ENVIRONMENTAL IMPACT STATEMENT

RED HILL MINING LEASE

Section 07
Surface Water

Section 07 Surface Water

7.1 Introduction

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

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 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).
- A future incremental expansion option of the existing Goonyella Riverside Mine (GRM).
- A future Red Hill Mine (RHM) underground expansion option located to the east of the GRM.

The three project elements described above are collectively referred to as 'the project'.

This section of the environmental impact statement (EIS) presents the surface water aspects of the proposed project. The information and assessments describe:

- relevant legislation for surface water management;
- assessment methodologies for water quality characterisation, flooding, geomorphology and water management;
- baseline (existing) surface water environment and associated environmental values;
- assessment of the proposed project to identify and evaluate potential impacts on the surface water regime; and
- proposed mitigation measures.

Surface water related impacts are multifaceted due to different aspects of the project, how the project operations intend to manage waters and interactions of surface water systems. The following generalised impacts might potentially arise from a mining activity:

- There may be changes in the quantity (flow) and quality of waters downstream of the mine, which might in turn affect water users, aquatic ecosystems, and other identified environmental values of waters. This might include changes that occur as a result of day to day activities as well as changes arising from unforeseen events.
- The mining activity may cause changes in flood characteristics, and this then has potential to influence geomorphological response of the waterways through and downstream of the EIS study area. For this reason this section of the EIS also presents the geomorphological context, potential impacts and mitigation.

Mine water arising from the Broadmeadow extension will be managed as part of the overall BRM water management network. Mine water from the proposed RHM is to be transferred to the GRB mine complex for storage and reuse and, hence, there are no direct discharges associated with the future RHM or GRM incremental expansion.

In order to investigate these potential impacts, a range of technical studies were undertaken to address specific aspects of significance to surface water or geomorphology. Most of the technical studies are also interrelated with outputs of some studies providing input and information to other studies. All the technical studies that support the EIS surface water and geomorphology assessments are listed in **Appendix I**. A summary of the technical studies, their general scope, and relationship to the other technical studies is presented in **Table 7-1**.

Table 7-1 Summary of Technical Reports Supporting EIS Surface Water Assessment

Appendix	Technical Report & Author	Summary Scope & Contents	Key Inputs
I1	Subsidence Prediction Report (IMC)	Professional mining engineers' analysis and predictions of estimated subsidence arising from the project.	Mine plan and geological information provided by BMA
I2	Mine Water Management Overview Report (BMA)	Strategy for project's mine water management. Summary of mine water balance modelling assessments.	Project Water Strategy (BMA) **Appendix I3** Red Hill Mining Lease water balance modelling (SKM)
I3	Red Hill Mining Lease EIS Water Balance Modelling (SKM 2012)	Mine water balance modelling to assess the performance of proposed RHM water management system.	Project Water Strategy (BMA) GRB Mine Water Balance Model Documentation (URS 2011) **Appendix J** Groundwater Technical Report (URS 2012)
I4	Red Hill Mining Lease Flood Hydrology (URS)	Estimation of design flood hydrology for river and creek flood events.	Isaac River Cumulative Impact Assessment (Alluvium 2009)
I5	Red Hill Mining Lease Flood Hydraulics (URS)	Estimation of design flood hydraulics for river and creek flood events.	**Appendix I1** Subsidence Prediction Report (IMC) **Appendix I4** Red Hill Mining Lease Flood Hydrology (URS) Detailed survey data (BMA)
I6	Red Hill Mining Lease EIS Geomorphic Impact Assessment (Alluvium)	Assessment of subsidence (and flood risk) impacts on geomorphology of watercourses.	**Appendix I1** Subsidence Prediction Report (IMC) Isaac River Cumulative Impact Assessment (Alluvium 2009) **Appendix I5** Red Hill Mining Lease Flood Hydraulics (URS)
I7	Subsidence Water Resources Hydrology Impacts (URS)	Assessment of impacts of subsidence on water resources hydrology, for subsidence ponding outside of Isaac River.	**Appendix I1** Subsidence Prediction Report (IMC) **Appendix I2** Mine Water Management Overview Report (BMA)
I8	Surface Water Quality Assessment (URS)	Identification of environmental values, assessment of existing (available data) water quality, base case water quality, project case impacts and mitigation.	Water quality guidelines Historical water quality data (BMA) **Appendix I3** Red Hill Mining Lease water balance modelling (SKM 2012) Erosion and sediment control recommendations (**Section 5.3**)

The assessment of surface water has drawn upon the findings of a broad range of the EIS studies and also informed other studies of potential impacts to ensure that the overall potential environmental impacts of the project are appropriately managed.

To obtain a complete understanding of the significance of surface water values and the possible impacts of the project, the following EIS studies relevant to surface water are also referenced:

- Land Resources (**Section 5**);
- Mineral Waste (**Section 6**);
- Groundwater (**Section 8**); and
- Aquatic Ecology (**Section 10**).

7.2 Description of Environmental Values and Baseline Conditions

7.2.1 Environmental Values

7.2.1.1 Surface Water Context of the Project

The EIS study area is located completely within the Isaac-Connors sub-catchment, of the greater Fitzroy Basin. In the greater regional catchment context, the EIS study area shown on **Figure 7-1** is in the far upstream headwaters of the Fitzroy Basin, and relatively high in the headwaters of the Isaac River sub-catchment.

The proposed mining activities associated with the RHM underground expansion option and the GRM incremental expansion will span across the Isaac River and tributary catchments of Goonyella Creek and 12 Mile Gully. Other nearby tributaries around the EIS study area include; Eureka Creek, Fisher Creek, and Platypus Creek as shown in **Figure 7-2**. The extension of three underground longwall panels (14, 15 and 16) within the BRM, are not expected to result in any additional impacts on the surface water receiving environment, as they do not involve any significant disruption of surface water flows within the watercourses described above or any other localised tributaries.

A more detailed description of the catchment context for the proposed project is presented in **Section 7.2.2**.

7.2.1.2 Legislative and Policy Framework

Key legislation potentially relevant for surface water aspects of the project include the:

- *Commonwealth Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act) and *EPBC Amendment Act (2013)* (the 'water trigger');
- *Water Act 2000* (Water Act) (Queensland); and
- *Environmental Protection Act 1994* (EP Act) (Queensland).

This legislation and its relevance to surface water values and surface water aspects of the project are described below.

Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides for the management and protection of flora and fauna of national environmental significance, referred to as Matters of National Environmental Significance (MNES). Large coal mining developments such as the proposed Project can potentially disrupt aquatic ecosystems and therefore have adverse impacts on aquatic species, water resources and Ramsar wetland sites. Any action with the potential for a significant impact on these MNES must be referred to the Minister for the Commonwealth Department of the Environment and may require approval under the EPBC Act.

The nine MNES under the EPBC Act are as follows:

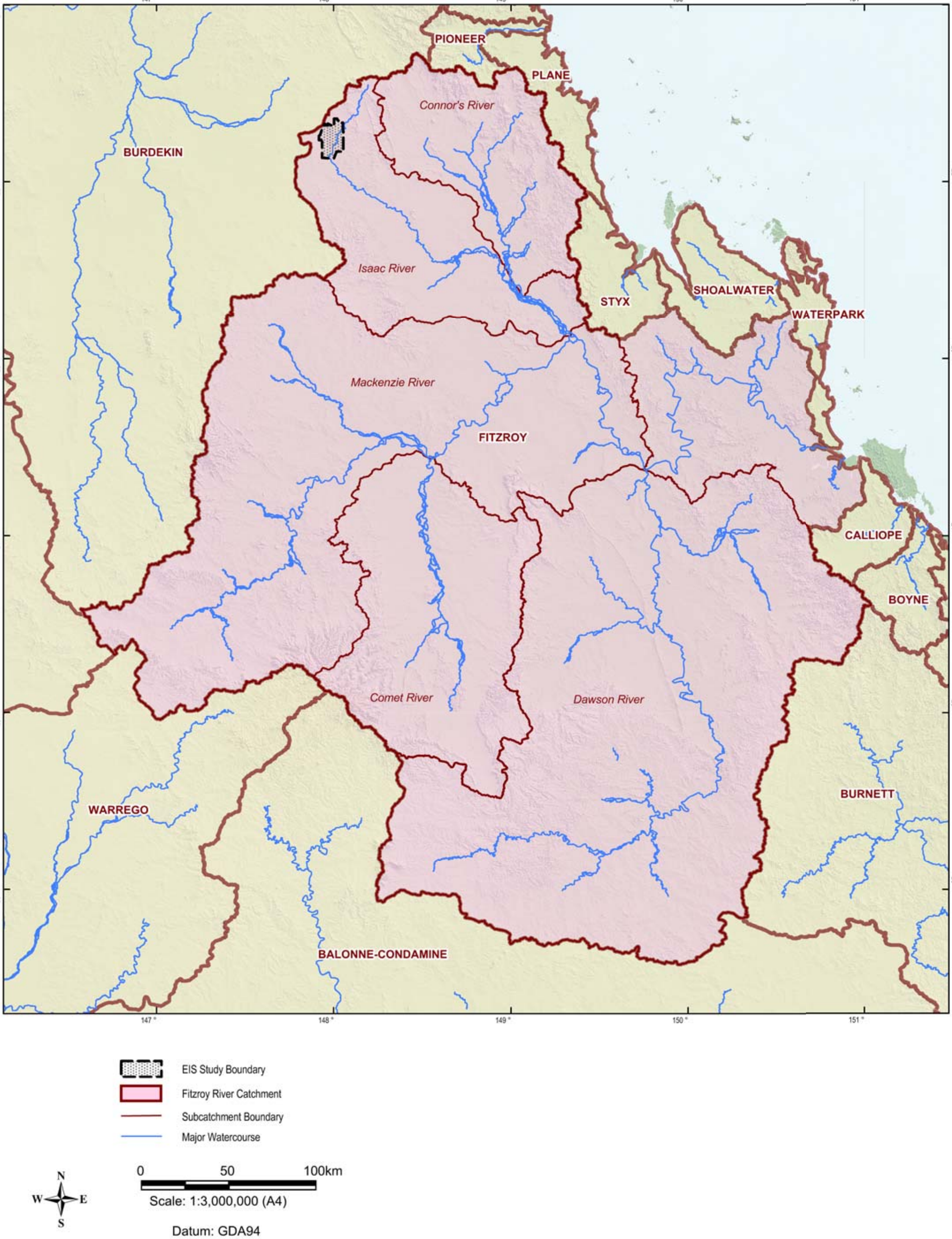
- world heritage properties;
- national heritage places;
- wetlands of international importance (often called 'Ramsar' wetlands after the international treaty these wetlands are listed);
- nationally threatened species and ecological communities;
- migratory species;
- Commonwealth marine areas;
- the Great Barrier Reef Marine Park;
- nuclear actions (including uranium mining); and
- a water resource, in relation to coal seam gas development and large coal mining development.

Commonwealth EPBC Amendment Act 2013

An amendment to the EPBC Act, commonly known as the ‘water trigger’, was enacted on 22 June 2013, and incorporates changes to Division 1 Part 3 regarding the “protection of water resources from coal seam gas development and large coal mining development”. These changes include restrictions to the actions of proponents of major coal seam gas and coal mining projects if it is expected that their proposed action will have or is likely to have a significant impact on a water resource. The amendment also sets out definitions of offences under these provisions, and the civil penalties that would be enforced if proponents were found to contravene the EPBC Act with regards to actions resulting in significant impacts on water resources. The Department of the Environment has listed the proposed project as being subject to the ‘water trigger’ and as such will be subject to a review by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC). A report has been prepared separately to address potential concerns that may arise within that review (refer to **Appendix Q3** of this EIS).

Water Act 2000 (Queensland)

In Queensland, the Water Act provides a basis for the planning and allocation of Queensland water resources, which in turn must make allowances for the provision of water purely for the support of the natural processes that underpin the ecological health of natural river systems, that is, environmental flows. The Water Act is administered primarily by the Department of Natural Resources and Mines (NRM), except that the Department of Environment and Heritage Protection (EHP) administers Chapter 3, and the Department of Energy and Water Supply administers Chapter 2A and the part of Chapter 4 that relates to Category 1 Water Authorities.



BNE

BMA
BHP Billiton Mitsubishi Alliance

RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

REGIONAL CATCHMENT CONTEXT

URS

SURFACE WATER

Figure: **7-1**

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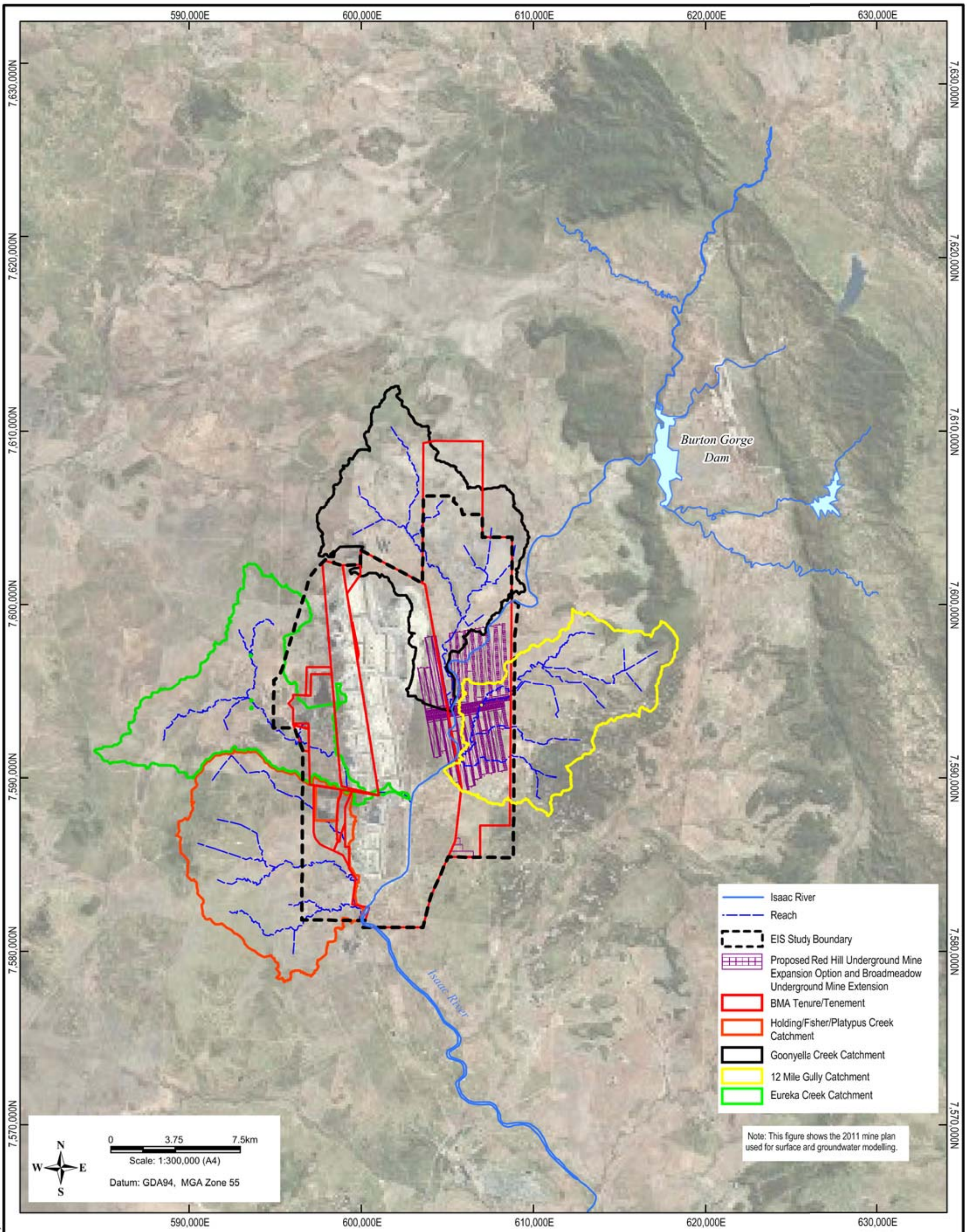

BHP Billiton Mitsubishi Alliance

RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

LOCAL CATCHMENT CONTEXT AND WATERCOURSE

URS

SURFACE WATER

Figure: **7-2**

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Water Planning Provisions of Water Act

The Water Act prescribes the process for preparing water resource plans (WRP) and resource operation plans (ROP) which are specific for catchments within Queensland. Under this process, the WRP identifies a balance between waterway health and community needs and are applied on a catchment scale. The WRP establishes environmental flow objectives (EFO) that are of importance for waterway health, and sets water allocation security objectives which are important to maintain water availability for community needs. The ROP provides the operational details on how this balance can be achieved. The WRP and ROP determine conditions for granting water allocation licences, permits and other authorities, as well as rules for water trading and sharing.

The EIS study area is located within the Fitzroy Basin and water resources are therefore managed under the *Water Resource (Fitzroy Basin) Plan 2011*. The EIS study area is not within a supplemented area of the Fitzroy Basin which means that flows in the Isaac River are not regulated by releases from upstream dams and weirs.

The Fitzroy Basin ROP came into force in January 2004, and was amended in October 2011 (Revision 3). It details how the objectives of the Fitzroy WRP will be met on an operational level, and defines strategies to support the overall goals of the WRP for water entitlement security and ecological health.

In general the ROP provides the basis and rules for trading of water allocations, allows for unallocated water to be identified and allocated and also details operating rules for the use of water management infrastructure such as weirs and dams.

Under the Water Act, WRP, and ROP, water storages required for the project will not require approval for taking overland flow as these are required to meet the requirements of an environmental authority (EA), and also have catchment areas less than 250 hectares.

Provisions of Water Act to Protect Watercourses

The Water Act specifies requirements for works causing disturbance to the bed and banks of watercourses. Watercourses potentially impacted by the project are listed in **Section 7.2.2.2**.

Works within a watercourse that fall within the provisions of the NRM (2011a) *Guideline - activities in a watercourse, lake or spring associated with mining operations* (WAM/2008/3435 – Version 2 2010), can be undertaken within the provision of that code. These works are usually limited to works necessary for the carrying out of the mining activity and for example allow for the need for services and road crossings across watercourse. Subsidence impacts of watercourses are not covered by this guideline.

Works within a watercourse that do not fall within the provisions of the abovementioned NRM guideline require a riverine protection permit (as defined by the Water Act).

Works to physically divert a watercourse (e.g. stream diversion around a mining project) must be authorised under a *water licence* administered under the Water Act.

The proposed project will not require physical diversion of a watercourse.

BMA has been advised by the then Department of Environment and Resource Management (DERM) (now NRM) (letter dated 29 April 2011) that subsidence of a watercourse does not constitute interference with a watercourse under the Water Act, and it is the NRM view that subsidence impacts are more appropriately managed under an EA administered under the EP Act. The advice also states that if physical works are required in a watercourse to remediate subsidence impacts then such works would require authorisation under Riverine Protection provisions of the Water Act.

Environmental Protection Act 1994 (Queensland)

The EP Act provides the key legislative and policy framework for environmental management and protection in Queensland.

