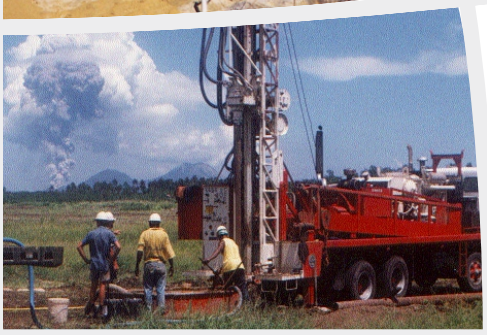

Australasian Groundwater & Environmental Consultants Pty Ltd

REPORT on

GROUNDWATER IMPACT ASSESSMENT

TAROBORAH COAL PROJECT

prepared for
AUSTRALASIAN RESOURCE CONSULTANTS PTY LTD

Project No. G1588
October 2014

ABN:64 080 238 642

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DFB:tl (Taroborah)
Project No. G1588
October 2014

GROUNDWATER IMPACT ASSESSMENT

REPORT FOR THE

TAROBORAH COAL PROJECT

1 INTRODUCTION

The Taroborah Coal Project (the Project) is a proposed coal mine in Central Queensland, located approximately 22 km west of Emerald and 340 km northwest of the port at Gladstone (Figure 1). The Project is located on Mineral Development Licence (MDL) 467, which is held by Shenhua International Group Pty Ltd (the Proponent).

The Proponent proposes a combination of underground and open-cut mining methods to develop the resource, with an on-site Coal Handling and Preparation Plant (CHPP) for washing the coal. The proposed open-cut mine is situated within the southern part of the MDL, south of the Capricorn Highway; whilst the underground mine is to the north.

The Proponent engaged AustralAsian Resource Consultants Pty Ltd (AARC) to manage the environmental approvals process. An Environmental Impact Statement (EIS) is required for the development to be approved and issued with an Environmental Authority (EA). AARC commissioned Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to complete the groundwater impact assessment as part of the EIS for the Project, which is presented in this report. Amendments to the report during the approvals processes were commissioned directly by the Proponent.

1.1 Scope of Work

The scope of work for the groundwater impact assessment is based on the Terms of Reference (TOR) for the Project EIS, prepared by the Queensland Government Department of Environment and Heritage Protection (EHP) and briefing discussions held between AGE and AARC.

In order to address the TOR and complete the groundwater impact assessment, six key tasks were undertaken, described below:

1. Review of all available data and historical reports to develop an appreciation of the physical, geological and hydrogeological setting of the area including:
    - existing baseline groundwater data;
    - geological and environmental reports from the Project area and surrounds;
    - site specific exploration data; and
    - existing bore data held on the Department of Natural Resources and Mines (DNRM) groundwater database (GWDB).

- collecting site specific data in the field to address knowledge gaps identified during the review stage including:
    - drilling and installation of monitoring bores;
    - measuring groundwater levels and quality;
    - testing hydraulic properties; and
    - identifying existing groundwater users through a landholder bore census.

2. Developing a conceptual understanding of the local groundwater system based on existing data and the data collected during field investigations;
3. Constructing a numerical groundwater model based on the conceptual understanding - the modelling included a predictive assessment of the scale and extent of mining impacts on groundwater levels, water quality, and existing groundwater users during mine operations and post closure;
4. developing mitigation and management strategies where potential environmental issues, and potential impacts on existing and future groundwater users, were identified from the predictive modelling; and
5. Formulating a groundwater monitoring program to collect data (levels and quality) before, during, and after mining, in order to assess actual impacts from the mining operation.

2 PHYSICAL SETTING

2.1 Land Use

Within the Project area cattle grazing is the main land use, which utilises groundwater for stock water supply. Groundwater is also used for limited farm water supply. The area has been largely cleared of native vegetation except along watercourses, where some remnant riparian vegetation exists. The Fairburn State Forest is adjacent to the eastern boundary of the project and is used for forestry purposes. Historically, the Retreat Creek alluvium located west (upstream) of the Project area has been mined for gravel and gemstones.

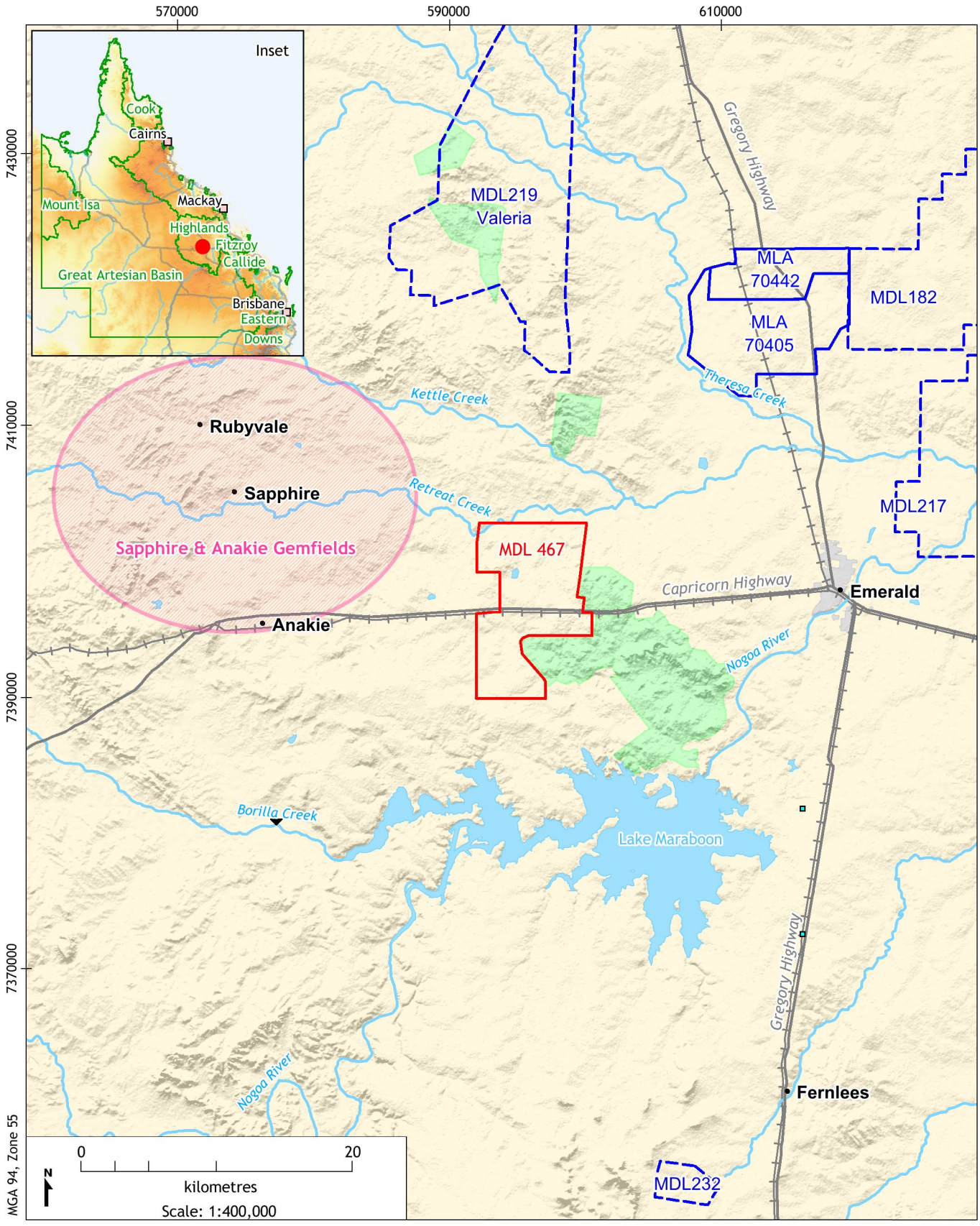
No operating mines currently exist within 10 km of the Project boundary. The closest operating mines are relatively remote, with Minerva Coal Mine located over 45 km to the south, as well as Ensham Coal Mine and Kestrel Coal Mine located over 50 km north-east of the Project area. A proposed mine development, the Valeria Coal Project (MDL 219), is located 13 km north of the Project. Figure 1 shows the site location and surrounding features.

2.2 Groundwater Dependent Ecosystems

The Federal Government has established the National Atlas of Groundwater Dependent Ecosystems (GDEs)[1], based on the current knowledge of GDEs across Australia. The atlas shows known GDEs and ecosystems that potentially use groundwater, and is considered the most comprehensive inventory of the location and characteristics of GDEs in Australia. The GDE Atlas was created using remote sensing data, previous mapping and literature reviews.

Data derived from the Bureau of Meteorology (2012) Groundwater Dependent Ecosystems Atlas shows that ecosystems within and surrounding the Project area have a low to moderate potential for groundwater interaction (Figure 2).

[1] http://www.bom.gov.au/water/groundwater/gde/index.shtml



LEGEND:

- Taroborah MDL Boundary
- Mineral Development License
- Mining Lease Application
- State Forest
- Reservoirs
- Sapphire & Anakie Gemfields
- Major Rivers and Creeks
- Highway
- Railway

Inset

- Declared Sub-Artesian Areas

Taroborah Coal Project
Groundwater Assessment (G1588)

Site Location

DATE: 26/9/2014

FIGURE No: 1

2.3 Topography and Drainage

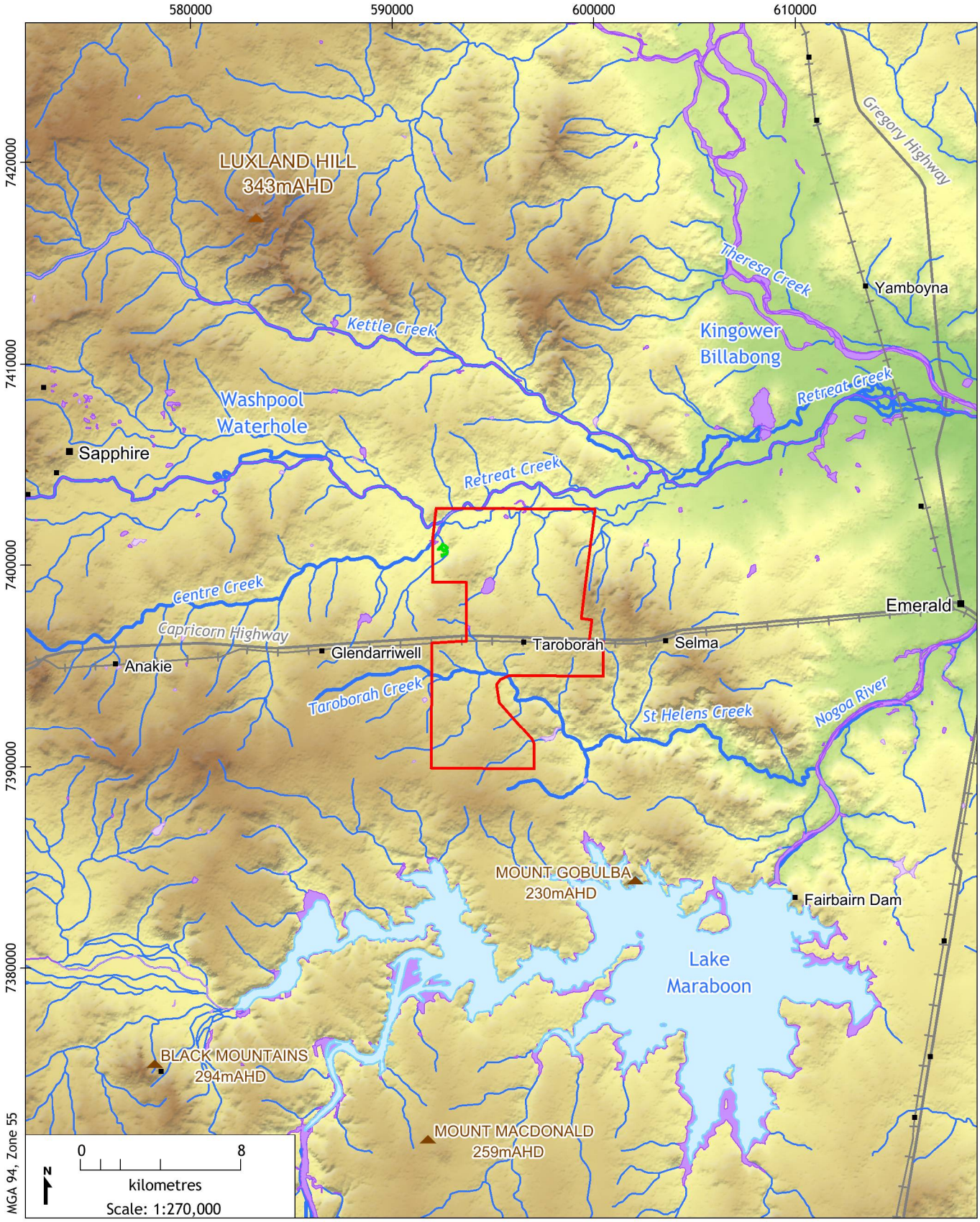
Figure 2 shows topography and drainage across the Project area and surrounds the land surface gently undulates in the Project area and varies from about 200 m above Australian Height Datum (AHD) to 255 mAHD. Topographic highs surrounding the Project area include Luxland Hill (343 mAHD) to the northwest, and the Anakie Range located approximately 30 km west of the Project area.

There are several eastward flowing ephemeral drainage features within the region, including:

- Retreat Creek;
- Taroborah Creek;
- St Helens Creek; and
- Kettle Creek.

Retreat Creek crosses the north-west corner of the Project area, while Taroborah Creek runs east-west, to the south of the Capricorn Highway. Taroborah Creek joins St Helens Creek some five km east of the MDL before flowing into the Nogoa River (Figure 2).

Lake Maraboon, Queensland's second largest lake is located approximately 5 km south of the Project boundary. The lake was created following construction of the Fairburn Dam in 1972 and currently provides water to about 300 irrigators within the Emerald Region. Lake Maraboon discharges to the Nogoa River with flow maintained to supply a consistent water supply to the downstream irrigators.



LEGEND:

- MDL Boundary (467)
- Populated Place
- Watercourse
- Highway
- Railway
- Mountain
- Swamp
- Lake

GDE Atlas (BOM)
(Surface Expression of Groundwater)

- High potential for GW interaction
- Moderate potential for GW interaction
- Low potential for GW interaction

Elevation (mAHD)

587
300
200
153

Taroborah Coal Project
Groundwater Assessment (G1588)

Topography, Drainage and GDEs

DATE: 26/9/2014

FIGURE No: 2

2.4 Climate

The Project area has a sub-tropical climate, typical for Central Queensland. Climatic data is available from the (now decommissioned) Bureau of Meteorology (BoM) weather station at Emerald Post Office (Station No. 35027) for the period 1881 and 1992; and from Emerald Airport (Station No. 35264) from 1992. Emerald Airport is located about 25 km to the east of the Project, and is the closest long-term BoM meteorological station to the Project. Table 1 shows a summary of average monthly rainfall at the two BoM stations between 1900 and 2013.

Table 1: MONTHLY AVERAGE RAINFALL (STATION No. 35027 and 35264)

Average Monthly Rainfall (mm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	99.5	95.9	66.1	35	32.7	31.9	26.6	19.4	22.6	38.7	61.1	91.9	621.5

The data in Table 1 shows that rainfall is highest during the summer months of December, January, and February. The average annual rainfall from 1900 to 2013 is 621.5 mm.

The Cumulative Rainfall Departure (CRD) method (Weber and Stewart, 2004) shows graphically rainfall trends compared against long-term average monthly rainfall. A rising trend in the CRD indicates periods of above average rainfall, whilst a falling slope indicates periods of below average rainfall. Figure 3 shows the CRD for the period 1900 to 2013, and Figure 3, indicates the area experienced below average rainfall from 2000 to 2006, (this period is now known as the Millennium drought) followed by above average rainfall.

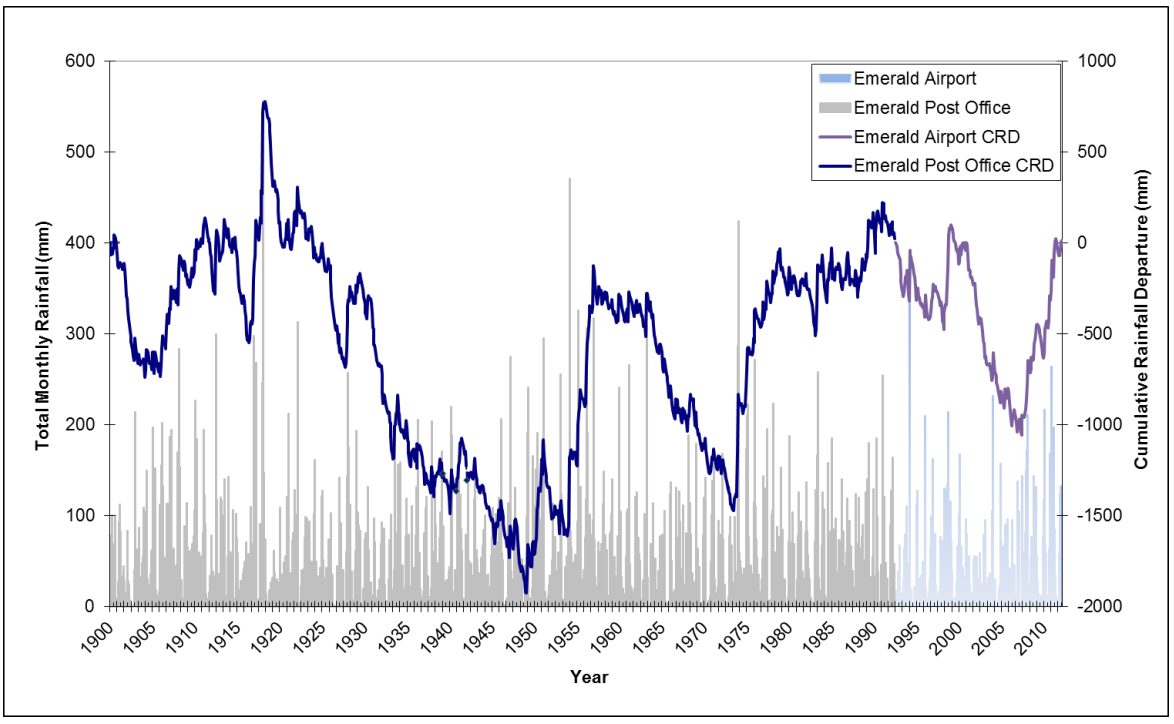


Figure 3: Cumulative Rainfall Departure Graph – Emerald Airport (Station 35264) and Emerald Post Office (Station 35027)

3 GEOLOGICAL SETTING

The sections below describe the geological setting of the area. Data used to describe the geology has been obtained from the following three sources:

- historical investigations from published reports;
- published surface and basement geology maps; and
- recent exploration and resource drilling across the Project area.

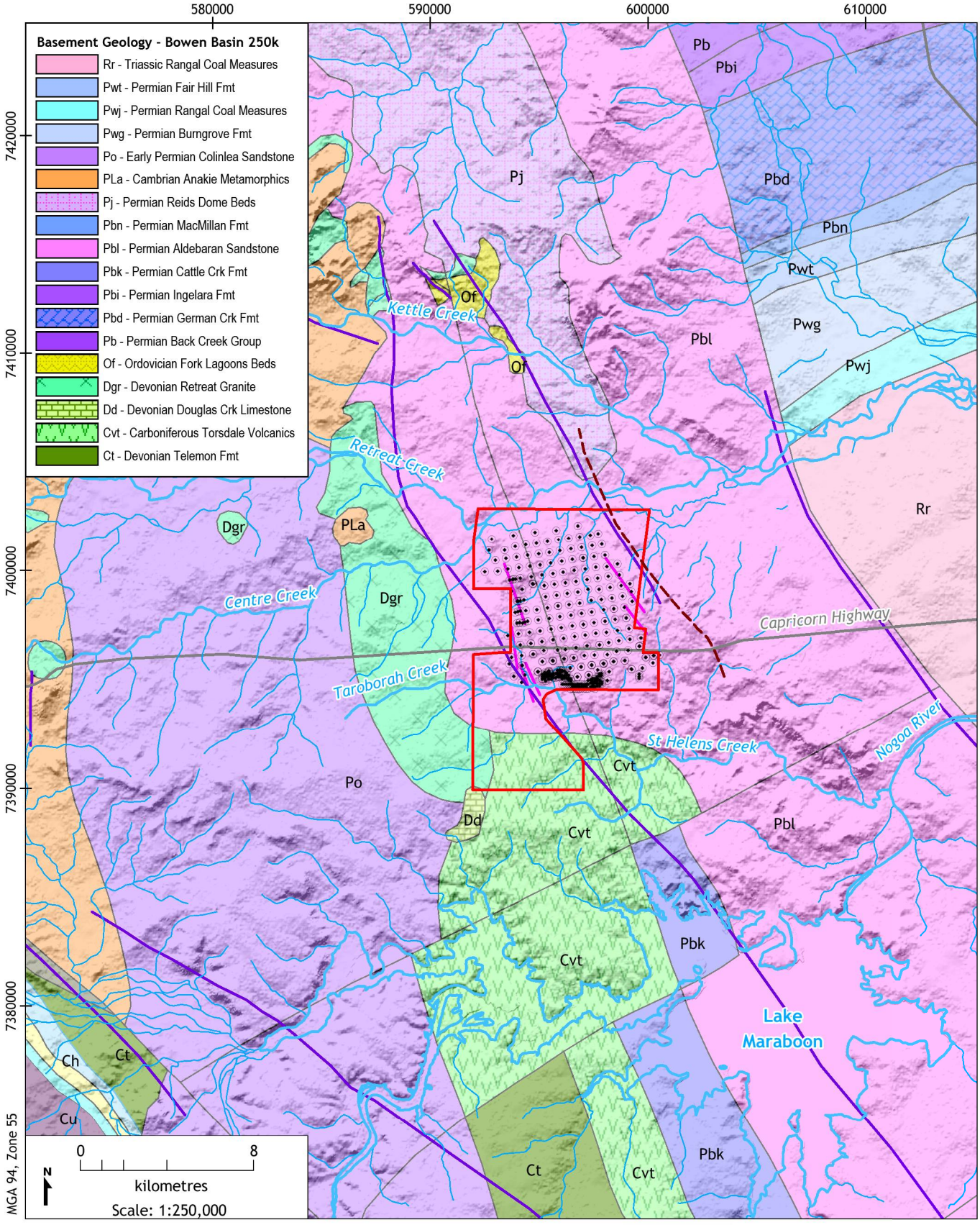
Figure 4 illustrates 1:250,000 scale Bowen Basin basement geology map for the Project area. Figure 5 illustrates the surface geology for the Project area based on the 1:100,000 scale Rubyvale (Sheet 8451) and Anakie (Sheet 8450) geological map sheets. The basement geology map (Figure 4) shows that the Project area is within Permian aged sediments, located approximately 2 km east of the Devonian aged Anakie Metamorphics.

Exploration drilling by the Proponent has confirmed that three major geological units are present within the Project area at depths shallower than 250 m. The stratigraphy typically comprises Permian coal measures overlain by Tertiary basalts and Quaternary alluvium. Table 2 summarises the stratigraphy of the Project area and surrounds.

Table 2: STRATIGRAPHY OF PROJECT AREA

Age	Unit	Map Symbol	Lithology	Thickness
Quaternary - Tertiary	Alluvium	Qa	Sands and minor gravel related to present day streams, creeks and rivers; deposited during the Quaternary.	<30 m
	Colluvium	Qr	Silt, mud, basalt derived colluvial and residual deposits; deposited during the Quaternary.	
	High-level alluvium	TQa	Poorly consolidated sand, silt, clay, minor gravel, generally related to present-day stream valleys; deposited during the Quaternary (and late Tertiary).	
Tertiary	Basalt/Clay	Tb	Olivine basalt where fresh. Clay where highly weathered.	<90 m
Permian	Aldebaran Sandstone	Pbl	Fine grained marine sandstone.	<150 m
			Fine to coarse fluvio-deltaic sandstone. Contains coal and coarse grained pebbly unit. Coal seams include the A and B seams, which are the target seams for the Project.	50 m – 100 m

Section 3.1 to Section 3.3 describe the stratigraphy of the area according to stratigraphic order, from youngest to oldest.



LEGEND:

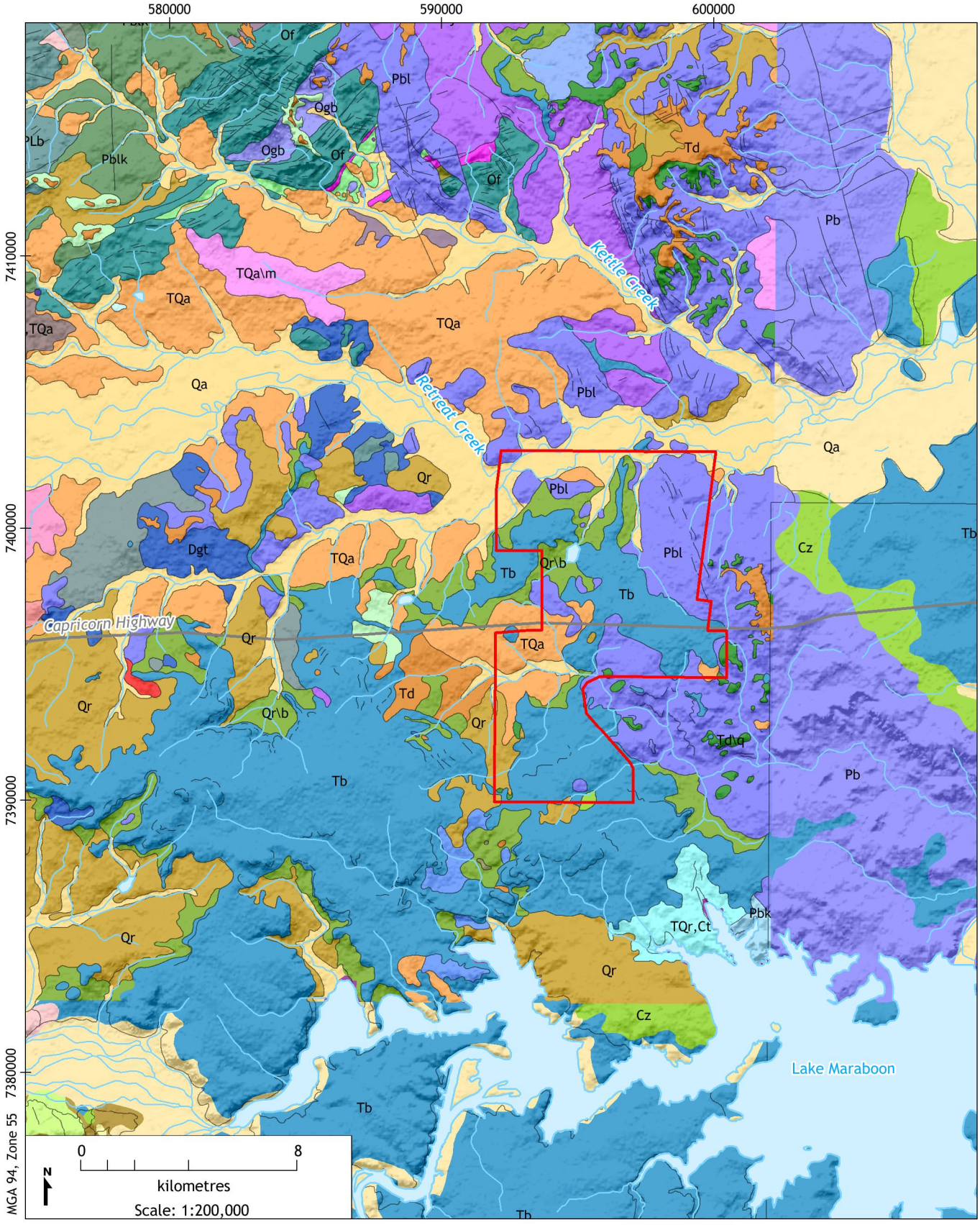
- Bowen Basin Fault
- IMC Inferred Fault
- Inferred Anticline (Veevers et al, 1962)
- Exploration Drill Hole
- MDL Boundary
- Watercourse and Lake
- Highway

Taroborah Coal Project
Groundwater Assessment (G1588)

Basement Geology

DATE: 26/9/2014

FIGURE No: 4



LEGEND:

- MDL Boundary
- Lake
- Watercourse
- Highway

Geology Key - 100k

- Qa - Quaternary alluvium
- Qr - Quaternary colluvium
- TQa\m - Tertiary/Quaternary alluvium
- Tb - Tertiary basalt
- Td - Tertiary duricrust
- TQa - Tertiary/Quaternary alluvium
- Pbl - Permian Aldebaran Sandstone
- Pbk - Permian Cattle Creek Formation
- Pj - Permian Reids Dome Beds
- Po - Permian Colinlea Sandstone
- Dg - Devonian Grandiorite
- Dgt - Devonian Taroborah Granodiorite
- Of - Ordovician Fork Lagoon Beds

Taroborah Coal Project
Groundwater Assessment (G1588)

Surface Geology

DATE: 26/9/2014

FIGURE No: 5

3.1 Quaternary Alluvium

The 1:100,000 surface geology (Figure 5) shows a thin cover of alluvial (Qa and TQa) and colluvial (Qr) sediments deposited across much of the western and northern portions of the Project area. Recent exploration drilling shows that the alluvial cover, where encountered, generally comprises less than 25 m of poorly consolidated clays, silts, sands and gravels. Thicker alluvial deposits are likely to exist within the present-day floodplains of Retreat Creek and Taroborah Creek.

The alluvial and colluvial deposits unconformably overlie Tertiary basalt (Tb) and sediments. Where the Tertiary geology is absent, the Quaternary alluvium and colluvium directly overlie the Permian Aldebaran Sandstone (Pbl).

Available exploration drill logs indicate that the extent of the alluvium is relatively consistent with the 1:100,000 geological mapping. However, exploration drilling has largely been conducted outside the alluvial floodplain, and therefore, some areas of mapped alluvium are expected to differ from local ground conditions.

3.2 Tertiary Basalt and Sediments

The 1:100,000 surface geology shows that Tertiary basalts outcrop throughout much of the middle and southern portions of the Project area (Figure 5). Where fresh, the basalt is described as being of a dark grey olivine type that is often highly vesicular (D'Arcy, 1988).

Three main observations about the nature of the Tertiary deposits can be deduced from the recent exploration drilling across the Project area. Firstly, fresh basalt occurs only sporadically, and where present is generally less than 30 m thick. Secondly, fresh basalt (where present) is generally underlain by highly weathered Tertiary clays and sands, and occasional silts and gravels that range in thickness from 30 m to 90 m. And lastly the weathered clays and sands progressively grade into weathered Permian deposits beneath.

3.3 Permian Strata

The Permian Aldebaran Sandstone underlies the Tertiary deposits. The 1:100,000 basement geology (Figure 4) shows that the Aldebaran Sandstone sub-crops throughout the central and northern areas of the Project area.

Exploration logs and previous reporting (D'Arcy, 1988) indicates the Aldebaran Sandstone is predominantly composed of quartzose sandstone deposited during cyclic marine to fluvial-deltaic environments and interbedded with conglomerate, shale, siltstone and coal. Below the base of weathering, strata is dominated by fine to very fine grained sandstones with occasional medium grained horizons deposited during a marine transgression. This fine grained sandstone has been removed by erosion in the south, where outcropping granite is present, but is up to 150 m thick in the northern portion of the Project area.

Coarser grained fluvio-deltaic sandstones interspersed with several coal seams underlie the fine grained sandstone. The upper two coal seams in this sequence are locally referred to as the A and B seams, which are the target coal seams for the proposed mining operation. Site exploration data indicates that:

- the A seam has an average thickness of 1.2 m, and the underlying B seam 3.0 m thickness;
- interburden which ranges in thickness from 5 m to 14 m, with an average thickness of 10 m separates the A and B seams;

- interburden material comprises fine to coarse grained sandstone with occasional thin siltstone, mudstone and pebble horizons; and
- depth to the A seam ranges from about 40 mbgl where it occurs at sub-crop, to the north of Taroborah Creek in the south, deepening to about 200 mbgl at the northern Project boundary.

3.4 Structural Geology

The Project area is situated on the north-western edge of the Denison Trough, in the south-west of the Bowen Basin. The major period of deformation within the Denison Trough occurred prior to the Permian. Consequently, the pre-Permian basement is generally steeply dipping with major faults generally trending in a NNW-SSE, NW-SE and WSW-ENE direction.

Within the Emerald region, a potential fault trace along the Comet Platform displaces the Reids Dome Beds to the south. This likely relates to the upthrown, subsurface expression of the Reids Dome Beds to the north of Kettle Creek and the Project area. This indicates a rapid change in the stratigraphic bedding of the Aldebaran Sandstone, which have been mapped from exploration drilling and seismic surveys as dipping towards the north.

The structural geology to the east of the Project area has been variably mapped as being either:

- on the western limb of the north-north-west continuation of the Springsure Anticline (Veevers *et al.,* 1962); or
- within a fault bound graben structure, which trends northward and is positioned to the west of the main Denison Trough (D'Arcy, 1988).

Historic and recent exploration drilling indicates that the Project area contains a considerable thickness of Permian sediments that unconformably overlie a mixed basement of block faulted pre-Permian Retreat Granite and Drummond Basin sedimentary units. Seismic surveys and exploration drilling have identified several NW-SE trending faults to the east and west of the Project area (Figure 4). Thin, lower coal measures have been documented outside of the fault zones; however, no coal was intersected along the hinge zone of the inferred anticline (Veevers *et al.,* 1962). Overall, geological investigations and mapping show that the region has undergone extensive periods of deformation, resulting in disconnection of the coal seams from stratigraphy east of the Veevers *et al.* (1962) inferred anticline.

4 FIELD INVESTIGATIONS

AGE undertook groundwater investigations at the Project site between December 2011 and April 2013. Data collected from the field investigations has been used to determine the baseline groundwater conditions for the Project, and to conceptualise the groundwater regime. These investigations have comprised the following:

- a detailed field investigation program to install monitoring bores within each of the major geological units;
- several 'bore census', to determine existing groundwater use at the Project site and its surrounds;
- groundwater sample collection and water quality analyses; and
- hydraulic testing.

Further details of the field investigation methodology and data are included in Appendix A.

4.1 Groundwater Monitoring Network

The groundwater monitoring network across the Project area comprises 19 bores, which were constructed in two stages. Matrixplus Consulting Pty Ltd (Matrixplus) installed seven monitoring bores within exploration holes between May 2008 and September 2009, which are identified as the TAR series bores. An additional 12 monitoring bores (MB series bores) were drilled and constructed between January and March 2013 as part of the AGE field investigation (Appendix A).

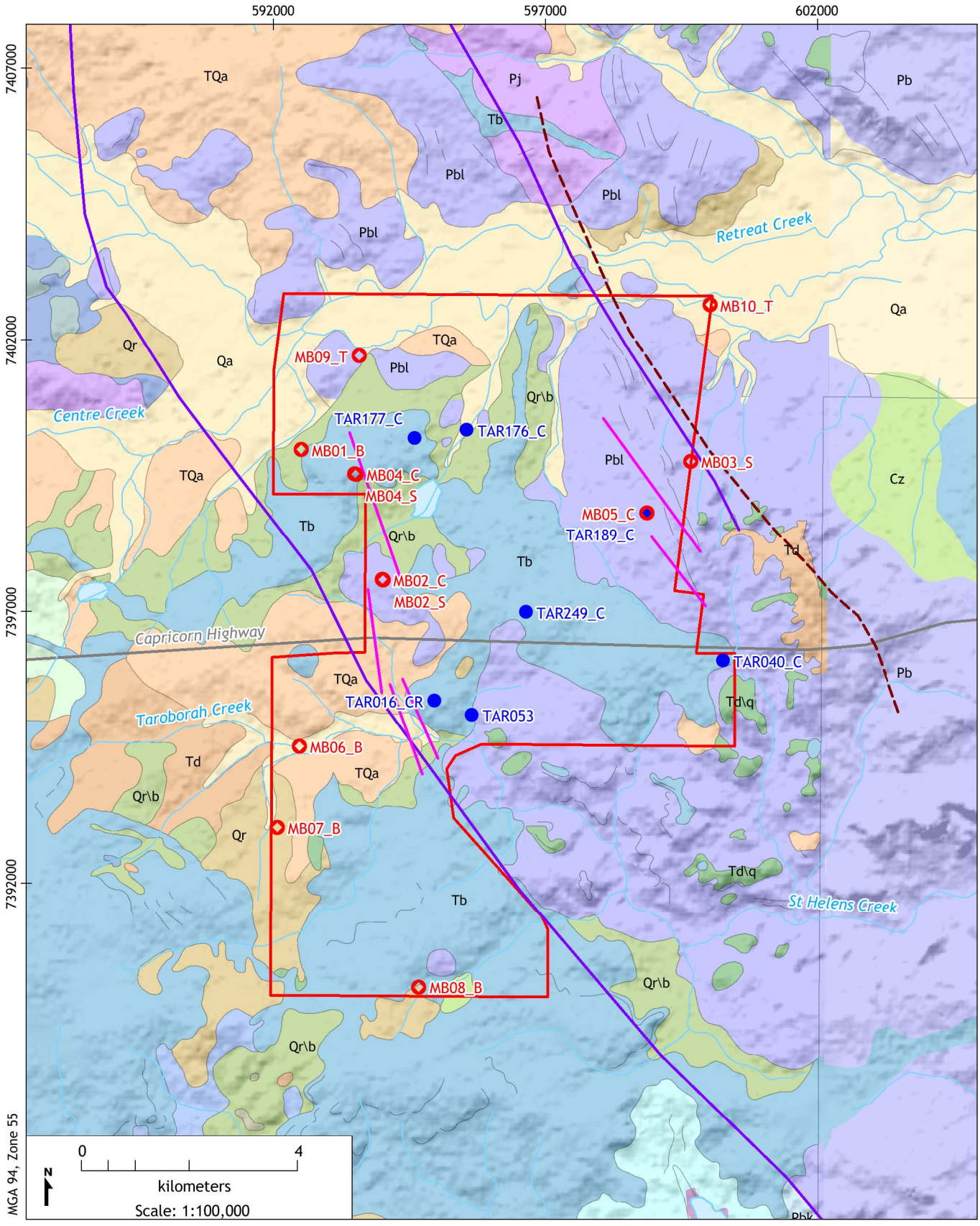
Limited historical groundwater level data is available from the monitoring bores installed prior to 2013, due to instrument error. One round of groundwater level and quality monitoring was conducted in April 2013, with dataloggers installed in 18 of the 19 existing monitoring bores. Another groundwater sampling round was carried out in May 2014, with a datalogger installed in the remaining monitoring bores. The groundwater level hydrographs are presented in Section 6.

The bore locations overlain on the surface geology map are shown in Figure 6, and construction details are summarised in Table 3 below. Further construction and monitoring details are included within Table A-2 of Appendix A.

Table 3: GROUNDWATER MONITORING NETWORK

	Hole ID	Coordinates		Geological Unit	Lithology	Drilled Depth (mbGL)	Screen (mbGL)
		mE	mN				
2013 MB Series Bores	MB01_B	592504	7399983	Tertiary	Clay, silt	43	27.9 - 33.9
	MB02_C	593997	7397592	Aldebaran Sandstone	Coal – B Seam	103	92.2 - 95.2
	MB02_S	594017	7397580	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying B Seam)	154	89.35 - 95.35
	MB03_S	599667	7399771	Aldebaran Sandstone	Coarse horizon within fine grained sandstone	163	76 - 82
	MB04_C	593513	7399534	Aldebaran Sandstone	Coal – B seam	173	118.5 - 120.5
	MB04_S	593493	7399537	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying B Seam)	130	100 - 106
	MB05_C	598860	7398819	Aldebaran Sandstone	Coal – A seam	151	141 - 144
	MB06_B	592471	7394530	Tertiary	Clay, Silt	40	19.4 - 25.4
	MB07_B	592065	7393041	Aldebaran Sandstone	Fine grained sandstone	31.2	27.5 - 30.6
	MB08_B	594668	7390096	Tertiary	Clay, gravel	60	40 - 46
	MB09_T	593575	7401714	Quaternary alluvium	Sand	43	24 - 30
	MB10_T	600020	7402656	Quaternary alluvium	Silt, gravel	30	12.7 -18.7
2008/2009 TAR Series Bores	TAR016_CR	594956	7395372	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A Seam)	85	58 - 64
	TAR040_C	600263	7396108	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A Seam)	84.1	55 - 58
	TAR053	595642	7395113	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A Seam)	97	52 - 58
	TAR176_C	595549	7400349	Aldebaran Sandstone	Fine grained sandstone	168	97 - 103
	TAR177_C	594586	7400197	Tertiary	Fresh basalt	202	18 - 21
	TAR189_C	598843	7398818	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A Seam)	164	137.5 - 140.5
	TAR249_C	596635	7397000	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A Seam)	110.4	84.5 - 87.5

Note: *Coordinates in MGA 94 Zone 55*
mbGL – metres below ground level



LEGEND:

- Monitoring Bore (TAR Series)
- Monitoring Bore (2013 MB Series)
- MDL Boundary
- Lake
- Bowen Basin Fault
- Inferred Anticline (Veevers et al, 1962)
- IMC Inferred Fault
- Watercourse
- Highway

Geology Key - 100k

- Qa - Quaternary alluvium
- Qr - Quaternary colluvium
- Tb - Tertiary basalt
- Td - Tertiary duricrust
- TQa - Tertiary/Quaternary alluvium
- Pbl - Permian Aldebaran Sandstone
- Pj - Permian Reids Dome Beds

Taroborah Coal Project
Groundwater Assessment (G1588)

Monitoring Bore Locations

DATE: 26/9/2014

FIGURE No: 6

4.2 Bore Census

Forty-five existing groundwater bores were identified within 10 km of the Project boundary during field surveys undertaken in December 2011 and April 2013. Twenty-two of these bores were identified as being currently in use, with the main use being for stock purposes. Some bores are identified as being used for farm water supply and one bore is identified as being used for untreated drinking water. The identified bores have the following spatial distribution:

- five within the Project boundary;
- nine within 5 km of the Project boundary; and
- eight between 5 km and 10 km from the Project boundary.

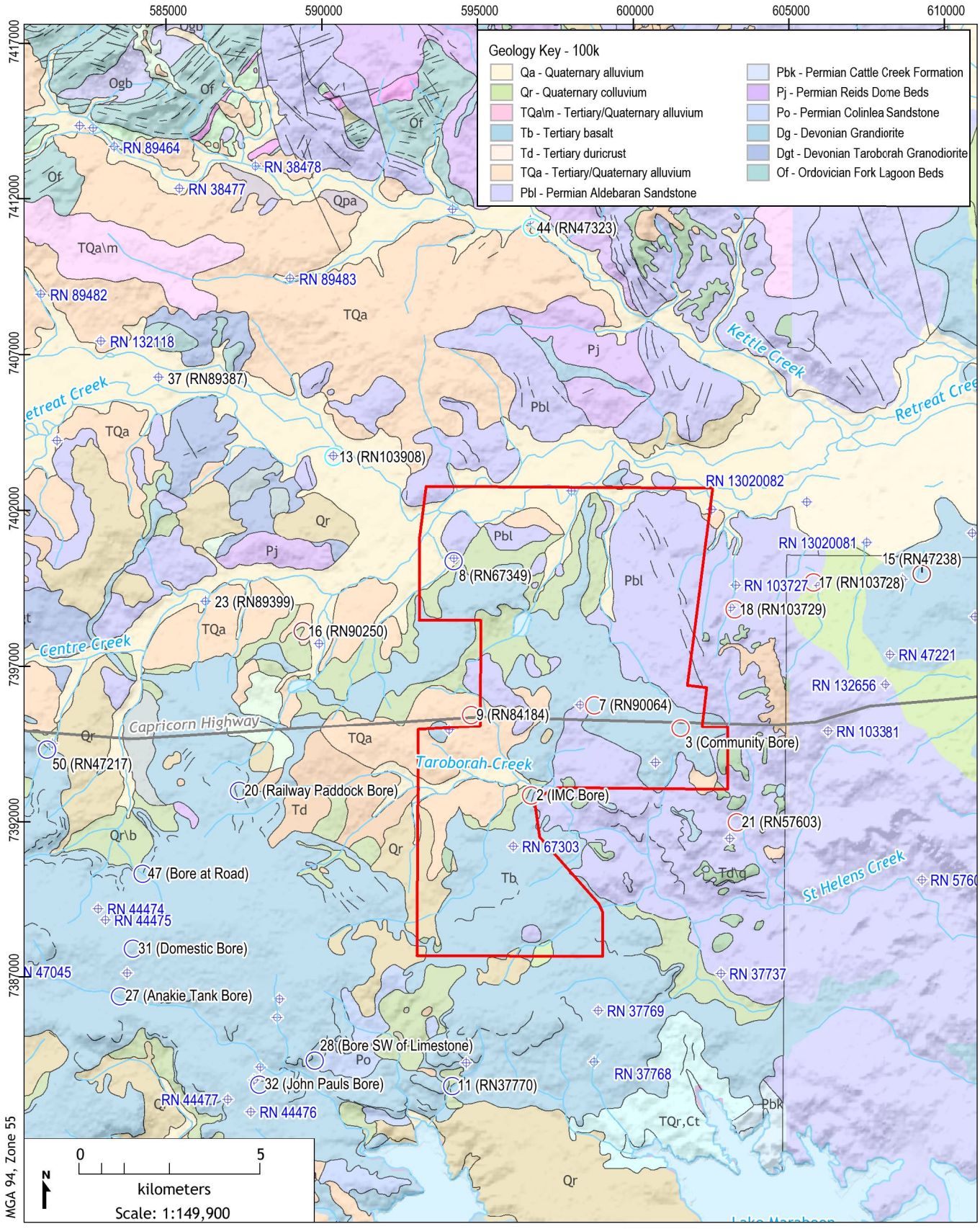
Table 3 summarises bore details for the 22 bores identified as being currently in use, and Figure 7 shows the location of these bores. A summary of the full bore survey results is provided in Appendix A, Table A-7. Private bores draw water from the following five geological units:

- Tertiary Basalt – 11 bores;
- Aldebaran Sandstone – six bores;
- Quaternary alluvium – three bores;
- Tertiary gravels – one bore; and
- Colinlea Sandstone – one bore.

The main source of groundwater within the Project area is from the Aldebaran Sandstone. All six bores inferred to be screened across Aldebaran Sandstone are located either within the Project area, or immediately to the east of the Project boundary (Figure 7). In contrast, the main source of groundwater outside the Project area is from the Tertiary basalt. The majority of bores using the basalt are located to the west of the Project boundary. This coincides with observations from exploration drilling that the basalt within the Project area is thin (less than 30 m) and poorly distributed.

Landholders utilising groundwater within the Quaternary alluvium are located north of the Project area, where three groundwater bores are associated with the alluvium of Retreat Creek and Kettle Creek. Two landholder bores are also located along Centre Creek, west (upstream) of the Project area. According to the DNRM GWDB, one targets the Colinlea Sandstone (RN 89399), while the other (RN 90250) targets the Tertiary gravels.

Limited data was available from the landholder bores due to access constraints and operational issues. Therefore hydraulic parameters, drawdown data and long-term monitoring data were not available from these bores for this assessment.



LEGEND:

- Registered Bore (DNRM)
- MDLA Boundary
- Highway
- Watercourse
- Lake

Landholder Bore: AGE Bore ID (RN/Name)

Inferred Aquifer

- Quaternary Alluvium
- Tertiary basalt
- Tertiary sediments
- Aldebaran Sandstone
- Unknown

Taroborah Coal Project
Groundwater Assessment (G1588)

Bore Census Landholder Bore Locations

DATE: 14/10/2014

FIGURE No: 7

Table 4: CURRENTLY USED LANDHOLDER BORES IDENTIFIED DURING BORE CENSUS						
Project Bore ID	**DNRM Registered Bore No.**	**Easting (m)**	**Northing (m)**	**Bore Use**	**Data Recorded**	**Inferred Geological Unit**
Within Project Area						
2	Not Registered	595087	7394403	Stock	-	Tertiary Basalt / Aldebaran Sandstone
3	Not Registered	599193	7396249	Stock, farm and	Field pH and salinity	Aldebaran Sandstone – Pebbly coarse grained sandstone
7	90064	596819	7396888	Stock and farm water	Field pH and salinity	Aldebaran Sandstone – Pebbly coarse grained sandstone
8	67349	592950	7400839	Stock	Water level, field pH and salinity	Tertiary Basalt
9	84184	593437	7396628	Stock	-	Aldebaran Sandstone (Unit?)
Within 5 km of Project boundaries						
11	37770	592914	7386412	Stock	Water level	Tertiary basalt
13	103908	589653	7403718	Stock	Field pH and salinity	Quaternary Alluvium (Retreat Creek)
15	47238	605840	7400508	Stock and farm water	Water level, field pH and salinity	Tertiary Basalt/Sediments
16	90250	588803	7398913	Stock	-	Tertiary Gravel
17	103728	602849	7400245	Stock	Field pH and salinity	Aldebaran Sandstone (Unit?)
18	103729	600681	7399512	Stock	Field pH and salinity	Aldebaran Sandstone (Unit?)
20	Not Registered	587049	7394528	Stock and farm water	Water level, field pH and salinity	Tertiary Basalt (vesicular)
21	57603	600739	7393663	Stock	-	Aldebaran Sandstone (Unit?)
23	89399	586128*	7399707*	Stock and farm water	-	Colinlea Sandstone
Between 5 km and 10 km of Project boundaries						
27	Not Registered	583773	7388873	Stock	Field pH and salinity	Tertiary Basalt
28	Not Registered	589127	7387106	Stock	-	Tertiary Basalt
31	Not Registered	584132	7390174	Farm water	Water level, field pH and salinity	Tertiary Basalt
32	Not Registered	587605	7386451	Stock	-	Tertiary Basalt
37	89387	584831*	7405866*	Stock	-	Quaternary Alluvium (Retreat Creek)
44	47323	595100	7410014	Stock	Water level, field pH and salinity	Quaternary Alluvium (Kettle Creek)
47	Not Registered	584393	7392258	Stock and spray rigs	Field pH and salinity	Tertiary Basalt (vesicular)
50	47217	581765	7395658	Stock	Water level, field pH and salinity	Tertiary Basalt (vesicular)

Notes: *Co-ordinate datum GDA94, Zone 55*
** bore location identified from DNRM GWDB (all other bore locations identified by handheld GPS in the field)*

5 PREVIOUS GROUNDWATER INVESTIGATIONS

Historically, the groundwater potential of the Project area was recognised during resource drilling undertaken by the Queensland Department of Mines between 1985 and 1987. Groundwater observations during this drilling program are summarised by D'Arcy (1988) as follows:

"*Significant groundwater resources are present in the Taroborah area. During the second stage of departmental drilling, flows of between 1600 litres/hour and 9100 litres/hour were recorded from a number of holes. Smaller flows were obtained from aquifers in the Cainozoic sandstone gravels and vesicular basalts. Larger flows were obtained from a number of thick sandstone beds in the Permian strata. Local landholders report that water flows were smaller and less common prior to construction of Fairburn Dam, which now probably acts as a recharge source for many of the aquifers*."

More recently, groundwater yields were measured during exploration drilling between 2008 and 2010. Flow rate testing was conducted during drilling operations by measuring air-lift yields at the base of the hole or at any depth where significant groundwater flows were intersected. Groundwater flows were recorded for over 100 intersections, particularly within units of the Aldebaran Sandstone, with measured flow rates of between 0.02 L/s and 20 L/s. Further discussion of the results is presented in Section 6 of this report.

A numerical groundwater model for the Taroborah Project was previously undertaken in 2009 by Matrixplus (Matrixplus, 2009). Conceptualisation of the groundwater system relied heavily on geological data collected from exploration drilling, as well as published geological maps. Hydraulic properties for the different model layers were largely inferred from the Kestrel and Crinum coal mines (50 km to the north-east) as limited site-specific data was available at the time.

6 EXISTING GROUNDWATER REGIME

The following description of the existing groundwater regime for the Project area is based on a review of the site geology and data obtained from the following sources:

- DNRM GWDB and bore census results (Section 4.2 and Appendix A);
- exploration drilling for the Project area;
- field investigations undertaken for the Project including lithological logs, water intersections, groundwater yield, water quality data and standing water levels measured from monitoring bores (Appendix A); and
- previous groundwater investigations (Section 5).

The following geological units form groundwater systems within and surrounding the Project area:

- Quaternary alluvium, located primarily along Taroborah Creek, Retreat Creek and Kettle Creek;
- Tertiary basalt, and to a lesser extent Tertiary sands and gravels; and
- Permian Aldebaran Sandstone.

This section of the report discusses the different groundwater systems, and the data used to develop the conceptual groundwater model.

