.155	ne	2	1.5	11	<0.1	0.2	1.2					2	0.2	-	0.4
Nutrients																	
Nitrite + Nitrate as N	0.95	2.15	0.015	ne	ne	13	0.02	0.2	0.9	3	0.05	0.09	0.33	2	0.125	-	0.315
Total Phosphorus as P	ne	ne	0.03	ne	ne	13	0.03	0.5	5.08	3	0.78	1.49	1.56	2	0.47	-	0.75
Metals (Dissolved)																	
Aluminium	ne	ne	0.055	5	ne	13	<0.01	<0.01	0.1	3	0.04	0.05	0.05	2	0.05	-	<0.1
Antimony	ne	ne	ne	ne	0.003	2	0.004	-	0.007	3	<0.001	0.004	0.004	-	-	-	-
Arsenic	ne	ne	0.013	0.5	0.01	7	<0.001	0.002	0.024	3	0.001	0.008	0.013	2	<0.001	-	<0.01
Barium	ne	ne	ne	ne	2	2	0.168	-	0.313	3	0.046	0.095	0.107	-	-	-	-

Parameter	Guidelines					Moranbah Coal Measures				Back Creek Group				Quaternary Alluvium			
	EPP(Water) – 50th Percentile, Shallow (<30 m depth)[1]	EPP(Water) – 50th Percentile, Deep (>30 m depth)[1]	ANZECC (2000) and QWQG (2009) - Freshwater Ecosystems[2]	ANZECC (2000) - Livestock Drinking Water[3]	NHMRC (2011) - Human Drinking Water[4]	Count[5]	Min (mg/L)	Med (mg/L)	Max (mg/L)	Count[5]	Min (mg/L)	Med (mg/L)	Max (mg/L)	Count[5]	Min (mg/L)	Med (mg/L)	Max (mg/L)
Beryllium	ne	ne	ne	ne	0.06	2	<0.001	-	<0.001	3	<0.001	<0.001	0.001	-	-	-	-
Boron	ne	ne	0.37	5	4	7	<0.1	0.26	0.6	3	1.51	1.82	3.32	2	<0.1	-	0.1
Cadmium	ne	ne	0.0002	0.01	0.002	7	<0.0001	0.0002	0.005	3	0.0002	0.0005	0.0006	2	0.0002	-	<0.005
Chromium	ne	ne	0.001	1	0.05	7	<0.001	0.002	0.01	3	0.002	0.003	0.004	2	0.002	-	<0.01
Cobalt	ne	ne	ne	1	ne	7	<0.001	0.003	0.01	3	0.018	0.02	0.08	2	<0.001	-	<0.01
Copper	0.01	0.03	0.0014	1	2	7	<0.001	0.002	0.01	3	0.001	0.002	0.004	2	<0.001	-	<0.01
Gallium	ne	ne	ne	ne	ne	2	<0.001	-	<0.001	3	<0.001	<0.001	<0.001	-	-	-	-
Iron	0.03	0.05	ne	ne	ne	13	<0.01	<0.05	1.2	3	<0.05	0.12	1.94	2	<0.05	-	<0.05
Lead	ne	ne	0.0034	0.1	0.01	7	<0.001	0.001	0.01	3	<0.001	<0.001	<0.001	2	<0.001	-	<0.01
Lithium	ne	ne	ne	ne	ne	2	0.041	-	0.136	3	0.206	0.276	0.41	-	-	-	-
Manganese	0.01	0.05	1.9	ne	0.5	13	0.002	0.18	1.23	3	0.958	0.991	1.07	2	0.037	-	0.16
Mercury	ne	ne	0.00006	0.002	0.001	2	<0.0001	-	<0.0001	3	<0.0001	<0.0001	<0.0001	-	-	-	-
Molybdenum	ne	ne	ne	0.15	0.05	7	<0.001	0.01	0.021	3	<0.001	0.002	0.003	2	<0.001	-	<0.01
Nickel	ne	ne	0.011	1	0.02	2	0.002	-	0.033	3	0.009	0.028	0.131	-	-	-	-
Selenium	ne	ne	0.005	0.02	0.01	7	<0.01	<0.01	0.05	3	<0.01	0.01	0.03	2	<0.01	-	<0.01
Strontium	ne	ne	ne	ne	ne	2	1.75	-	3.86	3	0.675	8.52	10.7	-	-	-	-
Thorium	ne	ne	ne	ne	ne	2	<0.001	-	<0.001	3	<0.001	<0.001	<0.001	-	-	-	-

Parameter	Guidelines					Moranbah Coal Measures				Back Creek Group				Quaternary Alluvium			
	EPP(Water) – 50th Percentile, Shallow (<30 m depth)[1]	EPP(Water) – 50th Percentile, Deep (>30 m depth)[1]	ANZECC (2000) and QWQG (2009) - Freshwater Ecosystems[2]	ANZECC (2000) - Livestock Drinking Water[3]	NHMRC (2011) - Human Drinking Water[4]	Count[5]	Min (mg/L)	Med (mg/L)	Max (mg/L)	Count[5]	Min (mg/L)	Med (mg/L)	Max (mg/L)	Count[5]	Min (mg/L)	Med (mg/L)	Max (mg/L)
Titanium	ne	ne	ne	ne	ne	2	<0.01	-	<0.01	3	<0.01	<0.01	<0.01	-	-	-	-
Uranium	ne	ne	ne	0.2	0.017	2	0.002	-	0.005	3	<0.001	0.002	0.003	-	-	-	-
Vanadium	ne	ne	ne	ne	ne	2	<0.01	-	<0.01	3	<0.01	<0.01	<0.01	-	-	-	-
Zinc	0.015	0.025	0.008	20	ne	7	<0.01	0.013	0.13	3	0.05	0.054	0.174	2	0.008	-	0.02

1 – EPP (Water) Isaac River Sub-basin Environmental Values and Water Quality Objectives for Zone 34 groundwater.
2 – ANZECC (2000) and QWQG (2009) trigger values for moderately disturbed upland stream freshwater ecosystems.
3 – ANZECC (2000) guidelines for livestock watering of beef cattle.
4 – NHMRC (2011) health based guidelines for drinking water.
5 – Number of samples.
6 – EPP (Water) Isaac River Sub-basin Environmental Values and Water Quality Objectives for drinking water.
ne – No guideline value established.

4.2.3 Groundwater Use

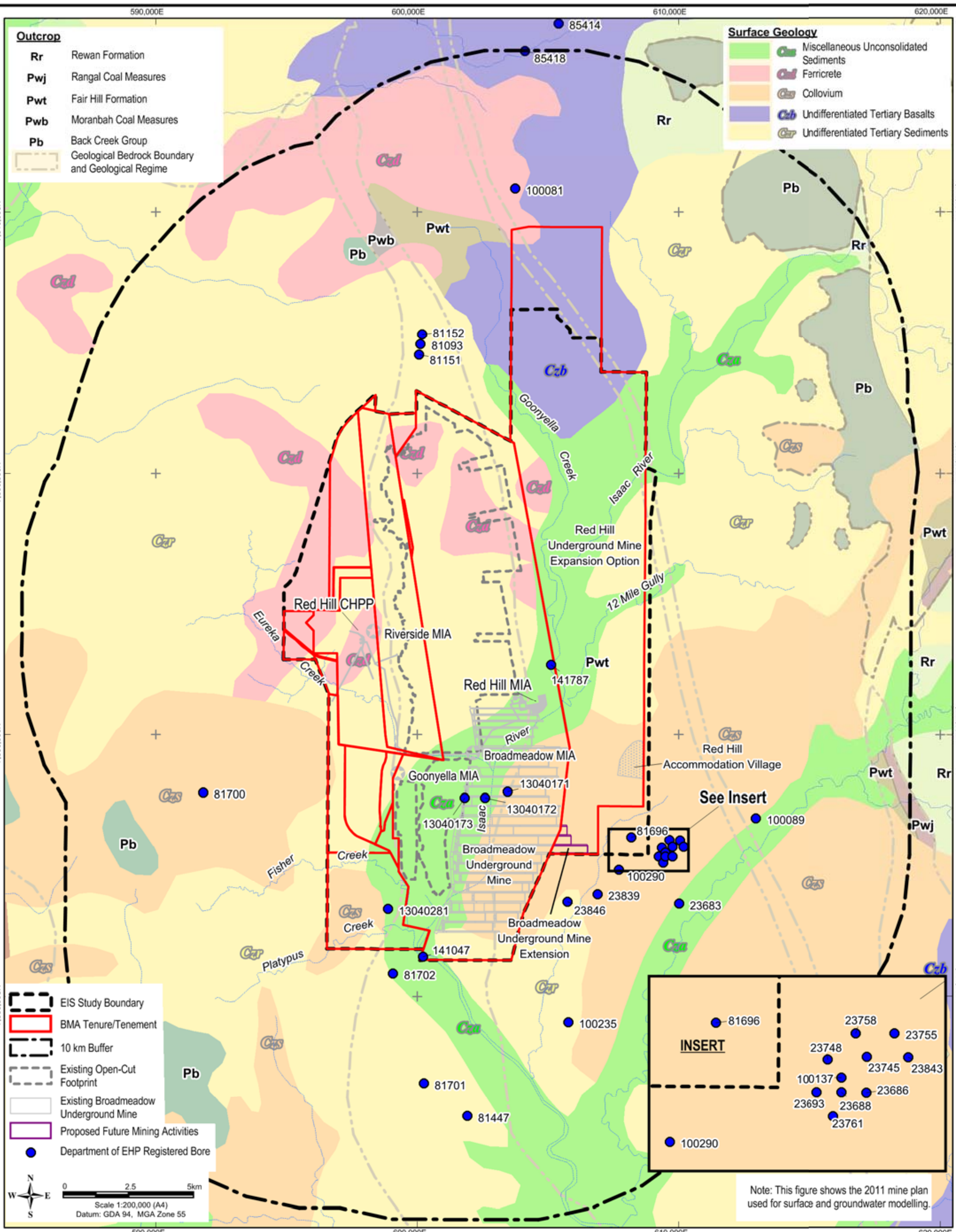
A groundwater bore census was conducted on properties within the study area to collect information on groundwater bores installed before registration was a requirement, and additional information on bores registered in the NRM database. Four bores were recorded during the census, two on 'Denham Park' and two on 'Broadmeadow'. The location of these bores is shown on **Figure 4-5** and summary of bore details are provided in **Table 4-4**. The bores on 'Denham Park' intersect the basalt aquifers to the northwest of the study area, however, the basalt does not extend into the project's infrastructure or mine areas and so these bores are unlikely to be impacted by mining activities. The bores on 'Broadmeadow' are considered to be constructed into the base of Tertiary (basal sand/sandstone) or the top of the Permian formations. These bores are generally used for stock watering, with one (Tex's bore on Denham Park) also used for household supply during drought.

Table 4-4 Summary of Bore Census Information

Property	Bore Name	Drilled Depth (mbgl)	Depth to Water (mbgl)	Water Use	Pumping Rate (L/s)	Landholder Description of Water Quality
Denham Park	Tex's Bore	118.9	34.13	Domestic and stock watering in drought	4.5	
Denham Park	Old Mill Bore	117.1	90.66	Stock watering	1.9	
Broadmeadow	Skeleton Bore (DERM Registration 81696)	63.7	28.41	Stock watering when required	1.3	'Good'
Broadmeadow	Cleanskin Gully	25.34	14.02	Stock watering when required	2.6	'Good'

There are no active dewatering bores operating on the GRB mine complex. There have been dewatering bores on site in the past for the establishment of GRM box cuts; however, these were not replaced when they were mined out because groundwater inflow to the open cut pits is limited once mining is established. Due to the large surface area of the open cut pits and the significant excess of evaporation (four times greater) over rainfall in the area during periods of average rainfall, groundwater, which seeps from the coal seams along the walls of the open pits mostly evaporates, with limited amounts collected in sumps. Where groundwater does reach the sumps is then pumped to the mine water system for reuse. Given unseasonably high rainfall events over recent wet seasons / flood events (2009/10 and 2010/11), the current open cut pit volumes accommodate residual flood water, which can only be discharge from site under the current licencing conditions (see **Section 5.1.10**).

Groundwater is, despite the volumes held in some of the GRB mine complex pits, not actively dewatered in advance of mining in the BRM. Total groundwater contribution rates to the mine water system are not monitored as these are at low levels.



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NRM REGISTERED BORES AND CENSUS BORE LOCATIONS

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Figure: 4-5

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4.3 Surface Water Overview

4.3.1 Surface Water Hydrology

Six 'waterways' classified as *watercourses* (under section 5 of the *Water Act 2000*) have been identified within the study area (**Figure 4-6**). They are the Isaac River and tributaries, Goonyella Creek, Eureka Creek, 12 Mile Gully, Fisher Creek, and Platypus Creek. All other streams located in the study area are contributing drainage systems to these watercourses. All streams within or adjacent to the study area were identified as upland freshwater streams which are defined as (freshwater) streams or stream sections above 150 metres in elevation (ANZECC 2000).

The Isaac River and tributaries in and around the study area are ephemeral. Flow mainly occurs for a short period during and immediately after rainfall events. Assessment of available stream flow data indicates that base flow is limited and appears to be sustained by surface base flow stores rather than distinct groundwater contribution. Base flow that recedes after rainfall events is typically limited to a few days up to approximately less than one or two weeks after surface runoff (quick flow) has drained from contributing sub-catchments.

Annual rainfall in the study area is highly variable and subject to prolonged periods of above and below average rainfall. The mean monthly rainfall data indicates a distinct seasonal distribution (**Figure 4-2**) with monthly rainfall totals greatest in the wet season extending from November through March, and typically peaking in January with an average of just over 100 millimetres. The average monthly evaporation exceeds the average monthly rainfall throughout the year with a maximum of around 245 millimetres average monthly evaporation in December. It is important to note that average monthly statistics are not used for the purpose of water management assessment and design, as high wet season rainfall in wetter years (which can be highly variable) can substantially exceed evaporation rates. Additional climate data are presented in **Section 4.1**. Rainfall, particularly when it occurs in extremes (i.e. large variation between wet and dry seasons) can influence stream flow and associated base flow properties in the study area. Analysis of stream flow records for the purpose of runoff model calibration for an environmental evaluation undertaken in 2007 (URS 2007) identified that long term mean annual runoff is approximately 50 to 55 millimetres per year, or approximately 10 per cent of mean annual rainfall. At a local scale, much higher runoff can occur as a result of intense rainfall events, particularly when catchments are saturated from preceding rainfall. Under these rainfall conditions runoff over a short duration of intense runoff depths can be up to 80 per cent or more relative to rainfall depths.

Stream flow records for the Queensland Government stream flow gauge on the Isaac River at Goonyella (GS13014A, near the existing railway bridge) indicate a mean flow of approximately 58,000 ML per year (ML/year) from the period June 1983 to November 2011. The hydrology of the Isaac River has been modified by construction of Burton Gorge Dam in 1992, and hence the stream flow records at the Goonyella gauge represent a mix of pre-dam and post-dam stream flow hydrology.

Stream flow data has also been derived by modelling undertaken by the Queensland Government for the purpose of statutory water resource plans (Integrated Quantity and Quality Models (IQQM)) and this modelling includes the representation of Burton Gorge dam influence on the Isaac River hydrology. Statistics of the Queensland Government modelled (IQQM) stream flow across the period 1898 to 1995 for the Isaac River have been documented by Alluvium (2008) for the purpose of impact assessment of mining subsidence on the Isaac River. This information indicates that the mean annual flow of the Isaac River through the study area is approximately 50,000 ML/year.

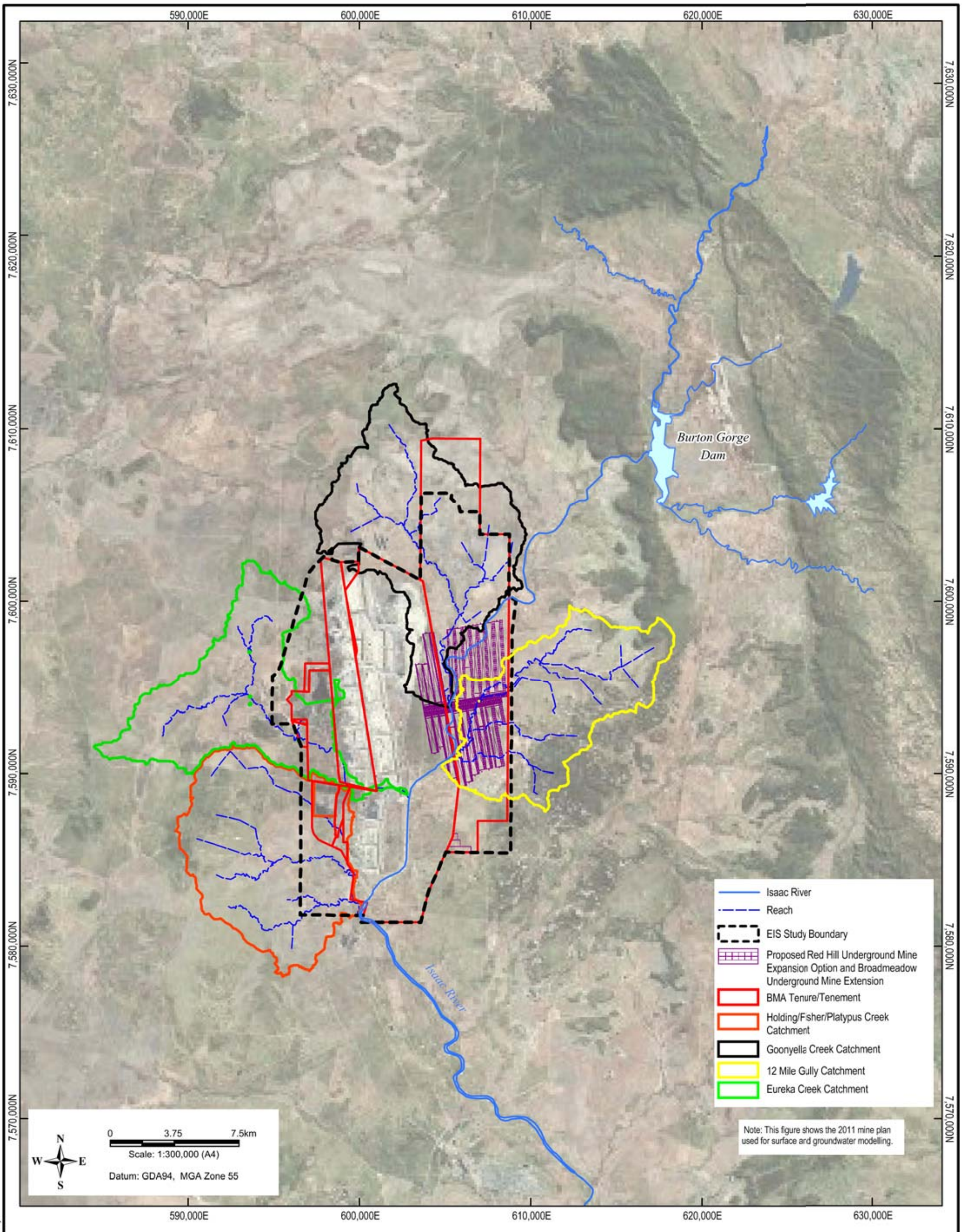

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Figure: **4-6**

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The 12 Mile Gully tributary has a sub-catchment area of approximately 84 km^2 to the junction with the Isaac River. For the 12 Mile Gully watercourse the estimated long term mean annual flow contribution into the Isaac River is approximately 4,400 ML/year, or approximately slightly less than 10 per cent of the Isaac River mean annual flow through the study area.

4.3.2 Surface Water Quality

The Surface Water Quality Assessment Technical Report was prepared to assess baseline conditions and the potential impacts of the proposed project on surface water quality in watercourses within and downstream from the study area. The purpose of the assessment was to identify applicable environmental values in accordance with EPP (Water), Australian New Zealand Environment and Conservation Council Guidelines (ANZECC 2000), the QWQG (2009) and Schedule 1 of EPP (Water).

Regionally the Isaac-Connors River catchment provides potable water supply, supports primary and secondary contact recreation, industrial uses, and agricultural uses including stock watering, farm use and irrigation.

The existing water quality of the watercourses flowing both within and downstream of the study area was assessed to characterise the condition of the existing surface water receiving environment. The assessment was based on a review of existing surface water quality monitoring data collected by BMA for the existing GRB mine complex. Data was collected over the period between August 2010 and April 2011.

Table 4-5 presents median values for key physico-chemical parameters at sites upstream and downstream of the proposed project as well as for tributaries unaffected by other mining activities. The results for toxicants are shown in **Table 4-6**. Median values for each site were compared against the water quality objectives and bold figures in **Table 4-5**, **Table 4-6** and **Table 4-7** denote values in exceedence of the objectives. The water quality objectives consisted of guideline values stipulated within Schedule 1 of the EPP Water (Isaac-Connors catchment, 2011); the QWQG (2009), and trigger values defined within the Environmental Authority for the existing GRB mine complex (EPML00853413). A complete list of these objectives is contained within **Table 4-8**.

The locations of historic surface water monitoring points are presented in **Figure 4-7**.

Table 4-5 Median Values for Physico-Chemical Parameters - (2010-2011)

Site	Number of Samples	Total Suspended Solids (mg/L)	EC (µS/cm)	Sulphate (mg/L)	pH (pH units)	Ammonia N (µg/L)	Turbidity (NTU)
Fisher Creek	12	**98**	92	2	7.3	10	**371**
Platypus Creek	12	**116**	70	2	7.2	10	**262**
Upper Eureka	51	**183**	160	2.2	7.4	20	**238**
Upper Isaac	45	**340**	180	2	7.8	20	**450**
Lower Isaac	53	**380**	246	5	7.8	10	**597**
Water Quality Objective		30	720	25	6.5 - 8.5	20	50

Note: Bold denotes median values exceeding water quality objectives

Table 4-5 shows that median turbidity and total suspended solids (TSS) concentrations exceeded water quality guidelines at all sites.

Median, 25th percentile and 75th percentile values for pH were all within the guidelines for aquatic ecosystem protection at all sites; median and 75th percentile values for EC (salinity) were also within the existing EA trigger value of 2,000 µS/cm (high flow conditions) at all sites. The EA trigger value was applied to the observed water quality results (rather than the EPP Water guideline of 720 µS/cm) because monitoring was generally conducted under flow conditions during the 2010-2011 wet season.

Table 4-6 and **Table 4-7** present a comparison of median values for soluble and total metals, ammonia and nitrate at monitoring sites, with the relevant guidelines for toxicants in surface waters. These results clearly indicated that heavy metals are largely adsorbed to sediment in the study area surface water environment, resulting in more elevated concentrations of total metals than soluble (dissolved) metals. The results also indicate that toxicants are within guideline values when dissolved metal fractions are considered. Aluminium and iron appear to be naturally high in this catchment.

Table 4-6 Median Values for Soluble Metals, Ammonia and Nitrate (2010-2011)

Parameter	Guideline Values for Toxicants					Median values				
	ANZECC 2000 / EA EPML00853413 (1)	NHMRC (2008) Primary Contact Recreation	ANZECC (2000) Livestock Drinking Water	ANZECC (2000) Suitability for Irrigation: Long Term Use	ANZECC (2000) Suitability for Irrigation: Short Term	Lower Isaac	Upper Isaac	Upper Eureka Creek	Fisher Creek	Platypus Creek
Aluminium (µg/L)	1,530	2,000	5,000	5,000	20,000	420	405	420	4,200	5,050
Chromium (µg/L)	3	500	1000	ND	ND	0.5	0.5	1	2	3
Copper (µg/L)	3	ND	1000	50	100	3	2	3	2	2
Iron (µg/L)	970	3,000	ND	200	10,000	240	260	350	765	790
Molybdenum (µg/L)	34	500	ND	10	50	1	0.5	0.5	0.5	0.5
Nickel (µg/L)	11	200	1,000	200	2,000	2	2	4	3	2
Selenium (µg/L)	10	100	20	20	50	2.5	2.5	2.5	2.5	2.5
Uranium (µg/L)	1	20	20	10	100	0.2	0.2	0.05	0.05	0.05
Vanadium (µg/L)	10	ND	ND	100	500	2.5	2.5	2.5	2.5	2.5
Zinc (µg/L)	8	30,000	20,000	2,000	5,000	2.5	2.5	2.5	5	5
Ammonia (µg/L)	20	500	ND	ND	ND	10	20	20	10	10
Nitrate (µg/L)	1,100	50,000	ND	ND	ND	50	20	20	25	5

Note 1: Some values have been modified from ANZECC (2000) guidelines to reflect local background values.

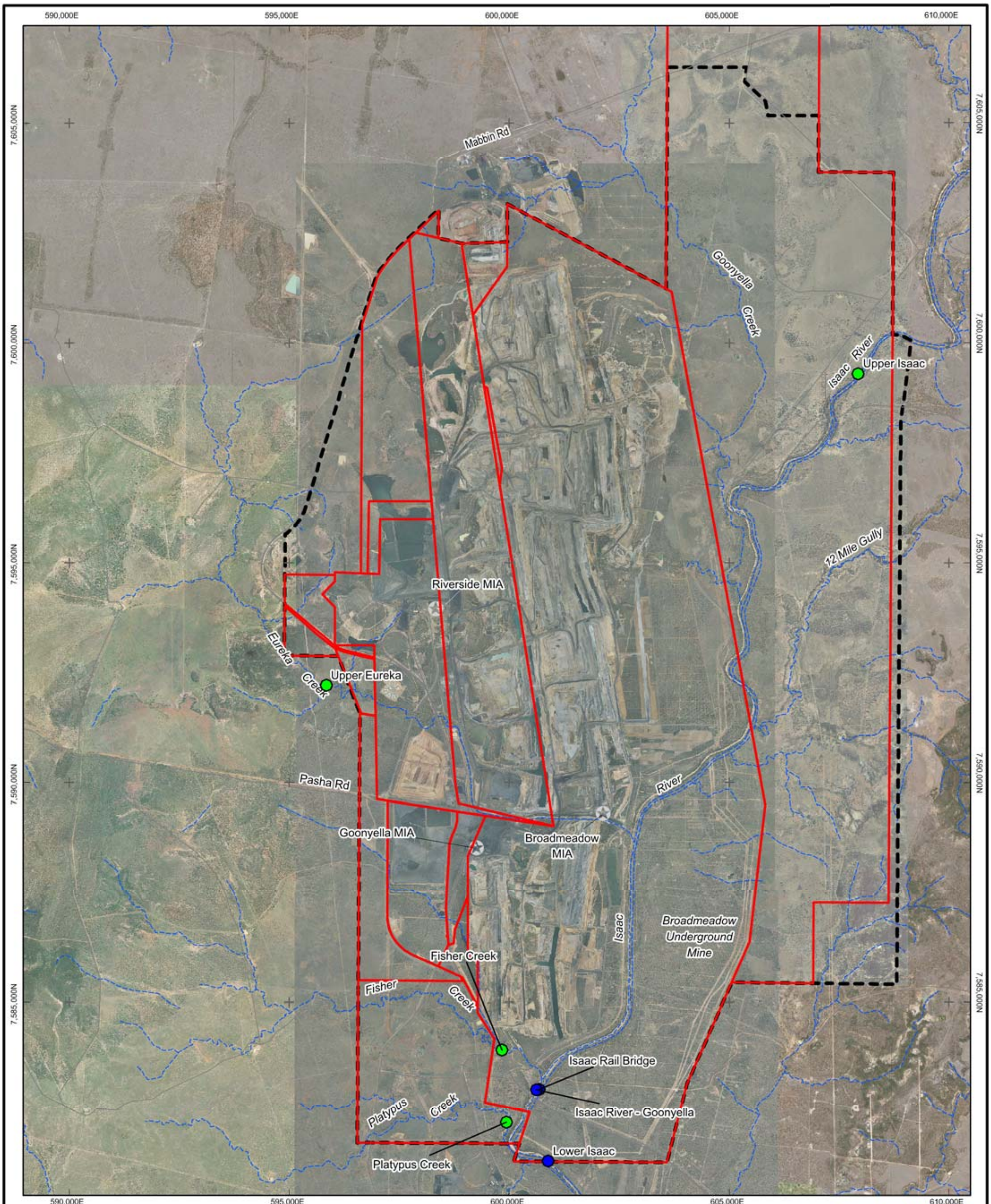
ND = not detected

Table 4-7 Median Values for Total Metals (2010-2011)

Parameter	Guideline Values for Toxicants					Median values				
	ANZECC 2000 / EA EPML00853413 (1)	NHMRC (2008) Primary Contact Recreation	ANZECC (2000) Livestock Drinking Water	ANZECC (2000) Suitability for Irrigation: Long Term Use	ANZECC (2000) Suitability for Irrigation: Short Term	Lower Isaac	Upper Isaac	Upper Eureka Creek	Fisher Creek	Platypus Creek
Aluminium (µg/L)	1,530	2,000	5,000	5,000	20,000	8,520	8,500	4,600	7,680	6,400
Chromium (µg/L)	3	500	1000	ND	ND	16	15	13	17.5	16
Copper (µg/L)	3	ND	1000	50	100	11	11	6	2.5	3.75
Iron (µg/L)	970	3,000	ND	200	10,000	11,000	11,000	7,190	7,595	6,560
Molybdenum (µg/L)	34	500	ND	10	50	2.5	2.5	2.5	2.5	2.5
Nickel (µg/L)	11	200	1,000	200	2,000	19	15	11	9	7
Selenium (µg/L)	10	100	20	20	50	2.5	2.5	2.5	2.5	2.5
Uranium (µg/L)	1	20	20	10	100	.0.5	0.5	0.25	0.25	0.25
Vanadium (µg/L)	10	ND	ND	100	500	29	26.5	17	20	20
Zinc (µg/L)	8	30,000	20,000	2,000	5,000	30	24	12	8.5	10

Table 4-8 Water Quality Guidelines for Physico-Chemical Stressors and Toxicants in the Surface Water Receiving Environment

Parameter	Units	Water Quality Objectives	Guideline Source
Physico-chemical parameters, nutrients and hydrocarbons			
Total Suspended Solids	mg/L	30	EPP (Water) 2011
Electrical Conductivity	µS/cm	2,000 (high flow)	EPML00853413, Table W5
Sulphate (SO_4)	mg/L	1,000	EPML00853413, Table W5
Total Nitrogen	µg/L	500	EPP (Water) 2011
Total Phosphorus	µg/L	50	EPP (Water) 2011
pH	pH units	6.5-8.5	EPP (Water) 2011
Ammonia Nitrogen	µg/L	20	EPP (Water) 2011
Oxidised Nitrogen (NO_x)	µg/L	60	EPP (Water) 2011
Organic Nitrogen	µg/L	420	EPP (Water) 2011
Nitrate	µg/L	1,100	QWQG 2009
Filterable Reactive Phosphorus	µg/L	20	EPP (Water) 2011
Chlorophyll-α	µg/L	5	EPP (Water) 2011
Dissolved oxygen	% saturation	85 - 110	EPP (Water) 2011
Turbidity	NTU	50	EPP (Water) 2011
Petroleum hydrocarbons (C6-C9)	µg/L	50	LoR for analytical methods defined in EPML00853413
Petroleum hydrocarbons (C10-C36)	µg/L	200	LoR for analytical methods defined in EPML00853413
Toxicants (Total and Dissolved)			
Aluminium	µg/L	1,530	EPML00853413, Table W3
Chromium	µg/L	3	EPML00853413, Table W3
Copper	µg/L	3	EPML00853413, Table W3
Iron	µg/L	970	EPML00853413, Table W3
Nickel	µg/L	11	EPP (Water) 2011/ ANZECC 2000
Zinc	µg/L	8	EPP (Water) 2011/ ANZECC 2000
Molybdenum	µg/L	34	EPP (Water) 2011/ ANZECC 2000
Selenium	µg/L	10	EPP (Water) 2011/ ANZECC 2000
Uranium	µg/L	1	EPP (Water) 2011/ ANZECC 2000
Vanadium	µg/L	10	EPP (Water) 2011/ ANZECC 2000



N W E S

0 1.25 2.5km

Scale 1:120 000 (A4)

Datum: GDA 94, MGA Zone 55

EIS Study Boundary

BMA Tenure/Tenement

SW Monitoring Location (Upstream of GRM Operations)

SW Monitoring Location (Downstream of GRM Operations))

Source: © Mapinfo Australia Pty Ltd and PSMA Australia Ltd., © Copyright Commonwealth of Australia (Geoscience Australia) 2006 , © Copyright The State of Queensland (Department of Natural Resources and Water) 2008, © The State of Queensland (Department of Mines and Energy) 2006-2008, © The State of Queensland (Department of Environment and Resource Management) 2010, Bing Maps © Microsoft Corporation and its data suppliers, Images from Client Oct 2011

BMA
BHP Billiton Mitsubishi Alliance

RED HILL MINING LEASE
IESC REPORT

LOCATION OF HISTORICAL WATER QUALITY MONITORING SITES

URS

IESC REPORT

File No: 42627136-g-2236.wor Drawn: VH Approved: CT Date: 24-10-2013

Figure: 4-7 Rev. A A4

4.3.3 Surface Water Use

There are five registered water licensees located within 100 kilometres downstream of the study area, along the Isaac River. Four of these are using water for stock and domestic purposes and the fifth licence is in relation to a diversion. There were no licensed water users identified within the study area, however the Water Act does allow landholders adjacent to rivers to take water for stock and domestic purposes without a licence.