Chapter 5 of the EP Act establishes a process for obtaining an EA for mining activities. A Level 1 EA (mining activities) is applicable to the project. Under the EP Act, EHP is the regulatory authority with responsibility for granting the EA, as well as compliance, auditing and monitoring of the environmental management of the project activities.

Environmental Authority Relevance to Surface Water Management

Dams containing hazardous waste (including tailings storage facilities and mine water dams) are not referable dams (as legislated under the *Water Supply Safety and Reliability Act 2008*) and instead are regulated as regulated dams through EA conditions. Surface water discharges from the project and the associated surface water monitoring are also regulated with EA conditions.

Environmental Protection (Water) Policy 2009 (Queensland)

The *Environmental Protection (Water) Policy 2009* (EPP (Water)) is subordinate legislation under the EP Act that functions to establish environmental values associated with water and provide a framework for protection of these values to support the overall objective of the EP Act in relation to ecologically sustainable development. Schedule 1 of EPP (Water) prescribes environmental values for the Fitzroy Basin of the Queensland including waters of the Isaac River, which is within the EIS study area. The environmental values which apply to the waters in the study area are described in **Section 7.2.6.1**.

7.2.2 Surface Water Resources

7.2.2.1 Catchment Context

The project is located within the headwaters of the Isaac-Connors sub-catchment of the greater Fitzroy catchment (refer to **Figure 7-1**). The Isaac River is the main watercourse traversing the EIS 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 section of Isaac River draining through the study area has a contributing catchment area of approximately 1,215 square kilometres (km^2), as measured at the NRM stream gauge located upstream of the existing rail crossing (gauge 130414A; Isaac River at Goonyella). 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 EIS study area represents a very small part of greater Fitzroy River catchment and is located very high 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.

7.2.2.2 Watercourses

Six ‘waterways’ classified as *watercourses* (under section 5 of the Water Act) have been identified within the EIS study area (**Figure 7-2**). 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 EIS study area are contributing drainage systems to these watercourses. All streams within or adjacent to the EIS study area were identified as upland freshwater streams which are defined as (freshwater) streams or stream sections above 150 metres in elevation (QWQG 2009).

Works in creeks that meet the definition of watercourses may be subject to provisions of the Water Act in relation to disturbance of the bed and banks, as described in **Section 7.2.1.2**.

7.2.2.3 Existing Water Users

In 2011, there were five registered water licensees located within 100 kilometres downstream of the EIS 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 licenced water users identified within the EIS study area, however the Water Act does allow landholders adjacent to rivers to take water for stock and domestic purposes without a licence.

7.2.2.4 Land Use

The dominant land use within and 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.

Existing land uses downstream of the study site include mining, grazing (including modified improved pastures) and dry land cropping. Downstream environmentally sensitive areas are discussed in more detail in **Section 9**.

7.2.2.5 Climate

A detailed description of the climate at the EIS study area is presented in **Section 4** and **Appendix I8**. The primary climate influences on hydrology and surface water flows are rainfall and evaporation which are summarised herein.

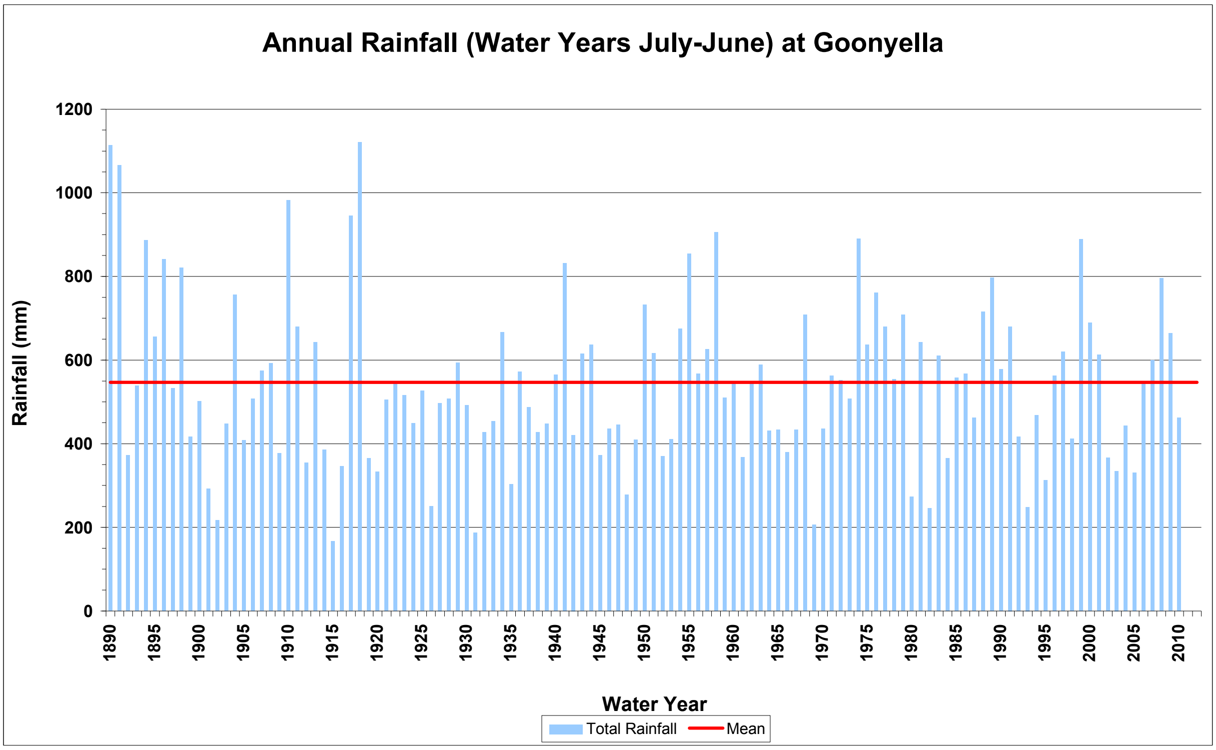
Historic climate data was sourced from the Bureau of Meteorology SILO Data Drill using 123 years of records (1889 to 2011). The data is produced by accessing grids of data derived from interpolating the bureau's records from individual weather recording stations. **Figure 7-3** shows annual water year totals for the site and **Figure 7-4** shows mean monthly rainfall and evaporation. From **Figure 7-3** it can be seen that annual rainfall at the EIS study area is highly variable and subject to prolonged periods of above and below average rainfall. The mean monthly rainfall shows a distinct seasonal distribution (**Figure 7-4**) 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.

7.2.2.6 Hydrology

The Isaac River and tributaries in and around the EIS 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.

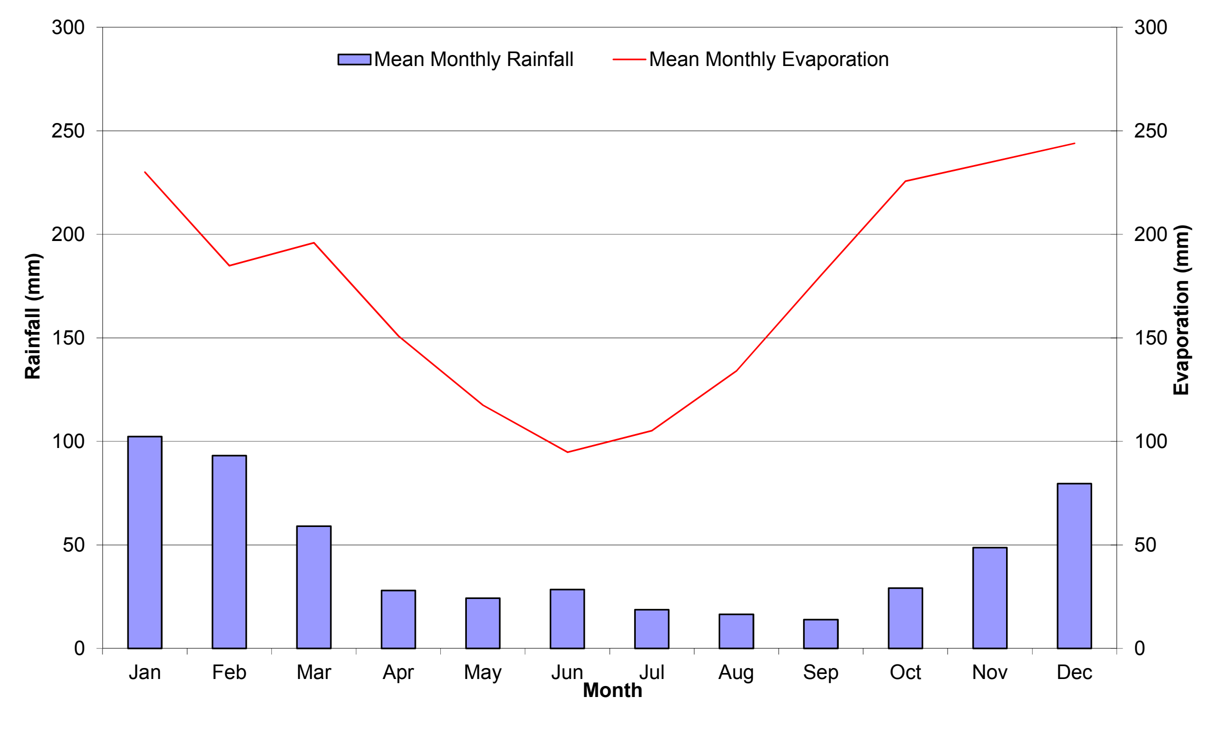
Analysis of stream flow records for the purpose of runoff model calibration for an environmental evaluation undertaken in 2007 (URS 2007) identified that long term mean annual runoff is approximately 50 to 55 millimetres per year, or approximately 10 per cent of mean annual rainfall.

Figure 7-3 Annual Rainfall Totals at Goonyella



Note: data from SILO Data Drill 1889 to 2011

Figure 7-4 Mean Monthly Rainfall and Evaporation at Goonyella



Note: data from SILO Data Drill 1889 to 2011.

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 NRM stream flow gauge on the Isaac River at Goonyella (130414A, near the existing railway bridge) indicated a mean flow of approximately 58,000 megalitres 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 Hydraulic 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.

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.

7.2.3 Mine Water Management

7.2.3.1 Project Context

The proposed project includes the following elements:

- The extension of BRM longwall panels 14, 15, and 16 into MLA70421. Key aspects 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 extension 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. Key aspects include:
  - underground mining associated with the RHM underground expansion option to target the Goonyella Middle Seam (GMS) on ML1763;
  - a new mine industrial area (MIA);
  - a 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
  - means for providing 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 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;
  - 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; and

– potential production capacity of 14mtpa of high quality hard coking coal over a life of 20 to 25 years.

The BRM 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 and hence, the existing mine water management system has been documented and examined in this EIS.

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 new coal handling and preparation plant (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) 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 EP Act.

This context is important as it has guided how water management assessments were undertaken for the EIS. For assessment of proposed mine water management, a mine water balance assessment is relevant to address the following requirements of the terms of reference (TOR):

- Sections 4.6 and 4.8 (water supply and storage);
- Section 4.8 (stormwater drainage);
- Section 5.11.1 (liquid waste); and
- Sections 5.3 and 5.4 (water resources).

A detailed 'whole of operation' mine water balance model assessment was undertaken to support the EIS and 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. A mine water management overview report describing the context of the baseline and project case is presented in **Appendix I2**. A technical report that details the mine water balance model is presented in **Appendix I3**. The overall purpose of the mine water balance assessments was to compare the performance of the GRB mine water management network 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.

As adequate mine water management system performance is important in order to protect surface water environmental values, the mine water management system needs to be able to cater for extreme climatic conditions ranging from very high rainfall, wet season conditions when management of excess waters is necessary, to the opposite extreme of prolonged dry periods which places greater demand on the requirement for reliable off site water supply. The mine water balance model is critical to determining that this is the case.

Adequate mine water management system performance is also equally important for sustainable business operations of the existing GRB mine complex operations with and without the project. Mine water needs to be managed so that there is a low risk of interruption to mining operations. During dry periods operations need to be maintained and the requirement for external water supply needs to be kept to a minimum. It is important that the GRB mine complex underground mine and open-cut pits are able to be effectively dewatered and any mine water be made available for reuse in the mine complex.

7.2.3.2 Mine Water Definition

Mine water is a generalised term adopted to describe water from a range of sources generated from the mining and processing activities. For the purpose of this EIS the term 'mine' water is adopted from the contemporary definition of 'mine affected water' as documented in the Model Water Conditions for Coal Mines in the Fitzroy Basin (EHP 2013b). This adopted definition of mine water is:

- pit water, tailings dam water and processing plant water;
- water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the Environmental Protection Regulation 2008 (EP Regulation) if it had not formed part of the mining activity;
- rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated. This excludes rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed to manage runoff containing sediment only, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water;
- groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated;
- groundwater from the mine's dewatering activities; and
- a mix of mine affected water and other water.

With this definition, descriptions of mine water in this EIS address the TOR requirements to describe 'stormwater' and 'liquid waste'. Sewage effluent is not considered to be mine water and management of sewage is described in **Section 15.5**.

For reference to descriptions of the mine water balance and water management herein, the mine water management network 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.

7.2.3.3 Baseline Water Management Scenario

The GRB mine water management system (excluding the proposed project) was modelled for the purpose of defining a baseline against which to assess the project. The baseline model configuration represents the mine water management system planned to be in place at GRB mine complex in 2015.

The baseline mine water management system storage capacity excluding contingency storage provision in low priority mine pits and the active tailings dam is approximately 24,000 megalitres (ML). When insufficient space is available in the key storages, pumping transfers commence to use contingency storage capacity in low priority mine pits. The total storage capacity of the baseline GRB mine water network including contingency storage provisions in low priority mine pits is approximately 74,000 ML (plus 10,000 ML design storage allowance as per regulated dam requirements).

7.2.3.4 Existing GRB Mine Environmental Authority Discharge Criteria

The current GRB mine complex EA EPML00853413 (dated 6th September 2013) permits discharge of water from the GS4A dam into the Isaac River, conditional upon satisfaction of the following criteria for flow conditions and salinity of discharges:

- Natural flow rate measured at the upstream Isaac River gauging station (upstream of confluence with Goonyella Creek) greater than or equal to 3 m^3/s.
- Release criteria under flow conditions:
  - the salinity of mine affected water released from GS4A must not exceed an electrical conductivity (EC) level 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.

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 water quality parameter for modelling purposes, it has been assumed that the GRB mine complex will also monitor these additional parameters in accordance with the EA before commencing a release.

7.2.3.5 Mine Water Reuse and Baseline Water Demands

An important aspect of the operational strategy for the GRB mine water management system is to reuse mine water wherever possible as a priority over use of external pipeline raw water supply. This has sustainability benefits in making the mine as self-sufficient as possible and to minimise the mine's reliance on external water supplies. It is also important to manage the storage inventory (total mine water volumes) in the mine water management system. This is important to ensure adequate storage can be made available for containment of wet and very wet seasonal conditions.

Not all of the mine operational water requirements can be supplied with mine water. Some of the water requirements for the operations require high quality water sourced from external pipeline raw water supply. These raw water demands form a very small portion of the overall site water use and include:

- water treated for potable uses (drinking, washrooms) – 180 ML/year;
- water used in the existing BRM – 365 ML/year;
- a small quantity of water required for the CHPP. While most of the water demand for the CHPP is met through recycled water, a minor component (typically three per cent) of the CHPP water use requires raw water. For Riverside and Goonyella combined this equates to 180 ML/year.

The major component of the total mine operational water demands (5,460 ML/year) that can be supplied with mine water include:

- Goonyella CHPP – 1,600 ML/year;
- Riverside CHPP – 1,600 ML/year;
- Riverside MIA – 500 ML/year; and
- dust suppression of haul roads and onto areas of the mine with intensive traffic or activity – 1,760 ML/year.

7.2.3.6 Dominant 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 containment catchments including 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 microSiemens per centimetre (µS/cm) electrical conductivity (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/day.

The groundwater sources into the mine water management system are notably more saline than mine waters sourced from surface runoff. **Section 8** provides groundwater salinity values for the various geological and hydrogeological units mapped within the EIS study area.

7.2.3.7 Mine Dewatering Operations

The existing GRB mine complex open-cut mine operations has 14 open-cut mine pits; however, there are typically only four or five open-cut mine pits actively mined at a given time in the mine schedule. With this arrangement it is not necessary to dewater all pits after rainfall, and low priority pits are available for mine water storage when surface storage capacity is insufficient. The operating rules that govern the priority sequence of pit dewatering for the baseline are described in further detail in **Appendix I2**.

7.2.3.8 Overview Description of the GRB Mine 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.

Mine water balance assessment has been undertaken for the project and is documented in the **Appendix I3**.

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. Key statistics of the climate data input into the model are presented in **Appendix I3**.

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. The AWBM runoff model parameters used in the model are documented in **Appendix I3**. 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.

7.2.3.9 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. 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 indicative 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 **Appendix I2**.

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, 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 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.
- 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 exceedences of the flow criteria is 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 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).

7.2.4 Baseline Flooding Assessment

A flooding assessment was conducted for the baseline (pre-subsidence) conditions in the EIS study area to assess flooding risks for the project and for comparison against the project conditions for the purpose of impact assessment. Several assumptions were established regarding the infrastructure and mining operations in place for the GRB mine complex operations prior to the start of the project, which was nominally assumed for the year 2015 are described in **Appendix I5**.

The flooding assessment considers flood hydrology which estimates the magnitude of potential for flood flows for a range of potential flood events. The assessment then considers flood hydraulics which estimates the levels, speed (velocity) and 'energy' of the flood flow through watercourses and across floodplains.

The baseline flooding assessment was modelled on the October 2011 mine plan. A new mining sequence has since been developed for the existing approved BRM. Further, the BRM and footprint has been revised. This has the potential to alter flood hydrology, hydraulics, and water quality over the life of mine. However, the mine plan and revised schedule are indicative only and sequencing of production and annual production rates may vary. Regardless of this, the changes are not anticipated to have a significant impact on baseline modelling predictions.

7.2.4.1 Flood Hydrology

A hydrologic assessment of the defined watercourses traversing the EIS study area and around the existing GRM site was undertaken to estimate design flood flows for these watercourses. The catchments included in the assessment were Isaac River, Eureka Creek, Goonyella Creek, 12 Mile Gully, Fisher Creek and Platypus Creek. The flood hydrology study for the project was based on and further refined from previous comprehensive hydrologic assessment of the Isaac River (Alluvium 2009). Additional hydrologic modelling was conducted for the tributaries of the Isaac River within the EIS study area.

The GRM operation has not experienced direct flooding from riverine or creek flooding since commencement of operations, including the flood recorded at the Goonyella gauge in January 1991. The historical records for floods are otherwise substantially height limited, and historical flooding alone only provides a limited understanding of potential flood risk to the mine.

To assess flood risks, design flood estimates for large and rare floods were evaluated. The hydrology study considered a wide range of design flood estimates with an annual exceedence probability (AEP) ranging up to the 1 in 2,000 AEP event. These included the 1 in 10; 1 in 20; 1 in 50; 1 in 100; 1 in 500; 1 in 1,000, and 1 in 2,000 AEP events for Isaac River. For all other tributaries, the events considered were 1 in 2; 1 in 5; 1 in 10; 1 in 20; 1 in 50; 1 in 100; 1 in 500; 1 in 1,000, and 1 in 2,000 AEP events. A detailed description of the methodology, input data and results of the hydrologic assessment is presented in **Appendix I4**.