6.1 Permian Aldebaran Sandstone

6.1.1 Nature, Distribution, Yield and Use

The Permian Aldebaran Sandstone appears on the 1:250,000 published basement geology map (Figure 4) as the predominant sub-surface geological unit within the Project area. The Aldebaran Sandstone was extensively drilled during exploration, and the geological distribution and structure of this formation is well defined within the Taroborah Project geological model.

As detailed under Section 3.4 of the report, geologically the region has undergone extensive periods of deformation, resulting in disconnection of the coal seams from stratigraphy east of the Project area. This can therefore be considered as representing a regional boundary to groundwater flow.

Observations during recent drilling of groundwater monitoring bores, together with exploration drilling results, have shown groundwater to be present under confined conditions throughout a number of different horizons within the Aldebaran Sandstone including:

- A and B coal seams;
- pebbly coarse-grained sandstone unit directly overlying A seam; and
- shallower, predominantly fine-grained sandstones.

Bore census results show that the Permian Aldebaran Sandstone is the most commonly used groundwater system within the Project area. However, regionally only six of the 22 landholder bores identified within 10 km of the Project area (Section 4.2) target the Aldebaran Sandstone. This indicates that landholder water usage is supplemented by surface water capture and mains water supply (i.e. for drinking water supply). Each of the Permian Aldebaran Sandstone horizons are discussed as follows.

Fine grained sandstones

Borelogs show that groundwater within the fine grained sandstones is not only present within the fine-grained portion of the unit, but is typically also present where coarser grained horizons, or palaeochannels, are intersected. As observed throughout other areas of the Bowen Basin, groundwater flow within the fine-grained component typically occurs through secondary fractures, with the amount of flow controlled by the extent of the fracturing.

Air-lift yields measured during exploration drilling (51 groundwater intersections) varied between 0.17 L/s and 15 L/s, with an average of 1.9 L/s. Yields are generally higher in the north of the Project area. There is no correlation between air-lift yield and grain size. The exploration yields are likely to be biased towards higher values as water flows were only measured where significant flows were intercepted.

During installation of additional groundwater monitoring bores in 2013 (see Appendix A), the air-lift yield for a bore intersecting the fine grained Aldebaran Sandstone (MB03_S) was recorded at a rate of 0.07 L/s. Bore MB07_B, which is also screened across the fine grained sandstone, was drilled as a dry hole, highlighting that the unit is not saturated over its full thickness.

Pebbly coarse grained sandstone layer

The main water bearing unit within the Project area is the pebbly coarse grained sandstone unit that lies directly on top of A seam. Drilling results show that this coarse layer is consistent and present throughout most of the Project area. Observations of geological cores and chip samples suggest this unit contains both primary porosity where groundwater is contained within pore spaces and secondary porosity where groundwater occurs within joints and/or fractures. The unit may act as either a confined or leaky unit, depending on the contact with the underlying coal seam. Where the contact with the underlying A seam is comprised of coarse sandstone, groundwater may leak from the unit into the coal seam. In contrast, where the contact with the underlying seam comprises siltstone or mudstone, hydraulic connection between the coarse sandstone and coal seam may be limited.

During exploration drilling, air-lift yields measured at 13 groundwater intersections were recorded at rates of between 0.5 L/s and 20 L/s, with an average of 3.1 L/s. Similar results were recorded during the 2013 monitoring bore installation program, where air-lift yields for five bores intersecting the pebbly course sandstone were measured at rates of between 0.3 L/s and 7 L/s. Similarly to the fine grained sandstone unit, yields for this coarse grained sandstone unit are generally higher in the north of the Project area.

Coal seams

Observations during drilling have shown groundwater to be present within the A and B coal seams within the Project area. Air-lift yields within the coal seams were recorded for two bores during the exploration drilling program with measured flows of 0.5 L/s (TAR199_C) and 1 L/s (TAR187_C). The potential for these flows to be influenced by the presence of the overlying sandstone is unknown. Air-lift yields measured during the 2013 monitoring bore installation program showed no significant increase in flows upon interception of the deeper coal seam.

As observed throughout the Bowen Basin, groundwater storage and movement within coal typically occurs within the coal cleats and fissures, and within open fractures that intersect the seams. The hydraulic connection between the A seam and the overlying pebbly coarse sandstone layer is likely to be dependent on the nature of the contact between these units, as described above. Likewise, the hydraulic connection between the A and B seams depends on the composition of the interburden material. Where the interburden is largely comprised of permeable coarse grained sandstones, the A and B seams are likely to be hydraulically connected. In contrast, hydraulic connection will be limited where the interburden contains low permeability siltstones or mudstones, and the A and B seams are likely to be hydraulically disconnected.

6.1.2 Hydraulic Parameters

Table 5 summarises the results of falling head tests conducted during the 2013 field investigation (Appendix A) for ten bores. The results indicate the hydraulic conductivity is over one order of magnitude higher in the pebbly coarse-grained sandstone compared to the underlying coal seams and overlying fine grained sandstone. In general, the hydraulic conductivity results for the Permian strata are comparable to those measured in similar units for neighbouring projects.

Table 5: HYDRAULIC CONDUCTIVITY OF ALDEBARAN SANDSTONE				
Lithology	**Hydraulic Conductivity (m/day)**			**No. of Tests**
	Min.	**Max.**	**Avg.**	
Pebbly coarse-grained sandstone	3.0×10^{-2}	3.00	1.10	5
Coal seams	2.3×10^{-2}	1.7×10^{-1}	8.1×10^{-2}	3
Fine grained sandstone	1.1×10^{-2}	5.4×10^{-2}	3.3×10^{-2}	2

6.1.3 Potentiometric Surface, Recharge, Flow and Discharge

Nested facilities, which are bores located within the same site but intersecting different strata, can be used to measure the vertical hydraulic gradients between different geological units. There are three nested facilities across the Project, located at the following locations:

- MB02_C (B seam) and MB02_S (pebbly coarse sandstone);
- MB04_C (B seam) and MB04_S (pebbly coarse sandstone); and
- MB05_C (A seam) and TAR189_C (pebbly coarse sandstone).

Recent groundwater levels at MB02 show a measured upward gradient from the pebbly coarse sandstone (188.92 mAHD at MB02_S) and the B coal seam (189.96 mAHD at MB02_C). The 1 m difference in groundwater levels suggest that the pebbly sandstone and underlying B seam are partially hydraulically disconnected at this location. A degree of hydraulic disconnection is also indicated by a difference in EC values between the two bores (2,153 µS/cm at MB02_C compared to 1,463 µS/cm at MB02_S).

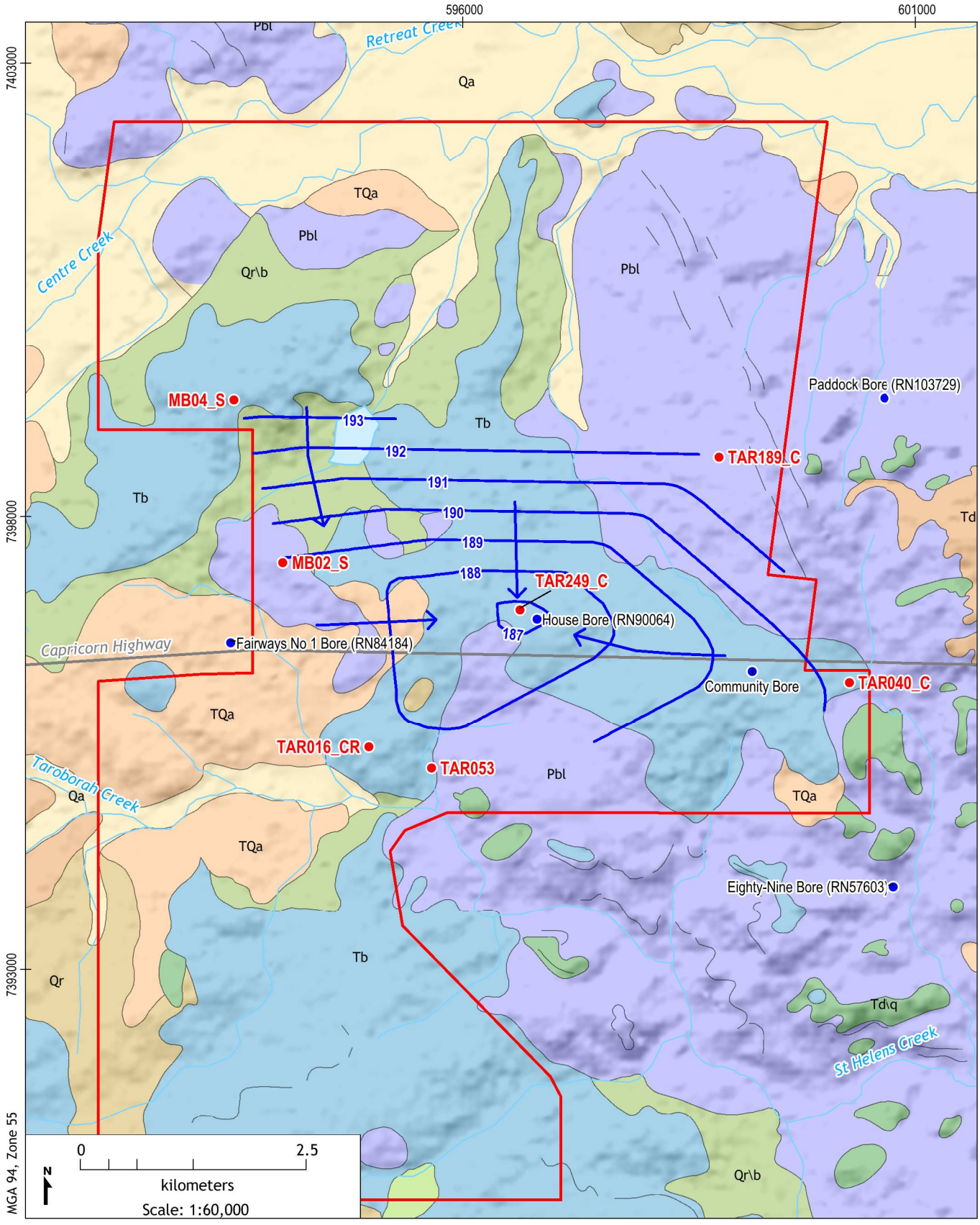
In contrast, groundwater levels at the other nested facilities are very similar (193.6 mAHD at MB04_S versus 192.35 mAHD at MB04_C; and 191.98 mAHD at MB05_C versus 191.98 mAHD at TAR189_C). The similarity in groundwater levels suggest that the pebbly coarse sandstone and coal seams are hydraulically connected at these locations. Hydraulic connection at MB04 is also indicated by the similarity in EC values between MB04_C (2,377 µS/cm) and MB04_S (2,313 µS/cm).

Figure 8 shows the potentiometric surface of the pebbly coarse sandstone unit inferred from groundwater levels measured in monitoring bores during May 2014. The contours indicate that groundwater flow within the pebbly coarse sandstone reflects topography flows towards the south. Pumping from bore RN90064 appears to locally influence groundwater levels in the coarse sandstone creating a local zone of drawdown.

Recharge potentially occurs via rainfall percolation from mapped sub-crops of the Aldebaran Sandstone, shown on the 1:250,000 surface geology map (Figure 5). However, review of lithology east of the project area (MB03_S), where the Aldebaran Sandstone subcrops, indicates the presence of thick sequences of shallow silts and clays that would inhibit recharge. Therefore, recharge predominantly occurs via more permeable zones within the regolith and Tertiary basalt, as well as downward percolation from Quaternary alluvium associated with Retreat Creek.

Section 1.3.4 within Appendix B discusses the application of recharge in the numerical model. There are not enough measured groundwater levels within the fine sandstone unit and coal seams to produce potentiometric contours for these units. Groundwater levels measured within the coal seams show little variation across the Project, with a range of 191.56 mAHD (MB02_C) to 192.34 mAHD (MB04_C).

Recharge to the fine grained sandstones and coal seams are likely to originate from the same sources as the pebbly coarse sandstone. Recharge to the Aldebaran Sandstone may also occur from leakage of overlying geological units. Discharge from the Aldebaran Sandstone will occur down-gradient from the groundwater flow direction.



LEGEND:

- MDL Boundary
- Lake
- Watercourse
- Highway
- Monitoring Bore
- Private bore
- Groundwater Contour (mAHD)
- Groundwater Flow Direction

Geology Key - 100k

- Qa - Quaternary alluvium
- Qr - Quaternary colluvium
- TQa\m - Tertiary/Quaternary alluvium
- Tb - Tertiary basalt
- Td - Tertiary duricrust
- TQa - Tertiary/Quaternary alluvium
- Pbl - Permian Aldebaran Sandstone
- Pbk - Permian Cattle Creek Forma
- Pj - Permian Reids Dome Beds
- Po - Permian Colinlea Sandstone
- Dg - Devonian Grandiorite
- Dgt - Devonian Taroborah Granoc
- Of - Ordovician Fork Lagoon Beds

Taroborah Coal Project
Groundwater Assessment (G1588)

Coarse Sandstone Above A-Seam Water Level Contours

DATE: 13/10/2014

FIGURE No: 8

Figure 9 presents water level hydrographs for the Permian monitoring bores.

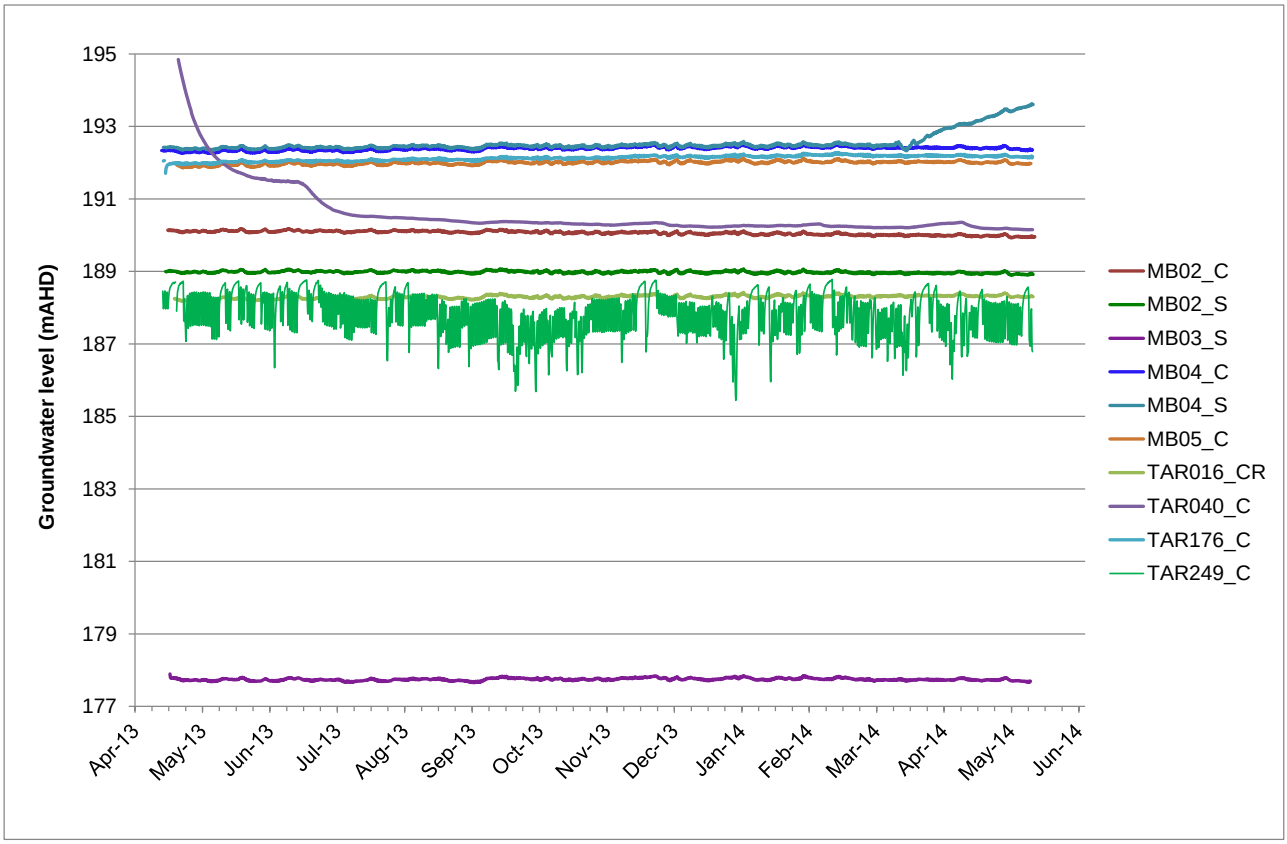


Figure 9: Water Level Hydrographs – Permian Monitoring Bores

The hydrographs show a general flat trend for all bores. However, there are some bores (TAR040_C, MB04_S and TAR249_S) that show variability in the data record.

The water level within TAR040_C reduced 5 m in mid 2013, then remained stable for the remainder of the water level record. This would suggest an error in the early time data that is not representative of the bore. MB04_S does not fluctuate for the majority of the record, with a marked upward trend from March 2014. This unusual upward trend is considered to be drift within the logger sensor and is not considered representative of the water level in the bore.

Bore TAR249_C shows a water level trend that is typical of interference from a local water supply bore (the closest bore identified in the census is RN90064). The trend shows drawdown and recovery in the order of 2 m to 3 m, however in general, the bore is exhibiting a relatively flat hydrograph over the record.

The groundwater levels for MB03_S are over 10 m below the other bores. MB03_S is located east of the project, and is screened within low permeability Aldebaran Sandstone. Whilst this lower water level may appear to indicate a degree of hydraulic disconnection, this bore was not adequately developed following construction, so it is possible the measured levels are not considered representative.

6.2 Tertiary Basalt and Sediments

6.2.1 Nature, Distribution, Yield and Use

Bore census results show that Tertiary basalts are predominantly used by landholders located to the west of the Project area, where the basalts are typically described as being fresh and vesicular (Figure 7). The basalt is not heavily used within the Project area, with only one landholder bore identified during the bore census.

Groundwater within basalt typically occurs within fractured and vesicular horizons. The yield from the basalts depends on the extent, interconnection and intensity of the fractures. Air-lift yields within Tertiary basalts were recorded for four bores during the exploration drilling program, with measured flows of between 0.6 L/s and 5 L/s.

Drilling has shown groundwater to also be present within Tertiary clays, sands, and gravels, with measured yields generally lower than that of the basalts. The presence of thick impermeable Tertiary clays throughout the Project area suggests the Tertiary units are likely to be confined and hydraulically disconnected from the underlying Aldebaran Sandstone. Groundwater flows were too low to be measured by air lift tests for monitoring bores MB01_B (clay, silt) and MB08_B (clay, gravel). Bore MB06_B, screened across clay and silt; was drilled as a dry hole and indicates that Tertiary sediments are not fully saturated throughout the area.

6.2.2 Hydraulic Parameters

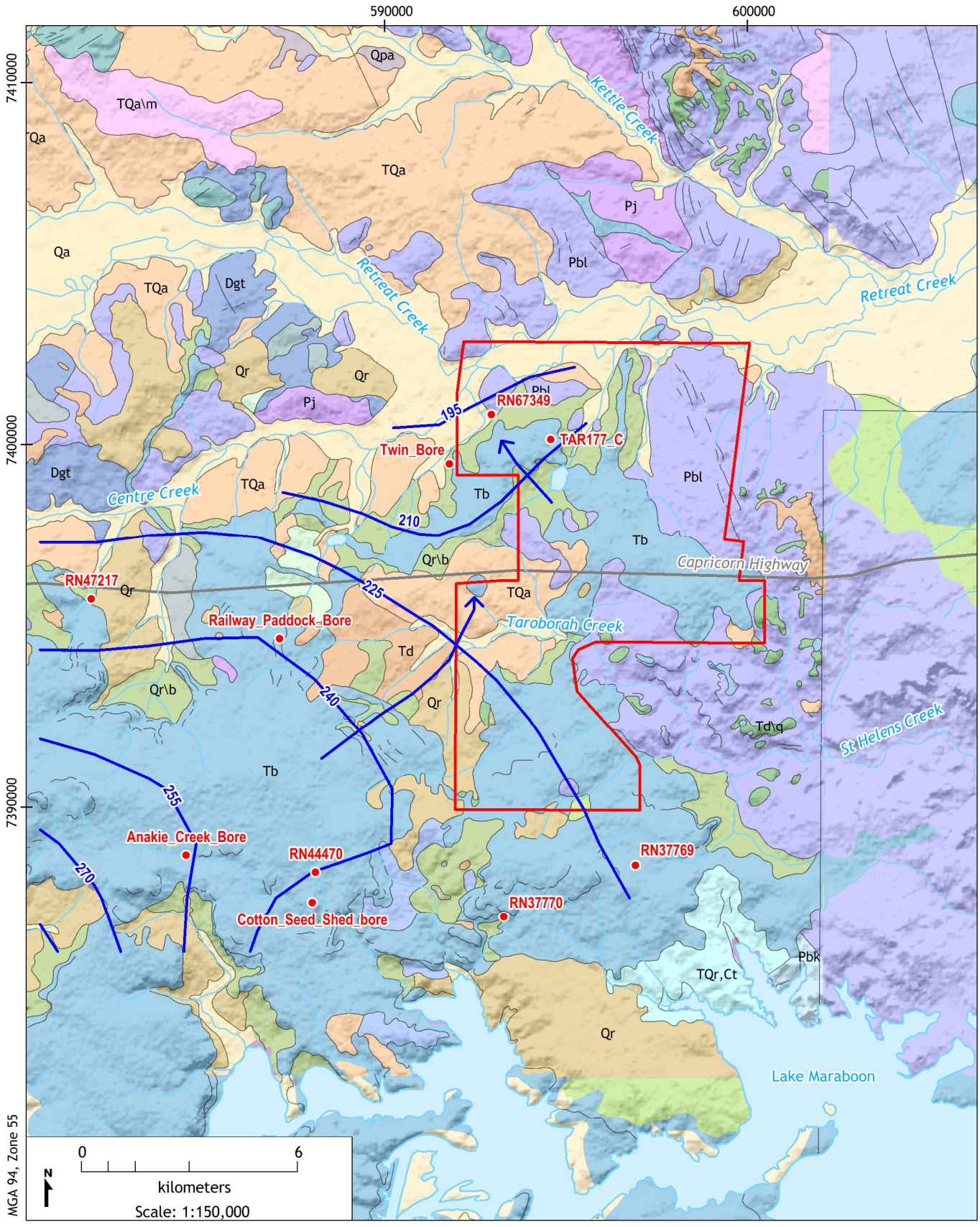
Results of permeability tests for three bores within Tertiary basalts and sediments show a range in hydraulic conductivity between 1.3×10^{-1} m/day and 5.5×10^{-4} m/day (Appendix A). The highest hydraulic conductivity was measured in fresh basalt (TAR177_C) and the lowest measured across clay (MB01_B).

6.2.3 Potentiometric Surface, Recharge, Flow and Discharge

Potentiometric contours, presented in Figure 10, indicate that groundwater flow within the Tertiary is towards the east and northeast within the Project area and surrounds. This flow direction suggests that the main source of recharge to the Tertiary is from rainfall percolation in the sub-crop areas to the west and south-west of the Project area. The influence of Lake Maraboon on water levels and recharge is unknown. Contour elevations vary from about 255 mAHD in the west, to about 195 mAHD in the northeast corner of the Project area.

The potentiometric surface of the Tertiary basalt and sediments was inferred from groundwater levels measured in nine landholder bores during the bore census surveys, and monitoring bore TAR177_C (Appendix D). Elevations of landholder bores were estimated from 1 arc second DEM-S (smoothed digital elevation model – 1 second SRTM derived) data which is considered to have height errors of up to 3 m in clear flat-lying areas such as the terrain present at Taroborah.

Discharge from Tertiary sediments is likely to occur as lateral flow down-gradient of the Project area. Leakage to underlying units may also occur where impermeable Tertiary clays are absent in the geological profile.



LEGEND:

- MDL Boundary
- Lake
- Watercourse
- Highway
- Monitoring Bore
- Groundwater Contour (mAHD)
- Groundwater Flow Direction

Geology Key - 100k

- Qa - Quaternary alluvium
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- Pbk - Permian Cattle Creek Formation
- Pj - Permian Reids Dome Beds
- Po - Permian Colinlea Sandstone
- Dg - Devonian Grandiorite
- Dgt - Devonian Taroborah Granodiorite
- Of - Ordovician Fork Lagoon Beds

Taroborah Coal Project
Groundwater Assessment (G1588)

Potentiometric Contours
Tertiary Basalt

DATE: 14/10/2013

FIGURE No: 10

Figure 11 shows water level hydrographs for the Tertiary monitoring bores.

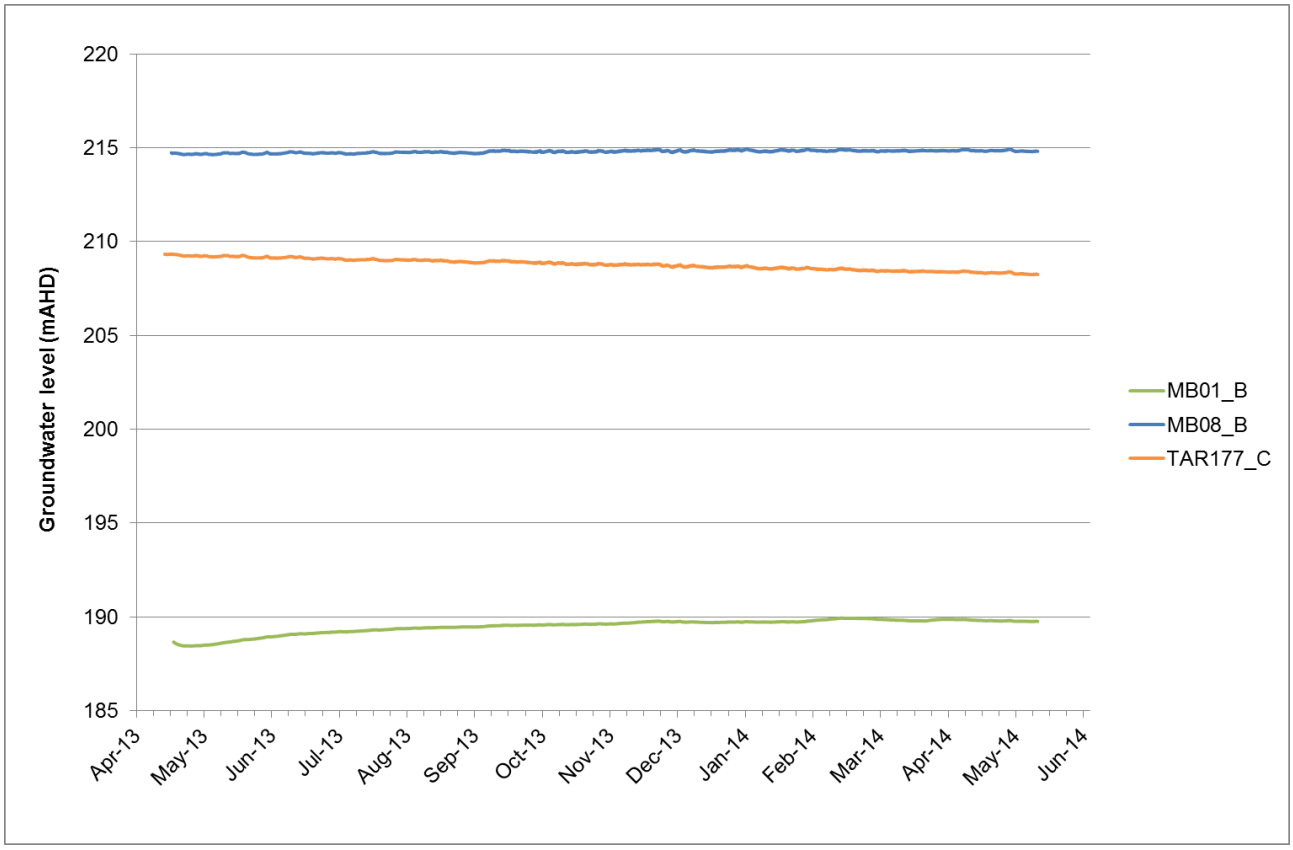


Figure 11: Water Level Hydrographs – Tertiary Monitoring Bores

Bore TAR177_C, which is the only bore intersecting the fresh basalt, recorded a gradual 1 m decline in groundwater levels since April 2013. Nearby bore MB01_B intersects silts and clays of the Tertiary regolith, and recorded a gradual rise in groundwater levels since 2013. This increase likely relates to recovery of groundwater levels within the low permeability unit following groundwater sampling.

Bore MB08_B intersects sandy gravels and silty clays of the Tertiary regolith, and recorded stable to slightly rising groundwater levels since 2013. The groundwater elevations are highest at MB08_B compared to all other bores, which is as expected due to its elevated location to the south of Taroborah Creek.

6.3 Quaternary Alluvium

6.3.1 Nature, Distribution, Yield and Use

Bore census results show that the Quaternary alluvium is used by landholders located to the north of the Project area, within the present day floodplains of Retreat and Kettle Creeks.

Alluvium within the Project area has limited groundwater potential, as drilling shows it is typically thin (<30 m) and has limited lateral extent. Observations during drilling of MB06_B, located approximately 20 m from Taroborah Creek, show that alluvial sands adjacent to the creek are dry in that location. No users of alluvium where identified within the Project area during the bore census. Where groundwater is present, the alluvium it is likely to be unconfined.

An air-lift yield of 1.0 L/s was recorded for the thick sequence of sands and gravels intersected at MB09_T. However, no flows were observed during drilling at MB10_T, which intersects sandy silt and a thin sequence of silty gravel. This highlights the variability in the depositional environment, and consequently the stratigraphy, of the alluvial sequences.

6.3.2 Hydraulic Parameters

Permeability results for the two alluvial bores (MB09_T and MB10_T) were recorded at rates of 2.0 m/day and 4.6 x 10^{-2} m/day, respectively (Appendix A). The significant difference in permeability between the two alluvial bores highlights the heterogeneity of the alluvial aquifer.

6.3.3 Water Table, Recharge, Flow and Discharge

Groundwater levels measured in monitoring and landholder bores throughout the Project area show that the water table is shallow and generally less than 10 mbGL. Water table contours for the alluvium could not be inferred due to the scarcity of monitoring bores within it; however, the water table in the alluvium is expected to reflect topography, with groundwater flow being towards drainage features and watercourses. The spatial distribution and depth of alluvial deposits suggests recharge occurs by direct rainfall percolation and seepage from adjacent creeks during periods of surface flow.

Comparison of groundwater levels within the alluvium (MB09_T and MB10_T) and Permian hard-rock sequences indicates that the alluvium is generally a losing system (down-ward leakage to underlying sequences). Stored water within the alluvium is likely to largely discharge as baseflow to adjacent creeks or as leakage to nearby sub-cropping Tertiary and Permian units. The ephemeral nature of the creeks suggests that discharge from the alluvium is unlikely to be significant or sustained, as shown in Figure 12.

Figure 12: Retreat Creek near MB10_T (Courtesy IMC 5/9/2013)

The water level hydrograph for MB10_T is shown in Figure 13, compared against the CRD for Emerald Airport (station 35264).The data shows a slight reduction (1.5 m) in water level over the monitoring record. This trend is similar to that recorded for Tertiary basalt bore TAR177_C, and appears to correspond with a decline in rainfall over this period.

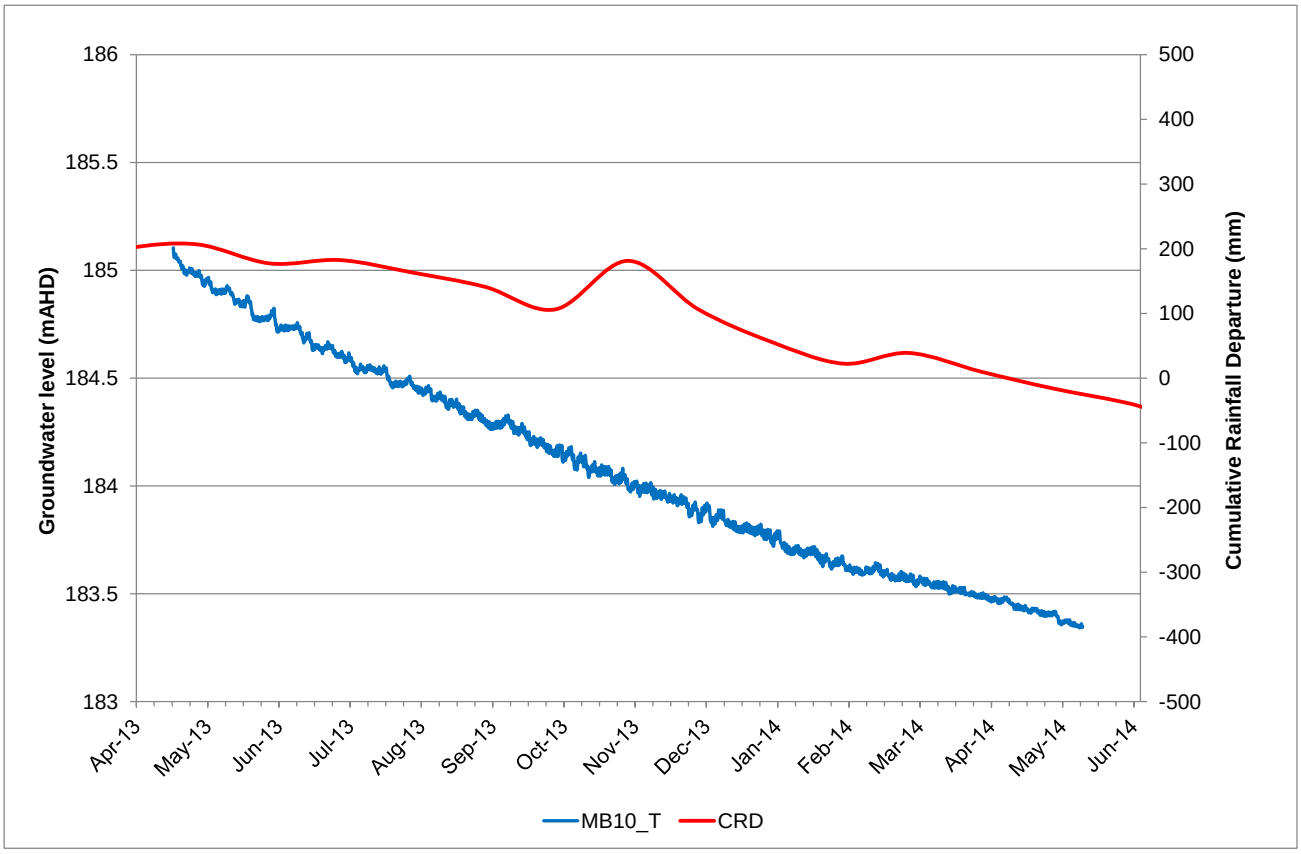


Figure 13: Water Level Hydrograph – Quaternary Monitoring Bore

7 GROUNDWATER CHEMISTRY AND QUALITY

7.1 Salinity

Table 6 summaries the major ion concentrations for the groundwater units. Data represented is derived from three sampling events in late 2009, March / April 2013 and May 2014. The data provides a period of baseline groundwater quality and captures some seasonal or temporal variation.

Table 6: SUMMARY OF WATER QUALITY RESULTS – ALL GEOLOGICAL UNITS							
Parameter	**Statistic**	**Aldebaran Sandstone**			**Tertiary regolith**	**Tertiary basalt**	**Alluvium**
		CG	**FG**	**Coal**			
Field EC @ 25°C (µS/cm)	Avg.	1,435	1,765	2,301	2,059	1,354	1,431
	Min.	546	782	1,570	1,430	1,315	917
	Max.	2,572	3,130	3,180	2,533	1,380	1,775
Total Dissolved Solids (mg/L)	Avg.	848	1,060	1,415	1,186	793	853
	Min.	471	403	1,010	789	676	605
	Max.	1,590	1,990	2,000	1,410	910	1,010
Field pH (pH units)	Avg.	8	9	8	8	7	7
	Min.	7	7	7	7	7	6
	Max.	9	11	8	8	7	8
Calcium (mg/L)	Avg.	56	36	66	58	77	52
	Min.	17	2	37	30	71	34
	Max.	128	58	97	70	85	77
Magnesium (mg/L)	Avg.	55	25	81	116	107	52
	Min.	3	1	47	81	98	29
	Max.	89	47	129	163	116	78
Sodium (mg/L)	Avg.	167	253	273	213	72	186
	Min.	66	101	151	122	69	123
	Max.	494	482	354	257	74	262
Bicarbonate (mg/L)	Avg.	442	150	301	512	687	389
	Min.	21	1	245	398	629	225
	Max.	1,180	276	416	620	778	641
Chloride (mg/L)	Avg.	231	329	490	324	65	216
	Min.	48	124	291	129	52	134
	Max.	903	560	718	497	73	338
Sulfate (mg/L)	Avg.	41	131	125	81	22	64
	Min.	6	37	66	7	20	37
	Max.	156	293	198	131	25	84
Number of Samples		17	5	6	5	3	4

Note: *CG – coarse grained sandstone*
FG – fine grained sandstone

The results indicate that the groundwater within the alluvium and Tertiary basalt are generally fresher than the regolith and Aldebaran Sandstone units, with lower major ion concentrations.

Salinity is a key constraint to water management and groundwater use and can be determined indirectly by measuring Electrical conductivity (EC) of water samples. The following EC ranges (µS/cm) are commonly used to categorise salinity:

- Fresh 0 µS/cm to 750 µS/cm;
- Slightly brackish 750 µS/cm to 1,500 µS/cm;
- Brackish 1,500 µS/cm to 4,550 µS/cm;
- Moderately saline 4,550 µS/cm to 10,600 µS/cm;
- Saline 10,600 µS/cm to 21,200 µS/cm; and
- Highly saline 21,200 µS/cm to 53,000 µS/cm.

Figure 14 presents a histogram of the available EC data classified according to this system. The distribution of EC values shows that groundwater quality across the Project area generally varies from slightly brackish to brackish.

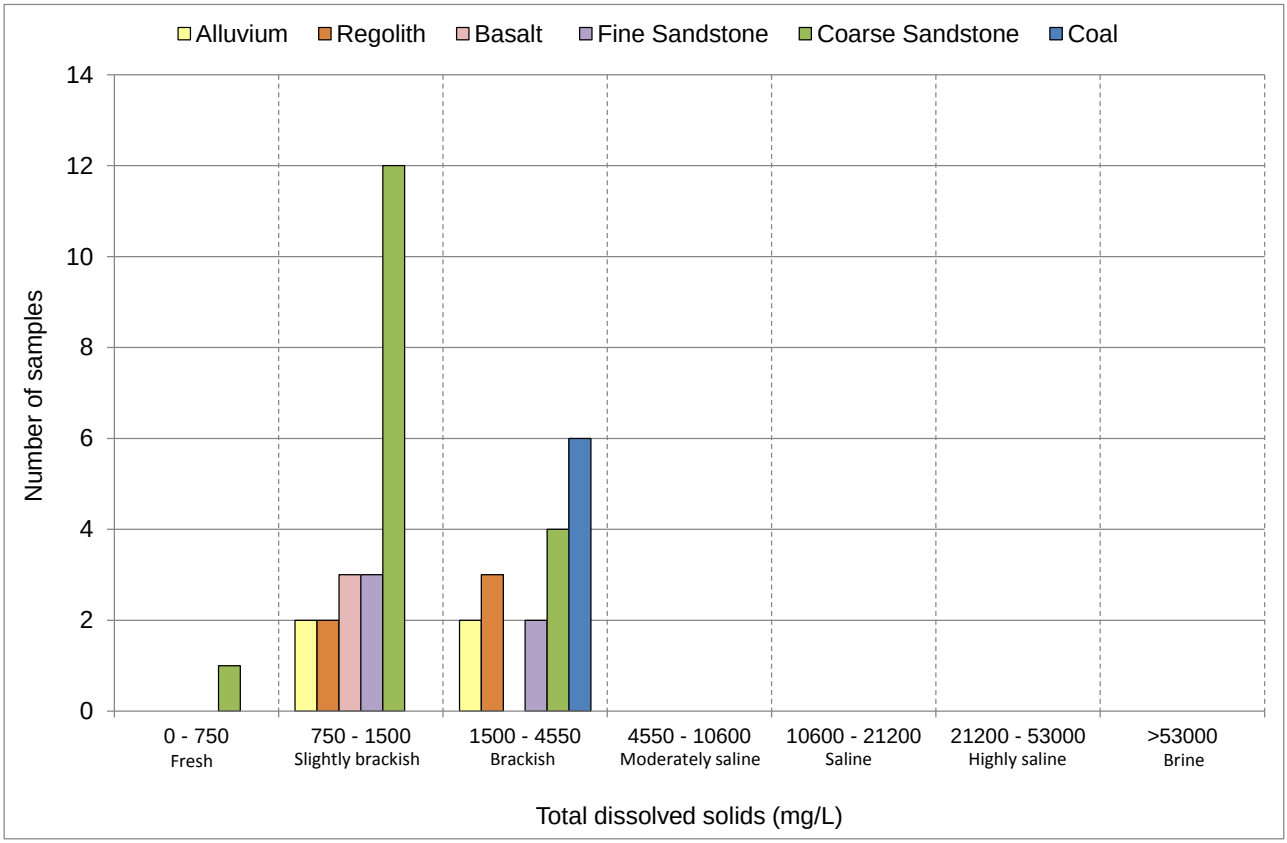


Figure 14: EC Histogram – All Geological Units

The results for field EC shown in Figure 14 indicate that groundwater within the Quaternary alluvium is slightly brackish to brackish, with an average EC of 1,400 µS/cm. The coarse grained sandstone is generally less saline than the alluvium, with fresh water quality recorded at TAR249_C in 2014, and a larger number of samples classified as slightly brackish.

The A and B coal seams have brackish water quality with an average EC of 2,300 µS/cm. EC of the coal seams is comparatively low for the Bowen Basin, which can typically vary from 5000 µS/cm to over 50,000 µS/cm. The lower EC of the A and B seams is likely related to leakage of 'fresher groundwater' from the immediately overlying pebbly coarse sandstone unit and from rainfall infiltration where it occurs at sub-crop to the south.

A significant portion of the EC dataset exceeds the 80th percentile limit that is specified for deep (> 30 m) groundwater quality objectives in the Nogoa River / Theresa Creek sub-basin (see Section 9.1). Major ion exceedances include Na, Ca, Mg, HCO_3, Cl and SO_4. A number of minor ions and metals also exceed the water quality objectives defined in Section 9.1. This assessment indicates that future assessment of the groundwater quality should be undertaken based on baseline (pre-mining) data and not the specified water quality objectives.

7.2 Water Types

The relative proportions of anions and cations were calculated for each sample to determine if any unique water signatures are evident in the groundwater data. Figure 15 presents this data graphically as a Piper diagram.

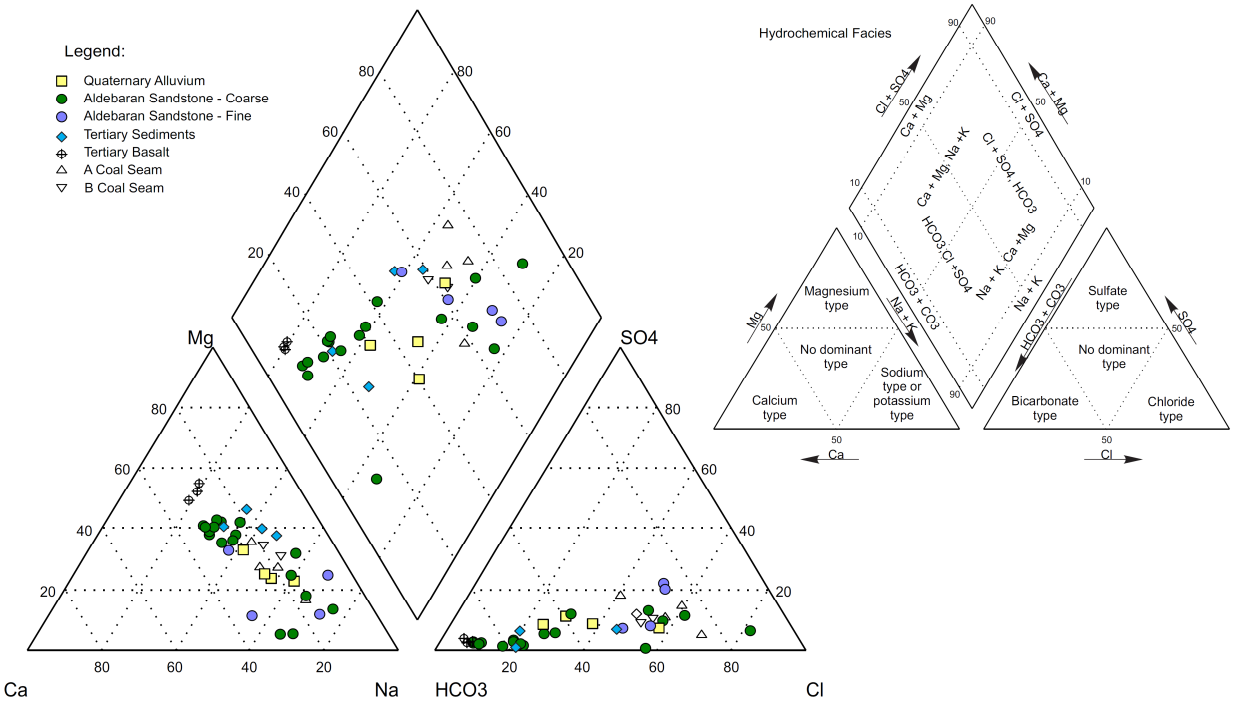


Figure 15: Piper Diagram – All Geological Units

The graphic shows variability in the water types, but some loose grouping of water samples from some coarse grained Aldebaran sandstone. The results for the alluvium show a broad range in anion/cation proportions, which indicates a degree of heterogeneity in the alluvial sequences. The coal seams and Aldebaran Sandstone samples collected from the northern end of the Project area generally record high proportions of sodium, magnesium and chloride. The Aldebaran Sandstone dips towards the north, resulting in the Permian stratigraphy occurring at greater depth. The water quality results and geological setting indicates that the Permian groundwater in the northern end of the Project area has a higher residence time and salinity.

The shallower Aldebaran Sandstone bores (TAR04_S, TAR016_CR and TAR053) record lower proportions of chloride, and higher proportions of bicarbonate. This likely relates to increased recharge rates and potential interaction with faults.

Water quality results for fresh basalt bore TAR177_C indicates high proportions of bicarbonate, calcium and magnesium, but low proportions of chloride. This indicates the potential presence of fracturing within the basalt, which may enhance recharge by rainfall percolation.

7.3 Agricultural Usage

Table A-4 of Appendix A compares the groundwater quality data to the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000), commonly referred to as the ANZECC (2000) guidelines. Comparison of results to the ANZECC (2000) stock water guidelines indicates that all bores are suitable for stock water supply.

Comparison of the data against the guidelines for irrigation provided by ANZECC (2000) indicates that groundwater collected from most of the bores is suitable for short term irrigation. However, the guideline levels for chloride, boron and phosphorous were not assessed, as the guidelines stipulate that these analytes are dependent on individual factors, such as soil properties, crop tolerance, climatic conditions and water table depth.

7.4 Human Consumption/Drinking Water

To assess the suitability of groundwater for human consumption, the groundwater quality results were compared to the Australian Drinking Water Guidelines 2011 (NRMMC, 2011), commonly referred to as the ADWG (Table A-4 of Appendix A).

Results show that in general all of the groundwater tested is not suitable for human consumption because it exceeds either ADWG aesthetic or health guidelines. All bores exceed the ADWG aesthetic guidelines for at least two criteria, including TDS, pH, total hardness, chloride, sodium, sulfate, aluminium, iron, and manganese. Aesthetic guidelines exclude the water from being suitable for human consumption based on smell, taste, and appearance. Two bores (TAR053 and TAR177_C) exceed the ADWG aesthetic guideline for ferrous iron. The elevated iron concentrations likely relate to the installation of the monitoring bores within existing exploration holes, which may have steel surface casing present.

One unregistered bore identified within the Project boundary during the bore census (see Table 4), known locally as the “community bore”, was reported by landowners to be used as an untreated source of drinking water for three properties. A TDS reading of 650 mg/L was measured for this bore during the bore census and indicates that this bore is marginally suitable for human consumption.

8 HYDROGEOLOGICAL REGIME – CONCEPTUALISATION

The conceptual understanding of the hydrogeological regime within the Project area is shown in Figure 16 and Figure 17 and summarised below.

The unconsolidated Quaternary and Tertiary alluvium form localised aquifer systems along the watercourses of Retreat Creek, Centre Creek, Kettle Creek and Nogoa River. The bore census indicated private bores extract water from the alluvial groundwater systems associated with Retreat Creek up-gradient of the Project area, within the Anakie and Sapphire Gemfields region, but the usage within the Project area is limited. The creeks form losing systems, recharging the underlying alluvium when flowing. The alluvium is lithologically heterogeneous with slightly brackish water quality.

Within the Project area, the Tertiary basalts are commonly weathered, with only localised, dissected areas of fresh basalt. The thickness of the basalt varies and in some areas thins out and becomes unsaturated. This means the basalt does not form a productive aquifer and there is a lack of landholder bores targeting the basalt within the Project area. Government drilling indicates that the basalt to the south and south-west of the Project area is generally thicker and fresh, which corresponds with the presence of several landholder bores targeting the basalt for water supply purposes. The basalt is recharged by diffuse rainfall, as well as surface water features (i.e. Lake Maraboon). Due to the nature of deposition and weathering, hydrogeological connection across the mapped extent of the Tertiary basalt is considered unlikely.

The Permian aged stratigraphy occurs within a region that has undergone extensive periods of deformation which has resulted in groundwater flow boundaries within the Permian stratigraphy to the:

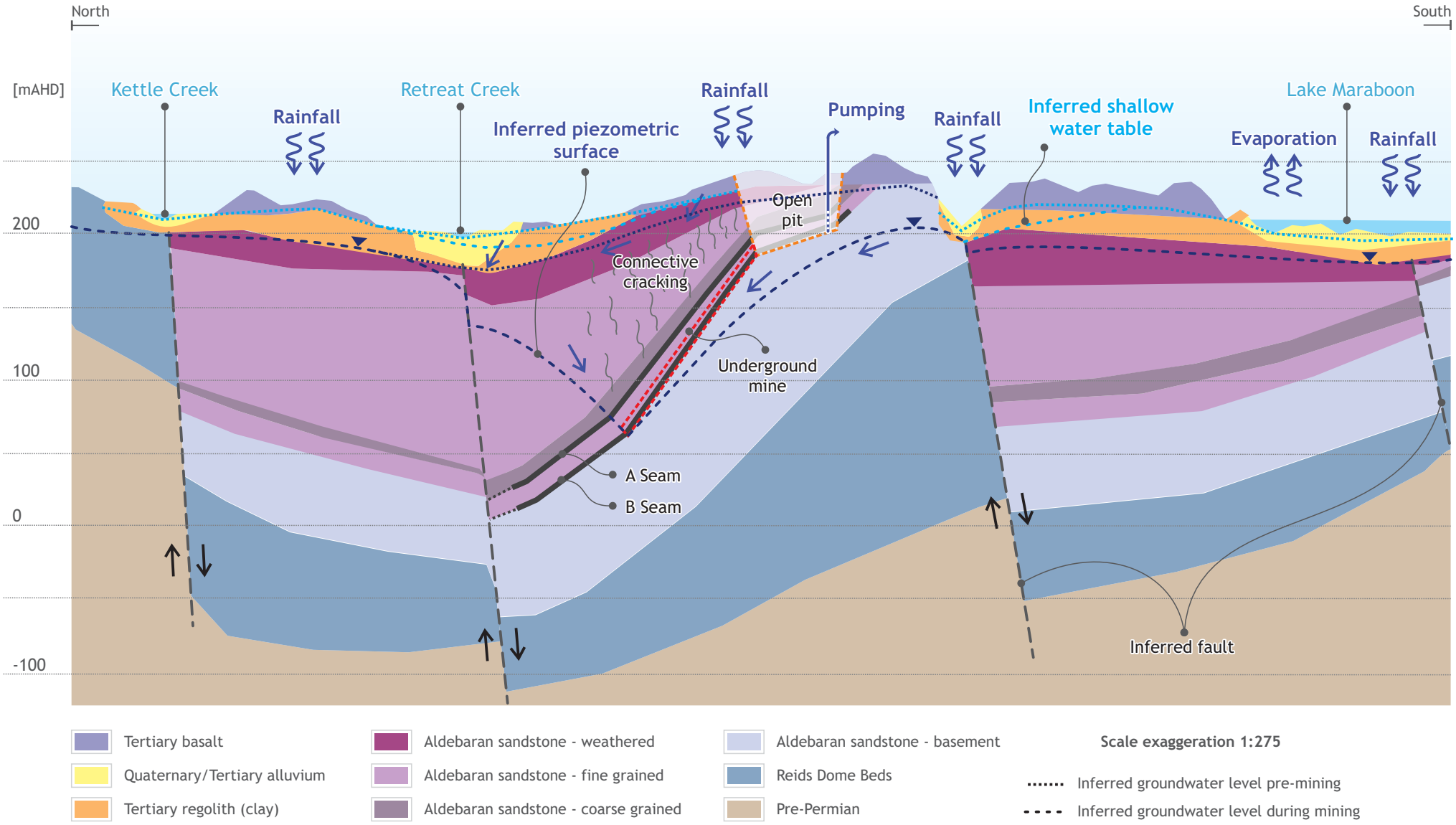
- West: where the extent of the Permian sequences is truncated by the presence of the Devonian aged Anakie metamorphics. A series of NW-SE trending faults have also been identified by IMC during exploration drilling, which show absence of the target mining seams but presence of the underlying, thinner coal seams and indicates significant upward stratigraphic displacement.
- East: exploration drilling and lithological logging for monitoring bore MB03_S indicates that the coal seams do not occur east of the Project area. This corresponds with the presence of a potential anticline (Veevers *et al.*, 1962) and a series of NW-SE trending faults identified by IMC during exploration drilling.
- South: geological maps and exploration drilling shows that the Permian sequences sub-crop approximately 2 km south of the Capricorn Highway. The stratigraphy dips in a northerly direction, with minor parasitic folding identified during exploration drilling. Water quality results indicate that the Permian sequences are fresher further to the south (up-dip), indicating likely rainfall recharge of the groundwater system where it occurs at sub-crop.
- North: the presence of the older Reids Dome Beds stratigraphy to the north of Kettle Creek (within the Valeria exploration area) indicates extensive stratigraphic displacement, likely caused by an east-west trending fault.