4.3.3.1 Mine Water Management

The Broadmeadow extension will be integrated with the existing BRM operations, including all aspects of water management. The future RHM will operate separately from the existing GRB mine complex; however, there will be an interaction between the two operations in relation to mine water management.

Mine waters generated by the project will be transferred to GRB mine complex and water demands that can be met from reuse of mine water such as the Red Hill CHPP will be supplied from the GRB mine water inventory. This type of mine water exchange arrangement also occurs between other coal mining operations in Queensland. There are provisions in the Model Water Conditions for Coal Mines in the Fitzroy Basin (EHP 2013a, Version 4) that allow for exchange of mine waters between separate coal mine operations including requirements for proper management and responsibility for general environmental duty as defined in the *Environmental Protection Act 1994* (EP Act).

A detailed 'whole of operation' mine water balance model assessment was undertaken to assess impacts on mine water management performance. A baseline scenario was set up in the model to represent the GRB mine water management system (without the project), and another scenario set up to represent the inclusion of the project. The overall purpose of the mine water balance assessments was to compare the performance of the GRB mine water management system with and without inputs from the project in terms of containment storage, water inventory and compliance with discharge criteria and conditions defined in the existing GRB mine complex EA No. EPML00853413.

For reference to descriptions of the mine water balance and water management herein, the mine water management system is defined as the combined influence and operation of:

- catchments and drainage that collect mine waters (and exclude clean waters);
- dams that capture and store mine water; and
- the pumping or transfer systems that are used to distribute mine water through the system for reuse in the operations, or to make controlled compliant releases of mine water to downstream waterways.

Mine Water Sources, Catchments and Typical Salinity

The dominant mine water sources include surface water runoff from mine catchments (including pits) and groundwater dewatering.

Surface water runoff volumes are highly variable in response to rainfall. In above average wet season conditions surface runoff volumes are substantial due to the large area of the mine and mine water containment catchments. The total effective area of the baseline GRB mine water management system including containment catchments and mine pits is approximately 80 km^2.

The mine surface runoff volumes in average rainfall years is valuable to meet mine water demands, but typically is insufficient to meet the total demand.

In exceptionally high wet season conditions very large runoff volumes can be generated and cause the most 'stress' on the mine water management system for containment performance and discharge compliance. By necessity the strategy to make controlled and compliant release of mine water whenever external flow conditions allow is essential for sustainable performance of the mine water management system and recovery of mining operations. Releases from the GRB mine water management for baseline and the project occur through controlled transfers within the water management system and direct catchment flows to GS4A.

The typical salinity associated with mine surface runoff sources varies depending on the catchment conditions across mine disturbed areas. Typical salinities for different surface runoff catchments are:

- Open-cut mine pit waters are typically in the order to 2,000 to 7,000 µS/cm EC, and occasionally higher EC values occur during very dry periods. The water collected in mine pits is primarily rainfall runoff. Very little, if any, groundwater flow into the mine pits has been evident in the operations to date.
- Mine spoil runoff is typically in the order of 500 to 2,000 µS/cm EC and occasionally higher EC values occur if base flow occurs as seepage from mine spoil.
- Stormwater runoff from industrial, CHPP, and run-of-mine (ROM) areas is typically in the order of 1,000 to 3,000 µS/cm EC.
- Tailings dam surface waters are typically in the order of 2,000 to 4,000 µS/cm EC and higher salinity can occur after prolonged dry periods.

The main source of groundwater dewatering is from the existing BRM. The groundwater source forms only a minor portion of the overall mine water volumes managed in the mine water management system. The volume of groundwater removed from BRM through mine dewatering operations is approximately 2.4 ML per day (ML/day).

The groundwater sources into the mine water management system are notably more saline (**Table 4-2**) than mine waters sourced from surface runoff.

Section 05 Site Specific Water Balance Model

The design of the water management system and assessment of water management performance risks is guided by a dynamic integrated water and salt balance model of the entire mine water management system.

Climate data (rainfall and evaporation) are the primary inputs for the mine water balance model. This allows the model to assess system performance in response to extremes of climate including high rainfall events, exceptionally high rainfall wet seasons, potential sequential years with high wet seasons, and also drought periods.

The mine water balance model operates on a daily time-step and converts rainfall to runoff using the Australian Water Balance Model (AWBM) runoff model. This method of runoff estimation produces higher runoff for a given rainfall rate when catchments are wet (e.g. above average wet seasons) and lower runoff for a given rainfall rate when catchments are dry (e.g. below average rainfall seasons).

The mine water balance model also represents different runoff characteristics from natural catchments and classifications of mine disturbed catchments across the site. The catchment 'landtype' classifications used in the model include:

- natural (undisturbed land within and outside the mine lease);
- mine spoil (generalised for all types of mine spoil dumps and surface across the site);
- hardstand (generalised to represent pit walls, pit floor, haul roads, ROM, and general 'hardstand' surfaces around the CHPP and industrial areas of the site); and
- rehabilitated (mine spoil that has been revegetated).

The hardstand land-type classification produces the highest rates of runoff, and the natural land-type classification produces the lowest rates of runoff. These were developed from detailed evaluation of site specific data and model validation as part of the environmental evaluation undertaken in 2007 (URS 2007).

The mine water balance model simulates water volumes and salt mass (in salinity of waters) from all sources. This allows estimates of water quality (salinity as total dissolved solids (TDS)) to be determined from the model results to guide operations for discharges and assess capability to comply with the EA conditions.

The mine water balance model represents daily estimates of flow (or volume) and salinity of mine waters for all connected components of the GRB mine water management system. It also represents natural flows (rates and salinity) in the surrounding creeks and rivers upstream and immediately downstream of the mine. This allows the model to simulate the opportunity for discharges from GS4A dam related to flow conditions in the Isaac River. This also allows the model to estimate downstream salinity in the Isaac River after mixing of natural Isaac River flows and discharges from the GS4A dam.

The mine water balance model simulations are undertaken for a static configuration of the mine representative of a given point in time, which for the baseline used in this EIS is nominally 2015. The simulation periods are performed with the complete 108 years of climate data (to test extremes of climate influence) and time series results are produced for water volumes (or flows in waterways) and salinity. The long period time series results are then statistically analysed to quantify risks to characterise the mine water management system performance.

5.1 Project Data

5.1.1 Base model

The water balance model developed by Engeny in 2013 was used as the basis for this assessment. The development of that model is documented in *“Goonyella Riverside Mine Water Balance Model, Technical Report, February 2013 (Ref: M11000_018)”*.

5.1.2 Climate data

Rainfall and evaporation data used within the model were run for the period of 01/01/1900 to 31/12/2007. This climate data were sourced from the Queensland Climate Change Centre of Excellence Climate Data Bank – SILO data drill that was obtained via http://www.longpaddock.qld.gov.au/silo/datadrill/index.php. The two reference locations were used to represent the variation of rainfall in the area, locations requested were:

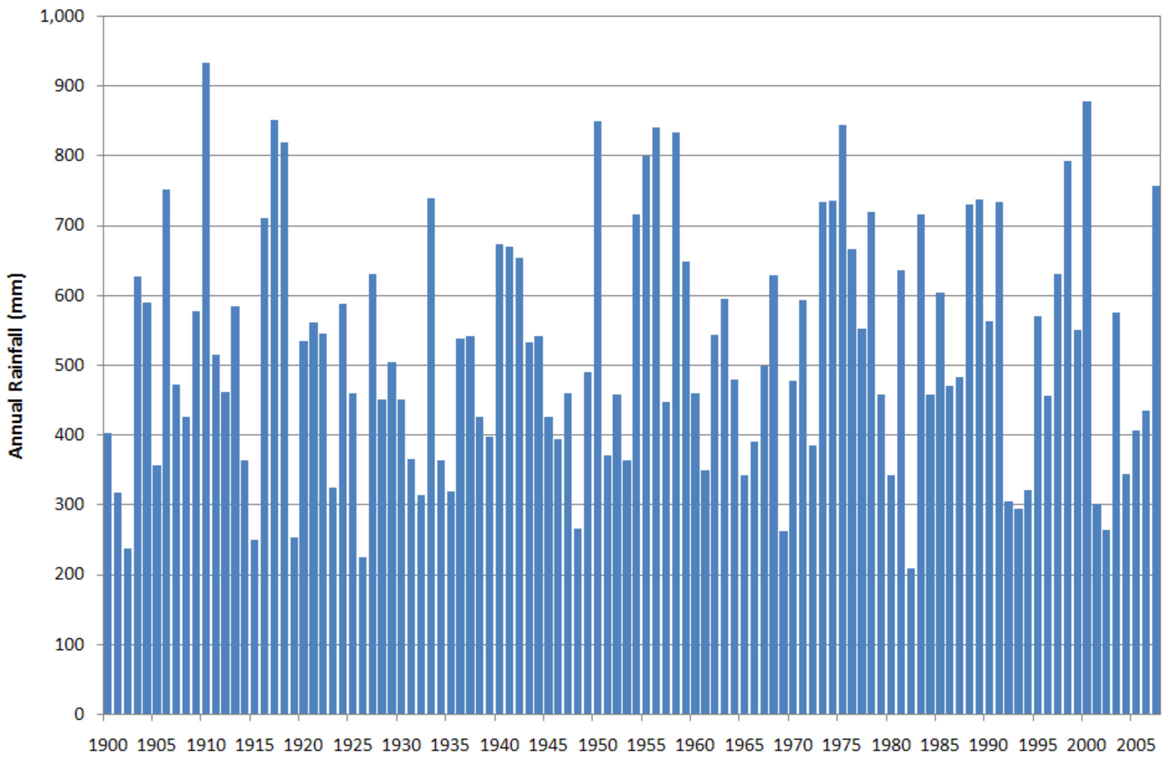
- GRM catchments climate data extracted for 147.95’E, 21.75’S; and
- Upper Isaac catchments data extracted for 148.05’E, 21.65’S.

Actual data recorded by the GRB mine complex through its hydrological monitoring system operated by Ecowise Environmental for the 2007 / 2008 wet season were used to replace the corresponding values in the SILO data set. Summary of the long term climate data is detailed in **Table 5-1** and **Figure 5–1** presents the annual rainfall for the GRM over 108 year period.

Table 5-1 Long Term Climate Averages (millimetres)

Climate	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
Rainfall	97	88	58	27	24	27	18	15	12	28	50	80	523
Evaporation	230	187	194	151	118	95	105	134	180	225	234	243	2,096

Figure 5-1 GRB Mine Complex Annual Rainfall Data (SILO Data Drill)



5.1.3 IQQM Model

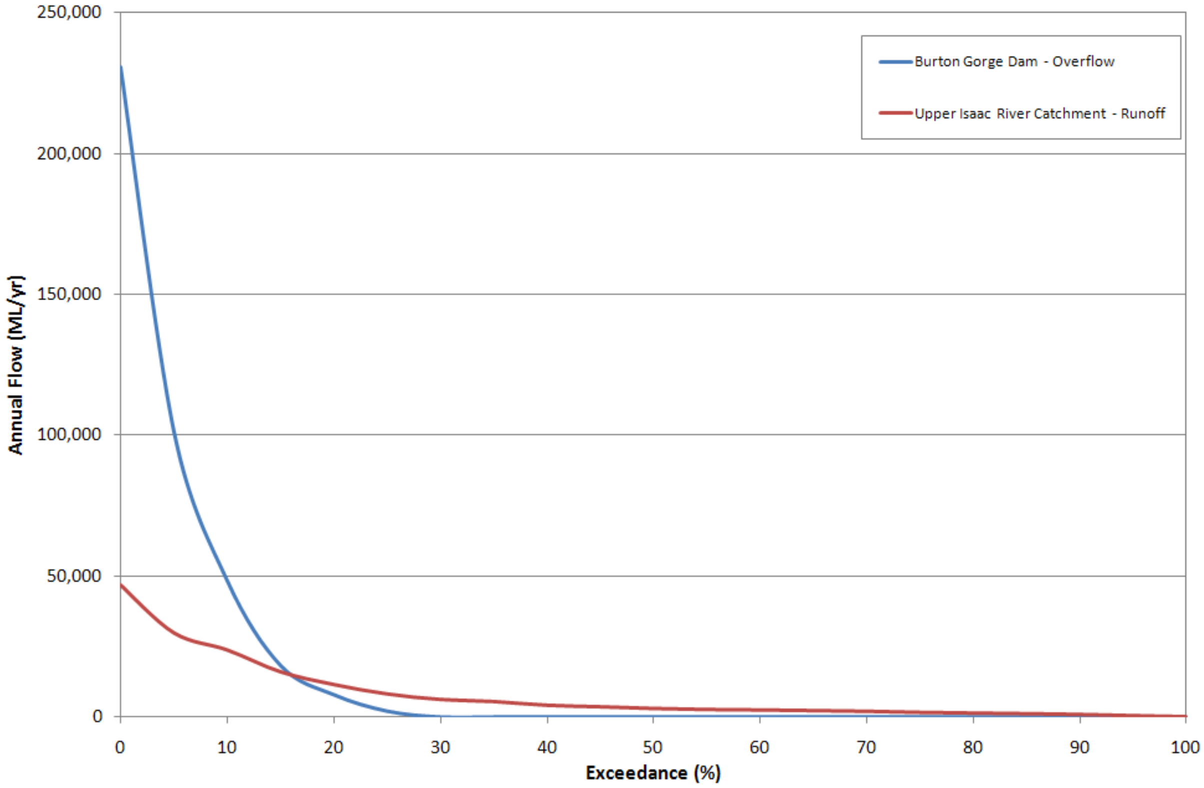
Burton Gorge Dam is located on the Isaac River in the Upper Isaac River catchment approximately 40 kilometres upstream of GRM. This dam is privately owned and operated and has a capacity of 18,000 ML. Water from the dam is extracted under the terms of a water licence to supply water to coal mines in the area.

The current EA release conditions for the GRB mine complex (dated 28th February 2013) require the release flow to be calculated on the basis of flow at the gauging station on the upper Isaac River, approximately 15 kilometres downstream of the dam. The catchment area to this point is approximately 760 km^2, of which 80 per cent is above the Burton Gorge Dam. Therefore, the Burton Gorge Dam catchment has the potential to contribute significant flows to the Isaac River when overflow of the dam occurs. To ensure the frequency and magnitude of the overflows from Burton Gorge Dam were represented appropriately; the Water Resources (Fitzroy Basin) Plan 2011 was reviewed.

The Water Resources (Fitzroy Basin) Plan 2011 includes an IQQM of Isaac and Connors Rivers sub-catchments. The IQQM model was obtained through the Department of Environment and Heritage Protection (EHP) under licence CAS2089. Investigation of the IQQM results for the Burton Gorge Dam showed that when overtopping of the dam occurred, significant flow volumes were conveyed downstream.

Figure 5–2 details the theoretical flow duration for the overflows estimated from the Burton Gorge Dam and the upper Isaac River catchment below the Burton Gorge Dam to the GRB mine complex over the 108 year period from 1900 to 2007. The Burton Gorge Dam overflows from the IQQM model were used in the water balance model to predict the flows at the upper Isaac River gauging station.

Figure 5-2 Burton Gorge Dam Overflows and Upper Isaac River Flows



5.1.4 Demands

Coal Handling and Preparation Plant

A summary of the water demand of the existing Goonyella and Riverside CHPP, as well as the proposed Red Hill CHPP for use within the Baseline and Project Case scenario have been provided by BMA and are detailed below in **Table 5-2**.

Table 5-2 CHPP Water Demand

Item	Demand (ML/yr)
Goonyella CHPP	1,600
Riverside CHPP	1,600
Red Hill CHPP	1,300*
Total	**4,500**

**this demand is averaged over the project life and is significantly less than the current Goonyella/Riverside operations due to incorporation of belt press filter technology*

Raw Water Demands

Demands for raw water supply for use within the BRM and RHM underground mining operations as well as raw water uses for the CHPP and potable water are detailed in **Table 5-3**.

Table 5-3 Raw Water Demand

Item	Demand (ML/yr)
Broadmeadow Underground	365
Goonyella and Riverside CHPP*	180
Water Treatment Plant	180
Red Hill Potable	145
Red Hill Underground	730
Red Hill CHPP	30
Total	**1,630**

* combined value for both CHPPs

Haul Road Dust Suppression

Demands for haul road dust suppression used in the EIS Baseline scenario are the same as assumed in the reporting by Engeny (2013). Demands are split evenly between the Goonyella and Riverside mining operations and detailed in **Table 5-4**. As the RHM does not have any demands for dust suppression, demand assumptions remain the same in the Baseline and Project Case scenario.

Table 5-4 Haul Road Dust Suppression Demands

Item	Demand (ML/yr)
Goonyella	1,100
Riverside	1,100
Total	**2,200**

MIA Demand

Demands for use within the MIA used in the EIS Baseline scenario have been provided by BMA and details are outlined in **Table 5-5**.

Table 5-5 MIA Demands

Item	Demand (ML/yr)
GRB mine complex*	500
Red Hill	70
Total	**570**

* There are three MIAs at the GRB mine complex

5.1.5 AWBM Catchment Runoff Parameters

The AWBM catchment runoff is used in modelling of the EIS Baseline and Red Hill scenario. A summary of the AWBM parameters are presented in **Table 5-6**.

Table 5-6 AWBM Catchment Runoff Parameters

	Area Fractions			Soil Storage (mm)			Surface	Baseflow	
	A1	A2	A3	C1	C2	C3	Ks	Kb	BFI
Natural	0.134	0.433	0.433	10	55	115	0.3	0.60	0.45
Spoil	0.134	0.433	0.433	10	50	120	0.1	0.60	0.35
Rehabilitated	0.134	0.433	0.433	12	71	141	0.1	0.60	0.35
Hardstand	0.134	0.433	0.433	5	20	40	0.1	1.00	0.00
Tailings	0.134	0.433	0.433	10	20	40	0.1	1.00	0.00

5.1.6 Catchment Characteristics

A summary of the catchments and land-use applied in both modelling scenarios is provided in **Table 5-7**.

Table 5-7 Catchment Characteristics

Catchments	Land-Use Classification (ha)					
	Natural	Spoil	Rehabilitated	Hardstand & Pits	Tailings	Total
Northern Storages	779	1,613	366	785	0	3,543
Central Storages	808	1,106	464	1,130	297	3,805
South Storages	446	724	215	885	105	2,375
Regional Waterways	48,891	168	201	77	0	49,337
Total	50,924	3,611	1,246	2,877	402	59,060

5.1.7 Water Quality (Salinity)

A summary of the salinity parameters applied within the water balance model is detailed in **Table 5-8** and **Table 5-9**.

Table 5-8 Catchment Runoff Salinity Parameters

Land-Use	Reference Depth	A	B	Maximum TDS (mg/L)	Maximum EC (µS/cm)
Natural	Excess Runoff	65	-0.25	700	1,190
Rehabilitated	Excess Runoff	65	-0.25	2,200	3,730
Spoil	Excess Runoff	1,500	-0.20	1,500	2,540
Hardstand	Excess Runoff	1,000	-0.20	700	1,10
Hardstand – Water Storage Pit	90 Day Rainfall	16,000	-0.20	16,000	27,120
Hardstand – Active Pit	90 Day Rainfall	16,000	-0.35	22,000	37,290
GS1 TSF	28 Day Rainfall	6,000	-0.16	3,000	5,080
RS1 TSF	28 Day Rainfall	3,800	-0.14	6,000	10,1710

TDS loadings for each catchment are determined through application of following:

- Natural, spoil and hardstand – *Runoff TDS (mg/L) = A x Runoff (mm/day)* [B].
- Mining Pits – *Runoff TDS (mg/L) = A x 90 day rainfall (mm)* [B].
- Tailings Dam – *Runoff TDS (mg/L) = A x 28 day rainfall (mm)* [B].

Table 5-9 Water Source Salinity

Water Source	TDS (mg/L)	EC (µS/cm)
Groundwater	3,000	5,080
Raw Water	200	340
Underground Mining Dewatering	4,270	7,240

5.1.8 Storage Characteristics

Storage characteristics were used to represent each of the storages and pits within the model, as shown in **Table 5-10**.

Table 5-10 Storage Characteristics

Water Storages	Storage Capacity (ML)	Water Storages	Storage Capacity (ML)
GS1 TSF	644	Ramp 21/22/23	49,635
GS1A	1,791	Ramp 24	858
GS2	94	Ramp 27	1,664
GS3	82	GR_S126	2,760
GS4A	252	GR_S55	29
GS14	65	GR_S79	165
GS16	547	GR_S8	64
RS1 TSF	7,956	GR_S3	81
RS1N	756	GR_S157	6
RS2	135	GR_S32	25
RS3	44	GR_S150	184
RS5	956	GR_S19	68
RS6	549	GR_S2	189
RS7	24	GR_S4	19
RS10	1,160	GR_S95	110
H13	805	GR_S51	115
SD1	59	GR_S64	6
SD2	34	GR_S151	15
SD3	9	GR_S31	209
SD4	10	GR_S6	54
SD5	32	GR_S87	42
SD6	18	GR_S136	8
SD7	44	GR_S149	49
GS9	110	GR_S153	21
IDC02	330	GR_S154	2
IDC04	732	GR_S155	217

Water Storages	Storage Capacity (ML)	Water Storages	Storage Capacity (ML)
Old Ramp 28	103	GR_S158	266
Ramp 13 Void	4,199	GR_S159	128
Kakadu	6,000	GR_S162	22

5.1.9 Groundwater

Potential groundwater inflows into pits and the undergrounds, and IMG dewatering have been represented in the model. The groundwater rates applied to each system are outlined in **Table 5-11**.

Table 5-11 Groundwater Inflow / Dewatering Rates

System	Rate (ML/day)
Open Cut Pits	0
Broadmeadow Underground	2.4
Red Hill Underground	4.1

5.1.10 Release Conditions

Environmental Authority

GRM operates under EA EPML00853413 (dated 6th September 2013) (previously MIN100921609), which details compliance requirements for the GRB mine complex in relation to discharges of mine water. In relation to water management, this EA permits the release of mine affected water from the GS4A dam into the Isaac River when the following criteria are satisfied:

- Natural flow rate measured at the upstream Isaac River gauging station (upstream of confluence with Goonyella Creek) > 3 cubic metres per second (m^3/s).
- Release criteria under flow conditions:
  - the salinity of mine affected water released from GS4A must not exceed an EC of 10,000 µS/cm; and
  - the salinity in the Isaac River at the downstream release point must not exceed an EC of 2,000 µS/cm.

It is to be noted that the water balance modelling undertaken only estimates the salinity of the system. The EA also refers to the monitoring of the water quality parameters pH, turbidity and sulphates. Whilst salinity is considered the dominant contaminant for modelling purposes, it has been assumed that the GRB mine complex will also monitor these additional parameters in accordance with the existing EA before commencing a release.

Release from GS4A

Releases from the GRB mine complex are simulated to occur when a release is made through the release gate or when the capacity of GS4A of 250 ML is exceeded. The following functionality has been applied to potential sources of inflow into GS4A:

- Ramp 21/22 Release – The release system associated with the Ramp 21/22 storage will be the main release source of mine affected water. Releases from this storage are calculated to ensure that both the quantity and quality of release volumes are in accordance with the requirements of the EA. The release system has a maximum capacity of 6.8 m^3/s (587 ML/day). The release is restricted if the mine water from when the total site water inventory becomes less than 14,000 ML. This condition is aimed at maintaining a minimum inventory of water on site for water supply purposes.
- Storage Overflow – Mine affected water may contribute through uncontrolled overflow to GS4A via the overtopping of the GS3, RS10 and Sediment Dams 1 to 7. The model is set up to identify if these sources result in the exceedence of the prescribed water quality criteria.
- Mine Water Transfers – Mine affected water is directed to GS4A via mine water transfers within the site. Under the Baseline and Project Case scenarios only, dewatering of Ramps 0, 2, 4 and 10 is directed to GS4A.

5.2 Baseline Scenario

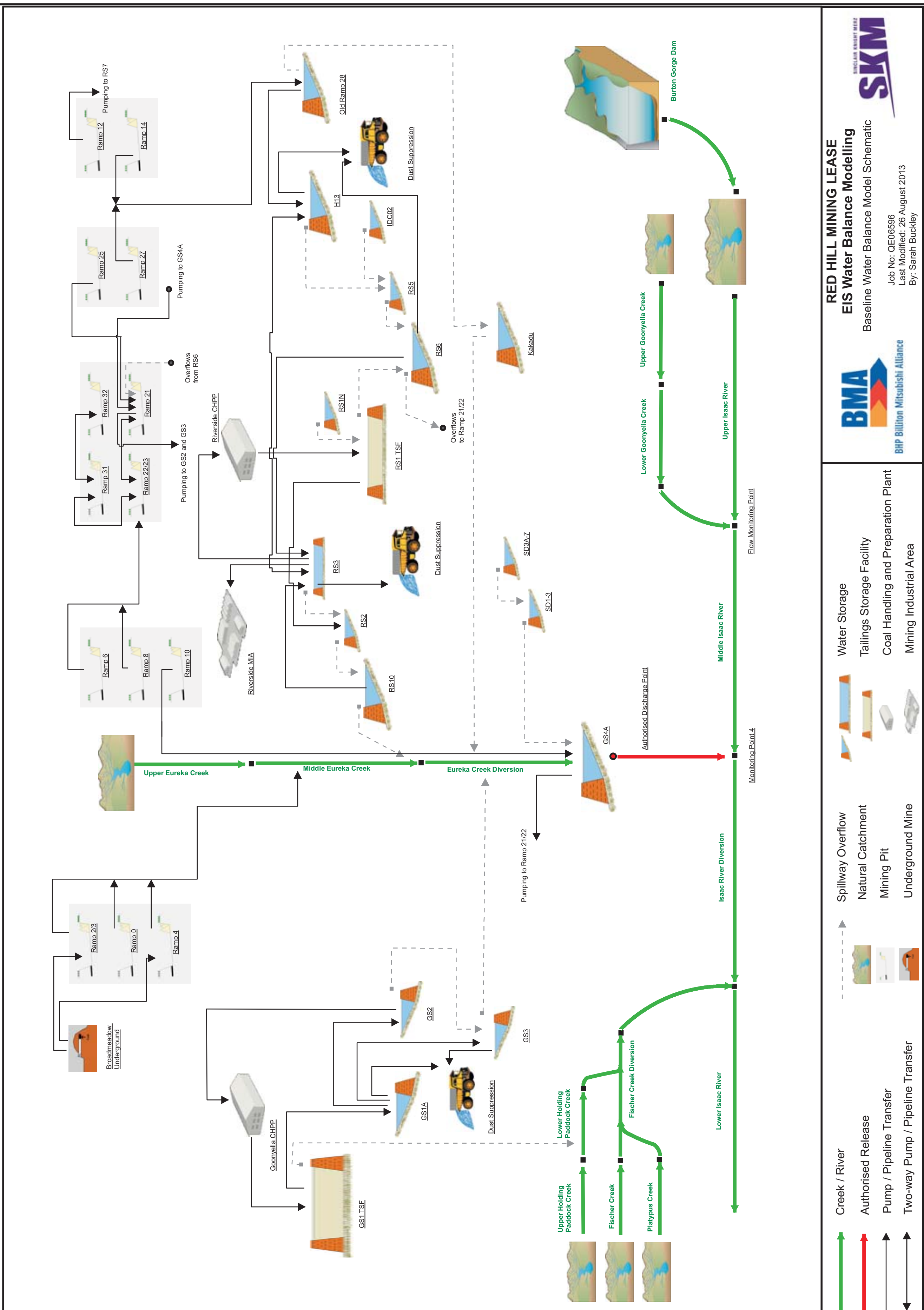
The GoldSim model prepared by Engeny (2013) which is used as the operational water balance model for the GRB mine complex has been used as the basis for modelling undertaken as part of the EIS. To represent the Baseline scenario the following updates have been made as provided by BMA:

- high dump area overflows (sediment dams 1 to 7) to GS4A;
- CHPP tonnages and demands; and
- minimum site water inventory of 14,000 ML.