The key objectives of the hydrology study were to estimate the flood hydrology to support flood modelling assessment of the EIS study area for the project. The process included hydrological assessment of the catchments within the EIS study area and surrounding areas to estimate rainfall frequency and intensity and design peak flow rates at key locations.

There was insufficient reliable stream gauge data available for the watercourses within and upstream of the EIS study area suitable for flood frequency analysis. It is noted that although there are approximately 30 years of data available for the Isaac River gauge at Goonyella, this data was not considered 'stationary' for flood frequency analysis because of the influence of Burton Gorge Dam, which was constructed in 1992.

The flood hydrology study utilised and compared two different methodologies to estimate the design peak flood flows for the study area watercourses. The methods included:

- rainfall runoff routing of design rainfall events for the specific project area catchments using software widely known as the RORB model, and relevant empirical methods to estimate the key RORB model parameters;
- validation of the RORB rainfall runoff modelling results with empirical peak flood flow estimation methods including:
  - the Australian Coal Association Research Program (ACARP) (2002, project C9068) empirical equations developed for Central Queensland; and
  - the recently developed Queensland Quantile Regression Technique based on Ordinary Least Squares (QRT-OLS) empirical equations for the Australian Rainfall and Runoff Revision Project (Engineers Australia 2009).

The estimated design peak flood flows (cubic metres per second) for key locations shown on **Figure 7–5** and corresponding critical storm durations (hours) for peak flooding are summarised in **Table 7-2**. These peak flood flows were used for the subsequent hydraulic (flood modelling) assessment.

Table 7-2 Summary of Peak Flow at Catchment Outlets (m^3/s)

AEP	Isaac River Site 1	Eureka Creek Site 2	Fisher & Platypus Creek Site 3	Goonyella Creek Site 4	12 Mile Gully Site 5
1 in10	780 (18hr)	220 (6hr)	180 (6hr)	280 (6hr)	190 (6hr)
1 in 20	1,040 (12hr)	330 (3hr)	280 (6hr)	400 (6hr)	280 (6hr)
1 in 50	1,440 (12hr)	480 (3hr)	390 (6hr)	570 (3hr)	380 (3hr)
1 in 100	2,050 (24hr)	640 (3hr)	530 (3hr)	770 (3hr)	500 (3hr)
1 in 500	3,440 (18hr)	1,000 (3hr)	850 (3hr)	1,200 (3hr)	800 (3hr)
1 in 1,000	4,120 (18hr)	1,200 (3hr)	1,000 (3hr)	1,400 (3hr)	970 (3hr)
1 in 2,000	4,900 (18hr)	1,400 (3hr)	1,200 (3hr)	1,700 (3hr)	1,200 (3hr)

7.2.4.2 Flood Hydraulics

A study of the hydraulic conditions during flood events within the watercourses traversing the EIS study area was undertaken to assess the flooding impacts of the proposed project. The key objectives of this investigation were to identify adverse flooding impacts from the project on the environment, and to estimate the likely flood risk to the project development and operations.

The methodology for hydraulic flood modelling assessment is described in **Appendix I5**. In summary, the process undertaken was as follows:

- develop hydraulic models of the baseline conditions and calibrate the model to recorded water levels at the Goonyella gauge on the Isaac River;
- develop hydraulic models of the baseline situation to estimate flows, inundated areas, depths, velocity and stream power for a range of design flood events;
- develop hydraulic models of the proposed project case to estimate flows, inundated areas, depths, velocity and stream power for a range of design flood events;
- assess the extent of flood levees required to protect mine infrastructure;
- compare baseline and proposed development case hydraulic model results to assess the potential change in flow conditions as a result of the project; and
- identify mitigation measures to mitigate adverse impacts on flooding.

The results of the hydraulic study were then further used to support the geomorphic assessment for the project.

The ten highest recorded water levels (and estimated flows from the rating curve) at the NRM Goonyella gauge (130414A) were selected for calibrating the Isaac River hydraulic model. The discharges ranged from approximately 640 to 1,740 m^3/s and the largest event was the January 1991 flood. The model roughness values were varied until the modelled water levels replicated the recorded levels for the same flow. The model calibration, details of model selection and set-up are described in further detail in **Appendix I5**.

Existing bridges and other structures in the river channel and floodplain were incorporated into the model. Note also that a new bridge over the Isaac River is proposed to be constructed to provide access for existing operations and exploration activities. It is assumed that this bridge will be designed such that it does not impede flood flows.

7.2.4.3 Baseline Flood Hydraulic Model Results

The flood hydraulic results are presented grouped as two separate hydrologic regimes based on their context to the project:

- Frequent flood events have been defined as the flood events that are generally confined to the river/creek banks and for sandy mobile beds found in the EIS study area, are important for channel morphology, stability and sediment transport. For the project, this will be important to estimate hydraulic and morphologic impacts due to the predicted underground mine subsidence. The hydraulic results show that these events approximately range from the 1 in 2 to 1 in 50 AEP for the creeks and river within the EIS study area. Hydraulic parameters of interest to characterise the river flood hydraulics for the frequent events were channel flood velocity and stream power.

- Larger, less frequent events have been defined as the flood events that the river/creek utilises the floodplain. For the project, this will be important for siting of key facilities and to identify protection works, such as levee embankments.

The baseline flood hydraulic model results, flow velocity and stream power, for the frequent floods are summarised in **Table 7-3**. The results show that the velocities through the various creeks typically ranges from 1 to 3.5 metres per second (m/s) and stream power is in the range of 200 to 400 watts per square metre (W/m^2). These values are generally within the range of the modelled results from the ACARP guidelines (Fisher Stewart 2002).

Further details of the velocity and stream power flood hydraulic modelling results for events 1 in 100 to 1 in 2,000 AEP are presented in the **Appendix I5**. The baseline flood levels, stream velocity and stream power results are also presented as a series of longitudinal profile plots in **Appendix I5** to show the variation along the watercourses.

The baseline flood hydraulic model results, water surface elevation, for the less frequent flood events are summarised in **Table 7-4**. The purpose of modelling a range of flood events from the 1 in 100 AEP flood event to the 1 in 2,000 AEP was to quantify key hydraulic parameters, in particular the maximum flood levels. The 1 in 1,000 AEP flood level is of particular interest for the minimum level of flood protection for the underground mine. Flooding extents for baseline 1 in 1,000 AEP are presented in **Figure 7-5**. Flood extents for the other modelled flood events are presented in the **Appendix I5**.

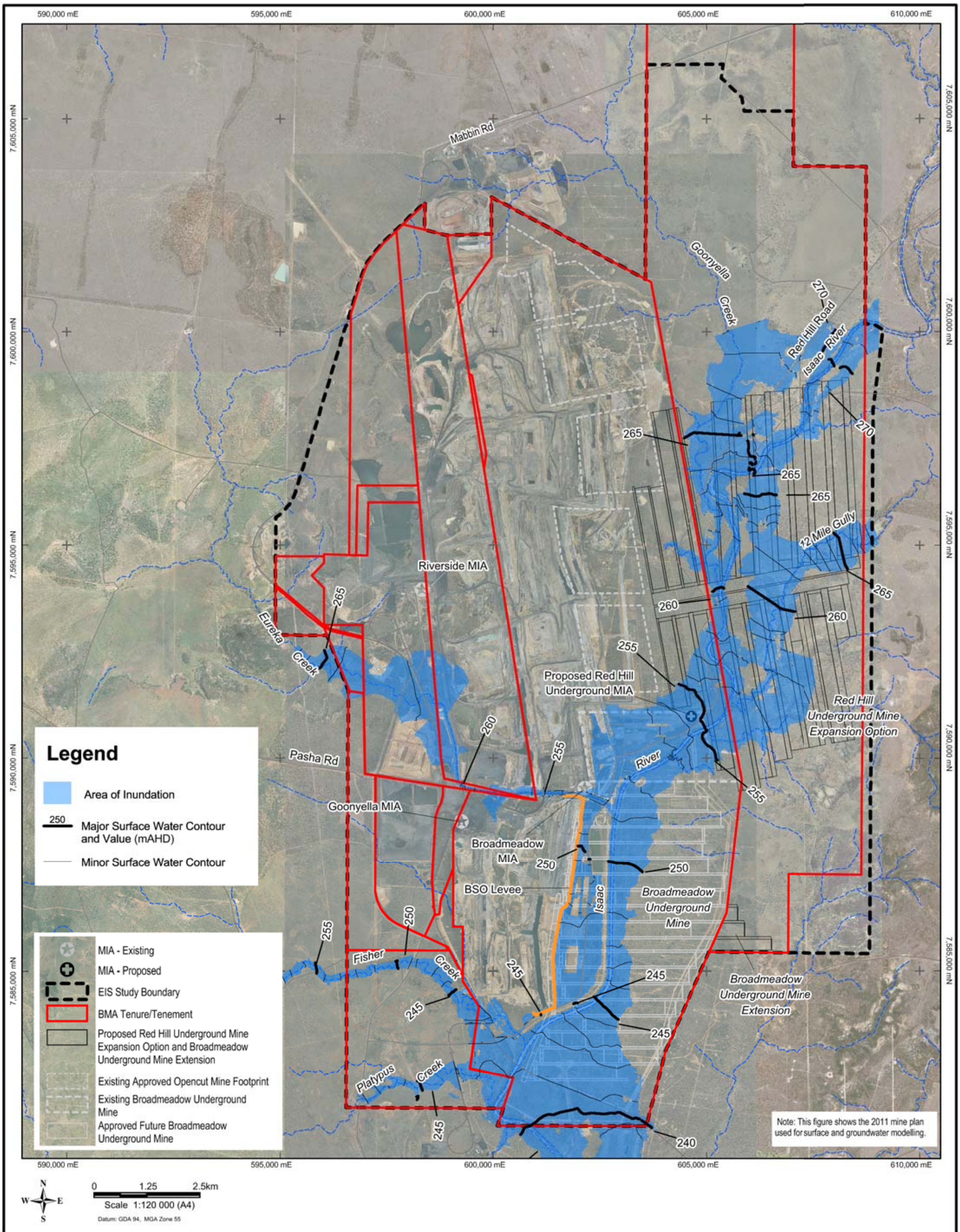
Table 7-3 Summary Flood Hydraulics Parameters for Isaac River, Goonyella and 12 Mile Gully

Hydraulic Parameter	Flood Event (AEP)	Baseline Results and Parameter Units (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
Stream power	1 in 10 1 in 20 1 in 50	68 W/m^2 94 W/m^2 106 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
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
12 Mile Gully from Isaac River Confluence to 8.7 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

Hydraulic Parameter	Flood Event (AEP)	Baseline Results and Parameter Units (Reach Average)
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

Table 7-4 Estimated Baseline Flood Levels

Reach	AEP Event	Water Surface Elevation at Upstream Mine Lease Boundary (m AHD)	Water Surface Elevation at Downstream Mine Lease Boundary (m AHD)
Isaac River (upstream at mine lease boundary and downstream at confluence with Eureka Creek)			
Upstream bed level = 257.8 m AHD Downstream bed level = 237.8 m AHD	1 in 10	263.0	244.0
	1 in 20	264.4	244.8
	1 in 50	265.2	245.8
	1 in 100	268.9	249.5
	1 in 500	271.2	250.9
	1 in 1,000	272.0	251.3
	1 in 2,000	272.5	251.7
12 Mile Gully (upstream at project boundary and downstream at confluence with Isaac River)			
Upstream bed level = 265.5 m AHD Downstream bed level = 243.4 m AHD	1 in 10	267.6	248.9
	1 in 20	267.8	249.8
	1 in 50	267.9	250.6
	1 in 100	268.1	254.3
	1 in 500	268.5	255.5
	1 in 1,000	268.6	255.8
	1 in 2,000	268.8	256.0
Goonyella Creek (upstream at project boundary and downstream at confluence with Isaac River)			
Upstream bed level = 264.6 m AHD Downstream bed level = 247.0 m AHD	1 in 10	267.5	251.7
	1 in 20	267.7	252.9
	1 in 50	267.9	253.6
	1 in 100	268.1	257.3
	1 in 500	268.5	259.3
	1 in 1,000	268.7	259.9
	1 in 2,000	268.8	260.5



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

BASECASE 1:1000 AEP WATER SURFACE ELEVATION

URS

SURFACE WATER

Figure: **7-5**

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7.2.5 Existing Geomorphology Characterisation

Alluvium Consulting has undertaken a geomorphic assessment of the watercourses in the EIS study area. The Isaac River is the major watercourse traversing the EIS study area, along with major tributaries Goonyella Creek and 12 Mile Gully and numerous minor flow paths. A basic geomorphic categorisation for channel attributes (presence/absence, continuity and number of channels) has been undertaken and this is presented in **Figure 7-6**. The character, behaviour and condition of the Isaac River and its tributaries are discussed below. Typical views are presented on **Figure 7-7**.

7.2.5.1 Isaac River

The Isaac River is an ephemeral sand bed stream that is largely alluvial downstream of the Burton Gorge (refer to **Table 7-5** for geomorphic categorisation). Burton Gorge is located approximately 15 kilometres upstream of the proposed RHM and while there are some bedrock controls on the river over this distance, these bedrock controls are not dominant. The reach of Isaac River through the EIS study area can be categorised as a low to moderate sinuosity alluvial stream. That is, the alluvial channel boundaries (the bed and banks) can adjust in response to changes in variables such as flow, gradient, riparian vegetation, sediment supply and sediment transport.

Within that categorisation, the Isaac River can further be defined as terrace confined. The contemporary channel is constrained by a terrace, which is essentially a Paleo floodplain. The contemporary floodplain is a narrow (150 to 500 metres wide) band on one or both sides of the channel that is two to four metres lower in elevation than the terrace (which is 2,000 to 5,000 metres wide). Flow events up to approximately 1 in 100 AEP are contained within the narrow floodplain belt before inundating the much broader terrace in larger flow events. Where the contemporary channel impinges on the terrace (such as near the main headings in the proposed mine plan) it produces vertical scarps, which appear to be more actively eroding than the banks elsewhere that are at slopes of 1 horizontal to 1 vertical (h:v) to 4h to 1v. However, the terrace material is older, more consolidated and weathered and generally more resistant to erosion processes than the Quaternary alluvium.

The terrace is likely to have been formed by the river during climatic conditions that produced larger discharges than the contemporary climate and hydrologic regime. There are examples of infill of the Tertiary channel in the banks of the current channel where it crosses the northern end of longwall RH205 (see **Figure 7-19**). There are also geologic influences on the extents of the terrace such as constraints provided by Tertiary basalt in the northwest area of the project and further north.

Permian bedrock is noted to outcrop sporadically in the channel bed through the mine footprint. Its presence/absence and continuity along the bed of the river is not known and would depend on the depth of the erosion surface and channel in the Tertiary strata. This bedrock will provide some control that would limit potential deepening of the channel but may also increase the risk of bank erosion at the control.

The condition of the Isaac River is compromised by the excess sediment inputs that have been generated through the catchment with historical changes in land use. This has smothered nearly all bedforms, in-filling pools and creating a smooth sand bed profile with limited potential for aquatic habitat outside of the wet season. The riparian vegetation in the reaches through the project area remains reasonably continuous at the over-storey level but substantially impacted at the under-storey level by cattle. Groundcover is variable but often dense with dominant exotic grasses which also suppress native under-storey regeneration. The dense grass cover provides conditions for deposition of a mud drape which enhances bank stability.

Subsidence that has occurred to date in the Isaac River downstream of the EIS study area at BRM and Moranbah North Mine has had no influence on the condition of the Isaac River in the EIS study area. Geomorphic response to subsidence has been effectively managed at those sites to date.

Table 7-5 Geomorphic Categorisation of Isaac River over the EIS Study Area

Geomorphic Aspect	Description	
General Characterisation	Alluvial Continuous – terrace confined	
Channel geometry	Compound with low and high level benches. Floodplain inset below broad terrace.	
Channel pattern	Single, low to moderate sinuosity.	
Geomorphic units	Channel zone: Plain sand bed, low and high level benches, point bar/bench complexes, occasional bedrock bars.	Floodplain/terrace zone: Occasional gilgai in the terrace, scroll bars with ridge and swale topography in floodplain.
Geomorphic behaviour	Oblique accretion trend with present sediment supply regime. Limited lateral activity.	
Sediment transfer behaviour	Transport limited, oblique accretion storing some sediment on banks.	

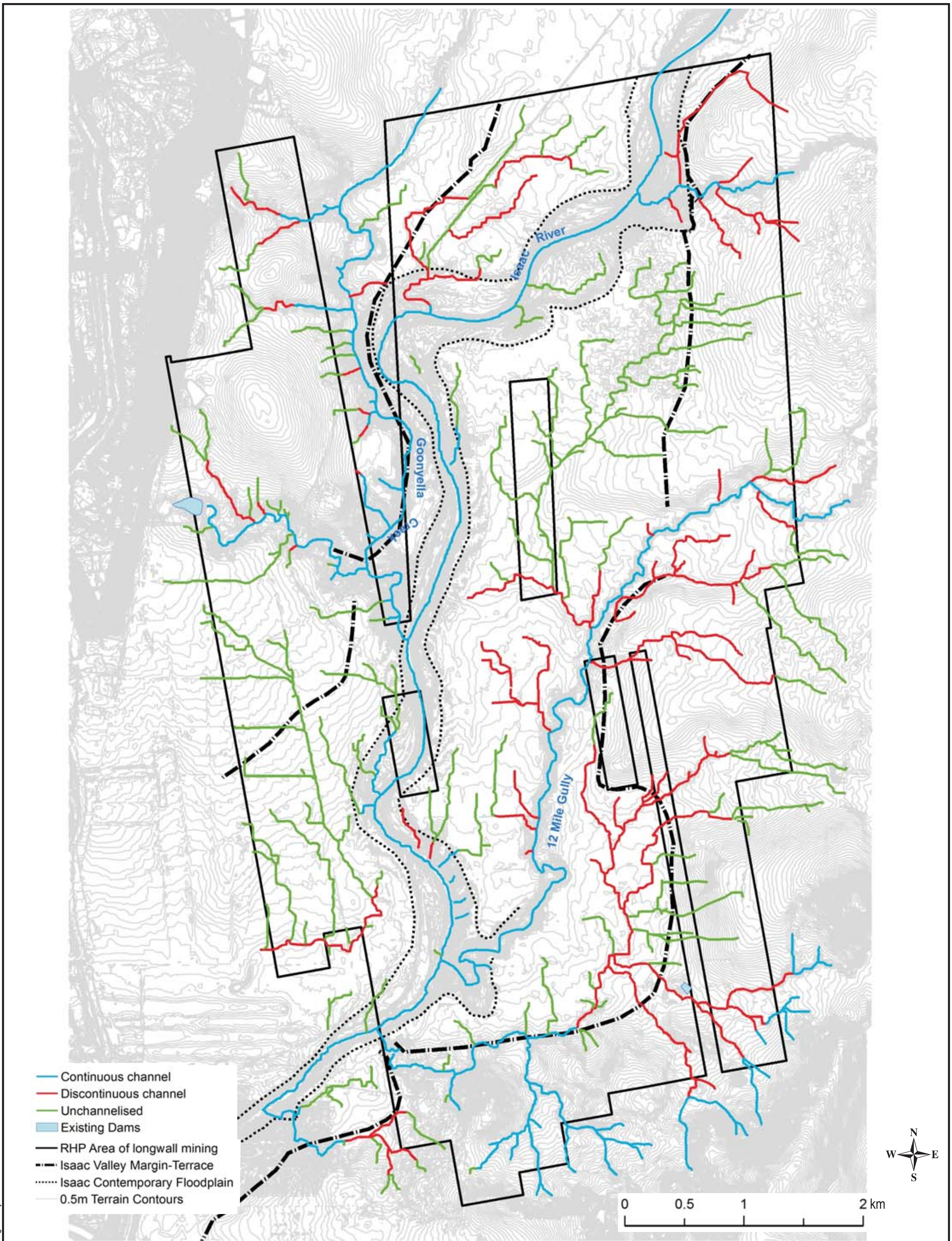
7.2.5.2 Goonyella Creek

Goonyella Creek is an ephemeral partly confined single low to moderate sinuosity channel (refer to **Table 7-6**) that sits largely at the terrace-valley margin of the Isaac River. It has frequent bed and lower bank bedrock controls upstream of Red Hill Road. Its lower end (last 2.5 kilometres) runs parallel with the Isaac River channel in the terrace and may have some interaction with Isaac River flooding during extreme flood events.