The upper 250 m of Permian aged stratigraphy within the Project area comprises the Aldebaran Sandstone. The Aldebaran Sandstone contains relatively continuous stratigraphic layers of fine to coarse grained sandstones and coal seams, which dip in a northerly direction. The main water bearing unit within the Permian sequences is the pebbly to coarse grained sandstone, which directly overlies the A seam and records flow rates of between 0.5 L/s to 20 L/s. Water quality within the pebbly to coarse grained sandstone is only slightly brackish, and landholder bores accessing the groundwater unit use the water for stock watering purposes and farm water supply. One bore within the Permian is used for untreated drinking water.

The two main coal seams within the Project area, A seam and B seam, are approximately 1.2 m and 3.0 m thick, respectively. The coal seams are relatively permeable, and contain slightly brackish to brackish water quality. The coal seams show heterogeneous connection to the overlying pebbly to coarse grained sandstone sequence, and are also likely recharged where the seams occur at sub-crop south of the Capricorn Highway.

Within the project area, the Proponent has defined a graben (fault bound) structure in which the coal measures are to be mined. These faults have been defined through project specific seismic data, detailed exploration drilling and State government drilling and mapping. However, aside from the physical location of these structures and the vertical offset, there is no hydrogeological information available on these faults to assess whether they are barriers or conduits to groundwater flow.

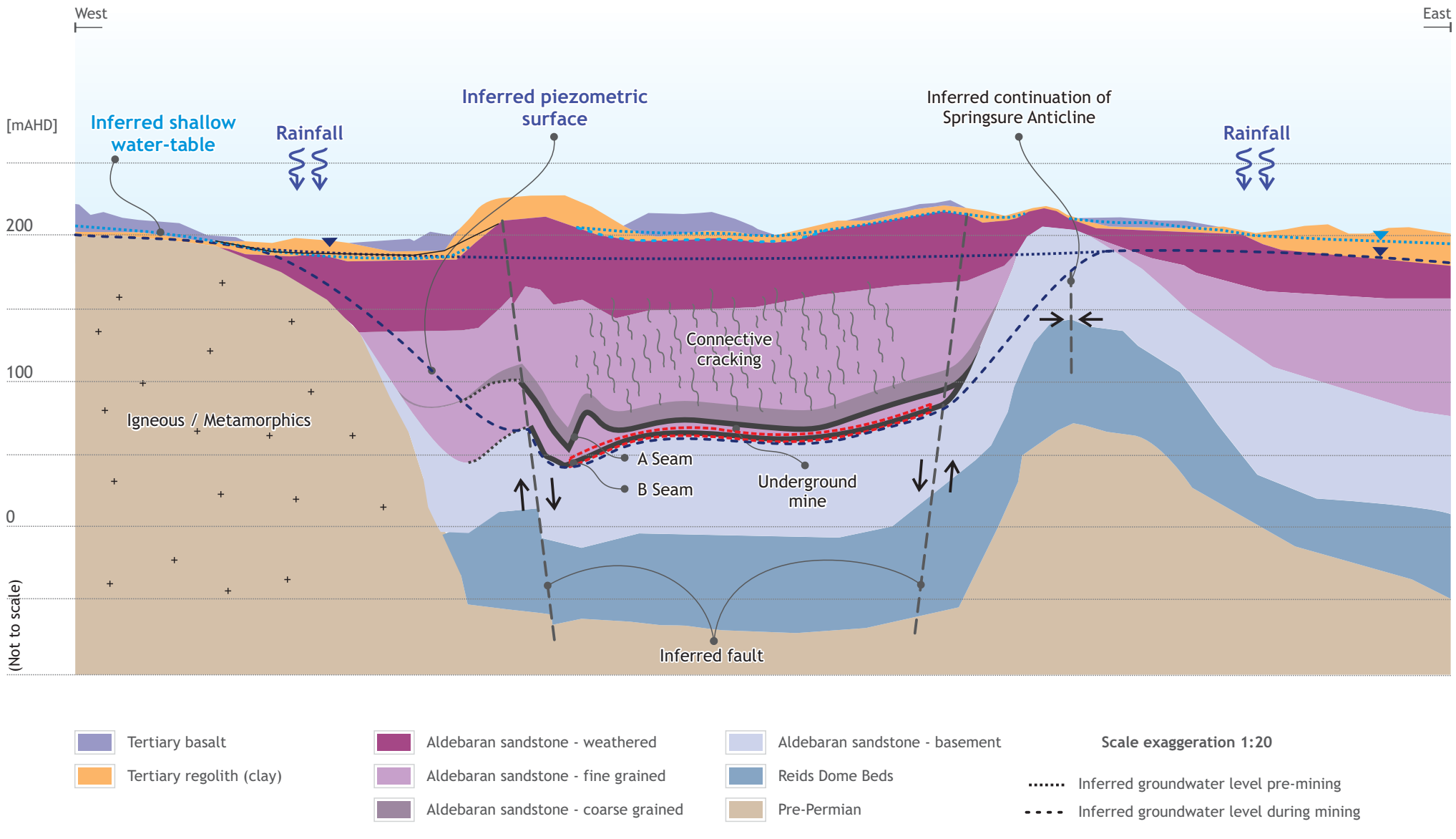
Therefore a conservative approach has been developed to represent these faults (graben structure) in the impact assessment model. Rather than defining linear fault features in the model, drape features are inferred, with hydraulic continuity on either side of the mapped fault. As detailed above, drilling has identified that the coal seams do not extend immediately east of the project area. This is possibly due to the presence of an anticline structure, where the coal seams have been eroded away and the basal units of the Aldebaran Sandstone are exposed.



Conceptual Groundwater Model Cross Section (North to South)

Figure 16

Taroborah (G1588)



Conceptual Groundwater Model Cross Section (West to East)

Figure 17

Taroborah (G1588)

9 LEGISLATION, POLICY AND GUIDELINES

The following sections summarise the Queensland Government legislation and policy for groundwater that applies to the Project.

9.1 Environmental Protection (Water) Policy 2009

The Environmental Protection (Water) Policy 2009 (EPP Water) provides a framework to protect and / or enhance the environmental values and hence suitability of Queensland waters for various beneficial uses. Groundwater resources within the Project area lie within the Lower Nogoa River / Theresa Creek Sub-basin as listed in Schedule 1 of the EPP Water.

This policy guides the setting of indicators that will protect the environmental values of any resource. The EPP states that the environmental values for groundwaters within the Lower Nogoa River / Theresa Creek Sub-basin that need to be considered are aquatic ecosystems, drinking water, recreational use, cultural and spiritual values, industrial use, aquaculture, irrigation, stock water and farm supply.

The EPP provides water quality objectives (WQOs) to support and protect the various environmental values identified for waters within the Lower Nogoa River / Theresa Creek catchments. The WQOs are long-term goals for water quality management. They are defined by DERM (2011) as *"numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated environmental values for those waters. They are based on scientific criteria or water quality guidelines but may be modified by other inputs"*.

The WQOs for Fitzroy Basin groundwaters are provided according to their chemistry zone and depth category (Table 14 of DERM, 2011). In this instance, the Lower Nogoa River / Theresa Creek catchments are classified as chemistry zone 13, a low to moderate salinity (balanced cations HCO_3, Cl) type water. The WQOs for zone 13 are summarised in Table 7.

The groundwater chemistry data relevant to the Project is summarised in Table 7, with individual water quality results included in Appendix A. Comparison of this data with the WQOs indicates that all groundwater units exceed at least one of the 80th percentile criteria for deep and shallow groundwater listed in Table 7. This indicates that if the project proceeded, future assessment of groundwater should be undertaken based on baseline (pre-mining) data and not the specified WQOs.

9.2 Water Act 2000 and Water Regulation 2002

The purpose of the *Water Act 2000* (Water Act) is to advance sustainable management and efficient use of water and other resources by establishing a system for planning, allocation and use of water. The act also provides a framework under which catchment based Water Resource Plans (WRP) are developed in Queensland. The WRP provides a framework for sustainable management of water resources in the plan area.

Groundwater areas have been established to protect underground water resources. Groundwater areas are referred to using various terms under subordinate legislation, including sub-artesian areas declared under the *Water Regulation 2002* (Water Regulation), groundwater management areas (GMAs), management areas, management units or sub-artesian management areas. A groundwater area is an area identified in the Water Regulation, a WRP or a wild river declaration within which management requirements for groundwater exist. An authorisation is required to access groundwater and/or construct works to take groundwater for certain purposes (as defined under the Water Regulation, a WRP or a local water management policy).

Table 7: WQO FOR GROUNDWATERS IN THE NOGOA RIVER/THERESA CREEK SUB BASIN (ZONE 13)

Depth (±30 m)	Shallow < 30 m			Average Site Water Quality*			Deep > 30 m			Average Site Water Quality*		
Percentile	20th	50th	80th	Alluvium	Tertiary	Tertiary Basalt	20th	50th	80th	CG SS	FG SS	Coal
EC (µS/cm)	630	1,150	2,509	1,431	2,059	1,354	720	1,256	1,955	1,435	1,765	**2,301**
Hardness as $CaCO_3$ (mg/L)	145	350	650	342	**677**	636	136	326	540	348	215	496
pH	7.5	8	8.3	7.3	7.6	7.1	7.5	7.9	8.2	7.7	**9.0**	7.9
Alkalinity (mg/L)	249	409	626	395	549	**716**	262	355	560	492	254	313
Ca (mg/L)	21	40	73	52	58	**77**	21	40	72	56	36	66
Mg (mg/L)	21	54	119	52	116	107	15	51	88	55	25	81
Na (mg/L)	56	135	326	186	213	72	75	139	279	167	253	273
Cl (mg/L)	30	110	400	216	324	65	54	141	327	231	**329**	**490**
SO_4 (mg/L)	5	24	125	64	81	22	8	25	67	41	**131**	**125**
HCO_3 (mg/L)	295	490	754	389	512	687	315	429	673	442	150	301
NO_3 (mg/L)	0.5	3	16.39	0.03	0.05	0.03	0.000	1	4.93	0.01	0.05	0.02
SiO_2 (mg/L)	28	46	60	-	-	-	18	37	56	-	-	-
F (mg/L)	0.2	0.31	0.594	0.30	**1.63**	0.15	0.157	0.2	0.37	**0.55**	**0.38**	**0.50**
Fe (mg/L)	0.000	0.01	0.04	**0.12**	**0.05**	**0.25**	0.000	0.02	0.09	**0.17**	0.05	0.06
Mn (mg/L)	0.000	0.01	0.02	**0.07**	**0.07**	**0.07**	0.000	0.01	0.04	0.03	0.02	**0.09**
Zn (mg/L)	0.000	0.015	0.05	0.02	<LOR	<LOR	0.01	0.035	0.135	<LOR	<LOR	<LOR
Cu (mg/L)	0.000	0.01	0.03	<LOR	0.002	<LOR	0.000	0.01	0.035	<LOR	<LOR	<LOR
SAR	1.6	3.15	7.01	4.5	3.4	1.2	2	3.5	8.96	4.0	6.0	5.5
RAH (meq/L)	0.3	1.79	4.08	-	-	-	0.51	2.23	3.98	-	-	-
EH (mV)	ID	ID	ID	-	-	-	ID	ID	ID	-	-	-

Note: ** Averages based on water quality data from late 2009, March / April 2013 and May 2014. EC and pH are based on field parameters, metals represent dissolved metal concentrations, and results below the limit of reporting (LOR) were set at the LOR.*

9.3 Declared Sub-Artesian Groundwater Area

As detailed in Schedule 11 of the Water Regulation, the Project is located in the Highlands Sub-artesian Area where:

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

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

A water licence is required to take water, or interfere with sub-artesian water in declared sub-artesian areas or in areas defined in a WRP. The requirement for a water licence is based on a number of factors and is determined by DNRM on a case by case basis. DNRM considers factors such as the extent of proposed dewatering; impacts on existing users; and whether the impacted aquifer is capable of being used as a water supply.

9.4 Fitzroy Water Resource Plan

The Project site is located within the Water Resource (Fitzroy Basin) Plan 2011 area. Water to which this plan applies includes water in watercourses and lakes, water in springs, overland flow water and groundwater. Under the WRP, the Project is located in the Highlands Groundwater Management Area (GMA) of the Fitzroy Basin catchment GMA. The plan further divides the Highlands GMA into the following groundwater units:

- Highlands Groundwater Unit 1, containing Quaternary alluvium aquifers of Sandy Creek; and
- Highlands Groundwater Unit 2, containing all sub-artesian aquifers within the Highlands GMA other than the aquifers included in Highlands Groundwater Unit 1.

The Project occurs within Highlands Groundwater Unit 2.

10 MINE PLAN

The Taroborah Coal Project is currently managed under MDL 467, which covers an area of approximately 7,966 hectares (ha). Mining is proposed to take 21 years, with open-cut mining within the initial seven years and underground mining commencing from Year 5 (Figure 18). The proposed mine includes:

- Open-cut mining, via hydraulic excavator and dump truck, in the southern part of the proposed mining area;
- Underground mining, either through longwall mining or bord and pillar extraction techniques, in the northern part of the proposed mining area;
- Processing of mined coal at a coal handling and preparation plant (CHPP), processing includes coal sizing, handling and washing; and
- Transport of the coal to the port of Gladstone via the Central West and Blackwater rail systems.

Figure 18 shows the mine plan, with the open-cut mine located on the southern side of the Capricorn Highway and the underground mine on the northern side. The open-cut pit will be largely backfilled with spoil, except in the north-west and north-east corners, which will be left as open voids. The underground mine will progress towards the north through the north-west void, with the longwall panels orientated in an east-west direction.

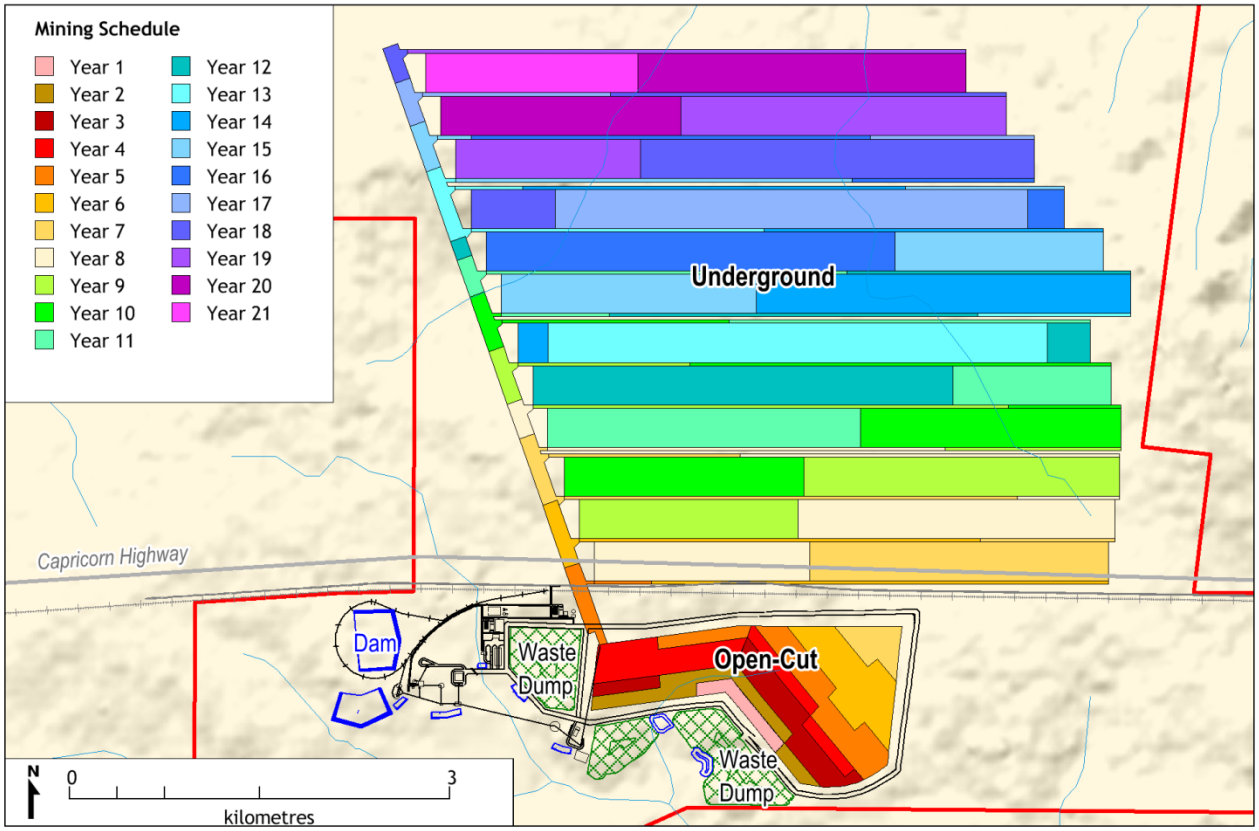


Figure 18: Mine Plan

11 GROUNDWATER IMPACT ASSESSMENT

11.1 Overview of Groundwater Modelling

The objective of the groundwater modelling was to produce a tool that suitably represented the current understanding of the groundwater environment and can predict changes in groundwater conditions due to future activities within the model domain, including but not limited to the development of the Project.

The design, construction and calibration of the model were all tailored to meet these objectives as well as providing a framework for future iterations of the model following the addition of new data. The objectives of the modelling, based on Australian modelling guidelines, were to:

- replicate measured groundwater levels at each observation bore (steady state), with an overall scaled root square mean error of less than 10% for all observation points;
- produce water budgets with a numerical error of less than 1% at each time step and on a cumulative basis;
- estimate groundwater seepages to the open-cut and underground mining areas over the Project life;
- predict the zone of depressurisation in alluvium and other aquifers from mining activities and the level and rate of drawdown at specific locations;
- predict any changes to surface flows and other groundwater users due to Project operations; and
- identify areas of potential risk where groundwater impact mitigation/control measures may be necessary.

A three-dimensional numerical groundwater flow model was developed for the Project using MODFLOW-SURFACT. The model consisted of a 10-layer representation with a model extent of 41 km x 40 km. The model was built around the conceptual groundwater model (Figure 16 and Figure 17). The model was calibrated to a steady state pre-mining condition, using water level observation data from the Project site, and from neighbouring bores, to achieve a suitable fit in accordance with modelling guidelines. Consideration was given to carrying out a transient calibration, however, the existing water level data (Sections 6.1.3, 6.2.3 and 6.3.3) shows little seasonal variation, and a transient calibration of the groundwater model was not considered beneficial. There are no reliable recharge or discharge processes evident in the water level hydrographs with which to calibrate the model against.

Once calibrated, the model was used to predict the groundwater level behaviour of the systems, in response to simulated mining. The model simulated mining over a 21-year period, consistent with the mine plan. The model also simulated groundwater level recovery post mining over a 1,000 year period.

The model allows groundwater levels, inflows and fluxes to be predicted within the model extent, and this model output is presented in the following sections on impact assessment. Detail in the regional model domain was applied to those areas considered to have the greatest influence in the impact assessment (the mine area). The model mesh was generated in accordance with the Australian guidelines. No faults have been represented in the model domain to ensure a conservative approach that maximises the predicted impacts.

Predictive sensitivity was addressed as part of the modelling assessment. Sensitivity analysis is often used to determine the sensitivity of the model calibration to variations in model parameters. In this instance, the sensitivity analysis showed the parameters of hydraulic conductivity and specific storage were most sensitive to calibration. Appendix B details the setup and calibration of the groundwater model. It is assessed that the model objectives have been addressed and it is considered fit for purpose.

11.2 Inflow to Mined Void

Full details of the predictive model results are included in Appendix B, Section 3.6. To summarise the findings, it is predicted that a maximum of 5.7 ML/day of groundwater will be intercepted by the proposed Taroborah open-cut and underground mine, with the peak inflows occurring around Year 19 of the Project.

Figure 19 shows the rate of predicted mine water inflows over time for the open-cut pit and underground mine. The results indicate inflows to the open-cut mine peak at 3.3 ML/day around Year 5, while the underground inflows peak at 4.8 ML/day in Year 19. On average, the inflows the mine operations are predicted at approximately 2.6 ML/day. The predictive modelling has allowed for the simulation of porosity and permeability changes to the Permian strata as a result of mining induced subsidence. Section 3.5 in Appendix B details the methodology and modelled parameters.

It is important to note that the predicted mine inflows do not represent the volume of water that will require pumping, rather the maximum loss from the groundwater systems. The estimates include ‘unseen water’, including moisture in coal and evaporation and extraction from the mine ventilation. Although it is difficult to quantify these components, the ‘unseen water’ is likely to account for 10% of the model predicted inflows. Therefore, accounting for the ‘unseen water’, it is predicted that total groundwater inflows will be around 2.3 ML/day on average, with up to 3 ML/day entering the open-cut pit, and up to 4.3 ML/day entering the underground mine.

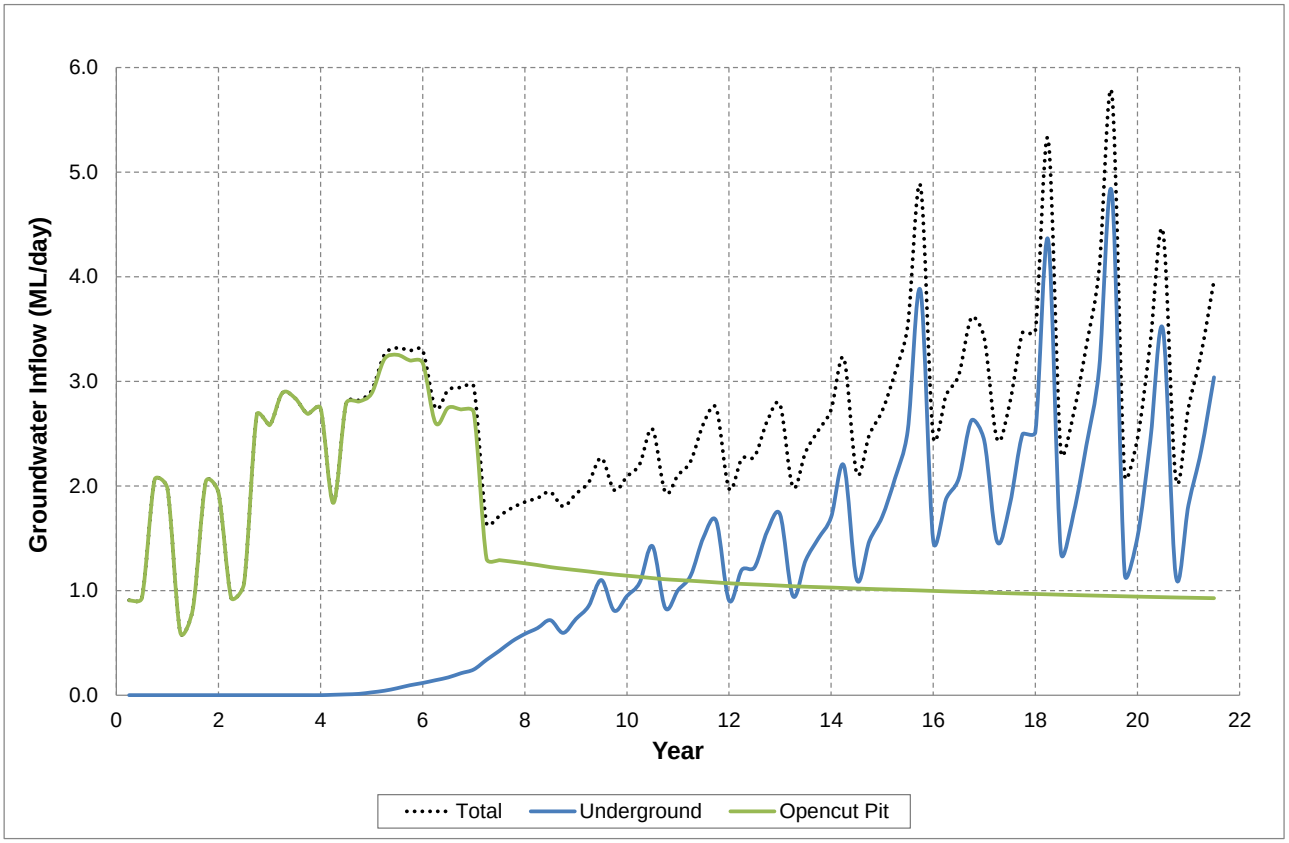


Figure 19: Predicted Mine Inflows

11.3 Mining Phase Water Budget Summary

Figure 20 shows the change in water budgets components as a result of the proposed mine. It is important to note that these are not total fluxes to or from the model but represent a change from the pre-mine steady state condition. These changes include:

- Mine dewatering (open-cut and underground) extracts an average of 2.6 ML/day of groundwater;
- Evaporation removes approximately 0.4 ML/day of groundwater. This occurs after mining of the open-cut and the development of a final void and pit lake;
- Recharge contributes an additional 0.3 ML/day to the groundwater system as a result of the proposed mine, on top of the 6.5 ML/day predicted for the baseline water budget. This additional recharge occurs after mining of the open cut and occurs as additional recharge to the void and spoil;
- A 0.9 ML/day increase in water entering the model through the SURFACT river package as leakage through the river bed. This occurs where there is a greater hydraulic gradient beneath the streams; and
- A 0.9 ML/day increase in water leaving the model through the SURFACT river package as baseflow or drains. This occurs in the lower lying areas where there is a greater hydraulic gradient beneath the streams. The changes in the SURFACT river package effectively cancel each other out so that the net change in flow that mining has on the cells representing streams or rivers is close to 0 ML/day.

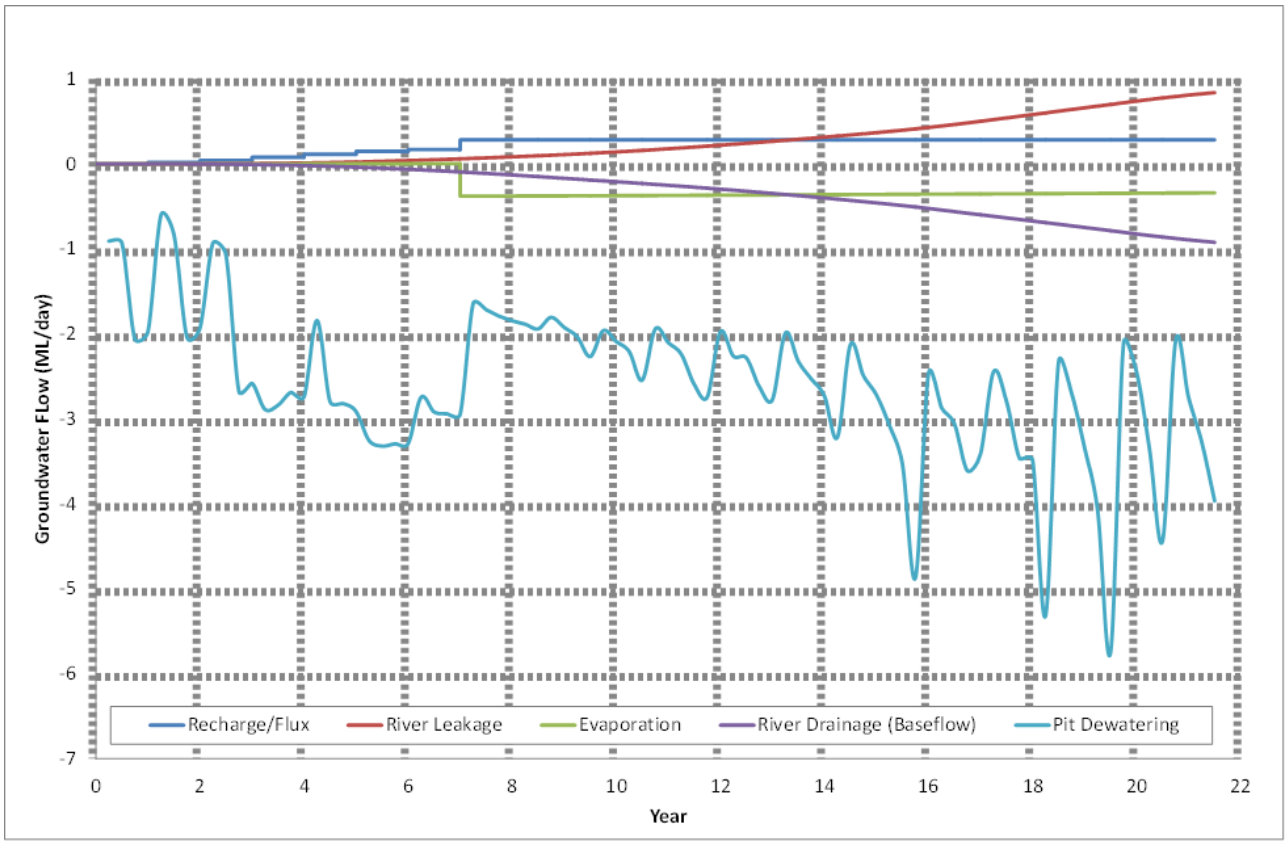


Figure 20: Predicted Water Budget

The numerical model was calibrated to water levels considered representative of steady state conditions, with the assumption of constant surface recharge to the groundwater system. Constant recharge was applied in the predictive model and as a result, the model does not simulate seasonal variations in recharge. Recent groundwater level data has shown that the groundwater systems (in particular the Permian coal measures) are largely unaffected by seasonal rainfall, with immeasurable hydraulic response following rainfall events. Therefore, the model did not simulate seasonal recharge in the predictive model scenarios, but an annual average.

As groundwater inflow occurs from the Permian coal measures, any short-term fluctuations (increases or decreases) in recharge to the outcrop or subcrop of the Permian coal measures will not be observed in the groundwater discharge to the mine. The modelled recharge rate is low and groundwater travel times are long enough for the strata to buffer any additional water that may be accepted into the groundwater system as recharge.

The predicted groundwater inflow from the Permian coal measures will be unaffected by any seasonal changes in rainfall or recharge. Seasonal changes in rainfall will affect runoff into the open cut. However, this water balance component is not represented in the groundwater model and it is understood that this is included in the surface water modelling.

11.4 Depressurisation and Drawdown

Drawdown contours and results for the Quaternary and Tertiary alluvium, Tertiary basalt (Layer 1) and Seam B (Layer 9) are detailed within Appendix B, Section 3.7. The results presented are based on the modelled geological extent of each unit, and indicate:

- drawdown within the alluvium could extend up to 3.5 km east (downstream) of MDL 467;
- drawdown within the Tertiary basalt could extend up to 3 km south of MDL 467; and
- drawdown within Seam B (Layer 9) is largely contained within MDL 467.

It is important to note that the model only allows for porous media flow, and does not mimic natural heterogeneity within the alluvium and basalt, which was observed from field observations (see Section 6.2 and Appendix A). Therefore, it is anticipated that the extent of drawdown, in real terms, will be lower than predicted.

11.5 Impact on Groundwater Users

Model results presented in Section 3.8 of Appendix B indicate that eight active (existing) private landholder bores could report groundwater level declines of greater than 2 m as a result of the proposed mine. This includes:

- one bore used for stock water supply, with a predicted decline of less than five metres;
- two bores used for stock water supply, with a predicted decline of between five to ten metres;
- four bores used for stock and farm water supply, with a predicted decline of over ten metres; and
- one bore used for stock, farm and drinking water supply with a predicted drawdown of over ten metres.

Table 8 summarises these eight bores and provides an assessment of the reduction in available drawdown in the bore.

Table 8: PREDICTED DRAWDOWN IN PRIVATE BORES

Bore ID	Stratigraphy	Use	Bore Depth (mbgl)	SWL (mbgl)	Predicted Drawdown (m)	Head available (m)	Reduction in available drawdown*
RN57603	Aldebaran Sandstone	Stock	80.0	5.5*	2.5	77.5	3%
RN67349	Tertiary Basalt	Stock	32.0	7.83	7.2	24.8	29%
Twin Bore	Tertiary Basalt / Aldebaran Sandstone	Stock - Not currently in use	46	19	8.5	37.5	23%
Census Bore 2	Aldebaran Sandstone	Used for stock	137	10.6*	20.3	116.7	17%
RN84184	Aldebaran Sandstone	Stock	76.5	30.7*	17.3	59.2	29%
RN90064	Aldebaran Sandstone / Coal	Stock & farm water	92.0	42.0*	29.7	62.3	48%
RN103729	Aldebaran Sandstone	Stock	121.5	33.7*	10.1	111.4	9%
Census Bore 3	Aldebaran Sandstone	Stock, farm& drinking water	123	47.8*	23.6	99.4	24%

Note: **SWL estimated from groundwater model*

Table 8 shows that, as a result of the Project, one bore is predicted to have a nearly 50% reduction in available drawdown, two bores are between 25% and 50%, and five bores are reduced by <25%.

Those bores with a reduction of greater than 50% are likely to be significantly impacted and are likely to require an alternative source of water to replace this supply. This may be a replacement bore or supplementation of the supply. Bores with a reduction of between 25% and 50% are likely to be impacted and may require to be deepened, replaced or supplemented with an alternative supply. Those bores with a reduction of available drawdown of less than 25% may be impacted by the project. These bores may require deepening or supplementation with an alternative supply.

Any significant loss of groundwater supply in affected bores will be replaced by the Proponent. Mitigation measures may entail deepening of the bore, deepening of the pump, constructing a replacement bore or supplementation of supply with alternative water. Details of the mitigation measures will be developed in agreement with the landholder at the appropriate time.

11.6 Groundwater Dependent Ecosystems

As detailed under Section 3.9 of Appendix B, the maximum predicted drawdowns within the unconsolidated stratigraphy correspond to some areas of mapped ecosystems with low to moderate potential for groundwater dependence (GDE Atlas). For information on the impact of groundwater drawdown on GDEs the reader is referred to the EIS Ecology Report.

11.7 Groundwater Recovery

The model simulated recovery of the groundwater system for 1,000 years post mining (Year 1021). The simulation utilised the predicted groundwater levels and hydraulic properties at the end of the mining period. The drain cells used to simulate dewatering from the coal seam were removed, allowing the groundwater levels in geological units above and beneath the coal seams to recover (gradually return to pre mine dewatering conditions).

The results indicate that groundwater levels within the underground mine recover relatively quickly following cessation of mining; however, groundwater levels in both pit voids will begin to stabilise approximately 500 years following active mining, with:

- groundwater levels within the western pit void maintained at around 194 mAHD;
- groundwater levels within the eastern pit void maintained at around 190 mAHD; and
- both pit lake levels fall well below the pit crest, and are highly unlikely to over-top.

Groundwater level recovery in the pit voids is likely to be slow primarily due to evaporation rates exceeding rainfall. The rate of groundwater recovery will be governed by groundwater inflow overcoming evaporation in the pit void. The private landholder bores are generally all predicted to recover within 5 m of pre-mining water levels with the majority predicted to recover within 3 m. This recovery typically occurs within 200 to 300 years post mining, with the rate of recovery dependent upon proximity to the pit voids.

11.8 Sensitivity Analysis

Sensitivity analysis was conducted to test what input parameters had the greatest impact on the final model predictions. Parameters assessed for sensitivity included hydraulic conductivity (horizontal and vertical), recharge rates, specific storage and specific yield. The results from the sensitivity analysis indicate:

- model predictions for mine inflow rates are most sensitive to changes in storage, hydraulic conductivity and the representation of the subsurface fracturing above the longwall mine; and
- model drawdown extent is most sensitive to changes in storage.

Results from the sensitivity analysis are detailed further within Appendix B. It is important to note that the sensitivity results are presented in order to show the degree of variability inherent within numerical modelling and the model design. As the hydraulic parameters are largely based on field data, the sensitivity results relating to significant changes in hydraulic parameters are not considered realistic for the Project.

11.9 Groundwater Contamination

There is potential for shallow groundwater contamination to occur as a result of hydrocarbon and metals contamination from workshops, waste disposal, and mining and non-mining fuel storage. However, adequate bunding and immediate clean-up of spills which is standard practice and a legislated requirement at mine sites, should prevent the contamination of shallow groundwater systems.

12 MANAGEMENT AND MONITORING

As potential groundwater impacts have been identified, a groundwater monitoring program will need to be implemented to provide an on-going assessment of the impacts from the mine, and a proactive indicator of any unexpected impacts on the groundwater regime. Long-term groundwater level data sourced from the on-going monitoring can also be utilised to undertake transient calibration of the numerical model, which would better refine the precision and accuracy of the model predictions.

The groundwater monitoring program, established as part of the groundwater investigations, will continue throughout the life of the Project. Any monitoring bores that are impacted during the life of the Project will be replaced as and when required. The existing groundwater monitoring network details are summarised in Table 9.

The network of 19 monitoring bores summarised below is not the final proposed monitoring network for the mine, but a list of all sites where monitoring bores have been installed. These bores are considered relevant for long term monitoring. It is acknowledged by the Proponent that a monitoring network will need to be approved by DNRM and incorporated into the conditions of any future water licence (if required) or environmental authority. The monitoring plan will be designed in accordance with ANZECC and DEHP guidelines to consider the risk to the environment and the environmental value of the groundwater resources.

Table 9: GROUNDWATER MONITORING BORES - CONSTRUCTION DETAILS

Hole ID	Coordinates		Geological Unit	Lithology	Screen
	mE	mN			(mbGL)
MB01_B	592504	7399983	Tertiary	Clay, silt	27.9 - 33.9
MB02_C	593997	7397592	Aldebaran Sandstone	Coal – B seam	92.2 - 95.2
MB02_S	594017	7397580	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	89.35 - 95.35
MB03_S	599667	7399771	Aldebaran Sandstone	Coarse horizon within fine grained sandstone	76 - 82
MB04_C	593513	7399534	Aldebaran Sandstone	Coal – B seam	118.5 - 120.5
MB04_S	593493	7399537	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	100 - 106
MB05_C	598860	7398819	Aldebaran Sandstone	Coal – A seam	141 - 144
MB06_B	592471	7394530	Tertiary	Clay, Silt	19.4 - 25.4
MB07_B	592065	7393041	Aldebaran Sandstone	Fine grained sandstone	27.5 - 30.6
MB08_B	594668	7390096	Tertiary	Clay, gravel	40 - 46
MB09_T	593575	7401714	Quaternary alluvium	Sand	24 - 30

Table 9: GROUNDWATER MONITORING BORES - CONSTRUCTION DETAILS					
Hole ID	Coordinates		Geological Unit	Lithology	Screen
	mE	mN			(mbGL)
MB10_T	600020	7402656	Quaternary alluvium	Silt, gravel	12.7 -18.7
TAR016_CR	594956	7395372	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	58 - 64
TAR040_C	600263	7396108	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	55 - 58
TAR053	595642	7395113	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	52 - 58
TAR176_C	595549	7400349	Aldebaran Sandstone	Fine grained sandstone	97 - 103
TAR177_C	594586	7400197	Tertiary	Fresh basalt	18 - 21
TAR189_C	598843	7398818	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	137.5 - 140.5
TAR249_C	596635	7397000	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	84.5 - 87.5

Note: *Coordinates are in MGA 94 Zone 55*
mbGL – metres below ground level

A final void management plan will be developed prior to the completion of open cut mining and will incorporate groundwater and surface water quality monitoring. The post closure groundwater monitoring network is unlikely to maintain bores within the spoil or emplacement areas as there is no perceived level of environmental risk within the spoil or pit void. The pit void is assessed to be a sink post mining and the network is more likely to be installed to monitor groundwater within groundwater systems around the void, from which local groundwater supplies are extracted, with the objective of monitoring and maintaining the environmental value of the resource.

12.1 Water Level Monitoring Plan

The recording of groundwater levels from the above groundwater monitoring network within the Project area will be facilitated by using electronic loggers installed in all bores, as well as manual recordings. Monitoring of these bores will continue from pre- to post-mining in order to:

- enable natural water level fluctuations (such as responses to rainfall, river/creek flows or landholder usage) to be distinguished from potential water level impacts due to depressurisation resulting from mining; and
- assist with determination of groundwater trigger levels.

The groundwater monitoring bores have been equipped with electronic loggers to record water levels at six-hourly intervals to assist with the collection of background levels. In addition to the installation of loggers, groundwater levels will be manually measured at quarterly intervals. Data collected from the dataloggers will be downloaded manually at quarterly intervals.

Following completion of the initial 24-month baseline sampling, the frequency of this monitoring will be reviewed.

12.2 Water Quality Monitoring Plan

Comparison of water quality data with the WQOs indicates that all bores exceed at least one of the 80th percentile criteria for deep and shallow groundwaters. Future assessment of groundwater should be undertaken based on baseline (pre-mining) data and not the specified WQOs. Groundwater quality sampling of existing monitoring bores will continue so that the following groundwater parameters can be acquired and monitored:

- establish baseline groundwater quality;
- assist with the determination of trigger levels; and
- assess the potential groundwater quality impacts during and post-mining.

On-going sampling will be undertaken approximately every three months for a period of two years. Collected samples will be analysed for the following:

- pH, EC and TDS;
- Major anions (CO_3, HCO_3, Cl, SO_4);
- Major cations (Ca, Mg, Na, K);
- Dissolved Metals (Al, Ar, Be, Cd, Cr, Cu, Pb, Ni, Se, Mo, Ag, Zn, B, Fe, Hg); and
- Nutrients (ammonia, nitrite, nitrate, total nitrogen, total phosphorus).

Field determinations for pH, EC and temperature will be measured and recorded for each sampling event. The collection, storage and transport of water quality samples for laboratory analysis will be undertaken in accordance with procedures outlined by the EHP Monitoring and Sampling Manual (2009) and other relevant guidelines.

Any trigger levels that are derived for the project must be carried out in accordance with the DEHP and ANZECC guidelines. Data will be reported at appropriate intervals in accordance with operating requirements and Environmental Authority conditions.

12.3 Mine Water Inflow Monitoring

Monitoring of mine dewatering will be undertaken in order to enable groundwater inflow rates and water quality to be estimated.

12.4 Data Management and Reporting

It is recommended that data management and reporting include:

- Annual assessment of departures from identified monitoring data trends. If consecutive monitoring data, over a period of six months, exhibit an increasing divergence from the previous data or from the established or predicted trends, then these departures should be investigated to assess appropriate actions to determine the likely cause. These may include a need to conduct more intensive monitoring, or to invoke impact re-assessment and/or mitigation measures;
- Formal review of depressurisation of coal measures and alluvium should be undertaken annually by a suitably qualified hydrogeologist;
- Annual reporting (including all water level and water quality data); and
- All groundwater data should be stored in a database, with suitable QA/QC controls.

13 CONCLUSIONS

The Taroborah Coal Project is a proposed open-cut and underground mine located approximately 22 km west of Emerald on MDL 467. The Project area is currently used for cattle grazing, with groundwater used for stock water supply and farm water use.

Geologically the Project area comprises alluvial sediments, localised along Retreat Creek and Kettle Creek to the north, which are generally less than 25 m thick. Relatively thin sequences of weathered Tertiary basalts sporadically occur across the Project area, with thick sequences of fresh basalt mapped to the south-west of the Project area. Tertiary sediments / regolith also occur across the Project area, which are underlain by the Permian aged Aldebaran Sandstone. The Permian sequences dip steeply to the north, with structural and hydrogeological divides surrounding the Project area, including:

- displacement of Permian stratigraphy to the east due to fault structures and / or a north-north-west continuation of the Springsure Anticline;
- sub-crop of the Aldebaran Sandstone to the south of the Project area;
- displacement of the Permian stratigraphy to the west of the Project area due to faults and the presence of Carboniferous and Devonian igneous complexes; and
- likely fault structures localised along Kettle Creek, with an approximate 250 m displacement causing the Reids Dome Beds, which stratigraphically underlie the Aldebaran Sandstone, to occur at sub-crop.

The two main economic coal seams within the Aldebaran Sandstone are the A seam and B seam, which have an average thickness of 1.2 m and 3.0 m respectively. Low permeability interburden separates the two coal seams, and Seam A is overlain by a laterally, extensive coarse grained sandstone. Review of water quality and groundwater levels indicates a degree of connectivity between the coarse grained sandstone and the underlying coal seams. The Aldebaran Sandstone is likely recharged by rainfall where it occurs at sub-crop at the southern end of the Project area, as well as from river leakage and leakage from the inferred faults that occur west and east of the Project area.

Overall the groundwater is generally not suitable for human consumption; however, groundwater within the alluvium, fresh Tertiary basalts and Aldebaran Sandstone is considered suitable for stock water supply and limited irrigation (ANZECC, 2000).

A three-dimensional numerical simulation of groundwater flow for the Project was undertaken using the MODFLOW-SURFACT code, in order to estimate groundwater seepage into the open-cut pit and underground mine. The model was also used to predict the zone of depressurisation in alluvial and other aquifers, and predict changes in the groundwater regime. The model was calibrated in steady state, with a resulting scaled root mean square (RMS) value of 7.70%, which indicates a good calibration and is within the Australian guidelines (Barnett *et al.*, 2012) of 10% for scaled RMS. The predictive model was run over the life of the mine (21 years), and indicates that:

- the proposed mine has a predicted average inflow rate of 2.6 ML/day of groundwater, which peaks at 5.7 ML/day around Year 19. Approximately 10% of the predicted inflows are likely to be ‘unseen water’ accounting for moisture in the coal and evaporation loss;
- groundwater level drawdown within the alluvium could extend up to 3.5 km east of MDL 467;
- groundwater level drawdown within the Tertiary basalt could extend up to 3 km south of MDL 467;

- following mine closure, groundwater levels will recover to 194 mAHD and 190 mAHD for the western and eastern pit voids, respectively, with both pit lake levels well below the pit crest;
- model results and findings from a bore census conducted within the Project area show that eight active private bores are predicted to report declines in groundwater levels of over 2 m as a result of the proposed mine;
- a comprehensive groundwater monitoring network has been established within the Project area, with all sites equipped with data loggers. In order to monitor potential impacts from the mine and establish baseline groundwater data on natural variations, it is recommended that:
    - groundwater levels within the monitoring bore network be manually checked and the data downloaded from the data loggers on a three monthly (quarterly) basis over a 24-month period;
    - surface water (i.e. Taroborah and Retreat Creeks) and groundwater quality samples be collected and analysed on a three monthly basis; and
    - ongoing monitoring and annual reporting of groundwater data is conducted, in order to identify any departures from the baseline trends that could trigger further investigation and re-assessment of management and impact mitigation measures.

The predicted modelling has been carried out using a number of assumptions regarding not only the numerical model, but also the construction and integrity of the private landholder bores. Outside of the mine area, the geology is not as well understood and the model layering and parameterisation has been simplified to suit a conservative understanding, that is a hydraulic connection across the structural features that separate the mine area and areas further to the east, west and north. The model makes assumptions regarding the model layers into which the private landholder bores are constructed. As a result, the model and its predictions are conservative in nature, and the drawdown predicted by the model is considered to be a worst case scenario.

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15 ABBREVIATIONS

AARC	AustralAsian Resource Consultants Pty Ltd
ADWG	Australian Drinking Water Guidelines
AGE	Australasian Groundwater and Environmental Consultants Pty Ltd
AHD	Australian Height Datum
BoM	Bureau of Meteorology
CHPP	Coal Handling Preparation Plant
CMB	Chloride Mass Balance
CRD	Cumulative Rainfall Departure
EHP	Department of Environment and Heritage Protection
DEM	Digital Elevation Model
DRNM	Department of Natural Resources and Mines
EA	Environmental Authority
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EPP Water	Environmental Protection (Water) Policy 2009
GDEs	Groundwater Dependent Ecosystems
GMA	Groundwater Management Area
GWDB	Groundwater Database
HC	Hydraulic Conductivity (horizontal)
LOR	Limit of Reporting
maGL	meters above ground level
mbGL	meters below ground level
MDL	Mineral Development Licence
MOLR	Method of last resort
NATA	National Association of Testing Authorities
OM	Order of Magnitude
Pbl	Permian Aldebaran Sandstone
Qa	Quaternary alluvium
Qa/Qc	Quality assurance/ Quality control
Qr	Quaternary colluvium
RCH	Recharge
RMS	Root Mean Square
SRMS	Scaled Root Mean Square
SRTM	Shuttle Radar Topography Mission
SS	Specific Storage
SY	Specific Yield

Tb	Tertiary basalt
TDS	Total Dissolved Solids
ToC	Top of Casing
TOR	Terms of Reference
TQa	Tertiary/Quaternary alluvium
VHC	Vertical Hydraulic Conductivity
WQO	Water Quality Objectives
WRP	Water Regulation Plan

16 GLOSSARY

Alluvium - Sediment (gravel, sand, silt, clay) transported by water (i.e. deposits in a stream channel or floodplain).

Aquiclude - A low-permeability unit that forms either the upper or lower boundary of a ground-water flow system.

Aquifer - Rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

Aquifer, Confined - An aquifer that is overlain by a confining bed. The confining bed has a significantly lower hydraulic conductivity than the aquifer.

Aquifer, Perched - A region in the unsaturated zone where the soil may be locally saturated because it overlies a low-permeability unit.

Aquifer, Semi-confined - An aquifer confined by a low-permeability layer that permits water to slowly flow through it. During pumping of the aquifer, recharge to the aquifer can occur across the confining layer. Also known as a leaky artesian or leaky confined aquifer.

Aquifer, Unconfined - An aquifer in which there are no confining beds between the zone of saturation and the surface. There will be a water table in an unconfined aquifer. Water-table aquifer is a synonym.

Aquitard - A low-permeability unit than can store ground water and also transmit it slowly from one aquifer to another.

Colluvium - Sediment (gravel, sand, silt, clay) transported by gravity (i.e. deposits at the base of a slope).

Cone of Depression - The depression in the water table around a well or excavation defining the area of influence of the well. Also known as cone of influence.

Drawdown - A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of ground water from wells or excavations.

Falling/Rising Head Test - A test made by the instantaneous addition, or removal, of a known volume of water to or from a well. The subsequent well recovery is measured.

Farm water supply – Suitability of domestic farm water supply, other than drinking water. For example laundry and produce preparation.

Head - sum of datum level, elevation head and pressure head which in unconfined aquifers is equal to the groundwater elevation.

Hydraulic Conductivity - A measure of the rate at which water moves through a soil/rock mass. It is the volume of water that moves within a unit of time under a unit hydraulic gradient through a unit cross-sectional area that is perpendicular to the direction of flow.

Hydraulic Gradient - The change in total head with a change in distance in a given direction. The direction is that which yields a maximum rate of decrease in head.

Infiltration - The flow of water downward from the land surface into and through the upper soil layers.

Model Calibration - The process by which the independent variables of a digital computer model are varied in order to calibrate a dependent variable such as a head against a known value such as a water-table map.

Packer Test - An aquifer test performed in an open borehole to determine rock permeability; the segment of the borehole to be tested is sealed off from the rest of the borehole by inflating seals, called packers, both above and below the segment.

Piezometer - A non-pumping well, generally of small diameter, that is used to measure the elevation of the water table or potentiometric surface. A piezometer generally has a short well screen through which water can enter.

Porosity - The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.

Potentiometric Surface - A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer.

Pumping Test - A test made by pumping a well for a period of time and observing the response/change in hydraulic head in the aquifer in order to determine aquifer hydraulic characteristics.

Slug Test - A test made by the instantaneous addition, or removal, of a known volume of water to or from a well. The subsequent well recovery is measured and analysed to provide a permeability value.