Outlined below in **Table 5–11** are the operational rules that have been used to represent the Baseline scenario and the water balance model schematic for the Baseline scenario is presented in **Figure 5-3**.

Table 5-12 Operational Rules for Baseline Scenario

Source	Destination	Pump Rate (L/s)
Ramp 0	GS4A	450
Ramp 2 (BRM Sumps)	GS4A	400
Ramp 4 (BRM Sumps)	GS4A	160
Ramp 6	Ramp 21/22	200
Ramp 8	Ramp 21/22	200
Ramp 10 North	RS7	200
Ramp 10 South	GS4A	300
Ramp 12 (North)	Old Ramp 28	200
Ramp 12 (South)	RS7	200
Ramp 14	Old Ramp 28	200
Ramp 24	RS6	160
Ramp 25	Ramp 21/22	200
Ramp 31	Ramp 21/22	100
Ramp 32	Ramp 21/22	200
H13	Truck Fill Points	80
	RS3	160
Old Ramp 28	H13	160
RS1 (TSF Decant)	RS2	150
RS3	Riverside CHPP	100
	H13	110
RS6	Ramp 21 Fill Point	100
RS10	RS3	100
Ramp 21/22	Controlled Release (via GS4a)	6,800
	GS3	160
	GS2	160
GS1A	Ramp 23 Fill Point	80
	GS2	130
	GS3	130
GS2	Goonyella CHPP	100
GS3	Twin Tanks Fill Point	200
GS1 (TSF Decant)	GS1A	150
GS4A	Ramp 21/22	500 L/s – On RL 244.6 – Off RL 244.5 500 L/s – On RL 244.9 – Off RL 244.8 500 L/s – On RL 245.2 – Off RL 245.1 500 L/s – On RL 245.5 – Off RL 245.4



Source: BMA Supplied

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BASELINE WATER BALANCE MODEL

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5.2.1 Baseline GRB Mine Water Management System Performance

The mine water balance model was used to assess the performance of the baseline GRB mine water management system prior to the implementation/operation of the proposed project (**Figure 5–3**). There are two primary performance indicators used to characterise the expected base case water management performance which include:

- compliance of discharge releases (overflows and gate releases) at GS4A with the EA criteria; and
- shortfall of mine water volumes in dry periods (lack of availability of mine water for reuse) to meet the mine water demands (which provides an assessment of required external pipeline raw water supply).

In addition, some secondary performance indicators are used to characterise the mine water management system performance for interest in the effectiveness and capacity of the mine water management system. These include:

- statistics of the total mine water volume (inventory) in the mine water management system which provides an indication of whether the total system storage capacity is sufficient, and how often low priority mine pits will be required for use as contingency mine water storage; and
- annual volumes and frequency of overflows from GS4A into the Isaac River which provides an indication of effectiveness of allowing clean upper Eureka Creek flow to pass through the site.

A detailed description of the baseline mine water balance modelling results for each of these key mine water management performance characteristics is presented in Red Hill Mining Lease EIS Appendix I3.

The results of the baseline mine water balance modelling assessments of the GRB mine water management prior to implementation and operation of the proposed project indicate that, in relation to performance against the requirements of the EA:

- The model predicted no occurrences during the 108 year modelling period when the EC of releases from GS4A exceed the specified 'end of pipe' discharge limit (EC of 10,000 µS/cm).
- The model identified three one-day occurrences, as shown in **Table 5–12** and **Figure 5–4**, during the 108 year modelling period, that the EC of releases from GS4A causes the downstream EA receiving water trigger level of 2,000 µS/cm to be exceeded. These modelled exceedences are a result of flows entering GS4A, from both natural and site catchments, that are in excess of the 2 m^3/s pumping capacity from GS4A, while there is no flow in the Isaac River.

Table 5-13 Baseline Site Release Exceedences

Event	Flow Eureka Creek to GS4A (m3/s)	Site Runoff to GS4A (m3/s)	GS4A Overflow (m3/s)	GS4A Overflow EC (µS/cm)	Receiving Water Flow (m3/s)	Receiving Water EC (µS/cm)
1	0.04	2.8	0.8	2,787	0.8	2,778
2	0.05	2.6	0.3	2,444	0.3	2,443
3	0.06	2.5	0.7	2,901	0.7	2,899

The existing GRB mine complex EA conditions require that the flow rate of releases from GS4A must only occur when the flow in the upper Isaac River is greater than 3 m^3/s or there is a natural flow measured at Eureka Creek at monitoring point 2. **Figure 5–5** shows the modelled GS4A release flow against the modelled upper Isaac River flow. This figure demonstrates that releases under the Baseline scenario are managed appropriately to ensure compliance with the relative flow criteria.

The model identified 14 occurrences, during the 108 year modelling period, of the flow release from GS4A when the flow in the upper Isaac River is less than 3 m^3/s and the release volume is greater that the natural flow recorded at monitoring point 2 on Eureka Creek. There are no active releases made from storages on the site in these events. The modelled exceedences of the flow criteria are a result of variable rainfall in the area. More rainfall has fallen in the Eureka Creek catchment than in the upper Isaac River catchment. The rainfall in the Eureka Creek and site catchments has caused the pumps of GS4A to be overwhelmed and overflow has occurred from GS4A. Although there are 14 modelled occurrences of overflows from GS4A, only three of these modelled overflows result in non-compliance with the current receiving water quality limit.

The model identifies that the predicted peak wet season volumes on site can be accommodated with site storage capacity, including use of low priority pits.

In conclusion, the existing GRB mine water management system capability is sufficient to comply with the EA conditions with a high level of confidence for releases from GS4A. Infrastructure capacity and operations capability is sufficient to comply with the EA conditions for salinity compliance limits applicable in the Isaac River downstream of the mine releases.

Releases from GRB mine complex can only occur when there is sufficient flow in the Isaac River to allow releases without compromising salinity in the receiving water. The modelling indicates that approximately 14 per cent of release opportunities, as shown by flow in the Isaac River, are utilised by the GRB mine complex operations. Hence, it is unlikely that the ability of GRB mine complex to make sufficient releases to manage its onsite water inventory would be adversely affected by other existing or proposed releases upstream.

Existing allocations are sufficient from external water sources to meet shortfalls in site demands. The baseline scenario has sufficient storage capacity (including use of low priority pits for contingency storage) to cater for maximum mine water volumes that could occur (based on climate extremes evident in available historical data).

Figure 5-4 Baseline Scenario Modelled Downstream Isaac Salinity Compliance

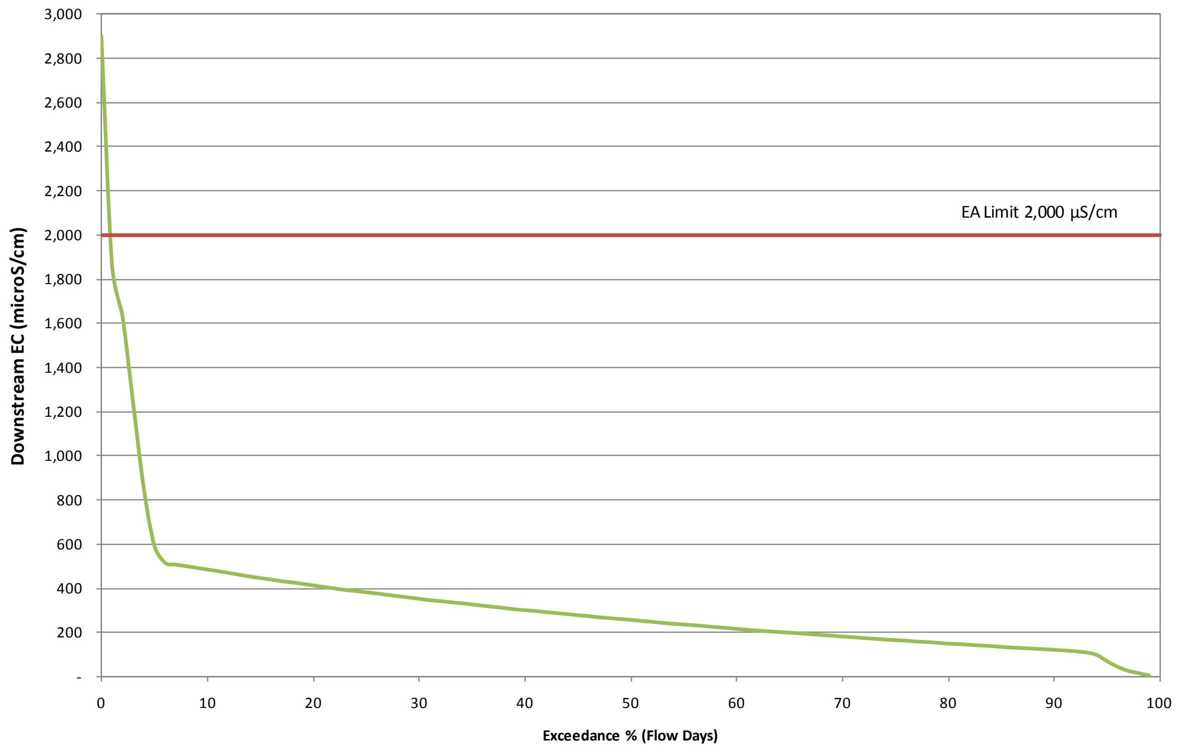
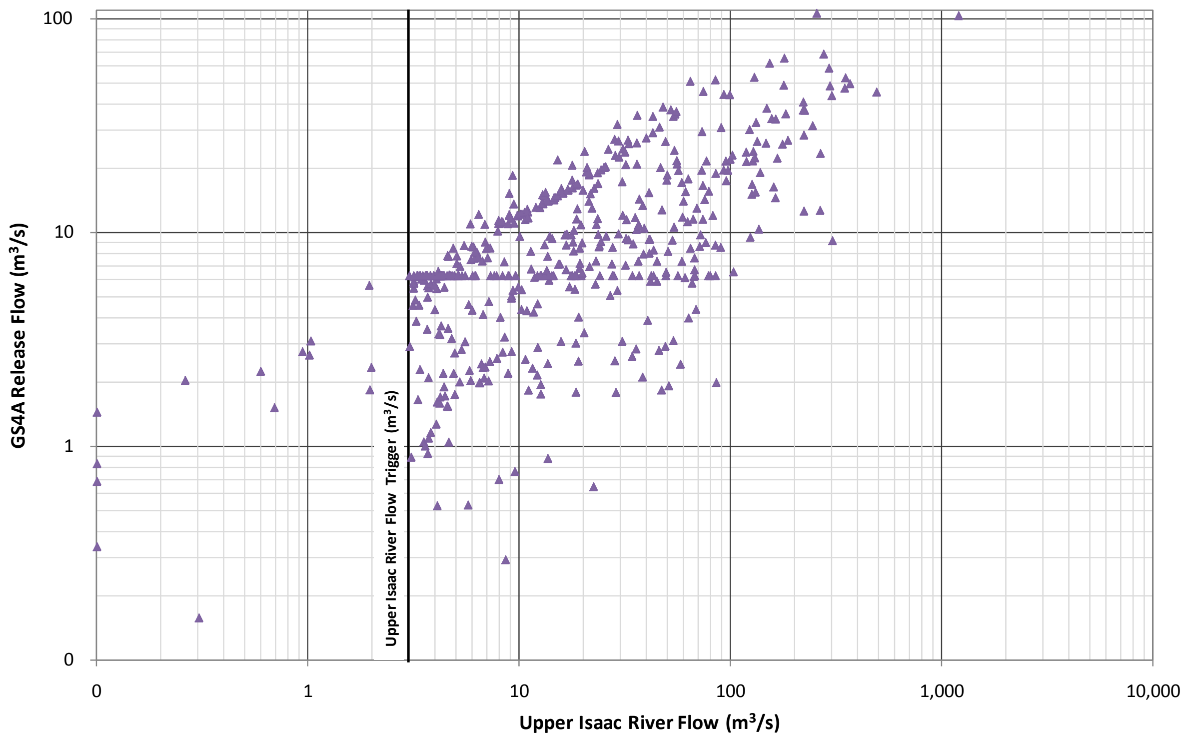


Figure 5-5 Baseline Scenario Modelled Compliance with Flow Trigger



5.3 Project Scenario

Mine water from the RHM will be managed by transferring it to the GRB mine water management system. For the purpose of environmental management responsibilities, this will involve the RHM collecting its mine waters and transferring mine water (and associated general environmental duty of care) to the GRB mine complex operations. Waters will then be managed, reused in coal processing and dust suppression and released in accordance with the existing EA in place for the GRB mine complex.

The RHM will be responsible for the design, construction, maintenance, surveillance, operation, management, and risks of the mine water management infrastructure with the RHM EA area.

The project does not propose any controlled mine water release facilities for the RHM mine water facilities. RHM mine waters will be effectively contained to prescribed containment performance criteria and transferred to the GRB mine water management system. Dams used in the RHM operation, being an MIA dam (nominal capacity 50 ML) and a smaller contingency storage for IMG production water are not expected to be regulated structures, but if a hazard category assessment indicates that these are regulated structures, these will be designed, operated and maintained to the NRM guidelines for regulated dams.

The GRB mine complex will not require new licensed discharge points.

The Red Hill CHPP will be located within the GRB mine complex mine lease and water supply to the Red Hill CHPP will effectively operate as part of the GRB mine water management system.

Detailed descriptions of the project case integrated mine water management system and operations are presented in the EIS. Key information that has guided the assessment and assessment outcomes are presented herein.

The mine waters generated by RHM will be predominantly groundwater from mine dewatering operations, and IMG management. Estimates of the groundwater volumes to be removed over the life of mine are described in **Section 4.4.3**. These estimates have been applied to plan the management of the RHM waters in the GRB mine water management system.

The expected production of groundwater derived mine water for the project are summarised as:

- Longwall mine dewatering and gas dewatering were adopted as 4.1 ML/day and this value has been used as a high estimate for project design.
- IMG drainage waters will vary over the mine life. The current estimates show gas drainage waters being produced up to a maximum rate of 790 ML/year.

A salinity of 7,000 µS/cm was used for mine water from RHM as input into the mine water balance model.

The RHM will also produce a relative minor amount of mine water from surface runoff around the Red Hill MIA. These waters will be contained in a Red Hill MIA mine water dam and pumped into Ramp 21/22 in the GRB mine water management system. The mine water runoff rates and salinity of the Red Hill MIA runoff is expected to be similar to the mine waters generated as surface runoff around the existing Goonyella CHPP and MIA facilities.

The Red Hill CHPP will not produce additional tailings slurry water (mine water) because the plant will recover water from waste products with belt press filters. The Red Hill CHPP will not require additional tailings dams at GRB mine complex for its waste products because waste will be dewatered and disposed into mine spoil. Stormwater runoff from the Red Hill CHPP is not included as the area where the CHPP is to be located is within the existing GRB mine water management area.

The Project Case scenario has been developed to assess any impacts that may result from the inclusion of the proposed RHM within the overall GRB mine water management system. As such, to assess what impacts may result as part of this EIS assessment; the Baseline scenario has formed the basis for this assessment. To represent the Project Case scenario the following updates have been made to the Baseline scenario model (**Figure 5–6**).

- Red Hill underground mine;
- Red Hill CHPP (up to an additional 18 mtpa ROM);
- Red Hill MIA;
- Red Hill 50 ML dam; and
- Excess water from RHM is dewatered to Ramp 21/22 via the Red Hill 50 ML dam.

Outlined below in **Table 5-14** are the operational rules that have been used to represent the Project Case scenario and the water balance model schematic is represented in **Figure 5-6**.

Table 5-14 Changes to Operational Rules for Red Hill Scenario

Source	Destination	Pump Rate (l/s)
RH Dam	Ramp 21/22	150
RH Dam	Red Hill CHPP	50

Project Water Requirements

Water requirements for the operation of the RHM will include raw water sourced from external pipeline raw water supply. The estimated raw water demands include:

- Water treated for potable uses (drinking water, amenities) – and additional 75 ML/year over and above baseline requirements for the existing GRB mine complex operations. Total combined between GRB mine complex and RHM operations will be 255 ML/year.
- Water used in the two new RHM longwall mine – 730 ML/year. Total combined longwall water demand with both GRB mine complex and RHM operations will be 1,095 ML/year.
- Water used in the project's MIA – 70 ML/year.
- Raw water requirements for the Red Hill CHPP, which requires about three per cent of its total water demand to be raw water – 30 ML/year.

The Red Hill CHPP will also require mine water, which will be drawn from the GRB mine water management system. The Red Hill CHPP peak operational water demands (for 14 mtpa maximum project production) that can be sourced from mine water are estimated at 1,300 ML/year.

Project Case Water Management Assessment Modelling

Although the proposed project is expected to have an overall mine water deficit during the majority of operations, there is a potential for the project to generate an average water surplus of approximately 640 ML/year during the latter stages of operations. The results provided below were used to identify whether compliance with EA conditions would be affected by any such water surplus and if any further works would be required in order for the GRB mine water system to manage the potential water surplus generated from RHM.

The project case scenario has been developed to assess any potential impacts, which may result from the inclusion of the proposed RHM within the overall GRB mine water management system under conditions where the project produces a surplus of mine water. As such, to assess what impacts may result as part of this EIS assessment; the baseline scenario has formed the comparative basis for this assessment. To represent the Red Hill scenario the following updates have been made to the baseline scenario model (**Figure 5-6**):

- RHM;
- Red Hill CHPP;
- Red Hill MIA;
- Red Hill MIA dam (nominally 50 ML); and
- excess water from RHM is dewatered to Ramp 21/22 via the Red Hill 50 ML dam.

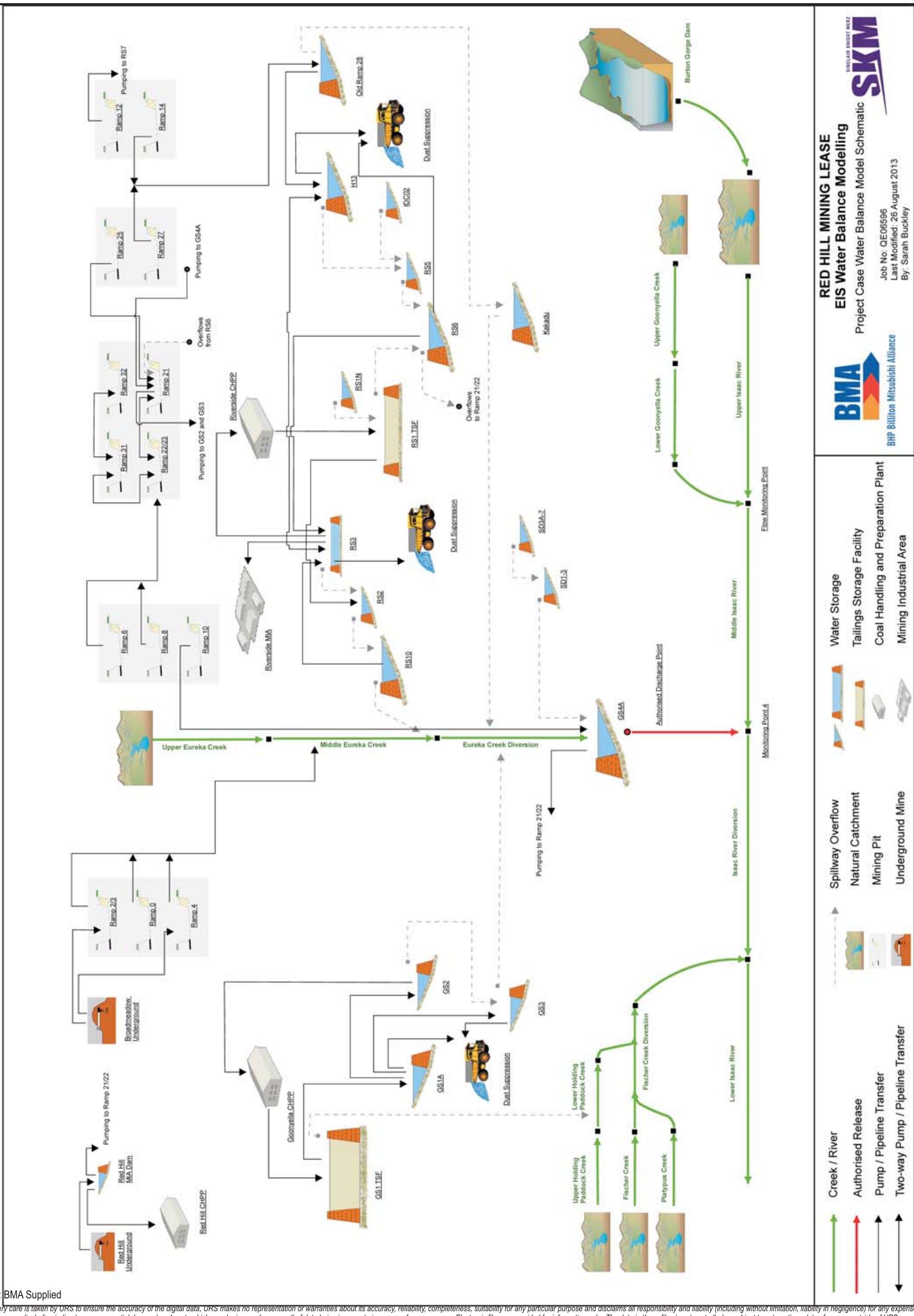
The operating rules for the project case GRB mine water management system were also modified to reflect the upgraded configuration of the system.

For the project case scenario, the EA conditions for releases from the GRB mine water management system were assumed to be the same as the baseline conditions.

Project Case Mine Water Management System Summary

The mine water balance model was used to assess the performance of the project case GRB mine water management system integrated with the RHM operations (**Figure 5–6**). The project case mine water balance modelling assessments of the impacts of a potential RHM surplus on the GRB mine water management system indicate that:

- The project will not adversely impact on the capability of the GRB mine water management system to comply with current EA conditions for release of mine water from GS4A for respective salinity criteria at the end of pipe limit
- The project will not adversely impact on the capability of the GRB mine water management system to comply with the current EA conditions for salinity compliance limits applicable in the Isaac River downstream of the mine releases. Similar to the baseline model, the project model identified three one-day occurrences, during the 108 year modelling period, that the EC of releases from GS4A causes the downstream EA receiving water trigger level of 2,000 µS/cm to be exceeded, as shown in **Figure 5–7** and **Figure 5–8**. These modelled exceedences are a result of flows entering GS4A, from both natural and site catchments, that are in excess of the 2 m^3/s pumping capacity from GS4A, while there is no flow in the Isaac River.



Source: BMA Supplied

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PROJECT CASE WATER BALANCE MODEL

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Figure: **5-6**

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- The project will not adversely impact on the capability of the GRB mine water management system to comply with the current EA conditions for flow release limits applicable in the Isaac River downstream of the mine releases. Similar to the baseline model, the project model identified 14 occurrences, during the 108 year modelling period, of the flow release from GS4A when the flow in the upper Isaac River is less than 3 m^3/s and the release volume is greater that the natural flow recorded at monitoring point 2 on Eureka Creek. There are no active releases made from storages on the site in these events. The modelled exceedences of the flow criteria are a result of variable rainfall in the area. More rainfall has fallen in the Eureka Creek catchment than in the upper Isaac River catchment. The rainfall in the Eureka Creek and site catchments has caused the pumps of GS4A to be overwhelmed and overflow has occurred from GS4A. Although there are 14 modelled occurrences of overflows from GS4A, only three of these modelled overflows result in non-compliance with the receiving water quality limit.
- There will not be a significant impact on the requirements for external water supply.
- The GRB mine water management system will have sufficient storage capacity (including use of low priority pits for contingency storage) to cater for maximum mine water volumes from the combined GRB mine complex and proposed project operations that could occur, based on climate extremes evident in available historical data.

Figure 5-7 Project Case Scenario Modelled Downstream Isaac Salinity Compliance

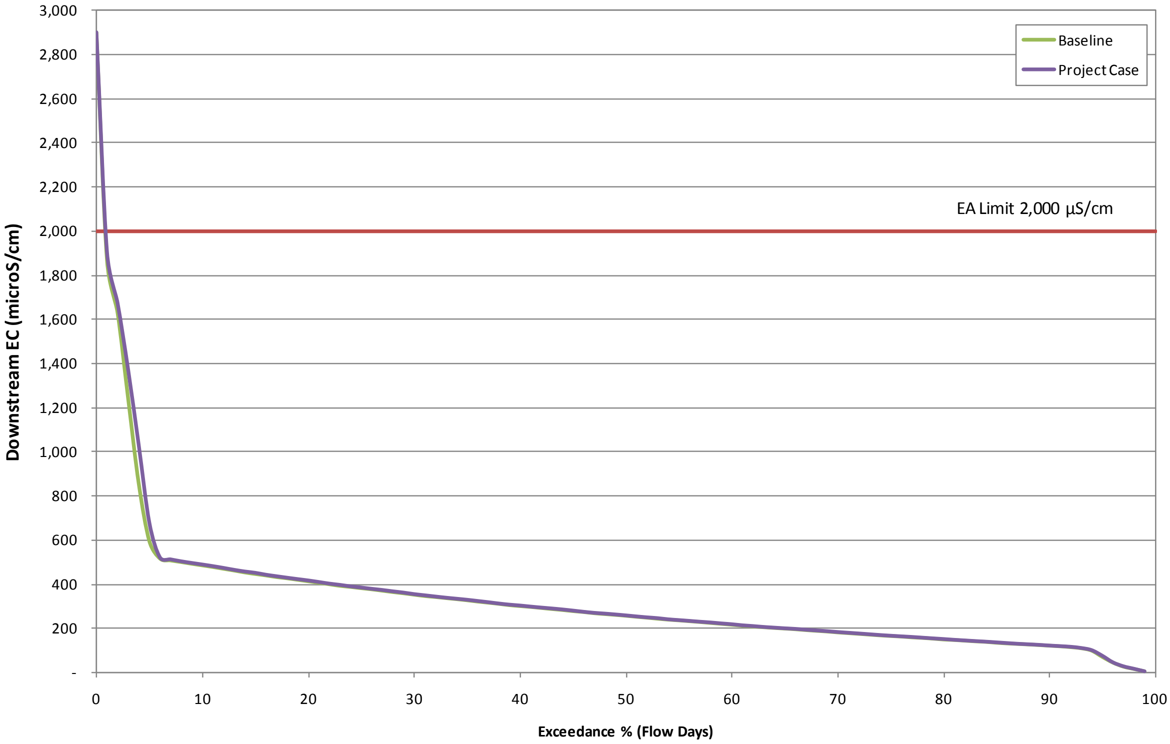
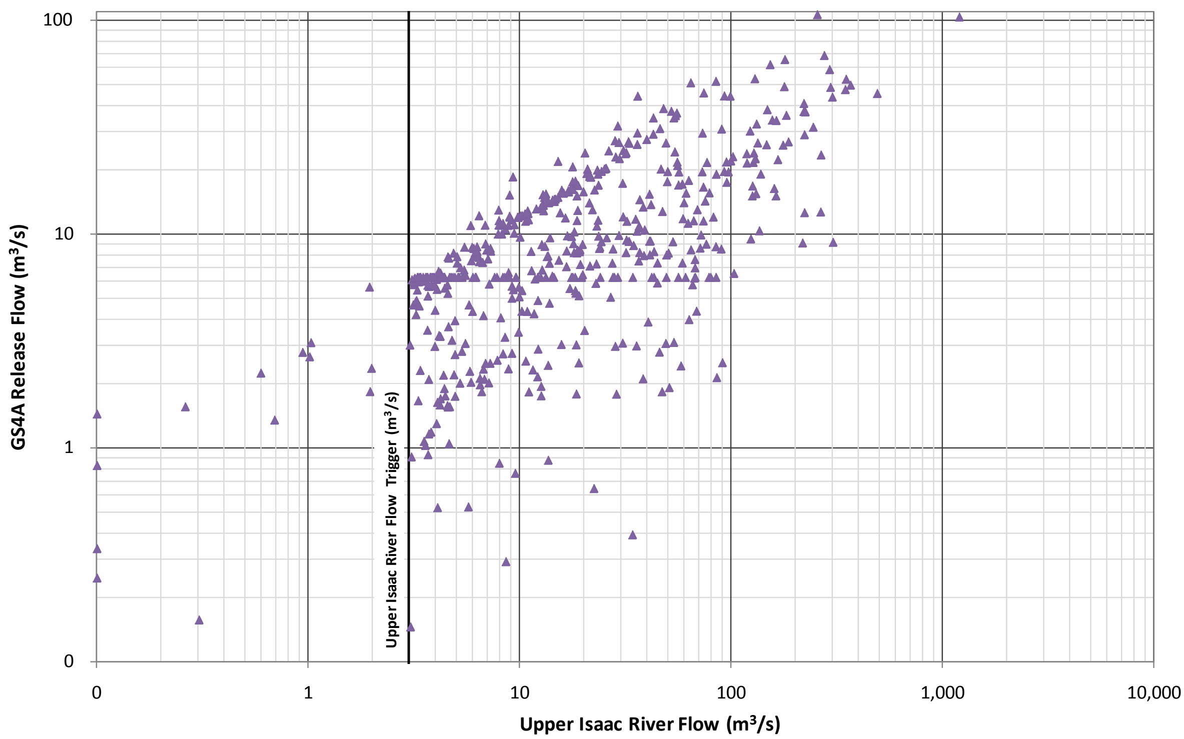


Figure 5-8 Project Case Scenario Modelled Compliance with Flow Trigger



5.4 Data Uncertainties

Several important limitations of the water balance model are important to note for evaluation of the model results.