The channel is relatively narrow and deep in the Isaac River terrace with thick mud drape covered banks and a reasonably diverse pool-riffle-run bed form due to a gradient that is steep enough to transport sediment supplied to it. Sediment supply characteristics appear to be influenced by the presence of basalt in the catchment, which means it is not oversupplied with sand as are many of the other waterways in the Isaac River catchment.

Table 7-6 Geomorphic Categorisation of Goonyella Creek over the EIS Study Area

Geomorphic Aspect	Description	
General Characterisation	Partly confined low to moderate sinuosity	
Channel geometry	Compound with low level benches.	
Channel pattern	Single, low to moderate sinuosity with frequent bedrock or terrace controls on planform.	
Geomorphic units	Channel zone: Pool-riffle-run bed, benches, bank.	Floodplain/terrace zone: As per Isaac terrace.
Geomorphic behaviour	Limited channel adjustment where bedrock controlled. Mud drape covered banks limit change in bank profile in Isaac terrace.	
Sediment transfer behaviour	Hydraulic conditions able to transfer most sediment through reach.	



Source: BMA Supplied

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

CHARACTERISATION OF MAJOR FLOW PATHS

URS

SURFACE WATER

Figure: 7-6

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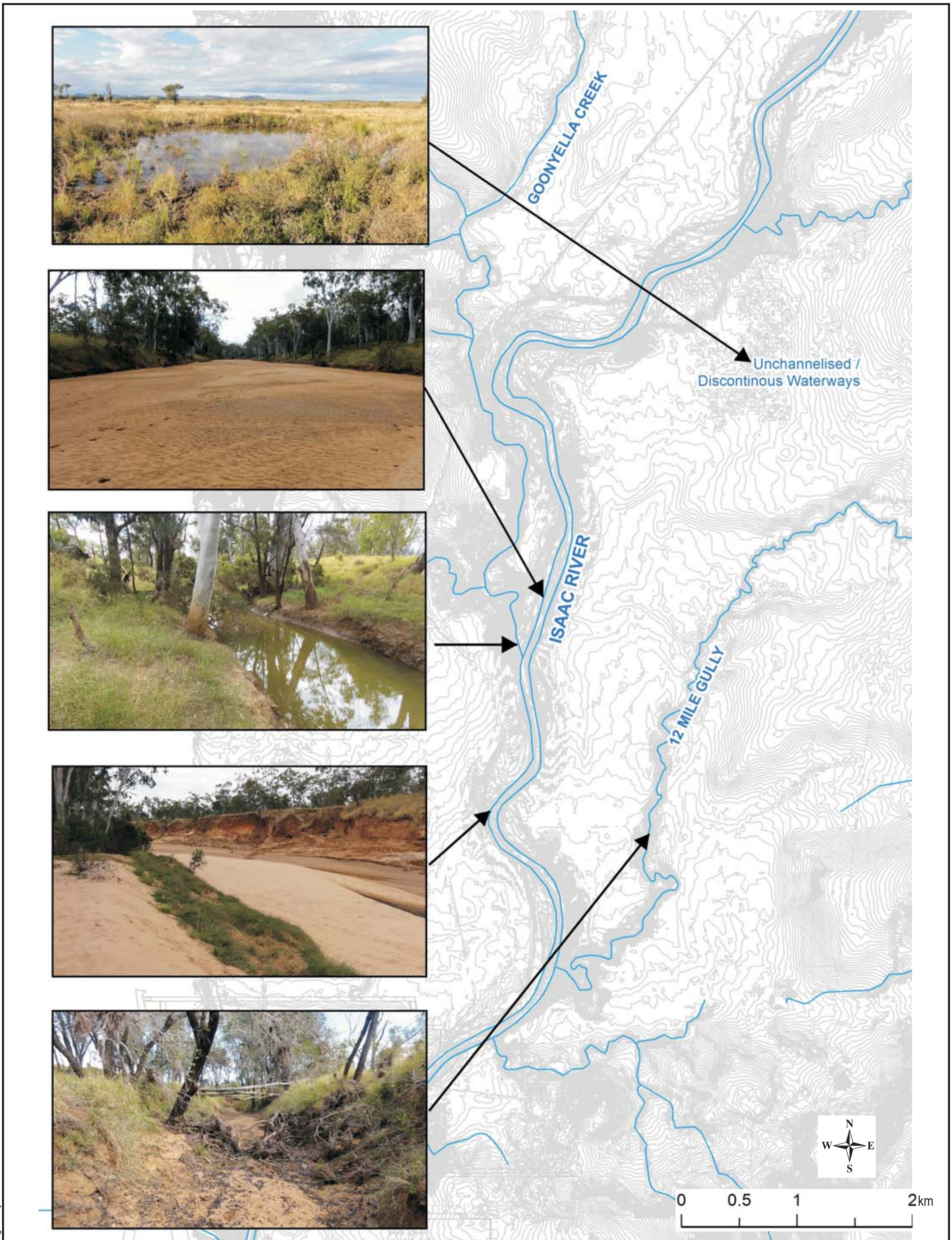

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

TYPICAL FEATURES OF WATERWAYS ACROSS THE EIS STUDY AREA

URS

SURFACE WATER

Figure: **7-7**

File No: **42627136-g-1115.cdr** Drawn: **VH** Approved: **CT** Date: **08-07-2013** Rev.**A** A4

7.2.5.3 12 Mile Gully

12 Mile Gully is an ephemeral tributary of the Isaac River. The majority of 12 Mile Gully over the proposed project mine plan is in the Isaac River terrace. Where the channel flows out from the hill slopes to the east, 12 Mile Gully is directed south, parallel to the Isaac River as the Isaac River has influenced the location of the confluence. It is a moderate to high sinuosity single alluvial channel waterway in a broad floodplain with numerous flood channels (**Table 7-7**). 12 Mile Gully is presently grazed heavily with cattle and has associated bank erosion due to grazing impacts.

Table 7-7 Geomorphic Categorisation of 12 Mile Gully over the EIS Study Area

Geomorphic Aspect	Description	
General Characterisation	Alluvial Continuous – Meandering Single Channel	
Channel geometry	Symmetrical straights, asymmetrical bends.	
Channel pattern	Moderate to high sinuosity with meander cut offs.	
Geomorphic units	Channel zone: sand smothered bed, point bar/bench complexes on high angle meanders, banks.	Floodplain zone: flood channel(s), meander cut offs, gilgai.
Geomorphic behaviour	Laterally active channel with outside of bend bank erosion prevalent. Meander cut offs prevalent. Incises down to Isaac River invert level in lower reaches where there are near vertical banks.	
Sediment transfer behaviour	Excess sediment supply from upstream smothering bedforms in some reaches. Where steeper and more incised most sand transported through.	

7.2.5.4 Minor Tributaries and Flow Paths

There are numerous un-named and/or unmapped minor tributaries of the watercourses described above across the EIS study area. Many of them are within the Isaac River terrace and have low gradients and are unconfined. These conditions have produced many waterways that are un-channelised, such as a number of the chains of ponds (some of which are the same in appearance as gilgai) or discontinuous cut and fill flow paths. In the hill slopes around the eastern and southern perimeter of the future RHM footprint there are continuous headwater gullies of the minor tributaries. These often 'flood out' onto the terrace. A flood out is where a continuous channel loses sufficient energy and confinement to no longer maintain a channel (discontinuous) and becomes part of a broader plain. Where these minor tributaries approach the Isaac River they become continuous as the channel cuts down through the terrace to meet its downstream control which is the Isaac River bed.

Discontinuous and unchannelised waterways are important stores of sediment and water in the landscape. Due to land use change and various disturbances, much of this component of the waterway network, which has low resilience to change, has been subject to gully erosion throughout the catchment. The impact of gully erosion or channelisation is that runoff is concentrated and, hence, flow peaks are higher and shorter and delivered to trunk streams in a more efficient manner. Water no longer moves slowly through the landscape. It also means that much greater quantities of sediment are liberated and transported to the main watercourses.

7.2.6 Existing Water Quality

The Surface Water Quality Assessment Technical Report (**Appendix I8**) 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 EIS study area. The assessment was undertaken in the context of identifying applicable environmental values in accordance with Schedule 1 of the EPP

(Water), Australian New Zealand Environment and Conservation Council Guidelines (ANZECC 2000), the Queensland Water Quality Guidelines (QWQG) 2009 (EHP 2009b).

The methodology adopted for the surface water quality impact assessment included:

- identification of relevant environmental values applicable to water quality management using classifications outlined in the EPP (Water);
- assessment and preliminary description of the background surface water quality based on available historic water quality datasets from a nearby NRM monitoring station and project specific water quality sampling conducted between August 2010 and April 2011;
- description of the features and activities of the project relevant to the surface water quality impact assessment and description of potential impacts;
- identification of mitigation strategies and measures required to manage the potential impacts on surface water quality; and
- identification of the potential residual impacts, following implementation of mitigation strategies and measures.

7.2.6.1 Environmental Values

Environmental values for the watercourses within the EIS study area are included within Schedule 1 of the EPP (Water).

The watercourses within the EIS study area are ephemeral in nature and provide seasonal habitat for aquatic fauna and flora. The local watercourses are noted to be slightly-to-moderately disturbed from historic land use changes, and current mining and grazing activities. The identified environmental values for surface water for these catchments are:

- suitable for visual recreation;
- have cultural and spiritual values; and
- support agricultural activities including livestock drinking water.

The ephemeral nature of the Isaac River and other tributaries places a temporal limit on beneficial uses. The impact of the Burton Gorge Dam on low flow hydrology in the Isaac River is another factor influencing the disturbed status of aquatic habit values in the Isaac River.

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 not in pristine condition and water quality impacts are evident particularly in suspended solids and turbidity.

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

Regionally the Isaac/Connors River System also provides a drinking water supply, supports primary and secondary contact recreation, industrial uses, and agricultural uses including stock watering, farm use and irrigation. The waters are not known for aquaculture and production of aquatic food for human consumption. The full derivation of environmental values is presented in **Appendix I8**.

7.2.6.2 Water Quality Objectives and Guidelines

Relevant water quality objectives to protect the environmental values identified for the Isaac-Connors catchment are defined within Schedule 1 of the EPP (Water). In addition the EA for the GRB mine complex (EPML00853413) defines local water quality trigger level criteria for selected toxicants for the section of the Isaac River immediately below the release point. The water quality related conditions for the GRB mine complex EA were amended in September 2013.

Relevant water quality guidelines are shown in **Table 7-8**.

Table 7-8 Water Quality Guidelines for Physio-chemical Stressors and Toxicants in surface waters within the EIS Study Area

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

7.2.6.3 Existing Water Quality

The existing water quality of the watercourses flowing through the EIS study area and the downstream receiving environment of the EIS study area was assessed to characterise existing water quality conditions. The assessment was based on a review of existing surface water quality monitoring data collected by BMA for the existing GRB mine complex. The period of data collected covers the period from August 2010 to April 2011.

Table 7-9 presents median values for key physicochemical 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 7-10**. Median values for each site were compared against the water quality objectives and bold figures in **Table 7-9** and **Table 7-10** denote values above the objectives. Detailed analysis is provided in Section 5 of **Appendix I8**. The locations of historic surface water monitoring points are presented in Figure 4-1 in **Appendix I8**.

Table 7-9 Median Values for Physico-Chemical Parameters - (2010-2011)

Site	Number of Samples (n)	TSS (mg/L)	EC (µS/cm)	Sulphate (mg/L)	pH (pH units)	Ammonia N (µg/L)	Turbidity (NTU)
Fisher Creek	12	**98**	103	2	7.3	10	**371**
Platypus Creek	11	**116**	77	1	7.2	10	**262**
Upper Eureka	51	**183**	170	2.6	7.4	20	**238**
Upper Isaac	45	**340**	170	2	7.8	20	**450**
Lower Isaac	51	**380**	220	5	7.8	10	**597**
Water Quality Objective		30	2,000	1,000	6.5 - 8.5	20	50

Note: Bold denotes median values exceeding water quality objectives

Table 7-9 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 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 7-10 and **Table 7-11** 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. A more detailed analysis, including representations of data distribution, is included in **Appendix I8**.

Table 7-10 Median Values for Soluble Metals, Ammonia and Nitrate (2010-2011)

Parameter	Guideline Values for Toxicants					Median values				
	ANZECC 2000 / EA EPML00853 413 (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	1,000	ND	ND	0.5	0.5	1	2	3
Copper (µg/L)	3	ND	1,000	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 7-11 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	1,000	ND	ND	16	15	13	17.5	16
Copper (µg/L)	3	ND	1,000	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

Note 1: Some values have been modified from ANZECC (2000) guidelines to reflect local background values.
ND = not detected

7.3 Potential Impacts and Mitigation Measures

Assessment of potential impacts on surface water and identified mitigation measures are described in this section.

As noted earlier, flood hydrology, flood hydraulics and surface water quality predictions were modelled on the October 2011 mine plan. A new mining sequence has since been developed for the RHM, Broadmeadow extension and the existing approved BRM. Further, both the BRM and the proposed Broadmeadow extension footprints have been revised. This has the potential to alter flood hydrology, flood hydraulics and surface water quality over the life of mine. However, the mine plan and revised schedule are indicative only and sequencing of production and annual production rates may vary. Regardless of this, the changes are not anticipated to have a significant impact on modelling predictions.

7.3.1 Construction Phase

For the purpose of the EIS surface water assessment of 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 and are discussed in **Section 7.3.4**.

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 complex, hence, any sediment laden or contaminated runoff from these construction activities will be captured and managed within the GRB 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 7-12**, 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 7-12 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. Further details are provided in **Section 5.3**. • 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. • 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.

Impacts During Construction	Mitigation Measures
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 are outlined in **Section 5.4.2.3** and **Section 20** and will minimise likelihood of release to surface waters. • Measures outlined in **Section 5.4.2** 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 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 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.

Sewage will be generated by the construction workforce at the Red Hill accommodation village, MIA and CHPP. Sewage will be treated in package treatment plants and treated effluent will either be reused in the mine water management system or disposed of by land irrigation. This is discussed further in **Section 15**. Surface water quality impacts are not expected to arise from sewage generation, treatment or disposal.

There are no construction activities associated with the Broadmeadow extension as this is an extension of an existing mining activity.

7.3.2 Operational Phase Project Case Mine Water Management

7.3.2.1 Overview and Organisational Responsibilities

Mine water from the RHM will be managed by transferring it to the GRB mine water management network. 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 envisage 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 network.

Detailed descriptions of the project case integrated mine water management system and operations are presented in **Appendix I2**. Key information that has guided the assessment and assessment outcomes are presented herein.

7.3.2.2 Mine Waters Generated by RHM

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 8** of this EIS. These estimates have been applied to plan the management of the RHM waters in the GRB mine water management system as described in **Appendix I2** and **Appendix I3**.

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 to 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 (**Section 3.7.7.4**). 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 as described in **Section 6**. 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.

7.3.2.3 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 operational water demands (for 14 mtpa maximum project production) that can be sourced from mine water are estimated at 1,300 ML/year.

7.3.2.4 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:

- RHM;
- Red Hill CHPP;
- Red Hill MIA;

- Red Hill MIA dam (nominally 50 ML); and
- excess water from RHM is dewatered 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. Complete details of all of the modelling inputs and assumptions are presented in **Appendix I3**.

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.

7.3.2.5 Project Case Mine Water Management Impact 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. A detailed interpretation and description of the project case mine water balance modelling results for key mine water management performance indicators is presented in **Appendix I2**.

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 (see also **Section 7.2.3.9** for discussion on system compliance).
- 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. These 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.
- 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 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 network 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.

7.3.3 Flood Assessment

An assessment of operational to post mine phase impacts of the project on flooding was undertaken with consideration of reasonably known concepts of structures to be built on the floodplain, and predicted subsidence resulting from the project. The proposed structures reasonably known at this point are described below. Description is also provided for other structures (e.g. including gas drainage water staging dams, and Isaac River bridge).

It is important to note that the subsidence will gradually occur across the mine area throughout the life of the project. Hence the flooding assessment of all subsidence used for the modelling described herein is more indicative of a point in time near the end of the mine life and into the post mine phase.

7.3.3.1 Structures in Flood Plain and Context for Project Case Assessment

Flood protection is required for the MIA and mine access. Flood modelling for the project assumed that this would be provided through a levee, located north of the confluence of the Isaac River and Eureka Creek. The Red Hill levee would be constructed prior to operation of the MIA in order to protect the MIA from potential flooding in the Isaac River. The proposed Red Hill levee would extend from the pillar area between panels 102 and 103 (refer **Figure 3-7**), south-west through Panel 103, then generally following the existing Red Hill Road alignment to the existing GS4A dam.

The IMG production water dam would be located on the main headings and on higher ground such that it has minimal to no effect on the floodplain flows and will not be affected by subsidence.

A bridge over the Isaac River is required for the project. This bridge is planned to be located over the mains heading. Design of the proposed bridge is subject to further project planning and design and consequently the potential bridge influences have not included the project case flooding assessments. It is intended that the Isaac River bridge will be designed to provide minimal obstruction to flood flows and, hence, should have no significant impact on flooding. This can be achieved by:

- Ensuring that road approaches to the bridge across floodplain areas are constructed at the level of the existing floodplain. This will ensure that the road does not obstruct or restrict floodplain flows.
- Designing the bridge superstructure and deck level at the same level or slightly higher than the existing top of bank levels for the main Isaac River channel, and abutments will be constructed at positions that minimise the encroachment into the main Isaac River channel. This will ensure that adequate waterway beneath the bridge is provided approximately similar to the existing waterway cross section area of the main Isaac River channel.

It is expected that services crossing the Isaac River will be buried in trenches in the river bed. If overhead services crossings are required over the Isaac River, these will be designed such that there is minimal obstruction to channel and floodplain flows. Once design details for the bridge are available, flood modelling may need to be repeated to check that the proposed bridge design does not impact on flood sensitive areas.