Specific Yield - The ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of the rock or soil. Gravity drainage may take many months to occur.

Storativity - The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer, per unit change in head.

Transmissivity - A measure of the rate at which water moves through an aquifer of unit width under a unit hydraulic gradient.

Unsaturated Zone - The zone between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched ground water, may exist in the unsaturated zone. Also called zone of aeration and vadose zone.

Water Budget - An evaluation of all the sources of supply and the corresponding discharges with respect to an aquifer or a drainage basin.

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Appendix A

FIELD INVESTIGATIONS

1 FIELD INVESTIGATIONS

Hydrogeological field investigations were undertaken by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) between December 2011 and May 2014. Field investigations included:

- installing groundwater monitoring bore;
- collecting groundwater samplings for laboratory analyses;
- testing hydraulic conductivity;
- surveying private landholder bores; and
- measuring groundwater levels and installing data loggers.

Each of the field investigations is described in the sections below.

2 GROUNDWATER MONITORING BORE INSTALLATIONS

A total of 12 PVC monitoring bores were drilled and constructed by Gibson Drilling Services Pty Ltd between January 2013 and March 2013. IMC Mining Group Pty Ltd (IMC) supervised the drilling and prepared lithological logs with remote assistance from AGE.

The monitoring bore locations and bore depths were selected based on the proposed mine plan, exploration drilling results, and published 1:100,000 geological maps. The bores were drilled to intersect the main geological units including the Aldebaran Sandstone, Tertiary basalt, and Quaternary alluvium, to measure groundwater level and quality. Table A-1 provides the construction details for all monitoring bores and Appendix A-1 includes the bore construction logs.

Bores with a ‘C’ suffix were screened across the A or B coal seams, ‘S’ across fine or coarse sandstones, ‘T’ across Quaternary alluvium, and ‘B’ across Tertiary sediments. All monitoring bores with the suffix ‘B’ were originally intended to target Tertiary basalt and relied heavily on the published 1:100,000 surface geology as guidance to plan locations. During drilling, Tertiary basalts were found to be absent at all of these locations which showed that the published geological mapping is not entirely accurate. Monitoring bore MB07_B was instead screened across a fine-grained Aldebaran Sandstone unit and monitoring bores MB01_B, MB06_B and MB08_B screened across Tertiary clays, silts, and gravels.

All holes were drilled using open-hole rotary air drilling techniques and constructed in accordance with the requirements of the ‘Minimum Construction Requirements for Water Bores in Australia, Edition 3, February 2012’. The monitoring bores were constructed with 50 mm diameter, flush threaded, Class 18 uPVC with Class 18 machine slotted (0.4 mm aperture) uPVC screen. Additionally, for every 0.5 m of screen length, a handsaw was used to increase aperture size to 1 mm to allow for entry of stygofauna. A filter pack of clean rounded to sub-rounded gravel of 3 mm to 6 mm diameter was placed in the annulus to a height that covered the screened interval. Bentonite pellets were placed above and below the filter gravel to form a seal to hydraulically isolate the screened section whilst the remainder of the annulus was sealed by pumping a cement/bentonite grout via a tremie line. A steel lockable protector was cemented around the protruding casing at the surface.

Table A-1: GROUNDWATER MONITORING BORES - CONSTRUCTION DETAILS										
Hole ID	Coordinates*		Geological Unit	Lithology	Elevation (mAHD)		Screen (mbGL)	Gravel Pack (mbGL)	Static Water Level April 2013	
	mE	mN			ToC*	Ground*			(mbToC)	(mAHD)
MB01_B	592503.7	7399983.3	Tertiary	Clay, silt	214.73	213.69	27.9 - 33.9	25.6 - 35.5	26.00	188.73
MB02_C	593996.9	7397592.4	Aldebaran Sandstone	Coal – B seam	238.20	236.83	92.2 - 95.2	91.7 - 95.2	46.64	191.56
MB02_S	594017.2	7397580.4	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	238.07	236.78	89.35 - 95.35	83 - 95.45	47.77	186.30
MB03_S	599667.0	7399771.3	Aldebaran Sandstone	Coarse horizon within fine grained sandstone	231.80	230.52	76 - 82	74.5 - 82	53.92	177.88
MB04_C	593513.3	7399534.1	Aldebaran Sandstone	Coal – B seam	236.09	234.89	118.5 - 120.5	117.5 - 120.5	43.75	192.34
MB04_S	593492.8	7399536.9	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	236.26	235.03	100 - 106	99 - 106	43.84	192.42
MB05_C	598859.7	7398818.8	Aldebaran Sandstone	Coal – A seam	238.60	237.34	141 - 144	140 - 144	46.64	191.96
MB06_B	592470.6	7394530.3	Tertiary	Clay, Silt	222.40	221.11	19.4 - 25.4	17.5 - 26	Dry	-
MB07_B	592064.5	7393041.1	Aldebaran Sandstone	Fine grained sandstone	234.30	233.05	27.5 - 30.6	26 - 30.6	Dry	-
MB08_B	594667.9	7390096.2	Tertiary	Clay, gravel	243.86	242.60	40 - 46	36 - 46.5	29.13	214.73
MB09_T	593575.2	7401713.7	Quaternary alluvium	Sand	202.91	201.61	24 - 30	22 - 32	6.72	196.19
MB10_T	600019.6	7402656.4	Quaternary alluvium	Silt, gravel	194.71	193.39	12.7 -18.7	10.5 - 18.7	9.62	185.09

Notes: *Coordinates GDA94, Zone 55* *ToC = Top of Casing*
mbGL = metres below ground level *mAHD = metres above height datum*
mbToC = metres below top of casing
** Bore coordinates, ToC (mAHD) and ground level (mAHD) surveyed with differential GPS*

Table A-2: EXISTING GROUNDWATER MONITORING BORES - CONSTRUCTION DETAILS

Hole ID	Coordinates		Geological Unit	Lithology	Elevation (mAHD)		Screen (mbGL)	Gravel Pack (mbGL)	Static Water Level April 2013	
	mE	mN			ToC	Ground			(mbToC)	(mAHD)
TAR016_CR	594956	7395372	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	228.15*	na	58 - 64	56 - 66	39.84	188.31
TAR040_C	600263	7396108	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	230.50*	na	55 - 58	53 - 59.5	35.74	194.76
TAR053	595642	7395113	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	213.55*	na	52 - 58	46.3 - 60.8	25.56	187.99
TAR176_C	595549	7400349	Aldebaran Sandstone	Fine grained sandstone	203.98*	na	97 - 103	95 - 104.5	11.92	192.06
TAR177_C	594586	7400197	Tertiary	Fresh basalt	221.11*	na	18 - 21	15.5 - 21.7	11.76	209.35
TAR189_C	598843	7398818	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	236.76*	na	137.5 - 140.5	136.5 - 142	44.77	191.99
TAR249_C	596635	7397000	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	236.18#	na	84.5 - 87.5	83.5 - 88.6	47.71	188.47

Notes: *Coordinates GDA94, Zone 55 (Handheld GPS)*
ToC = Top of Casing
mbGL = metres below ground level
mAHD = metres above height datum
mbToC = metres below top of casing
**ToC RL estimated from IMC (2009)[1]*
#ToC RL estimated from IMC (2010)[2]

[1] IMC (2009), "*Annual Report for Year 3 (12 Month Period Ending 31 January 2009) EPC1011 – Taroborah".*

[2] IMC (2010), *"Year 4 (2009) Exploration of EPC1011 – Taroborah (12 Month Period Ending 31 January 2010)".*

Bores were airlift developed for between 45 mins and 4 hours until all fines were expelled and field water quality parameters (pH and electrical conductivity) were stable.

In addition to the newly drilled bores, seven existing monitoring bores are present throughout the Project area. The construction details of the existing monitoring bores are presented in bore conversion reports completed by Matrix Plus between 2008 and 2009. The existing monitoring bores were sampled for water quality in 2009 and were also tested as part of the field investigations (see Sections 3.0 and 4.0).

3 GROUNDWATER SAMPLING AND TESTING

Field water quality parameters were measured and laboratory samples collected from all accessible bores as part of the field investigations. All newly drilled monitoring bores (Table A-1) were sampled between February and March 2013, and existing bores (Table A-2) during April 2013. An additional sampling round was completed in 2014.

Newly drilled monitoring bores were purged during development and a representative groundwater sample collected at the end of development. In contrast, the existing monitoring bores were purged and sampled using a combination of a disposable bailer and a Waterra inertial pump. Samples were collected by purging a minimum three bore volumes until field water quality parameters (pH, electrical conductivity (EC) and temperature) had stabilised. Field water quality probes were calibrated daily prior to use. Prior to purging, the standing water level (SWL) was measured with a water level dipper.

Table A-3 summarises the final stabilised field water quality parameters. Groundwater samples collected during the field investigations were analysed for the following suite of parameters:

- physico-chemical parameters (pH, EC, total dissolved solids (TDS), total hardness, sodium adsorption ratio, total suspended solids);
- major anions (CO_3, HCO_3, Cl, SO_4);
- major cations (Ca, Mg, Na, K);
- fluoride;
- dissolved and total metals (Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe^{2+}, Hg, Mn, Mo, Ni, Pb, Sb, Se, U, V, Zn); and
- nutrients (ammonia, nitrite, nitrate, total nitrogen, reactive phosphorus and total phosphorus).

Each sample was collected in a laboratory supplied container. Samples requiring dissolved metal analysis were filtered in the field using a 0.45 micron filter. All samples were itemised on a Chain of Custody Form, which accompanied the samples to the laboratory.

The water samples were submitted to and analysed by ALS Environmental Laboratories (ALS) which is National Association of Testing Authorities (NATA) accredited. Laboratory results are provided in Appendix A-2. Samples could not be collected from newly drilled bores MB06_B and MB07_B as these bores were dry during the field investigation. Samples from existing bores TAR040_C and TAR189_C were unable to be collected in April 2013 due to poor access conditions.

Table A-3 shows that field measured EC values in all bores are below 3,180 µS/cm. Based on these EC values, the groundwater in all monitoring bores is suitable for stock watering purposes.

Table A-3: SUMMARY OF FIELD WATER QUALITY PARAMETERS

Hole ID	Geological Unit	April 2013			May 2014		
		pH	EC (µS/cm)	Temp (^{0}C)	pH	EC (µS/cm)	Temp (^{0}C)
MB01_B	Tertiary	8.26	2,450	-	6.63	2,533	26.6
MB02_C	Aldebaran Sandstone	8.35	3,180	24.1	6.98	2,153	24.5
MB02_S	Aldebaran Sandstone	8.24	1,395	25.4	7.04	1,463	26.8
MB03_S	Aldebaran Sandstone	7.95	3,130	26.8	11.05	2,850	27.7
MB04_C	Aldebaran Sandstone	8.39	2,760	25.3	7.14	2,377	26.9
MB04_S	Aldebaran Sandstone	8.34	2,570	24.5	9.07	2,313	25.7
MB05_C	Aldebaran Sandstone	8.37	1,570	26.9	8.45	1,767	29.3
MB08_B	Tertiary	8.47	1,434	-	7.10	1,430	27.2
MB09_T	Quaternary Alluvium	8.21	917	-	6.46	1,351	26.2
MB10_T	Quaternary Alluvium	7.92	1,679	-	6.79	1,775	26.4
TAR016_CR	Aldebaran Sandstone	6.75	1,328	26.6	6.89	1,236	27.0
TAR040_C	Aldebaran Sandstone	-	-	-	7.05	1,194	21.7
TAR053	Aldebaran Sandstone	7.24	956	26.2	6.96	973	27.0
TAR176_C	Aldebaran Sandstone	8.66	893	26.7	7.25	1,170	26.0
TAR177_C	Tertiary	7.06	1,368	26.0	6.94	1,315	26.8
TAR189_C	Aldebaran Sandstone	-	-	-	7.8	2267	29.0
TAR249_C	Aldebaran Sandstone	7.68	797	25.7	9.06	546	24.4

Table A-4 and Table A-5 compare the laboratory results against ANZECC (2000)[5] livestock drinking guidelines, and ADWG (2011)[6] aesthetic and health guidelines for samples collected in 2013 and 2014, respectively.

[5] ANZECC, (2000), *"Australian Water Quality Guidelines for Fresh and Marine Waters",* Australia and New Zealand Environment and Conservation Council and the Agricultural and Resource Management Council of Australia and New Zealand.

[6] NHMRC, NRMMC, (2011), *"Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy".* National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.

Table A-4: LABORATORY WATER QUALITY RESULTS – APRIL 2013

Analytes	Units	LOR	ANZECC 2000		ADWG (2011)		MB01_B	MB02_C	MB02_S	MB03_S	MB04_C	MB04_S	MB05_C	MB08_B	MB09_T	MB10_T	TAR016_CR	TAR053	TAR176_C	TAR177_C	TAR249_C
Aquifer	-	-	Irrigation Water	Livestock Drinking	Aesthetic	Health	Tertiary Clay, Silt	Aldebaran Sandstone - B seam	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - Fine Sandstone	Aldebaran Sandstone - B seam	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - A seam	Tertiary Clay, Gravel	Quaternary Alluvium	Quaternary Alluvium	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - Fine Sandstone	Tertiary Basalt	Aldebaran Sandstone - Coarse Sandstone
Date Sampled	-	-					12/3/2013	13/3/2013	12/3/2013	13/3/2013	12/3/2013	12/3/2013	13/3/2013	21/2/2013	11/3/2013	11/3/2013	23/4/2013	22/4/2013	18/4/2013	18/4/2013	22/4/2013
Field - Physical Parameters																					
pH Value	pH Unit	-	-	-	6.5 - 8.5	-	8.26	8.35	8.24	7.95	8.39	8.34	8.37	8.47	8.21	7.92	6.75	7.24	8.66	7.06	7.68
Electrical Conductivity @ 25°C	µS/cm	-	-	-	-	-	2,450	3,180	1,395	3,130	2,760	2,570	1,570	1,434	917	1,679	1,328	956	893	1,368	797
Total Dissolved Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	864	624	-	-	520
Temperature	°C	-	-	-	-	-	-	24.1	25.4	26.8	25.3	24.5	26.9	-	-	-	26.6	26.2	26.7	26.0	25.7
Laboratory - Physical Parameters																					
pH Value	pH Unit	0.01	-	-	6.5 - 8.5	-	8.35	8.23	8.16	8.36	8.24	8.20	8.45	-	8.33	8.36	7.59	7.93	8.65	7.40	8.56
Electrical Conductivity @ 25°C	µS/cm	1	-	-	-	-	2,170	3,070	1,370	3,060	2,630	2,440	1,590	1,450	931	1,560	1,290	980	930	1,400	783
Sodium Adsorption Ratio	-	0.01	-	-	-	-	4.3	4.5	2.7	11.8	6.32	8.98	3.52	-	3.74	6.32	1.97	1.51	3.73	1.24	3.79
Total Dissolved Solids (Calc.)	mg/L	10	-	3,000-13,000*	600	-	1,410	2,000	890	1,990	1,710	1,590	1,030	942	605	1,010	838	637	604	910	509
Total Suspended Solids	mg/L	5	-	-	-	-	49,700	270	126	8,020	3,470	163	240	313	390	54,400	11	7	<5	5	85
Total Hardness as $CaCO_3$	mg/L	1	-	-	200	-	674	773	446	318	583	385	348	-	204	326	459	371	186	655	137
Alkalinity																					
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	15	<1	<1	11	<1	<1	20	17	5	16	<1	<1	28	<1	14
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	398	248	472	276	245	376	260	559	225	454	537	445	157	778	75
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	413	248	472	288	245	376	280	576	231	470	537	445	186	778	90
Major Ions																					
Calcium	mg/L	1	-	1,000	-	-	59	97	60	58	77	57	39	30	34	43	75	58	53	71	17
Chloride	mg/L	1	refer to guideline	-	250	-	428	718	154	540	594	488	291	129	134	191	117	48	199	73	179
Fluoride	mg/L	0.1	2.0	2	-	1.5	<4.0	0.4	0.6	0.6	0.5	0.8	0.4	-	0.2	<0.4	0.5	0.5	0.2	0.2	0.4
Magnesium	mg/L	1	-	-	-	-	128	129	72	42	95	59	61	81	29	53	66	55	13	116	23
Potassium	mg/L	1	-	-	-	-	10	13	5	83	18	44	12	2	2	3	3	5	16	3	10
Sodium	mg/L	1		-	180	-	257	288	131	482	351	405	151	193	123	262	97	67	117	73	102
Sulfate as SO_4	mg/L	1	-	1,000 - 2000	250	500	131	67	36	293	185	156	66	45	37	84	22	13	37	20	42
Dissolved Metals																					
Aluminium	mg/L	0.01	-	-	0.2	-	<0.01	0.02	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.01

Table A-4: LABORATORY WATER QUALITY RESULTS – APRIL 2013																				
Analytes	**Units**	**LOR**	**ANZECC 2000**		**ADWG (2011)**		**MB01_B**	**MB02_C**	**MB02_S**	**MB03_S**	**MB04_C**	**MB04_S**	**MB05_C**	**MB08_B**	**MB09_T**	**MB10_T**	**TAR016_CR**	**TAR053**	**TAR176_C**	**TAR177_C**	**TAR249_C**
Antimony	mg/L	0.001	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001
Arsenic	mg/L	0.001	-	-	-	-	0.002	<0.001	0.004	0.002	<0.001	0.003	0.002	<0.001	0.001	0.013	0.001	0.005	0.002	<0.001	<0.001
Barium	mg/L	0.001	-	-	-	-	0.091	0.146	0.047	0.093	0.082	0.163	0.108	0.117	0.018	0.087	0.121	0.388	0.078	0.096	0.031
Beryllium	mg/L	0.001	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	-	-	-	-	0.07	0.13	0.09	0.28	0.14	0.08	0.11	0.12	0.06	0.09	0.1	0.06	0.1	0.07	0.05
Cadmium	mg/L	0.0001	-	-	-	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	-	-	-	-	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.003	0.002	0.003	<0.001	<0.001	<0.001
Copper	mg/L	0.001	-	-	-	-	0.002	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Ferrous Iron	mg/L	0.05	-	-	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05	<0.05	0.22	1.29	<0.05	0.44	<0.05
Lead	mg/L	0.001	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	-	-	-	-	0.076	0.022	0.008	0.029	0.016	0.01	0.017	0.006	0.073	0.031	0.051	0.029	0.001	0.077	0.003
Mercury	mg/L	0.0001	-	-	-	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	-	-	-	-	0.034	0.002	0.009	0.015	0.007	0.003	0.002	0.01	<0.001	0.039	0.002	0.003	0.011	0.005	0.011
Nickel	mg/L	0.001	-	-	-	-	0.009	<0.001	<0.001	0.001	0.001	<0.001	0.002	0.001	<0.001	0.002	0.002	0.004	<0.001	0.003	0.001
Selenium	mg/L	0.01	-	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.001	-	-	-	-	0.005	<0.001	0.008	0.012	0.005	<0.001	0.001	0.013	<0.001	0.007	0.01	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	-	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	-	-	-	-	0.012	0.005	<0.005	0.006	<0.005	0.005	0.007	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	0.008	0.008
Total Metals																					
Aluminium	mg/L	0.01	20	5	-	-	183	0.51	0.5	1.01	17.4	46.7	0.21	2.59	1.07	116	0.26	0.04	0.02	0.02	1.88
Antimony	mg/L	0.001	-	-	-	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.010	<0.001	<0.001	<0.001	<0.001	0.001
Arsenic	mg/L	0.001	2	0.5	-	0.01	0.022	0.002	0.002	0.003	0.004	0.01	0.002	<0.001	0.003	0.115	0.002	0.004	0.001	<0.001	0.002
Barium	mg/L	0.001	-	-	-	2	1.49	0.14	0.176	0.131	0.237	0.446	0.097	0.144	0.03	2.12	0.125	0.343	0.078	0.109	0.052
Beryllium	mg/L	0.001	0.5	-	-	0.06	0.016	0.001	<0.001	0.003	0.004	0.012	<0.001	<0.001	<0.001	<0.010	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	refer to guideline	5	-	4	0.05	0.14	0.06	0.3	0.13	0.12	0.11	0.1	0.06	0.54	0.1	0.06	0.09	0.05	0.07
Cadmium	mg/L	0.0001	0.05	0.01	-	0.002	0.0061	<0.0001	<0.0001	0.0002	0.0002	0.0004	<0.0001	<0.0001	<0.0001	0.0012	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	1	1	-	0.05	0.238	<0.001	<0.001	0.001	0.004	0.004	<0.001	0.002	0.006	0.264	<0.001	<0.001	<0.001	<0.001	0.016
Cobalt	mg/L	0.001	0.1	1	-	-	0.354	0.001	<0.001	0.003	0.003	0.006	<0.001	0.001	0.003	0.154	0.002	0.003	<0.001	<0.001	0.002
Copper	mg/L	0.001	5	0.5	1	2	0.645	0.008	0.001	0.004	0.013	0.022	<0.001	0.002	0.004	0.266	<0.001	<0.001	<0.001	<0.001	0.017
Ferrous Iron	mg/L	0.05	10	-	0.3	-	<0.05	0.08	<0.05	0.1	<0.05	<0.05	<0.05	-	<0.05	<0.05	0.2	-	-	-	-
Lead	mg/L	0.001	5	0.1	-	0.01	0.234	0.009	0.001	0.024	0.026	0.074	<0.001	0.002	0.002	0.213	0.001	<0.001	<0.001	<0.001	0.008
Manganese	mg/L	0.001	10	-	0.1	0.5	45.9	0.085	0.02	0.375	0.274	0.727	0.024	0.029	0.088	13.4	0.052	0.03	0.001	0.092	0.067
Mercury	mg/L	0.0001	0.002	0.002	-	0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0008	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	0.05	0.15	-	0.05	0.004	0.002	0.003	0.015	0.006	0.007	0.002	0.007	<0.001	<0.010	0.002	0.004	0.012	0.005	0.014
Nickel	mg/L	0.001	2	1	-	0.02	0.798	0.002	0.002	0.003	0.009	0.009	0.003	0.003	0.003	0.081	0.002	0.004	<0.001	0.003	0.019
Selenium	mg/L	0.01	0.5	0.02	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.001	0.1	0.2	-	0.017	0.045	0.001	<0.001	0.015	0.011	0.027	0.002	0.015	<0.001	0.152	0.01	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	0.5	-	-	-	0.41	<0.01	<0.01	<0.01	0.01	0.02	<0.01	<0.01	0.02	0.38	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	5	20	3	-	1.38	0.015	0.009	0.038	0.074	0.069	0.006	0.02	0.022	0.459	0.01	<0.005	<0.005	0.005	0.16
Nutrients																					

Table A-4: LABORATORY WATER QUALITY RESULTS – APRIL 2013

Analytes	Units	LOR	ANZECC 2000		ADWG (2011)		MB01_B	MB02_C	MB02_S	MB03_S	MB04_C	MB04_S	MB05_C	MB08_B	MB09_T	MB10_T	TAR016_CR	TAR053	TAR176_C	TAR177_C	TAR249_C
Ammonia	mg/L	0.01	-	-	0.5	-	0.08	0.14	0.08	0.92	0.22	0.13	0.17	-	0.1	0.05	0.02	0.38	0.54	0.03	0.26
Nitrate as N	mg/L	0.01	-	-	-	50	0.01	0.02	*<0.01*	0.02	*<0.01*	*<0.01*	0.03	-	0.02	0.02	0.02	*<0.01*	*<0.01*	0.02	0.02
Nitrite as N	mg/L	0.01	-	30	-	3	*<0.01*	*<0.01*	*<0.01*	0.02	*<0.01*	*<0.01*	*<0.01*	-	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*
Nitrite + Nitrate as N	mg/L	0.01	-	400	-	-	0.01	0.02	*<0.01*	0.04	*<0.01*	*<0.01*	0.03	0.18	0.02	0.02	0.02	*<0.01*	*<0.01*	0.02	0.02
Total Kjeldahl Nitrogen as N	mg/L	0.1	-	-	-	-	3	0.4	*<0.1*	0.8	0.7	0.2	*<0.1*	*<0.1*	*<0.1*	1.7	0.2	0.5	0.6	0.2	1
Total Nitrogen as N	mg/L	0.1	-	-	-	-	3	0.4	*<0.1*	0.8	0.7	0.2	*<0.1*	0.2	*<0.1*	1.7	0.2	0.5	0.6	0.2	1
Reactive Phosphorus as P	mg/L	0.01	refer to guideline	-	-	-	0.04	0.04	0.02	*<0.01*	*<0.01*	0.01	0.02	-	*<0.01*	0.04	*<0.01*	*<0.01*	*<0.01*	0.02	*<0.01*
Total Phosphorus as P	mg/L	0.01	-	-	-	-	31.7	0.44	0.1	0.42	0.17	0.43	0.63	0.17	0.06	41.5	*<0.01*	0.08	*<0.01*	0.02	0.08
Ion Balance																					
Total Anions	meq/L	0.01	-	-	-	-	23	26.6	14.5	27.1	25.5	24.5	15.2	16.1	9.17	16.5	14.5	10.5	10.1	18	7.72
Total Cations	meq/L	0.01	-	-	-	-	24.9	28.3	14.8	29.4	27.4	26.4	13.8	16.6	9.48	18	13.5	10.5	9.21	16.3	7.43
Ionic Balance	%	0.01	-	-	-	-	3.86	3.12	0.74	4.15	3.56	3.74	4.62	1.57	1.69	4.18	3.65	0.27	4.59	4.91	1.91

* Guideline Value depends on type of livestock.

Exceeds ANZECC (2000) short term irrigation water guideline value.

Exceeds Australian Drinking Water Guidelines (2011) aesthetic guideline value.

Exceeds Australian Drinking Water Guidelines (2011) health guideline value.

1000 Exceeds ANZECC (2000) livestock drinking water guideline value.

Table A-5: LABORATORY WATER QUALITY RESULTS – MAY 2014

Analytes	Units	LOR	ANZECC 2000		ADWG (2011)		MB01_B	MB02_C	MB02_S	MB03_S	MB04_C	MB04_S	MB05_C	MB08_B	MB09_T	MB10_T	TAR016_CR	TAR040_C	TAR053	TAR176_C	TAR177_C	TAR189_C	TAR249_C
			Irrigation Water	Livestock Drinking	Aesthetic	Health																	
Aquifer	-	-					Tertiary Clay, Silt	Aldebaran Sandstone - B seam	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - Fine Sandstone	Aldebaran Sandstone - B seam	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - A seam	Tertiary Clay, Gravel	Quaternary Alluvium	Quaternary Alluvium	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone	Aldebaran Sandstone - Coarse Sandstone	Aldebaran Sandstone - Fine Sandstone	Tertiary Basalt	Aldebaran Sandstone	Aldebaran Sandstone - Coarse Sandstone
Date Sampled	-	-					15/5/2014	16/5/2014	16/5/2014	14/5/2014	15/5/2014	15/5/2014	14/5/2014	16/5/2014	15/5/2014	14/5/2014	16/5/2014	15/5/2014	16/5/2014	15/5/2014	15/5/2014	14/5/2014	15/5/2014
Field - Physical Parameters																							
pH Value	pH Unit	-	-	-	6.5 - 8.5	-	6.63	6.98	7.04	11.05	7.14	9.07	8.45	7.10	6.46	6.79	6.89	7.05	6.96	7.25	6.94	7.84	9.06
Electrical Conductivity @ 25°C	µS/cm	-	-	-	-	-	2,533	2,153	1,463	2,850	2,377	2,313	1,767	1,430	1,351	1,775	1,236	1,194	973	1,170	1,315	2,267	546
Total Dissolved Solids	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Temperature	°C	-	-	-	-	-	26.6	24.5	26.8	27.7	26.9	25.7	29.3	27.2	26.2	26.4	27.0	21.7	27.0	26.0	26.8	29.0	24.4
Laboratory - Physical Parameters																							
pH Value	pH Unit	0.01	-	-	6.5 - 8.5	-	7.85	8.36	8.28	10.4	8.21	8.82	8.54	8.17	8.03	8.15	8.19	8.26	8.26	8.4	8.25	8.48	8.91
Electrical Conductivity @ 25°C	µS/cm	1	-	-	-	-	2,460	2,030	1,380	2,640	2,460	2,250	1,720	1,310	1,390	1,680	1,180	1,050	904	1,130	1,240	2,150	521
Sodium Adsorption Ratio	-	0.01	-	-	-	-	3.5	8.53	2.69	40.8	5.12	11.4	4.74	2.34	4.23	3.53	1.98	1.74	1.53	2.41	1.21	6.1	3.66
Total Dissolved Solids (Calc.)	mg/L	10	-	3,000-13,000 *	600	-	1,380	1,220	783	1,660	1,520	1,380	1,010	789	869	928	604	559	471	645	676	1,170	1,000
Total Suspended Solids	mg/L	5	-	-	-	-	915	103	5	759	67	111	52	7,390	14	813	256	223	327	114	53	49	10,500
Total Hardness as $CaCO_3$	mg/L	1	-	-	200	-	846	326	436	22	582	215	364	512	324	513	491	378	351	333	616	439	67
Alkalinity																							
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	72	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	18	<1	194	<1	70	34	<1	<1	<1	<1	<1	<1	20	<1	38	31
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	620	416	492	<1	358	322	279	587	237	641	520	442	444	254	653	450	1180
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	620	434	492	267	358	392	313	587	237	641	520	442	444	274	653	488	1210
Major Ions																							
Calcium	mg/L	1	-	1,000	-	-	70	53	64	9	93	25	37	70	54	77	78	51	55	56	85	29	22

Table A-5: LABORATORY WATER QUALITY RESULTS – MAY 2014

Analytes	Units	LOR	ANZECC 2000		ADWG (2011)		MB01_B	MB02_C	MB02_S	MB03_S	MB04_C	MB04_S	MB05_C	MB08_B	MB09_T	MB10_T	TAR016_CR	TAR040_C	TAR053	TAR176_C	TAR177_C	TAR189_C	TAR249_C
Chloride	mg/L	1	refer to guideline	-	250	-	497	370	185	560	589	502	377	136	338	202	114	108	57	220	69	501	146
Fluoride	mg/L	0.1	2.0	2	-	1.5	0.2	0.9	0.8	0.5	0.5	0.9	0.3	0.7	0.2	0.4	0.6	0.2	0.5	0.2	0.1	0.3	<0.5#
Magnesium	mg/L	1	-	-	-	-	163	47	67	<1	85	37	66	82	46	78	72	61	52	47	98	89	3
Sodium	mg/L	1	-	-	180	-	234	354	129	445	284	385	208	122	175	184	101	78	66	101	69	294	69
Potassium	mg/L	1		-	-	-	8	8	6	175	13	57	44	2	3	16	3	9	5	15	4	10	6
Sulfate as SO_4	mg/L	1	-	1,000 - 2000	250	500	93	198	42	225	141	108	94	7	55	78	18	12	12	42	20	8	26
Dissolved Metals																							
Aluminium	mg/L	0.01	-	-	0.2	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	mg/L	0.001	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	-	-	-	-	<0.001	0.003	<0.001	0.006	<0.001	0.002	<0.001	<0.001	<0.001	0.004	<0.001	0.002	0.004	<0.001	<0.001	<0.001	0.002
Barium	mg/L	0.001	-	-	-	-	0.098	0.096	0.125	0.052	0.122	0.066	0.102	0.233	0.03	0.108	0.214	0.233	0.398	0.113	0.116	0.154	0.034
Beryllium	mg/L	0.001	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	-	-	-	-	0.09	0.12	0.09	0.07	0.1	0.1	0.08	0.07	0.05	0.08	0.08	0.11	0.06	0.1	0.05	0.13	0.05
Cadmium	mg/L	0.0001	-	-	-	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	-	-	-	-	<0.001	<0.001	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	-	-	-	-	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ferrous Iron	mg/L	0.05	-	-	-	-	<0.05	<0.05	<0.05	<0.05	0.09	<0.05	<0.05	<0.05	<0.05	0.33	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead	mg/L	0.001	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	-	-	-	-	0.159	0.296	0.029	<0.001	0.125	0.009	0.036	0.049	0.032	0.125	0.039	0.102	0.028	0.032	0.07	0.017	<0.001
Mercury	mg/L	0.0001	-	-	-	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	-	-	-	-	0.006	0.012	0.006	0.042	0.002	0.013	0.036	0.003	<0.001	0.008	0.003	0.008	0.003	0.004	0.006	0.004	0.01
Nickel	mg/L	0.001	-	-	-	-	0.008	0.002	0.003	<0.001	0.004	<0.001	0.004	0.003	0.004	0.006	0.007	0.002	0.008	0.003	0.002	0.001	<0.001
Selenium	mg/L	0.01	-	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.001	-	-	-	-	<0.001	0.001	<0.001	<0.001	0.001	0.001	<0.001	0.008	<0.001	0.002	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	-	-	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	-	-	-	-	0.007	0.007	0.017	<0.005	<0.005	<0.005	<0.005	<0.005	0.042	0.02	0.039	0.016	0.021	<0.005	0.013	<0.005	<0.005
Total Metals																							
Aluminium	mg/L	0.01	20	5	-	-	9.96	0.29	0.08	3.62	0.11	0.17	0.63	13.2	0.03	2.82	1.14	1.3	1.27	1.93	0.11	0.32	101
Antimony	mg/L	0.001	-	-	-	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	2	0.5	-	0.01	0.004	0.004	<0.001	0.007	<0.001	0.009	0.001	0.002	<0.001	0.005	0.002	0.003	0.007	0.002	<0.001	<0.001	0.101
Barium	mg/L	0.001	-	-	-	2	0.136	0.105	0.134	0.207	0.122	0.084	0.124	0.331	0.034	0.203	0.238	0.272	0.454	0.14	0.124	0.172	2.07
Beryllium	mg/L	0.001	0.5	-	-	0.06	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.02
Boron	mg/L	0.05	refer to guideline	5	-	4	0.09	0.12	0.1	0.13	0.13	0.15	0.12	0.09	0.07	0.08	0.1	0.12	0.08	0.11	0.09	0.15	0.2
Cadmium	mg/L	0.0001	0.05	0.01	-	0.002	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0042
Chromium	mg/L	0.001	1	1	-	0.05	0.034	0.001	0.004	0.038	<0.001	0.002	0.012	0.011	0.042	0.013	0.002	0.002	0.002	0.005	0.001	<0.001	0.103
Cobalt	mg/L	0.001	0.1	1	-	-	0.013	<0.001	<0.001	0.003	<0.001	<0.001	0.001	0.004	<0.001	0.005	0.005	<0.001	0.011	0.001	<0.001	<0.001	0.072

Table A-5: LABORATORY WATER QUALITY RESULTS – MAY 2014

Analytes	Units	LOR	ANZECC 2000		ADWG (2011)		MB01_B	MB02_C	MB02_S	MB03_S	MB04_C	MB04_S	MB05_C	MB08_B	MB09_T	MB10_T	TAR016_CR	TAR040_C	TAR053	TAR176_C	TAR177_C	TAR189_C	TAR249_C
Copper	mg/L	0.001	5	0.5	1	2	0.024	0.001	0.002	0.006	<0.001	<0.001	0.004	0.009	0.006	0.013	0.003	0.002	0.002	0.005	0.001	0.014	0.397
Ferrous Iron	mg/L	0.05	10	-	0.3	-	2.32	<0.05	<0.05	0.88	0.19	<0.05	0.06	<2.50#	<0.05	0.45	<0.25#	<1.25#	<1.25#	<0.05	0.24	0.1	31.5
Lead	mg/L	0.001	5	0.1	-	0.01	0.006	0.001	<0.001	0.005	<0.001	<0.001	0.001	0.013	<0.001	0.004	0.01	0.005	0.009	0.004	0.004	0.001	0.479
Manganese	mg/L	0.001	10	-	0.1	0.5	1.24	0.325	0.042	0.079	0.144	0.027	0.055	0.262	0.035	0.601	0.061	0.117	0.05	0.078	0.192	0.024	5.74
Mercury	mg/L	0.0001	0.002	0.002	-	0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	0.05	0.15	-	0.05	0.004	0.013	0.006	0.042	0.002	0.019	0.038	<0.001	0.001	0.005	0.003	0.009	0.003	0.004	0.005	0.004	0.01
Nickel	mg/L	0.001	2	1	-	0.02	0.03	0.002	0.004	0.006	0.005	0.002	0.032	0.012	0.006	0.017	0.013	0.005	0.024	0.007	0.003	0.003	0.272
Selenium	mg/L	0.01	0.5	0.02	-	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.07
Uranium	mg/L	0.001	0.1	0.2	-	0.017	0.002	0.002	<0.001	0.002	0.001	0.003	<0.001	0.014	<0.001	0.004	0.008	<0.001	0.001	<0.001	<0.001	<0.001	0.074
Vanadium	mg/L	0.01	0.5	-	-	-	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.11
Zinc	mg/L	0.005	5	20	3	-	0.053	0.009	0.023	0.023	0.009	<0.005	0.024	0.039	0.047	0.034	0.084	0.093	0.037	0.036	0.008	0.013	1.26
Nutrients																							
Ammonia	mg/L	0.01	-	-	0.5	-	0.05	0.09	0.04	2.7	0.12	0.17	0.22	1.22	0.08	0.01	0.02	8.19	0.11	0.3	0.1	0.56	0.47
Nitrate as N	mg/L	0.01	-	-	-	50	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	0.03	0.14	0.04	0.05	<0.01	<0.01	<0.01	0.13	0.04	<0.01	<0.01
Nitrite as N	mg/L	0.01	-	30	-	3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	-	400	-	-	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	0.03	0.14	0.04	0.05	<0.01	<0.01	<0.01	0.13	0.04	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	-	-	-	-	0.3	0.1	<0.1	3.2	0.2	0.2	0.3	1.3	<0.1	0.2	<0.1	8.3	0.2	0.3	0.1	0.6	9.2
Total Nitrogen as N	mg/L	0.1	-	-	-	-	0.3	0.1	<0.1	3.2	0.2	0.2	0.3	1.4	<0.1	0.2	<0.1	8.3	0.2	0.4	0.1	0.6	9.2
Reactive Phosphorus as P	mg/L	0.01	refer to guideline	-	-	-	0.02	<0.01	0.01	0.03	<0.01	<0.01	0.01	0.03	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	0.01	0.04	<0.01
Total Phosphorus as P	mg/L	0.01	-	-	-	-	0.56	0.06	0.01	0.11	0.06	0.02	0.08	0.42	<0.01	0.64	0.07	0.21	0.08	0.02	0.04	0.07	3.45
Ion Balance																							
Total Anions	meq/L	0.01	-	-	-	-	28.3	23.2	15.9	25.8	26.7	24.2	18.8	15.7	15.4	20.1	14	12.1	10.7	12.6	15.4	24	28.8
Total Cations	meq/L	0.01	-	-	-	-	27.3	22.1	14.5	24.3	24.3	22.5	17.4	15.6	14.2	18.7	14.3	11.2	10	11.4	15.4	21.8	4.5
Ionic Balance	%	0.01	-	-	-	-	1.91	2.48	4.79	3.07	4.67	3.75	3.85	0.38	4.22	3.77	1.07	4.04	3.42	4.65	0.02	4.89	73

* Guideline Value depends on type of livestock

\# Anomalous LOR reported by laboratory

Exceeds ANZECC (2000) short term irrigation water guideline value.

Exceeds Australian Drinking Water Guidelines (2011) aesthetic guideline value.

Exceeds Australian Drinking Water Guidelines (2011) health guideline value.

1000 Exceeds ANZECC (2000) livestock drinking water guideline value.

4 HYDRAULIC TESTING

Falling head tests were undertaken on 15 monitoring bores located throughout the Project area. Tests were performed by pouring 10 litres to 20 litres of water into the bore casing and monitoring the groundwater level response until the water level recovered to pre-test levels. This procedure estimates the average hydraulic conductivity of the geological material in the immediate vicinity of the bore screen.

Monitoring bores completed within the Tertiary sediments and Aldebaran Sandstone were analysed using the Hvorslev (1951)[7] method for confined aquifers. Bores screened within alluvium were analysed using the Bouwer and Rice (1976)[8] method for unconfined aquifers. Appendix A-3 presents an interpretation of the falling head tests, whilst Table A-6 summaries the results. Aquifer storage properties (specific yield and specific storage) are not measured by falling head tests.

Table A-6: PERMEABILITY TEST RESULTS

Bore	Geological Unit	Lithology	Hydraulic Conductivity (m/day)	Analysis Method
MB01_B	Tertiary	Clay, silt	5.53×10^{-4}	Hvorslev
MB02_C	Aldebaran Sandstone	Coal – B seam	2.33×10^{-2}	Hvorslev
MB02_S	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	1.32	Hvorslev
MB03_S	Aldebaran Sandstone	Coarse horizon within fine grained marine sandstone	1.12×10^{-2}	Hvorslev
MB04_C	Aldebaran Sandstone	Coal – B seam	4.79×10^{-2}	Hvorslev
MB04_S	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam	2.62×10^{-1}	Hvorslev
MB05_C	Aldebaran Sandstone	Coal – A seam	1.73×10^{-1}	Hvorslev
MB08_B	Tertiary	Clay, gravel	1.25×10^{-1}	Hvorslev
MB09_T	Quaternary Alluvium	Sand	2.00	Bouwer & Rice
MB10_T	Quaternary Alluvium	Silt, gravel	2.60×10^{-2}	Bouwer & Rice
TAR016_CR	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam	3.00	Hvorslev
TAR053	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A Seam)	9.10×10^{-1}	Hvorslev
TAR176_C	Aldebaran Sandstone	Fine grained marine sandstone	5.40×10^{-2}	Hvorslev
TAR177_C	Tertiary	Fresh basalt	1.30×10^{-1}	Hvorslev
TAR249_C	Aldebaran Sandstone	Pebbly coarse grained sandstone (directly overlying A seam)	3.00×10^{-2}	Hvorslev

Note: *Bores MB06_B and MB07_B were dry*
Bores TAR040_C and TAR189_C were not tested

[7] Hvorslev M.J., (1951), *"Time Lag and Soil Permeability in Ground Water Observations"*, U.S. Army Corps of Engineers Waterway Experimentation Station, Bulletin 36.

[8] Bouwer, H. and Rice, R.C., (1976), *"A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells"*, Water Resources Research, Vol. 12, No. 3, pp. 423-428.

5 LANDHOLDER BORE CENSUS

A bore census was conducted between December 2011 and April 2013 to identify private bores within 10 km of the Project area. Bores were identified from the Department of Natural Resources and Mines (DNRM) groundwater database (GWDB) and by consulting with local landowners.

A search of the DNRM GWDB identified 48 registered bores within 10 km of the Project area, including seven within the Project area. Ten of the registered bores were recorded as being abandoned or destroyed and therefore were not visited during the bore census (Table A-7). The remaining 38 registered bores were visited during the bore census undertaken in December 2011 and April 2013; however, five of these bores were on land that had access prevented. An additional 13 unregistered bores were identified during the bore census. Appendix A-4 contains the field reports for all private bores visited during the bore census.

Table A-7: DNRM GWDB - DESTROYED OR ABANDONED

Registered Bore No.	Current Status	Coordinates	
		Easting	Northing
37768	Abandoned and destroyed	596803	7387038
44476	Abandoned and destroyed	587368	7385666
44477	Abandoned and destroyed	586731	7386009
44478	Abandoned and destroyed	587632	7386899
89483	Abandoned and destroyed	588451	7408599
13020027	Abandoned	607916	7396972
13020078	Abandoned	607612	7403274
13020080	Abandoned	607714	7400981
13020081	Abandoned	604305	7401322
13020082	Abandoned	602650	7402448

Note: *Coordinates in MGA94 Zone 55 and estimated from DNRM GWDB*

Where possible, groundwater levels and field water quality parameters (pH, EC, and temperature), were measured for the private bores. Bore details for the five bores unable to be visited during the bore census were obtained from the DNRM GWDB and from discussions with landholders. Results of the bore census are presented in Table A-8, with the locations of bores shown in Figure 7 of the main report.

Data shows that there are 22 used bores within 10 km of the Project area with the main use being for stock watering and farm water purposes. Geological units were inferred for each of the landholder bores from one of more of the following sources:

- DNRM borelogs;
- owners borelogs;
- nearby exploration borelogs; and
- 1:100,000 published geology maps.

Table A-8: LANDHOLDER BORE CENSUS RESULTS

Site No.	Registered Bore No.	Other Bore Name	Easting GDA94 Z55	Northing GDA94 Z55	Property Description	Date Surveyed	Ground Elevation (mAHD)	Casing Diameter (mm)	Casing Type	Date Drilled	Bore Depth (m)	Yield	Equipment	Bore Status	Bore Use	Water Level (mbgl)	Inferred Geological Unit	Data Source	Field Water Quality				Comments
																			Temp (°C)	pH	EC (µS/cm)	TDS (mg/L)	
Within Project Area																							
1	13020220	-	600038*	7402243*	-	07/12/2011	-	-	-	2009*	-	-	-	Bore not found	Abandoned or Destroyed	-	-	-	-	-	-	-	Bore no longer exists - DNRM bore database comment.
2	67303	Plantagenet 11 Replacement Bore	595087	7394403	Lot 4 Plan PT352	07/12/2011	222		Steel	-	137	-	Submersible pump	In use	Stock	-	Aldebaran Sandstone	Inferred from 1:100,000 geology maps & exploration drill log	-	-	-	-	Bore used for stock watering. Within area there was the GSQ Plantagenet 11 exploration hole, this bore is apparently a replacement bore. Landholder did not identify any other bores in use on property.
3	-	Community Bore	599193	7396249	Lot 24 Plan DN40201	20/04/2013	248	-	-	1980s	123	1000 gallons/hour	Electric Submersible	In use	Farm water /stock	-	Aldebaran Sandstone - coarse grained pebbly sandstone	Inferred from bore depth and nearby exploration borelogs	25.1	7.45	997	650	Used daily. Supplies drinking water to 3 properties. Field water quality readings taken from nearby storage tank.
4	67302		598517*	7395249*	Lot 203 Plan DSN377	07/12/2011	-	-	Steel*	-	-	-	-	Bore not found	Unlikely to exist	-	-	-	-	-	-	-	Bore unable to be located. DNRM reports bore was drilled for coal seam gas exploration. Bore is unlikely to exist.
5	57649	Mono pump Bore	596184*	7402744*	Lot 76 Plan PT372	Unable to visit (landholder access)	-	140*	PVC*	1980*	16*	-	Not equipped	Not in use	-	-	Quaternary alluvium (Retreat Creek)	DNRM database	-	-	-	-	Owner commented that bore has gone dry and is no longer in use.
6	-	Camp Bore	594281	7397364	Lot 14 Plan RP881318	08/12/2011	249	150	Steel	-	-	-	Not equipped	Not in use	-	43.38	Aldebaran Sandstone (unit?)	Inferred from bore location and 1:100,000 geology maps	-	7.16	1293	-	Not in use. Field water quality readings taken by bailing from bore.
7	90064	House Bore	596819	7396888	Lot 14 Plan RP881318	08/12/2011	248	140	PVC	1993*	92*	1000 gallons/hour	Submersible pump	In use	Stock and farm water	-	Aldebaran Sandstone - coarse grained pebbly sandstone	DNRM database	-	7.44	1904	-	Used daily for farm water supply and stock watering of up to 400 cattle.
8	67349	The Swamp	592950	7400839	Lot 14 Plan RP881318	08/12/2011	215	140	PVC	1986*	32*	-	Submersible pump	In use	Stock	7.83	Tertiary basalt	DNRM database	-	7.28	1602	-	Used every few days for stock watering of up to 400 cattle.
9	84184	Fairways No 1 Bore	593437	7396628	Lot 13 Plan RP881318	08/12/2011	-	127*	Steel*	1987*	76.5*	-	Submersible pump	In use	Stock	-	Aldebaran Sandstone (unit?)	Inferred from bore depth and 1:100,000 geology maps	-	-	-	-	
Within 5 km of Project Boundaries																							
10	37769	Home Bore	596523	7387519	Lot 21 Plan DSN572	08/12/2011	260	150	Steel	1972*	51.8*	0.2 L/s*	Not equipped	Not currently in use	Stock	20.68	Tertiary basalt	DNRM database	-	7.19	1267	-	Old windmill bore not used anymore. Reported as having high sulphur content.
11	37770	Paul Springs Bore	592914	7386412	Lot 21 Plan DSN572	08/12/2011	229	150	Steel	1972*	30.5*	-	Jet pump	In use	Stock	0.31	Tertiary basalt	Inferred from bore depth and 1:100,000 geology maps	-	-	-	-	Used daily for stock watering of up to 300 cattle.
12	44471		588060	7388392	Lot 3 Plan PT373	16/04/2013	260	125	Steel	1900*	91.4	-	Not equipped	Not currently in use	Stock	0.15+	Tertiary basalt	DNRM database	-	-	-	-	Bore previously used for stock watering. Unlikely to be used in the future.
13	103908	Bottom Paddock Bore	589653	7403718	Lot 96 Plan SP227975	20/04/2013	213	150	PVC	-	18*	5000 L/hr	Submersible pump	In use	Stock	-	Quaternary alluvium (Retreat Creek)	Inferred from owners comments, bore depth and 1:100,000 geology maps	23.5	7.74	1407	942	Waters stock across the whole property, approx. 1000 breeding cows. Field water quality readings taken from nearby stagnant stock trough. This bore and Washburn Spring are the main water sources for the farm.
14	47221		605177	7398398	Lot 212 Plan DSN839	08/12/2011	233	127	Steel	1960*	9.66	-	Not equipped	Not in use	-	Dry	Tertiary (unit?)	Inferred from bore depth and 1:100,000 geology maps	-	-	-	-	Bore is no longer used and dry.
15	47238		605840	7400508	Lot 212 Plan DSN839	08/12/2011	207	127	Steel	1975*	78	-	Submersible pump	In use	Stock & farm water	25.07	Tertiary (unit?)	Inferred from bore depth and 1:100,000 geology maps	-	7	506	-	Used approx. twice weekly for stock and farm water purposes.
16	90250		588803	7398913	Lot 74 Plan SP159661	21/04/2013	216	150*	PVC*	1993*	54*	3.91 L/s*	Submersible pump	In use	Stock	-	Tertiary gravel	DNRM database	-	-	-	-	Used for stock watering.
17	103728	Back of House	602849	7400245	Lot 13 Plan DSN703	19/04/2013	221	150	Steel	2003	121.5	0.96 L/s*	Submersible pump	In use	Stock	-	Aldebaran Sandstone (unit?)	DNRM database	29	7.96	2533	1527	Used daily for stock watering of up to 200 cattle. Field water quality readings taken from nearby stagnant stock trough.
18	103729	Paddock Bore	600681	7399512	Lot 13 Plan DSN703	19/04/2013	225	140*	Steel	2003	121.5	0.92 L/s*	Submersible pump	In use	Stock	-	Aldebaran Sandstone (unit?)	DNRM database	28.3	7.25	2792	1703	Used daily for stock watering of up to 100 cattle. Field water quality readings taken from nearby stagnant stock trough.
19	37737		600290*	7389461*	Lot 3 Plan DSN801	Not visited	-	127*	Steel*	1953*	55*	-	Windmill (broken)	Not in use	Bore Damaged	-	Basalt? Aldebaran Sandstone?	Inferred from bore depth and 1:100,000 geology maps	-	-	-	-	Owner reported windmill is broken. Was used before dam was constructed on property approx. 60 years ago. Not used since.
20	-	Railway Paddock Bore	587049	7394528	Lot 1 Plan PT117	19/04/2013	257	125	Steel	1998	40	250 gallons/hour	Windmill	In use	Stock and farm water	8.3	Tertiary basalt (vesicular)	Inferred from bore depth, 1:100,000 geology maps and field observations	29.9	6.8	1417	845	Used daily for stock watering of up to 100 cattle. Large vesicular basalt boulders visible around bore. Field water quality readings taken from pressure tank near bore head.