The water balance model does not include any allowance for seepage or transmission loss from dams and open channel drains. This assumption will tend to overestimate mine water volumes in the mine water management system and potential salt loads. This is conservative from the perspective of assessing containment performance and release compliance, and also risks of prolonged water accumulation in the open cut mine pits. This assumption is not conservative for assessing the availability of mine water to be reused in mine operations.

The model does not include representation of any other mines discharging waters into the Isaac River or other creeks represented in the model catchments. The potential releases from the existing Goonyella North Mine (Peabody operation north of the GRB mine complex) cannot be represented because details of releases from this mine are not known to BMA.

The mine water balance model simulations are undertaken for a static configuration of the mine representative of a given point in time, which for the purposes of the project mine water balance assessment and baseline is nominally 2015. The simulation periods are performed with the complete 108 years of climate data (to test extremes of climate influence) and time series results are produced for water volumes (or flows in waterways) and salinity for every part of the model.

Section 06 Potential Impacts of Development on Water Resources

The impacts on water resources from the development, operation, closure and post-closure of the project have been evaluated.

6.1 Potential Groundwater Impacts during Development and Operation

Potential impact of the RHM on the regional groundwater regime was assessed using predictive groundwater modelling. The groundwater model was developed to estimate groundwater extraction (passive seepage and active dewatering for gas control) over the mine life, project drawdown in aquifers, evaluate the zone of influence and direct and indirect impacts of dewatering, and evaluate the possible impact on other groundwater users. The groundwater model was constructed using the geological model, hydraulic parameters determined on site and from literature, and groundwater level information within the survey area.

Mining within the GRB mine complex area commenced after the granting of the original Goonyella mining lease (ML1763) in 1971 and the Riverside mining lease (ML1764) in 1978. While the main aquifers within the area are the coal seams, groundwater inflow from the exposed seams to the current GRM pit voids have not been significant. Dewatering of groundwater in advance of mining is generally not required for the current open pit or underground workings.

The Goonyella North mine is located along the strike of the Moranbah Coal Measures immediately north of the study area, with the Moranbah North mine located immediately south. Given the close proximity of these coal mines, this assessment considers the additional and, where possible, the cumulative impact of the project on the current (mine influenced) groundwater resources in the groundwater survey area.

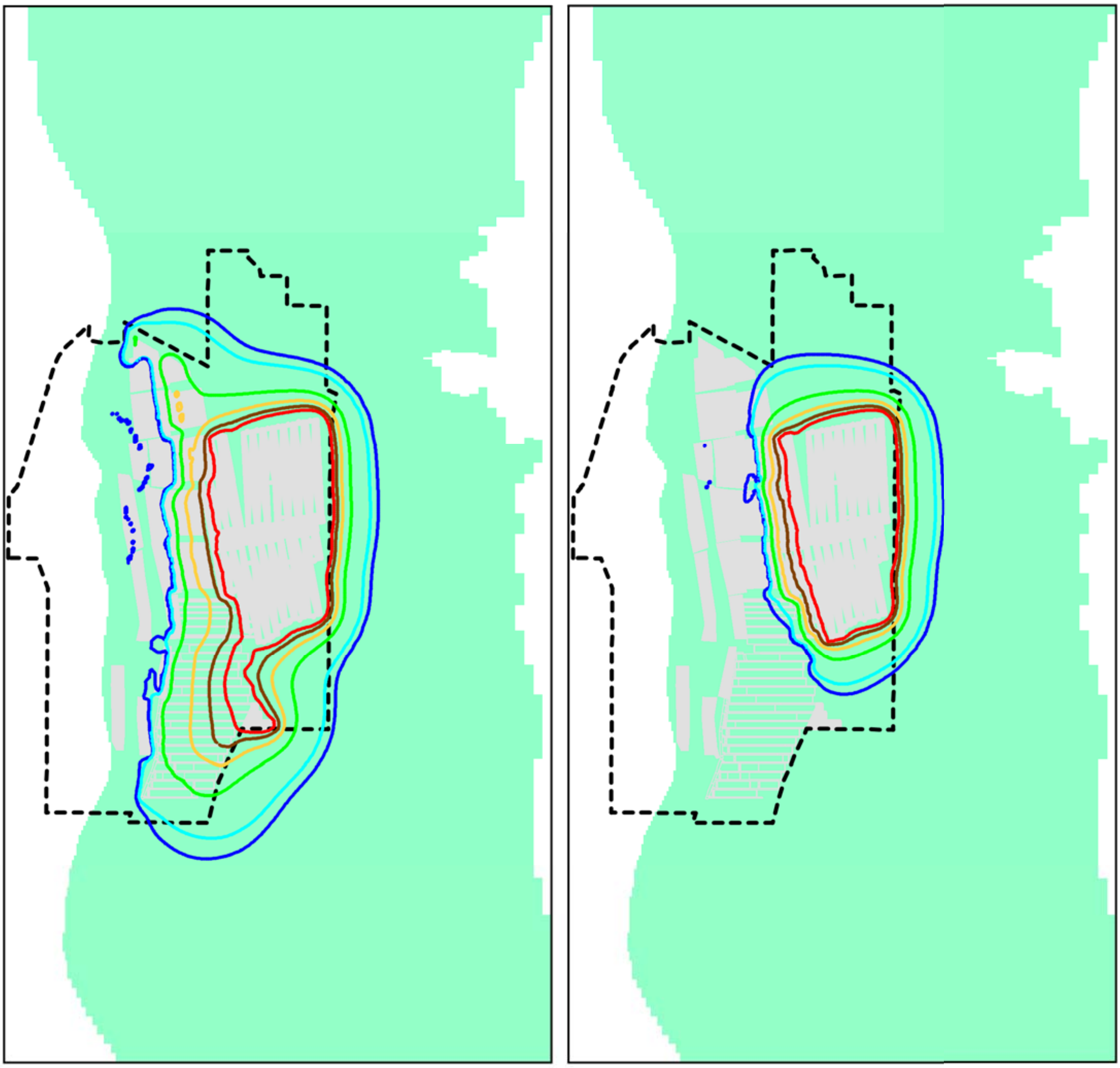
6.1.1 Impacts on Water Levels

The project is within the declared Isaac Connors GMA; however, there are few groundwater users locally. During the life of mine, groundwater inflow from the aquifers to the underground mine workings or extraction as part of gas depressurisation will lead to increased drawdown of the potentiometric surface in the vicinity of the mine workings when compared to drawdown from the existing approved coal mines in the area.

6.1.2 Impacts on Permian Formation Aquifers

Dewatering resulting from IMG drainage and groundwater ingress into the mine workings will cause drawdown of groundwater levels as depicted in **Figure 6–1** and **Figure 6–2**. Resultant variations in the current groundwater levels, which have already been altered due to existing mine dewatering, were predicted.

Groundwater modelling was used to project drawdown caused by dewatering and IMG drainage of the proposed RHM. Predictive modelling indicates that drawdown of five metres (from pre-RHM mining levels) will occur to a distance of up to four kilometres from the proposed RHM footprint. The drawdown predictions were simulated for the target GMS, allowing for the prediction of the largest zone of influence at the end of mining.



Drawdown modelled for Goonyella Riverside, Broadmeadow and proposed Red Hill Mine

Drawdown as a result of proposed Red Hill Mine

Drawdown (m)

(blue line)	5
(cyan line)	10
(green line)	50
(yellow line)	100
(brown line)	150
(red line)	200

Note: This figure shows the 2011 mine plan used for surface and groundwater modelling.

N W E S

0 3.75 7.5km

Scale

EIS Study Boundary

Open-Cut and Underground Mining Operations

Model Extent

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MODELLED DRAWDOWN IN GMS 2040

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Figure: **6-1**

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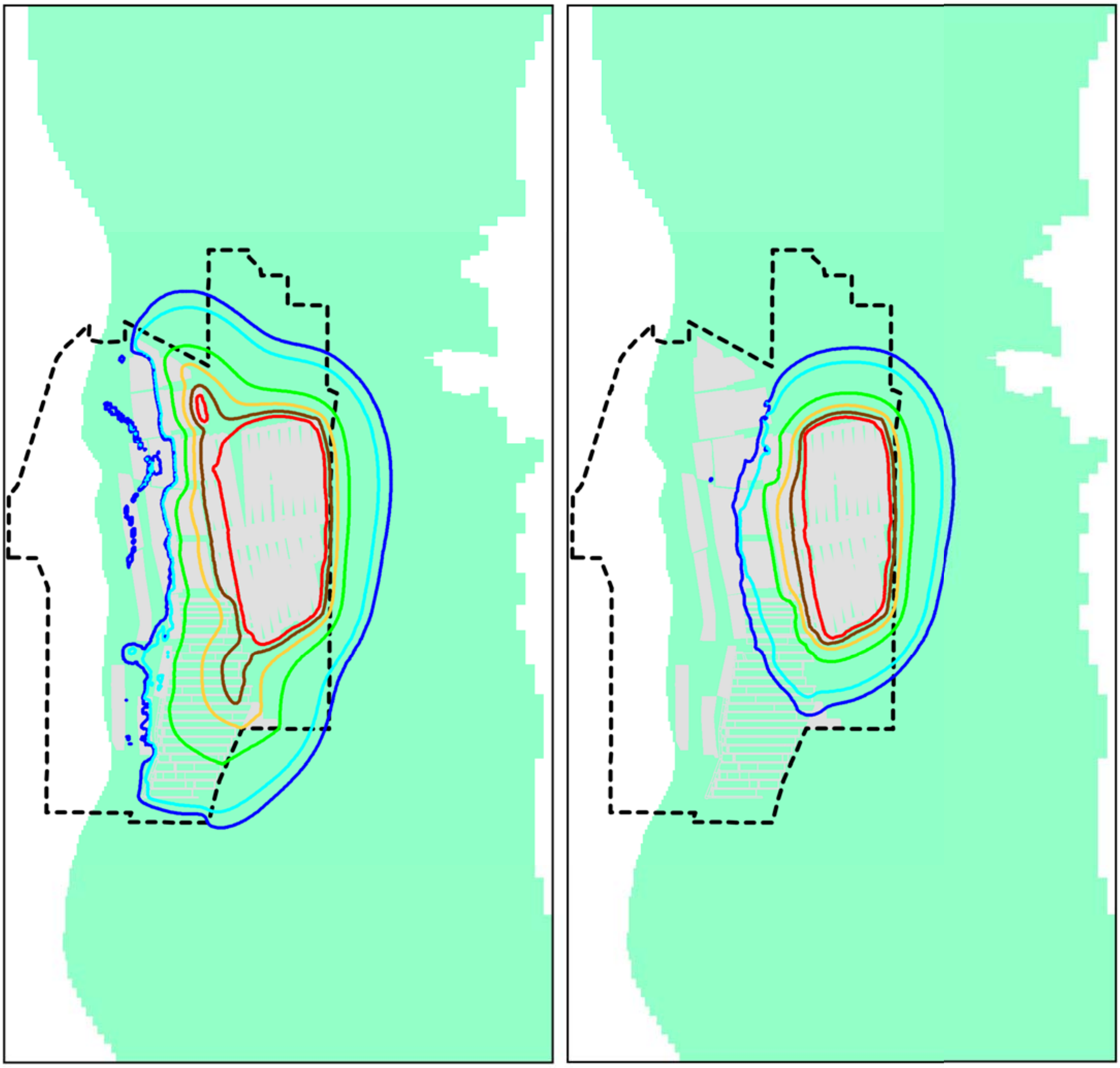
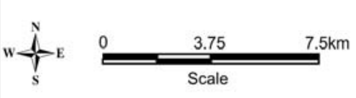


Drawdown modelled for Goonyella Riverside, Broadmeadow and proposed Red Hill Mine

Drawdown as a result of proposed Red Hill Mine



Note: This figure shows the 2011 mine plan used for surface and groundwater modelling.

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MODELLED DRAWDOWN IN GMS END 2068

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Figure: **6-2**

File No: **42627136-g-2240.wor** Drawn: **VH** Approved: **CT** Date: **08-10-2013** Rev.**A** A4

Groundwater drawdown will also occur in the units above the GMS due to induced flow towards the depressurised coal seam and the impact of the goaf resulting in increasing vertical permeability. The extent and degree of drawdown within these overlying units, decreases with increasing distance above the dewatered seams.

The North Goonyella and Moranbah North mines are located along strike and also target the Moranbah Coal Measures to the north and south of RHM, respectively. The cumulative impact of these mines will be to superimpose the drawdown of each mine such that the Moranbah Coal Measures between the mines will be significantly dewatered. No groundwater users were identified between the mines.

Drawdown in bores of five metres or more is considered, in fractured rock aquifers, to have a material impact on bore yield. There are no identified groundwater supply bores within the predicted five metre drawdown zone. Thus, no 'at risk' bores have been identified.

Two production bores (Skeleton Bore (NRM Registration 81696), and Cleanskin Gully Bore), on the 'Broadmeadow' property are located outside the predicted five metre drawdown contours as shown **Figure 4–3**. While it is expected that users of these two bores will still have access to groundwater and not realise a marked change in supply it is recommended that monitoring be conducted to validate predictions.

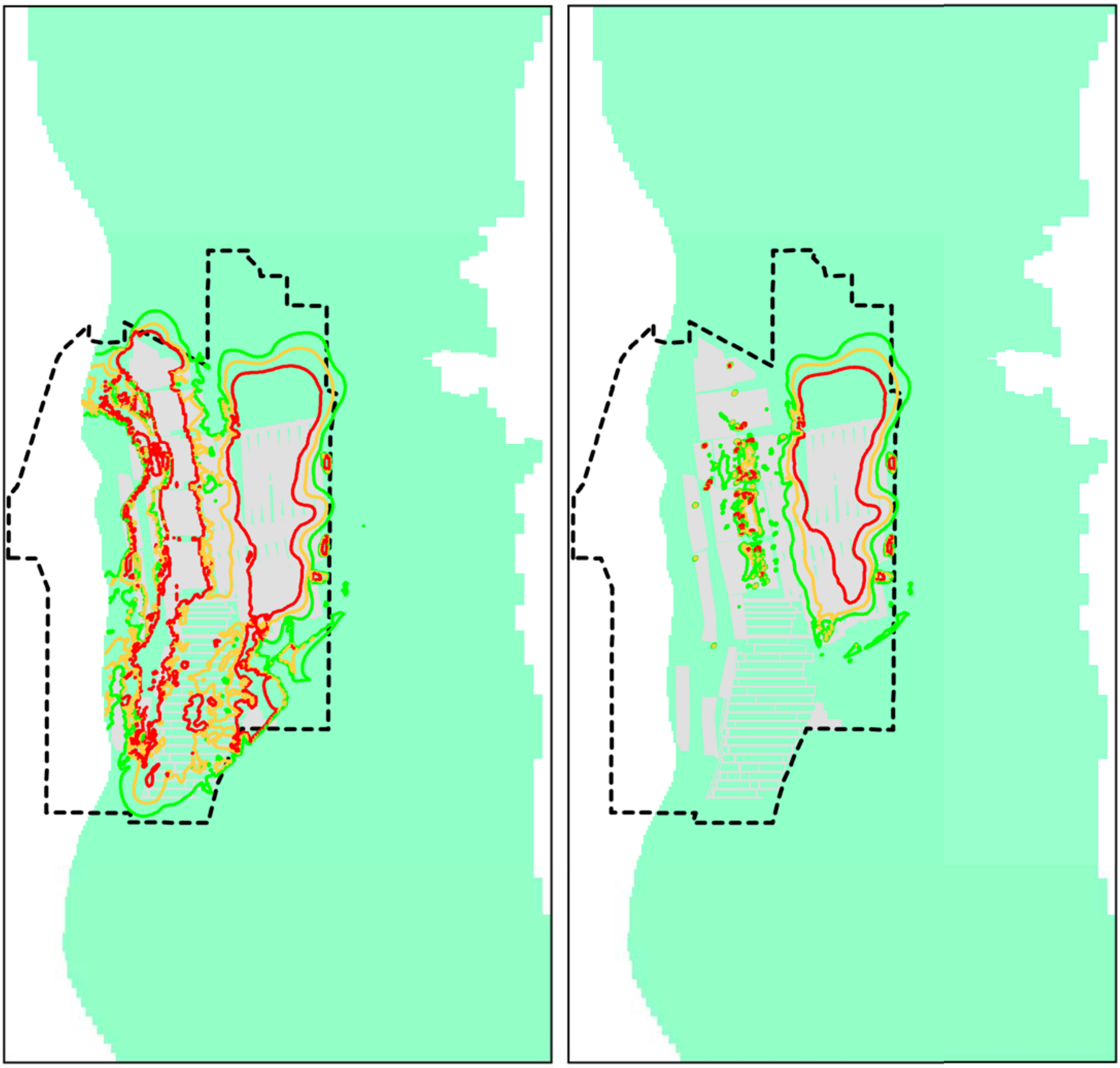
Additional bores that may potentially be affected by mine dewatering and IMG drainage are the CSG bores themselves. These bores are, however, designed to remove groundwater to allow gas extraction and, hence, mine-induced drawdown should not cause any impacts on these bores.

6.1.3 Impacts on Quaternary and Tertiary Units

Where excavations required for the surface infrastructure and mine access portals encounter Quaternary alluvium near creeks or the Isaac River and/or Tertiary sediments, groundwater inflow may occur (i.e. direct drainage impacts). The aquifers in these units are typically ephemeral and are not considered significant aquifers. Due to the expected low hydraulic gradients (one to two metres) and low conductivity, the drawdown zone of influence, as a result of the direct impacts, is considered to only extend some 10 to 100 metres around excavations. This area around the excavations will remain dewatered, as recognised in the GRB mine complex open-cut pits, as evaporation exceeds recharge.

The Quaternary alluvium associated with the Isaac River is considered, based on permeability and water quality, to be the most significant aquifer within the survey area. However, is unlikely to be significantly impacted by groundwater drawdown as there are no major excavations to take place in close proximity to the Isaac River and limited hydraulic connection between the perched water tables in the alluvium and the confined coal seam aquifers (which will be depressurised and dewatered).

Although the numerical model indicates the potential for drawdown of over two metres in the Tertiary/Quaternary units (together referred to as Cainozoic units) (as shown in **Figure 6–3** and **Figure 6–4**), this is not considered to occur in reality due to the ephemeral nature of the Cainozoic units. The model simulations assume fully saturated conditions in the Tertiary sediments and Quaternary alluvium and that these units are in hydraulic connection with the underlying confined aquifers. In reality, due to the short periods over which the aquifers are actually saturated, drawdown due to mining will be much less than predicted.



Drawdown modelled for Goonyella Riverside, Broadmeadow and proposed Red Hill Mine

Drawdown as a result of proposed Red Hill Mine

Note: This figure shows the 2011 mine plan used for surface and groundwater modelling.

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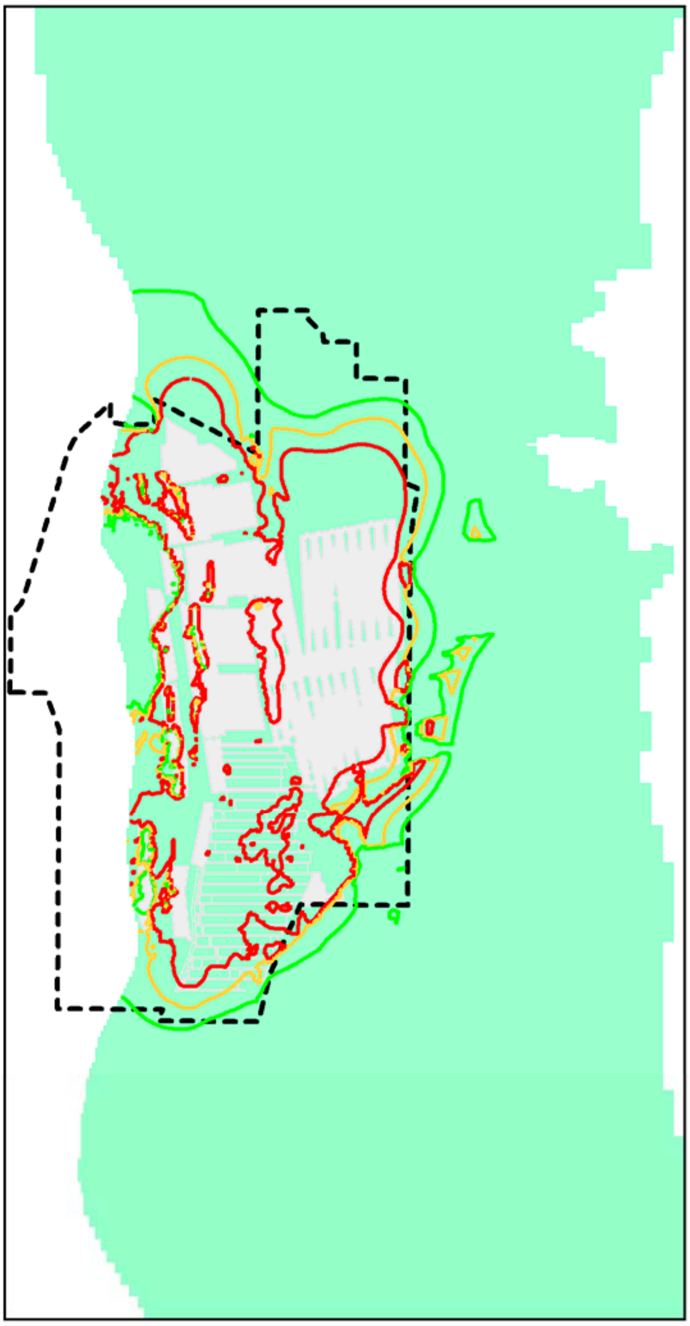
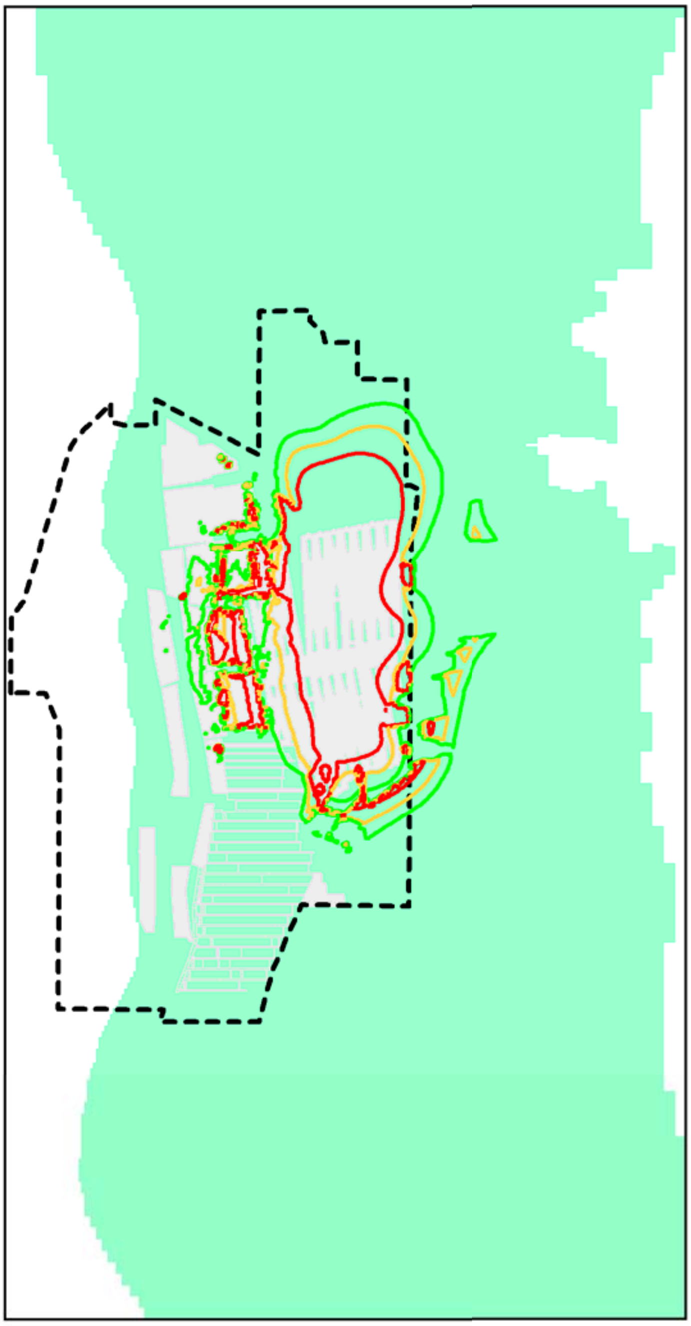
MODELLED GROUNDWATER DRAWDOWN IN CAINOZOIC UNITS - 2040



Drawdown modelled for Goonyella Riverside, Broadmeadow and proposed Red Hill Mine



Drawdown as a result of proposed Red Hill Mine

Note: This figure shows the 2011 mine plan used for surface and groundwater modelling.

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MODELLED GROUNDWATER DRAWDOWN IN CAINOZOIC UNITS - 2068

Subsidence is predicted to create cracking at surface (IMC 2011). The clay-rich nature of the Tertiary sediments, Quaternary alluvium, and weathered Permian will, however, self-heal. This will reduce the potential of leakage from surface to the mine workings. Observations at the adjacent Broadmeadow Mine appear to confirm this.

All creeks and the Isaac River within the study area are ephemeral and there are no perennial water holes or groundwater dependant ecosystems present, as discussed in **Section 4.3**; on this basis, impacts on groundwater dependent ecosystems are not expected.

IMG drainage activities are not expected to impact on the Tertiary or Quaternary aquifers as the bores will be sealed where they intersect these aquifers.

6.1.4 Impacts on Groundwater Quality

The groundwater quality of the Permian strata is brackish to saline and not suitable for human consumption or irrigation, but has some use for stock water according to the limits set in the Australian Drinking Water Guidelines (2004) and ANZECC (2000) water quality guidelines.

During mining operations, groundwater quality within aquifers surrounding the site is not expected to change from pre-mining conditions. This would be a result of all RHM water and waste storage facilities infrastructure being designed, constructed, and managed to ensure little or no potential of seepage. In the event that groundwater contamination did occur contaminant migration off site in the groundwater will not occur. Any potential contaminant plumes would not leave site in the groundwater as during degassing and mining operations, groundwater will be continually extracted from bores or sumps in the underground workings to ensure a safe working environment. This abstraction of groundwater will create a depression in the potentiometric surface around the workings such that the net movement of groundwater is towards the workings during mine operation. This drawdown and alteration in groundwater flow effectively limits the potential for contaminant plumes to migrate off site via groundwater.

Groundwater quality away from the influence of the project will not deteriorate as these resources will continue to receive recharge via the same processes that occurred pre-mining.

Groundwater quality data (with respect to major anions and cations and dissolved metals) indicate that groundwater in the alluvial aquifers and basalt is of similar or better quality when compared to the coal seam aquifers of the Moranbah Coal Measures. Hence, any inadvertent mixing of groundwater during and post mining by induced downward movement from the upper to lower aquifers is unlikely to result in a deterioration of groundwater quality in the Permian aquifers.

Another potential source of contamination for groundwater is through contact with mine waste materials which may be acid forming or leach salt or metal contaminants to groundwater. The geochemical assessment of the coal and mine wastes (waste rock and tailing) undertaken indicates that overburden excavated for mine access and reject generated by the proposed mining and coal processing operation is predominantly geochemically benign and is expected to generate seepage and surface run-off with slightly alkaline pH and low-to-moderate salinity following surface exposure. Overburden and reject materials are unlikely to generate acid given the lack of oxidisable sulphur content, excess acid neutralising capacity and existing alkaline pH of these materials.

The expected water quality of overburden and coal reject materials (runoff and seepage) and the water quality of the coal seam aquifers indicate that groundwater seeping into the underground mine will require dilution or treatment to reduce the salinity prior to reuse. The acid-base classification of coal samples found that most coal samples were potentially acid forming, although the potential for acidification of groundwater in contact with exposed coal seams is expected to be relatively low. This is due to the low sulphur concentration of coal and the significantly greater proportion of pH-neutral material and in the roof and floor of the underground mine compared to coal.

The waste rock dumps, waste placement areas, CHPP and coal stockpiles are located over the relatively saline aquifers of the Permian formations (Moranbah Coal Measures or Back Creek Group), not the fresh water aquifers of the Isaac River Quaternary alluvium or Tertiary sediments. Thus, any potential seepage or runoff is unlikely to result in a marked alteration to groundwater quality of the underlying Permian formations.