Estimated catchment flood flows for the Isaac River and the various creeks from the baseline study assessment were used for the project case hydraulic flood modelling. All flood events in the Isaac River (including small events such as the 1 in 5 AEP) have large flood flow volumes and, hence, the influence of subsidence from the project will not substantially alter flood hydrology because the subsidence voids are relatively very small compared to design flood hydrograph volumes.

Flood modelling for the project case conditions was performed by modifying the baseline hydraulic models to incorporate the predicted subsidence depths (specifically subsided landform topography) and the proposed flood protection levee.

The project case hydraulic models generally assumed the following:

- Subsidence predictions at the end of the project:
  - The end of the project scenario was selected in order to estimate the potential hydraulic and geomorphologic impacts with the greatest extents of subsidence. If necessary, select intermediate scenarios may be considered in the future as part of subsidence management in order to estimate hydraulic conditions for a particular 'snapshot' in time. The case as the end of project with all subsidence extents was considered appropriate for EIS assessment as it presents a conservative worst case.
  - Predicted subsided topography was utilised directly for the hydraulic modelling assuming that no erosion of the channel bed or sediment deposition occurs. This is a conservative assumption that will tend to overestimate increases and decreases in stream power, velocity, and shear stress results. This conservative assumption is necessary as current flood hydraulic modelling technology is not capable of modelling dynamic morphological response during floods with sufficient reliability that takes account of actual sediment supply variability and geological conditions of beds and banks of river channels.
- A proposed Red Hill MIA levee alignment along the west side of the Isaac River, extending from the Isaac River and Eureka Creek confluence and generally following Red Hill Road north. A hypothetical embankment crest elevation of greater than the 1 in 2,000 AEP flood level was adopted for the MIA levee for the purpose of modelling to avoid overtopping in the model which would otherwise lead to unstable model results. The actual levee design would be to protect the MIA from the 1 in 1,000 flood.

7.3.3.2 Project Case Flood Hydraulic Model Results

The project case flood hydraulic model results, flow velocity and stream power for the frequent floods are summarised in **Table 7-13**, 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 **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. As described above, 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. The geomorphological implications of subsidence are described separately in **Section 7.3.4.5**.

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 EIS study area. A comparison of the modelled flood levels at key locations within the EIS study area is presented in **Table 7-13**.

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.

The flood inundation extents for the 1 in 10 AEP and 1 in 1,000 AEP are presented in **Figure 7-8** and **Figure 7-9**, respectively. The flood extents show that temporary flood inundation ponding may occur within the subsided panel areas during frequent flood events. 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 **Appendix I5**.

7.3.3.3 Subsidence of the Project Flood Protection Levee

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.

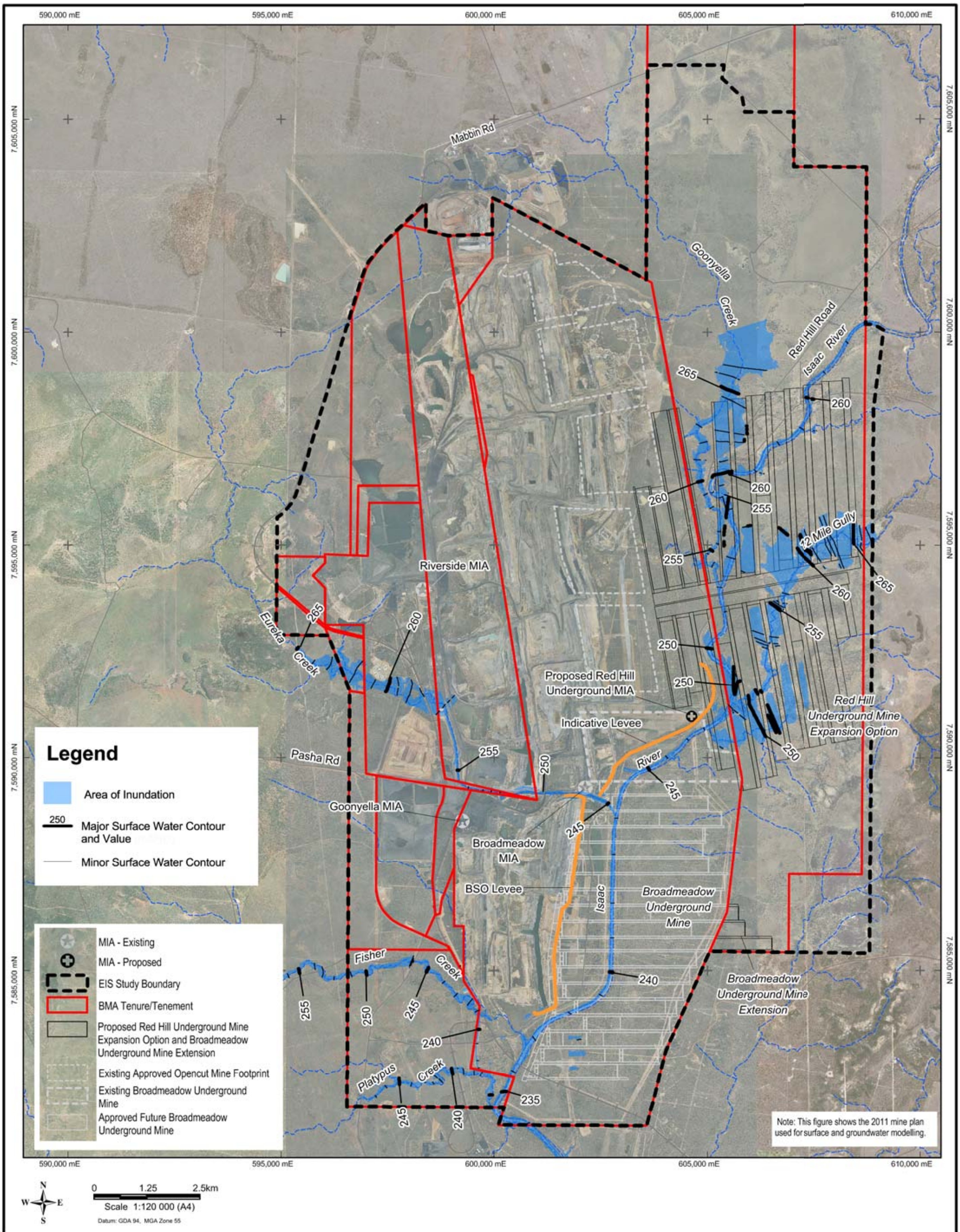
Table 7-13 Summary Project Case Flood Hydraulics for Isaac River, Goonyella, and 12 Mile Gully

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

Hydraulic Parameter	Flood Event (AEP)	Baseline Results (Reach Average)	Project Case Results (Reach Average)
12 Mile Gully from Isaac River Confluence to 8.70 km Upstream of Confluence			
Velocity	1 in 2	1.1 m/s	1.0 m/s
	1 in 5	1.3 m/s	1.1 m/s
	1 in 10	1.3 m/s	1.1 m/s
	1 in 20	1.4 m/s	1.4 m/s
	1 in 50	1.5 m/s	1.5 m/s
Stream power	1 in 2	69 W/m^2	73 W/m^2
	1 in 5	58 W/m^2	91 W/m^2
	1 in 10	44 W/m^2	101 W/m^2
	1 in 20	56 W/m^2	89 W/m^2
	1 in 50	58 W/m^2	116 W/m^2

Table 7-14 Comparison of Modelled Flood Levels at Key Locations in the EIS Study Area

AEP Event	Confluence of Isaac River and Goonyella Creek (m AHD)			Confluence of Isaac River and 12 Mile Gully (m AHD)			Isaac River Downstream of Red Hill Subsidence Panels (m AHD)		
	Baseline	Project Conditions	Difference (m)	Baseline	Project Conditions	Difference (m)	Baseline	Project Conditions	Difference (m)
1 in 10	252.1	252.1	0.0	249.1	248.6	-0.5	246.3	246.5	0.2
1 in 20	253.2	253.1	-0.1	250.0	249.5	-0.5	247.1	247.2	0.1
1 in 50	254.0	253.9	-0.1	250.8	250.3	-0.5	248.0	247.8	-0.2
1 in 100	257.3	256.9	-0.4	254.3	253.7	-0.6	251.6	251.4	-0.2
1 in 500	259.3	258.4	-0.9	255.5	255.0	-0.5	252.9	252.7	-0.2
1 in 1,000	259.9	258.9	-1.0	255.8	255.3	-0.5	253.2	253.0	-0.2
1 in 2,000	260.5	259.4	-1.1	256.0	255.6	-0.4	253.5	253.3	-0.2



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

FLOOD INUNDATION WITH PROJECT CONDITIONS 1:10 AEP

URS

SURFACE WATER

Figure: **7-8**

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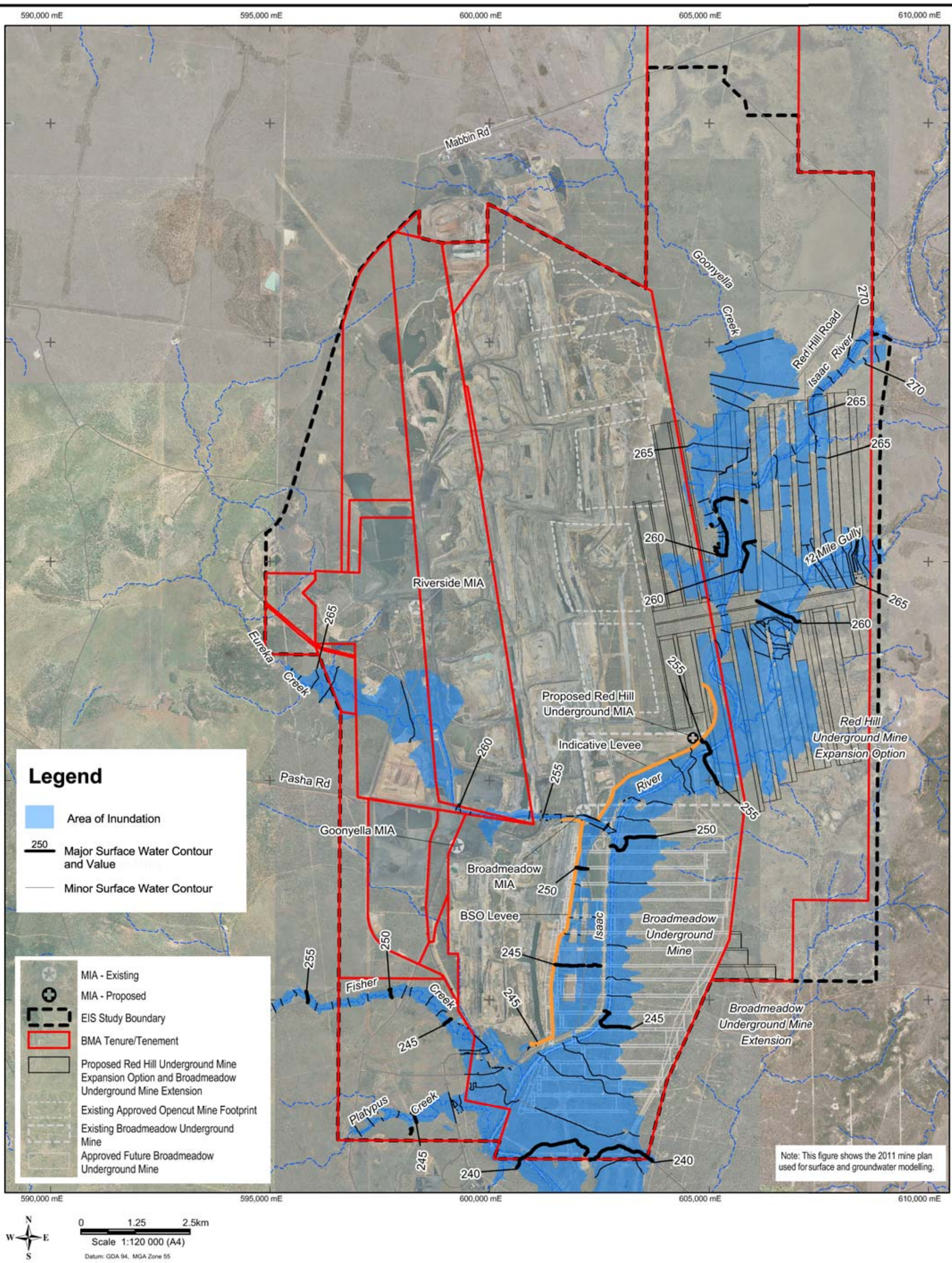

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

FLOOD INUNDATION EXTENTS WITH PROJECT FOR 1:1000 AEP

URS

SURFACE WATER

Figure: 7-9

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7.3.4 Operational Phase Water Quality Impacts

7.3.4.1 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 7-10** below which shows the percentage of time that a particular electrical conductivity level is exceeded at the downstream monitoring point, while **Figure 7-11** is the same graph but focussing on the lower probability occurrences.

Figure 7-10 EC Levels in Isaac River Downstream during Mine Water Releases – Project Case Comparison with Baseline

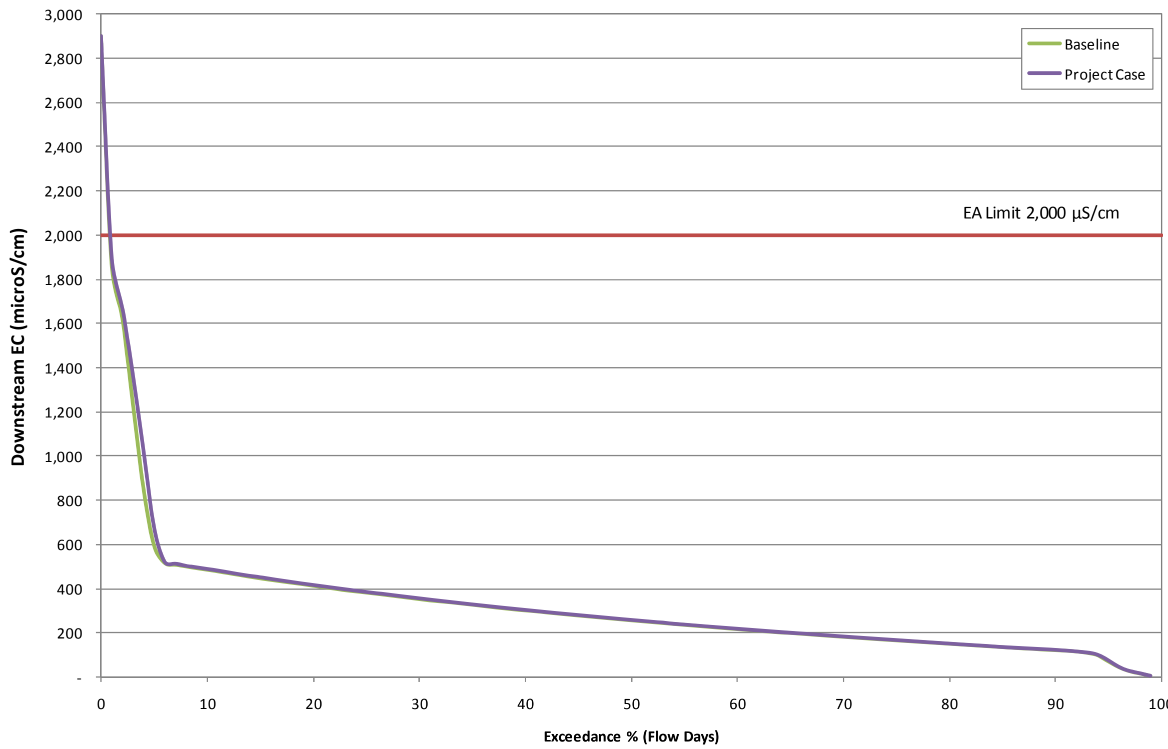
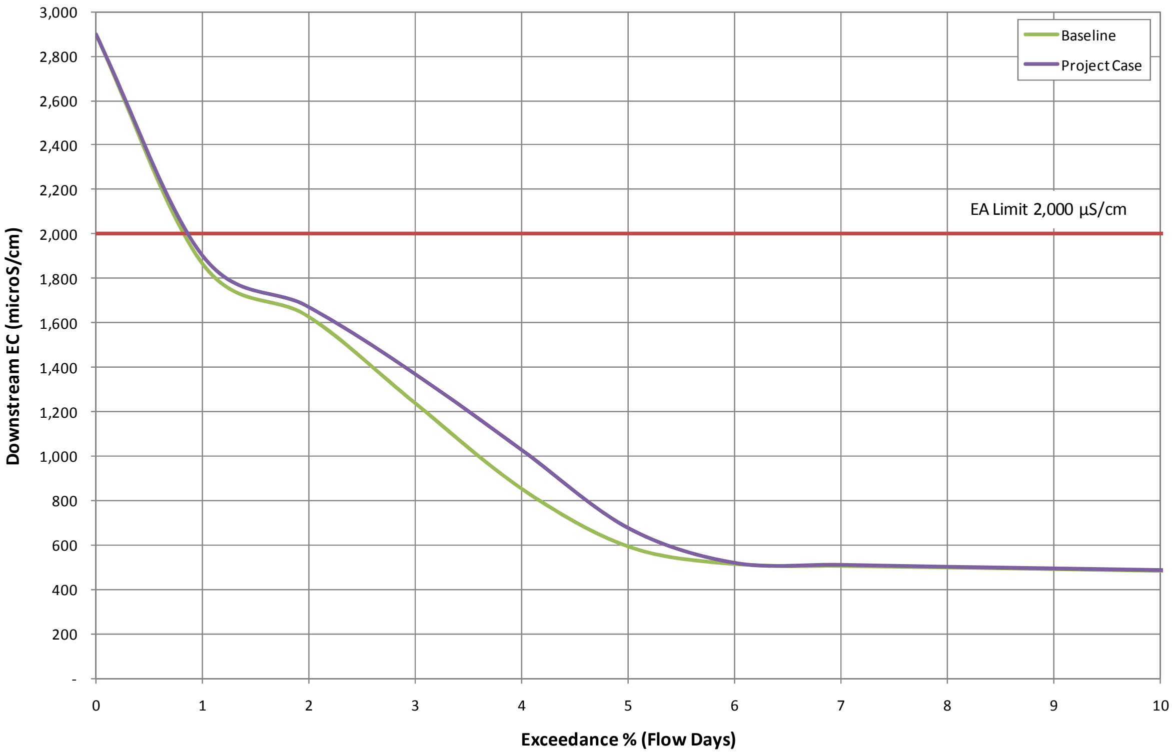


Figure 7-11 EC Levels in Isaac River Downstream during Mine Water Releases – Project Case Comparison with Baseline (Low probability occurrences)



The 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 94 to 99 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.

Mine water balance modelling also examined the effect of water from the RHM on the GRB mine complex's compliance with 'end of pipe' discharge limits and flow related discharge limits. The modelling did not identify any change to compliance levels discussed in **Section 7.2.3.9**, that is:

- The project case 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. These 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.
- The project case 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 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 occurrences of overflows from GS4A, only three of these overflows result in non-compliance with the receiving water quality limit.