Table A-8: LANDHOLDER BORE CENSUS RESULTS

Site No.	Registered Bore No.	Other Bore Name	Easting GDA94 Z55	Northing GDA94 Z55	Property Description	Date Surveyed	Ground Elevation (mAHD)	Casing Diameter (mm)	Casing Type	Date Drilled	Bore Depth (m)	Yield	Equipment	Bore Status	Bore Use	Water Level (mbgl)	Inferred Geological Unit	Data Source	Field Water Quality				Comments
																			Temp (°C)	pH	EC (µS/cm)	TDS (mg/L)	
21	57603	Eighty-Nine Bore	600739	7393663	Lot 1 Plan DSN984	09/12/2011	214	150	Steel	1900*	80	-	Windmill	In use	Stock	-	Aldebaran Sandstone (unit?)	Inferred from bore depth and 1:100,000 geology maps	-	-	-	-	Used for stock watering of up to 170 cattle.
22	-	Twin Bore	591671	7399335	Lot 14 Plan RP881318	08/12/2011	211	-	Steel	2004	46	-	Not equipped	Not currently in use	Backup bore for stock during droughts	19	Tertiary basalt / Aldebaran Sandstone	Inferred from bore depth and 1:100,000 geology maps	-	6.97	7286	-	Used in drought only
23	89399	House Bore	586128*	7399707*	Lot 95 Plan SP227975	Not visited	-	125*	PVC*	1993*	50*	-	Submersible pump	In use	Stock & farm water	-	Colinlea Sandstone	Inferred from DNRM database, bore depth and 1:100,000 geology maps	-	-	-	-	Spoke to owner Cameron Backus. Bore is used for stock and farm water supply.
24	103381		603235*	7396143*	Lot 1 Plan DSN984	09/12/2011	-	127*	Steel*	1900*	14.5*	-	-	Bore not found	Abandoned or Destroyed	-	-	-	-	-	-	-	Bore unable to be located and owner unaware of bore at this location. DNRM database reports bore is abandoned.
25	132656		604831*	7397432*	Lot 202 Plan DSN773	Not visited	-	140*	PVC*	2007*	124*	0.58*	?	?	?	-	Aldebaran Sandstone (unit?)	Inferred from bore depth and 1:100,000 geology maps	-	-	-	-	
Between 5 km and 10 km of Project Boundaries																							
26	-	Anakie Creek Bore	584863	7388596	Lot 3 Plan PT373	16/04/2013	262	125	PVC	2006	37	-	Not equipped	Not currently in use	Backup bore for stock	1.2	Tertiary basalt (Fractured)	Owners borelog	-	-	-	-	Never equipped. This is a backup bore in case problems with other bores.
27	-	Anakie Tank Bore	583773	7388873	Lot 3 Plan PT373	16/04/2013	268	150	PVC	1996	26.5	-	Submersible mono pump	In use	Stock	-	Tertiary basalt	Inferred from bore depth, 1:100,000 geology maps and surrounding bores	23.8	7.6	2115	1404	Bore used daily. Field water quality readings taken from nearby storage tank.
28	-	Bore SW of Limestone	589127	7387106	Lot 3 Plan PT373	16/04/2013	235	125	PVC	2001	51.2	500 gallons/hour	Jack pump	In use	Stock	-	Tertiary basalt	Inferred from bore depth, 1:100,000 geology maps and surrounding bores	-	-	-	-	Used approx. monthly to refill storage tanks. Bore was pump tested after drilled – 15 m of drawdown after 18.5 hours pumping.
29	44475	Burr Paddock Bore	583703	7390734	Lot 3 Plan PT373	16/04/2013	269	150	Steel	1971*	54.9	-	Not equipped	Not currently in use	Backup bore for stock & farm water	2.1	Tertiary basalt/Colinlea Sandstone	DNRM database	-	-	-	-	A submersible has been used in the past. This is a backup bore in case problems with other bores.
30	-	Cotton Seed Bore	587875	7387322	Lot 3 Plan PT373	16/04/2013	257	125	PVC	2000	42	1700 gallons/hour	Not equipped	Not currently in use	Backup bore for stock	11.6	Tertiary basalt (vesicular and fractured)	Owners borelog	-	-	-	-	Never equipped. This is a backup bore in case problems with other bores.
31	-	Domestic Bore	584132	7390174	Lot 3 Plan PT373	16/04/2013	275	150	Steel	1986	30.5	~500 gallons/hour	Submersible pump	In use	Farm water	11.28	Tertiary basalt	Inferred from owners comments, bore depth and 1:100,000 surface geology	27.3	7.2	1360	845	Used daily for farm water use. Not used for drinking water. Water reported as being 'very hard'. Field water quality readings taken from nearby storage tank.
32	-	John Pauls Bore	587605	7386451	Lot 3 Plan PT373	16/04/2013	256	125	PVC	1/02/1999	39	940 gallons/hour	Submersible pump	In use	Stock	-	Tertiary basalt	Inferred from bore depth, 1:100,000 geology maps and surrounding bores	-	-	-	-	Frequency of use depends on number of cattle and can vary from daily to monthly.
33	44470	Little Phils Bore	588108	7388433	Lot 3 Plan PT373	16/04/2013	258	150	Steel	Pre - 1979	54.3	-	Not equipped	Not currently in use	Never used	1.2	Tertiary basalt	DNRM database	-	-	-	-	Unlikely to be used in the future.
34	-	Unregistered Bore	583663	7390526	Lot 3 Plan PT373	16/04/2013	276	100	Steel	Pre 1979	-	-	Not equipped	Not currently in use	Never used	3.05	Tertiary basalt	Inferred from nearby bores and 1:100,000 geology maps	-	-	-	-	Bore has never been used by current landholder. Landholder plans to remove this bore.
35	-	Unregistered Bore with Jack pump	583667	7389075	Lot 3 Plan PT373	16/04/2013	274	125	Steel	Pre 1979	-	-	Not equipped	Not currently in use	Backup bore for stock	3.51	Tertiary basalt	Inferred from nearby bores and 1:100,000 geology maps	-	-	-	-	Landholder may use bore in the future.
36	44474	Burr Paddock Well	583089	7391287	Lot 3 Plan PT373	16/04/2013	272	-	Steel	Pre 1979	12.2	-	Not equipped	Not currently in use	Backup bore for stock	-	Tertiary basalt	Inferred from bore depth and 1:100,000 geology maps	-	-	-	-	Bore currently not in use, but has been used for stock watering in the past. Currently a backup in case problems with other bores.
37	89387	Kubota Bore	584831*	7405866*	Lot 96 Plan SP227975	Unable to access bore	-	142*	-	1993*	18.5*	2500 L/hr	Submersible pump	In use	Stock	-	Quaternary alluvium (Retreat Creek)	DNRM database	-	-	-	-	Unable to access bore due to wet conditions during survey. Bore supplies approx. one third of the farm with stock water when required.
38	47228		610828	7398058	Lot 164 Plan DSN731	19/04/2013	214	150	Steel	1975*	6.92	-	Windmill (broken)	Not in use	-	Dry	Tertiary (unit?)	Inferred from bore depth and 1:100,000 geology maps	-	-	-	-	Bore not in use and dry. Unlikely to be used in the future
39	47225	A15	607285*	7399295*	Lot 212 Plan DSN839	19/04/2013	-	127*	Steel*	1973*	30*	-	-	Bore not found	Abandoned or Destroyed	-	-	-	-	-	-	-	Could not locate bore and owners were not aware of a bore at this location. A turkeys nest type depression found nearby at 607229E, 7399101N which occasionally fills with water even when no recent rain.
40	13020071		609322	7399195	-	19/04/2013	215	50*	PVC*	1976*	13*	-	Not equipped	-	Groundwater monitoring	-	Tertiary basalt (weathered)	DNRM database	-	-	-	-	DNRM groundwater monitoring bore.

Table A-8: LANDHOLDER BORE CENSUS RESULTS

Site No.	Registered Bore No.	Other Bore Name	Easting GDA94 Z55	Northing GDA94 Z55	Property Description	Date Surveyed	Ground Elevation (mAHD)	Casing Diameter (mm)	Casing Type	Date Drilled	Bore Depth (m)	Yield	Equipment	Bore Status	Bore Use	Water Level (mbgl)	Inferred Geological Unit	Data Source	Field Water Quality				Comments
																			Temp (°C)	pH	EC (µS/cm)	TDS (mg/L)	
41	13020086		609311	7399819	-	19/04/2013	227	50*	PVC*	1979*	28*	0.32 L/s*	Not equipped	-	Groundwater monitoring	-	Tertiary basalt	DNRM database	-	-	-	-	DNRM groundwater monitoring bore.
42	13020090		607703	7400986	-	19/04/2013	195	50*	PVC*	1979*	17.5*	-	Not equipped	-	Groundwater monitoring	-	Tertiary basalt	DNRM database	-	-	-	-	DNRM groundwater monitoring bore.
43	13020107		609564	7401583	-	19/04/2013	200	50	PVC*	1979*	9.8*	-	Not equipped	-	Groundwater monitoring	2.65	Tertiary basalt (fresh)	DNRM database	-	-	-	-	DNRM groundwater monitoring bore.
44	47323	Fork Lagoon	595100	7410014	Lot 1 Plan CLM11	02/12/2011	212	950	Concrete	1973*	8.9	-	Jet pump	In use	Stock	3.8	Quaternary alluvium (Kettle Creek)	Owners borelog	25	10.6	2170	-	Bore surveyed as part of bore census for nearby Valeria coal project. Bore used daily for stock watering. Field water quality readings taken from nearby stagnant stock trough.
45	47322	Fork Lagoon	591443	7410299	Lot 1 Plan CLM11	02/12/2011	219	914	Concrete	-	8.88	-	Windmill	Not in use	Bore Damaged	3.6	Quaternary alluvium (Kettle Creek)	Owners borelog	-	-	-	-	Bore surveyed as part of bore census for nearby Valeria coal project. Bore is not used and the windmill is damaged, unlikely to be used in the future.
46	44473		583654	7389078	Lot 3 Plan PT373	09/12/2011	273	127	Steel	-	55*	150 gallons/hour	Jack pump	Not in use	Stock	-	Tertiary basalt	DNRM database	-	-	-	-	Old bore, not in use.
47	-	Bore at Road	584393	7392258	Lot 1 Plan PT117	19/04/2013	255	125	PVC	1998	35	-	Jet pump	In use	Stock and spray rigs	-	Tertiary basalt (vesicular)	Inferred from owners comments, bore depth, and 1:100,000 geology maps	28.1	8.03	786	481	Bore used as required for stock watering of up to 100 cattle. Owner commented that bore screened across 'honeycomb' basalt. Nearby Creek with water in it. Field water quality readings taken from nearby storage tank.
48	13020097		607251	7401603	Lot 158 Plan DSN695	19/04/2013	191	150	Steel	1979*	9.8*	-	Not equipped	-	Groundwater monitoring	-	Tertiary clay	DNRM database	-	-	-	-	DNRM groundwater monitoring bore.
49	57602		605902	7391555	Lot 1 Plan DSN984	09/12/2011	193	152*	Steel	1900*	45	-	Windmill (broken)	Not in use	Bore Damaged	5.02	Aldebaran Sandstone (unit?)	Inferred from bore depth and 1:100,000 geology maps	-	-	-	-	Windmill broken and no longer in use.
50	47217	Gun Club Bore	581765	7395658	Lot 8 Plan PT346	19/04/2013	249	125	Steel	1975*	13.7*	400 gallons/hour	Submersible pump	In use	Stock	3.65	Tertiary basalt (vesiclar)	Inferred from bore depth, 1:100,000 geology maps and field observations	27.9	7.28	1580	975	Windmill in place above bore but an electrical submersible is used. Bore used daily for stock watering of up to 500 cattle. Field water quality readings taken from nearby storage tank. Large vesicular basalt boulders visible around bore.
51	103504		587454*	7386543*	Lot 3 Plan PT373	16/04/2013	-	141*	PVC*	2000*	41*	2.27 L/s*	-	Bore not found	Unlikely to exist	-	-	-	-	-	-	-	Could not locate bore and owners were not aware of a bore at this location. Bore is unlikely to exist.

Notes: ** data obtained from DNRM GWDB*
ground elevation estimated from handheld GPS.
mbGL = metres below ground level
mAHD = metres above height datum

6 GROUNDWATER LEVELS AND LOGGER INSTALLATIONS

Groundwater levels were measured from all monitoring bores during April 2013. Groundwater levels measured within newly drilled monitoring bores are summarised in Table A-1, whilst levels from existing bores are summarised in Table A-9 below.

Table A-9: GROUNDWATER LEVELS EXISTING BORES

Hole ID	Coordinates		Geological Unit	Lithology	ToC Elevation (mAHD)	Static Water Level April 2013	
	mE	mN				(mbToC)	(mAHD)
TAR016_CR	594956	7395372	Aldebaran Sandstone	Coarse grained pebbly sandstone	228.15	39.84	188.31
TAR040_C	600263	7396108	Aldebaran Sandstone	Coarse grained pebbly sandstone	230.50	35.74	194.76
TAR053	595642	7395113	Aldebaran Sandstone	Coarse grained pebbly sandstone	213.55	25.56	187.99
TAR176_C	595549	7400349	Aldebaran Sandstone	Fine grained sandstone	203.98	11.92	192.06
TAR177_C	594586	7400197	Tertiary	Fresh basalt	221.11	11.76	209.35
TAR189_C	598843	7398818	Aldebaran Sandstone	Coarse grained pebbly sandstone	236.76	44.77	191.99
TAR249_C	596635	7397000	Aldebaran Sandstone	Coarse grained pebbly sandstone	236.18	47.71	188.47

Notes: *Coordinates GDA94, Zone 55 (Handheld GPS)*
ToC = Top of Casing (estimated from IMC, 2009)
mAHD = metres above height datum
mbToC = metres below top of casing

Solinst leveloggers were installed in all monitoring bores, and programmed to record groundwater levels at six hourly intervals. In addition to the leveloggers, a barometric logger was also installed at MB02_S. The water level hydrographs for the monitoring bores are presented in Sections 6.1.3, 6.2.3 and 6.3.3 in the main groundwater report.

Appendix A-1

BORE CONSTRUCTION LOGS – NEW BORES

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB01_B

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **6/2/2013 - 6/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **592503.7 mE**
NORTHING: **7399983.3 mN**
DATUM: **GDA94 Z55**
RL: **213.7 mAHD**
TD: **43 mBGL**

COMMENTS: **No groundwater flows observed during drilling. Seepage entered bore after drilling.**

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		215 / 0		Protective lockable steel monument
SOIL: brown to black, sandy and silty, dry		213 / 2		PVC Stick up, 0.81m
		211 / 4		169mm hammer bit, 0m to 43m (air rotary)
CLAYEY SILT: yellow to brown to grey, very low strength, extremely weathered, dry		209 / 6 207 / 8 205 / 10 203 / 12 201 / 14		Cement and bentonite grout mix (2.5% mix), 0m to 24.6m 50mm ID, uPVC, blank casing, +0.81m to 27.9m
SILTY CLAY: brown, very low strength, extremely weathered, dry		199 / 16		
CLAYEY SILT: brown to grey, very low strength, extremely weathered, dry		197 / 18 195 / 20 193 / 22 191 / 24		Bentonite seal (1/4" pellets), 24.6m to 25.6m
SILTY CLAY: green, very low strength, extremely weathered 24m to 26m, distinctly weathered 26m to 28m, dry		189 / 26 187 / 28		SWL: 16-Feb-13: 28.23 mBGL
SILT: green, very low strength, distinctly weathered, minor very fine sand, dry		185 / 30 183 / 32		3-6mm washed, rounded, quartz gravel pack, 25.6m to 35.5m 50mm ID, uPVC, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 27.9m to 33.9m, 3 × centralisers, end cap
SILTY CLAY: green to brown, very low strength, distinctly weathered to extremely weathered, minor very fine sand, dry		181 / 34 179 / 36		Bentonite seal (1/4" pellets), 35.5m to 36m
SAND: red, very fine grained, very low strength, extremely weathered, minor clay, dry		177 / 38 175 / 40 173 / 42		Gravel backfill, 36m to 43m
		171 / 44 169		Total Depth 43m Bore Developed: 1 hr, EC: 2450 µS/cm; pH: 8.26

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB02_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **10/2/2013 - 11/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593996.9 mE**
NORTHING: **7397592.4 mN**
DATUM: **GDA94 Z55**
RL: **236.8 mAHD**
TD: **103 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		237 / 0		Protective lockable steel monument PVC Stick up, 0.68m
SOIL: black, dry		235 / 2		254mm hammer bit, 0m to 69m (air rotary)
		233 / 4		
		231 / 6		Cement and bentonite grout mix (2.5% mix), 0m to 89.5m
		229 / 8		
		227 / 10		
		225 / 12		180mm ID, uPVC Class 12, blank casing, 0m to 69m
		223 / 14		
		221 / 16		
		219 / 18		
		217 / 20		
		215 / 22		
		213 / 24		
		211 / 26		
		209 / 28		
		207 / 30		50mm ID, uPVC Class 18, blank casing, +0.68m to 92.2m
		205 / 32		
		203 / 34		
SAND: brown to grey, very fine grained, extremely weathered to distinctly weathered, silty and clayey, dry		201 / 36		
		199 / 38		

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB02_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **10/2/2013 - 11/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593996.9 mE**
NORTHING: **7397592.4 mN**
DATUM: **GDA94 Z55**
RL: **236.8 mAHD**
TD: **103 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		197 / 40		
		195 / 42		
		193 / 44		
		191 / 46		SWL: 11-Feb-13: 46.9 mBGL
		189 / 48		
		187 / 50		
		185 / 52		
		183 / 54		
		181 / 56		
		179 / 58		
		177 / 60		
		175 / 62		
		173 / 64		
		171 / 66		
		169 / 68		
		167 / 70		
		165 / 72		V-notch @71m: 0.33 L/s
		163 / 74		169mm hammer bit, 69m to 103m (air rotary)
		161 / 76		V-notch @76m: 2.56 L/s
		159 / 78		
SANDSTONE: yellow-brown, coarse grained, low strength, angular quartz clasts up to 10mm across, producing water from 71m		157 / 80		V-notch @80m: 3.92 L/s

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB02_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **10/2/2013 - 11/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593996.9 mE**
NORTHING: **7397592.4 mN**
DATUM: **GDA94 Z55**
RL: **236.8 mAHD**
TD: **103 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
SANDSTONE: yellow-brown, coarse grained, low strength, angular quartz clasts up to 10mm across, producing water from 71m		155 / 82 153 / 84 151 / 86 149 / 88 147 / 90 145 / 92		V-notch @87m: 4.42 L/s Bentonite seal (1/4" pellets), 89.5m to 91.7m 3-6mm washed, rounded, quartz gravel pack, 91.7m to 95.2m V-notch @93m: 4.42 L/s
COAL: B seam		143 / 94 141 / 96		50mm ID, uPVC Class 18, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 92.2m to 95.2m, 2 × centralisers, end cap Bentonite seal (1/4" pellets), 95.2m to 97m
SANDSTONE/SILTSTONE: interbedded sandstone and siltstone with carbonaceous laminae		139 / 98 137 / 100 135 / 102		Gravel backfill, 97m to 103m Total Depth 103m
		133 / 104 131 / 106 129 / 108 127 / 110		Bore Developed: 5.5 hr, EC: 3180 µS/cm; pH: 8.35

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB02_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **9/2/2013 - 10/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **594017.2 mE**
NORTHING: **7397580.4 mN**
DATUM: **GDA94 Z55**
RL: **236.8 mAHD**
TD: **154 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		237 / 0		Protective lockable steel monument PVC Stick up, 0.87m
SOIL: brown, sandy and silty with clay, dry		235 / 2		254mm hammer bit, 0m to 74m (air rotary)
		233 / 4		
		231 / 6		Cement and bentonite grout mix (2.5% mix), 0m to 80.8m
		229 / 8		
SILTY CLAY: white to brown to grey, extremely weathered to distinctly weathered, dry		227 / 10		
		225 / 12		180mm ID, uPVC Class 12, blank casing, 0m to 74m
		223 / 14		
		221 / 16		
		219 / 18		
SAND: brown, fine grained, distinctly weathered, dry		217 / 20		
		215 / 22		
CLAY: white to light grey, dry		213 / 24		
		211 / 26		
		209 / 28		
SANDSTONE: white to brown, very fine to fine grained, clayey in places, distinctly weathered, dry		207 / 30		50mm ID, uPVC Class 18, blank casing, +0.87m to 89.35m
		205 / 32		
		203 / 34		
		201 / 36		
		199 / 38		

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BOREHOLE LOG

MB02_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **9/2/2013 - 10/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **594017.2 mE**
NORTHING: **7397580.4 mN**
DATUM: **GDA94 Z55**
RL: **236.8 mAHD**
TD: **154 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
SILTY CLAY: reddish-brown to yellow-brown, some very fine sand, distinctly weathered, dry		197 / 40 195 / 42 193 / 44 191 / 46		
		189 / 48 187 / 50 185 / 52 183 / 54 181 / 56 179 / 58 177 / 60 175 / 62 173 / 64 171 / 66 169 / 68 167 / 70 165 / 72 163 / 74 161 / 76 159 / 78 157	SWL: 10-Feb-13: 47.2 mBGL	
SANDSTONE: grey to brown, very fine to coarse grained at base, fresh from 60m, water from 75m				169mm hammer bit, 74m to 154m (air rotary)

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BOREHOLE LOG

MB02_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **9/2/2013 - 10/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **594017.2 mE**
NORTHING: **7397580.4 mN**
DATUM: **GDA94 Z55**
RL: **236.8 mAHD**
TD: **154 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		157 / 80		
		155 / 82		Bentonite seal (1/4" pellets), 80.8m to 83m
		153 / 84		V-notch @84m: 1.06 L/s
		151 / 86		3-6mm washed, rounded, quartz gravel pack, 83m to 95.45m
		149 / 88		
		147 / 90		50mm ID, uPVC Class 18, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 89.35m to 95.35m, 3 × centralisers, end cap
		145 / 92		
		143 / 94		
		141 / 96		Bentonite seal (1/4" pellets), 95.45m to 97m
COAL: A seam		139 / 98		V-notch @97m: 6.99 L/s
		137 / 100		
SANDSTONE: grey, coarse grained, low strength, fresh		135 / 102		V-notch @103m: 6.99 L/s
		133 / 104		
		131 / 106		Gravel backfill, 97m to 154m
COAL: B seam		129 / 108		
		127 / 110		
		125 / 112		
		123 / 114		
		121 / 116		
		119 / 118		
		117 / 120		

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BOREHOLE LOG

MB02_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **9/2/2013 - 10/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **594017.2 mE**
NORTHING: **7397580.4 mN**
DATUM: **GDA94 Z55**
RL: **236.8 mAHD**
TD: **154 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
SANDSTONE/SILTSTONE: grey, medium to high strength, fresh, interbedded sandstone and siltstone, occaional carbonaceous laminae,		115 / 122 113 / 124 111 / 126 109 / 128 107 / 130 105 / 132 103 / 134 101 / 136 99 / 138 97 / 140 95 / 142 93 / 144 91 / 146		
SANDSTONE: grey to brown, coarse grained, silicious, medium to high strength, well cemented		89 / 148 87 / 150 85 / 152 83 / 154		Total Depth 154m V-notch @154m: 6.99 L/s Bore Developed: 45 mins, EC: 1395 µS/cm; pH: 8.24
		81 / 156 79 / 158 77 / 160		

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BOREHOLE LOG

MB03_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **23/2/2013 - 4/3/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **599667 mE**
NORTHING: **7399771.3 mN**
DATUM: **GDA94 Z55**
RL: **230.5 mAHD**
TD: **163 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		231 / 0		Protective lockable steel monument PVC Stick up, 0.78m
SOIL: black, dry.		229 / 2		254mm hammer bit, 0m to 62m (air rotary)
		227 / 4		
		225 / 6		Cement and bentonite grout mix (2.5% mix), 0m to 70m
		223 / 8		
		221 / 10		
		219 / 12		180mm ID, uPVC Class 12, blank casing, 0m to 62m
SILT: light brown to dark grey, low to very low strength, extremely weathered, dry		217 / 14		
		215 / 16		
		213 / 18		
		211 / 20		
		209 / 22		
		207 / 24		
		205 / 26		
		203 / 28		
		201 / 30		50mm ID, uPVC Class 18, blank casing, +0.78m to 76m
SAND: white to pink to brown, fine to medium grained, very low strength, extremely weathered, clayey between 35m and 37m, dry		199 / 32		
		197 / 34		
		195 / 36		
		193 / 38		
COAL: dull black, dry		191 / 40		
		189 / 42		
SILT: dark grey, low strength, slightly weathered, dry		187		

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BOREHOLE LOG

MB03_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **23/2/2013 - 4/3/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **599667 mE**
NORTHING: **7399771.3 mN**
DATUM: **GDA94 Z55**
RL: **230.5 mAHD**
TD: **163 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
SILT: dark grey, low strength, slightly weathered, dry		44 / 185		
		46 / 183		
		48 / 181		SWL: 6-Mar-13: 49 mBGL
		50 / 179		
		52 / 177		
		54 / 175		
		56 / 173		
		58 / 171		
SANDSTONE/SILTSTONE: light grey to dark grey, interbedded fine grained sandstone and siltstone, low to medium strength, slightly weathered to fresh, occasional carbonaceous material, dry		60 / 169		
		62 / 167		169mm hammer bit, 62m to 163m (air rotary)
		64 / 165		
		66 / 163		
		68 / 161		
		70 / 159		Bentonite seal (1/4" pellets), 70m to 74.5m
		72 / 157		
		74 / 155		3-6mm washed, rounded, quartz gravel pack, 74.5m to 82m
SANDSTONE: dark grey, medium to coarse grained, low to medium strength, fresh, moist		76 / 153		
		78 / 151		50mm ID, uPVC Class 18, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 76m to 82m, 3 × centralisers, end cap
		80 / 149		
		82 / 147		Bentonite seal (1/4" pellets), 82m to 83m
		84 / 145		
		86 / 143		
		88 / 141		

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BOREHOLE LOG

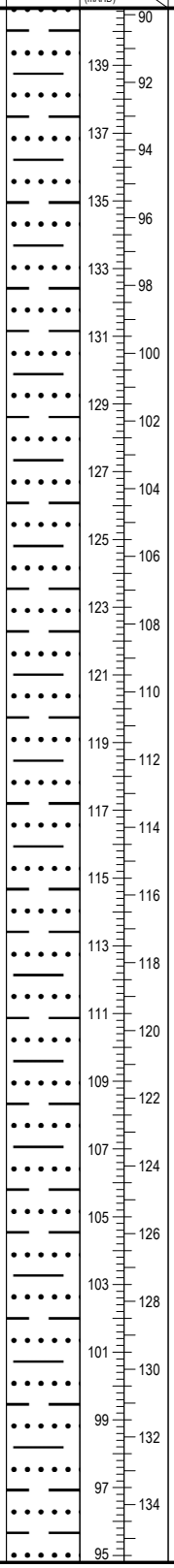
MB03_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **23/2/2013 - 4/3/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **599667 mE**
NORTHING: **7399771.3 mN**
DATUM: **GDA94 Z55**
RL: **230.5 mAHD**
TD: **163 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
SANDSTONE/SILTSTONE: light grey to dark grey, interbedded sandstone and siltstone, high strength, fresh, occasional carbonaceous laminae, water from 91m		90 / 139 92 / 137 94 / 135 96 / 133 98 / 131 100 / 129 102 / 127 104 / 125 106 / 123 108 / 121 110 / 119 112 / 117 114 / 115 116 / 113 118 / 111 120 / 109 122 / 107 124 / 105 126 / 103 128 / 101 130 / 99 132 / 97 134 / 95		V-notch @91m: 0.07 L/s Gravel backfill, 83m to 163m

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BOREHOLE LOG

MB03_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **23/2/2013 - 4/3/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **599667 mE**
NORTHING: **7399771.3 mN**
DATUM: **GDA94 Z55**
RL: **230.5 mAHD**
TD: **163 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		93 136 91 138 89 140 87 142 85 144 83 146 81 148 79 150 77 152 75 154 73 156 71 158 69 160 67 162 65 164 63 166 61 168 59 170 57 172 55 174 53 176 51 178 180		Total Depth 163m V-notch @163m: 0.61 L/s Bore Developed: 1.5 hrs, EC: 3130 µS/cm; pH: 7.95

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB04_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **11/2/2013 - 12/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593513.3 mE**
NORTHING: **7399534.1 mN**
DATUM: **GDA94 Z55**
RL: **234.9 mAHD**
TD: **173 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
				Protective lockable steel monument PVC Stick up, 0.91m
SOIL: black, dry		235 – 0		254mm hammer bit, 0m to 73m (air rotary), foam used from 24m to 73m
		233 – 2		
		231 – 4		
		229 – 6		Cement and bentonite grout mix (2.5% mix), 0m to 115.5m
		227 – 8		
		225 – 10		
CLAY: red to brown to grey, extremely weathered, dry		223 – 12		180mm ID, uPVC Class 12, blank casing, 0m to 73m
		221 – 14		
		219 – 16		
		217 – 18		
		215 – 20		
SAND: yellow to brown, coarse grained, siliceous, extremely weathered, dry		213 – 22		
CLAY: light grey, extremely weathered, dry		211 – 24		
SAND: yellow to brown, medium grained, siliceous, extremely weathered, dry				
		209 – 26		
		207 – 28		
		205 – 30		50mm ID, uPVC Class 18, blank casing, +0.91m to 118.5m
		203 – 32		
		201 – 34		
		199 – 36		
SANDY CLAY: yellow-brown to reddish-brown, extremely weathered, dry		197 – 38		
		195 – 40		
		193 – 42		
		191		

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BOREHOLE LOG

MB04_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **11/2/2013 - 12/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593513.3 mE**
NORTHING: **7399534.1 mN**
DATUM: **GDA94 Z55**
RL: **234.9 mAHD**
TD: **173 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		191 / 44		SWL: 12-Feb-13: 44.24 mBGL
GRAVEL: dark grey, sandstone and quartz clasts up to 20mm across, dry		189 / 46 187 / 48 185 / 50 183 / 52 181 / 54 179 / 56 177 / 58 175 / 60		
SANDSTONE: grey, very fine grained, silty, dry		173 / 62 171 / 64 169 / 66 167 / 68 165 / 70 163 / 72 161 / 74		
SILTSTONE: dark grey, low to medium strength, fresh, dry		159 / 76 157 / 78 155 / 80 153 / 82 151 / 84 149 / 86 147 / 88		169mm hammer bit, 73m to 173m (air rotary)

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BOREHOLE LOG

MB04_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **11/2/2013 - 12/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593513.3 mE**
NORTHING: **7399534.1 mN**
DATUM: **GDA94 Z55**
RL: **234.9 mAHD**
TD: **173 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		145 – 90 143 – 92 141 – 94 139 – 96 137 – 98		
SANDSTONE: grey, fine to coarse grained, low to medium strength, fresh, producing water from 102m		135 – 100 133 – 102 131 – 104 129 – 106 127 – 108 125 – 110 123 – 112 121 – 114		V-notch @102m: 0.33 L/s V-notch @109m: 0.46 L/s
COAL: B seam		119 – 116 117 – 118 115 – 120		Bentonite seal (1/4" pellets), 115.5m to 117.5m 3-6mm washed, rounded, quartz gravel pack, 117.5m to 120.5m V-notch @118m: 1.25 L/s 50mm ID, uPVC Class 18, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 118.5m to 120.5m, 2 × centralisers, end cap
		113 – 122 111 – 124 109 – 126 107 – 128 105 – 130 103 – 132 101 – 134		Bentonite seal (1/4" pellets), 120.5m to 121.5m Gravel backfill, 121.5m to 173m

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BOREHOLE LOG

MB04_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **11/2/2013 - 12/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593513.3 mE**
NORTHING: **7399534.1 mN**
DATUM: **GDA94 Z55**
RL: **234.9 mAHD**
TD: **173 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
SANDSTONE/SILTSTONE: grey, medium strength, fresh, interbedded sandstone and siltstone, minor coal 157m to 158m		99 / 136 97 / 138 95 / 140 93 / 142 91 / 144 89 / 146 87 / 148 85 / 150 83 / 152 81 / 154 79 / 156 77 / 158 75 / 160 73 / 162 71 / 164 69 / 166 67 / 168 65 / 170 63 / 172 61 / 174 59 / 176 57 / 178 55 / 180		V-notch @157m: 1.53 L/s V-notch @172m: 2.56 L/s Total Depth 173m Bore Developed: 45 mins, EC: 2760 µS/cm; pH: 8.39

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB04_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **12/2/2013 - 13/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593492.8 mE**
NORTHING: **7399536.9 mN**
DATUM: **GDA94 Z55**
RL: **235 mAHD**
TD: **130 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		236 / 0		Protective lockable steel monument PVC Stick up, 0.93m
SOIL: black, dry		234 / 2		254mm hammer bit, 0m to 73m (air rotary), foam used from 27m to 73m
		232 / 4		
		230 / 6		Cement and bentonite grout mix (2.5% mix), 0m to 97m
		228 / 8		
		226 / 10		
CLAY: red to brown to grey, extremely weathered, dry		224 / 12		180mm ID, uPVC Class 12, blank casing, 0m to 73m
		222 / 14		
		220 / 16		
		218 / 18		
		216 / 20		
		214 / 22		
SAND: yellow to brown, coarse grained, siliceous, extremely weathered, dry		212 / 24		
CLAY: light grey, extremely weathered, dry				
SAND: yellow to brown, medium grained, siliceous, extremely weathered, dry		210 / 26		
		208 / 28		
		206 / 30		50mm ID, uPVC Class 18, blank casing, +0.93m to 100m
		204 / 32		
		202 / 34		
		200 / 36		
		198 / 38		
SANDY CLAY: yellow-brown to reddish-brown, extremely weathered, dry		196 / 40		
		194 / 42		
		192		

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB04_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **12/2/2013 - 13/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593492.8 mE**
NORTHING: **7399536.9 mN**
DATUM: **GDA94 Z55**
RL: **235 mAHD**
TD: **130 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		44 / 190		SWL: 14-Feb-13: 48 mBGL
GRAVEL: dark grey, sandstone and quartz clasts up to 20mm across, dry		46 / 188		
		48 / 186		
		50 / 184		
		52 / 182		
		54 / 180		
		56 / 178		
		58 / 176		
		60 / 174		
SANDSTONE: grey, very fine grained, silty, carbonaceous laminae, dry		62 / 172		
		64 / 170		
		66 / 168		
		68 / 166		
		70 / 164		
		72 / 162		
		74 / 160		
		76 / 158		169mm hammer bit, 73m to 130m (air rotary)
		78 / 156		
		80 / 154		
		82 / 152		
		84 / 150		
		86 / 148		
		88 / 146		

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BOREHOLE LOG

MB04_S

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **12/2/2013 - 13/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593492.8 mE**
NORTHING: **7399536.9 mN**
DATUM: **GDA94 Z55**
RL: **235 mAHD**
TD: **130 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
SANDSTONE: grey, fine to coarse grained, low to medium strength, damp from 96m, water from 102m		90 / 144 – 92 / 142 – 94 / 140 – 96 / 138 – 98 / 136 – 100 / 134 – 102 / 132 – 104 / 130 – 106 / 128 – 108 / 126 – 110 / 124 – 112 / 122 – 114 / 120 – 116 / 118 – 118 / 116 – 120 / 114 – 122 / 112 – 124 / 110 – 126 / 108 – 128 / 106 – 130 / 104 – 132 / 102 – 134 / 100		Bentonite seal (1/4" pellets), 97m to 99m 3-6mm washed, rounded, quartz gravel pack, 99m to 106m 50mm ID, uPVC Class 18, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 100m to106m, 3 × centralisers, end cap Bentonite seal (1/4" pellets), 106m to 107m V-notch @109m: 0.38 L/s V-notch @113m: 0.8 L/s V-notch @117m: 1.01 L/s Gravel backfill, 107m to 130m Total Depth 130m V-notch @130m: 1.01 L/s Bore Developed: 1 hr, EC: 2570 µS/cm; pH: 8.34
COAL: B seam				
SANDSTONE: creamy-brown, coarse grained, moderately cemented, occasional siltstone and carbonaceous laminae				

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BOREHOLE LOG

MB05_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **7/3/2013 - 8/3/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **598859.3 mE**
NORTHING: **7398819.2 mN**
DATUM: **GDA94 Z55**
RL: **237.4 mAHD**
TD: **151 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		238 / 0		Protective lockable steel monument PVC Stick up, 0.96m
SOIL: brown, dry		236 / 2		254mm hammer bit, 0m to 68m (air rotary)
		234 / 4		
		232 / 6		Cement and bentonite grout mix (2.5% mix), 0m to 138m
		230 / 8		
		228 / 10		
		226 / 12		180mm ID, uPVC Class 12, blank casing, 0m to 68m
		224 / 14		
		222 / 16		
		220 / 18		
		218 / 20		
		216 / 22		
		214 / 24		
SAND: brown to white to yellow, interbedded sands, silts and clays, extremely weathered, dry		212 / 26		
		210 / 28		
		208 / 30		50mm ID, uPVC Class 18, blank casing, +0.96m to 141m
		206 / 32		
		204 / 34		
		202 / 36		
		200 / 38		

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB05_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **7/3/2013 - 8/3/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **598859.3 mE**
NORTHING: **7398819.2 mN**
DATUM: **GDA94 Z55**
RL: **237.4 mAHD**
TD: **151 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		198 / 40		
		196 / 42		
		194 / 44		SWL: 13-Mar-13: 43.6 mBGL
		192 / 46		
		190 / 48		
SANDSTONE: moderately cemented, extremely weathered, dry		188 / 50		
		186 / 52		
		184 / 54		
		182 / 56		
GRAVELLY CLAY: red, extremely weathered, gravel clasts up to 5cm across		180 / 58		
		178 / 60		
		176 / 62		
		174 / 64		
		172 / 66		
		170 / 68		
		168 / 70		
		166 / 72		
SANDSTONE/SILTSTONE: medium grey, interbedded sandstone and siltstone, medium strength, fresh, dry		164 / 74		
		162 / 76		169mm hammer bit, 68m to 151m (air rotary)
		160 / 78		
		158		

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB05_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **7/3/2013 - 8/3/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **598859.3 mE**
NORTHING: **7398819.2 mN**
DATUM: **GDA94 Z55**
RL: **237.4 mAHD**
TD: **151 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		80 / 156		
		82 / 154		
		84 / 152		
SANDY GRAVEL: grey, gravel with coarse quartz sands, clayey, distinctly weathered, dry		86 / 150		
		88 / 148		
		90 / 146		
		92 / 144		
		94 / 142		
		96 / 140		
		98 / 138		
		100 / 136		
		102 / 134		
		104 / 132		
SANDSTONE/SILTSTONE: interbedded fine to medium sandstone and siltstone, fresh, producing water from about 103m		106 / 130		
		108 / 128		V-notch @109m: 0.07 L/s
		110 / 126		
		112 / 124		
		114 / 122		
		116 / 120		
		118 / 118		
		120		

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB05_C

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **7/3/2013 - 8/3/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **598859.3 mE**
NORTHING: **7398819.2 mN**
DATUM: **GDA94 Z55**
RL: **237.4 mAHD**
TD: **151 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
CLAY: creamy		116 / 122		
SILTSTONE: dark grey, clayey, medium strength, fresh, thin band of very hard gravels at 124m		114 / 124 – 112 / 126 – 110 / 128 – 108 / 130 – 106 / 132 – 104 / 134		
CLAYEY GRAVEL: well weathered, clasts approximately 5mm to 10mm across		102 / 136		
SANDSTONE: creamy to brown, low strength, moderately cemented, fresh, water		100 / 138 – 98 / 140 – 96 / 142		Bentonite seal (1/4" pellets), 138m to 140m V-notch @139m: 1.25 L/s 3-6mm washed, rounded, quartz gravel pack, 140m to 144m
COAL: A seam		94 / 144		50mm ID, uPVC Class 18, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 141m to 144m, 2 × centralisers, end cap
SANDSTONE: light grey, medium grained, medium strength, fresh		92 / 146 – 90 / 148 – 88 / 150		Bentonite seal (1/4" pellets), 144m to 145m V-notch @145m: 1.25 L/s Gravel backfill, 145m to 151m Total Depth 151m
COAL: B seam		86 / 152 – 84 / 154 – 82 / 156 – 80 / 158 – 78 / 160		V-notch @151m: 1.84 L/s Bore Developed: 1.25 hrs, EC: 1570 µS/cm; pH: 8.37

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB06_B

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **3/2/2013 - 3/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **592470.6 mE**
NORTHING: **7394530.3 mN**
DATUM: **GDA94 Z55**
RL: **221.1 mAHD**
TD: **40 mBGL**

COMMENTS: **No groundwater flows observed during drilling.**

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		223		Protective lockable steel monument PVC Stick up, 0.99m
SOIL: black to brown, very low strength, dry		221 0 / 219 2		169mm hammer bit, 0m to 40m (air rotary)
SAND: brown to yellow, coarse grained, quartz dominant, extremely weathered, dry		217 4		Cement and bentonite grout mix (2.5% mix), 0m to 16.5m
SILTY CLAY: brown to yellow to grey, very low strengh, extremely weathered (tuff?), dry		215 6 / 213 8 / 211 10 / 209 12 / 207 14 / 205 16 / 203 18 / 201 20 / 199 22		50mm ID, uPVC, blank casing, +0.99m to 19.4m Bentonite seal (1/4" pellets), 16.5m to 17.5m 3-6mm washed, rounded, quartz gravel pack, 17.5m to 26m 50mm ID, uPVC, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 19.4m to 25.4m, 3 × centralisers, end cap
CLAYEY SILT: grey to black, very low to low strength, distinctly weathered to slightly weathered at base, dry		197 24 / 195 26 / 193 28 / 191 30 / 189 32 / 187 34 / 185 36		Bentonite seal (1/4" pellets), 26m to 26.5m Gravel backfill, 26.5m to 40m
CARBONACEOUS SILTSTONE: grey to black, low strength, slightly weathered, dry		183 38 / 181 40		Total Depth 40m
		179 42 / 177 44		No water observed during drilling, measured dry, 7th Feb 13

Australasian Groundwater & Environmental Consultants Pty Ltd

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BOREHOLE LOG

MB07_B

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **23/1/2013 - 23/1/2013**
LOGGED BY: **C. Vincent (AGE)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **592064.5 mE**
NORTHING: **7393041.1 mN**
DATUM: **GDA94 Z55**
RL: **233.1 mAHD**
TD: **31.2 mBGL**

COMMENTS: **No groundwater flows observed during drilling.**

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		234 / 0		Protective lockable steel monument PVC Stick up, 0.81m
SOIL: black, sandy, soft, dry		232 / 2		191mm hammer bit, 0m to 31.2m (air rotary)
		230 / 4		
		228 / 6		Cement and bentonite grout mix (2.5% mix), 0m to 25m
		226 / 8		
		224 / 10		
CLAY: brown, sandy and silty, very low strength, extremely weathered, dry		222 / 12		50mm ID, uPVC, blank casing, +0.81m to 27.5m
		220 / 14		
		218 / 16		
		216 / 18		
		214 / 20		
		212 / 22		
		210 / 24		
SILTSTONE: grey, low to medium strength, slightly weathered to fresh near base, laminated, dry		208 / 26		Bentonite seal (1/4" pellets), 25m to 26m
		206 / 28		3-6mm washed, rounded, quartz gravel pack, 26m to 30.6m
		204 / 30		50mm ID, uPVC, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 27.5m to 30.6m, 2 × centralisers, end cap
SANDSTONE: grey, fine to medium grained, medium strength, fresh, dry		202 / 32		Bentonite seal (1/4" pellets), 30.6m to 31.2m
		200 / 34		Total Depth 31.2m
		198 / 36		No water observed during drilling, measured dry, 7th Feb 13

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB08_B

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **4/2/2013 - 4/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **594667.9 mE**
NORTHING: **7390096.2 mN**
DATUM: **GDA94 Z55**
RL: **242.6 mAHD**
TD: **60 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		243 / 0		Protective lockable steel monument PVC Stick up, 0.52m
SOIL: brown to black, very low strength, sandy, dry		241 / 2		169mm hammer bit, 0m to 60m (air rotary)
		239 / 4		
		237 / 6		Cement and bentonite grout mix (2.5% mix), 0m to 35m
		235 / 8		
		233 / 10		
		231 / 12		
		229 / 14		
		227 / 16		
		225 / 18		
		223 / 20		50mm ID, uPVC, blank casing, +0.52m to 40m
		221 / 22		
SILTY CLAY: brown to yellow with occasional red horizons, very low strengh, extremely weathered limestone fragments up to 10mm across, damp at base		219 / 24		
		217 / 26		
		215 / 28		SWL: 7-Feb-13: 28.52 mBGL
		213 / 30		

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

MB08_B

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **4/2/2013 - 4/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **594667.9 mE**
NORTHING: **7390096.2 mN**
DATUM: **GDA94 Z55**
RL: **242.6 mAHD**
TD: **60 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
		211 / 32		
		209 / 34		
		207 / 36		Bentonite seal (1/4" pellets), 35m to36 m
		205 / 38		3-6mm washed, rounded, quartz gravel pack, 36m to 46.5m
		203 / 40		
		201 / 42		50mm ID, uPVC, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 40m to 46m, 3 × centralisers, end cap
		199 / 44		
		197 / 46		Bentonite seal (1/4" pellets), 46.5m to 47m
SANDY GRAVEL: brown to yellow, very low strength, slightly weathered, silty in places, limestone fragments up to 20cm across decreasing with depth, quartz and calcite increasing with depth, damp		195 / 48		
		193 / 50		Gravel backfill, 47m to 54.5m
		191 / 52		
		189 / 54		
		187 / 56		Bentonite seal (1/4" pellets), 54.5m to 55m
		185 / 58		Gravel backfill, 55m to 60m
		183 / 60		Total Depth 60m
				No water observed during drilling, slow seepage observed overnight
		181 / 62		Bore Developed: 3.5 hr, EC: 1434 µS/cm; pH: 8.47
		179 / 64		

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BOREHOLE LOG

MB09_T

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **5/2/2013 - 6/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **593575.2 mE**
NORTHING: **7401713.7 mN**
DATUM: **GDA94 Z55**
RL: **201.6 mAHD**
TD: **43 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		203 / 0		Protective lockable steel monument PVC Stick up, 0.44m
SOIL: black, silty, moist		201 / 2		169mm hammer bit, 0m to 43m (air rotary)
SANDY SILT: yellow to brown to red, low strength, extremely weathered to slightly weathered at base, occasional gravel fragments up to 20mm across, moist at base		199 / 4 197 / 6 195 / 8 193 / 10 191 / 12 189 / 14 187 / 16 185 / 18 183 / 20		SWL: 7-Feb-13: 6.5 mBGL 50mm ID, uPVC, blank casing, +0.44m to 24m Cement and bentonite grout mix (2.5% mix), 0m to 20.4m
SAND: brown to yellow to grey, fine grained between 19.5m and 28m, medium to coarse grained between 28m and 32m, clayey between 32m and 33m, very low strength, slightly weathered, making water from approx. 27m		181 / 22 179 / 24 177 / 26 175 / 28 173 / 30 171 / 32		Bentonite seal (1/4" pellets), 20.4m to 22m 3-6mm washed, rounded, quartz gravel pack, 22m to 32m 50mm ID, uPVC, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 24m to 30m, 3 × centralisers, end cap V-notch @28m: 1.01 L/s V-notch @31m: 3.92 L/s
SANDSTONE: light grey, low strength, slightly weathered, minor clay, wet		169 / 34 167 / 36 165 / 38 163 / 40 161 / 42 159 / 44 157		Bentonite seal (1/4" pellets), 32m to 33m Gravel backfill, 33m to 43m Total Depth 43m V-notch @43m: 3.92 L/s Bore Developed: 2.5 hr, EC: 917 µS/cm; pH: 8.21

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BOREHOLE LOG

MB10_T

PROJECT No: **G1588**
PROJECT NAME: **Taroborah**
DATE DRILLED: **5/2/2013 - 5/2/2013**
LOGGED BY: **M. Cavanagh (IMC)**
LICENCED DRILLER: **M. Gibson**

DRILLING COMPANY: **Gibson Drilling Services**
DRILLER: **M. Gibson**
DRILLING METHOD: **Rotary Air**
DRILL RIG: **Bourne 1250**

EASTING: **600019.6 mE**
NORTHING: **7402656.4 mN**
DATUM: **GDA94 Z55**
RL: **193.4 mAHD**
TD: **30 mBGL**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
		194 / 0		Protective lockable steel monument PVC Stick up, 0.81m
SOIL: brown to black, very low strength, sandy and silty, dry		192 / 2		169mm hammer bit, 0m to 30m (air rotary)
		190 / 4		
		188 / 6		Cement and bentonite grout mix (2.5% mix), 0m to 9.4m
		186 / 8		50mm ID, uPVC, blank casing, +0.81m to 12.7m
SANDY SILT: brown to greenish-brown, very low strength, fresh, occasional gravel fragments up to 20mm across, dry		184 / 10		SWL: 7-Feb-13: 8.73 mBGL Bentonite seal (1/4" pellets), 9.4m to 10.5m
		182 / 12		3-6mm washed, rounded, quartz gravel pack, 10.5m to 18.7m
GRAVEL: green, coarse sand and silty matrix, fresh, dry		180 / 14 178 / 16		50mm ID, uPVC, machine slotted casing, 0.4mm aperture throughout, 1mm handsawed slots every 0.5m, 12.7m to 18.7m, 3 × centralisers, end cap
		176 / 18		
		174 / 20		Bentonite seal (1/4" pellets), 18.5m to 19.5m
SANDY SILT: greenish-brown to grey at base, very low strength, fresh, occasional gravel, clayey between 22m and 23.5m, dry		172 / 22 170 / 24		Gravel backfill, 19.5m to 30m
		168 / 26		
		166 / 28		Total Depth 30m
		164 / 30		No water flow observed during drilling, slow seepage observed overnight
		162 / 32		Bore Developed: 6 hrs, EC: 1679 µS/cm; pH: 7.92
		160 / 34		
		158 / 36		

Appendix A-2

GROUNDWATER QUALITY RESULTS & LABORATORY CERTIFICATES

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph.02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: IMC	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)	☑ Standard TAT (List due date):	**FOR LABORATORY USE ONLY (Circle)**
OFFICE: Brisbane		☐ Non Standard or urgent TAT (List due date):	Custody Seal Intact? Yes / No / N/A
PROJECT: G1588 Taroborah	**ALS QUOTE NO.:** BN - 735-11 V2 BQ	**COC SEQUENCE NUMBER (Circle)** COC: 1 2 3 4 5 6 7	Free ice / frozen ice bricks present upon receipt? Yes / No / N/A
ORDER NUMBER:		OF: 1 2 3 4 5 6 7	Random Sample Temperature on Receipt: °C
PROJECT MANAGER: James Tomlin	**CONTACT PH:** 07 32572055		Other comment:
SAMPLER: Michael Cavanagh	**SAMPLER MOBILE:** 0477673302		
COC emailed to ALS? (YES / NO)	**EDD FORMAT (or default):**		
Email Reports to (will default to PM if no other addresses are listed): mike@imcmining.com.au and claire.stephenson@ageconsultants.com.au			
Email Invoice to (will default to PM if no other addresses are listed):			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Michael Cavanagh	Toll NQX		Jodie
DATE/TIME: 21/2/13 1530	DATE/TIME: 21/2/13 1530	DATE/TIME:	DATE/TIME: 26/2/13 10:35

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	NT-14 Extended Water Suite B Ca, Mg Na, K, pH, EC, Cl, SO4, Alkalinity, F, Hardness, TDS, Nitrate, Nitrite, Amonia, Ortho Phosphate	Suspended Solids (SS) - Standard Level	W3 - 13 Metals (Dissolved & Total) (As, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, V, Zn, Hg)	Dissolved & Total Metals Al, B, Se, Sb, Mo, Fe2+, U	NT-11 Total Nitrogen, TKN, NOx, Total Phosphorous				Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
	MB08_B	21/2/13/1300		P	3	✓	✓	✓	✓					
				SP	1					✓				
				TOTAL	4	1	1	1	1	1				

Environmental Division Brisbane
Work Order
EB1304803

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1304803**	Page	: 1 of 5
Client	: **AUST GROUNDWATER & ENVIRO CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR JAMES TOMLIN	Contact	: Customer Services
Address	: LEVEL 2, 15 MALLON STREET BOWEN HILLS QLD, AUSTRALIA 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: james.tomlin@ageconsultants.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 32572055	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32572088	Facsimile	: +61 7 3243 7218
Project	: G1588 Taroborah	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 26-FEB-2013
Sampler	: Michael Cavanagh	Issue Date	: 06-MAR-2013
Site	: ----		
		No. of samples received	: 1
Quote number	: BN/735/11 V2	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.**

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
Jonathon Angell	Inorganic Coordinator	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MB08_B	----	----	----	----
				Client sampling date / time	21-FEB-2013 13:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1304803-001	----	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**1450**	----	----	----	----
EA016: Non Marine - Estimated TDS Salinity									
Total Dissolved Solids (Calc.)	----	1	mg/L		**942**	----	----	----	----
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		**313**	----	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		**17**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**559**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**576**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**45**	----	----	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**129**	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**30**	----	----	----	----
Magnesium	7439-95-4	1	mg/L		**81**	----	----	----	----
Sodium	7440-23-5	1	mg/L		**193**	----	----	----	----
Potassium	7440-09-7	1	mg/L		**2**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.117**	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.002**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.006**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.001**	----	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L		**0.01**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MB08_B	----	----	----	----
				Client sampling date / time	21-FEB-2013 13:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1304803-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Zinc	7440-66-6	0.005	mg/L		<0.005	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.010**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L		**0.013**	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.12**	----	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**2.59**	----	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.144**	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.001**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L		**0.002**	----	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.002**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.029**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.003**	----	----	----	----
Lead	7439-92-1	0.001	mg/L		**0.002**	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.020**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.007**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L		**0.015**	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.10**	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.18**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		<0.1	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MB08_B	----	----	----	----
				Client sampling date / time	21-FEB-2013 13:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1304803-001	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ **Total Nitrogen as N**	----	0.1	mg/L		**0.2**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.17**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**16.1**	----	----	----	----
Total Cations	----	0.01	meq/L		**16.6**	----	----	----	----
Ionic Balance	----	0.01	%		**1.57**	----	----	----	----

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle**: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ **Brisbane**: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville**: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ **Melbourne**: 2-4 Westall Rd. Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide**: 2-1 Burma Rd. Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Perth**: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston**: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: IMC	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	☑ Standard TAT **(List due date):**	**FOR LABORATORY USE ONLY (Circle)**
OFFICE: Brisbane Attn: Dave Thomas		☐ Non Standard or urgent TAT **(List due date):**	Custody Seal Intact? Yes No N/A
PROJECT: G1588 Taroborah	**ALS QUOTE NO.:** BN - 735-11 V2	**COC SEQUENCE NUMBER (Circle)**	Free ice / frozen ice bricks present upon receipt? Yes No N/A
ORDER NUMBER: IMC Mining Group Pty Ltd.		COC: 1 2 3 4 5 6 7	Random Sample Temperature on Receipt: °C
PROJECT MANAGER: James Tomlin	**CONTACT PH:** 07 32572055	OF: 1 2 3 4 5 6 7	Other comment:

SAMPLER: M. Cavanagh	**SAMPLER MOBILE:**	**RELINQUISHED BY:** M. Cavanagh	**RECEIVED BY:** R. Brennan.
COC emailed to ALS? (YES (NO)	**EDD FORMAT (or default):**	DATE/TIME: 11/3/13 1555	DATE/TIME: 11.3.13 1600.
Email Reports to (will default to PM if no other addresses are listed): mike@imcmining.com.au and claire.stephenson@ageconsultants.com.au		**RELINQUISHED BY:**	**RECEIVED BY:**
Email Invoice to (will default to PM if no other addresses are listed): dthomas@imcmining.com.au		DATE/TIME:	DATE/TIME: 12/3 9.00.