The quality of the groundwater in the shallow Quaternary alluvium or Tertiary sediments (Cainozoic) groundwater resources that may exist within the project footprint have the potential to be impacted by spills or seepage from the MIA and waste disposal and fuel storage areas where these are in sufficient quantities to leach through soils to groundwater. Any spills from these areas are typically localised and not regionally significant in terms of groundwater impacts. The risk of groundwater contamination from chemical or fuel storage will be minimised by storage and handling of fuels, oils and other chemicals in accordance with Australian standards and requirements of Material Safety Data Sheets. The design of storage and handling facilities will provide full containment, and procedures for immediate clean-up of spills will be available. These measures are standard practice or a legislated requirement at mine sites. Areas of hydrocarbon and chemical storage will have spill control measures in place and a regular inspection regime will be required in order to monitor activities that could potentially lead to contamination of groundwater.

During mine operation, groundwater quality within aquifers surrounding the mine areas will continue to be suitable for the same purposes applicable during the pre-mining period. The groundwater quality within the aquifers surrounding the study area will be monitored to ensure no marked deterioration in groundwater is occurring as a result of the proposed mining activities.

6.1.5 Subsidence-related Impacts

Underground mining using the thick seam mining method (longwall top coal caving) will result in subsidence of the overlying strata in the mined-out areas behind the longwall, with fracturing extending from the extraction horizon toward the surface. This caving and subsidence can cause fractures and joints in the overlying strata. AGE (2002) state that following the passage of longwall panels and stabilisation of subsidence, fracturing in the bulk of the strata will generally close up, allowing strata permeability to return to near to the pre-mining levels. Within the tensile zone above and adjacent to the longwall panels the vertical and horizontal strata permeability will be markedly and permanently altered due to sub-surface fracturing. The vertical extent of these fractures is dependent on numerous factors, such as mine design, geological conditions, surface topography, and the distance between the mine workings and the ground surface and in the RHM is predicted to extend up to 10 metres above the mine workings (IMC 2011).

With the proposed project mine plan, eight longwall panels are planned to subside the Isaac River over the 20 to 25 year life of mine. Conservative estimates for subsidence are that a maximum vertical subsidence expressed at the surface will be five to six metres which will produce troughs within the river channel creating an estimated total void of 1,309,000 cubic metres. The subsidence troughs vary in length depending on the orientation of the longwall panel to the river channel; however, each is separated by pillars.

During flow events, a depositional environment is created through the subsidence troughs while an increase in velocity, shear stress and stream power is predicted wherever there is a localised increase in the gradient of the flow surface profile such as what happens when the river crosses over the remnant sections of channel that remain raised (pillar zones, main headings, immediately upstream and downstream of mine plan).

These changes in hydraulic energy conditions cause bed instability by deepening of the mobile sand bed over the pillar zones and at the upstream limit of subsidence. Deepening has also been observed to occur downstream of subsidence due to interruptions to transport of bed load sediments. The negative impact associated with deepening is bank instability as initial deepening will expose the un-vegetated toe of the riverbank and reduce support for the bank. Lateral migration may also occur where riverbanks are less resistant to erosion than the riverbed. However, for the reach of the Isaac River through the study area, bank erosion is likely to be localised, temporary and managed by engineering techniques such as timber pile fields and enhancing riparian vegetation coverage (these are currently employed effectively on site).

Sediment supply, transport and budget yield are all considered in assessing the likely geomorphic response of the river during operations and afterward. An assessment of the likelihood and timing of sediment transport into the project reach showed that the sediment supply will overwhelm the subsidence voids as summarised in **Figure 6-5**. This shows that the mine plan produces an equivalent average depth of 3.1 metres over the RHM longwalls (termed strip depth). This happens relatively quickly, most in the first 10 years of mine life and all within 15 years of commencement. Based on the flow regime of the Isaac River it has been estimated that the river will infill this strip depth within 40 years, given continuing oversupply of sediment to the system. There is only a 35 per cent chance of this occurring during the 15 years of mining that subsides the river.

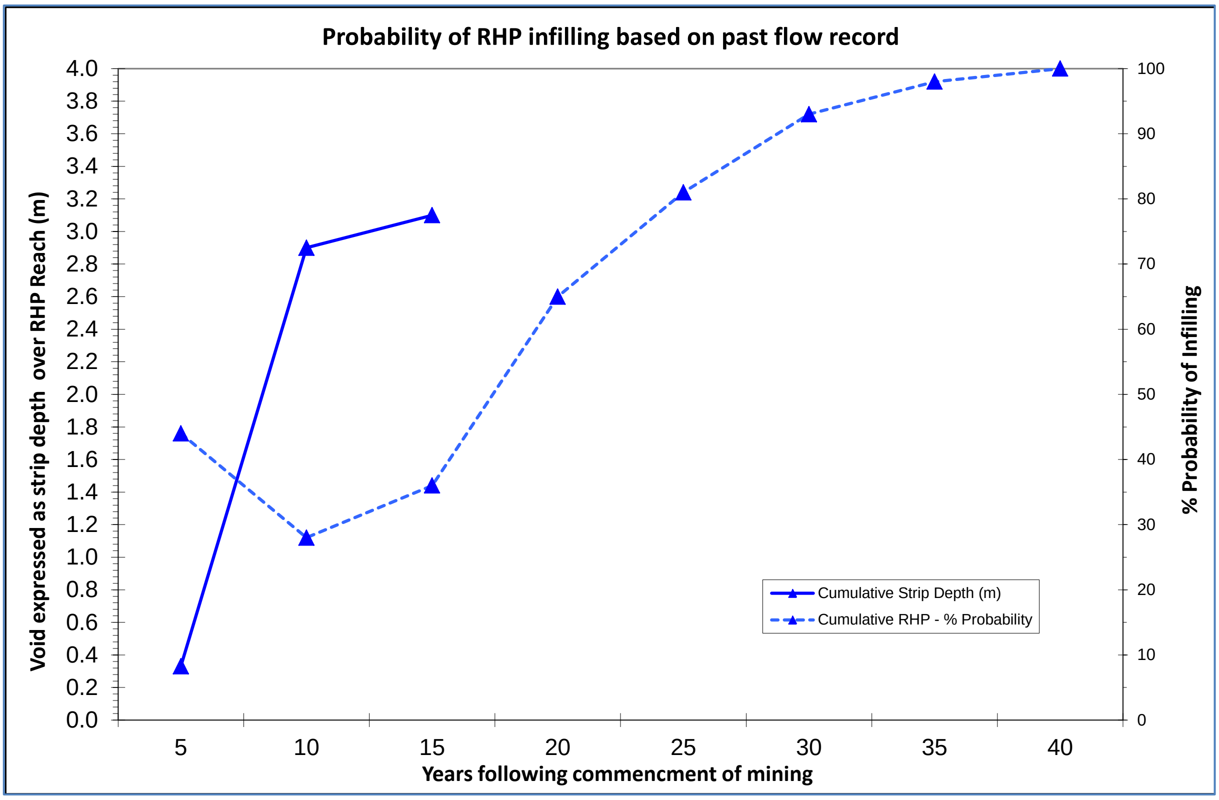
The implications of this are that there will be a period of up to 40 years where there is increased risk of bank erosion over pillar zones, the main headings and downstream of the mine plan. There is also increased possibility of maintaining surface water pools in the river over that time which has impacts, positive and negative, on other aquatic ecology and flow regime related environmental aspects.

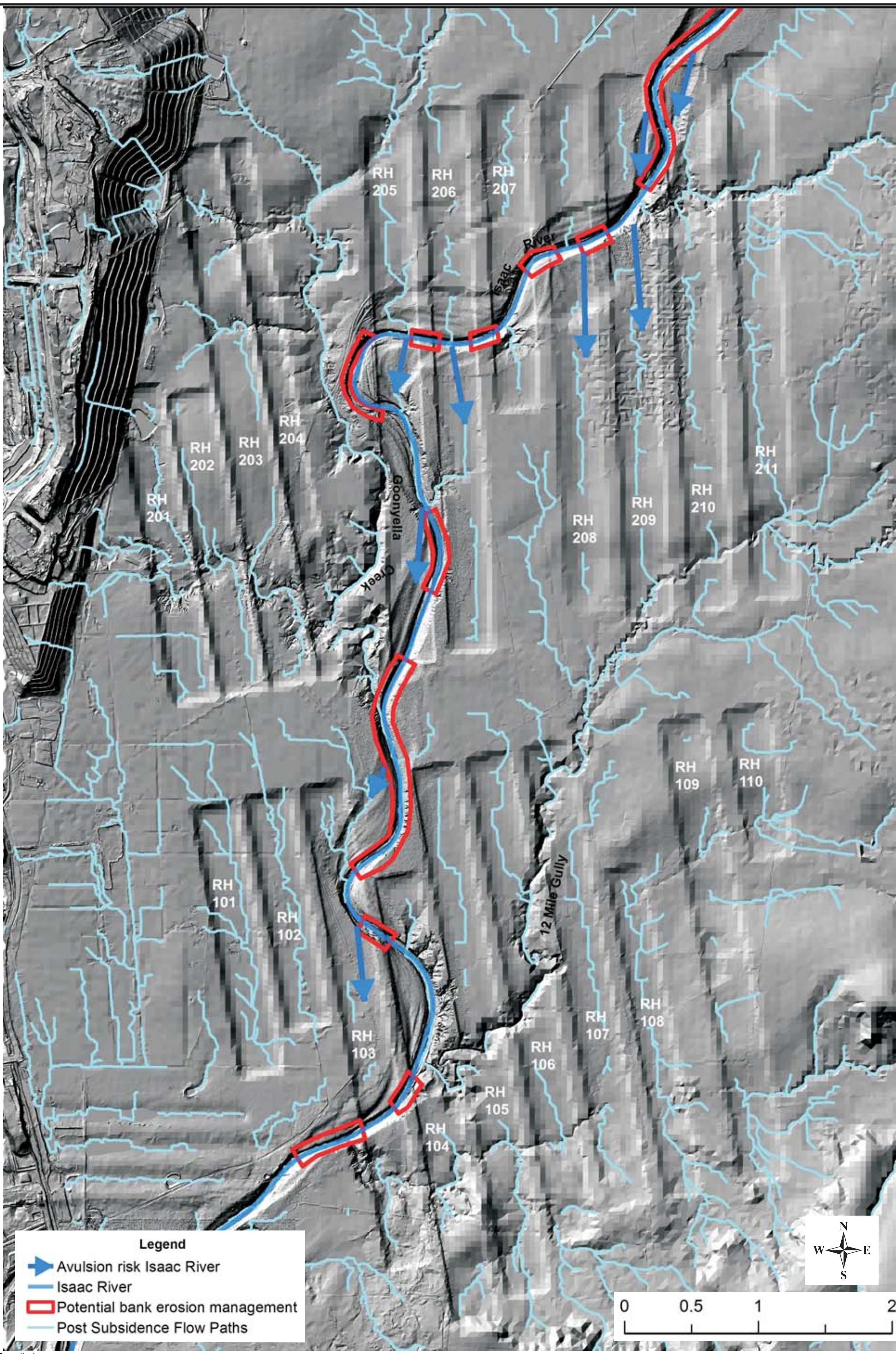
The depth of subsidence of the proposed mine plan of up to six metres increases the likelihood of channel avulsions for the Isaac River. Avulsions are where the river channel finds a new path due to a change in conditions and usually during a flood or a series of floods. There is one location where an avulsion (meander cut-off in this instance) is almost certain based on the mine plan and subsided topography (refer to **Figure 6-6**). This is at the upstream interception of RH205 panel by the Isaac River as it will be engaged in most flow events through sparsely vegetated sandy alluvium. Many other potential avulsion paths exist, however these are only engaged by rare and extreme flood events (some greater than 1 in 50 year annual exceedence probability (AEP), others greater than 1 in 500 year AEP), hence their likelihood of occurrence is low.

A summary of the geomorphic response of the Isaac River, potential impacts and mitigation options recommended for project is provided in **Table 6–1**.

It is noted that should the subsidence be less than predicted that the geomorphic response processes are unlikely to change. It will be the magnitude and duration of those processes that will change.

Figure 6-5 Response to Subsidence and Timeframe to infilling by Sand Supplied from Upstream





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POTENTIAL AREAS OF INSTABILITY AND ACCELERATED EROSION FOR ISAAC RIVER

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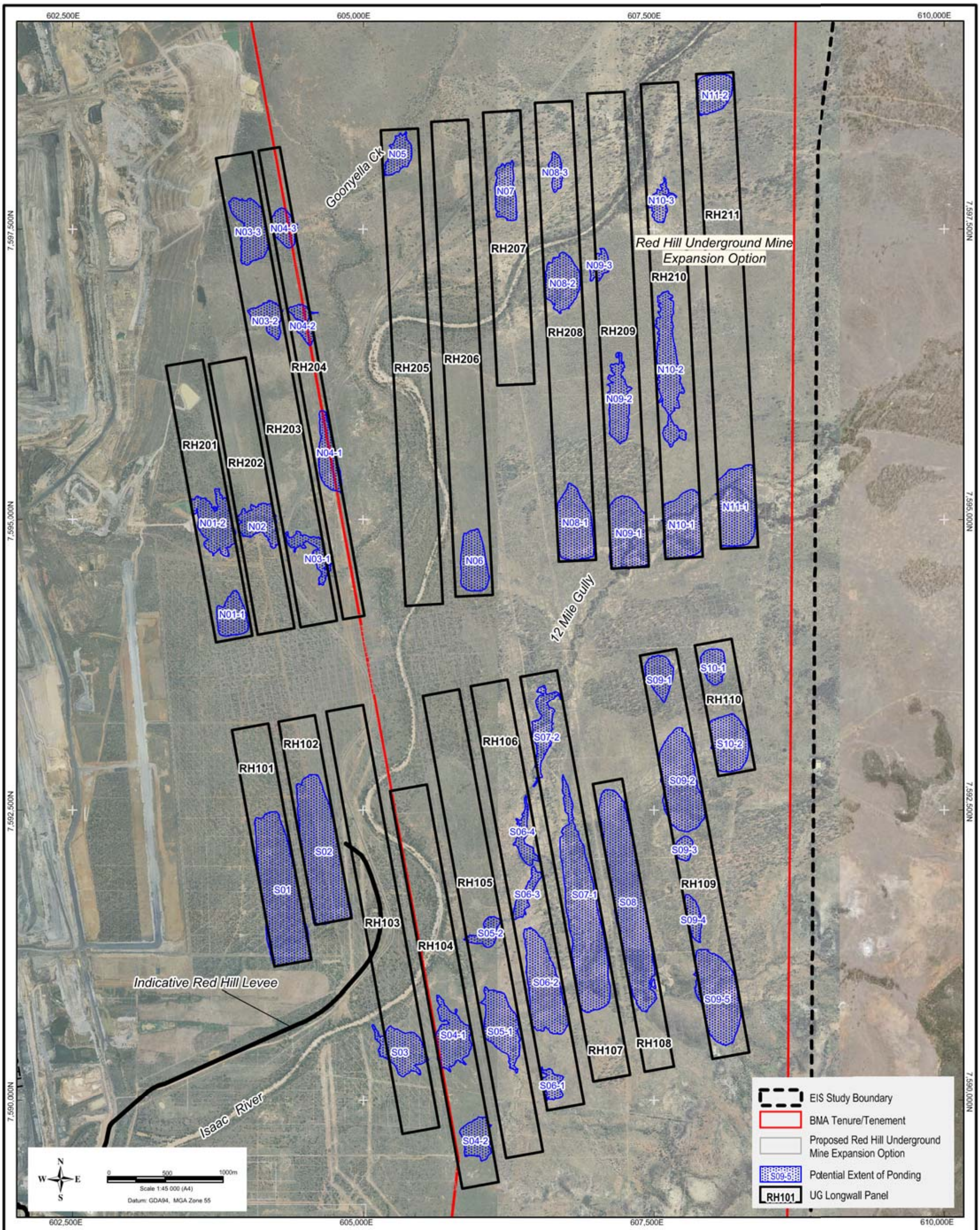
IESC REPORT

Figure: **6-6**

File No: **42627136-g-2246b.cdr** Drawn: **VH** Approved: **CT** Date: **24-10-2013** Rev.**B** A4

Table 6-1 Summary of Predicted Geomorphic Response for the Isaac River, Impacts, Mitigation Options and Risk

Feature / Environmental Value	Geomorphic Response	Potential impact	Mitigation Options
Isaac River	Upstream deepening, occasional natural bedrock controls will limit the progression of deepening upstream.	• Bed and bank instability.	Implement toe of bank protection measures near upstream limit of subsidence.
	Downstream deepening through BRM due to medium term loss/reduction of bed sediment supply due to RHM subsidence.	• Bed and bank instability through the natural reach of Isaac River. • Further destabilisation of the Isaac River diversion.	Bank protection measures already implemented over pillar zones through the natural reach of Isaac River at BRM will reduce the risk of bank erosion as a result of downstream deepening. These measures will continue as part of BRM and RHM impact management. Develop and implement a management strategy for the diversion that takes into account risks posed by the future RHM and BRM. The strategy will need to account for the potentially reduced sediment supply conditions that the future RHM is predicted to generate.
	Deepening/erosion over the pillar zones.	• Bed and bank instability.	Implement toe of bank protection measures over pillar zones.
	Accelerated erosion processes due to creation of flow paths with suitable hydraulic conditions for avulsion development by RHM subsidence.	• Avulsion / meander cut-off leading to loss of existing river channel environmental values. Potential for change in system behaviour, multi-channel system for a period of time. • Accelerated input of suspended sediment that will be transported beyond the study area.	High density vegetation cover should be maintained where potential for avulsion or cut off identified. Monitor these areas following flood events. Actions need to be consistent with the panel catchment management component of the subsidence management plan for ponding and overland flow. Earthworks such as broad fill areas within the panel which mitigate avulsion risk pathways to be considered as part of subsidence management plan. A meander cut off of Isaac River in RH205 (see **Figure 6-7**) (upstream subsidence trough) is highly likely. Given the location, this should be allowed to occur and managed to minimise any potential negative impacts (none foreseen).



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POTENTIAL PONDING IN SUBSIDENCE AREAS

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Figure: **6-7**

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The likely impact of subsidence on tributaries and minor flow paths across the study area has been assessed qualitatively based on the geomorphic characterisation of waterways and the first order impacts of subsidence. Outcomes of flood modelling for large and rare floods (1 in 100 year AEP and greater) have also been utilised.

The predicted geomorphic response of tributaries and flow paths on the floodplain is dependent on their existing characteristics and the extent to which the creation of panel catchments interferes with channel gradient and/or changes to runoff volume or flow concentration. Broadly, the following impacts are anticipated:

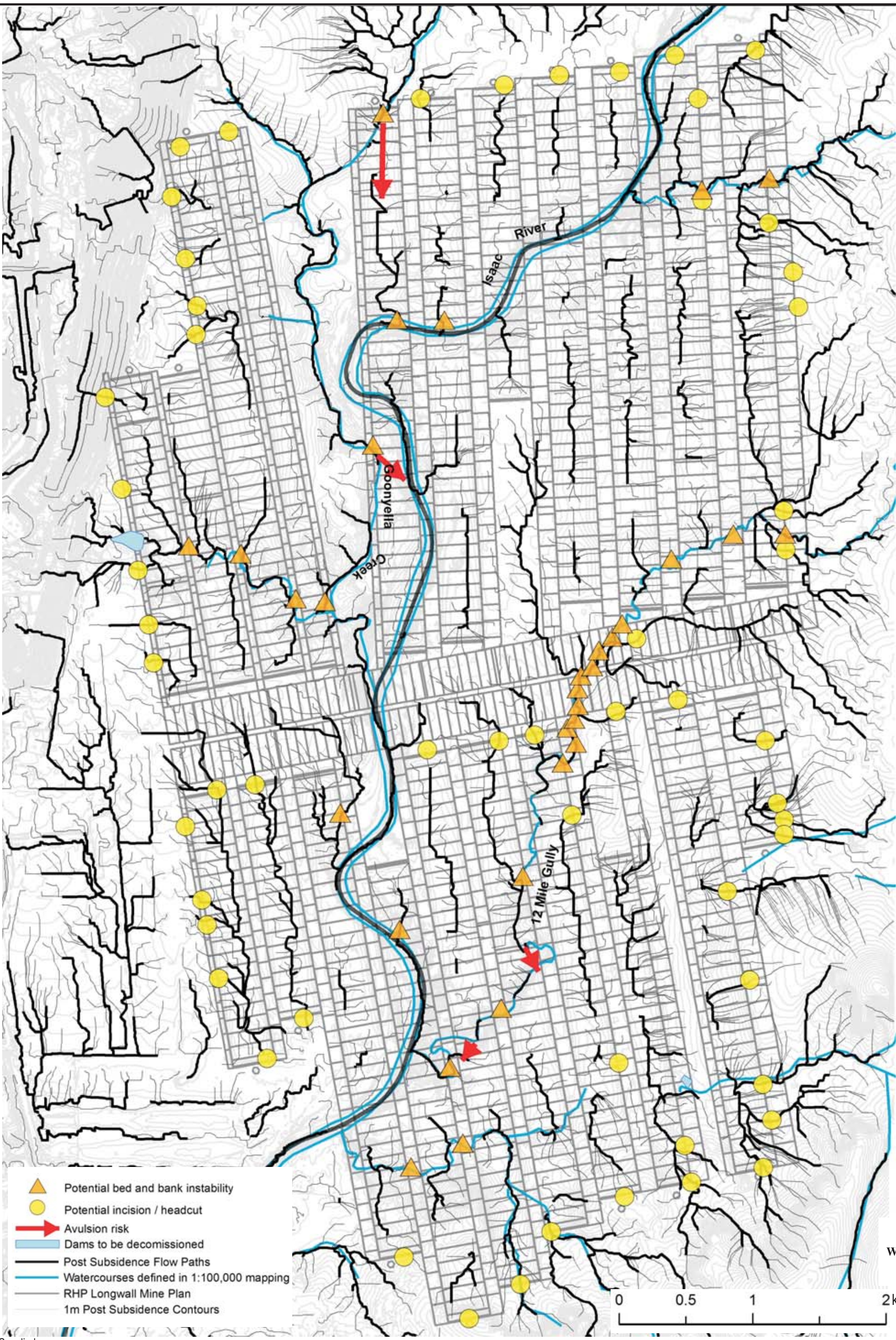
Upstream/outer limit of subsidence:

- Existing unchannelised flow paths and discontinuous waterways may incise headcut erosion into the landscape due to an increase in local gradient and concentration of runoff.
- Bed and bank instability may also occur in channelised waterways due to the changes in local bed gradient and upstream progressing deepening (headcuts/incision).

Within subsidence zone:

- For unchannelised and discontinuous waterways, flow paths will generally realign down the centre of the panel catchment, creating a low energy, fill and spill environment. Due to the relatively small catchment area upstream of the RHM subsidence, this is not likely to create instability issues. However, some incision or bed and bank instability may occur at the confluence of existing waterways (e.g. 12 Mile Gully) should that waterway be subject to deepening.
- Similar to the Isaac River, subsidence troughs created by panels and pillars are likely to create temporary ponds in channelised waterways, until such time as they are infilled with sediment, or if limited supply these will persist as pools. A lowering of the mobile sand bed over the pillar zones is anticipated in the short term, which will in turn increase the risk of local bank erosion.
- Post subsidence of longwall panel RH205 (see **Figure 6-7**), there is an increased risk of Goonyella Creek avulsing into the Isaac River in several locations upstream of its existing confluence, with significant erosion and loss of riparian habitat.

The areas of potential erosion in tributaries and panel catchments across the RHM are highlighted in **Figure 6-8**. Mitigation options and risks for the geomorphic response and potential impacts described above are summarised in **Table 6-2**. Apart from maintaining vegetation cover wherever possible, and stabilising creek crossings wherever creeks are crossed by gas drainage infrastructure, no management intervention prior to subsidence is required other than for Goonyella Creek. Monitoring of risk areas throughout the operational phase is required and erosion risk managed once subsidence has occurred.



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AREAS OF POTENTIAL EROSION IN TRIBUTARIES AND PANEL CATCHMENTS

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Figure: 6-8

File No: 42627136-g-2254.cdr | Drawn: VH | Approved: CT | Date: 24-10-2012 | Rev.A | A4

Table 6-2 Summary of Predicted Geomorphic Response for Tributaries and Panel Catchments, Impacts, Mitigation Options and Risk

Feature / Environmental Value	Geomorphic Response	Potential impact	Mitigation Options
Tributaries	Deepening/erosion at upstream limit of subsidence and over pillar zones.	Bed and bank instability.	No mitigation recommended prior to subsidence. Monitoring of risk areas proposed. Grade control (e.g. rock chutes) and bank protection techniques may need to be implemented immediately after full subsidence has occurred and prior to wet season where practical.
	Accelerated erosion processes.	Avulsion of Goonyella Creek into the Isaac River in RH205 (see **Figure 6-7**).	High density vegetation cover should be maintained. Options to maintain the lower end of Goonyella Creek in current channel include filling part of north end of panel RH205 to prevent capture of the creek by this longwall or diverting around the panel with associated levee.
Unchannelised waterways and flow paths	Incision and erosion headcut instigation.	• Substantial sediment generation; and • Loss of inherent environmental values.	Treated with appropriate grade control and flow management immediately after any headcuts are instigated following subsidence. Standard gully management grade control rock chute techniques are appropriate.
Ephemeral wetland areas	Panel catchments (low energy, fill and spill environment) created in areas of overland flow or unchannelised flow paths.	• Vegetation changes (more wetland species); and • increased water storage on the floodplain.	None proposed for geomorphic impacts, may be required due to overall impacts on low flow regime of Isaac or due to impacts on flora/fauna by extended ponding. Constructed drainage may cause more environmental harm than benefit (5^{th} order impact) and should be considered on a case by case basis for best environmental and operational safety outcome.
	Creation of pools in channel from subsidence voids.	• Aquatic habitat; and • Temporary due to excess sediment inputs.	Maintaining the positive impact in the long term would require reduction in sediment inputs on a catchment scale, beyond the project lease and beyond the control of the proponent.

6.1.6 Post Mining Impacts on Regional Groundwater Levels

The remnants of the mine void will collect and accumulate water from groundwater ingress through the walls and goaf of the final workings. There is also the potential for water ingress to occur from surface through leakage down the ventilation shafts, the mine access drift, old exploration holes or abandoned bores. These pathways facilitate groundwater rebound post mining.

The mine workings will fill up and groundwater levels will recover over time. The groundwater modelling, which does not take account of these leakage sources, indicates that a lag effect will persist after groundwater extraction is stopped, with residual drawdown in the GMS persisting until 2068. The groundwater system will re-adjust to the new (altered and enhanced) aquifer conditions surrounding and within the mined area. Groundwater levels and potentiometric pressures within the regional aquifers will, over time, attain a new equilibrium level. This new equilibrium for the groundwater system will have a different potentiometric surface from that which was present pre-mining owing to the presence of the mined workings and the different hydrogeological parameters of the goaf.

A detailed study of groundwater level recovery within RHM has not been conducted because the closure requirements for the GRM will have a marked impact on recharge to groundwater and the rate of groundwater recovery. Groundwater levels are expected to recover within RHM after closure during the period of continued operation of GRM (mine plan to 2068), and further work will need to be undertaken throughout the GRM mine life to determine the hydrological regimes, and the expected water levels in the mine voids. It is considered that the groundwater levels will recover in RHM, over time, to the base of the GRB mine complex open pits. The GRB mine complex final voids will, based on size and climate conditions (evaporation exceeding rainfall), permanently alter groundwater flow patterns towards the GRB mine complex final voids.

6.1.7 Impacts on Groundwater Quality

A rise in the groundwater salinity within the RHM workings may occur as a result of atmospheric weathering of the exposure of wall, roof and floor rock during mining. However, any increase in groundwater salinity is expected to be minor compared to the natural salinity of the groundwater in the Permian formations. Current and previous geochemical analysis in the Moranbah Coal Measures lithology show that there is low acid generation potential, with the roof and floor strata having excess buffering capacity, thus there is a low risk that metals will be mobilised into the groundwater.

Post-mining water quality within all aquifers surrounding the study area is expected to remain similar to pre-mining water quality. Local groundwater flow patterns will be towards the GRB mine complex thus reducing the potential for poor quality groundwater to migrate off site within the groundwater.

6.2 Potential Surface water impacts

6.2.1 Construction Phase

For the purpose of the surface water assessment of project construction phase impacts, the construction phase is considered to be construction of surface infrastructure and mine facilities to support the project. Mine access development, subsidence and gas drainage related impacts are considered to be relevant for operational phase and post mining impacts of the project.

In general terms the project requires limited surface construction activity. Construction of the Red Hill CHPP and conveyors will take place within the GRB mine complex mine lease within the containment extents of the GRB mine complex mine lease.

The construction activities which will be undertaken outside the existing GRB mine water management area comprise the following:

- construction of the MIA, Red Hill levee and drift portal;
- construction of the Red Hill accommodation village; and
- construction of internal access roads and associated bridge across the Isaac River.

Plant and equipment utilised during construction will contain diesel, oil and other hydrocarbons and it will also be necessary to store diesel and oil for use during construction.

In addition, where excavations are required, it may be necessary to dewater these, producing water that may be high in suspended solids.

Construction of the CHPP and conveyors takes place within the GRB mine water management system and, hence, any sediment laden or contaminated runoff from these activities will be captured in the mine water management system. It is unlikely that dewatering of excavations will be required for these facilities.

The construction activities which will be undertaken outside the existing mine footprint and mine water management area comprise the following:

- Construction of the MIA, Red Hill levee and drift portal. These activities will take place in an area which drains directly to the Isaac River.
- Construction of the Red Hill accommodation village. The accommodation village is located in the 12 Mile Gully catchment which flows to the Isaac River.
- Construction of internal access roads including a road to the Red Hill accommodation village and associated bridge across the Isaac River. These works take place in the 12 Mile Gully catchment and areas that drain directly to the Isaac River.