Modelling indicates that the addition of mine water from the RHM will not impact on the ability of the GRB mine complex to achieve compliance with the existing EA.

Mine water balance modelling also examined the potential effect on water quantity to determine whether the GRB mine water storage capacity would be exceeded. **Figure 7-12** shows the GRB mine water inventory and available storage with and without the RHM water component. This figure illustrates that there is negligible impact between the project case and baseline scenario. The percentage of time during which surface water storage operating levels are exceeded is predicted to increase from 25 to 27 per cent. When exceedence of the maximum surface storage capacity occurs, water will be stored in one of the low priority pits, as is currently the case. Further details relating to the potential impacts on the impacts on the GRB mine water inventory are presented in **Appendix I3**.

It should be noted that **Figure 7-12** represents surplus conditions for the RHM. In early and middle years of the life of the mine, it is likely that the interface between Red Hill Mine and GRB mine complex will result in a deficit at GRB mine complex as water produced from the proposed RHM will be insufficient to meet demand from the Red Hill CHPP.

The Broadmeadow extension will not have any measurable effect on GRB mine water management as it represents an extension of the existing Broadmeadow Mine without any increase in production.

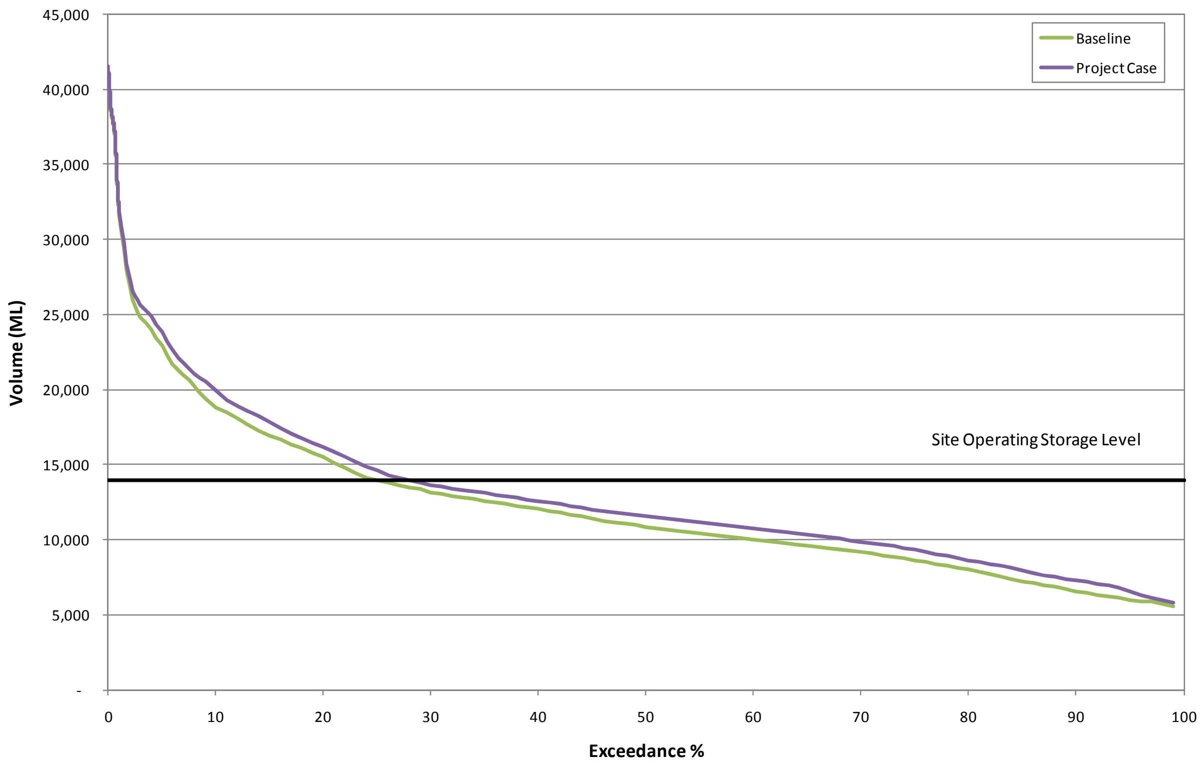
7.3.4.2 Subsidence Impacts on Water Quality

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 EIS 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 (see also **Section 7.3.6.7**). Depending on the extent of actual subsidence that occurs in this area, it may be necessary to drain these ponds as described in **Appendix I7**. 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 for stabilising the land surface after subsidence are outlined in **Section 5.5**.

Figure 7-12 Project Case Scenario Modelled Exceedence of Site Water Volumes



7.3.4.3 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 identified in **Section 5.3.3.4** in relation to erosion and sediment control and **Section 5.4** in relation to prevention of land contamination, together with mitigation measures identified for the construction phase in relation to water quality (**Table 7.11**) will minimise the potential for adverse impacts on water quality.

Drilling muds will be contained and managed in accordance with requirements set out in **Section 15.5**.

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

7.3.4.4 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 7-15** 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 7-15 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 (**Appendix I2**) 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 2013a) – 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.

Impacts During Mine Operation	Mitigation Measures
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. (Erosion and sediment release impacts associated with IMG management infrastructure is discussed in **Section 7.3.4.3**).	• Develop and implement an erosion and sediment control plan for any ground disturbing activities outside the existing mine and stormwater management areas. Further details on erosion and sediment control are provided in **Section 5.3.3.4**. • Conduct regular inspections of any drains and other features of stormwater management systems which are 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.	• Measures in relation to fuel and chemical storage and handling, including refuelling are outlined in **Section 5.4.2.3** and **Section 20** and will minimise likelihood of release to surface waters. • Measures outlined in **Section 5.4.2.3** in relation to spill response will minimise likelihood of release to surface waters. • 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.

7.3.4.5 Water Quality Monitoring Program

A receiving environment monitoring program is already in place for the GRB mine complex, in accordance with requirements of the EA EPML00853413. Water quality monitoring for the proposed RHM will be based on the existing EA and REMP, with some augmentation as required to address possible impacts on Goonyella Creek and 12 Mile Gully, as well as to progressively replace existing water quality monitoring sites that may be affected by subsidence.

Water quality monitoring will be undertaken in accordance with the DERM (2010b) water quality *Monitoring and Sampling Manual 2009*, which provides guidance on techniques, methods and standards for sample collection; sample handling; quality assurance and control; and data management.

Table 7-15 sets out proposed additional water quality monitoring locations for the operations phase of the RHM underground expansion option and GRM incremental expansion. Where baseline data is not already available from the GRB mine complex EA and REMP, monitoring baseline data will be collected over a two year period prior to disturbance. The Upper Isaac sites will be developed as subsidence affects existing Isaac River upstream monitoring points. Final locations will be determined based on access, suitability of the stream channel and operational requirements. Monitoring sites will be equipped with continuous water quality measurement for EC, pH and turbidity.

Table 7-16 Proposed New Water Quality Monitoring Locations

Site ID	Site Description	Coordinates (Indicative)	
		Latitude	Longitude
RHSW1	12 Mile Gully (upstream)	-21.740032	148.053816
RHWS2	Upper Isaac u/s Red Hill	-21.7081	148.042489
RHSW3	Goonyella Creek	-21.712069	148.020328
RHSW4	Upper Isaac	-21.801764	147.994955
RHSW5	12 Mile Gully (downstream of subsidence)	-21.78033	148.02174
RHSW6	Isaac River Rail Bridge	-21.855446	147.973224
RHSW7	Lower Isaac	-21.870222	147.975359

Monitoring parameters will include:

- physico-chemical: electrical conductivity (field and lab), pH (field and lab), suspended solids, turbidity (field), flow rate, dissolved oxygen (field), temperature (field), sulphate (lab), fluoride (lab), sodium (lab);
- metals (total and dissolved): aluminium, chromium, copper, iron, molybdenum, nickel, selenium, uranium, vanadium, zinc;
- total petroleum hydrocarbons: C6 to C9, C10 to C36; and
- nitrate.

The parameters to be analysed for the ongoing monitoring program are selected based on protecting the environmental values of the watercourses and include parameters that may be impacted on by coal mining operations.

Monitoring will be undertaken fortnightly during and after major rainfall events where flow is sufficient and safe access is available.

In addition, the following will be monitored and recorded in relation to water transferred from RHM to GRB mine complex:

- daily flow;
- pH;
- electrical conductivity.

7.3.5 Impacts of Subsidence on River Geomorphology

7.3.5.1 Impacts on Stream Geomorphology

Isaac River Cumulative Impact Assessment of Mine Developments

The potential impacts of longwall mining on the Isaac River have been subject to investigation within the EIS study area, including at Broadmeadow Mine. Anglo American Metallurgical Coal (AAMC) Moranbah North Mine began subsidence impact investigations in 2001 for the Isaac River. This was followed by the development of a management strategy in 2002 and 2003. BMA's BRM undertook subsidence impact investigations and development of a management strategy in 2005 to 2006. Both investigations were largely based around the single mine. However, river systems are a continuum and impacts (including management actions to mitigate impacts) at different locations are likely to influence each other and may compound. BMA and AAMC recognised the need to undertake an assessment of the Isaac River and potential impacts on a broader scale than individual mine leases, hence the Isaac River Cumulative Impact Assessment of Mine Developments (IRCIA) was undertaken (Alluvium Consulting 2009).

The then DERM was included as the key stakeholder in the assessment and involved in each stage of the project, providing input to the scope and method and signing off on the process and technical studies along the way. The impacts of longwall mining on alluvial stream systems were categorised by industry stakeholders at a workshop convened by the then DERM in Rockhampton in April 2007. Impacts on waterways from subsidence were categorised into the following hierarchy:

- 1st order – direct physical effects of subsidence;
- 2nd order – geomorphic response to subsidence;
- 3rd order – changes to water quantity and quality;
- 4th order – biological response; and
- 5th order – impacts of human response to other impacts.

The IRCIA developed and quantified 1st and 2nd order impacts across all the existing and proposed underground mine plans that were planned to extend beneath the Isaac River as they were known in 2007, which included a superseded mine plan for the project. Overall, plans to subside approximately 28 kilometres of the Isaac River channel were included with approximately 60 longwalls extending beneath the river with maximum subsidence of 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, such as potential for river bed deepening of up to 1.8 metres and subsequent widening through bank erosion within the BRM plan reach. Such impacts are presently being managed at the local scale with soft engineering solutions such as timber pile fields and vegetation as implemented at BRM and Moranbah North mine.

In summary, the predicted geomorphic responses of the Isaac River were:

- establishment of temporary pools in the river bed;
- upstream migrating streambed degradation (also referred to as upstream deepening or head cut erosion);
- sediment starvation and downstream bed degradation;
- incision in the tributaries; and
- potential avulsion paths and interruption to overland flow paths on the floodplain.

The geomorphic assessment undertaken for this EIS has reviewed the geomorphic responses and potential impacts for waterways across the project for the current mine plan and an increased maximum depth of subsidence for each longwall panel of five to six metres.

Potential Impacts on the Isaac River from the RHM

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 a total void of 1,309,033 cubic metres (refer to **Figure 7-13** and **Table 7-17**). For visualisation purposes, this volume is equivalent to an average increase of 3.1 metres in depth over the 10.6 kilometre project reach of the Isaac River channel. The subsidence troughs vary in length depending on the orientation of the longwall panel to the river channel; however, each is separated by pillars that only subside up to one metre.

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). Refer to **Figure 7-14** for an example of the change in hydraulic parameters on the subsided profile of the Isaac River.

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 which is conceptualised in **Figure 7-15**. The negative impact associated with deepening is bank instability as initial deepening will expose the unvegetated 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 EIS study area, bank erosion is likely to be localised, temporary and managed by soft engineering techniques such as timber pile fields and enhancing riparian vegetation coverage.

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 which will overwhelm the subsidence voids is provided in **Appendix I6**. The outcomes are summarised in **Figure 7-16**. 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.

Table 7-17 Summary of Subsidence Void Space Created in Isaac River

Red Hill 100 Series Longwall Panels (South of Main Headings)			
Panel ID	**Max Depth (m)**	**Subsidence void (m^3)**	**Timeframe for Mining**
RH103a	- 6	135121	2026-2030
RH103b	-6	79975	2021-2025
RH104	-6	338697	2026-2030
	Sub-total	*553,792*	
Red Hill 200 Series Longwall Panels (North of Main Headings)			
Panel ID	**Max. Depth (m)**	**Subsidence void (m^3)**	**Timeframe for Mining**
RH205a	-6	58466	2021-2025
RH205b	-6	283360	2026-2030
RH205c	-6	131978	2026-2030
RH206	-6	53482	2026-2030
RH207	-6	110868	2026-2030
RH208	-5	34655	2026-2030
RH209	-6	71784	2031-2035
RH210	-4	10649	2031-2035
	Sub-total	*755,241*	

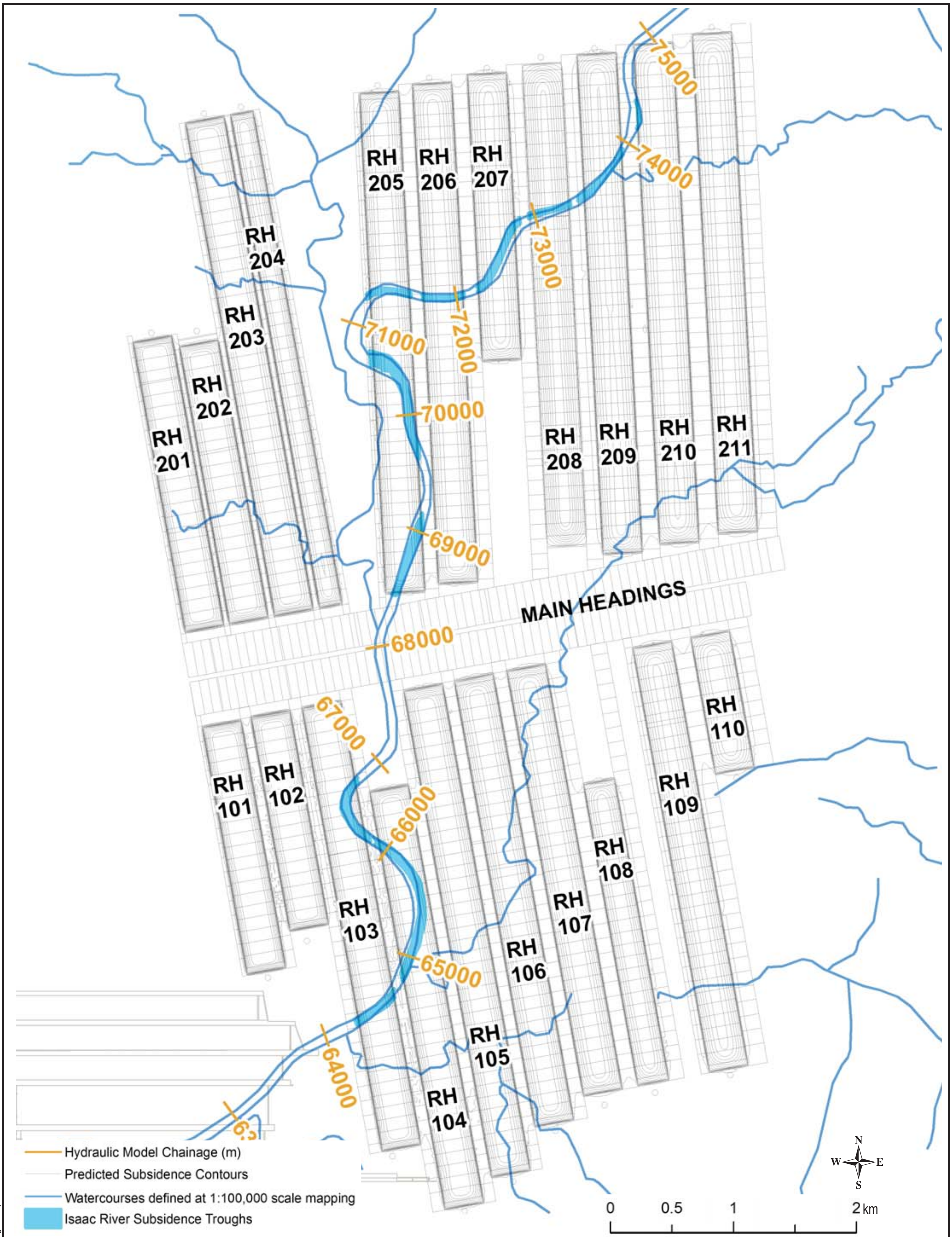
Based on the flow regime of the Isaac River it has been estimated that the river will infill this strip depth within 40 years, given continuing oversupply of sediment to the system. There is only a 35 per cent chance of this occurring during the 15 years of mining that subside the river.

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 7-17**). 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 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 7-17**.

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.