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where **Metals** are required, specify **Total** (unfiltered bottle required) or **Dissolved** (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE *(refer to codes below)*	TOTAL BOTTLES	NT-14 Extended Water Suite B Ca, Mg Na, K, pH, EC, Cl, SO4, Alkalinity, F, Hardness, TDS, Nitrate, Nitrite, Amonia, Ortho Phosphate	Suspended Solids (SS) - Standard Level	W3 - 13 Metals (Dissolved & Total) (As, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, V, Zn, Hg)	Dissolved & Total Metals Al, B, Se, Sb, Mo, Fe2+, U	NT-11 Total Nitrogen, TKN, NOx, Total Phosphorous				Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	MB10_T	11/3/13 1130	W	P/SP	4	✓	✓	✓	✓	✓				HT
2	MB09_T	11/3/13 1500	W	P/SP	4	✓	✓	✓	✓	✓				
				TOTAL	8									

Environmental Division
Brisbane
Work Order
EB1306227

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1306227**	Page	: 1 of 5
Client	: **IMC MINING SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: MR MIKE CAVANAGH	Contact	: Customer Services
Address	: GPO BOX 2579 BRISBANE QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: mike@imcmining.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3226 9100	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3226 9101	Facsimile	: +61 7 3243 7218
Project	: G1588 Taroborah	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 12-MAR-2013
Sampler	: M.Cavanagh	Issue Date	: 19-MAR-2013
Site	: ----		
		No. of samples received	: 2
Quote number	: ----	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **EG020F&T: Filtered and total Molybdenum results for EB1306227-001 have been confirmed by re-preparation and re-analysis.**
- **EG035F:EB1306227#2 positive mercury results have been confirmed by repreparation and reanalysis.**
- **EG035T:EB1306227#1 positive result for mercury has been confirmed by repreparation and reanalysis.**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MB10_T	MB09_T	----	----	----
				Client sampling date / time	11-MAR-2013 11:30	11-MAR-2013 15:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1306227-001	EB1306227-002	----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		8.36	8.33	----	----	----
EA006: Sodium Adsorption Ratio (SAR)									
Sodium Adsorption Ratio	----	0.01	-		6.32	3.74	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		1560	931	----	----	----
EA016: Non Marine - Estimated TDS Salinity									
Total Dissolved Solids (Calc.)	----	10	mg/L		1010	605	----	----	----
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		54400	390	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		326	204	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		16	5	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		454	225	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		470	231	----	----	----
ED040F: Dissolved Major Anions									
Sulfate as SO4 2-	14808-79-8	1	mg/L		84	37	----	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		191	134	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		43	34	----	----	----
Magnesium	7439-95-4	1	mg/L		53	29	----	----	----
Sodium	7440-23-5	1	mg/L		262	123	----	----	----
Potassium	7440-09-7	1	mg/L		3	2	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L		0.002	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		0.013	0.001	----	----	----
Barium	7440-39-3	0.001	mg/L		0.087	0.018	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		0.003	0.001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB10_T	MB09_T	----	----	----
			Client sampling date / time	11-MAR-2013 11:30	11-MAR-2013 15:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1306227-001	EB1306227-002	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.031**	**0.073**	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Vanadium	7440-62-2	0.01	mg/L	**0.02**	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.039**	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.007**	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.09**	**0.06**	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**116**	**1.07**	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.010	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.115**	**0.003**	----	----	----
Barium	7440-39-3	0.001	mg/L	**2.12**	**0.030**	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.010	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0012**	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.154**	**0.003**	----	----	----
Chromium	7440-47-3	0.001	mg/L	**0.264**	**0.006**	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.266**	**0.004**	----	----	----
Manganese	7439-96-5	0.001	mg/L	**13.4**	**0.088**	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.081**	**0.003**	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.213**	**0.002**	----	----	----
Vanadium	7440-62-2	0.01	mg/L	**0.38**	**0.02**	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.459**	**0.022**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.010	<0.001	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.10	<0.01	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.152**	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.54**	**0.06**	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	**0.0001**	----	----	----
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MB10_T	MB09_T	----	----	----
				Client sampling date / time	11-MAR-2013 11:30	11-MAR-2013 15:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1306227-001	EB1306227-002	----	----	----
EG035T: Total Recoverable Mercury by FIMS - Continued									
Mercury	7439-97-6	0.0001	mg/L		**0.0008**	<0.0001	----	----	----
EG051G: Ferrous Iron by Discrete Analyser									
Ferrous Iron	----	0.05	mg/L		<0.05	<0.05	----	----	----
EG051GUF: Ferrous Iron by Discrete Analyser - Unfiltered									
Ferrous Iron	----	0.05	mg/L		<0.05	<0.05	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<0.4	**0.2**	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.05**	**0.10**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.02**	**0.02**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.02**	**0.02**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**1.7**	<0.1	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**1.7**	<0.1	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**41.5**	**0.06**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		**0.04**	<0.01	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**16.5**	**9.17**	----	----	----
Total Cations	----	0.01	meq/L		**18.0**	**9.48**	----	----	----
Ionic Balance	----	0.01	%		**4.18**	**1.69**	----	----	----

Invoice IMC Mining Group Pty Ltd. dthomas@imcmining.com.au

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph.02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT: IMC	TURNAROUND REQUIREMENTS : ☐ Standard TAT (List due date):		FOR LABORATORY USE ONLY (Circle)
OFFICE: IMC Brisbane Attn Dave Thomas.	(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics) ☐ Non Standard or urgent TAT (List due date):		Custody Seal Intact? Yes No N/A
PROJECT: G1588 Taroborah	ALS QUOTE NO.: BN - 735-11 V2	COC SEQUENCE NUMBER (Circle)	Free Ice / frozen Ice bricks present upon receipt? Yes No N/A
ORDER NUMBER: IMC Brisbane		COC: 1 2 3 4 5 6 7	Random Sample Temperature on Receipt: °C
PROJECT MANAGER: James Tomlin	CONTACT PH: 07 32572055	OF: 1 2 3 4 5 6 7	Other comment:
SAMPLER: M. Cavanagh (IMC)	SAMPLER MOBILE: 0477673302	RELINQUISHED BY: M. Cavanagh	RECEIVED BY: R. Brennan
COC emailed to ALS? (YES / (NO)	EDD FORMAT (or default):	DATE/TIME: 12/3/13 1430	DATE/TIME: 12.3.13 1030.
Email Reports to (will default to PM if no other addresses are listed): mike@imcmining.com.au and claire.stephenson@ageconsultants.com.au		RELINQUISHED BY:	RECEIVED BY: Jodie
Email Invoice to (will default to PM if no other addresses are listed): dthomas@imcmining.com.au		DATE/TIME:	DATE/TIME: 13/3/13 09:20

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	NT-14 Extended Water Suite B Ca, Mg Na, K, pH, EC, Cl, SO4, Alkalinity, F, Hardness, TDS, Nitrate, Nitrite, Amonia, Ortho Phosphate	Suspended Solids (SS) - Standard Level	W3 - 13 Metals (Dissolved & Total) (As, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, V, Zn, Hg)	Dissolved & Total Metals Al, B, Se, Sb, Mo, Fe2+, U	NT-11 Total Nitrogen, TKN, NOx, Total Phosphorous				Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc. HT
	MB01_B	12/3/13 0850	W	P/SP	4	✓	✓	✓	✓	✓				
	MB02_S	" 1400	W	"	4	✓	✓	✓	✓	✓				
	MB04_C	" 1045	W	"	4	✓	✓	✓	✓	✓				
	MB04_S	" 1200	W	"	4	✓	✓	✓	✓	✓				
				TOTAL	16									

Environmental Division Brisbane
Work Order JRI
EB1306286

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1306286**	Page	: 1 of 5
Client	: **IMC MINING SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: MR DAVE THOMAS	Contact	: Customer Services
Address	: GPO BOX 2579 BRISBANE QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: dthomas@imcmining.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3226 9100	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3226 9101	Facsimile	: +61 7 3243 7218
Project	: G1588 Taroborah	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: IMC Brisbane		
C-O-C number	: ----	Date Samples Received	: 13-MAR-2013
Sampler	: M. Cavanagh (IMC)	Issue Date	: 20-MAR-2013
Site	: ----		
		No. of samples received	: 4
Quote number	: ----	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **EG020F (Dissolved Metals) were found to be higher than EG020T (Total Metals) for EB1306286-001 (MB01_B). This was confirmed by re-digestion and re-analysis.**
- **EK040P (Fluoride): LOR's have been raised for sample EB1306286-001 (MB01_B) due to matrix interference.**
- **It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.**

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Andrew Epps	Metals Production Chemist	Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
		Brisbane Inorganics

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	MB01_B	MB02_S	MB04_C	MB04_S	----
				Client sampling date / time	12-MAR-2013 08:50	12-MAR-2013 14:00	12-MAR-2013 10:45	12-MAR-2013 12:00	----
					EB1306286-001	EB1306286-002	EB1306286-003	EB1306286-004	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		8.35	8.16	8.24	8.20	----
EA006: Sodium Adsorption Ratio (SAR)									
Sodium Adsorption Ratio	----	0.01	-		4.30	2.70	6.32	8.98	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		2170	1370	2630	2440	----
EA016: Non Marine - Estimated TDS Salinity									
Total Dissolved Solids (Calc.)	----	10	mg/L		1410	890	1710	1590	----
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		49700	126	3470	163	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		674	446	583	385	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		15	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		398	472	245	376	----
Total Alkalinity as CaCO3	----	1	mg/L		413	472	245	376	----
ED040F: Dissolved Major Anions									
Sulfate as SO4 2-	14808-79-8	1	mg/L		131	36	185	156	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		428	154	594	488	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		59	60	77	57	----
Magnesium	7439-95-4	1	mg/L		128	72	95	59	----
Sodium	7440-23-5	1	mg/L		257	131	351	405	----
Potassium	7440-09-7	1	mg/L		10	5	18	44	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	<0.01	<0.01	0.05	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Arsenic	7440-38-2	0.001	mg/L		0.002	0.004	<0.001	0.003	----
Barium	7440-39-3	0.001	mg/L		0.091	0.047	0.082	0.163	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	----
Cobalt	7440-48-4	0.001	mg/L		0.009	<0.001	<0.001	<0.001	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MB01_B	MB02_S	MB04_C	MB04_S	----
				Client sampling date / time	12-MAR-2013 08:50	12-MAR-2013 14:00	12-MAR-2013 10:45	12-MAR-2013 12:00	----
Compound	CAS Number	LOR	Unit		EB1306286-001	EB1306286-002	EB1306286-003	EB1306286-004	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L		**0.002**	<0.001	<0.001	<0.001	----
Manganese	7439-96-5	0.001	mg/L		**0.076**	**0.008**	**0.016**	**0.010**	----
Nickel	7440-02-0	0.001	mg/L		**0.009**	<0.001	**0.001**	<0.001	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Zinc	7440-66-6	0.005	mg/L		**0.012**	<0.005	<0.005	**0.005**	----
Molybdenum	7439-98-7	0.001	mg/L		**0.034**	**0.009**	**0.007**	**0.003**	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Uranium	7440-61-1	0.001	mg/L		**0.005**	**0.008**	**0.005**	<0.001	----
Boron	7440-42-8	0.05	mg/L		**0.07**	**0.09**	**0.14**	**0.08**	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**183**	**0.50**	**17.4**	**46.7**	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Arsenic	7440-38-2	0.001	mg/L		**0.022**	**0.002**	**0.004**	**0.010**	----
Barium	7440-39-3	0.001	mg/L		**1.49**	**0.176**	**0.237**	**0.446**	----
Beryllium	7440-41-7	0.001	mg/L		**0.016**	<0.001	**0.004**	**0.012**	----
Cadmium	7440-43-9	0.0001	mg/L		**0.0061**	<0.0001	**0.0002**	**0.0004**	----
Cobalt	7440-48-4	0.001	mg/L		**0.354**	<0.001	**0.003**	**0.006**	----
Chromium	7440-47-3	0.001	mg/L		**0.238**	<0.001	**0.004**	**0.004**	----
Copper	7440-50-8	0.001	mg/L		**0.645**	**0.001**	**0.013**	**0.022**	----
Manganese	7439-96-5	0.001	mg/L		**45.9**	**0.020**	**0.274**	**0.727**	----
Nickel	7440-02-0	0.001	mg/L		**0.798**	**0.002**	**0.009**	**0.009**	----
Lead	7439-92-1	0.001	mg/L		**0.234**	**0.001**	**0.026**	**0.074**	----
Vanadium	7440-62-2	0.01	mg/L		**0.41**	<0.01	**0.01**	**0.02**	----
Zinc	7440-66-6	0.005	mg/L		**1.38**	**0.009**	**0.074**	**0.069**	----
Molybdenum	7439-98-7	0.001	mg/L		**0.004**	**0.003**	**0.006**	**0.007**	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Uranium	7440-61-1	0.001	mg/L		**0.045**	<0.001	**0.011**	**0.027**	----
Boron	7440-42-8	0.05	mg/L		**0.05**	**0.06**	**0.13**	**0.12**	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	----
EG035T: Total Recoverable Mercury by FIMS									

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MB01_B	MB02_S	MB04_C	MB04_S	----
				Client sampling date / time	12-MAR-2013 08:50	12-MAR-2013 14:00	12-MAR-2013 10:45	12-MAR-2013 12:00	----
Compound	CAS Number	LOR	Unit		EB1306286-001	EB1306286-002	EB1306286-003	EB1306286-004	----
EG035T: Total Recoverable Mercury by FIMS - Continued									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	----
EG051G: Ferrous Iron by Discrete Analyser									
Ferrous Iron	----	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
EG051GUF: Ferrous Iron by Discrete Analyser - Unfiltered									
Ferrous Iron	----	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		<4.0	**0.6**	**0.5**	**0.8**	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.08**	**0.08**	**0.22**	**0.13**	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		**0.01**	<0.01	<0.01	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.01**	<0.01	<0.01	<0.01	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**3.0**	<0.1	**0.7**	**0.2**	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ Total Nitrogen as N	----	0.1	mg/L		**3.0**	<0.1	**0.7**	**0.2**	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**31.7**	**0.10**	**0.17**	**0.43**	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		**0.04**	**0.02**	<0.01	**0.01**	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**23.0**	**14.5**	**25.5**	**24.5**	----
Total Cations	----	0.01	meq/L		**24.9**	**14.8**	**27.4**	**26.4**	----
Ionic Balance	----	0.01	%		**3.86**	**0.74**	**3.56**	**3.74**	----

Invoice IMC Mining Group [illegible]

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd. Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph.02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-4 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	IMC	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	☐ Standard TAT (List due date): ☐ Non Standard or urgent TAT (List due date):
OFFICE:	IMC Brisbane Attn: dawe thomas		
PROJECT:	G1588 Taroborah	ALS QUOTE NO.:	BN - 735-11 V2
ORDER NUMBER:	IMC Brisbane.		
PROJECT MANAGER:	James Tomlin	CONTACT PH: 07 32572055	
SAMPLER:	M. Cavanagh	SAMPLER MOBILE: 0477673302	
COC emailed to ALS? (YES / (NO)		EDD FORMAT (or default):	
Email Reports to (will default to PM if no other addresses are listed): mike@imcmining.com.au and claire.stephenson@ageconsultants.com.au		dthomas@imcmining.com.au	
Email Invoice to (will default to PM if no other addresses are listed):		dthomas@imcmining.com.au	

COC SEQUENCE NUMBER (Circle)

COC: 1 2 3 4 5 6 7

OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact? Yes No N/A

Free ice / frozen ice bricks present upon receipt? Yes No N/A

Random Sample Temperature on Receipt: °C

Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
M. Cavanagh	D. Stewart		ONG Of
DATE/TIME: 13/3/13 1430	DATE/TIME: 13-3-13 1430	DATE/TIME:	DATE/TIME: 14/03/13 09:05

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).							Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	NT-14 Extended Water Suite B Ca, Mg Na, K, pH, EC, Cl, SO4, Alkalinity, F, Hardness, TDS, Nitrate, Nitrite, Amonia, Ortho Phosphate	Suspended Solids (SS) - Standard Level	W3 - 13 Metals (Dissolved & Total) (As, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, V, Zn, Hg)	Dissolved & Total Metals Al, B, Se, Sb, Mo, Fe2+, U	NT-11 Total Nitrogen, TKN, NOx, Total Phosphorous			Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
	MB02_C	13/3/13 0930	W	P/SP	4	✓	✓	✓	✓	✓			
	MB03_S	13/3/13 1145	W	P/SP	4	✓	✓	✓	✓	✓			
	MB05_C	13/3/13 1345	W	P/SP	4	✓	✓	✓	✓	✓			
				TOTAL	12								

HT

Environmental Division
Brisbane
Work Order
EB1306388

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1306388**	Page	: 1 of 5
Client	: **IMC MINING SOLUTIONS**	Laboratory	: Environmental Division Brisbane
Contact	: MR DAVE THOMAS	Contact	: Customer Services
Address	: GPO BOX 2579 BRISBANE QLD, AUSTRALIA 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: dthomas@imcmining.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 3226 9100	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 3226 9101	Facsimile	: +61 7 3243 7218
Project	: G1588 Taroborah	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: IMC Brisbane		
C-O-C number	: ----	Date Samples Received	: 14-MAR-2013
Sampler	: M. Cavanagh	Issue Date	: 21-MAR-2013
Site	: ----		
		No. of samples received	: 3
Quote number	: ----	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.**
- **It is recognised that EK061 (Total Kjeldahl Nitrogen) is less than EK055 (Ammonia) for some samples. However, the difference is within experimental variation of the methods.**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MB02_C	MB03_S	MB05_C	----	----
				Client sampling date / time	13-MAR-2013 09:30	13-MAR-2013 11:45	13-MAR-2013 13:45	----	----
Compound	CAS Number	LOR	Unit		EB1306388-001	EB1306388-002	EB1306388-003	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		8.23	8.36	8.45	----	----
EA006: Sodium Adsorption Ratio (SAR)									
Sodium Adsorption Ratio	----	0.01	-		4.50	11.8	3.52	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		3070	3060	1590	----	----
EA016: Non Marine - Estimated TDS Salinity									
Total Dissolved Solids (Calc.)	----	1	mg/L		2000	1990	1030	----	----
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		270	8020	240	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		773	318	348	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	11	20	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		248	276	260	----	----
Total Alkalinity as CaCO3	----	1	mg/L		248	288	280	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		67	293	66	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		718	540	291	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		97	58	39	----	----
Magnesium	7439-95-4	1	mg/L		129	42	61	----	----
Sodium	7440-23-5	1	mg/L		288	482	151	----	----
Potassium	7440-09-7	1	mg/L		13	83	12	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		0.02	<0.01	<0.01	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	0.002	0.002	----	----
Barium	7440-39-3	0.001	mg/L		0.146	0.093	0.108	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	MB02_C	MB03_S	MB05_C	----	----
				Client sampling date / time	13-MAR-2013 09:30	13-MAR-2013 11:45	13-MAR-2013 13:45	----	----
Compound	CAS Number	LOR	Unit		EB1306388-001	EB1306388-002	EB1306388-003	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	**0.001**	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L		**0.022**	**0.029**	**0.017**	----	----
Nickel	7440-02-0	0.001	mg/L		<0.001	**0.001**	**0.002**	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L		**0.005**	**0.006**	**0.007**	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.002**	**0.015**	**0.002**	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	**0.012**	**0.001**	----	----
Boron	7440-42-8	0.05	mg/L		**0.13**	**0.28**	**0.11**	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.51**	**1.01**	**0.21**	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	<0.001	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.002**	**0.003**	**0.002**	----	----
Barium	7440-39-3	0.001	mg/L		**0.140**	**0.131**	**0.097**	----	----
Beryllium	7440-41-7	0.001	mg/L		**0.001**	**0.003**	<0.001	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	**0.0002**	<0.0001	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.001**	**0.003**	<0.001	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	**0.001**	<0.001	----	----
Copper	7440-50-8	0.001	mg/L		**0.008**	**0.004**	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L		**0.085**	**0.375**	**0.024**	----	----
Nickel	7440-02-0	0.001	mg/L		**0.002**	**0.003**	**0.003**	----	----
Lead	7439-92-1	0.001	mg/L		**0.009**	**0.024**	<0.001	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L		**0.015**	**0.038**	**0.006**	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.002**	**0.015**	**0.002**	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	----	----
Uranium	7440-61-1	0.001	mg/L		**0.001**	**0.015**	**0.002**	----	----
Boron	7440-42-8	0.05	mg/L		**0.14**	**0.30**	**0.11**	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
EG035T: Total Recoverable Mercury by FIMS									

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	MB02_C	MB03_S	MB05_C	----	----
			Client sampling date / time	13-MAR-2013 09:30	13-MAR-2013 11:45	13-MAR-2013 13:45	----	----
Compound	CAS Number	LOR	Unit	EB1306388-001	EB1306388-002	EB1306388-003	----	----
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EG051G: Ferrous Iron by Discrete Analyser								
Ferrous Iron	----	0.05	mg/L	<0.05	<0.05	<0.05	----	----
EG051GUF: Ferrous Iron by Discrete Analyser - Unfiltered								
Ferrous Iron	----	0.05	mg/L	**0.08**	**0.10**	<0.05	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	**0.6**	**0.4**	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.14**	**0.92**	**0.17**	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	**0.02**	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.02**	**0.02**	**0.03**	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.02**	**0.04**	**0.03**	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.4**	**0.8**	<0.1	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**0.4**	**0.8**	<0.1	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.44**	**0.42**	**0.63**	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	----	0.01	mg/L	**0.04**	<0.01	**0.02**	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**26.6**	**27.1**	**15.2**	----	----
Total Cations	----	0.01	meq/L	**28.3**	**29.4**	**13.8**	----	----
Ionic Balance	----	0.01	%	**3.12**	**4.15**	**4.62**	----	----

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☑ **Brisbane**: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Melbourne**: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Perth**: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Launceston:** 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2156 E: launceston@alsenviro.com

CLIENT:	**AGE CONSULTANTS**	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	☑ Standard TAT (List due date): ☐ Non Standard or urgent TAT (List due date):
OFFICE:	**Brisbane (Level 2/15 Mallon Street, Bowen Hills, 4006)**		
PROJECT:	**G1588 Taroborah**	**ALS QUOTE NO.:**	**BN - 735-11 V2** BQ
ORDER NUMBER:	G1588		
PROJECT MANAGER:	Craig Vincent	**CONTACT PH:** 07 32572055	
SAMPLER:	**Craig Vincent/Chris Breislin**	**SAMPLER MOBILE: 0417237366**	
COC emailed to ALS? (YES / NO)		**EDD FORMAT (or default):**	

COC SEQUENCE NUMBER (Circle)
COC: (1) 2 3 4 5 6 7
OF: (1) 2 3 4 5 6 7

Email Reports to (will default to PM if no other addresses are listed):
claire.stephenson@ageconsultants.com.au; craig.vincent@ageconsultants.com.au

Email Invoice to (will default to PM if no other addresses are listed):

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
CRAIG	R. Brennan	R. Brennan	
DATE/TIME: 18/4/13 14:35	DATE/TIME: 18.4.13 1440	DATE/TIME: 18-4-13 1440	DATE/TIME: 19/4/13 9:10

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).						Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	NT-14 Extended Water Suite B Ca, Mg Na, K, pH, EC, Cl, SO4, Alkalinity, F, Hardness, TDS, Nitrate, Nitrite, Ammonia, Ortho Phosphate	Suspended Solids (SS) - Standard Level	W3 - 13 Metals (Dissolved & Total) (As, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, V, Zn, Hg)	Dissolved & Total Metals Al, B, Se, Sb, Mo, Fe2+, U	NT-11 Total Nitrogen, TKN, NOx, Total Phosphorous			Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
	~~TAR177_C~~											
1	TAR177_C	18/4/13 0800	W	Various	5	✓	✓	✓	✓	✓		
2	TAR178_C	18/4/13 1300	W	Various	5	✓	✓	✓	✓	✓		
				TOTAL								

HT

Environmental Division
Brisbane
Work Order
EB1309416

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1309416**	Page	: 1 of 5
Client	: **AUST GROUNDWATER & ENVIRO CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR CRAIG VINCENT	Contact	: Customer Services
Address	: LEVEL 2, 15 MALLON STREET BOWEN HILLS QLD, AUSTRALIA 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: craig.vincent@ageconsultants.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 32572055	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32572088	Facsimile	: +61 7 3243 7218
Project	: G1588 Tarborah	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: G1588		
C-O-C number	: ----	Date Samples Received	: 19-APR-2013
Sampler	: C.Vincent/C.Breislin	Issue Date	: 30-APR-2013
Site	: ----		
		No. of samples received	: 2
Quote number	: BN/735/11 V2	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.**

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Greg Vogel	Laboratory Manager	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	TAR177_C	TAR176_C	----	----	----
			Client sampling date / time	18-APR-2013 08:00	18-APR-2013 13:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1309416-001	EB1309416-002	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.40**	**8.65**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	**1.24**	**3.73**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1400**	**930**	----	----	----
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	10	mg/L	**910**	**604**	----	----	----
EA025: Suspended Solids								
Suspended Solids (SS)	----	5	mg/L	**5**	<5	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**655**	**186**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	**28**	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**778**	**157**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**778**	**186**	----	----	----
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**20**	**37**	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**73**	**199**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**71**	**53**	----	----	----
Magnesium	7439-95-4	1	mg/L	**116**	**13**	----	----	----
Sodium	7440-23-5	1	mg/L	**73**	**117**	----	----	----
Potassium	7440-09-7	1	mg/L	**3**	**16**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**0.02**	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.002**	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.096**	**0.078**	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TAR177_C	TAR176_C	----	----	----
				Client sampling date / time	18-APR-2013 08:00	18-APR-2013 13:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1309416-001	EB1309416-002	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.077**	**0.001**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.003**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.008**	<0.005	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.005**	**0.011**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.07**	**0.10**	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.02**	**0.02**	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	**0.001**	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.109**	**0.078**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		<0.001	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.092**	**0.001**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.003**	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.005**	<0.005	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.005**	**0.012**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.05**	**0.09**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS									

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	TAR177_C	TAR176_C	----	----	----
			Client sampling date / time	18-APR-2013 08:00	18-APR-2013 13:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1309416-001	EB1309416-002	----	----	----
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG051G: Ferrous Iron by Discrete Analyser								
Ferrous Iron	----	0.05	mg/L	**0.44**	<0.05	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.2**	**0.2**	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.03**	**0.54**	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.02**	<0.01	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.02**	<0.01	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.2**	**0.6**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**0.2**	**0.6**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.02**	<0.01	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.02**	<0.01	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**18.0**	**10.1**	----	----	----
Total Cations	----	0.01	meq/L	**16.3**	**9.21**	----	----	----
Ionic Balance	----	0.01	%	**4.91**	**4.59**	----	----	----

CHAIN OF CUSTODY

ALS Laboratory: please tick →

ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com
BRISBANE 32 Shand Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
GLADSTONE 46 Callemondah Drive Clinton QLD 4680 Ph: 07 7471 5600 E: gladstone@alsglobal.com
MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com
MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
MUDGEE 27 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com
NEWCASTLE 5 Rose Gum Road Warabrook NSW 2304 Ph: 02 4968 9433 E: samples.newcastle@alsglobal.com
NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 024423 2063 E: nowra@alsglobal.com
PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com
SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com
TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townesville.environmental@alsglobal.com
WOLLONGONG 99 Kenny Street Wollongong NSW 2500 Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: AGE CONSULTANTS	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)	☑ Standard TAT (List due date):
OFFICE: BRISBANE (Level 2/15 Mallon Street, Bowen Hills, 4006)		☐ Non Standard or urgent TAT (List due date):
PROJECT: G1588 Taroborah	**ALS QUOTE NO.:**	BN-735-11 V2
ORDER NUMBER: G1588		
PROJECT MANAGER: Craig Vincent	**CONTACT PH:** 07 32572055	
SAMPLER: Craig Vincent/Chris Breislin	**SAMPLER MOBILE:** 0417237366	
COC emailed to ALS? (YES / NO)	**EDD FORMAT (or default):**	
Email Reports to (will default to PM if no other addresses are listed): craig.vincent@ageconsultants.com.au		
Email Invoice to (will default to PM if no other addresses are listed): craig.vincent@ageconsultants.com.au		

COC SEQUENCE NUMBER (Circle)

COC: (1) 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
CRAIG VINCENT	R. Brennan	R. Brennan	[illegible]
DATE/TIME: 22/4/13 14:07	DATE/TIME: 22.4.13 1410	DATE/TIME: 22.4.13 1500	DATE/TIME: 23/04/13 09:05

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS (MATRIX: SOLID (S) WATER (W))			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	pH	EC	TDS	Total and dissolved metals - ICPMS: Al, As, Au, B, Ba, Be, Bi, Co, Fe, Pb, Hg, Mn, Mo, Ni, Ti, Sb, U, Zn	Total and dissolved metals - ORC ICPMS: Cd, Cr, Cu, Se and Ag	NT - N (nutrients)	Sulphate	Fluoride	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	Stans Dam	22/4/13 11:00	W	VARIOUS	5	✓	✓	✓	✓	✓	✓	✓	✓	HT
				TOTAL										

TF
Environmental Division
Brisbane
Work Order
EB1309670

SCANNED 23/4/13 MH

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1309670**	Page	: 1 of 5
Client	: **AUST GROUNDWATER & ENVIRO CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR CRAIG VINCENT	Contact	: Customer Services
Address	: LEVEL 2, 15 MALLON STREET BOWEN HILLS QLD, AUSTRALIA 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: craig.vincent@ageconsultants.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 32572055	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32572088	Facsimile	: +61 7 3243 7218
Project	: G1588 Taroborah	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: G1588		
C-O-C number	: ----	Date Samples Received	: 23-APR-2013
Sampler	: C Vincent/C Breislin	Issue Date	: 01-MAY-2013
Site	: ----		
		No. of samples received	: 1
Quote number	: BN/735/11 V2	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.**

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
		Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
		WB Water Lab Brisbane

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Stan's Dam	----	----	----	----
			Client sampling date / time	22-APR-2013 11:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1309670-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.66**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**480**	----	----	----	----
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	----	10	mg/L	**270**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**5**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.01**	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.020**	----	----	----	----
Bismuth	7440-69-9	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.021**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.005**	----	----	----	----
Titanium	7440-32-6	0.01	mg/L	<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.13**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	<0.05	----	----	----	----
Gold	7440-57-5	0.001	mg/L	<0.001	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.46**	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.001**	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.025**	----	----	----	----
Bismuth	7440-69-9	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Stan's Dam	----	----	----	----
			Client sampling date / time	22-APR-2013 11:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1309670-001	----	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.067**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.006**	----	----	----	----
Titanium	7440-32-6	0.01	mg/L	<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.007**	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.14**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.61**	----	----	----	----
Gold	7440-57-5	0.001	mg/L	<0.001	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG094F: Dissolved Metals in Fresh Water by ORC-ICPMS								
Selenium	7782-49-2	0.2	µg/L	<0.2	----	----	----	----
Cadmium	7440-43-9	0.05	µg/L	<0.05	----	----	----	----
Chromium	7440-47-3	0.2	µg/L	<0.2	----	----	----	----
Copper	7440-50-8	0.5	µg/L	**0.9**	----	----	----	----
Silver	7440-22-4	0.1	µg/L	<0.1	----	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS								
Selenium	7782-49-2	0.2	µg/L	<0.2	----	----	----	----
Cadmium	7440-43-9	0.05	µg/L	<0.05	----	----	----	----
Chromium	7440-47-3	0.2	µg/L	**1.3**	----	----	----	----
Copper	7440-50-8	0.5	µg/L	**1.5**	----	----	----	----
Silver	7440-22-4	0.1	µg/L	<0.1	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.3**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.04**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Stan's Dam	----	----	----	----
			Client sampling date / time	22-APR-2013 11:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1309670-001	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser - Continued								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**1.6**	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**1.6**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.03**	----	----	----	----

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☑ **Brisbane**: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
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☐ **Launceston:** 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	**AGE CONSULTANTS**	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g. Ultra Trace Organics)	☑ Standard TAT (List due date): ☐ Non Standard or urgent TAT (List due date):
OFFICE:	**Brisbane (Level 2/15 Mallon Street, Bowen Hills, 4006)**		
PROJECT:	**G1588 Taroborah**	**ALS QUOTE NO.:**	**BN - 735-11 V2**
ORDER NUMBER:	G1588		
PROJECT MANAGER:	Craig Vincent	**CONTACT PH:** 07 32572055	
SAMPLER:	**Craig Vincent/Chris Breislin**	**SAMPLER MOBILE: 0417237366**	
COC emailed to ALS? (YES / (NO)		**EDD FORMAT (or default):**	

COC SEQUENCE NUMBER (Circle)
COC: (1) 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

Email Reports to (will default to PM if no other addresses are listed):
claire.stephenson@ageconsultants.com.au; craig.vincent@ageconsultants.com.au

Email Invoice to (will default to PM if no other addresses are listed):

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
CRAIG VINCENT	R. Brennan	R. Brennan	
DATE/TIME: 14:07	DATE/TIME: 22.4.13 1410	DATE/TIME: 22.4.13 1500	DATE/TIME: 23/04/13 09:05

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	NT-14 Extended Water Suite B Ca, Mg Na, K, pH, EC, Cl, SO4, Alkalinity, F, Hardness, TDS, Nitrate, Nitrite, Ammonia, Ortho Phosphate	Suspended Solids (SS) - Standard Level	W3 - 13 Metals (Dissolved & Total) (As, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, V, Zn, Hg)	Dissolved & Total Metals Al, B, Se, Sb, Mo, Fe2+, U	NT-11 Total Nitrogen, TKN, NOx, Total Phosphorous			HT	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	TAR249-C	22/4/13 10:30	W	VARIOUS	5	✓	✓	✓	✓	✓				
2	TAL053	22/4/13 13:15	W	VARIOUS	5	✓	✓	✓	✓	✓				
				TOTAL										

Environmental Division Brisbane
Work Order
EB1309671

SCANNED 23/4/13 MH

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1309671**	Page	: 1 of 5
Client	: **AUST GROUNDWATER & ENVIRO CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR CRAIG VINCENT	Contact	: Customer Services
Address	: LEVEL 2, 15 MALLON STREET BOWEN HILLS QLD, AUSTRALIA 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: craig.vincent@ageconsultants.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 32572055	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32572088	Facsimile	: +61 7 3243 7218
Project	: G1588 Taroborah	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: G1588		
C-O-C number	: ----	Date Samples Received	: 23-APR-2013
Sampler	: C Vincent/C Breislin	Issue Date	: 02-MAY-2013
Site	: ----		
		No. of samples received	: 2
Quote number	: BN/735/11 V2	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.**

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Jonathon Angell	Inorganic Coordinator	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
Stephen Hislop	Senior Inorganic Chemist	Brisbane Inorganics
		Brisbane Inorganics

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	TAR249-C	TAR053	----	----	----
			Client sampling date / time	22-APR-2013 10:30	22-APR-2013 13:15	----	----	----
Compound	CAS Number	LOR	Unit	EB1309671-001	EB1309671-002	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.56**	**7.93**	----	----	----
EA006: Sodium Adsorption Ratio (SAR)								
Sodium Adsorption Ratio	----	0.01	-	**3.79**	**1.51**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**783**	**980**	----	----	----
EA016: Non Marine - Estimated TDS Salinity								
Total Dissolved Solids (Calc.)	----	1	mg/L	**509**	**637**	----	----	----
EA025: Suspended Solids								
Suspended Solids (SS)	----	5	mg/L	**85**	**7**	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**137**	**371**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**14**	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**75**	**445**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**90**	**445**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**42**	**13**	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**179**	**48**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**17**	**58**	----	----	----
Magnesium	7439-95-4	1	mg/L	**23**	**55**	----	----	----
Sodium	7440-23-5	1	mg/L	**102**	**67**	----	----	----
Potassium	7440-09-7	1	mg/L	**10**	**5**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.01**	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.001**	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.005**	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.031**	**0.388**	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.003**	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	TAR249-C	TAR053	----	----	----
				Client sampling date / time	22-APR-2013 10:30	22-APR-2013 13:15	----	----	----
					EB1309671-001	EB1309671-002	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.001**	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.003**	**0.029**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.001**	**0.004**	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.008**	<0.005	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.011**	**0.003**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.05**	**0.06**	----	----	----
EG020T: Total Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**1.88**	**0.04**	----	----	----
Antimony	7440-36-0	0.001	mg/L		**0.001**	<0.001	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.002**	**0.004**	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.052**	**0.343**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.002**	**0.003**	----	----	----
Chromium	7440-47-3	0.001	mg/L		**0.016**	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.017**	<0.001	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.067**	**0.030**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.019**	**0.004**	----	----	----
Lead	7439-92-1	0.001	mg/L		**0.008**	<0.001	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.160**	<0.005	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.014**	**0.004**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	<0.001	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.07**	**0.06**	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	----	----	----
EG035T: Total Recoverable Mercury by FIMS									

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	TAR249-C	TAR053	----	----	----
			Client sampling date / time	22-APR-2013 10:30	22-APR-2013 13:15	----	----	----
Compound	CAS Number	LOR	Unit	EB1309671-001	EB1309671-002	----	----	----
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG051G: Ferrous Iron by Discrete Analyser								
Ferrous Iron	----	0.05	mg/L	<0.05	**1.29**	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	**0.5**	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.26**	**0.38**	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.02**	<0.01	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.02**	<0.01	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**1.0**	**0.5**	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**1.0**	**0.5**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.08**	**0.08**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**7.72**	**10.5**	----	----	----
Total Cations	----	0.01	meq/L	**7.43**	**10.5**	----	----	----
Ionic Balance	----	0.01	%	**1.91**	**0.27**	----	----	----

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ALS Laboratory: please tick →

☐ **Sydney**: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ **Newcastle:** 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☑ **Brisbane**: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ **Townsville:** 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ **Melbourne**: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Perth**: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston:** 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	**AGE CONSULTANTS**	**TURNAROUND REQUIREMENTS :** (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)	☑ Standard TAT **(List due date):**
OFFICE:	**Brisbane (Level 2/15 Mallon Street, Bowen Hills, 4006)**		☐ Non Standard or urgent TAT **(List due date):**
PROJECT:	**G1588 Taroborah**	**ALS QUOTE NO.:**	**BN - 735-11 V2**
ORDER NUMBER:	G1588		
PROJECT MANAGER:	Craig Vincent	**CONTACT PH:** 07 32572055	
SAMPLER:	**Craig Vincent/Chris Breislin**	**SAMPLER MOBILE: 0417237366**	
COC emailed to ALS? (YES / (NO)		**EDD FORMAT (or default):**	

COC SEQUENCE NUMBER (Circle)
COC: (1) 2 3 4 5 6 7
OF: (1) 2 3 4 5 6 7

Email Reports to (will default to PM if no other addresses are listed):
claire.stephenson@ageconsultants.com.au; craig.vincent@ageconsultants.com.au

Email Invoice to (will default to PM if no other addresses are listed):

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

RELINQUISHED BY:	**RECEIVED BY:**	**RELINQUISHED BY:**	**RECEIVED BY:**
CRAIG VINCENT	R. Brennan	R. Brennan	David
DATE/TIME: 23/4/13 13:51	DATE/TIME: 23.4.13 13:55	DATE/TIME: 23.4.13. 14:30	DATE/TIME: 24/4 9:15

LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	NT-14 Extended Water Suite B Ca, Mg Na, K, pH, EC, Cl, SO4, Alkalinity, F, Hardness, TDS, Nitrate, Nitrite, Ammonia, Ortho Phosphate	Suspended Solids (SS) - Standard Level	W3 - 13 Metals (Dissolved & Total) (As, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, V, Zn, Hg)	Dissolved & Total Metals Al, B, Se, Sb, Mo, Fe2+, U	NT-11 Total Nitrogen, TKN, NOx, Total Phosphorous				Additional Information
	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			**CONTAINER INFORMATION**		**ANALYSIS REQUIRED including SUITES** (NB. Suite Codes must be listed to attract suite price) Where **Metals** are required, specify **Total** (unfiltered bottle required) or **Dissolved** (field filtered bottle required).								Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc. HT
1.	TARO16_CR	23/4/13 10:40	W	VIAL/ORS	5	✓	✓	✓	✓	✓				
					TOTAL									

Environmental Division
Brisbane
Work Order
EB1309871

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EB1309871**	Page	: 1 of 5
Client	: **AUST GROUNDWATER & ENVIRO CONSULTANTS**	Laboratory	: Environmental Division Brisbane
Contact	: MR CRAIG VINCENT	Contact	: Customer Services
Address	: LEVEL 2, 15 MALLON STREET BOWEN HILLS QLD, AUSTRALIA 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: craig.vincent@ageconsultants.com.au	E-mail	: Brisbane.Enviro.Services@alsglobal.com
Telephone	: +61 07 32572055	Telephone	: +61 7 3243 7222
Facsimile	: +61 07 32572088	Facsimile	: +61 7 3243 7218
Project	: G1588 Taroborah	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: G1588		
C-O-C number	: ----	Date Samples Received	: 24-APR-2013
Sampler	: C.Vincent/C.Breislin	Issue Date	: 03-MAY-2013
Site	: ----		
		No. of samples received	: 1
Quote number	: BN/735/11 V2	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Jonathon Angell	Inorganic Coordinator	Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
		Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics
		Brisbane Inorganics

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	TARO16_CR	----	----	----	----
				Client sampling date / time	23-APR-2013 10:40	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1309871-001	----	----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**7.59**	----	----	----	----
EA006: Sodium Adsorption Ratio (SAR)									
Sodium Adsorption Ratio	----	0.01	-		**1.97**	----	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**1290**	----	----	----	----
EA016: Non Marine - Estimated TDS Salinity									
Total Dissolved Solids (Calc.)	----	1	mg/L		**838**	----	----	----	----
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		**11**	----	----	----	----
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L		**459**	----	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**537**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**537**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**22**	----	----	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**117**	----	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**75**	----	----	----	----
Magnesium	7439-95-4	1	mg/L		**66**	----	----	----	----
Sodium	7440-23-5	1	mg/L		**97**	----	----	----	----
Potassium	7440-09-7	1	mg/L		**3**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L		<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.001**	----	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.121**	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L		**0.002**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	TARO16_CR	----	----	----	----
			Client sampling date / time	23-APR-2013 10:40	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1309871-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.051**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.005**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.002**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.010**	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.10**	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.26**	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.125**	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.002**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.052**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.001**	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.010**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.002**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.010**	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.10**	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								

Analytical Results

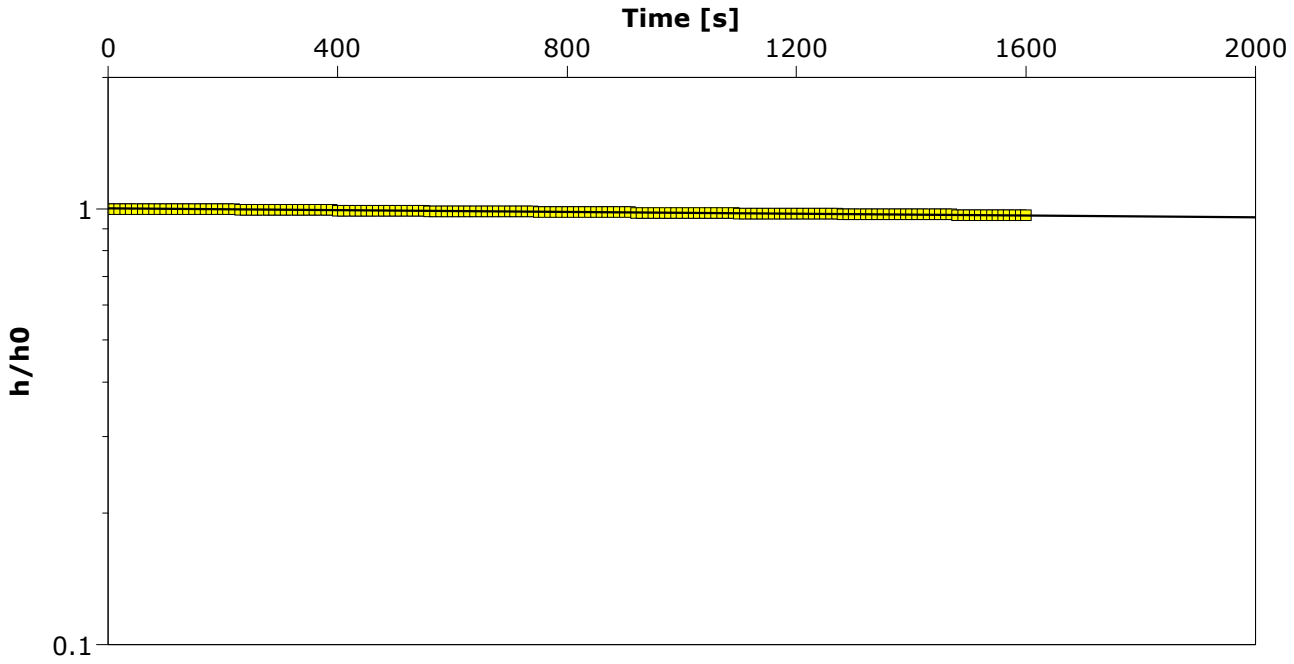
Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	TARO16_CR	----	----	----	----
			Client sampling date / time	23-APR-2013 10:40	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1309871-001	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS - Continued								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG051G: Ferrous Iron by Discrete Analyser								
Ferrous Iron	----	0.05	mg/L	**0.22**	----	----	----	----
EG051GUF: Ferrous Iron by Discrete Analyser - Unfiltered								
Ferrous Iron	----	0.05	mg/L	**0.20**	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.02**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.02**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.02**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.2**	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**0.2**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**14.5**	----	----	----	----
Total Cations	----	0.01	meq/L	**13.5**	----	----	----	----
Ionic Balance	----	0.01	%	**3.65**	----	----	----	----

Appendix A-3

FALLING-HEAD PERMEABILITY RESULTS AND ANALYSIS

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB01_B	Test Well: MB01_B
Test Conducted by: Chris		Test Date: 19/04/2013
Analysis Performed by: Chris	MB01_B	Analysis Date: 3/05/2013
Aquifer Thickness: 10.00 m		

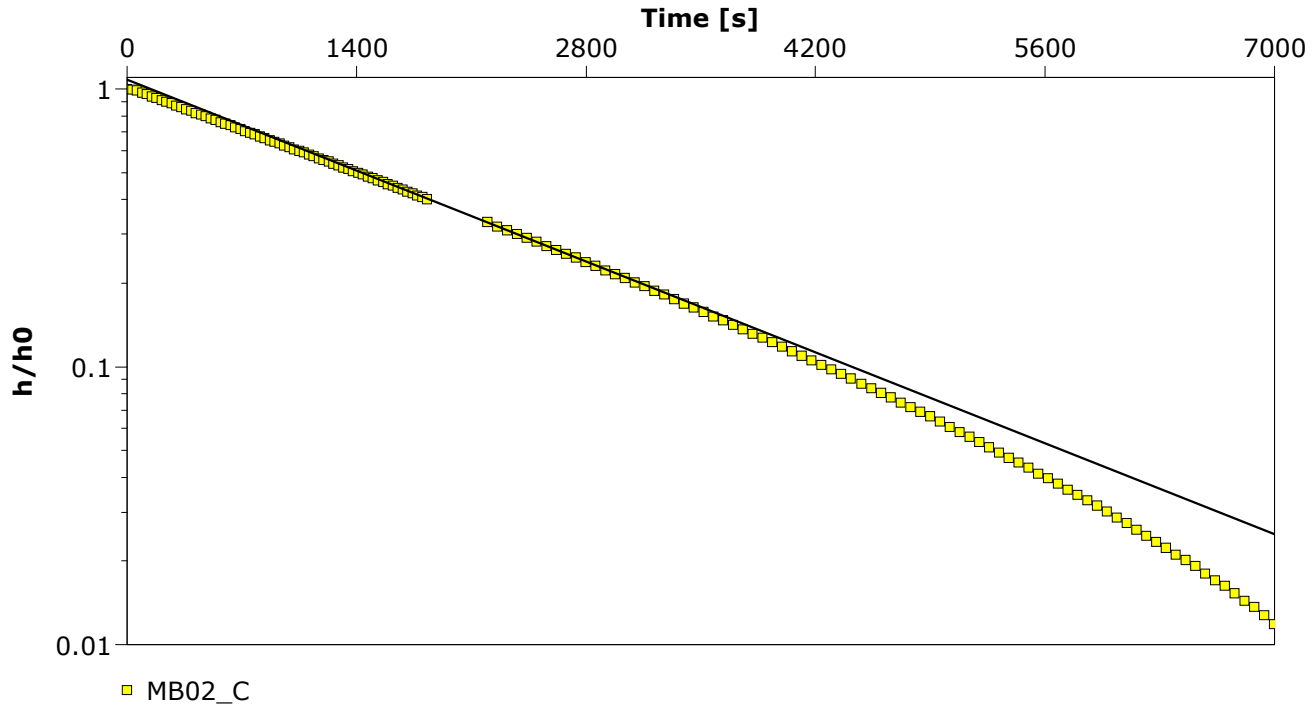


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB01_B	5.53×10^{-4}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB02_C	Test Well: MB02_C
Test Conducted by: CV/CB		Test Date: 21/04/2013
Analysis Performed by: Craig	MB02_C	Analysis Date: 14/05/2013
Aquifer Thickness: 3.00 m		