For these areas, there is potential for surface water runoff to convey contaminants to surface waters. While the quantities of contaminants will generally be low when considered at a sub-catchment scale, localised water quality impacts would be expected if controls are not implemented. Potential impacts on water quality throughout the construction phase are summarised in **Table 6-3**, along with the corresponding mitigation measures that will be implemented. Residual impacts are expected to be minimal with the implementation of these management strategies.

Table 6-3 Potential Construction Impacts on Surface Water Quality and Mitigation Measures

Impacts During Construction	Mitigation Measures
Sediment mobilisation Sediment mobilised during construction activities may enter surface water runoff during rainfall events and discharge to watercourses leading to adverse effects on water quality. Sediment exposed or generated during construction may also be carried by wind into surface water bodies.	Permanent stormwater management systems should be installed as early as possible in the construction program. An erosion and sediment control plan should be prepared and executed. Diversion bunds should be constructed to divert clean water flows around the construction site where practical. Erosion and sediment control protection measures should be installed prior to the commencement of land disturbance activities. Erosion and sediment control structures should be regularly inspected and maintained. Topsoil should be stockpiled away from drainage lines to protect it from erosion by surface water runoff. Vegetation clearing and earthworks should not be carried out during heavy rainfall. Dust suppression measures should be implemented. Water from vehicle washdown areas should be treated to remove seeds, oils and other contaminants before reuse for dust suppression or other on site use or directed to the GRB mine water management system for reuse. For the flood protection levee, construction should take place in the dry season wherever possible and practicable and, if possible, the other flood protection should be in place before the first wet season. If the accommodation village is staged, clearing should be progressive and occur immediately before construction of each stage if practicable.

Impacts During Construction	Mitigation Measures
	For stream crossings, construction of linear infrastructure should be conducted in the shortest possible time and in accordance with the *Guideline – Activities in a watercourse, lake or spring associated with mining operations* (NRM 2012). Wherever possible stream crossings will be constructed in low flow periods.
Contaminant Mobilisation Storage, handling and use of diesel and other hydrocarbons may result in releases to land or directly to watercourses. Releases to land may be mobilised to surface waters by stormwater flows. Water from vehicle washdown activities may also be contaminated with hydrocarbons. Sufficient quantities of hydrocarbons may result in toxic effects to aquatic plants and animals.	Measures in relation to fuel and chemical storage and handling, including refuelling will minimise likelihood of release to surface waters. Measures in relation to spill response will minimise likelihood of release to surface waters. Bunds and sumps should be emptied following rainfall events. Water and oily water from fuel and oil storage areas removed from bunds and sumps should be treated through an oil water separator and then reused for dust suppression or other on site use. Water and other contaminants from other chemical storage areas should be treated through on site wastewater treatment plants and then utilised in dust suppression or irrigated in accordance with the site EA. Refuelling is not to take place within 100 m of the Isaac River and 50 m of 12 Mile Gully and tributaries. Fuels, oils and other chemicals, including wastes contaminated with fuels, oils or other chemicals are not to be stored or placed within 100 m of the Isaac River and 50 m of 12 Mile Gully and tributaries. Vehicle washdowns should be located away from drainage lines or watercourses. Water from vehicle washdown areas should be treated to remove seeds, oils and other contaminants before reuse for dust suppression or other on site use or directed to the GRB mine complex water management system for reuse.
Dewatering of excavations Excavation works are required during the construction of the MIA and the drift portal. Dewatering of these excavations may be required following heavy rainfall. Poor management of this water may generate contaminated runoff with adverse impacts on receiving waters.	Water removed from excavations and from dewatering groundwater from the drift will be pumped to the MIA dam, if this is in place or directly to the GRB mine water management system if the MIA dam is not in place. This water can then be reused as mine water.

The construction phase is unlikely to adversely impact on flood occurrence or severity. If the flood protection levee is required, the location for this levee is above the level of the 1 in 100 AEP event in the Isaac River. It is unlikely that a flood greater than this will occur during levee construction, particularly if the levee can be constructed in the dry season. If the bridge across the Isaac River is constructed during the wet season, a flood response plan should be prepared for the construction works to cover:

- removing equipment that may impede flood flows if flood warnings are received; and
- removing any potential contaminants if flood warnings are received.

6.2.2 Operational Phase Water Quality Impacts

6.2.2.1 Mine Water Management

In order to assess the impact of the additional mine water from RHM on GRB mine water releases during operation, water and salt balance modelling was undertaken applying the conditions imposed in the EA for the GRB mine complex. It is expected that demand created by the proposed RHM and the Red Hill CHPP will exceed water produced from dewatering of the RHM, that is, will cause an overall deficit in water for the combined mine complex over most operating years. However, as it is recognised that surplus conditions may present a worst case in terms of compliance with the existing GRB mine complex EA, this scenario has been tested in the mine water balance modelling.

The mine water balance modelling results, for salinity at the downstream monitoring point, are shown in **Figure 6–9** below shows the percentage of time that a particular EC level is exceeded at the downstream monitoring point, while **Figure 6-10** is the same graph but focussing on the lower probability occurrences.

Figure 6-9 TDS Concentrations in Isaac River Downstream during Mine Water Releases – Project Case Comparison with Baseline

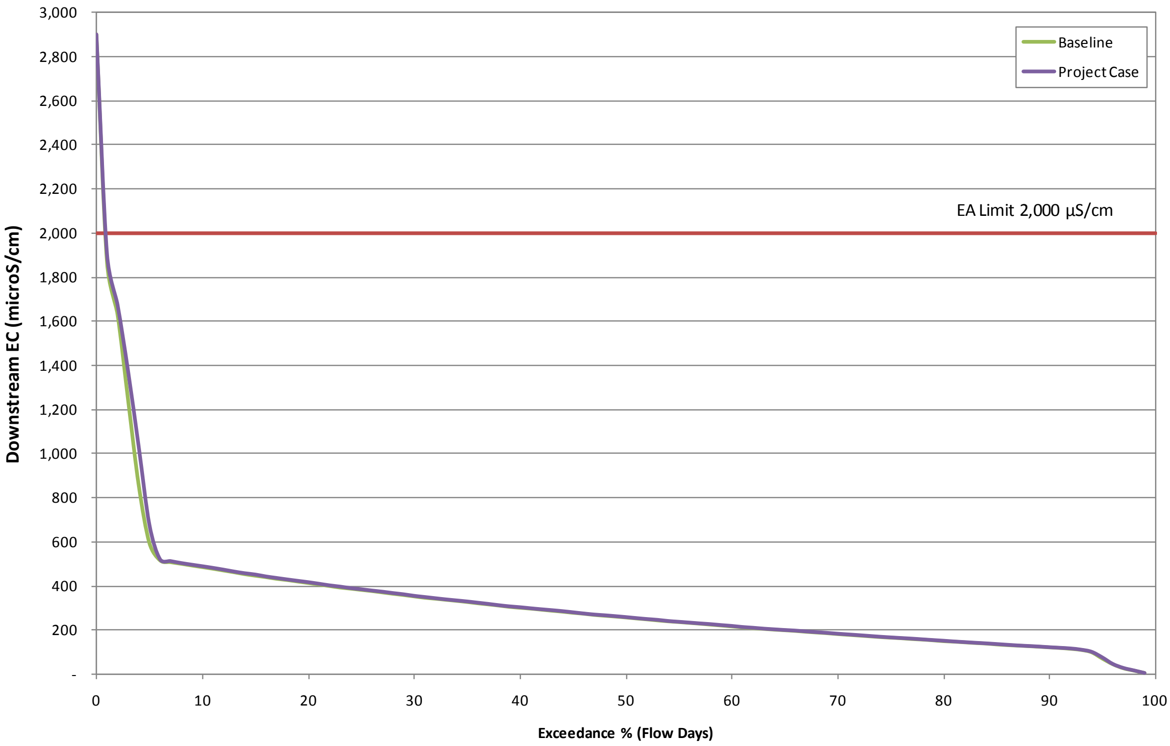
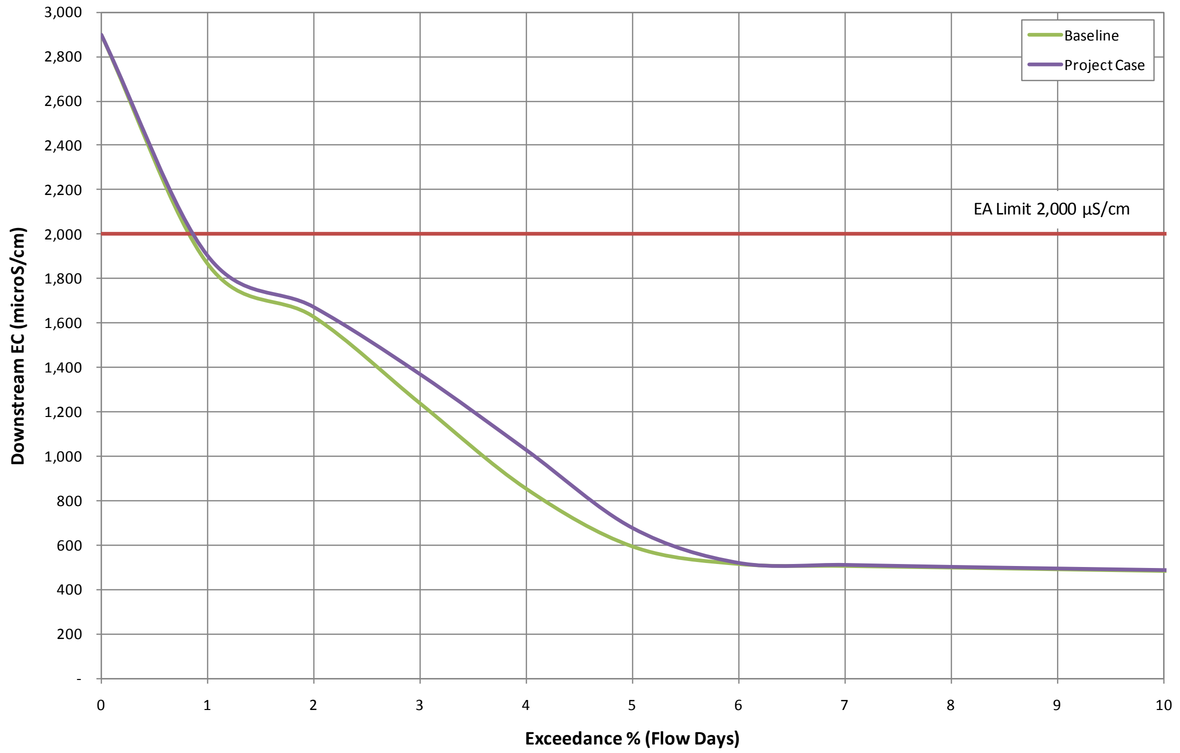


Figure 6-10 Concentrations in Isaac River Downstream during Mine Water Releases – Project Case Comparison with Baseline (Low probability occurrences)



The modelling results indicate that for 99 per cent of the time salinity concentrations downstream of the mine release would comply with the EA licence condition of 2,000 µS/cm with or without the addition of water from the proposed RHM.

Addition of the RHM water slightly increases the salt levels in the receiving environment for around 1 to 6 per cent of the time; however, for 99 to 94 per cent of the time, the difference between salt levels in the receiving environment with and without the addition of RHM water is negligible. This conclusion is based on the RHM generating a surplus. In fact, it is expected that in most years of operation, demand created by the Red Hill CHPP will exceed RHM dewatering volumes, and surplus water from the GRB mine complex will also be drawn on for RHM.

While this analysis has focused on TDS it is expected that if the mine water management system is operated correctly and, compliance with the existing EA conditions for other elements and compounds present within mine water releases is achieved, there would be negligible potential for adverse impacts to arise from releases.

6.2.2.2 Subsidence Impacts on Water Quality

Subsidence will create ponds of varying depths and permanence. Water quality in these ponds may become degraded during the dry season due to lack of flushing, concentration of salts through evaporation, and degradation by native, feral and grazing animals. These effects will be similar to those currently seen in ponds on watercourses throughout the study area and the wider region as water levels recede in the dry season. Ponded areas forming in subsidence troughs along 12 Mile Gully are predicted to be semi-permanent and therefore most at risk of containing degraded water quality in the dry season. Depending on the extent of actual subsidence that occurs in this area, it may be necessary to drain these ponds. This will reduce the potential for water quality degradation within ponded areas and will also contribute flushing flows for 12 Mile Gully.

Runoff from subsided areas will generally be trapped by subsidence troughs, and hence sediment mobilisation from the subsided area is not likely to be significant. Measures may be implemented for stabilising the land surface after subsidence.

6.2.2.3 Incidental Mine Gas Management Water Quality Impacts

Management of IMG will require installation and operation of gas wells, water and gas pipelines and access tracks across the underground mine footprint. As with construction activities, this will create the potential for sediment to be mobilised from disturbed areas to watercourses. Use of equipment containing diesel and other hydrocarbons will also create the potential for spills and leaks of hydrocarbons that may in turn be mobilised to surface waters by stormwater runoff. Finally, some drilling muds and drilling waste will be generated by the gas well installation. These are not toxic but, if released or mobilised to surface waters, may contribute sediment load and possibly salt.

Mitigation measures in relation to erosion and sediment control and in relation to prevention of land contamination, together with mitigation measures identified for the construction phase in relation to water quality (**Table 6-3**) will minimise the potential for adverse impacts on water quality.

Drilling muds will be contained and managed in accordance with relevant requirements.

With these measures in place, it is unlikely that the IMG management activities will result in any degradation of water quality.

6.2.2.4 Other Impacts

Other potential impacts to water quality during operation of the proposed RHM include:

- failure of water storages and water transfer equipment;
- mobilisation of sediment to surface waters from disturbed areas; and
- mobilisation of other contaminants such as fuels or chemicals from operational areas.

These impacts are evaluated in **Table 6–4** and mitigation measures proposed to further minimise impacts. With mitigation measures in place, and having regard to the small quantities of contaminants that may be mobilised through each of these impact mechanisms, impacts on surface water quality are not expected.

Table 6-4 Potential Operational Impacts on Surface Water Quality and Mitigation Measures

Impacts During Mine Operation	Mitigation Measures
Failure of water storages, storage embankments, pipelines, levees or bunds has the potential to result in releases of small to moderate quantities of mine water, with maximum possible release being 50 ML (MIA dam). Releases may cause localised scouring and erosion as well as contributing sediment and salt to receiving waters. Impact on water quality and aquatic ecosystems would depend on flow regime at the time of the release. Given the small to moderate quantities that might be released, and the nature of the receiving environment, significant water quality degradation is not expected to occur except at a local scale if there is limited flow in receiving waters.	• Design mine water storages using a mine water balance model which considers all inputs and outputs which has run through a long-term period of climatic data to test storage capacities particularly in high rainfall wet seasons. • Assess proposed mine water storages against *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* (EHP 2012). If these are regulated structures, design, construction, operation and maintenance will comply with: – *Guideline Structures which are dams or levees constructed as part of environmentally relevant activities* (EHP 2013b); and – Code of Environmental Compliance for Environmental authorities for high hazard dams containing hazardous waste (DERM 2009a). • Design pipes and pump systems based on volume requirements predicted from mine water balance modelling and design and construction under the supervision of qualified professional engineers. • Monitoring equipment is installed to monitor storage volume during operation and to prevent overfilling. • Regular inspections of mine water storages, particularly in relation to integrity of embankment. • Regular pipeline, drain, bund and levee inspections and maintenance.
Erosion and sediment mobilisation from disturbed areas may degrade surface water quality. During the mining operation, there will be limited ground disturbing activity outside MIA and accommodation village areas which will be contained with stormwater systems, or the CHPP and conveyor areas which are within the GRB mine water management system. Souring of drains around the accommodation village may also contribute sediment load.	• Develop and implement an erosion and sediment control plan for any ground disturbing activities outside the existing mine and stormwater management areas. • Conduct regular inspections of any drains and other features of stormwater management systems prone to scouring and proactively repair any damage identified.
Chemical and fuels leaks may be mobilised by stormwater runoff with potential adverse impacts on water quality in receiving waters. Chemical and fuel storage areas will be within stormwater containment areas or mine water management areas, and hence potential for mobilisation to surface waters is low.	• Secondary containment will be provided for all areas where liquid fuels and chemicals are stored or handled. • Spill kits will be available at the MIA and CHPP and mobile spill kits will also be available at the location of IMG management infrastructure construction and well installation activities. Workers will be trained in the use of the spill kits to respond promptly to small and medium sized spills and in the proper collection of contaminated material. • An incident report form will be completed for every fuel and chemical spill outside a bunded area. The report form will contain details on the location of the spill, type and quantity of material spilt and steps taken in initial response and follow up using BMA's "First Priority" system. • Response to large fuel and chemical spills will be incorporated into the site emergency management plan and consultation undertaken with the Queensland Fire

Impacts During Mine Operation	Mitigation Measures
	and Rescue Service in relation to spill response requirements and resources. A trained spill response team will be available. • Bunds and sumps should be kept emptied following rainfall events. Water and oily water from fuel and oil storage areas removed from bunds and sumps should be treated through an oil water separator and then reused for dust suppression or other onsite use. Water and other contaminants from other chemical storage areas should be treated through onsite wastewater treatment plants and then utilised in dust suppression or irrigated in accordance with the site EA. • Vehicle washdowns should be located away from drainage lines or watercourses and water from vehicle washdown areas should be treated to remove seeds, oils and other contaminants before reuse for dust suppression or other onsite use or directed to the GRB mine complex water management system for reuse.

6.2.3 Operational Phase Water Resources Hydrology Impacts

6.2.3.1 Subsidence Impacts on Water Resources Hydrology

Subsidence resulting from the project mining activities may potentially impact on the broader catchment hydrology and water resources availability in the locally subsided catchments and the Isaac River downstream of the mine depending on the rate of infill, however this extent and term of impact will depend on the rate of development and mining for the future RHM. As the panels subside, there is the potential that the volume of water that would have drained freely and contributed to the downstream river flow could be lost from the downstream river flows by formation of surface depressions (subsidence voids) which capture direct rainfall and surface runoff and no longer freely drain to the natural waterways. As water ponds in the subsidence depressions water may be lost as:

- evaporation from the water surface of the ponded waters; and
- potential percolation to the groundwater including through surface cracking resulting from the subsidence.

Evaporation from Water Ponding in Surface Subsidence Depressions

The potential loss of water resources that may occur via evaporation from waters ponded in the subsidence depressions depends on the geometry of the depression that captures water (particularly relationship between surface area and volume).

The variation of the volume of ponded waters in subsidence voids over time will be responsive to rainfall, sub-catchment area, and corresponding runoff volumes draining into the subsidence void. When direct rainfall and runoff inflows into the subsidence voids exceed the storage capacity, the excess water will overflow and contribute to flow volumes in drainage paths and watercourses downstream.

Hydrological analysis, as shown in more detail in the Red Hill Mining Lease Appendix I7, indicates that without mitigation, the potential loss of flow from 12 Mile Gully catchment due to ponding of waters in subsidence voids (worst case) could be in the order of 2,300 ML/year, or approximately 52 per cent of the mean annual flow. There are no known human users of water relying on water directly from 12 Mile Gully and the potential loss is not considered significant in that context. Nonetheless, an approximately 50 per cent reduction of mean annual flow in 12 Mile Gully is potentially significant for aquatic ecology and, hence, on this basis, mitigation has been considered to reduce ponding in the 12 Mile Gully catchment. There is potential to mitigate the loss of flow due to ponding in subsidence voids by undertaking drainage works to partially drain some of the voids created by subsidence. However, the works required to drain subsidence voids also introduce further potential for adverse environmental impacts due to the degree of physical landscape disturbance required to construct the drains, and potential on-going instability of erosion of the drainage lines and, therefore, is only considered where modelling indicates significant hydrological or other impacts. This potential mitigation case allows for partial draining of the voids to reduce maximum ponding depths to between 2 and 2.5 metres. With implementation of this mitigation option, the maximum total potential subsidence ponding of all voids in the 12 Mile Gully catchment would reduce to approximately 1,900 ML compared to 5,200 ML in the case with no mitigation.

Beyond the 12 Mile Gully catchment, it is known that there is reliance on water from the Isaac River for human and livestock supply and that the Isaac River supports aquatic habitat values that are more extensive than present in the 12 Mile Gully water course.

When considered in terms of 'whole-of-project' hydrological impacts, the loss of flow in the Isaac River due to potential worst case subsidence void ponding in the 12 Mile Gully catchment (with no mitigation) will be partially offset by the increase in mean annual flow from Eureka Creek through the GRB mine complex) which is predicted to increase by approximately 700 ML/year. The net loss of mean annual flow in the Isaac River would be approximately 1,600 ML/year.

The total Isaac River catchment mean annual flow is estimated to be approximately 50,000 ML/year. The reduction of mean annual flow in the Isaac River of approximately 1,600 ML/year represents a small component of approximately three per cent loss of the Isaac River mean annual flow at Goonyella.

The potential small loss of mean annual flow in the Isaac River will be practically immeasurable in a regional water resource plan context. In the statutory Water Resource (Fitzroy Basin) Plan 2011, the closest downstream location for which environmental flow objectives (EFO) apply is in the Isaac River at Yatton (node 9 in Schedule 5). At this location, the pre-development case mean annual flow is reported to be 2,270,000 ML/year in the Fitzroy Basin Draft Water Resources Plan Overview Report (DERM 2010). The EFO objective at this location is to ensure that mean annual flow is not less than 90 per cent of the pre-development mean annual flow.

The potential loss of 1,600 ML/year of mean annual flow in the Isaac River due to project impacts represents less than 0.07 per cent of the mean annual flow in the Isaac River at Yatton. Hence, the project impact on Isaac River flow volumes will not materially impact on the State's ability to meet the water resource plan environmental flow objectives. Hence, mitigation of ponding in the 12 Mile Gully catchment need only address local hydrological impacts with 12 Mile Gully water course.

Potential Water Losses in Percolation through Surface Cracking

The amount and magnitude of surface cracking that occurs as a result of subsidence varies depending on the geological strata overlying the coal that has been extracted, geological structures, and notably depth below surface that coal has been extracted. In the majority of the subsided areas (generally in the middle of the panels where water is more likely to pond), it is unlikely that there will be tension cracks.

Subsidence predictions for the project undertaken by IMC Mining Group (refer to Red Hill Mining Lease EIS Appendix I1) estimate that for a worst case scenario, cracking that expresses at the surface may be at widths up to 0.5 metres and depths to approximately 10 metres. In most areas, the surface cracking is anticipated to be less severe.

The general observations from recent experience of subsidence management of longwall mining in the Bowen Basin is that in gentle (low gradient) terrain with alluvial surface geology, subsidence surface cracking will tend to self-seal after a few rainfall events as fine sediments wash into, and seal up the cracks. These observations are affirmed at the existing BRM operations where prolonged ponding in subsidence depressions following rainfall events has been observed, indicating minimal percolation through cracks. However, some observations of cracking on steeper slopes of the subsided areas have been made at BRM and Moranbah North Mine (R Lucas, pers com 20/02/2012) and this will need to be monitored.

6.2.3.2 Subsidence Impacts on Flood Hydraulics

Baseline and project case flood hydraulic modelling were conducted to estimate the impacts from the proposed levee and subsidence. The hydraulic results, flow velocity and stream power for the frequent floods, are summarised in **Table 6-5**, with the baseline results presented for comparison. The flood modelling results shows that hydraulic parameters are generally within a similar hydraulic range to the baseline. Further details of the project case frequent flood event velocity and stream power results are presented in Red Hill Mining Lease EIS Appendix I5.

Localised higher velocities and stream power are likely at the upstream end of the subsidence areas and un-subsided pillar areas, and lower velocities and stream power within the subsided panels. Erosion and sediment deposition were not simulated in the analysis and actual changes to stream power and velocity will become less marked as the waterways morphologically adapt to the subsided profile.

For the less frequent (large to rare) events, the flood level elevation for the baseline and project conditions were compared to assess the impact of the project on flood levels in and upstream of the study area. The modelling results show that the project case would not increase flood levels for flood events in the range of 1 in 50 to 1 in 2,000 AEP. A potential minor increase in flood levels of 100 to 200 millimetres is estimated for 1 in 10 and 1 in 20 AEP events in a localised area near the Red Hill MIA levee. This increase is not significant as flooding in these events is contained in the river channel and it will not impact on third party premises or other existing infrastructure. Additional description of the results, flood inundation extents figures, and longitudinal plots of hydraulic flood modelling results for the project case conditions and comparison to the baseline conditions for all other events are presented in the Red Hill Mining Lease Appendix I5.

If a levee is used to provide flood protection for the MIA and mine access, subsidence of longwall panel RH103 will affect the levee by subsiding the embankment up to a maximum of six metres. The impacts to the physical integrity of the levee embankment may include reduced stability of the embankment in that section and increased risk of internal erosion failure (piping through embankment or foundation) due to cracking of the levee or the levee foundations. The crest level of levee embankment after subsidence would significantly reduce the flood immunity and would need to be reinstated back to design flood level requirements. Several options exist and would need to be evaluated in advance of planned subsidence of panel RH103.

In summary, the impacts from the project on flood hydraulics are expected to be low.

Table 6-5 Summary Project Case Flood Hydraulics for Isaac River, Goonyella, and 12 Mile Gully

Hydraulic Parameter	Flood Event (AEP)	Baseline Results (Reach Average)	Project Case Results (Reach Average)
Isaac River from Upstream Project Boundary to Eureka Creek			
Velocity	1 in 10 1 in 20 1 in 50	1.8 m/s 2.0 m/s 2.2 m/s	1.6 m/s 1.8 m/s 2.0 m/s
Stream power	1 in 10 1 in 20 1 in 50	68 W/m^2 94 W/m^2 106 W/m^2	97 W/m^2 132 W/m^2 148 W/m^2
Goonyella Creek from Isaac River Confluence to 8.03 km Upstream of Confluence			
Velocity	1 in 2 1 in 5 1 in 10 1 in 20 1 in 50	1.4 m/s 1.6 m/s 1.8 m/s 1.9 m/s 2.1 m/s	1.3 m/s 1.5 m/s 1.7 m/s 1.8 m/s 2.0 m/s
Stream power	1 in 2 1 in 5 1 in 10 1 in 20 1 in 50	39 W/m^2 54 W/m^2 54 W/m^2 62 W/m^2 70 W/m^2	56 W/m^2 85 W/m^2 85 W/m^2 72 W/m^2 82 W/m^2
12 Mile Gully from Isaac River Confluence to 8.70 km Upstream of Confluence			
Velocity	1 in 2 1 in 5 1 in 10 1 in 20 1 in 50	1.1 m/s 1.3 m/s 1.3 m/s 1.4 m/s 1.5 m/s	1.0 m/s 1.1 m/s 1.1 m/s 1.4 m/s 1.5 m/s
Stream power	1 in 2 1 in 5 1 in 10 1 in 20 1 in 50	69 W/m^2 58 W/m^2 44 W/m^2 56 W/m^2 58 W/m^2	73 W/m^2 91 W/m^2 101 W/m^2 89 W/m^2 116 W/m^2

6.3 Water Related Assets of National Environmental Significance

Relevant impacts to water related Matters of National Environmental Significance for surface and groundwater were considered. No wetlands or sensitive MNES vegetation were identified within the predicted impact zone (groundwater and surface water).

Potential impacts of mining operations could impact on vegetation communities. The impacts identified include:

- reduction of groundwater levels; and
- marked alteration of surface water drainage patterns.

These impacts are considered in the risk assessment in **Section 07**.

6.4 Data Uncertainty and Integrity Concerns

Groundwater impacts were assessed using predictive groundwater modelling. The groundwater flow model is a simplification of a real system, so it is subject to limitations. Limitations result from the simplification of the conceptual model upon which the numerical model is based, the model grid scale, the inaccuracies of measurement data, and the incomplete knowledge of the spatial variability of input parameters.

There are no pre-mining groundwater levels available, and since mining has been ongoing since the 1970s, there was no steady-state condition to calibrate against. Thus the available groundwater level measurements in the historical records are impacted by historic mine dewatering. The mine dewatering rates are also unavailable so the model could not be developed with a transient calibration. Therefore, the rule of parameter parsimony was adopted.

The best data available is the hydraulic conductivity values from aquifer tests, core tests, and the spatial distribution with depth. The groundwater model was thus calibrated to capture the regional groundwater flow trend identified from groundwater levels with the objective of obtaining an acceptable starting condition that represented the regional trend for the predictive simulation and reasonable parameter ranges. Verification of reliability of the model was conducted by undertaking uncertainty analysis for the predictive model.

Several important limitations of the water balance model are important to note for evaluation of the model results.

The water balance model does not include any allowance for seepage or transmission loss from dams and open channel drains. This assumption will tend to overestimate mine water volumes in the mine water management system and potential salt loads. This is conservative from the perspective of assessing containment performance and release compliance, and also risks of prolonged water accumulation in the open cut mine pits. This assumption is not conservative for assessing the availability of mine water to be reused in mine operations.

The model does not include representation of any other mines discharging waters into the Isaac River or other creeks represented in the model catchments. The potential releases from the existing Goonyella North Mine (Peabody operation north of the GRB mine complex) cannot be represented because details of releases from this mine are not known to BMA.

The mine water balance model simulations are undertaken for a static configuration of the mine representative of a given point in time, which for the purposes of the project mine water balance assessment and baseline is nominally 2015. The simulation periods are performed with the complete 108 years of climate data (to test extremes of climate influence) and time series results are produced for water volumes (or flows in waterways) and salinity for every part of the model.

Section 07 Water Related Risk Assessment

7.1 Methodology

The potential hazards and risks were identified through the use of a preliminary hazard analysis (PHA), in line with the BHP Billiton Group level Document (GLD) 017 Risk Management. The PHA took into consideration the AS/NZS ISO 31000:2009 Risk management – Principles and guidelines and IEC/ISO 31010 Risk management – Risk assessment techniques.