Source: BMA Supplied

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

SUBSIDENCE CONTOURS (0.5m) ACROSS THE RHM

URS

SURFACE WATER

Figure: **7-13**

File No: **42627136-g-1118.cdr** Drawn: **VH** Approved: **CT** Date: **08-07-2013** Rev.**A** A4

Figure 7-14 Hydraulic Parameter Change Profile on Subsided Surface Across the RHM

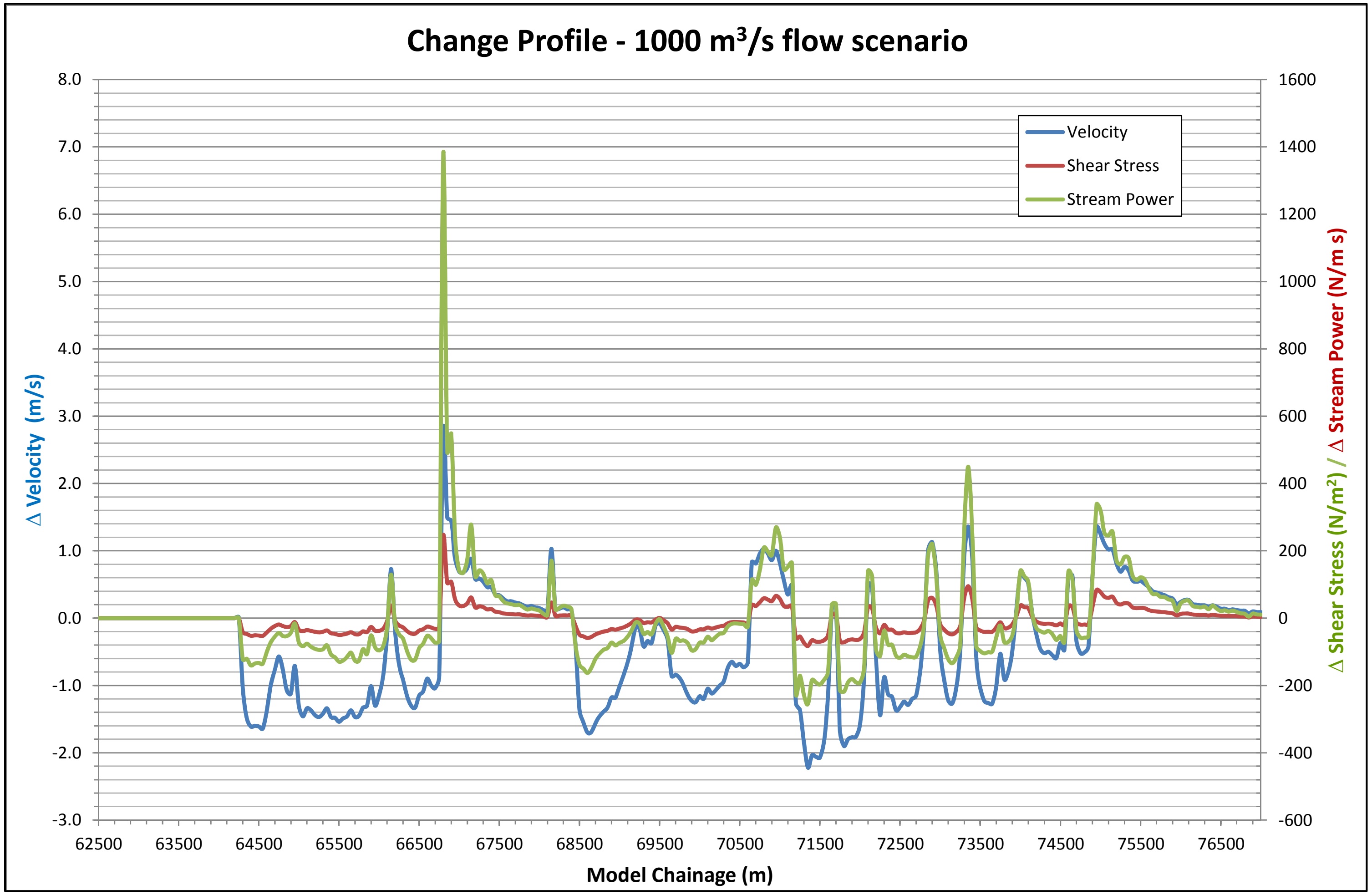
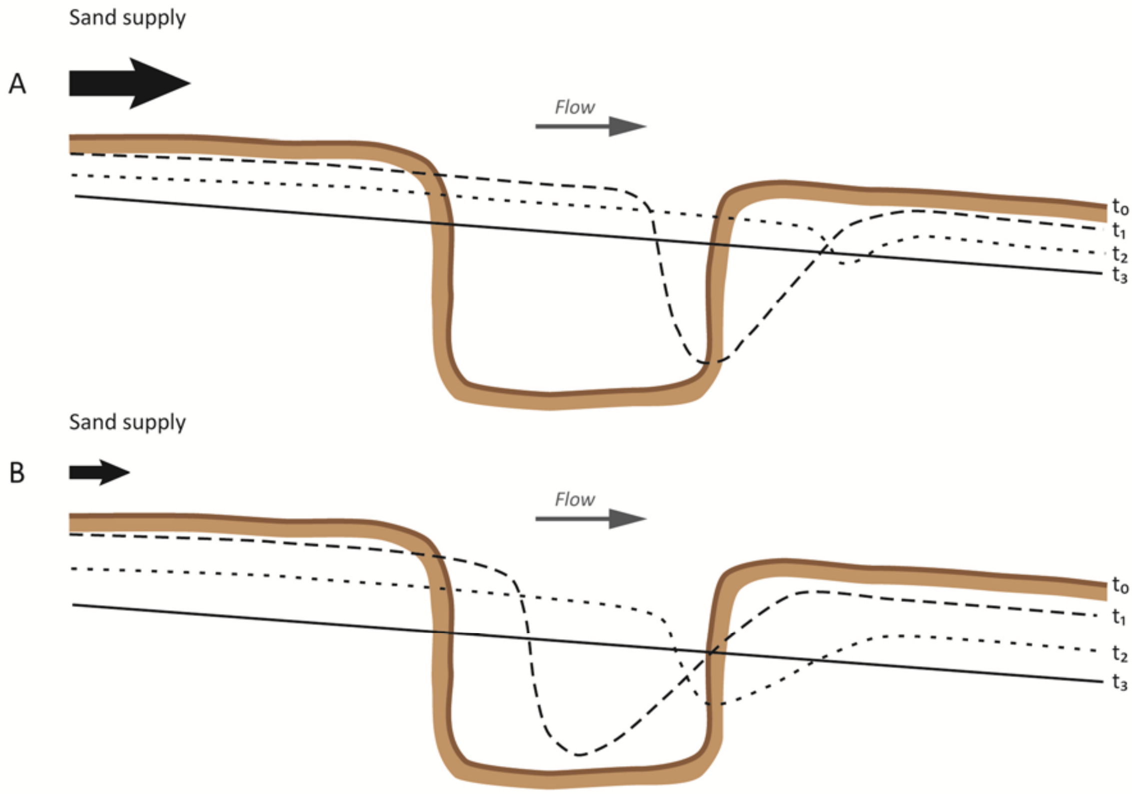


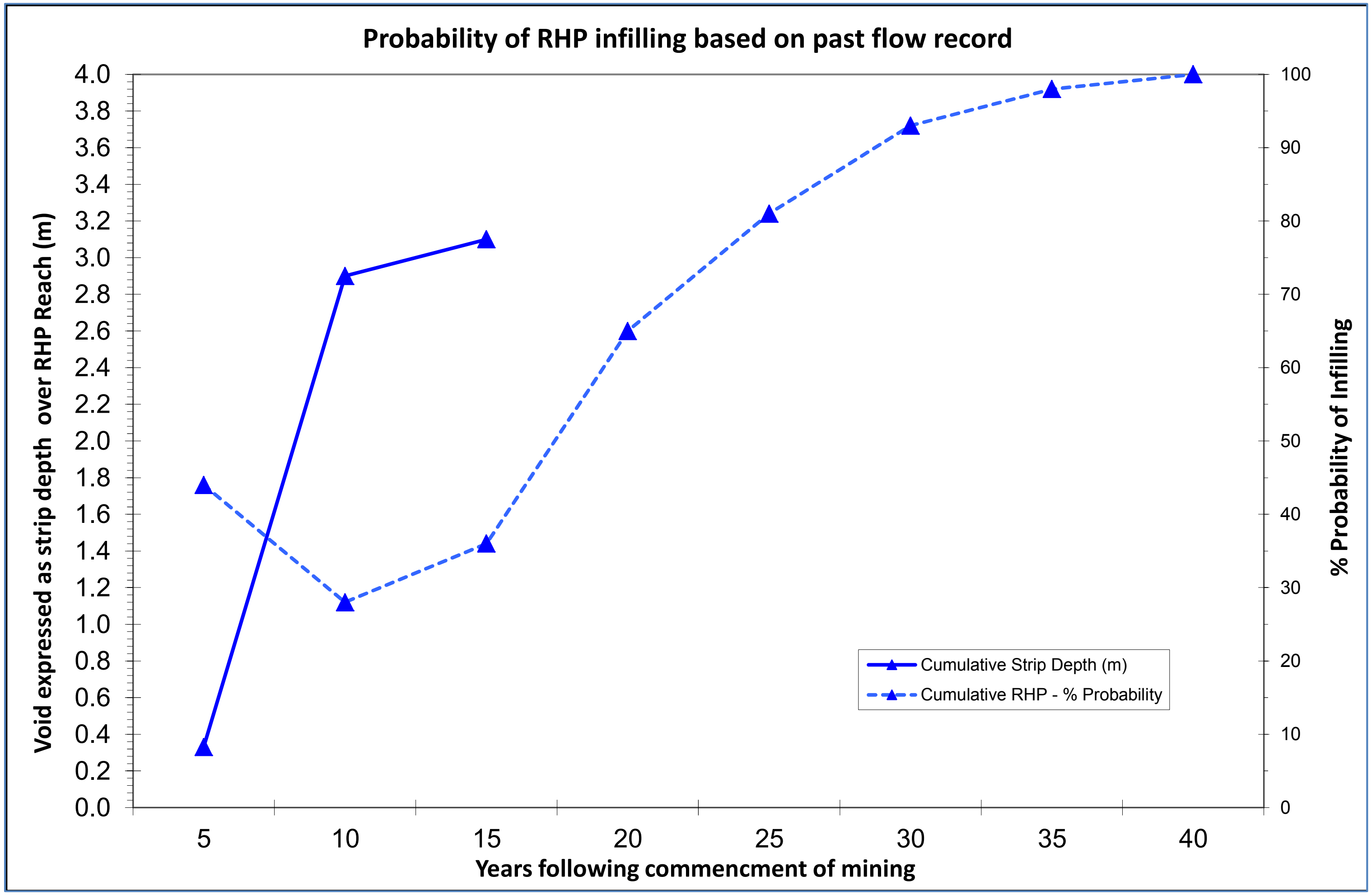
Figure 7-15 Conceptual Model of Stream Bed Adjustment to Subsidence

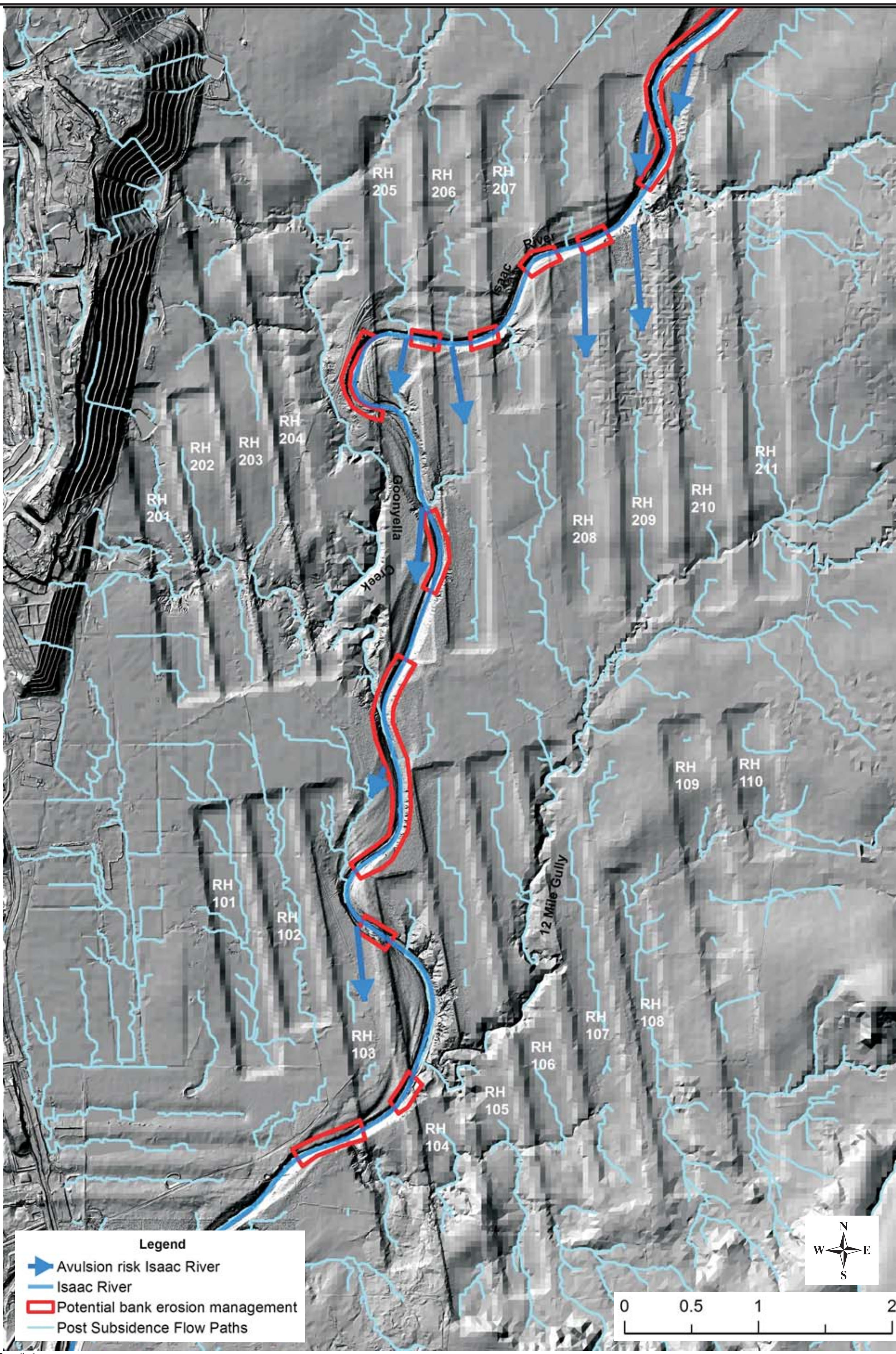


Schematic effects of extracting sediment from a stream bed.
In A, where there is a large sediment load, the pit migrates downstream, but overall bed lowering is small. In B, where sediment load is small, the pit fills slowly and the bed lowers considerably.

Adopted from Rutherford, I.D., Jerie, K. and Marsh, N. 2000. Stream Rehabilitation Manual, Vol.2, Land and Water Australia

Figure 7-16 Response to Subsidence and Timeframe to Infilling by Sand Supplied from Upstream





Source: BMA Supplied

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

POTENTIAL AREAS OF INSTABILITY AND ACCELERATED EROSION FOR ISAAC RIVER

URS

SURFACE WATER

Figure: **7-17**

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Table 7-18 Summary of the 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 EIS 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 7-19**) (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).

7.3.5.2 Impacts on Tributaries and Minor Flow Paths

The likely impact of subsidence on tributaries and minor flow paths across the EIS 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) presented in **Appendix I5** 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:

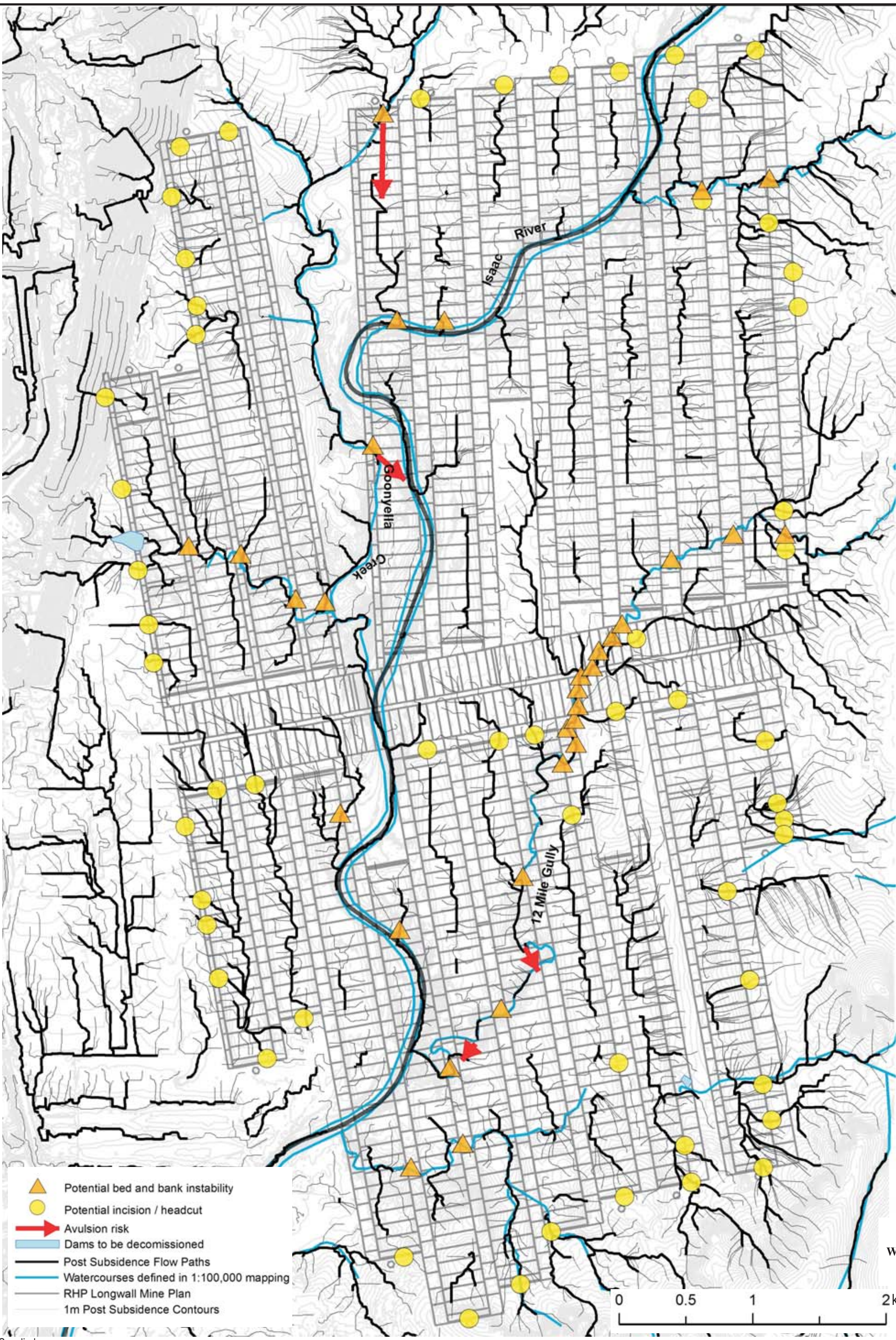
Upstream/outer limit of subsidence:

- 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 7-19**), 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 7-18**. Mitigation options and risks for the geomorphic response and potential impacts described above are summarised in **Table 7-18**. 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.



Source: BMA Supplied

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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

AREAS OF POTENTIAL EROSION IN TRIBUTARIES AND PANEL CATCHMENTS

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SURFACE WATER

Figure: **7-18**

File No: **42627136-g-1121.cdr** Drawn: **VH** Approved: **CT** Date: **24-06-2013** Rev.**A** A4

Table 7-19 Summary of the Predicted Geomorphic Response for Tributaries and Panel Catchments, Impacts, Mitigation Options and Risks

Feature / Environmental Value	Geomorphic Response	Potential impact	Mitigation Options[1]
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 7-19**).	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.

Note 1: Mitigation option examples are shown in **Appendix I6.**

7.3.5.3 Monitoring and Management

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 project. 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 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 (SMP) are typically:

- ongoing subsidence monitoring, evaluation, review and improvement program;
- 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.

7.3.6 Post Mine Phase Impacts on Water Resources Hydrology

7.3.6.1 Overview

Subsidence resulting from the project mining activities may potentially impact on the broader catchment hydrology and water resources availability in the Isaac River downstream of the mine. This will occur for a limited period of time ranging from the approximate 25 years life of mine up to approximately 40 years depending on the rate of infill. However, the extent and duration 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.

7.3.6.2 Mitigation of 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 **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.

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.

7.3.6.3 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). Note in the context described herein subsidence depressions are referred to as subsidence voids; however, this is not same as a mine pit void.

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.

Where the subsidence void storage capacity is small and the contributing upstream catchment is large, a few millimetres of catchment runoff will typically be sufficient to fill and overflow the subsidence void. In these situations the impact of water ponding in subsidence voids will have immeasurably low impact on the downstream flow volumes and not impact on the broader catchment water resources hydrology. This situation is relevant for the voids that will form in the main channel of the Isaac River where the upstream catchment is large and subsidence void volume is relatively small. Furthermore, based on the findings of the assessment of subsidence impacts on geomorphology it is expected that that subsidence voids in the Isaac River will eventually fill with sediment and their storage capacity will diminish (nominally in twenty to forty years – refer to **Section 7.3.4.5**). On this basis, the subsidence voids that will be created within the Isaac River channel will have no appreciable impact on the hydrology of the Isaac River flows.