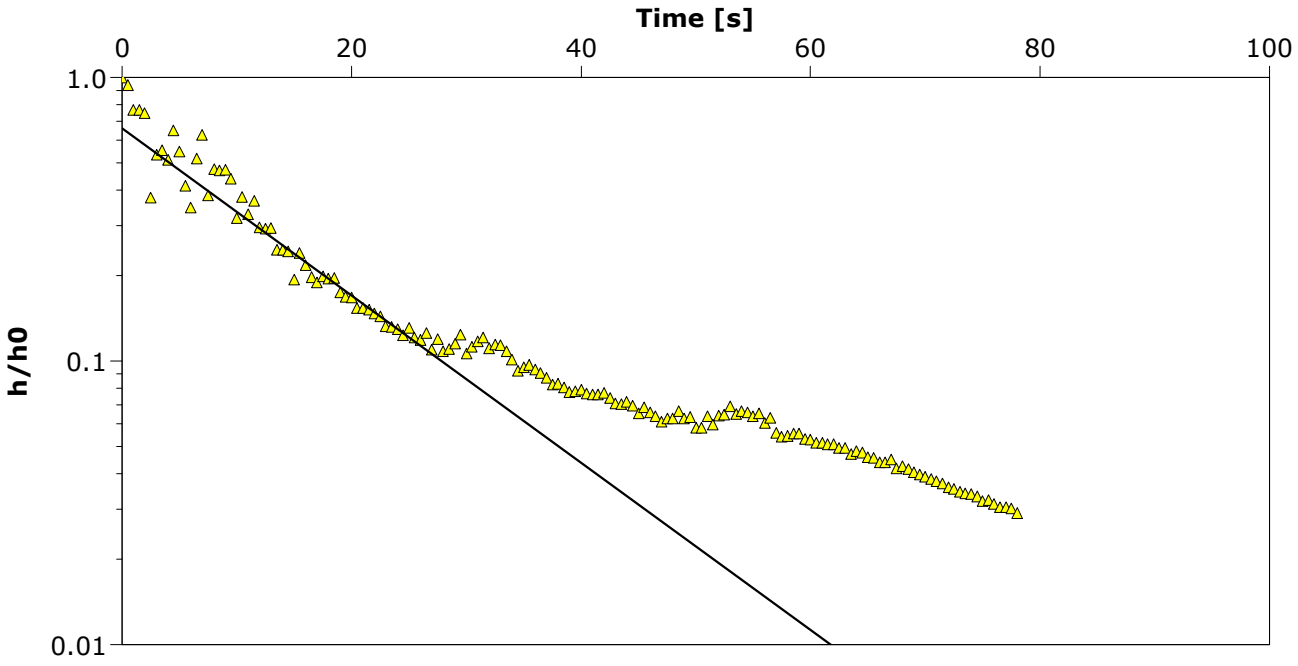


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB02_C	2.33×10^{-2}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB02_S	Test Well: MB02_S
Test Conducted by: CV/CB		Test Date: 21/04/2013
Analysis Performed by: Chris	MB02_S	Analysis Date: 3/05/2013
Aquifer Thickness: 50.00 m		

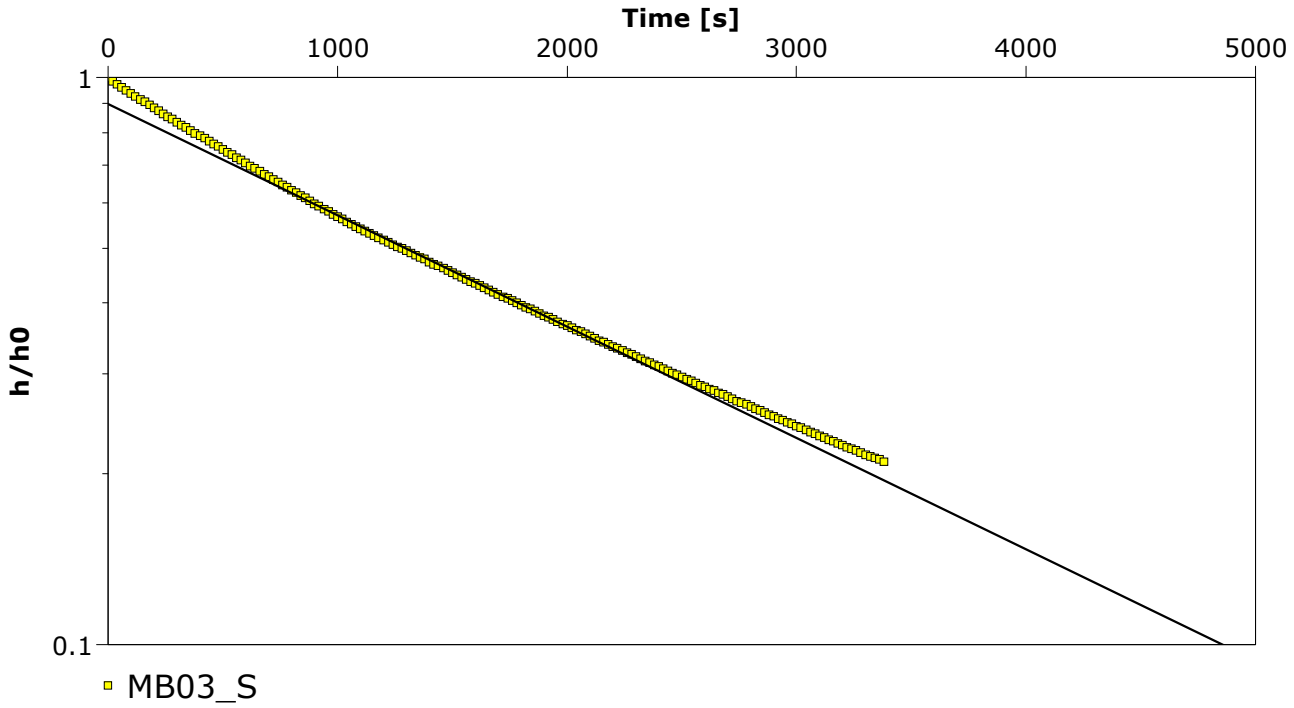


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB02_S	1.68×10^{0}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB03_S	Test Well: MB03_S
Test Conducted by: CV/CB		Test Date: 20/04/2013
Analysis Performed by: Chris	MB03_S	Analysis Date: 2/05/2013
Aquifer Thickness: 7.00 m		

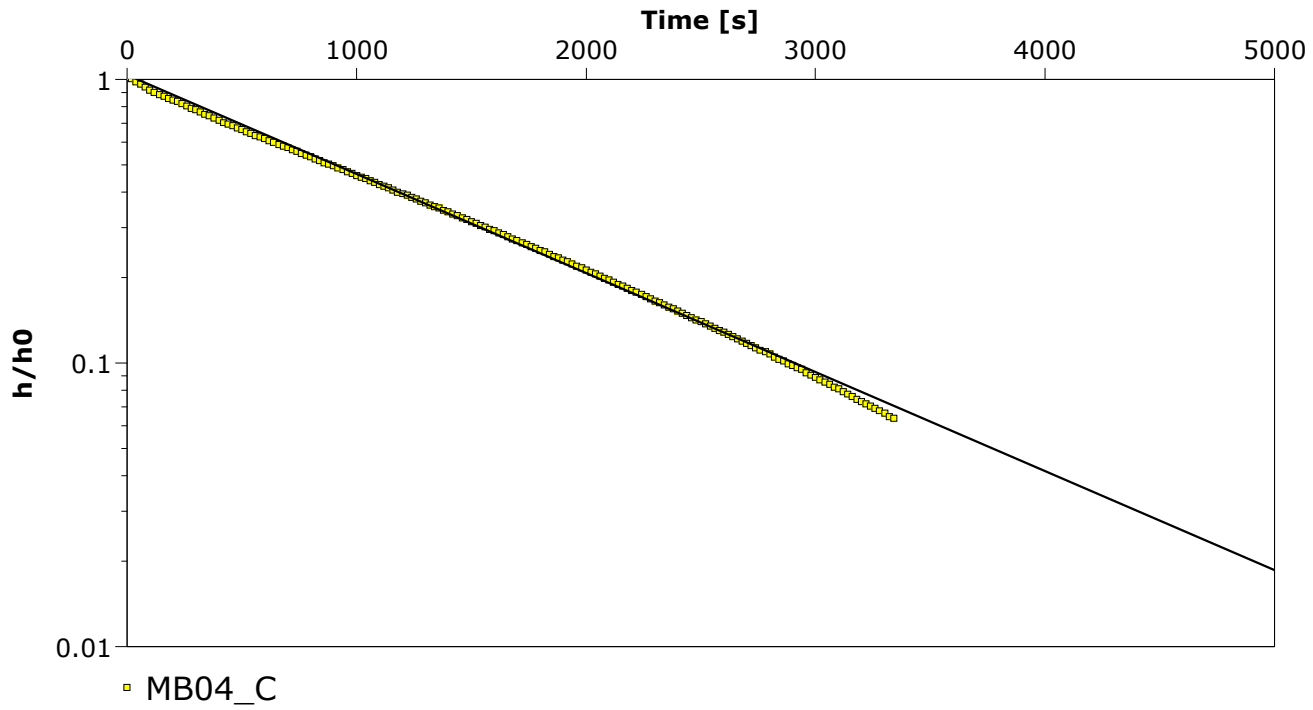


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB03_S	1.12×10^{-2}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB04_C	Test Well: MB04_C
Test Conducted by: CB/CV		Test Date: 26/04/2013
Analysis Performed by: Chris	MB04_C	Analysis Date: 3/05/2013
Aquifer Thickness: 2.00 m		

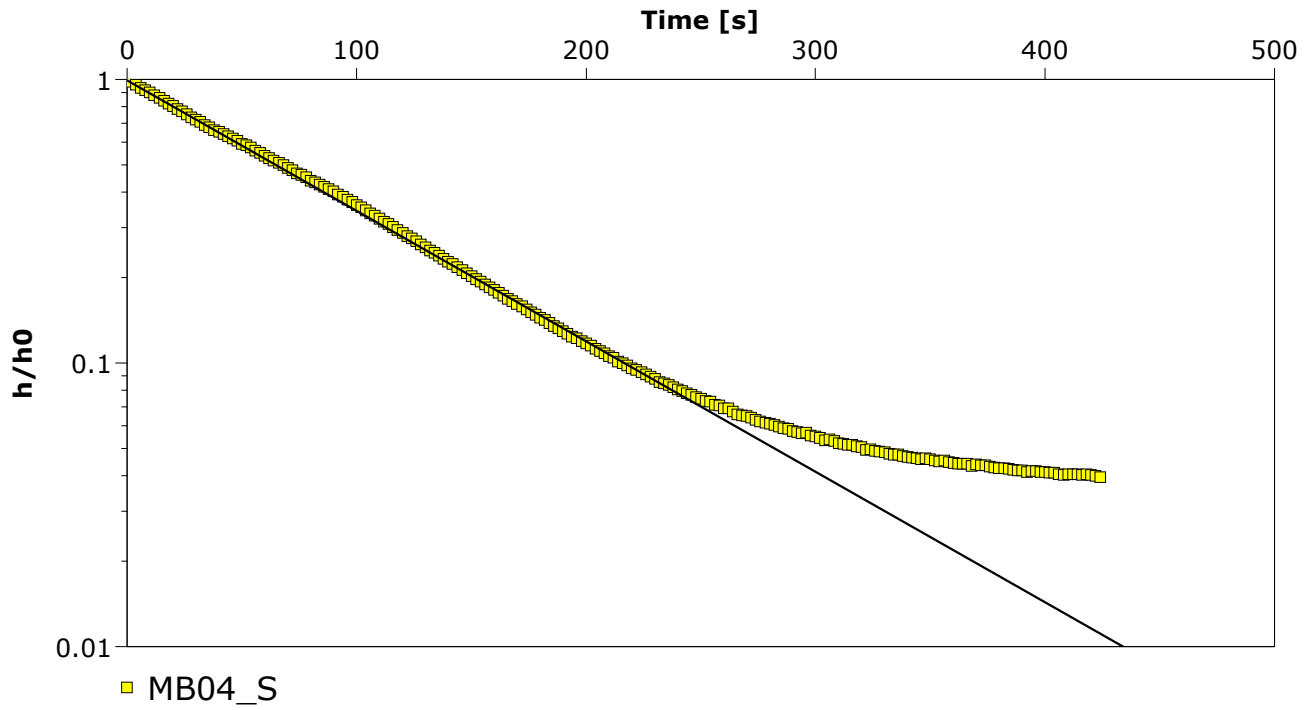


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB04_C	4.79×10^{-2}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB04_S	Test Well: MB04_S
Test Conducted by: CV/CB		Test Date: 25/04/2013
Analysis Performed by: Chris	MB04_S	Analysis Date: 2/05/2013
Aquifer Thickness: 56.00 m		

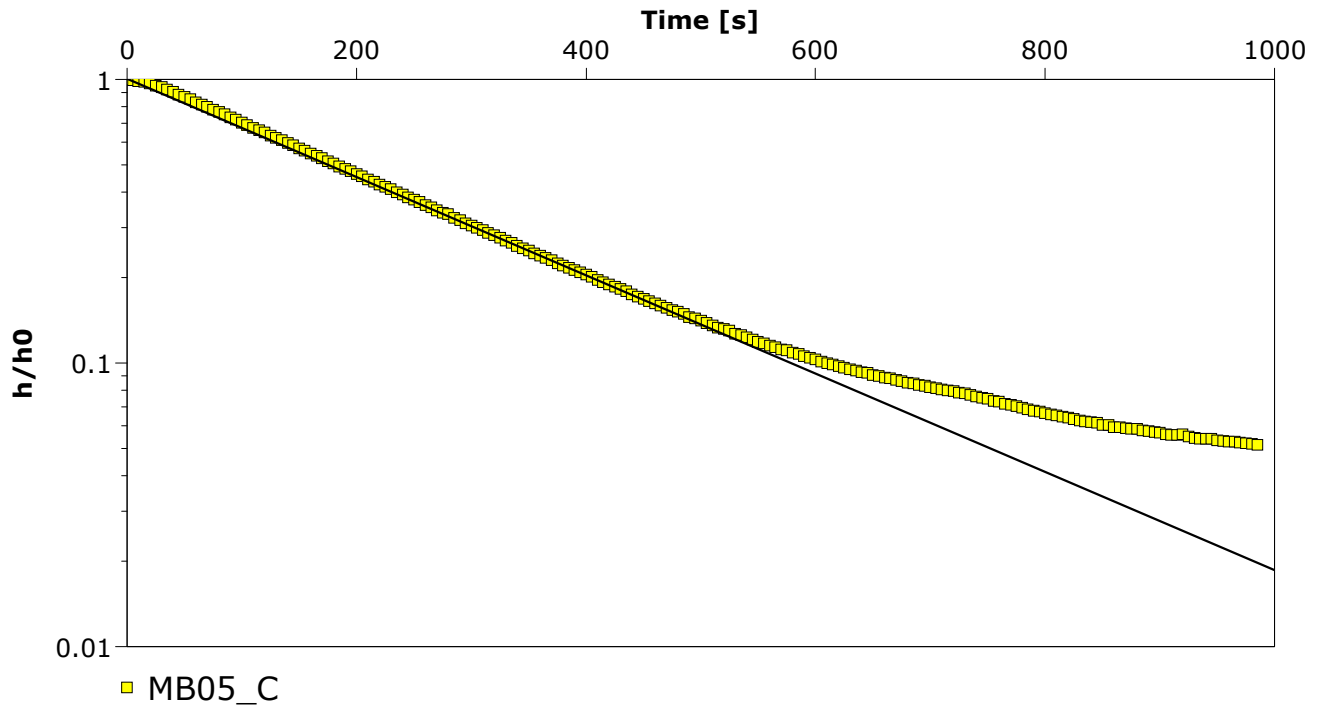


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB04_S	2.63×10^{-1}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB05_C	Test Well: MB05_C
Test Conducted by: CV/CB		Test Date: 21/04/2013
Analysis Performed by: Chris	MB05_C	Analysis Date: 3/05/2013
Aquifer Thickness: 2.00 m		

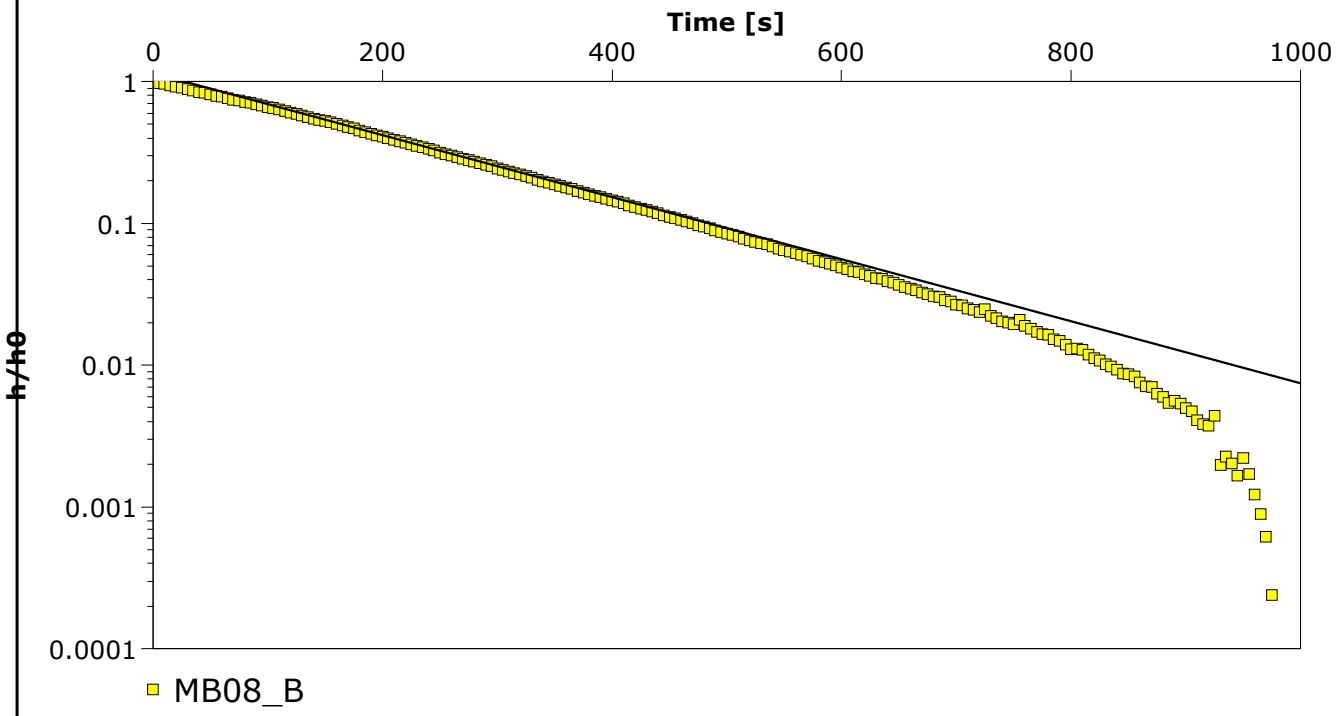


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB05_C	1.73×10^{-1}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB08_B	Test Well: MB08_B
Test Conducted by: CV/CB		Test Date: 19/04/2013
Analysis Performed by: Chris	MB08_B	Analysis Date: 3/05/2013
Aquifer Thickness: 22.00 m		

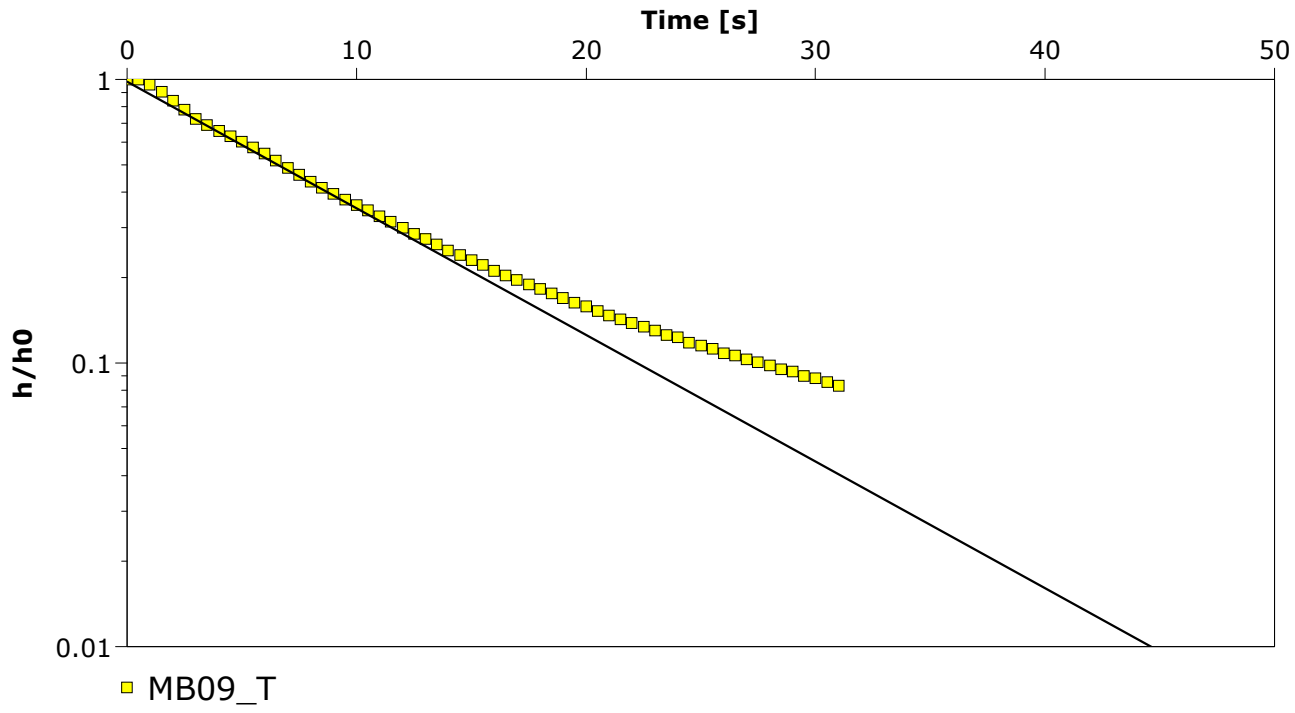


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB08_B	1.25×10^{-1}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB09_T	Test Well: MB09_T
Test Conducted by: CV/CB		Test Date: 19/04/2013
Analysis Performed by: Chris	MB09_T	Analysis Date: 2/05/2013
Aquifer Thickness: 14.00 m		

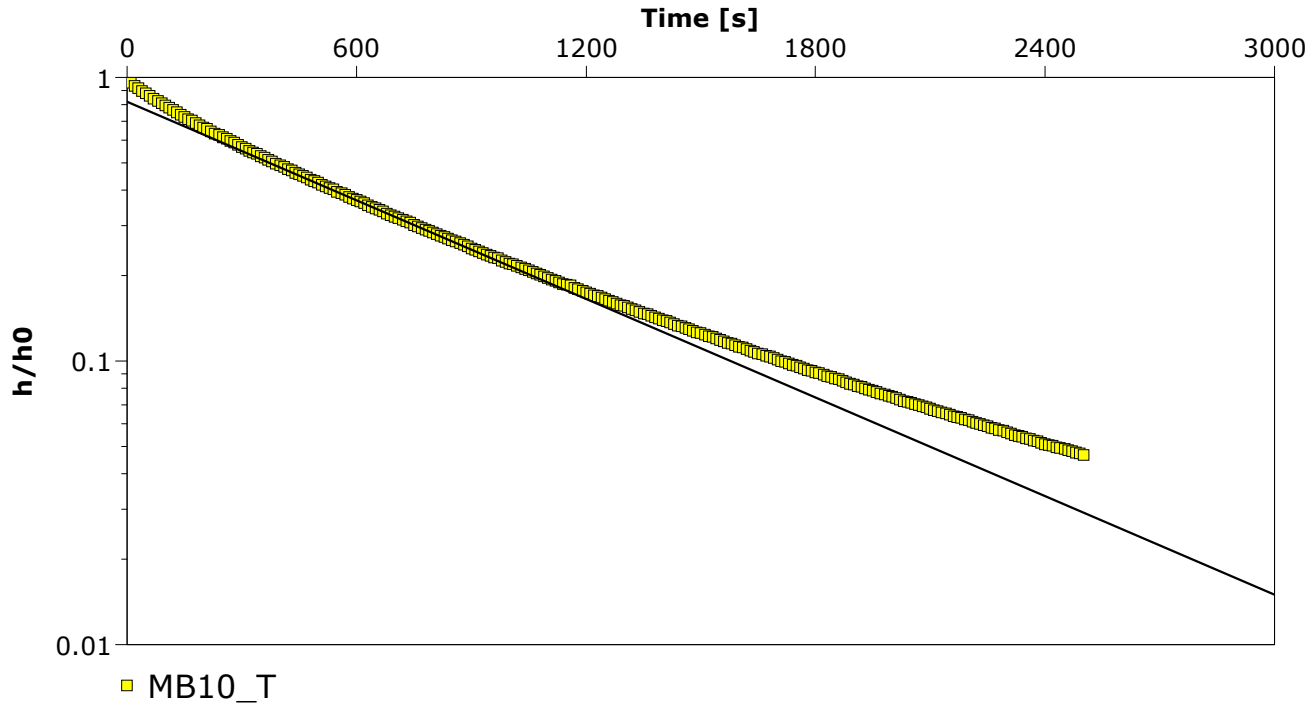


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB09_T	2.00×10^{0}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: MB10_T	Test Well: MB10_T
Test Conducted by: CV/CB		Test Date: 23/04/2013
Analysis Performed by: Chris	MB10_T	Analysis Date: 3/05/2013
Aquifer Thickness: 8.50 m		

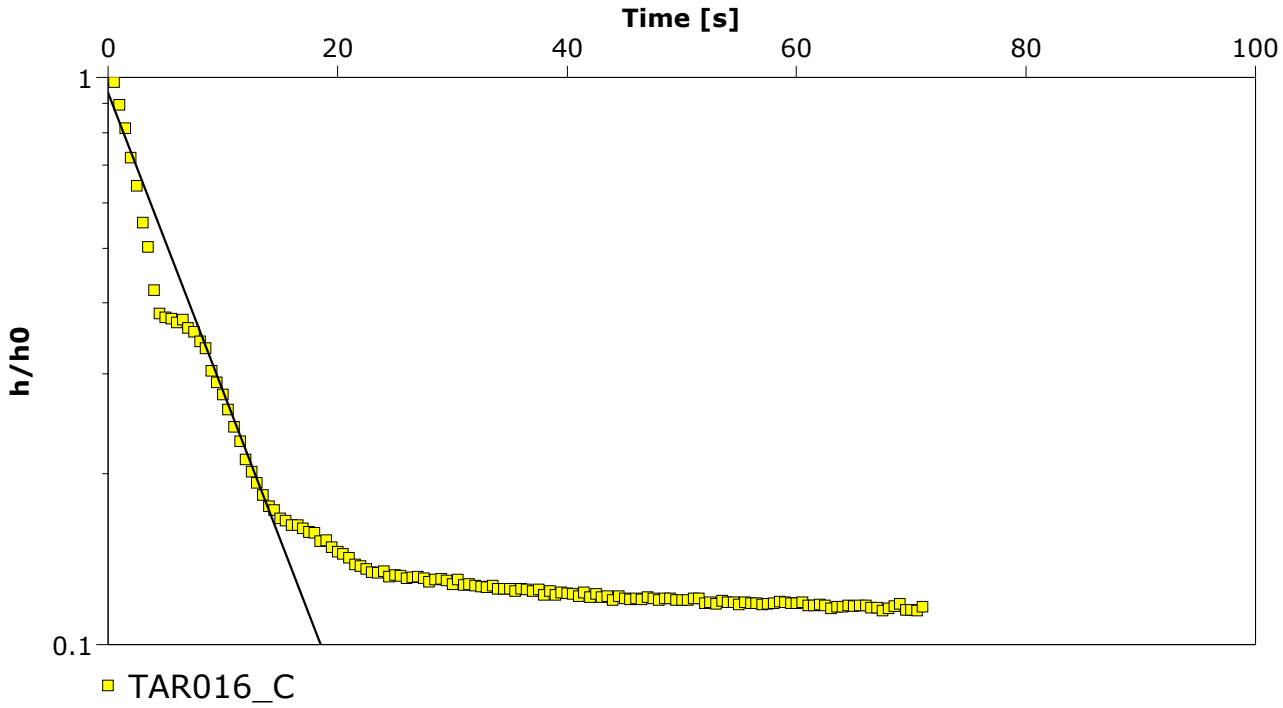


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB10_T	2.60×10^{-2}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: TAR016_CR	Test Well: TAR016_C
Test Conducted by: CV/CB		Test Date: 17/04/2013
Analysis Performed by: Chris	TAR016_C	Analysis Date: 3/05/2013
Aquifer Thickness: 20.00 m		

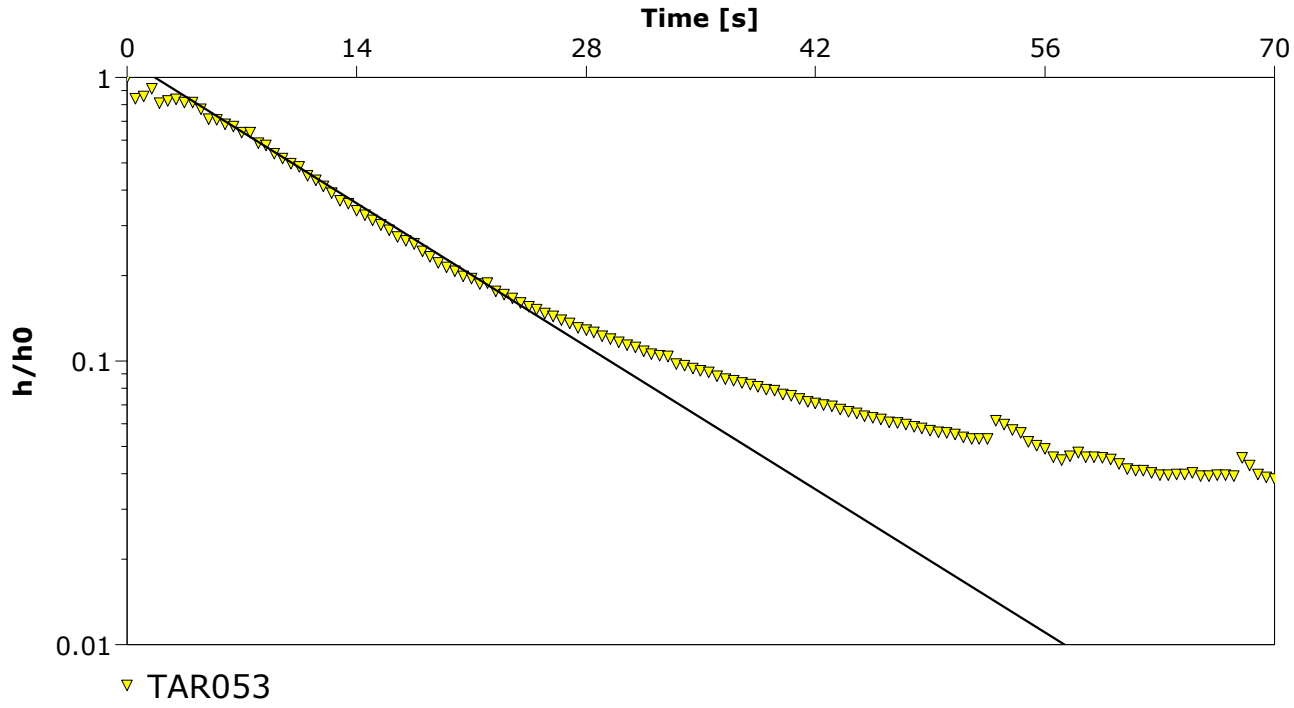


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
TAR016_C	3.00×10^{0}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: TAR053	Test Well: TAR053
Test Conducted by: CV/CB		Test Date: 3/05/2013
Analysis Performed by: Chris	TAR053	Analysis Date: 3/05/2013
Aquifer Thickness: 20.00 m		

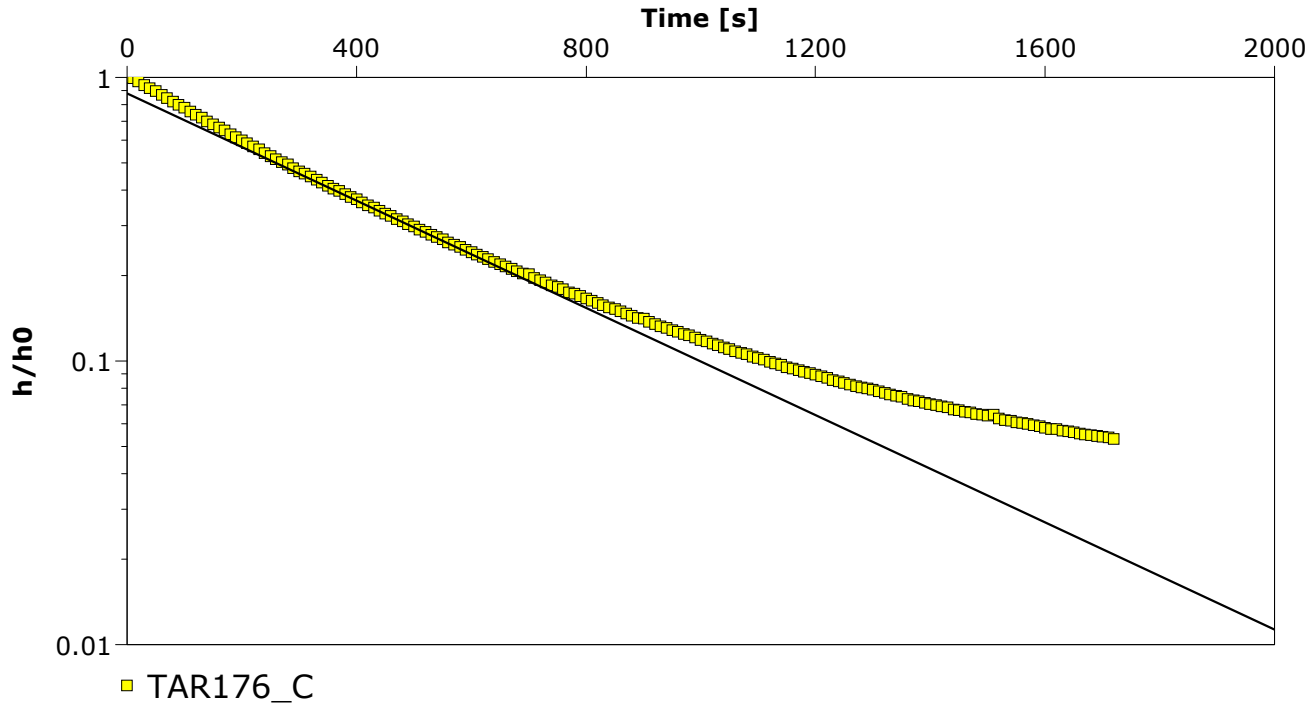


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
TAR053	9.10×10^{-1}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: TAR176_C	Test Well: TAR176_C
Test Conducted by: CV/CB		Test Date: 17/04/2013
Analysis Performed by: Chris	TAR176_C	Analysis Date: 3/05/2013
Aquifer Thickness: 20.00 m		

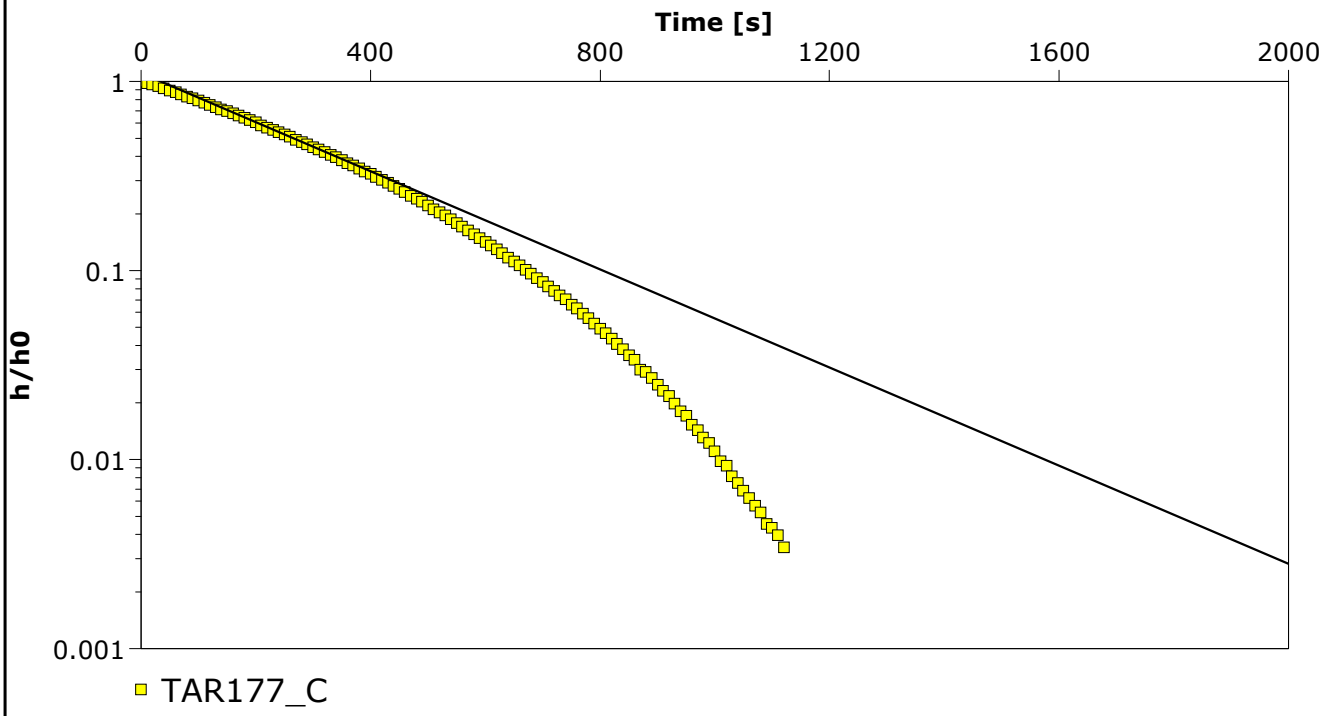


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
TAR176_C	5.40×10^{-2}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: TAR177_C	Test Well: TAR177_C
Test Conducted by: CV/CB		Test Date: 17/04/2013
Analysis Performed by: Chris	TAR177_C	Analysis Date: 3/05/2013
Aquifer Thickness: 20.00 m		

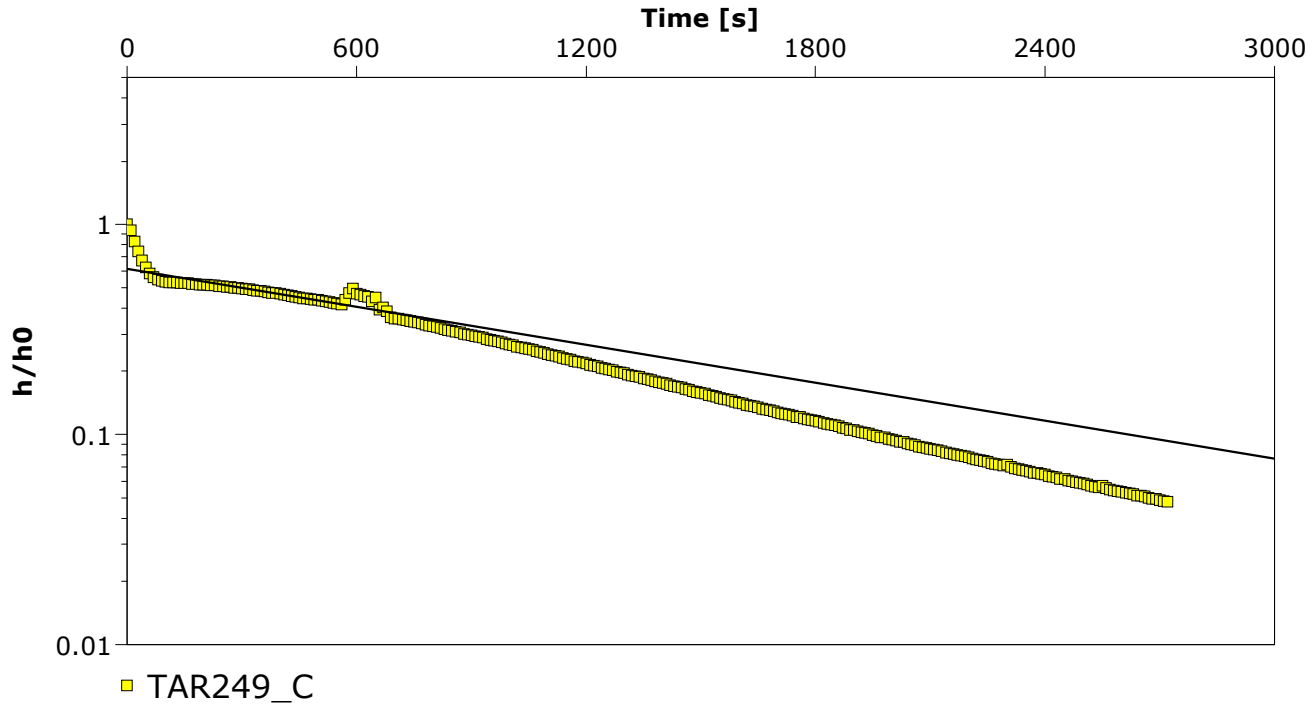


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
TAR177_C	1.30×10^{-1}	

AGE Consultants Level 2, 15 Mallon Street Bowen Hills, QLD 4006	**Slug Test Analysis Report**
	Project: Taroborah
	Number: G1588
	Client: AustralAsian Resource Consultants

Location: Taroborah	Slug Test: TAR249_C	Test Well: TAR249_C
Test Conducted by: CV/CB		Test Date: 20/04/2013
Analysis Performed by: Chris	TAR249_C	Analysis Date: 3/05/2013
Aquifer Thickness: 20.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
TAR249_C	3.00×10^{-2}	

Appendix A-4

LANDHOLDER BORE CENSUS SHEETS

Australasian Groundwater and Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, QLD 4006, Australia
Phone: 07 3257 2055 Mobile: 0438 341 727 Fax: 07 3257 2088

Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	DERM	Lot
Postal Address		Plan
Telephone		Property Name road reserve
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	13020220	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	600036	
Longitude	7402233	
Elevation	200	
Bore Status	Destroyed	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	N/A	
Diameter	-	
Artesian	-	
Bore Pump Details		
Frequency of use	N/A	
Typical pumping rate	-	
Purpose / Use of Bore	N/A	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- Bore has been destroyed
-

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Andrew Chapman	Lot
Postal Address		Plan
Telephone		Property Name Airlie Station
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	37769	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	596523	
Longitude	7387519	
Elevation	260 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	Pre - 1966	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Not equiped	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	Not in use	
Electrical Conductivity (µS/cm)	1267	
pH	7.19	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- According to Landholder the bore was low yielding
-

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Andrew Chapman	Lot
Postal Address		Plan
Telephone		Property Name Airlie Station
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	37770	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	592914	
Longitude	7386412	
Elevation	229 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	Pre - 1966	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Daily	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Jet pump	
Power supply	Petrol	
No. Stock on bore	200 - 300	
No. Of troughs	4 paddocks	
Storage type/volume	10,000 gallon tank	
Total depth of bore (m)	-	
Depth to water (m below ref)	1.29	
Height of Ref (m above groundlevel)	0.98	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

-

-

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Anakie Creek Bore	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	584863	
Longitude	7388596	
Elevation	262 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	Yes	
Date drilled/constructed	2006	
Depth at which water was struck (m)	12 m, 33 m	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	37 m	
Geological Formation Screened	-	
Bore Casing		
Material	PVC	
Diameter	125 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Never used	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	1.95	
Height of Ref (m above groundlevel)	0.75	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	Yes	

Comments

- Bore never equiped, back up bore
- Log available
- Likely screening Basalt

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Anakie tank bore	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	583773	
Longitude	7388873	
Elevation	268 m	
Bore Status	In Use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1996/97	
Depth at which water was struck (m)	35 ft	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	87 ft	
Geological Formation Screened		
Bore Casing		
Material	PVC	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Daily	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Submersible	
Power supply	Mono-line pump	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	110,000 L tank	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	In use	
Electrical Conductivity (µS/cm)	2115	
pH	7.6	
Temperature (^{o}C)	23.8	
Total Dissolved Solids (mg/L)	1404	
Drilling and construction records	No	

Comments

- Field reading taken from storage tank which bore feeds into.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Bore SW of Limestone	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	589127	
Longitude	7387106	
Elevation	235 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	2001/02	
Depth at which water was struck (m)	24.5	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	51.2	
Geological Formation Screened		
Bore Casing		
Material	PVC	
Diameter	125 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Monthly	
Typical pumping rate	500 gallons/hour	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Jack pump	
Power supply	Petrol motor	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Bull paddock bore	
QLD NRW registered number	44475	
QLD NRW water licence number		
Coordinate Datum	UTM Z55	
Latitude	583703	
Longitude	7390734	
Elevation	269 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	Pre - 1979	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	Estimated 120 ft	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use currently	
Typical pumping rate	-	
Purpose / Use of Bore	Stock watering	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	54.9	
Depth to water (m below ref)	2.9	
Height of Ref (m above groundlevel)	0.4	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Not in use at the moment although a submersible has been used in the past.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Cotton Seed Shed	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	587875	
Longitude	7387322	
Elevation	257 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	Yes	
Date drilled/constructed	26/01/2000	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	140 ft	
Geological Formation Screened	Bluestone (Basalt)	
Bore Casing		
Material	PVC	
Diameter	125 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	1700 Gallons/hour	
Purpose / Use of Bore	-	
Data Collected While On Site		
Pumping equipment	N/A	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	11.6	
Height of Ref (m above groundlevel)	0.4	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	Yes	

Comments

- Landholder didn't know that 103504 exists. He thought it was a failed abandoned bore.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Domestic bore	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	584132	
Longitude	7390174	
Elevation	275m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1986/87	
Depth at which water was struck (m)	40 ft	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	100 ft	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Daily	
Typical pumping rate	~500 gallons/hour	
Purpose / Use of Bore	Domestic supply	
Data Collected While On Site		
Pumping equipment	Submersible	
Power supply	Yes	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	7500 Gallon tank	
Total depth of bore (m)	-	
Depth to water (m below ref)	11.6m	
Height of Ref (above groundlevel)	0.32	
Pump status	In Use	
Electrical Conductivity (µS/cm)	1360	
pH	7.2	
Temperature (^{o}C)	27.3	
Total Dissolved Solids (mg/L)	845	
Drilling and construction records	No	

Comments

- When drilled water came up to 40 ft (WL), when in drought WL down to 70 ft.
- Casing 20 ft down to bluestone (Basalt) then open hole below that.
- Not used for drinking. Rainwater used for drinking.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	John Paul's Bore	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	587605	
Longitude	7386451	
Elevation	256 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1/02/1999	
Depth at which water was struck (m)	86 ft	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	128 ft	
Geological Formation Screened	-	
Bore Casing		
Material	PVC	
Diameter	125 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Weekly	
Typical pumping rate	940 Gallons/hour	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Submersible	
Power supply	Mono-line	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	7000 Gallon tank x3	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	In use	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Frequency of use dependent upon cattle. Sometimes daily, sometimes monthly.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Little Phil's bore	
QLD NRW registered number	44470	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	588108	
Longitude	7388433	
Elevation	258 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	Pre - 1979	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	54.3	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Never used	
Data Collected While On Site		
Pumping equipment	N/A	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	1.3	
Height of Ref (m above groundlevel)	0.1	
Pump status	N/A	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

-
-
-

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	444715	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	588060	
Longitude	7388392	
Elevation	260 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	Pre - 1979	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	91.4	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	125 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	N/A	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	0.55	
Height of Ref (m above groundlevel)	0.7	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Likely screening fractured Basalt, may have been drilled in 1900
- Probably will not be used again

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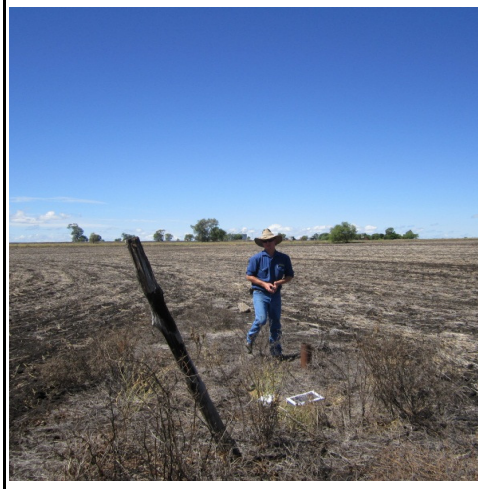
Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	N/A	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	583663	
Longitude	7390526	
Elevation	276 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	Pre - 1979	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	100 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Not in use	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	3.4	
Height of Ref (m above groundlevel)	0.35	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	



Comments

- Landholder plans to remove the bore

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Bore	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	583667	
Longitude	7389075	
Elevation	274 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	Pre - 1979	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	125 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Pump Jack	
Power supply	Yes	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	3.66	
Height of Ref (m above groundlevel)	0.15	
Pump status	Not in use	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Landholder may use bore in the future

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	16/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Ben Prewett	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Windmill well	
QLD NRW registered number	44474	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	583089	
Longitude	7391287	
Elevation	272 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	Pre - 1979	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Stock watering	
Data Collected While On Site		
Pumping equipment	None	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	12.2	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	20/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Bill Crowther	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Bottom Paddock Bore	
QLD NRW registered number	103908	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	589653	
Longitude	7403718	
Elevation	213 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	-	
Depth at which water was struck (m)	4 - 5 m	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	~18 m	
Geological Formation Screened	-	
Bore Casing		
Material	PVC	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	1 hour/day	
Typical pumping rate	5000 L/hr	
Purpose / Use of Bore	Stock water	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	Solar pannels/petrol	
No. Stock on bore	1000 breeding cows	
No. Of troughs	Many	
Storage type/volume	Feeds Turkeys nest	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	In use	
Electrical Conductivity (µS/cm)	1407	
pH	7.74	
Temperature (^{o}C)	23.5	
Total Dissolved Solids (mg/L)	942	
Drilling and construction records	No	

Comments

- Water feeds stock across whole property
- WQ from trough ~50 m away. Water quite greenish with moss/alge
- Pumps everyday, so difficult to estimate how stagnant the water has been.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	20/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Bill Crowther	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Kubota bore	
QLD NRW registered number	89387	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	-	
Longitude	-	
Elevation	-	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	-	
Date drilled/constructed	-	
Depth at which water was struck (m)	4 - 5	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	~18	
Geological Formation Screened	-	
Bore Casing		
Material	-	
Diameter	-	
Artesian	-	
Bore Pump Details		
Frequency of use	1 hour per day	
Typical pumping rate	2500 L/hr	
Purpose / Use of Bore	Stock watering	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	4 (2 more coming)	
Storage type/volume	2x 50,000 L tanks	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- Bore was not accessible. Track to the bore too muddy at creek crossing.
- The bore supplies ~1/3 of the farm.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Bob Ingram	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	47228	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	610828	
Longitude	7398058	
Elevation	214 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	Pre - 1979	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	-	
Data Collected While On Site		
Pumping equipment	Windmill (broken)	
Power supply	N/A	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	6.92 m	
Depth to water (m below ref)	Dry	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Not in use, unlikely to be in use in the future. Bore is dry and windmill broken.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	C.G. Fernie	Lot
Postal Address		Plan
Telephone		Property Name Yarrawonga
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	67303	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	595087	
Longitude	7394403	
Elevation	222 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	-	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	0.22	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

-

-

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	20/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Mike Walther	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Community Bore	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	599193	
Longitude	7396249	
Elevation	248 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1980's	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	405 ft	
Geological Formation Screened	-	
Bore Casing		
Material	Unable to see	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Daily	
Typical pumping rate	1000 Gallons/hour	
Purpose / Use of Bore	Domestic/Stock	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	Electrical	
No. Stock on bore	~150	
No. Of troughs	3	
Storage type/volume	Tank, ~50,000 L	
Total depth of bore (m)	-	
Depth to water (m below ref)	Unable to measure	
Height of Ref (m above groundlevel)	-	
Pump status	In use	
Electrical Conductivity (µS/cm)	997	
pH	7.45	
Temperature (^{o}C)	25.1	
Total Dissolved Solids (mg/L)	650	
Drilling and construction records	No	

Comments

- WQ readings from storage tank by lowering bailer down
- Stan Knight drilled the bore when he
- Cased down to ~380 ft, capable of pumping at 1700 Gallons/hour
- Plenty of water at ~280 ft but drilled further anyway

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Craig McCamley	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	47225	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	607229	
Longitude	7399101	
Elevation	208 m	
Bore Status	-	
Bore Construction Details	Could not locate	
Drilling and construction records available	N/A	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	-	
Diameter	-	
Artesian	-	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Not in use	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Could not locate a bore. There was a "turkey's nest" type depression a few hundred metres away.
- Landholder says it fills up with water occasionally, even when not raining. Possible spring?

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Craig McCamley	Lot
Postal Address		Plan
Telephone		Property Name Selma
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	47221	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	605177	
Longitude	7398398	
Elevation	233	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	9.66	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	-	
Data Collected While On Site		
Pumping equipment	Not equipped	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	9.66	
Depth to water (m below ref)	9.66 (dry)	
Height of Ref (m above groundlevel)	0.24	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- Bore was dry
-

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Craig McCamley	Lot
Postal Address		Plan
Telephone		Property Name Selma
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	47238	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	605840	
Longitude	7400508	
Elevation	207 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1975	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	78	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Twice weekly	
Typical pumping rate	-	
Purpose / Use of Bore	Domestic	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	Yes	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	7000 Gallon tank	
Total depth of bore (m)	-	
Depth to water (m below ref)	~20	
Height of Ref (m above groundlevel)	0.06	
Pump status	In use	
Electrical Conductivity (µS/cm)	506	
pH	7	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	21/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Dan McQuire	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	90250	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	588803	
Longitude	7398913	
Elevation	216 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	-	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	150 mm	
Artesian	-	
Bore Pump Details		
Frequency of use	-	
Typical pumping rate	-	
Purpose / Use of Bore	-	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	Petrol motor	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- Landholder was not present at the time of the visit, unable to attain information on bore use.
- No troughs nearby although could be pumping to turkeys nest at coordinates: 0588364 E, 7399246 N

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Government	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	13020071	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	609322	
Longitude	7399195	
Elevation	215 m	
Bore Status	DERM Bore	
Bore Construction Details		
Drilling and construction records available	-	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel surface casing	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Once a year	
Typical pumping rate	-	
Purpose / Use of Bore	Monitoring Bore	
Data Collected While On Site		
Pumping equipment	N/A	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- Old DERM monitoring bore, visited once a year.
- Bore locked so unable to take water level measurement.
- Water levels and construction details may be available from DERM website.