The PHA was carried out in accordance the New South Wales 'Hazardous Industry Planning Advisory Paper 6: Hazard Analysis (Consultation Draft) 2008' (DoP 2008) and the probability criteria matrix technique detailed in the IEC/ ISO 31010 Risk management – Risk assessment techniques. Further, the PHA was carried out based on BMA experience with construction and operational projects for coal mines and is in accordance with BHP Billiton's overarching guidance information, the GLDs.

The assessment outlines the implications for, and the impact on, the surrounding land uses. The PHA incorporates:

- relevant hazards (minor and major);
- the possible frequency of the potential hazards, accidents, spillages and abnormal events occurring;
- indication of cumulative risk levels to surrounding land uses;
- life of any identified hazards;
- the effects and rate of usage of the dangerous goods and hazardous substances to be used, stored, processed or produced by the project; and
- the type of machinery and equipment used.

Potential incident scenarios during the project were identified through consideration of:

- The range of activities carried out and facilities present during the construction, operation, and decommissioning phases. These included construction activities, energy supply, coal mining, transport, and wastewater management.
- The range of potentially hazardous incidents that might be associated with each of the activities/facilities identified in association with the project.

Having identified the range of hazards potentially occurring as a result of project activities, the following matters were considered for each hazard:

- Appropriate controls and mitigation factors expected to be put in place for the management of each hazard. These may include prevention and response measures.
- The consequences of each of the hazardous incidents if they were to occur. Consequences might include direct impacts of incidents and the potential for propagation and secondary incidents. Assessment of the severity of the consequences takes into consideration the proposed controls.
- Possible causes and the probability of these causes occurring and leading to the hazardous incident. The probability of each hazardous incident occurring takes into consideration the proposed controls. This information was then tabled to prioritise the risks and evaluate these levels against the concept of practicable.

- Where an extreme or high risk was identified, appropriate controls and mitigation measures were identified and the hazardous incident reassessed with these controls in place.

7.1.1 Risk Analysis Criteria

The risk assessment matrix, shown in **Table 7–1**, is based on the probability criteria matrix technique detailed in the IEC / ISO 31010 Risk management – Risk assessment techniques.

A likelihood of occurrence was assigned to each identified hazardous incident based on definitions described in **Table 7–2**. The contribution of preventative and protective management controls were taken into account when assessing the likelihood of occurrence and potential consequence from each hazardous incident. The probability of occurrence used for this risk assessment is based on the then AS 4360-2004 Risk Management. The risk levels denote residual risk.

The consequences assessed include both threats to health and safety of the public and the workforce and to the natural environment based on definitions shown in **Table 7–3**. Where a hazardous incident may have several outcomes, each potential outcome was assessed in turn. The severity classes for health and safety type outcomes are based on the then AS 4360-2004 Risk Management, while those for the threat to the natural environment are based on common environmental risk management consequence categories.

Table 7-1 Risk Assessment Matrix

		Consequence				
		1	2	3	4	5
Likelihood	A	High	High	Extreme	Extreme	Extreme
	B	Moderate	High	High	Extreme	Extreme
	C	Low	Moderate	High	Extreme	Extreme
	D	Low	Low	Moderate	High	Extreme
	E	Low	Low	Moderate	High	High

Table 7-2 Likelihood of Occurrence for Hazardous Incidents

Likelihood Rank	Descriptor	Description
A	Almost certain	80% chance of occurring; may occur more than once per year; happens often
B	Likely	50% chance of occurring; may occur once in a few years; easily happens
C	Possible	20% chance of occurring; may occur once in 5 years; has happened before
D	Unlikely	10% chance of occurring; may occur once in 10 years; is considered possible
E	Rare	2% chance of occurring; may occur once in 50 years; is considered conceivable

Table 7-3 Consequence Classes for Environmental Impact

Consequence Rank	Descriptor	Public / Workforce Health and Safety	Environmental Severity
5	Catastrophic	Multiple fatalities (2-20), or significant irreversible effects to >50 persons.	Unplanned serious or extensive impact on ecosystem or threatened species.
4	Major	Single fatality or severe irreversible disability (>30%) to one or more persons.	Unplanned major impact on ecosystem or threatened species.
3	Moderate	Moderate irreversible disability or impairment (<30%) to one or more people. Days lost.	Unplanned moderate impact to ecosystem or non-threatened species.
2	Minor	Objective but reversible disability/impairment. Medical treatment injury.	Unplanned minor impact to non-threatened species or their habitat.
1	Insignificant	Low level short-term inconvenience or symptoms. Not medical treatment.	Unplanned low level environmental impact.

The shading in the risk matrix in **Table 7-3** (below) refers to qualitative bands of risk level in accordance with Appendix E of AS 4360-2004 *Risk Management* and the probability criteria matrix technique included in the IEC / ISO 31010 *Risk management – Risk assessment techniques*.

7.2 Overall Level of Risk to Water Balance and Water Related assets

7.2.1 Summary of Impacts to Water from Project Activities

Table 7-4 Risk Assessment for Water Related Assets

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
Potential Impacts during development and operations							
Drawdown of Permian groundwater levels as a result of dewatering/ drainage and mining operations.	Almost certain	Minor	High	Very few groundwater users and no 'at-risk' users identified near the study area. Mitigation includes a groundwater monitoring network (with vibrating wire piezometers (VWPs)) to allow for routine monitoring of water levels throughout project lifecycle. Make good approach will be applied as necessary. It is considered that the groundwater levels will recover in RHM, over time, to the base of the GRB mine complex open pits.	Almost certain	Insignificant	High
Drawdown of Quaternary / Tertiary groundwater levels) as a result of dewatering/ drainage and mining operations.	Likely	Minor	High	The model simulations assume fully saturated conditions in the Tertiary sediments and Quaternary alluvium and that these units are in hydraulic connection with the underlying confined aquifers. In reality, due to the short periods over which the aquifers are actually saturated, drawdown due to mining will be much less than predicted. Mitigation includes a groundwater monitoring network (with VWPs) to allow for routine monitoring of water levels throughout project lifecycle. Make good approach will be applied as necessary.	Likely	Insignificant	Moderate

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
Impacts on groundwater quality as a result of degassing/ drainage and mining operations.	Possible	Minor	Moderate	Baseline studies indicate groundwater quality is not fit for human consumption but is suitable for livestock. Any inadvertent mixing of groundwater during and post mining by induced downward movement from the upper to lower aquifers is unlikely to result in a deterioration of groundwater quality in the Permian aquifers. The groundwater quality within the aquifers surrounding the study area will be monitored to ensure no marked deterioration in groundwater is occurring as a result of the proposed mining activities. Any possible seepage and /or surface run-off is expected to be slightly alkaline and have low-to-moderate salinity following surface exposure. Overburden and reject materials are unlikely to generate acid given the lack of oxidisable sulphur content, excess acid neutralising capacity and existing alkaline pH of these materials. As the direction of groundwater flow will be towards the mine workings, the buffering capacity of the groundwater is expected to neutralise any oxidation products of the coal seams due to mine dewatering, and any potential for the development of acid mine drainage is low. During mine operation, groundwater quality within aquifers surrounding the mine areas will continue to be suitable for the same purposes applicable during the pre-mining period. Groundwater quality away from the influence of the project will not deteriorate as these resources will continue to receive recharge via the same processes that occurred pre-mining. As such, post-mining water quality within all aquifers surrounding the study area is expected to remain similar to pre-mining water quality.	Unlikely	Minor	Low

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
Additional Potential Impacts during development and operations							
Subsidence, as a result of longwall mining can cause fractures and joints in the overlying strata. Within the tensile zone above and adjacent to the longwall panels the vertical and horizontal strata permeability will be markedly and permanently altered due to sub-surface fracturing.	Almost Certain	Moderate	Extreme	Following the passage of longwall panels and stabilisation of subsidence, fracturing in the bulk of the strata will generally close up, allowing strata permeability to return to near to the pre-mining levels. Regular monitoring of subsidence impacts will be conducted.	Possible	Insignificant	Low
Gas Removal: new degassing drilling techniques developed for the project in which drilling has the potential to impacts on groundwater (water quality mixing, gas migration (pathways if not sealed correctly), and resulting in composite potentiometric heads) by creating potential pathways for leakage between formations.	Possible	Minor	Moderate	Standard gas drainage well construction techniques, including fully cased and grouted wells and undertaking cement bond logs, will minimise the potential for inter-aquifer transfer through the bore. The IMG water production dam, where groundwater removed during the IMG drainage will be temporarily stored en-route to the mine water management system, will be fully lined with an impermeable lining, removing the potential for seepage to groundwater. Any gas drainage wells will be designed and constructed in accordance with industry standards, with the goal of maintaining hydraulic isolation between discrete water-bearing formations, and will therefore inherently mitigate the risk of gas migration into overlying aquifers and/or releases at the surface. In addition, the integrity of the wellhead and casing will be monitored as part of normal operations.	Unlikely	Minor	Low
Sediment mobilised during construction activities may	Unlikely	Insignificant	Low	Permanent stormwater management systems should be installed as early as possible in the construction	Unlikely	Insignificant	Low

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
enter surface water runoff during rainfall events and discharge to watercourses leading to adverse effects on water quality. Sediment exposed or generated during construction may also be carried by wind into surface water bodies.				program. An erosion and sediment control plan should be prepared and executed. Diversion bunds should be constructed to divert clean water flows around the construction site where practical. Erosion and sediment control protection measures should be installed prior to the commencement of land disturbance activities. Erosion and sediment control structures should be regularly inspected and maintained. Topsoil should be stockpiled away from drainage lines to protect it from erosion by surface water runoff. Vegetation clearing and earthworks should not be carried out during heavy rainfall. Dust suppression measures should be implemented. Water from vehicle wash down areas should be treated to remove seeds, oils and other contaminants before reuse for dust suppression or other on site use or directed to the GRB mine water management system for reuse. For the flood protection levee, construction should take place in the dry season wherever possible and practicable and, if possible, the other flood protection should be in place before the first wet season. If the accommodation village is staged, clearing should be progressive and occur immediately before construction of each stage if practicable. For stream crossings, construction of linear infrastructure should be conducted in the shortest			

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
				possible time and in accordance with the *Guideline – Activities in a watercourse, lake or spring associated with mining operations* (NRM 2012). Wherever possible stream crossings will be constructed in low flow periods.			
Storage, handling and use of diesel and other hydrocarbons may result in releases to land or directly to watercourses. Releases to land may be mobilised to surface waters by stormwater flows. Water from vehicle wash down activities may also be contaminated with hydrocarbons. Sufficient quantities of hydrocarbons may result in toxic effects to aquatic plants and animals.	Unlikely	Moderate	Moderate	Measures in relation to fuel and chemical storage and handling, including refuelling will minimise likelihood of release to surface waters. Measures in relation to spill response will minimise likelihood of release to surface waters. Bunds and sumps should be emptied following rainfall events. Water and oily water from fuel and oil storage areas removed from bunds and sumps should be treated through an oil water separator and then reused for dust suppression or other on site use. Water and other contaminants from other chemical storage areas should be treated through on site wastewater treatment plants and then utilised in dust suppression or irrigated in accordance with the site EA. Refuelling is not to take place within 100 metres of the Isaac River and 50 metres of 12 Mile Gully and tributaries. Fuels, oils and other chemicals, including wastes contaminated with fuels, oils or other chemicals are not to be stored or placed within 100 metres of the Isaac River and 50 metres of 12 Mile Gully and tributaries. Vehicle wash downs should be located away from drainage lines or watercourses and water from vehicle wash down areas should be treated to remove seeds, oils and other contaminants before reuse for dust suppression or other on site use or directed to the GRB mine complex water management system for reuse.	Unlikely	Moderate	Moderate

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
Excavation works are required during the construction of the MIA and the drift portal. Dewatering of these excavations may be required following heavy rainfall. Poor management of this water may generate contaminated runoff with adverse impacts on receiving waters.	Unlikely	Insignificant	Low	Water removed from excavations and from dewatering groundwater from the drift will be pumped to the MIA dam, if this is in place or directly to the GRB mine water management system if the MIA dam is not in place. This water can then be reused as mine water.	Unlikely	Insignificant	Low
The water balance model results indicate that for 99 per cent of the time salinity concentrations downstream of the mine release would comply with the EA licence condition of 2,000 µS/cm with or without the addition of water from the proposed RHM. Addition of the RHM water slightly increases the salt levels in the receiving environment for around 1 – 6 per cent of the time, however, for 99 to 94 per cent of the time, the difference between salt levels in the receiving environment with and without the addition of RHM	Unlikely	Moderate	Moderate	Regular monitoring of water storage levels and water usage will be continued to be implemented. Continue water quality measurements and monitoring of uncontrolled releases to the downstream watercourses. Regular updates to the water balance model based on updated water extraction and usage.	Unlikely	Moderate	Moderate

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
water is negligible. This conclusion is based on the RHM generating a surplus. In fact, it is expected that in most years of operation, demand created by the Red Hill CHPP will exceed RHM dewatering volumes, and surplus water from the GRB mine complex will also be drawn on for RHM.							
Subsidence will create ponds of varying depths and permanence. Water quality in these ponds may become degraded during the dry season due to lack of flushing, concentration of salts through evaporation, and degradation by native, feral and grazing animals. These effects will be similar to those currently seen in ponds on watercourses throughout the study area and the wider region as water levels recede in the dry season. Ponded areas forming in subsidence troughs along 12 Mile Gully are predicted to be semi-permanent and therefore most at risk of containing	Almost certain	Insignificant	High	Depending on the extent of actual subsidence that occurs in this area, it may be necessary to drain these ponds. This will reduce the potential for water quality degradation within ponded areas and will also contribute flushing flows for 12 Mile Gully.	Likely	Insignificant	Moderate

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
degraded water quality in the dry season.							
Failure of water storages, storage embankments, pipelines, levees or bunds has the potential to result in releases of small to moderate quantities of mine water, with maximum possible release being 50 ML (MIA dam). Uncontrolled releases may cause localised scouring and erosion as well as contributing sediment and salt to receiving waters. Impact on water quality and aquatic ecosystems would depend on flow regime at the time of the release.	Possible	Minor	Moderate	Design mine water storages using a mine water balance model which considers all inputs and outputs which has run through a long-term period of climatic data to test storage capacities particularly in high rainfall wet seasons. Assess proposed mine water storages against *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams* (EHP 2012). If these are regulated structures, design, construction, operation and maintenance will comply with: • *Guideline Structures which are dams or levees constructed as part of environmentally relevant activities* (EHP 2013b) • *Code of Environmental Compliance for Environmental authorities for high hazard dams containing hazardous waste* (DERM 2009a). Design pipes and pump systems based on volume requirements predicted from mine water balance modelling and design and construct under the supervision of qualified professional engineers. Monitoring equipment is installed to monitor storage volume during operation and to prevent overfilling. Regular inspections of mine water storages, particularly in relation to integrity of embankment. Regular pipeline, drain, bund and levee inspections and maintenance.	Possible	Minor	Moderate

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
Erosion and sediment mobilisation from disturbed areas may degrade surface water quality. During the mining operation, there will be limited ground disturbing activity outside MIA and accommodation village areas which will be contained with stormwater systems, or the CHPP and conveyor areas which are within the GRB mine water management system. Souring of drains around the accommodation village may also contribute sediment load.	Unlikely	Insignificant	Low	Develop and implement an erosion and sediment control plan for any ground disturbing activities outside the existing mine and stormwater management areas. Conduct regular inspections of any drains and other features of stormwater management systems which are prone to scouring and proactively repair any damage identified.	Unlikely	Insignificant	Low
Chemical and fuels leaks may be mobilised by stormwater runoff with potential adverse impacts on water quality in receiving waters.	Unlikely	Moderate	Moderate	Secondary containment will be provided for all areas where liquid fuels and chemicals are stored or handled. Spill kits will be available at the MIA and CHPP and mobile spill kits will also be available at the location of IMG management infrastructure construction and well installation activities. Workers will be trained in the use of the spill kits to respond promptly to small and medium sized spills and in the proper collection of contaminated material. An incident report form will be completed for every fuel and chemical spill outside a bunded area. The report form will contain details on the location of the spill, type and quantity of material spilt and steps taken in initial response and follow up using BMA's "First Priority"	Unlikely	Moderate	Moderate

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
				system. Response to large fuel and chemical spills will be incorporated into the site emergency management plan and consultation undertaken with the Queensland Fire and Rescue Service in relation to spill response requirements and resources. A trained spill response team will be available. Bunds and sumps should be kept emptied following rainfall events. Water and oily water from fuel and oil storage areas removed from bunds and sumps should be treated through an oil water separator and then reused for dust suppression or other onsite use. Water and other contaminants from other chemical storage areas should be treated through onsite wastewater treatment plants and then utilised in dust suppression or irrigated in accordance with the site EA. Vehicle wash downs should be located away from drainage lines or watercourses and water from vehicle wash down areas should be treated to remove seeds, oils and other contaminants before reuse for dust suppression or other onsite use or directed to the GRB mine complex water management system for reuse.			
The potential loss of water resources that may occur via evaporation from waters ponded in the subsidence depressions depends on the geometry of the depression that captures water (particularly relationship between surface area and volume).	Almost certain	Insignificant	High	Depending on the extent of actual subsidence that occurs in this area, it may be necessary to drain these ponds. This will reduce the potential for water quality degradation within ponded areas and will also contribute flushing flows for 12 Mile Gully.	Likely	Insignificant	Moderate

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
The variation of the volume of ponded waters in subsidence voids over time will be responsive to rainfall, sub-catchment area, and corresponding runoff volumes draining into the subsidence void. When direct rainfall and runoff inflows into the subsidence voids exceed the storage capacity, the excess water will overflow and contribute to flow volumes in drainage paths and watercourses downstream.							
Potential Water Losses in Percolation through Surface Cracking. The amount and magnitude of surface cracking that occurs as a result of subsidence varies depending on the geological strata overlying the coal that has been extracted, geological structures, and notably depth below surface that coal has been extracted. In the majority of the subsided areas (generally in the middle of the panels where water is	Almost certain	Insignificant	High	Where surface cracks are small it is not anticipated that any intervention will be required. Where surface cracks are large, or occur where the terrain has a more distinct relief, intervention will need to be undertaken to remediate surface cracking. The typical remedial works would involve ripping the surface surrounding the cracks, regrading to a smooth surface profile, and revegetating the cracked areas. Where necessary fine (clay) materials may be brought in to ensure that suitably low permeability sediment is available to seal the cracks. Monitoring for surface cracking and proposed remediation measures and criteria will be specified in a subsidence management plan for the project. It is considered that the criteria to trigger intervention and remediation measures to seal cracks will be based on surface geology, particularly presence, or lack of, clays and loams and terrain conditions rather	Likely	Insignificant	Moderate

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
more likely to pond, it is unlikely that there will be tension cracks.				than a prescribed crack width. With this approach, the remedial works will target areas where there is greatest risk that cracks will not self-seal.			
Localised higher velocities and stream power are likely at the upstream end of the subsidence areas and un-subsided pillar areas, and lower velocities and stream power within the subsided panels. Erosion and sediment deposition were not simulated in the analysis and actual changes to stream power and velocity will become less marked as the waterways morphologically adapt to the subsided profile. For the less frequent (large to rare) events, the flood level elevation for the baseline and project conditions were compared to assess the impact of the project on flood levels in and upstream of the study area. The modelling results show that the project case would not increase flood levels for flood events in the range of 1 in 50 to 1 in 2,000 AEP. A potential minor increase in	Almost certain	Insignificant	High	Implement the environmental monitoring plan to monitor the stability of the Isaac River and 12-mile gully reaches affected by subsidence. Monitor areas of excessive erosion and implement erosion control measures if required.	Almost certain	Insignificant	High

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
flood levels of 100 to 200 millimetres is estimated for 1 in 10 and 1 in 20 AEP events in a localised area near the Red Hill MIA levee. This increase is not significant as flooding in these events is contained in the river channel and it will not impact on third party premises or other existing infrastructure.							

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
Geomorphologic impacts to Isaac River and 12-mile gully. Bed and bank instability. • Bed and bank instability through the natural reach of Isaac River. Further destabilisation of the Isaac River diversion. • Avulsion / meander cut-off leading to loss of existing river channel environmental values. Potential for change in system behaviour, multi channel system for a period of time. Accelerated input of suspended sediment that will be transported beyond the study area.	Almost certain	Insignificant	High	Implement toe of bank protection measures near upstream limit of subsidence. Bank protection measures already implemented over pillar zones through the natural reach of Isaac River at BRM will reduce the risk of bank erosion as a result of downstream deepening. These measures will continue as part of BRM and RHM impact management. Develop and implement a management strategy for the diversion that takes into account risks posed by the future RHM and BRM. The strategy will need to account for the potentially reduced sediment supply conditions that the future RHM is predicted to generate. High density vegetation cover should be maintained where potential for avulsion or cut off identified. Monitor these areas following flood events. Actions need to be consistent with the panel catchment management component of the subsidence management plan for ponding and overland flow. Earthworks such as broad fill areas within the panel which mitigate avulsion risk pathways to be considered as part of subsidence management plan. A meander cut off of Isaac River in RH205 (upstream subsidence trough) is highly likely. Given the location, this should be allowed to occur and managed to minimise any potential negative impacts (none foreseen).	Almost certain	Insignificant	High
Potential Impacts Post-Mining							
Long term impacts on Groundwater Levels	Almost Certain	Minor	High	Typically, the mine workings will fill up and groundwater levels will recover over time. The groundwater system will readjust to the new (altered and enhanced) aquifer conditions surrounding and within the mined area with some localised changes to pre-mining characteristics.	Likely	Minor	High

Potential Impact	Pre-mitigated Risk			Mitigation / Adaptation	Residual Risk		
	Likeli-hood	Conse-quence	Risk		Likeli-hood	Conse-quence	Risk
				Groundwater levels and piezometeric pressures within the regional aquifers will, over time, attain a new equilibrium level. This new equilibrium for the groundwater system will have a different potentiometric surface from that which was present pre-mining, owing to the presence of the old workings and the different hydrogeological parameters of the goaf. Groundwater levels are expected to recover within RHM after closure during the continued operation of GRM, and further work will need to be undertaken throughout the GRM mine life to determine the hydrological regimes, and the expected water quality of the mine voids. It is considered that the groundwater levels will recover in RHM, over time, to the base of the GRB mine complex open pits. Mitigation includes a groundwater monitoring network (with VWPs) to allow for routine monitoring of water levels throughout project lifecycle.			
Impacts on groundwater quality are expected to include a rise in the groundwater salinity within the RHM void may occur as a result of atmospheric weathering of the exposure of wall, roof and floor rock during mining.	Possible	Moderate	High	Any increase in groundwater salinity is expected to be minor compared to the natural salinity of the groundwater in the Permian formations. Current and previous geochemical analysis in the Moranbah Coal Measures lithology show that there is low acid generation potential, thus there is a low risk that metals will be mobilised into the groundwater. Mitigation includes a groundwater monitoring network to allow for routine monitoring of water quality throughout the project lifecycle. Post-mining water quality within all aquifers surrounding the study area is expected to remain similar to pre-mining water quality.	Possible	Insignificant	Low

7.3 Mitigation Measures

7.3.1 Groundwater

7.3.1.1 General Groundwater Monitoring Program

A network of groundwater monitoring bores has been installed around the study area. Further groundwater monitoring bores are to be installed down-gradient of mine water and waste storage facilities with locations to be determined after finalisation of the site layout. These monitoring wells will be maintained to enable the long term monitoring of groundwater levels and groundwater quality, as well as to provide data for updates of the groundwater model.

Regular monitoring during the mining operation will provide early warning of any variation in response of the groundwater system to that predicted. This will enable BMA to undertake mitigation measures to minimise impact on surrounding groundwater users and the environment, such as the implementation of make good measures. In addition, the groundwater monitoring will enable the identification of any cumulative groundwater level drawdown impacts as a consequence of other mining operations in the area.

The monitoring bores are required to be completed in accordance with the Minimum Construction Requirements for Water Bores in Australia (Land and Water Biodiversity Committee 2003); the *Water Act 2000* and undertaken by licensed water bore driller. They must be surveyed for elevation levels of ground surface and monitoring measurement point to allow future groundwater levels to be measured to a consistent, known, datum and allow groundwater sampling as required.

Groundwater level and quality monitoring will be undertaken regularly to enable the detection of seasonal fluctuations and any groundwater level or quality trends or impacts. In turn, the monitoring data (level and chemistry) will be entered into a BMA environmental monitoring database to enable a regular assessment and interrogation to evaluate potential groundwater impacts.

A groundwater monitoring network and program will be developed and implemented to detect any marked change to ground water quality values due to activities that are part of the project. This will be consistent with the current suitability of the groundwater for agricultural use (stock watering), limited domestic use, and any discharge to surface waters that may occur after significant wet weather events.

Prior to commencement of mining at the proposed RHM, at least 12 groundwater monitoring events will be undertaken, across wet and dry seasons for at least two years to determine background groundwater quality as far as practicable in order to determine groundwater contaminant and trigger limits for comparison to the EPP (Water) groundwater quality objectives for the Isaac River sub-catchment (zone 34). The monitoring events will record:

- groundwater levels; and
- groundwater quality with analysis of the parameters: - pH, EC, TDS, major cations and anions, nutrients (total nitrogen, nitrous oxides, ammonia, phosphorous), selected dissolved metals (aluminium, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, and zinc), and total petroleum hydrocarbons (for bores monitoring potential fuel spill / seepage sources).

In addition, continuous groundwater level monitoring will be conducted across at least two wet and dry seasons using vibrating wire piezometers automatically recording water levels at least every 12 hours.

On completion of monitoring, groundwater trigger levels, based on the 85th percentile value of groundwater quality results and groundwater contaminant limits based on the 99th percentile of groundwater quality results will be determined.

During mining operations, groundwater monitoring will continue, including:

- Monitored of groundwater levels in standpipe monitoring bores and VWPs automatically with at least one reading every 48 hours.
- Groundwater quality sampling undertaken at least once very wet season and once every dry season with analysis of the parameters: - pH, EC, TDS, major cations and anions, nutrients, selected dissolved metals (aluminium, arsenic, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium and zinc), and total petroleum hydrocarbons (for bores monitoring potential seepage sources).
- Additional monitoring in one or more bores may be undertaken in the event of a significant spill of fuels or other contaminants with potential to cause groundwater contamination.
- Measurement of daily precipitation, evaporation, and gas drainage and mine dewatering volumes will be undertaken through operations.

Groundwater monitoring and sampling will be conducted by a suitably qualified and experienced professional in accordance with the current edition of the NRM Water Quality Sampling Manual, or subsequent updated versions; and the AS/NZS 5667.11:1998 Australian/New Zealand Standard for water quality – sampling Part 11; guidance on sampling groundwater.

Monitoring data (level and chemistry) will be entered into a BMA environmental monitoring database to enable a regular assessment and interrogation to evaluate groundwater trends.

If groundwater quality results exceed trigger levels set out in the EA, monitoring will be repeated within 60 days. If concentrations exceed trigger levels in the second sampling event then an investigation into cause, optimum response, and the potential for environmental harm must be conducted and mitigation measures developed and implemented to address the outcome of the investigation.

An annual review of the monitoring program will be conducted by a suitably qualified and experienced hydrogeologist. This annual review of the monitoring program will be conducted to evaluate the effectiveness of each monitoring location, to assess where new locations and modifications to the monitoring program may be needed, and to evaluate impacts that may be occurring. These data will, on a regular basis (no longer than three years), be used to validate model predictions.

Post-mining groundwater monitoring will be subject to detailed closure/relinquishment conditions. It is expected that during the operational phase of the project, the groundwater data collected for the region will be comprehensive enough to accurately predict the long term recovery of the aquifers. This will assist in the development and implementation of the closure strategy and the refinement of post-mining groundwater monitoring programs.

7.3.1.2 Impacts on Nearby Groundwater Users

While groundwater model predictions do not indicate any significant impacts on adjacent groundwater users, should a detrimental impact on landholder groundwater supplies be detected, and shown to be related to the project operations, then BMA will seek to reach mutually agreeable arrangements with affected neighbouring groundwater users for the provision of alternate water supplies. To this end, BMA will update its groundwater census of bores on properties within the predicted drawdown cone prior to commencement of mining, and enter into make-good agreements with landholders specifying trigger levels and appropriate responses.

Regular groundwater monitoring will enable groundwater level drawdown to be identified prior to any impacts being experienced in surrounding landholder bores. In turn, alternative water supplies can be put in place before supplies from relevant existing landholder bores are adversely affected. Options for alternate supplies include:

- installations of new pumps capable of extracting groundwater from greater depth within existing bores;
- deepening of existing bores;
- installation of a new bore at another location on the property; and/or
- provision of piped water sourced from the mine (i.e. surplus water from the gas depressurisation program, depending on quality).

The specific arrangements for affected properties will be discussed with each relevant landholder with a view to reaching a mutually acceptable agreement.

7.3.1.3 Seepage from Stockpiles and Surface Water Control Structures

Good environmental practice requires that reasonable effort be made to minimise seepage from stockpiles and surface water control structures wherever this may affect the groundwater system. All mine water storages will be constructed in accordance with the NRM (2002) dam guidelines. These guidelines include requirements for management of seepage from mine water storages.

The surface water runoff collection system from the MIA and CHPP will be managed as a non-release system with water stormwater returned to the mine water management system. Raw and product coal stockpiles will be contained within hardstand or compacted areas and drainage will be directed to the mine water management system.

Early detection of significant seepage will enable management of any potential problems. Potential seepage from the project surface water management system (such as the IMG water production dam for gas drainage works) and stockpile (coal product or waste) areas will be regularly assessed through the installation and monitoring of the monitoring bore network on-site, including down-gradient of all potential seepage sources. Management of surface water will include monitoring of water at selected locations for potential contaminants.

Installation of monitoring bores down-gradient of potential seepage sources is proposed to enable early detection of any leachate entering the shallow Quaternary alluvial or Tertiary sediment aquifers. The key indicator parameters of seepage will be monitored including (but not restricted to) standing water level, salinity (as TDS), dissolved metals, and major ions initially on a quarterly basis.