Where the subsidence void storage capacity is relatively large and has small or limited contributing upstream catchment area, the rainfall and runoff volumes may be insufficient to completely fill the subsidence void and these voids may rarely overflow, except in very high rainfall events or flood conditions. This is the case for 12 Mile Gully. In this situation, the waters trapped in the subsidence voids in typical average climate will primarily be lost to evaporation and represent a loss of flow to the downstream watercourses. An assessment has been undertaken to quantify this potential impact and is described further herein.

7.3.6.4 Extent of Surface Subsidence Voids Outside the Isaac River Channel

The worst case possible extent and magnitude of subsidence voids outside the Isaac River channel has been determined and mapped and is presented on **Figure 7-19**.

The process to determine the extent and magnitude of subsidence voids is described in detail in **Appendix I7**.

The mapped potential ponding extents represents the worst case scenario because of the assumption that no works are undertaken to drain or partially drain the voids, no erosion occurs of the overflow flowpaths, and no sedimentation occurs in the voids. It is expected that if no works are undertaken to drain the subsidence voids, their storage capacities could gradually diminish over time as erosion of the overflow flowpaths occurs, and sediment is deposited in the voids, similar to the processes described in the subsidence impacts on Isaac River geomorphology in **Section 7.3.4.5**. In contrast to the geomorphological responses predicted for the voids in the Isaac River channel, for the subsidence voids outside the Isaac River channel it is unlikely that the voids would completely fill with sediment, and the erosion of the overflow levels and deposition of silt would likely be relatively slow (over decades or centuries).

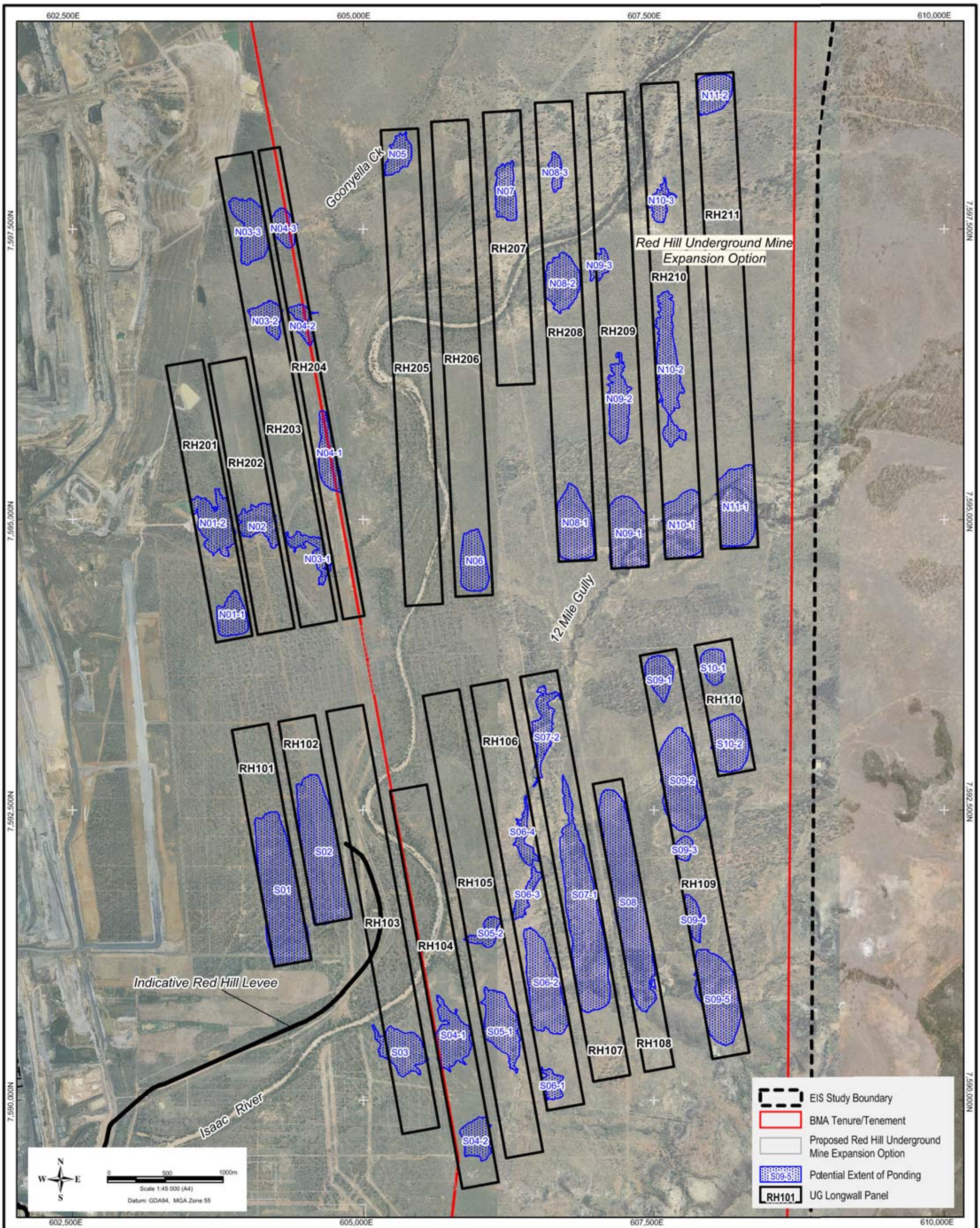
Although it is considered to be a worst case scenario for potential ponding volumes in the subsidence voids, the mapped potential ponding extents were considered a reasonable basis to assess worst case potential impacts of ponding on catchment water resources hydrology.

The mapping of potential subsidence void ponding extents and volumes (outside the Isaac River channel) identified 44 ponding areas, with the largest being 40 hectares. The subsidence voids would range from less than 10 ML capacity up to a maximum of approximately 1,100 ML capacity. The average capacity would be approximately 210 ML. The average area of the ponds would be approximately 12 hectares.

It is important to note that although subsidence predictions estimate up to six metre depth of subsidence, not all subsidence voids will be this deep to their overflow level. The maximum depth of subsidence void ponding depends on the geometry of the void which is influenced by the alignment of the longwall mine panels and topography of the existing landscape (before subsidence). Only a few of the identified subsidence voids would have potential depths up to five or six metres, and most would be typically in the range of three to four metres maximum depth of ponding. Detailed information of the estimated subsidence void characteristics is presented in the **Appendix I7**.

The combined total volume of the worst case subsidence voids is estimated to be approximately 9,500 ML.

There would be two large voids in longwall panels RH101 and RH102 (see **Figure 7-19**) located close to the proposed Red Hill MIA area approximately 2,100 ML combined capacity. If left un-mitigated, these ponds will overflow towards the MIA and mine access area, behind the proposed flood levee. This is contrary to the operating principle of keeping clean water out of the mine water system and may result in unmanageable volumes of water entering the Red Hill MIA dam. These voids will therefore need to be drained towards the Isaac River.



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POTENTIAL PONDING IN SUBSIDENCE AREAS - NO MITIGATION CASE

URS

SURFACE WATER

Figure: **7-19**

File No: **42627136-g-1107.wor** Drawn: **VH** Approved: **CT** Date: **24-06-2013** Rev.**A** A4

Assuming that the voids in RH101 and RH102 (see **Figure 7-19**) will be drained, the remaining total volume of the worst case subsidence voids would be approximately 7,400 ML. Of these approximately 5,200 ML of potential ponding in voids would be in the 12 Mile Gully catchment.

The subsidence voids that are located in the Goonyella Creek catchment are considered to have minimal potential to impact on the hydrology of Goonyella Creek flows into the Isaac River. The void volumes in the Goonyella Creek catchment are small with approximately 900 ML total capacity while the catchment of Goonyella Creek is large at approximately 100 km^2. In effect the subsidence void volumes in Goonyella Creek represent approximately the equivalent of nine millimetres of catchment runoff and therefore would fill quickly in relatively small rainfall events, and allow excess catchment runoff flows to continue along natural flow paths.

Conversely, given the volume of the subsidence voids in the 12 Mile Gully catchment compared to the size of the catchment, these could capture a large enough proportion of rainfall runoff and make a noticeable impact on downstream hydrology. To assess this further a hydrological simulation model of the 12 Mile Gully catchment was developed to quantify potential flow losses.

7.3.6.5 12 Mile Gully Hydrological Analysis - Case with No Mitigation

A hydrological simulation model of the 12 Mile Gully catchment with the worst case scenario of subsidence void ponding was developed to estimate potential net flows from the 12 Mile Gully catchment into the Isaac River. A detailed description of the model is presented in **Appendix I7**.

The hydrological model is a daily time step water balance type simulation that represents the runoff from sub-catchment areas for each of the subsidence voids, direct rainfall onto the ponded area surface, evaporation from the ponded area surface, and a minor amount of seepage loss. The model can then assess the variability of ponding volumes in the subsidence voids, and when large rainfall events occur, the model calculates overflows from the subsidence voids into downstream voids or channel flow reaching the Isaac River. A time-series output of net downstream flow from the 12 Mile Gully catchment is calculated as a key output of the model.

The model was analysed using climate data for the period July 1983 to November 2011.

The hydrological model analysis of the 12 Mile Gully catchment for the case with subsidence voids (worst case void volumes) estimated a mean annual flow of 2,100 ML/year (period 1983 to 2011). For the baseline of the existing catchment with no subsidence the mean annual flow is estimated to be 4,400 ML/year. From this it is estimated that the potential loss of water resources from the 12 Mile Gully catchment would be approximately 2,300 ML/year if no action is taken to drain or partially drain voids.

7.3.6.6 Significance of Hydrological Impacts - Case with No Mitigation

The hydrological analysis indicates that 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 (refer to **Section 10**) and, hence, on this basis, mitigation has been considered to reduce ponding in the 12 Mile Gully catchment as discussed in **Section 7.3.7.7**.

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 (refer to **Section 7.3.2.5**). 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 (refer **Section 7.2.2.5**). 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 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 Resource 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 within the 12 Mile Gully water course.

7.3.6.7 12 Mile Gully Hydrological Analysis - Case with Potential Mitigation

Overview

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.

Mitigation Assumptions

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. A potential mitigation which has considered a balanced approach has been identified and assessed. 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.

The potential mitigation option to partially drain the larger subsidence voids is presented in **Table 7-20**. A subsidence ponding map for the mitigated case is presented in **Figure 7-20**. 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.

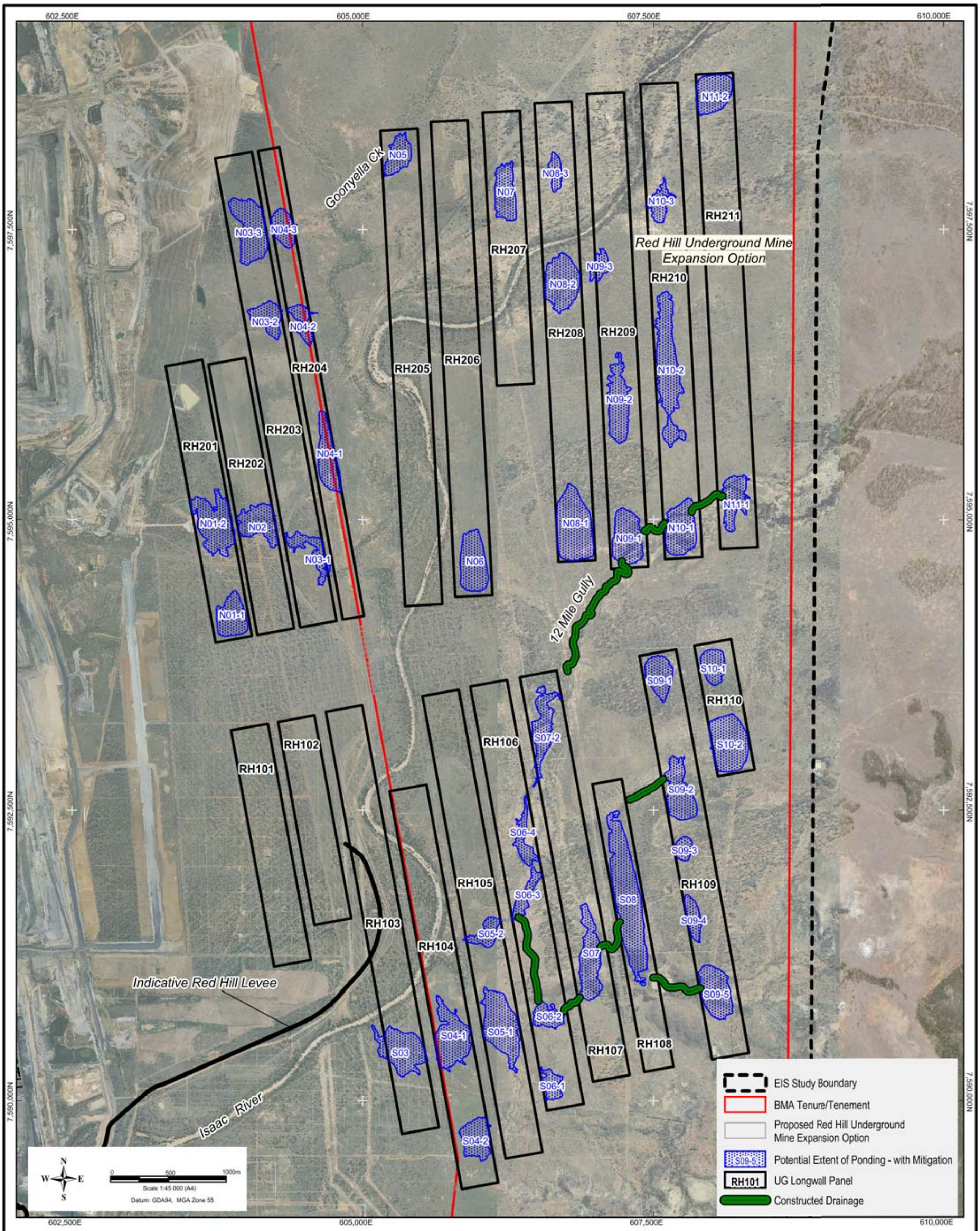
Table 7-20 Potential Subsidence Ponding Mitigation – Partial Drainage of Larger Voids

Void / Pond (1)	Longwall Panel	Unmitigated Case Voids (no drainage)			Mitigated Case Voids (partially drained)		
		Maximum Depth (m)	Maximum Volume (ML)	Maximum Surface Area (ha)	Maximum Depth (m)	Maximum Volume (ML)	Maximum Surface Area (ha)
N09-1	RH209	5.0	466	20.3	2.5	93	9.5
N10-1	RH210	4.0	385	18.5	2.0	104	9.6
N11-1	RH211	4.5	392	20.1	2.0	36	7.5
S06-2	RH106	4.0	276	21.9	2.0	34	4.8
S07-1	RH107	4.0	580	45.1	2.0	51	10.5
S08	RH108	4.0	927	48.0	2.0	216	23.1
S09-2	RH109	4.5	496	25.3	2.0	70	8.5
S09-5	RH109	5.0	514	23.1	2.5	108	9.7

Note 1 Refer void reference identifications in **Appendix I7.**

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.



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RED HILL MINING LEASE
ENVIRONMENTAL IMPACT STATEMENT

POTENTIAL PONDING IN SUBSIDENCE AREAS - EXAMPLE MITIGATION CASE

URS

SURFACE WATER

Figure: **7-20**

File No: **42627136-g-1123.wor** Drawn: **VH** Approved: **CT** Date: **24-06-2013** Rev.**A** A4

Summary of Subsidence Ponding Mitigation Requirements

Based on this assessment it is considered that hydrological impacts of the project on water resources in the Isaac River will not be significantly impacted. With no mitigation works the localised impacts on flows in 12 Mile Gully is potentially significant, however this can be mitigated with a reasonable balance of partially draining of some of the larger subsidence voids as part of progressive mine closure.

This assessment does not represent a definitive mitigation case, but rather demonstrates that, based on a worst case scenario for the extent of subsidence, adequate mitigation can be achieved by partially draining some of the larger subsidence voids. The eventual actual mitigation works to be implemented will be assessed and decided in more detail as part of progressive mine closure planning for the project. The assessments will consider the balance of trade-off between minimising the degree of disturbance required to partially drain some of the subsidence voids and the hydrological benefit gained from this strategy. The assessments will also consider detailed geotechnical information and best practice rehabilitation methods to ensure that created drainage pathways can be stable beyond mine closure. Recommendations for drainage design are provided in **Appendix I7**.

It is considered that potential hydrological impacts are not sufficiently significant that would warrant a need to completely drain subsidence voids to minimise ponding (other than two subsidence voids near Red Hill MIA which need to be drained for operational reasons). Works to subsidence void overflow flow paths may be necessary to stabilise geomorphological response of the 12 Mile Gully watercourse channel and would be decided based on a detailed monitoring program.

There could potentially be positive ecological benefits of allowing ponding to occur in the subsidence voids. It is therefore considered that the need to partly drain subsidence voids should be considered in conjunction with ecological assessment of the relative benefits and impacts of ponding in the subsidence voids. A final assessment of the need to partially drain the subsidence voids may be undertaken once the extent of final subsidence and the size of voids is known across the future RHM footprint.

7.3.7 Consideration of Climate Change Impacts on Flooding

The impacts of climate change on the proposed project are difficult to assess as there are a range of scenarios of predicted effects. However, in addressing the potential risk of climate change for the purposes of this EIS, it can be noted that Engineers Australia have published a paper entitled, *Implications of Climate Change on Flood Estimation, Discussion Paper For the Australian Rainfall and Runoff Climate Change Workshop No. 2* (February 2011). The paper summarises studies that have been completed or partially completed from Australia and other parts of the world. The conclusions reached for Australia were generally:

- New South Wales recommends a sensitivity analysis with a 10 to 30 per cent increase in extreme rainfall.
- Queensland is considering adopting a five per cent increase per degree temperature change for the 1 in 100 to 1 in 500 AEP events.
- The Bureau of Meteorology has concluded that it was 'not possible to confirm that probable maximum precipitation will definitely increase under a changing climate'.

As a simplified approach to estimate the potential impacts of climate change on the proposed project, a scenario has been considered where estimate peak flood flows will increase in frequency. For example the current 1 in 100 AEP flood estimate, may occur with a frequency of 1 in 50 AEP under a climate change scenario. The impacts of such an increase frequency of peak flood flows due to climate change would include the following:

- The more frequent events would have higher discharges. However, the relative changes to the existing watercourse flood hydraulics would generally remain the same.
- The current estimate of the 1 in 2,000 AEP flood event would become the 1 in 1,000 AEP flood event (with climate change) which still allow the proposed flood levees to provide the proposed level of protection of 1 in 1,000 AEP, but with less freeboard (approximately 0.1 metres, as opposed to 0.5 metres). Should the magnitude of flooding for a 1 in 1,000 AEP flood estimate increase during the life of the project due to further hydrologic studies, measures will be considered, at that time, to meet the required flood immunity and freeboard criteria, such as increasing the levee height.