In the unlikely event of groundwater impact, mitigation strategies will include some or all of the following measures (depending on the specific requirements):

- investigation of water management system integrity;
- removal of contaminant source and repair / redesign of any water management structures as required;

- installation of and pumping from, groundwater interception wells; and/or
- installation of and pumping from groundwater interception trenches.

7.3.1.4 Installation of Gas Drainage Bores

Any gas drainage wells will be designed and constructed in accordance with industry standards, with the goal of maintaining hydraulic isolation between discrete water-bearing formations, and will therefore inherently mitigate the risk of gas migration into overlying aquifers and/or releases at the surface. In addition, the integrity of the wellhead and casing will be monitored as part of normal operations.

7.3.2 Surface Water

7.3.2.1 Mitigation of Potential Geomorphologic Impacts

Mitigation and management strategies for subsidence that have already been implemented for BRM downstream of RHM revolve around the principles of adaptive management. The outcomes of the successes and learnings from those management strategies can be applied to the management approach for the future RHM. The principles of adaptive management are:

- assess the risk;
- design operational treatments (mitigation measures);
- implement treatments;
- monitor key response indicators;
- re-evaluate effectiveness of implemented mitigation measures; and
- adjust policies and/or practices.

The adaptive management approach for the geomorphological impacts accommodates the complexity involved with river processes, including the high variability of flow events and river response to management intervention. Mine plans are also known to change with time as will the nature and amount of subsidence, as it is highly dependent on strata and depth of extraction. The plan will be a combination of short and long-term measures aimed at creating a self-sustaining, healthy functioning waterway through the RHM suitable for relinquishment of management responsibility at or before life of mine.

Monitoring points will be established at areas of predicted risk such as pillar zones and main headings to capture response to subsidence and the performance of any management works. The monitoring program will include geomorphic and riparian vegetation data collection at fixed monitoring points, interpretation of processes (with the assistance of survey data) and evaluation of the performance of mitigation management works. Identified issues and management actions captured by the monitoring program will be evaluated on an annual basis following annual monitoring data collection and management recommendations.

Additional monitoring may also include ongoing evaluation of sediment supply to the RHM and downstream reaches by remote and/or on ground means and establishment of gauging stations at new mine plan/lease boundaries.

In the longer term it is likely that management of subsidence impacts and existing condition issues for the waterways will involve creating self-sustaining waterways that have the resilience to cope with 1st and 2nd order impacts, promote potential to maintain the positive impacts of subsidence on river health and removes the reliance on structures which are likely to require ongoing maintenance for stability. The monitoring and management program will also include 3rd and 4th order impact considerations and likely broader cumulative impact aspects.

The components of a subsidence management plan are typically:

- ongoing subsidence monitoring, evaluation, review and improvement program; and
- managing bed and bank stability;
- vegetation management;
- panel catchment management, including rehabilitation of subsidence cracking; and
- infrastructure protection or relocation where necessary.

A subsidence management plan will be developed for the project. Consideration will be given to an unpublished draft guideline under development by the NRM (and subsequent authorised versions) and learnings from management at BRM. The subsidence management plan will be updated regularly as part of the adaptive management response.

7.3.2.2 Mitigation of Potential Percolation through Surface Cracks due to Subsidence

Where surface cracks are small it is not anticipated that any intervention will be required. Where surface cracks are large, or occur where the terrain has a more distinct relief, intervention will need to be undertaken to remediate surface cracking. The typical remedial works would involve ripping the surface surrounding the cracks, regrading to a smooth surface profile, and revegetating the cracked areas. Where necessary fine (clay) materials may be brought in to ensure that suitably low permeability sediment is available to seal the cracks. Monitoring for surface cracking and proposed remediation measures and criteria will be specified in a subsidence management plan for the project. It is considered that the criteria to trigger intervention and remediation measures to seal cracks will be based on surface geology, particularly presence, or lack of, clays and loams and terrain conditions rather than a prescribed crack width. With this approach, the remedial works will target areas where there is greatest risk that cracks will not self-seal.

With the implementation of these mitigation measures, it is anticipated that the losses of surface water resources via percolation through subsidence surface cracking will be insignificant.

7.3.2.3 Mitigation of Ponded Areas due to Subsidence

There is potential to mitigate the loss of flow due to ponding in subsidence voids by undertaking drainage works to partially drain some of the voids created by subsidence. However, the works required to drain subsidence voids also introduce further potential for adverse environmental impacts due to the degree of physical landscape disturbance required to construct the drains, and potential on-going instability of erosion of the drainage lines and, therefore, is only considered where modelling indicates significant hydrological or other impacts.

The works that would be required to completely drain the subsidence voids to a point of no ponding (i.e. free draining landscape) would be very extensive and would represent a large and potentially unnecessary degree of physical disturbance and potential on-going instability well beyond mine closure. The need or desire to completely drain subsidence voids is not considered sufficient to warrant such a degree of disturbance, relative to the benefit that would be achieved for downstream watercourse flows. Hence, modelling was undertaken to determine a potential mitigation case for partial drainage of some of the larger ponds.

It is desirable to consider a balanced approach between the degree of physical disturbance required to create drains and the benefit obtained for flows to the downstream waterways. In general, the potential subsidence ponding mitigation considers partially draining some of the large subsidence voids. An example is if a subsidence void is up to five metres maximum depth, a drain would be cut to drain the top 2.5 metres, so the maximum ponding depth would be 2.5 metres.

An assumed potential mitigation case allows for partial draining of the voids to reduce maximum ponding depths to between 2 and 2.5 metres. With implementation of this mitigation option, the maximum total potential subsidence ponding of all voids in the 12 Mile Gully catchment would reduce to approximately 1,900 ML compared to 5,200 ML in the case with no mitigation.

The potential mitigation of partially draining some of the larger voids was reassessed in the hydrological model. The assessment indicated for the mitigated case, the mean annual flow from 12 Mile Gully into the Isaac River would be approximately 3,200 ML/year and represents a loss of approximately 1,200 ML/year (or approximately 30 per cent of the baseline mean annual flow).

When considered in the context of ’whole-of-project’ impacts (including the predicted 700 ML/year increase in mean annual flow from Eureka Creek), the net impact to the mean annual flow in the Isaac River would be a net loss of approximately 500 ML/year. This represents approximately one per cent of the mean annual flow of the Isaac River and is not significant.

7.4 Residual Risk

Potential residual surface water risks include:

- The levee for the project should be sized in accordance with regulatory requirements: minimum of 1:1,000 AEP plus 0.5 metre freeboard. There is a residual risk that a larger (less frequent) flood event could overtop the levee and inundate the MIA and underground areas. The risks to loss of life should be relatively low since the floodwaters should rise relatively slowly (hours to days).
- If a levee is used to provide flood protection for the MIA and mine access, subsidence of longwall panel RH103 will affect the levee by subsiding the embankment up to a maximum of six metres. The impacts to the physical integrity of the levee embankment may include reduced stability of the embankment in that section and increased risk of internal erosion failure (piping through embankment or foundation) due to cracking of the levee or the levee foundations. The crest level of levee embankment after subsidence would significantly reduce the flood immunity and would need to be reinstated back to design flood level requirements. Several options exist and would need to be evaluated in advance of planned subsidence of panel RH103.

Section 08 Cumulative Impacts

8.1 Regional Overview

Other nearby development projects relevant for the cumulative impact assessment in region were considered to include:

- projects within the envisaged sphere of influence of the project, as listed on the Department of State Development, Infrastructure and Planning website that are undergoing assessment under the *State Development and Public Works Organisation Act 1971* for which an Initial Advice Statement (IAS) or an EIS are available; and
- projects within the envisaged sphere of influence of the project, which are listed on the website of the Department of Environment and Heritage Protection (EHP) that are undergoing assessment under the EP Act for which an IAS or an EIS are available.

Projects currently undergoing assessment or having recently completed assessment under these processes and included in the cumulative impact assessment for the project are listed in **Table 8-1** and presented in **Figure 8-1**.

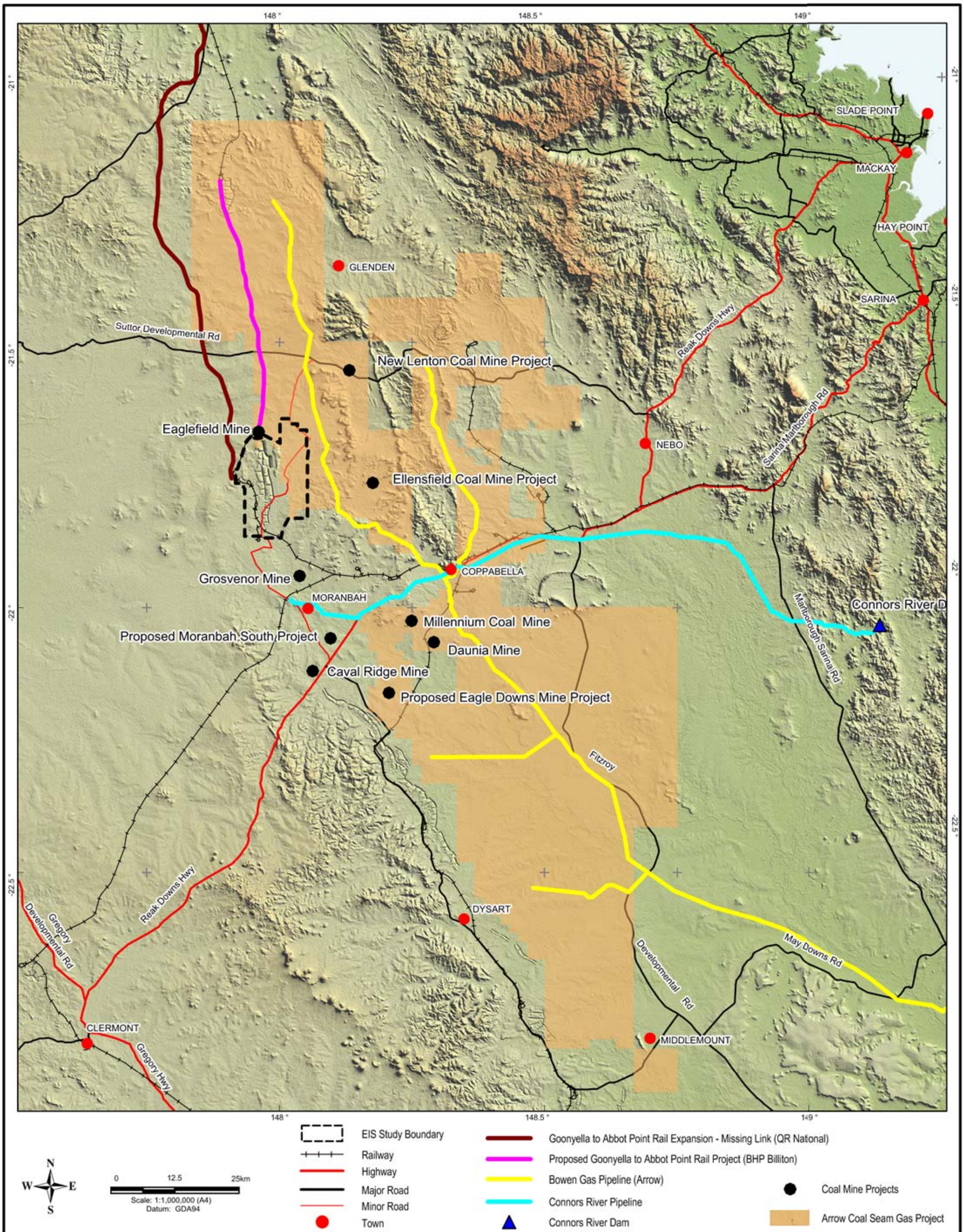
Table 8-1 Projects Considered in the Cumulative Impact Assessment

Project - Proponent	Description	EIS Status	Relationship to Red Hill Project	
			Timing	Location
Eaglefield Coal Mine Expansion-Peabody	Expansion of existing open-cut mine from 5 to 10.2 mtpa. Construction workforce will be 650 and the operational workforce will be 700. Construction is expected to start in 2012 with a 22 year mine life. Accommodation will be at on-site facilities. Coal will continue to be exported to Dalrymple Bay via existing rail infrastructure.	EIS assessment report	May have overlapping operational phases with the construction and operations of the GRM incremental expansion and the RHM underground expansion option.	Abuts the northern boundary of the Goonyella Riverside Mining lease. Drains to Goonyella Creek sub-catchment.
Ellensfield Coal Mine Project – Vale	New underground coal mine to produce 5.5 mtpa. Development also includes an on-site gas fired power station (8 to 20 MW). Construction workforce will be 160 and the operational workforce will be 280. Accommodation will be at Coppabella or Moranbah. Timing for commencement unknown.	EIS assessment report	May have overlapping operational phases with the construction and operations of the GRM incremental expansion and the RHM underground expansion option.	121 km to the west of the EIS study area May utilise the same transport networks Located within the Isaac River sub-catchment.

Project - Proponent	Description	EIS Status	Relationship to Red Hill Project	
			Timing	Location
Grosvenor Coal Mine Project – Anglo Coal	Greenfield underground mine to produce up to 5 mtpa. Construction and operation workforces will both be approximately 500 persons. Construction will commence in 2012 with full production by 2015. Workforce accommodation 25% in Moranbah and 75% remote workforce.	EIS process completed	Likely to have overlapping construction and operational phases with the proposed project.	9 km to the south of the EIS study area. Land surface drains to the Isaac River. May utilise the same transport networks and will locate workers and accommodation facilities at Moranbah.
New Lenton Coal Mine Project – New Hope	Greenfield open-cut and underground mine to produce 5 mtpa. Construction workforce will be 300 with an operational workforce of 200. Construction commencement not known.	IAS available. EIS lodgement proposed 2014	May have overlapping operational phases with the proposed project.	15 km to the north-east of the EIS study area. Within Isaac River sub catchment.
Eagle Downs Coal Mine Expansion - Aquila	Greenfield underground mine to produce 7 mtpa. Construction workforce will be 360 and operational workforce will be 570. Workforce to be accommodated at accommodation facilities in and around Moranbah. Construction commenced in 2013 and first coal is expected in 2015.	EIS process completed	Likely to have overlapping operational phases with the project.	39 km to the south-east of the EIS study area. May utilise the same transport networks and may locate workers at Moranbah. Located within the Isaac River sub-catchment.
Caval Ridge Coal Mine Project - BMA	Greenfield open-cut mine to produce 5 mtpa. Construction workforce will be 1760 with an operational workforce of 500. Remote workforce to be accommodated in single worker facilities. Construction commenced in 2012 with full production by 2014.	EIS process completed	May have overlapping operational phases with the construction and operations of the GRM incremental expansion and the RHM underground expansion.	29 km to the south of the EIS study area. May utilise the same transport networks. Within Isaac River sub-catchment.
Daunia Coal Mine Project - BMA	Greenfield open-cut mine to produce 4.5 mtpa. Construction workforce will be 1000 with an operational workforce of 450. Remote workforce to be accommodated in the Coppabella Accommodation Village. Construction commenced in 2009 with full production achieved in 2013.	EIS process completed	May have overlapping operational phases with the construction and operations of the GRM incremental expansion and the RHM underground expansion option.	36 km to the south-east of the EIS study area. May utilise the same transport networks. Within Isaac River sub-catchment.

Project - Proponent	Description	EIS Status	Relationship to Red Hill Project	
			Timing	Location
Millennium Coal Mine - Peabody	Expansion of an existing open-cut coal mine from 2 to 5.5 mtpa. Construction workforce of 627 with an additional operational workforce of 160. Accommodation for both construction and operational workforces to be at the Coppabella work camp on a remote workforce basis. Construction commenced in 2012 with full production by 2015.	EIS completed	May have overlapping operational phases with the construction and operations of the GRM incremental expansion and the RHM underground expansion option.	30 km to the south-east of the EIS study area. May utilise the same transport networks. Within Isaac River sub-catchment.
Moranbah South Project – Anglo Coal and Exxaro Australia Pty Ltd	Greenfield underground mine to produce 18 mtpa. Construction commencement not known.	EIS lodged, public notice period completed	May have overlapping construction and operation phases with the GRM incremental expansion and the RHM underground expansion option.	28 km to the south of the EIS study area. May utilise the same transport networks. Within Isaac River sub-catchment.
Connors River Dam and Pipeline – Sunwater (deferred)	Water supply dam on the Connors River and a water supply pipeline from the dam to Moranbah to service coal mines and communities in the Bowen Basin. Construction workforce will be 250 for the dam and 300 for the pipeline. There will be accommodation at an on-site construction camp. Project has been deferred.	EIS completed	May have overlapping construction and operation phases with the project. Dam construction will be remote from the proposed project with minimal impact. Pipeline construction will be short term.	Pipeline passes within 13 km to the south of the EIS study area. Dam is located in the Connors River subcatchment, approximately 10 km south of the EIS study area.
Goonyella to Abbot Point Rail Expansion Project – Aurizon	70 km long stretch of new rail, linking the Goonyella system to the Newlands system. Construction commenced in 2011, and was completed in 2012.	Complete	Operational overlap with the construction and operations of the GRM incremental expansion and the RHM underground expansion option.	Southern end is adjacent to GRM and 0.7 km from the EIS study area.

Project - Proponent	Description	EIS Status	Relationship to Red Hill Project	
			Timing	Location
Bowen Gas Pipeline – Arrow Energy	Construction of an approximate 580 km of pipelines and associated infrastructure, which will convey coal seam gas (CSG). Construction commencement not known. Construction workforce of approximately 700, commissioning and decommissioning workforce of 10, and operations workforce of 15.	EIS completed	May have overlapping construction and operational phase with the GRM incremental expansion and the RHM underground expansion option. Operational impacts not significant at a local or regional level.	Runs to the east of the EIS study area at a distance of 3 km at its closest point.
Bowen Gas project – Arrow Energy	Development of approximately 7,000 CSG production wells over an approximate 35 to 40 year life. Much of the gas produced by the Bowen Gas Project will be piped to the proposed Curtis Island LNG Plant. Construction commencement not known.	EIS lodged and supplementary EIS being prepared	Operational impacts will be managed as part of a co-development agreement with Arrow Energy.	CSG infrastructure to extend north to south from Glenden to Blackwater covering the majority of MLA70421.



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RED HILL MINING LEASE
IESC REPORT

PROJECTS CONSIDERED IN THE CUMULATIVE IMPACT ASSESSMENT

URS

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Figure: **8-1**

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8.2 Cumulative Risk Assessment

8.2.1 Surface Water Resources

8.2.1.1 Water Quality

The project is located just inside the catchment boundary for the Isaac River, which is a major tributary within the Fitzroy basin. The Fitzroy basin is the largest catchment in Queensland draining into the Pacific Ocean and also the largest catchment that drains to the Great Barrier Reef, although it does not contribute significant freshwater flows to the coastal environment when compared to river systems further north.

In 2008, the Queensland Government commenced an investigation into the cumulative effects of coal mining in the Fitzroy River basin on water quality (EPA 2009). The investigation found that:

- There were inconsistencies in discharge quality limits and operating requirements for coal mine water discharges as imposed through EAs.
- In some cases, discharge limits and operating conditions of coal mines were not adequately protecting downstream environmental values.

These conclusions led to a number of inter-related actions by Queensland Government and other stakeholders:

- WQOs were developed for the Fitzroy basin and added to Schedule 1 of the EPP (Water) in October 2011.
- Model water conditions were developed for coal mines in the Fitzroy basin (EHP 2013a, Version 4). These model water conditions are designed to manage water discharges to meet the water quality objectives set out in the EPP (Water) and to provide consistency between mining operations in the Fitzroy basin.
- EAs for a number of mining operations were amended to introduce conditions consistent with the model water conditions.
- A number of mining operations entered into Transitional Environmental Programs (TEP) under the EP Act. These TEPs were focussed on actions that would allow mines to achieve compliance with new EA conditions and upgrade operating conditions.

With these measures in place, a strong strategic and policy framework is now in place for management of cumulative water quality impacts from mining activities. This framework allows for management of individual mining activities in such a way that overarching water quality objectives can be achieved.

Mine water from the proposed RHM and Broadmeadow extension will be managed through the existing GRB mine complex water management system as this allows water to be reused in coal handling and preparation. The EA EPML00853413 (formerly MIN100921609) for the GRB mine was amended to bring it into line with the model water conditions, with discharge conditions and in-stream trigger levels aligned with water quality objectives in the EPP (Water). Using a mine water balance model, an analysis has been undertaken of the effect of water from the proposed RHM on the ability of GRB mine complex to maintain compliance with EA conditions (**Section 6.2**). This analysis indicates that the addition of mine water from the RHM makes no difference to the compliance profile for GRB mine complex and is negligible in terms of salt load to the Isaac River.

While the then Environmental Protection Authority (EPA) cumulative impact assessment of mining in the Fitzroy Basin (2009) focussed on salinity as the key water quality issue related to mining activities, surface disturbance associated with mining activities can result in erosion and increased sediment levels in surface waters. The Great Barrier Reef outlook report also identified that the Fitzroy Basin contributed one of the highest sediment loads to the reef, largely attributing sediment loads to use of land for agricultural activities (GBRMPA 2009). Water quality data presented in **Section 4.3.2** indicates that suspended solids and turbidity in the upper Isaac River and local tributaries are in excess of water quality objectives and hence, cumulative assessments must consider additional sediment inputs.

The water quality assessment undertaken for the project has identified that sediment inputs can be controlled through drainage, erosion and sediment control measures. Depressions created by subsidence in tributaries to the Isaac River (e.g. 12 Mile Gully) will tend to trap sediment and mitigation through allowing positive drainage will reduce the trapped sediment volumes. Depressions created by subsidence in the Isaac River will also tend to trap sediment until the depressions are in-filled (a matter of decades) and while this will mitigate effects of any erosion across the mine footprint, it is unlikely to create a significant reduction in sediment load in the lower Isaac River and Fitzroy system. On this basis, the proposed project is not expected to make any significant contribution to cumulative sediment loads in the Fitzroy River Basin.

Given that the GRB mine complex water releases are being managed within an overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine water from the project is expected to have negligible cumulative impact on surface water quality and associated environmental values.

8.2.1.2 Subsidence

In 2009, the then DERM, BMA and Anglo Coal undertook a cumulative impact assessment of the combined effects of subsidence of the BRM (BMA) and Moranbah North mine (AAMC) (Alluvium 2009).

The Isaac River Cumulative Impact Assessment (IRCIA) developed and quantified impacts from subsidence and associated geomorphic response of the Isaac River across all the existing and proposed underground mine plans that were planned to extend beneath the Isaac River as they were known in 2007. The IRCIA included a superseded mine plan for the Red Hill Mining Lease, hence findings of the assessment remain relevant for the proposed RHM. Overall, plans to subside approximately 28 kilometres of the Isaac River channel were included with approximately 60 longwalls extending beneath the river. The maximum predicted subsidence addressed in the IRCIA was approximately three metres.

The IRCIA identified that while there is potential for impacts on the Isaac River as a result of mine related subsidence, none were determined to be significant in terms of instigating long term large scale geomorphological change. Subsidence voids in the river channel based on the then current mine plans when considered on a reach scale were predicted to have close to 50 per cent or greater probability of infilling during the period of mining. Overall, subsidence voids were predicted to be infilled within 20 years after the cessation of mining on the Isaac River unless there is a substantial reduction of sediment inputs from the Isaac River catchment. Within the mining period however, risks were identified to bed and bank stability along the 28 kilometre reach considered, such as potential for river bed deepening of up to 1.8 metres and subsequent widening through bank erosion. Such impacts are presently being managed for existing mining operations at the local scale with soft engineering solutions such as timber pile fields and vegetation being implemented at BRM and Moranbah North mine.

While the current mine plan for RHM includes a different configuration of longwall panels, and potentially a greater depth of subsidence, the overall findings of the IRCIA remain relevant. The length of time within which subsidence troughs along the Isaac River can be expected to fill in will potentially increase from the IRCIA predictions because of the increased subsidence depth, however there is still a moderate probability that these troughs will infill during the life of the mine. Geomorphic effects are not significantly different.

BMA and Anglo Coal are currently engaging with Queensland Government agencies in relation to updating the IRCIA to take into account current mine plans for underground mines. This will include the current plans for RHM.

8.2.1.3 Flooding

A flooding assessment of the project was undertaken to model existing structures that may affect flood behaviour as well as structures proposed for the project. There are no known projects in the planning or development phase that might result in additional structures on the floodplain in the vicinity of the project. Cumulative impacts on flooding are not expected to lead to any adverse impacts on human populations, property or other environmental or social values.

8.2.1.4 Surface Water Flows

The major influence on water flows in the Isaac River is the Burton Dam, located upstream of the Red Hill Mining Lease. The Connors River Dam on the Connors River will also influence flows in the McKenzie River below the confluence of the Isaac River once it is operational. Both projects have been addressed in water resource planning as documented through the Water Resource (Fitzroy Basin) Plan 2011. There are no other major storages on the Isaac River. In Queensland, the water resource planning process focussed on balancing water extraction and use with protection of ecosystems and takes into account cumulative impacts from major water storages and extraction.

The project does not require any additional raw water allocations and therefore does not contribute to cumulative impacts in relation to extraction of surface water resources.

Depressions created by subsidence will trap overland flow and in-channel stream flows until such time as sediment carried by these flows in-fills the depressions, which is estimated to occur over a matter of decades for the Isaac River. For the 12 Mile Gully tributary, sediment load is lower and permanent ponds are expected to arise. These will retard flows in 12 Mile Gully and discharges from 12 Mile Gully to the Isaac River. Assessment has indicated that there will be no measurable change in water resources when considered against flow objectives established in the Water Resource (Fitzroy Basin) Plan 2011, however some localised effects may occur. Mitigation measures have been proposed to lower the water levels in subsidence troughs by creating overflow channels, if necessary, with the requirement for this to be determined post-subsidence. In any case, the proportion of water that may be retained is negligible when considered against environmental flow objectives in the Isaac River and is unlikely to make any measurable difference at downstream nodes. Given that mitigation measures are available to address the reduction in flow associated with containment of water in subsidence troughs, cumulative impacts on flows in the Isaac River and downstream rivers are not expected.

8.2.2 Groundwater

Cumulative impacts to groundwater resources have been assessed considering other coal mining operations in the immediate vicinity of the project. The project will increase impacts on the available groundwater resources within the study area by increasing groundwater extraction via mine dewatering and IMG drainage.

Groundwater in the area is limited (quality and quantity) and aquifers are compartmentalised by regional faults. This limits potential for regional-scale drawdown effects and also limits the extent to which existing users may be impacted by cumulative impacts.

Dewatering activities from the coal mining projects proximal to RHM will have varying impacts on regional groundwater levels in the region depending on mine plans, schedule, and IMG management requirements. Due to the low permeability nature of the Moranbah Coal Measure coal seams, marked alterations to groundwater levels (drawdown) are relativity restricted proximal to the mining areas, as recognised during the bore census which showed measurable groundwater levels adjacent to the existing GRB mine complex and the predictive modelling of the proposed RHM mining activities. Predictive modelling projects drawdown impacts limited to a zone of around four kilometres from the proposed mine. Based on the uniformity of the geology and that all coal mining proximal to the project target the same coal measures, the extent of drawdown around existing mines is considered to be on a similar scale.

The impact of additional mines, adjacent and along strike, where predicted drawdown cones overlap can result in an increase in the drawdown in groundwater level based on the principal of superposition. This depends on mine schedules as dewatering and limited recharge can result in new mine workings, within existing drawdown cones intersecting limited remaining groundwater resources. Mine dewatering impacts are, thus, recognised to have the largest impact immediately adjacent to the mining (the poor aquifer potential of the Permian units limit the extent of drawdown).

The extent of the drawdown cones is governed by the hydraulic conductivity. Dewatering impacts (drawdown cones) are predicted to elongate north and south, within the more permeable units (the coal seam aquifers). The cumulative impact of adding the additional mine dewatering will result in further elongation along strike.

The cumulative impacts to groundwater resulting from the project and the existing mining operations in the vicinity (GRM, BRM, Moranbah North, and North Goonyella Mine) were assessed based on the conceptualisation of multiple mines, as discussed above. The proposed RHM is located down-dip of GRM and down-dip and along strike of BRM. Moranbah North and North Goonyella Mine are located south and north respectively along strike within the Moranbah Coal Measures relative to the proposed RHM.

The additional impact of the RHM will be to increase drawdown in the Moranbah Coal Measures east of GRM and to the north east of BRM. This additional drawdown (model projected five metre drawdown extent in the target seam) will extend to approximately four kilometres from the RHM underground footprint, encompassing part of the GRM and BRM mines to the west and southwest.

After mining is completed, the groundwater system will re-adjust to the new aquifer conditions created through mining (i.e. alteration due to goaf). Groundwater levels and piezometeric pressures within the regional aquifers will, over time, attain a new equilibrium level. The rate of groundwater level recovery will be slowed due to the ongoing mining operations at GRM.

As drawdown of five metres below steady state conditions (drawdown identified to have marked impacts on bore yields) is only predicted to extend some four kilometres from the RHM footprint, coal mines further along strike within the Moranbah Coal Measures (Grosvenor, Caval Ridge, and Eagle Downs) are outside of the RHM impact area. Other coal mines further from the study area (Ellensfield, New Lenton, Daunia and Millenium), are well outside the RHM impact area and are separated by large fault systems. The faults, which displace units and compartmentalise aquifers, limit the extent of mine dewatering and depressurisation groundwater impacts.

Coal seam gas projects could occur within the project impact zone created by dewatering and depressurisation at RHM. The additional depressurisation created by CSG operations would, like mine dewatering, create deeper drawdown where drawdown cones overlap, and further elongation along strike. Drawdown in the hanging wall down dip of the operations will be limited towards the east due to the fault systems, which compartmentalise the coal and groundwater resources.

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