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Phone: 07 3257 2055 Mobile: 0438 341 727 Fax: 07 3257 2088

Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Government	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	13020086	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	609311	
Longitude	7399819	
Elevation	227 m	
Bore Status	DERM Bore	
Bore Construction Details		
Drilling and construction records available	-	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel surface casing	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Once a year	
Typical pumping rate	-	
Purpose / Use of Bore	Monitoring Bore	
Data Collected While On Site		
Pumping equipment	N/A	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- Old DERM monitoring bore, visited once a year.
- Bore locked so unable to take water level measurement.
- Water levels and construction details may be available from DERM website.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Government	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	13020090	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	607703	
Longitude	7400986	
Elevation	195 m	
Bore Status	DERM Bore	
Bore Construction Details		
Drilling and construction records available	-	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	N/A	
Typical pumping rate	N/A	
Purpose / Use of Bore	Monitoring Bore	
Data Collected While On Site		
Pumping equipment	N/A	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Old DERM monitoring bore, visited once a year.
- Bore locked so unable to take water level measurement.
- Water levels and construction details may be available from DERM website.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Government	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	13020107	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	609564	
Longitude	7401583	
Elevation	-	
Bore Status	DERM Bore	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	PVC	
Diameter	50 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	-	
Typical pumping rate	-	
Purpose / Use of Bore	Monitoring Bore	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	2.65	
Height of Ref (m above groundlevel)	0.15	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Old DERM monitoring bore, visited once a year.
- Water levels and construction details may be available from DERM website.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel		
Landholder Details		**Property Details**
Name	Hewitt	Lot
Postal Address		Plan
Telephone		Property Name Fork Lagoon
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Air strip well	
QLD NRW registered number	47323	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	595100	
Longitude	7410014	
Elevation	212 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	Yes	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	8.9	
Geological Formation Screened	Alluvium	
Bore Casing		
Material	Concrete	
Diameter	950 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Daily in summer	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Jet pump	
Power supply	yes	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	4.5	
Height of Ref (m above groundlevel)	0.7	
Pump status	In use	
Electrical Conductivity (µS/cm)	2170	
pH	10.6	
Temperature (^{o}C)	25	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- Large well, water level visible from surface.
- Water quality taken from stagnant trough so may not be accurate
- Logger installed

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		FL3
AGE Personnel		
Landholder Details		**Property Details**
Name	Hewitt	Lot
Postal Address		Plan
Telephone		Property Name Fork Lagoon
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Laneway well	
QLD NRW registered number	47322	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	591443	
Longitude	7410299	
Elevation	219 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	Yes	
Date drilled/constructed	1973	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	8.88	
Geological Formation Screened	Alluvium	
Bore Casing		
Material	Concrete	
Diameter	914 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Windmill	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	3.8	
Height of Ref (m above groundlevel)	0.23	
Pump status	Not in use	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- Large well, water level visible from surface. Well is not used and the windmill is damaged
- Logger Installed

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Francis Sypher	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Back of house	
QLD NRW registered number	103728	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	602849	
Longitude	7400245	
Elevation	221 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	Yes	
Date drilled/constructed	2003	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	~476 m	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Daily	
Typical pumping rate	Unknown	
Purpose / Use of Bore	Cattle drinking water	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	yes	
No. Stock on bore	100 - 150	
No. Of troughs	4-May	
Storage type/volume	Tank ~50,000 L	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	In use	
Electrical Conductivity (µS/cm)	2533	
pH	7.96	
Temperature (^{o}C)	29	
Total Dissolved Solids (mg/L)	1527	
Drilling and construction records	Yes	

Comments

- Salinity too high for domestic drinking water
- Struck water in sandstone
- Field WQ readings from trough ~100 m away. Trough fed from storage tank so not ideal
- Photos of drill logs available

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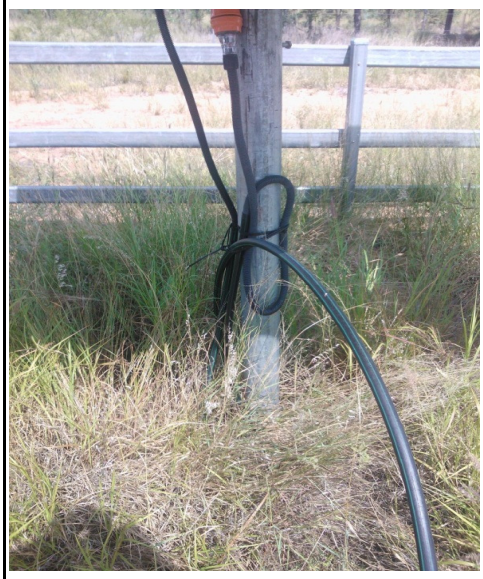
Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Francis Sypher	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	103729	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	600681	
Longitude	7399512	
Elevation	225 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	Yes	
Date drilled/constructed	2003	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	140 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Daily	
Typical pumping rate	-	
Purpose / Use of Bore	Stock water	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	Solar pannels	
No. Stock on bore	50 - 100	
No. Of troughs	1	
Storage type/volume	~20,000 L tank	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	In use	
Electrical Conductivity (µS/cm)	2792	
pH	7.25	
Temperature (^{o}C)	28.3	
Total Dissolved Solids (mg/L)	1703	
Drilling and construction records	Yes	



Comments

- Photo of drill logs available
- WQ field parameters taken from trough ~50 m from bore, fed from small storage tank

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	20/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Jan & Gavin Mestrez	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	37737	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	599917	
Longitude	7389456	
Elevation	216 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	~1950s	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	-	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Not in use	
Data Collected While On Site		
Pumping equipment	Windmill (broken)	
Power supply	N/A	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Windmill broken, turns but not connected to pipes
- Unable to see casing. Buried?
- Storage tanks nearby but not used
- Bore was used before dam was put in 60 years ago.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	John Prewitt	Lot
Postal Address		Plan
Telephone		Property Name Glendarriwell
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	44473	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	583654	
Longitude	7389078	
Elevation	273 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	130 ft	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	5"	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	150 gallons/hour	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

-

-

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	John Walters	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	67302	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	598517	
Longitude	7395249	
Elevation	247	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	-	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- No bore found
- PL4? 10m from location of 67302, no bore found

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Kenneth Cross	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Bore at Road	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	584393	
Longitude	7392258	
Elevation	255 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1998	
Depth at which water was struck (m)	~8 ft	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	~35 m	
Geological Formation Screened	-	
Bore Casing		
Material	PVC	
Diameter	125 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	When needed	
Typical pumping rate	-	
Purpose / Use of Bore	Stock/Spray rigs	
Data Collected While On Site		
Pumping equipment	Submersible	
Power supply	Jet pump	
No. Stock on bore	up to 100	
No. Of troughs	4	
Storage type/volume	10,000 Gallons total	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	In use	
Electrical Conductivity (µS/cm)	786	
pH	8.03	
Temperature (^{o}C)	28.1	
Total Dissolved Solids (mg/L)	481	
Drilling and construction records	No	

Comments

- 1500 Gallons/hour when pumping at full rate
- Nearby creek with water in it
- WL ~3 ft down according to landholder
- WQ parameters from storage tank ~200 m away

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Kenneth Cross	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Railway Paddock Bore	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	587049	
Longitude	7394528	
Elevation	257 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1998	
Depth at which water was struck (m)	~30, 80 and 100 ft	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	~130 ft	
Geological Formation Screened	Basalt	
Bore Casing		
Material	Steel	
Diameter	125 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Daily	
Typical pumping rate	250 Gallons/hour	
Purpose / Use of Bore	Stock and domestic	
Data Collected While On Site		
Pumping equipment	Windmill	
Power supply	N/A	
No. Stock on bore	~100	
No. Of troughs	4	
Storage type/volume	2x5000 Gallon tanks	
Total depth of bore (m)	-	
Depth to water (m below ref)	8.52	
Height of Ref (m above groundlevel)	0.22	
Pump status	in Use	
Electrical Conductivity (µS/cm)	1417	
pH	6.8	
Temperature (^{o}C)	29.9	
Total Dissolved Solids (mg/L)	845	
Drilling and construction records	No	

Comments

- Lots of water at ~80 ft, but went further and got even more water
- 2" pipe and 4" pump down hole
- Sample from pressure tank, so good representation of aquifer

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Mark Hampton	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	13020097	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	607251	
Longitude	7401603	
Elevation	191 m	
Bore Status	DERM bore	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1993	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	150 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Once a year	
Typical pumping rate	-	
Purpose / Use of Bore	Monitoring bore	
Data Collected While On Site		
Pumping equipment	No	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

- Old DERM monitoring bore, visited once a year.
- Bore locked so unable to take water level measurement.
- Water levels and construction details may be available from DERM website.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	21/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	Mark Payton	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	57649	
QLD NRW water licence number	-	
Coordinate Datum	-	
Latitude	-	
Longitude	-	
Elevation	-	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	-	
Date drilled/constructed	1980s	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	-	
Diameter	-	
Artesian	-	
Bore Pump Details		
Frequency of use	Not in use	
Typical pumping rate	-	
Purpose / Use of Bore	Not in use	
Data Collected While On Site		
Pumping equipment	-	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- According to the landholder, the bore went dry and is not used any more.
- Landholder has details of the bore, however these were not available at the time.

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Morrey Iddles	Lot
Postal Address		Plan
Telephone		Property Name Nogoa Downs
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Clyde's Yard	
QLD NRW registered number	57602	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	605902	
Longitude	7391555	
Elevation	193 m	
Bore Status	Not in Use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1901	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	~45	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	-	
Typical pumping rate	-	
Purpose / Use of Bore	Not in Use	
Data Collected While On Site		
Pumping equipment	Windmill (broken)	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

-
-

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Morrey Iddles	Lot
Postal Address		Plan
Telephone		Property Name Nogoa Downs
Mobile		
Bore Identification		**Photographs**
Landholder bore name	-	
QLD NRW registered number	57603	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	600739	
Longitude	7393663	
Elevation	214 m	
Bore Status	In Use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1901	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	~80	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Stock	
Typical pumping rate	-	
Purpose / Use of Bore	-	
Data Collected While On Site		
Pumping equipment	Windmill	
Power supply	-	
No. Stock on bore	170+	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	5.48	
Height of Ref (m above groundlevel)	0.46	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

- Windmill broken
- Unable to take a water sample

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Stan Knight	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Camp Bore	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	594281	
Longitude	7397364	
Elevation	249 m	
Bore Status	Not in use	
Bore Construction Details		
Drilling and construction records available	-	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	-	
Typical pumping rate	-	
Purpose / Use of Bore	-	
Data Collected While On Site		
Pumping equipment	Not equipped	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	43.52	
Height of Ref (m above groundlevel)	0.14	
Pump status	-	
Electrical Conductivity (µS/cm)	-	
pH	-	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Stan Knight	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	House bore	
QLD NRW registered number	90064	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	596819	
Longitude	7396888	
Elevation	248 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	early 1990s	
Depth at which water was struck (m)	180 - 200 ft	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	300 ft	
Geological Formation Screened	-	
Bore Casing		
Material	PVC	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	5 hours/day	
Typical pumping rate	1000 gallons/hour	
Purpose / Use of Bore	Stock and domestic	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	Yes	
No. Stock on bore	400	
No. Of troughs	-	
Storage type/volume	tank at home	
Total depth of bore (m)	-	
Depth to water (m below ref)	-	
Height of Ref (m above groundlevel)	-	
Pump status	In use	
Electrical Conductivity (µS/cm)	1904	
pH	7.44	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	No	

Comments

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Stan Knight	Lot
Postal Address		Plan
Telephone		Property Name Iona Station
Mobile		
Bore Identification		**Photographs**
Landholder bore name	The Swamp	
QLD NRW registered number	67349	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	592950	
Longitude	7400839	
Elevation	215 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	-	
Depth at which water was struck (m)	-	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	-	
Geological Formation Screened	-	
Bore Casing		
Material	PVC	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	Every 2 or 3 days	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	Petrol	
No. Stock on bore	400	
No. Of troughs	-	
Storage type/volume	5000 L tank	
Total depth of bore (m)	-	
Depth to water (m below ref)	8.46	
Height of Ref (m above groundlevel)	0.63	
Pump status	In use	
Electrical Conductivity (µS/cm)	1602	
pH	7.28	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date		
AGE Personnel	Thomas Muehe	
Landholder Details		**Property Details**
Name	Stan Knight	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Twin Bore	
QLD NRW registered number	-	
QLD NRW water licence number	-	
Coordinate Datum	WGS 84	
Latitude	591671	
Longitude	7399335	
Elevation	211 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	2004/05	
Depth at which water was struck (m)	~120 ft	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	~150 ft	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	-	
Artesian	No	
Bore Pump Details		
Frequency of use	In drought only	
Typical pumping rate	-	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Not equipped	
Power supply	-	
No. Stock on bore	-	
No. Of troughs	-	
Storage type/volume	-	
Total depth of bore (m)	-	
Depth to water (m below ref)	19.27	
Height of Ref (m above groundlevel)	0.27	
Pump status	-	
Electrical Conductivity (µS/cm)	7286	
pH	6.97	
Temperature (^{o}C)	-	
Total Dissolved Solids (mg/L)	-	
Drilling and construction records	-	

Comments

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Groundwater Bore Census

Client	AARC	**Client Bore Reference**
Census Date	19/04/2013	
AGE Personnel	Craig Vincent	
Landholder Details		**Property Details**
Name	William Hatte	Lot
Postal Address		Plan
Telephone		Property Name
Mobile		
Bore Identification		**Photographs**
Landholder bore name	Gun Club Bore	
QLD NRW registered number	47217	
QLD NRW water licence number	-	
Coordinate Datum	UTM Z55	
Latitude	581765	
Longitude	7395658	
Elevation	249 m	
Bore Status	In use	
Bore Construction Details		
Drilling and construction records available	No	
Date drilled/constructed	1970 - 1975	
Depth at which water was struck (m)	~2 m (estimated)	
Airlift yield at time of drilling (L/s)	-	
Total depth of bore (m)	~40 ft (estimated)	
Geological Formation Screened	-	
Bore Casing		
Material	Steel	
Diameter	125 mm	
Artesian	No	
Bore Pump Details		
Frequency of use	Daily	
Typical pumping rate	400 Gallons/hour	
Purpose / Use of Bore	Stock	
Data Collected While On Site		
Pumping equipment	Submersible pump	
Power supply	Electrical	
No. Stock on bore	~500	
No. Of troughs	7 - 8 km of pipeline	
Storage type/volume	~10,000 Gallon tank	
Total depth of bore (m)	-	
Depth to water (m below ref)	4.08	
Height of Ref (m above groundlevel)	0.45	
Pump status	In use	
Electrical Conductivity (µS/cm)	1580	
pH	7.28	
Temperature (^{o}C)	27.9	
Total Dissolved Solids (mg/L)	975	
Drilling and construction records	No	

Comments

- Old windmill equipment still in place above bore
- Basalt boulders at surface, bore likely screening fractured Basalt
- Water quality from storage tank
- Some standing water in Creek nearby

Appendix B

NUMERICAL MODEL – DEVELOPMENT & ASSUMPTIONS

1 MODEL DEVELOPMENT

1.1 Model Code

The modelling code was selected to meet the model objectives. Numerical simulation of groundwater flow for the Project was undertaken using the MODFLOW-SURFACT code (referred to as SURFACT for the remainder of the report). A commercial derivative of the standard MODFLOW code, SURFACT is distributed by HGL and has some distinct advantages over MODFLOW; advantages that are critical for the simulation of groundwater flow for the Project.

The MODFLOW code (on which SURFACT is based) is the most widely used code for groundwater modelling in Australia, and is considered an industry standard. Use of the SURFACT modelling package is becoming increasingly widespread, particularly in mining applications where groundwater dewatering and recovery are simulated.

First and foremost, SURFACT is capable of simulating unsaturated conditions. This is critical for the requirements of the Project where coal seams will be progressively dewatered with time until the end of mining when active dewatering will cease and groundwater recovery will occur. SURFACT is also supplied with more robust numerical solution schemes and an adaptive time-stepping function that aides the progression of the solution past difficult and complex numerical situations.

The input files for the SURFACT model were created using Fortran code and a special SURFACT edition of the Groundwater Data Utilities (Watermark Numerical Computing, 2012)[1]. These were used to allow for the additional capabilities of SURFACT that are not available through any commercial pre- or post-processor.

1.2 Modelling Approach

The methodology for predicting impacts associated with the Project involves the construction and calibration of an appropriate three-dimensional groundwater flow model and then using the model to predict changes to the groundwater regime resulting from the proposed coal mining activities.

SURFACT does not allow for the modification of hydraulic conductivity parameters with time. This modification is required for the Project to represent the development of subsidence and the mine void/spoil as mining progresses. A simplified iterative approach was applied involving running the model in annual time frames, applying the final water level conditions from the previous run as the initial conditions for the subsequent run, and adjusting the hydraulic conductivity parameters at the start of each run.

[1] Watermark Numerical Computing, (2012), *"Pest Model-Independent Parameter Estimation & Uncertainty Analysis"*, www.pesthomepage.org

1.3 Set-up and Assumptions

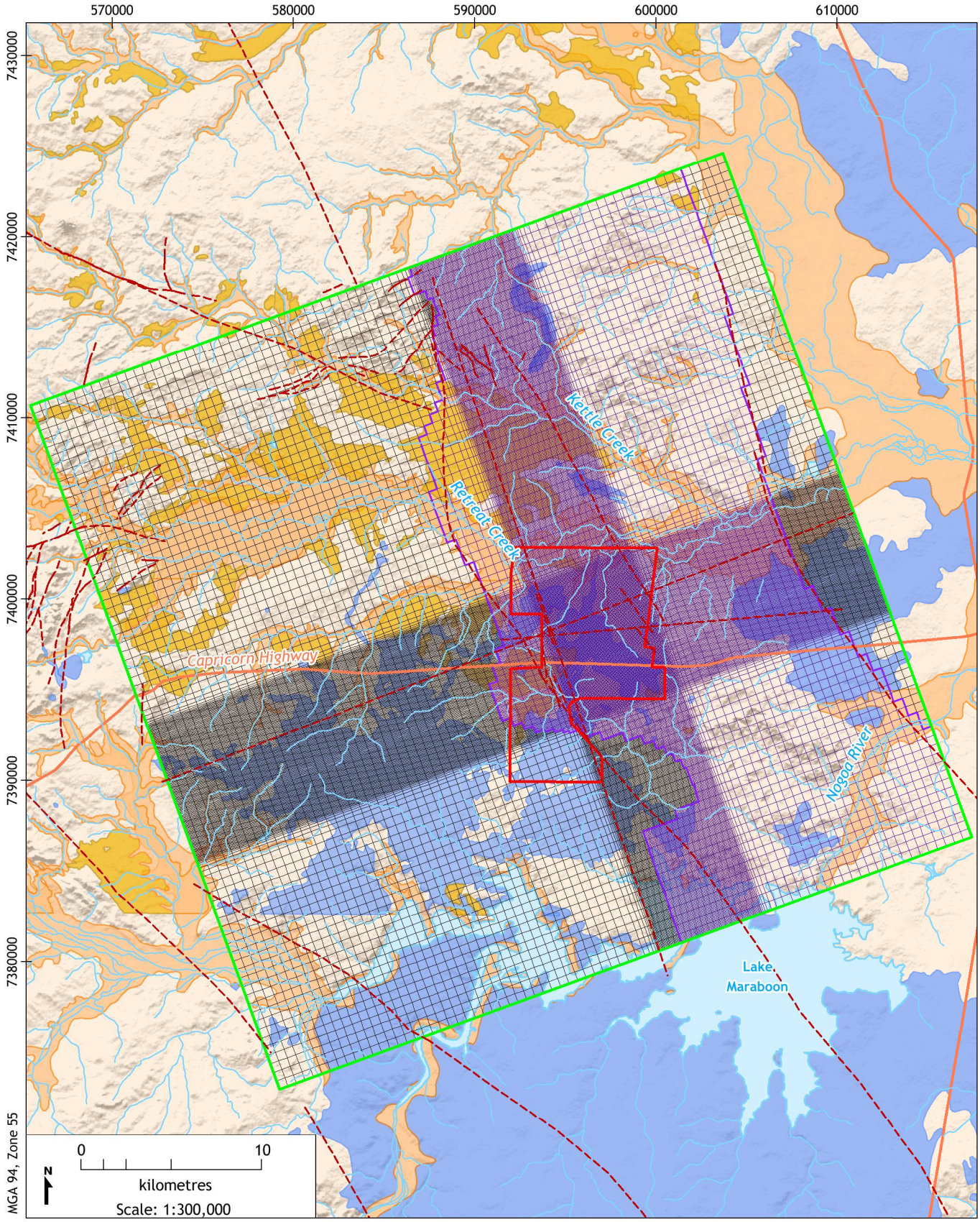
1.3.1 Model Geometry and Cell Size

The regional boundaries of the model are detailed below and shown on Figure B-1:

- Eastern Boundary – mapping of the basement geology shows a major northwest-southeast trending fault located approximately 9 km east of the Project area. Government exploration logs and government geological reports (Veevers, 1962)[2] indicate a major structural displacement, with an upthrown block of Triassic sediments on the eastern side.
- Western Boundary – mapping of the basement geology shows that Carboniferous and Devonian igneous complex dominates the western boundary, mapped from 5 km west of the Project area. The western boundary was extended out approximately 20 km from the Project area, in order to encompass the western extent of the mapped Tertiary basalts (Anakie 1:100,000 map and Rubyvale 1:100,000 map).
- Northern Boundary – the Kettle Creek Fault structure is located approximately 10 km north of the Project area, which displaces stratigraphy by up to 250 m, with the lower sequences (Reids Dome Beds) near surface north of Kettle Creek.
- Southern Boundary – located over 14 km south of the Project area, the southern boundary is based on a mapped structural variation (Bowen Basin geology); which, according to government exploration logs (Denison series), has an upthrown block on the southern side.

The model extends approximately 40 km from east to west, and 40 km from north to south, covering a total area of 1640 km^2. The model domain was discretised into 230 rows and 197 columns. The horizontal dimension of the model cells varies from 500 m x 500 m at the margins of the model domain, reducing to 50 m x 50 m within the proposed mine area. The active cell count for Layers 1 and 2 is 45,310 cells per layer, and for Layers 3 to 10, it is 33,180 active cells per layer.

[2] Veevers J.J., (1962), "*The geology of the Emerald 1:250,000 sheet area", Queensland,* Report 68, Bureau of Mineral Resources, Geology and Geophysics, Canberra.



LEGEND:

- MDL Boundary
- Inactive Cell - Layers 3 - 10
- Active Cell
- Lake
- Watercourse
- Highway

1:100,000 Geology (Anakie & Rubyvale)

- Qa - Quaternary Alluvium
- Tb - Tertiary Basalt
- Fault

Taroborah Coal Project
Groundwater Assessment (G1588)

Model Domain

DATE: 26/9/2014

FIGURE No: **B-1**

1.3.2 Layers

Ten layers are represented in the model and these are summarised below in Table B-1. These layers were interpolated from regional stratigraphic horizons, and are considered appropriate for this level of study.

Table B-1: MODEL LAYERS

Model Layer	Hydrostratigraphy
1	Regolith / Alluvium
2	Tertiary regolith (clay)
3	Weathered Aldebaran Sandstone
4	Fine grained sandstone – Aldebaran Sandstone
5	Fine grained sandstone – Aldebaran Sandstone
6	Coarse grained sandstone – Aldebaran Sandstone
7	Seam A – Aldebaran Sandstone
8	Interburden – Aldebaran Sandstone
9	Seam B – Aldebaran Sandstone
10	Basal Sediments – Aldebaran Sandstone

The Taroborah Mine geological model surfaces were provided for the base of Tertiary basalt, base of weathering (base Layer 3), base of the fine grained sandstone, base of the coarse grained sandstone, base of Seam A and the base of Seam B. Beyond the extent of the available mine data, the structure of the representative layers was interpolated from 1:100,000 geological mapping, historic geological reports (i.e. Denison Trough), geological data recorded for registered bores, and available drill logs from the Geological Survey of Queensland (Denison and Plantagent bores).

The numerical model has used regional scale faults and structural domains to provide the basis for the model extent. These are based upon the above referenced and publically available reports and mapping. As these regional scale faults and structural domains are at the boundary extents of the model domain, these are discussed briefly in terms of model development.

Within the project area, the Proponent has defined a graben (fault bound) structure in which the coal measures are to be mined. These faults have been defined through project specific seismic data, detailed exploration drilling and State Government drilling and mapping. A conservative approach has been developed to simulate this graben structure. Rather than defining linear fault features in the model, drape features have been implemented with layer hydraulic continuity on either side of the mapped fault. Therefore, there is modelled hydraulic connectivity on either side of these faults rather than simulating them as impermeable barriers. The coal seams have then been simulated to pinch out to the east and west of the respective bounding faults, as they do not exist in this region. The basis for pinching out the coal strata (model layers) is based upon regional drilling data. This approach was adopted as it is expected to provide a conservative overestimate of the extent of depressurisation outside the fault bounded blocks, and therefore represents a likely worst case scenario.

1.3.3 Staged Timing and Stress Periods

A steady state and historic transient model was run in order to establish starting heads within the predictive model. The steady state model was run to simulate pre-mining starting head conditions.

The predictive model was set up with quarterly stress periods (91.3 days), commencing from the commencement of open-cut mining (January 2018). The model simulated mining (dewatering of mine cells) on a quarterly basis until the end of mining. The transient model is run for a 21-year time period.

At the end of each year, the predictive model was stopped and aquifer parameters in the recently mined areas changed to represent the spoil emplacement in the pit. These changes were required to represent the resultant increase in the hydraulic conductivity, storage and recharge rate to the spoil. Once the open-cut pits were complete, voids were simulated using high hydraulic conductivity and storage values at Year 4 (western void) and Year 8 (eastern void). Stage period length and the effects of goafing were applied at the completion of each individual longwall panel. Stages varied from 12 months to 16 months, according to the current mining schedule.

1.3.4 Recharge and Discharge

Groundwater recharge was estimated based on the “Method of last resort (MOLR)” available as on-line dataset (http://www.csiro.au/products/Recharge-Discharge-Estimation-Suite). This method is based on chloride mass balance (CMB) calculation in conjunction with knowledge of soil type and vegetation type in a particular location. Three distinct recharge zones were assessed:

- Alluvium, which exhibits a low recharge rate of 0.8 mm/year to 2.8 mm/year (approximately 0.13% to 0.35% of annual rainfall);
- Regolith, which exhibits recharge rates of 0.83 mm/year to 1.35 mm/year (0.13% to 0.22% annual rainfall); and
- Weathered basalt, which exhibits recharge rates of around 2.1 mm/year (approximately 0.34% annual rainfall).

The potentiometric contours from the Permian Aldebaran Sandstone indicate potential recharge from either of the following two sources:

- downward percolation from Quaternary alluvium associated with Retreat Creek; or
- graben related fault leakage from the western fault zone.

Specific recharge zones for these potential processes were not included in the model development. Aside from geological mapping of the fault and the potentiometric contours, there is no hydrogeological data to support the assumption of additional recharge occurring at the surface expression of the fault. Furthermore, the model does not specifically represent any fault within the model domain and infers lateral connectivity in these areas.

With regards to downward percolation from the Quaternary alluvium to the Permian strata, the model layers represent some degree of hydraulic connection between these units via the application of vertical hydraulic conductivity.

The MOLR estimates are a high level assessment of potential recharge rates in an area and act as a guide for establishing localised recharge rates. Figure B-2 illustrates the range in recharge (as a percentage of annual rainfall) by CMB analysis (using field data), high-level MOLR analysis, and the recharge values used within the numerical calibration model. The recharge rates used in the model were set at a rate of 0.05% annual rainfall (0.31 mm/year) for alluvium, 0.1% annual rainfall (0.7 mm/year) for regolith and 0.8% annual rainfall (4.8 mm/year) for basalt. These model calibrated values are considered appropriate and are within the expected range of recharge values.

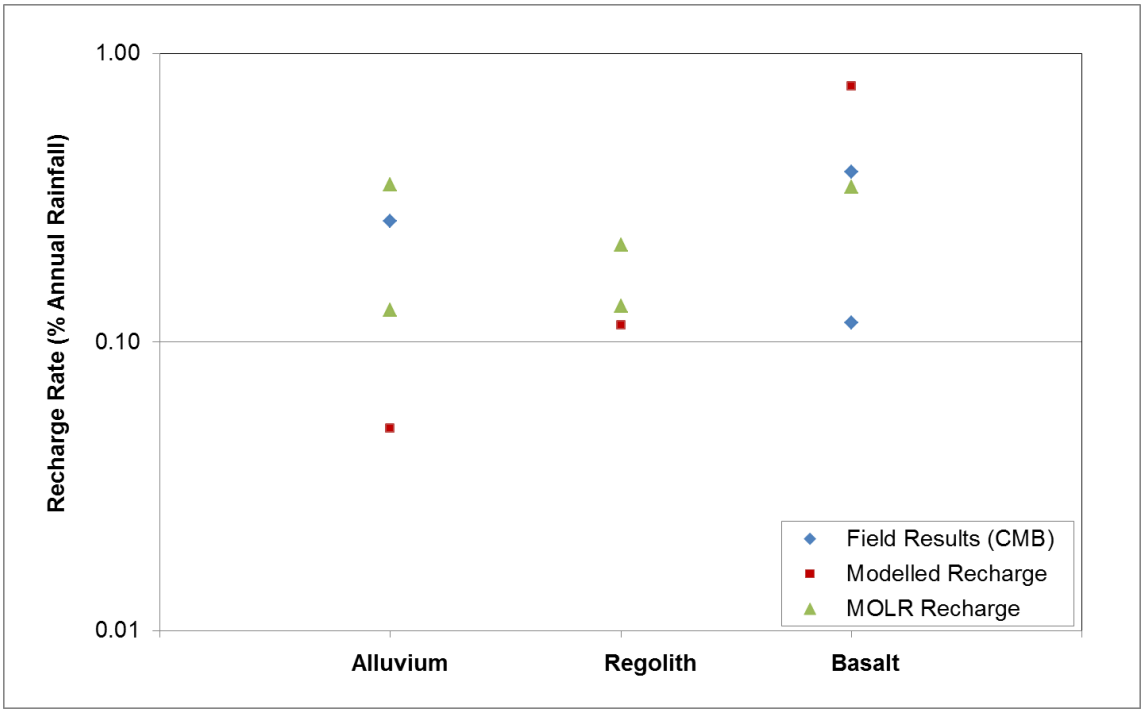


Figure B-2: Recharge Rate Distribution

Rivers and surface drainage were simulated using the SURFACT river package and were segregated into zones according to stream order. The rivers were simulated as follows:

- Retreat Creek – Upper (near the Gemfields) – the bed of the river was incised 15 m below ground level, with 1.0 m depth of permanent water set in the river and a bed conductance of 1 m/day;
- Retreat Creek – Lower (near Project area) – the bed of the river was incised 10 m below ground level, with 0.5 m depth of permanent water set in the river and a bed conductance of 1 m/day;
- Lake Maraboon – the bed of the lake was incised 20 m below ground level, with 20 m depth of permanent water set in the lake and a bed conductance of 1×10^{-5} m/day;
- Nogoa River – the bed of the river was incised 15 m below ground level, with 2.0 m depth of permanent water set in the river and a bed conductance of 2 m/day; and
- Minor tributaries (including Taroborah Creek) were modelled with a river bed incised 1 m below the local topography and given the function to only allow flow out of the ground, but no flow into the model.

The inlet and outlet of the main creeks and drainage lines were assigned with fixed head cells, within Layer 1 of the numerical model (Figure B-3). Outside of the mine area, the SURFACT river package was applied to 500 m grid cells. This application is considered appropriate for a regional impact assessment model. A finer grid resolution over a larger area would result in a model that is impractical to run and use as an impact assessment tool. The use of the SURFACT river package within 500 m grid cells allows the model objectives to be met and does not reduce the confidence or reliability of the model predictions.

1.3.5 Hydraulic Properties

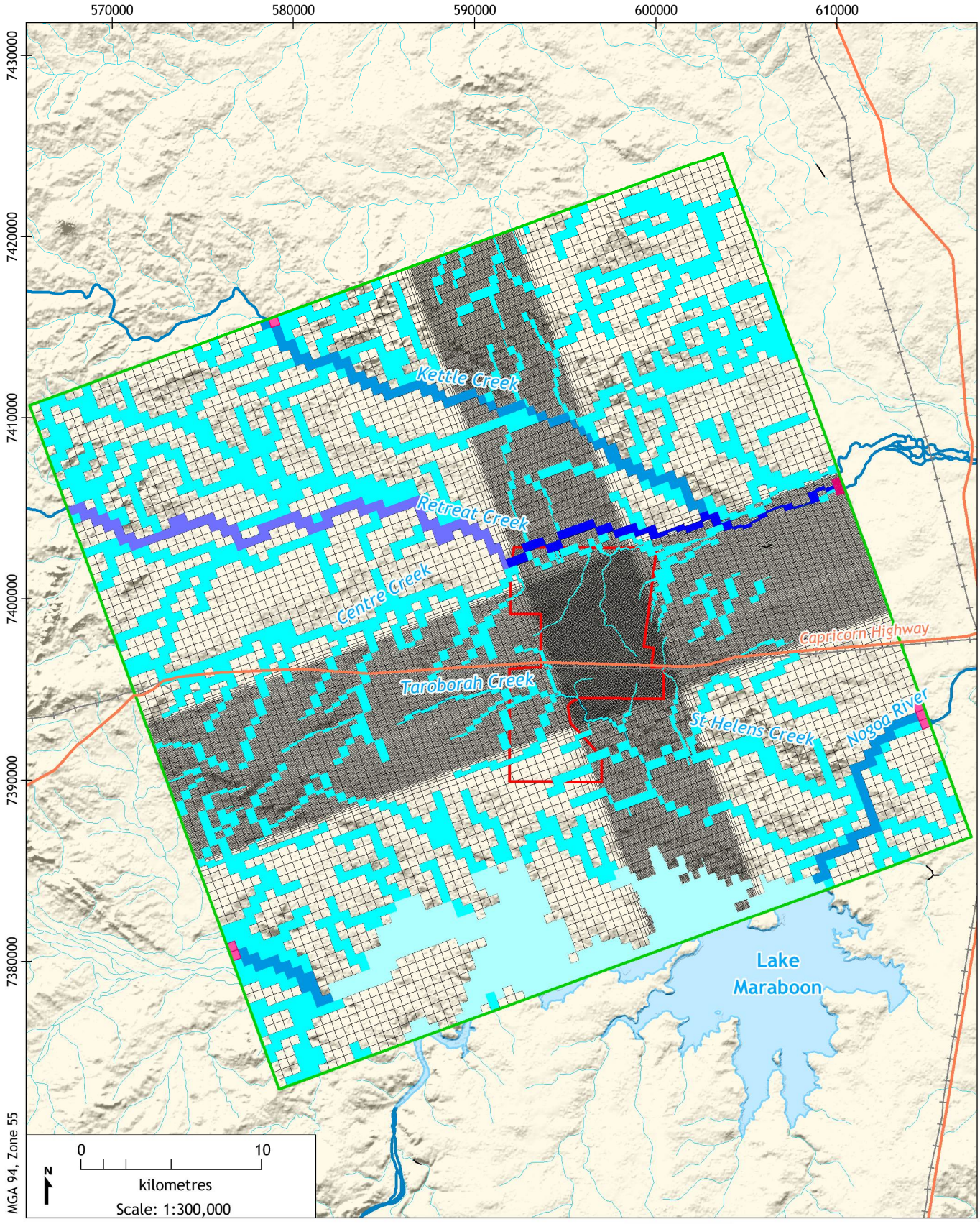
The hydraulic parameters were based on collation of all available field data within the model domain, parameters used within numerical models undertaken at the location and for similar geological provinces. The calibrated hydraulic parameters used in the numerical model are as shown in Table B-2.

Table B-2: HYDRAULIC PARAMETERS

Model Layer	Lithology	Horizontal Hydraulic Conductivity (m/day)	Vertical Hydraulic Conductivity (m/day)	Specific Yield Sy (%)	Specific Storage Ss (m^{-1})
1	Quaternary alluvium	3	4.87×10^{-01}	1.00×10^{-02}	1.00×10^{-04}
1	Quaternary/Tertiary gravels	5.00×10^{-01}	2.50×10^{-01}	1.00×10^{-02}	1.00×10^{-03}
1	Tertiary basalt	1.26×10^{-01}	3.11×10^{-02}	1.00×10^{-03}	1.00×10^{-04}
2	Regolith	4.00×10^{-02}	4.00×10^{-03}	1.00×10^{-03}	1.00×10^{-04}
2	Tertiary gravels	1	0.2	0.01	0.001
2	Tertiary clay	7.00×10^{-01}	7.00×10^{-04}	1.00×10^{-03}	1.00×10^{-04}
3	Weathered zone	7.00×10^{-03}	5.48×10^{-03}	1.00×10^{-03}	1.00×10^{-05}
4	Aldebaran Sandstone – fine grained	3.24×10^{-01}	7.00×10^{-03}	1.00×10^{-03}	1.00×10^{-04}
5	Aldebaran Sandstone – fine grained	3.24×10^{-01}	7.00×10^{-03}	1.00×10^{-03}	1.00×10^{-04}
6	Aldebaran Sandstone – coarse grained	0.3	5.00×10^{-02}	0.01	5.00×10^{-04}
7	Aldebaran Sandstone – Coal Seam A	6.36×10^{-03}	2.32×10^{-03}	1.00×10^{-03}	1.00×10^{-05}
8	Aldebaran Sandstone – interburden	5.00×10^{-04}	5.00×10^{-05}	1.00×10^{-03}	1.00×10^{-05}
9	Aldebaran Sandstone – Coal Seam B	1.00×10^{-03}	4.24×10^{-04}	1.00×10^{-03}	1.00×10^{-05}
10	Aldebaran Sandstone – basement	5.00×10^{-04}	5.00×10^{-05}	1.00×10^{-03}	1.00×10^{-05}

Figure B-4 compares the horizontal hydraulic conductivity parameters to field and previously modelled parameters, for each of the model layers.

It is important to note that no faults or structures have been represented in the model domain. The model layers assume lateral continuity.



LEGEND:

- MDL Boundary
- Model Grid
- Model Boundary
- Highway
- Railway
- River Cell - Baseflow
- River Cell
- River Cell - Retreat Creek (Upper)
- River Cell - Retreat Creek (Lower)
- River Cell - Lake Maraboon
- Fixed Head Cell

Taroborah Coal Project
Groundwater Assessment (G1588)

River Cells

DATE: 26/9/2014

FIGURE No: B-3

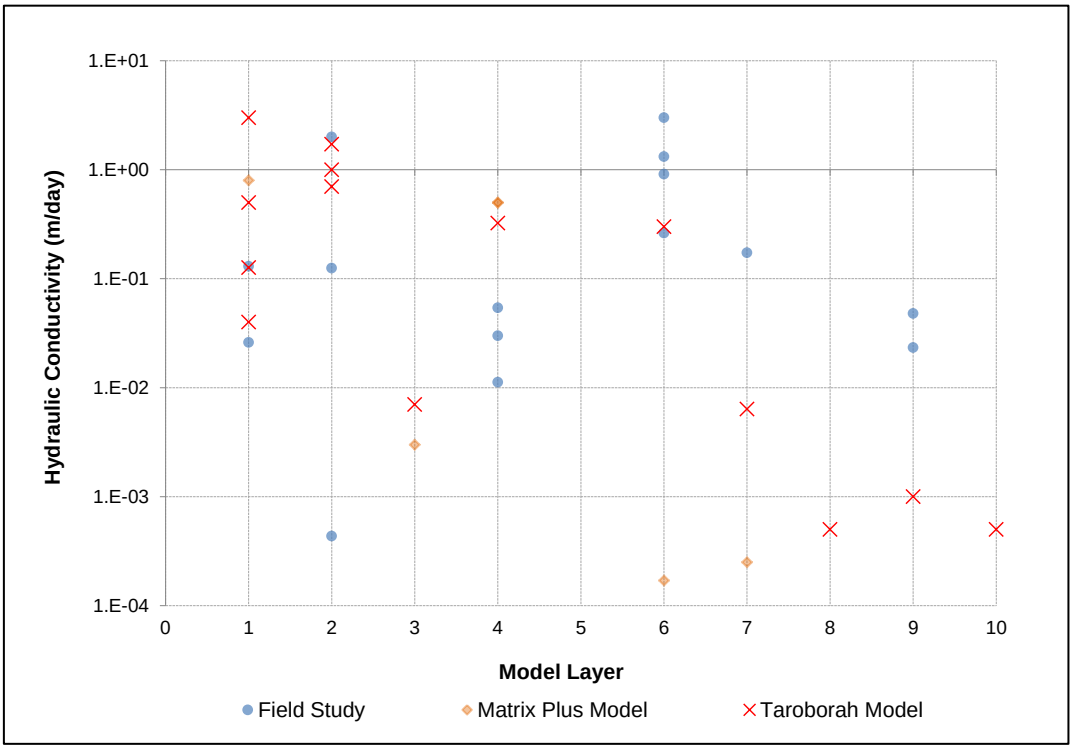


Figure B-4: Distribution of Horizontal Hydraulic Conductivity – Measured Values

2 MODEL CALIBRATION

The objective of the calibration of the model was to reproduce groundwater levels at the individual monitoring bores and hence replicate the general pattern of the groundwater potentiometric surface and the direction of groundwater flow. The model was calibrated in two stages. Firstly, the steady state model was manually calibrated as part of an initial testing phase to check model budgets and stability. This was achieved using uniform parameters across the entire model domain. The uniform model parameters were adjusted sequentially to determine sensitivity and correlation of the parameters. The calibration of the model followed the objectives set out by Barnett *et al*, (2012)[3] and the objectives presented in Section 11.1 of the main report.

The existing water level hydrographs show no seasonal variation and hence no recharge or discharge responses against which to calibrate. As a result, a transient calibration of the groundwater model was not considered appropriate or necessary. Once mining commences and mine inflow data is available, a transient calibration of the groundwater model should be carried out.

The automated parameter estimation software PEST was then used to calibrate the steady state groundwater model. The software makes small adjustments to the parameter set within the bounds determined by the user in order to provide the best possible match between the observed and simulated data. PEST adjusted the following properties in the model to achieve the calibration:

- horizontal hydraulic conductivity;
- vertical hydraulic conductivity; and
- recharge rate to each recharge zone.

[3] Barnett *et al*, (2012), *"Australian groundwater modelling guidelines"*, Waterlines report, National Water Commission, Canberra.

A well-calibrated regional model indicates that the model closely replicates real world hydrogeological conditions (the first modelling objective) and therefore provides confidence in the predicted changes to the groundwater regime due to mining.

2.1 Model Calibration Results

2.1.1 Calibration Data Points

The model simulated water levels in all available monitoring bores within the coal measures and alluvium. There are a total of 99 monitoring bores with documented groundwater levels, which includes:

- 67 registered landholder bores, with water levels recorded within the groundwater database;
- three registered landholder bores where groundwater levels were collected during the bore census, conducted in December 2011 (RN37769, RN57602 and RN67349);
- eight registered landholder bores where groundwater levels were collected during the bore census, conducted in April 2013 (RN37770, RN44470, RN44475, RN47217, RN47238, RN47322, RN47323, RN67349);
- two unregistered landholder bores, where groundwater levels were collected during the April 2013 bore census (Anakie Creek Bore and Twin Bore);
- four unregistered landholder bores, where groundwater levels were collected during the December 2011 bore census (Bore, Bore at Road, Cotton Seed Shed Bore and Railway Paddock Bore); and
- 15 monitoring bores within the Project area, with groundwater levels collected in April 2013.

The model weighted each bore according to the level of confidence in the data. Geological borehole logs were examined to ensure each bore was represented within the correct layer in the model.

A comparison of observed and simulated groundwater levels in the model area are given in Table B-3, and a scattergram of the results are shown in Figure B-5. The water levels in most of the bores selected for steady state calibration were considered to be representative of the long term average (steady state) groundwater levels (i.e. pre-mining groundwater conditions). However, fluctuations in groundwater levels are expected.

Table B-3: CALIBRATED TARGETS AND SIMULATED WATER LEVELS

Bore ID	Easting (m)	Northing (m)	Unit	Observed Water Level (mAHD)	Simulated Water Level (mAHD)	Difference (m)
37464	572750	7402260	Quaternary alluvium	220.4	221.4	-1.1
37769	596523	7387519	Tertiary basalt	220.3	219.1	1.2
38208	574236	7404259	Quaternary alluvium	214.7	219.6	-4.9
38293	582040	7404128	Quaternary alluvium	210.1	209.7	0.4
38476	582658	7412797	Quaternary alluvium	219.5	215.3	4.2
38477	585404	7411065	Quaternary alluvium	218.2	212.2	6.0
38478	587495	7411676	Quaternary alluvium	214.7	209.0	5.7
43974	578495	7403768	Quaternary alluvium	209.8	211.8	-2.0

Table B-3: CALIBRATED TARGETS AND SIMULATED WATER LEVELS						
Bore ID	**Easting (m)**	**Northing (m)**	**Unit**	**Observed Water Level (mAHD)**	**Simulated Water Level (mAHD)**	**Difference (m)**
43975	579724	7405925	Quaternary alluvium	206.2	210.6	-4.3
43976	576431	7406219	Quaternary alluvium	214.8	216.6	-1.8
44470	588108	7388433		244.9	242.9	2.0
44471	588060	7388392	Tertiary basalt	252.4	245.5	6.9
47014	575105	7404451	Quaternary alluvium	212.7	219.0	-6.3
47145	574242	7404314	Quaternary alluvium	214.6	219.1	-4.5
47199	573557	7404463	Quaternary alluvium	222.6	220.9	1.7
47217	581765	7395658	Tertiary basalt	231.0	233.5	-2.5
47218	613352	7393516	Quaternary alluvium	168.5	174.2	-5.7
47219	611026	7397912	Tertiary basalt	181.5	196.3	-14.9
47238	605840	7400508		188.1	188.7	-0.6
47322	591443	7410299	Quaternary alluvium	206.5	202.4	4.1
47323	595100	7410014	Quaternary alluvium	202.8	201.0	1.8
47450	573839	7404847	Quaternary alluvium	225.3	219.8	5.5
47707	574371	7400218	Quaternary alluvium	213.8	223.3	-9.5
57602	605902	7391555	Quaternary alluvium	193.2	190.1	3.0
67311	579962	7402562	Quaternary alluvium	213.9	211.0	2.9
67349	592950	7400839		197.5	195.0	2.6
84184	593437	7396628		193.1	200.5	-7.4
84229	574262	7404119	Quaternary alluvium	214.5	221.2	-6.7
89318	579307	7406644	Quaternary alluvium	212.9	211.1	1.9
89370	571025	7403152	Quaternary alluvium	224.2	225.0	-0.7
89387	584831	7405866	Quaternary alluvium	214.5	204.7	9.8
90079	570548	7403050	Quaternary alluvium	227.2	227.0	0.2
90080	571700	7403120	Quaternary alluvium	224.4	227.2	-2.9
103025	610546	7388384	Quaternary alluvium	167.4	174.1	-6.7
103098	610394	7390160	Quaternary alluvium	168.6	174.5	-5.9
103114	614207	7394959	Quaternary alluvium	178.4	173.2	5.2
103150	610927	7400625	Tertiary basalt	197.6	200.4	-2.8
103169	610967	7390563	Quaternary alluvium	162.9	172.4	-9.4
103358	569294	7405724	Quaternary alluvium	221.0	231.9	-11.0
103807	611953	7386830	Quaternary alluvium	170.2	173.2	-3.0
13020004	570660	7403469	Quaternary alluvium	227.1	227.0	0.1
13020005	570688	7403437	Quaternary alluvium	226.8	227.0	-0.2
13020006	570688	7403407	Quaternary alluvium	225.9	227.0	-1.1
13020007	575407	7404860	Quaternary alluvium	214.6	217.6	-3.0
13020008	575319	7404430	Quaternary alluvium	213.8	216.9	-3.1
13020009	575316	7404401	Quaternary alluvium	213.7	216.9	-3.2
13020010	575317	7404257	Quaternary alluvium	212.5	216.9	-4.4

Table B-3: CALIBRATED TARGETS AND SIMULATED WATER LEVELS						
Bore ID	**Easting (m)**	**Northing (m)**	**Unit**	**Observed Water Level (mAHD)**	**Simulated Water Level (mAHD)**	**Difference (m)**
13020011	575245	7404010	Quaternary alluvium	214.3	217.8	-3.5
13020012	573661	7402680	Quaternary alluvium	214.0	219.3	-5.3
13020013	573802	7401948	Quaternary alluvium	213.6	218.5	-4.9
13020014	574030	7401277	Quaternary alluvium	212.3	218.6	-6.3
13020015	573976	7401292	Quaternary alluvium	213.0	218.6	-5.6
13020016	574258	7404338	Quaternary alluvium	214.0	219.1	-5.1
13020017	574269	7404308	Quaternary alluvium	221.9	219.6	2.3
13020024	574140	7404299	Quaternary alluvium	224.5	219.4	5.1
13020025	614461	7394545	Quaternary alluvium	171.1	172.4	-1.3
13020027	607916	7396972	Tertiary basalt	196.7	189.2	7.5
13020028	611100	7397286	Tertiary basalt	192.0	192.5	-0.5
13020037	570660	7403341	Quaternary alluvium	222.5	227.0	-4.6
13020039	611040	7396470	Tertiary basalt	193.1	188.2	4.9
13020040	610822	7396703	Tertiary basalt	194.1	188.2	5.9
13020041	610643	7396898	Tertiary basalt	194.3	189.9	4.4
13020042	610161	7397205	Tertiary basalt	196.8	190.2	6.6
13020043	610723	7397509	Tertiary basalt	196.3	191.5	4.8
13020044	610862	7397449	Tertiary basalt	195.0	191.5	3.6
13020067	610981	7391897	Quaternary alluvium	181.1	175.1	6.1
13020068	611138	7396808	Tertiary basalt	193.5	188.2	5.3
13020069	612563	7399227	Tertiary basalt	195.2	203.8	-8.5
13020070	610871	7399290	Tertiary basalt	194.1	201.2	-7.1
13020072	610740	7400942	Tertiary basalt	196.1	198.5	-2.3
13020080	607714	7400981	Tertiary basalt	179.3	190.0	-10.7
13020082	602650	7402448	Quaternary alluvium	179.7	186.7	-7.0
13020090	607703	7400986	Tertiary basalt	193.0	190.0	3.0
13020097	607251	7401603	Tertiary basalt	190.7	187.9	2.8
13020105	611025	7400610	Tertiary basalt	196.1	200.7	-4.6
13020106	611685	7399508	Tertiary basalt	196.8	202.5	-5.7
13020107	609564	7401583	Tertiary basalt	194.4	193.3	1.0
13020207	610986	7391901	Quaternary alluvium	179.8	175.1	4.7
Anakie Creek Bore	584523	7388725	Tertiary basalt	256.5	246.2	10.3
Bore	583269	7389220		263.0	248.9	14.1
Bore at Road	584334	7392405	Tertiary basalt	248.4	242.2	6.3
Cotton Seed Shed Bore	592504	7399983	Tertiary basalt	234.7	238.3	-3.5
Railway Paddock Bore	588003	7387427	Tertiary basalt	240.4	242.3	-1.9

Table B-3: CALIBRATED TARGETS AND SIMULATED WATER LEVELS						
Bore ID	**Easting (m)**	**Northing (m)**	**Unit**	**Observed Water Level (mAHD)**	**Simulated Water Level (mAHD)**	**Difference (m)**
Twin Bore	600020	7402656		201.0	196.3	4.7
MB01_B	593513	7399534	basalt?	191.2	195.7	-4.5
MB02_C	593493	7399537	B Seam	190.8	197.5	-6.7
MB02_S	598860	7398819	Aldebaran Sandstone	189.9	197.4	-7.6
MB04_C	592065	7393041	B Seam	194.4	195.6	-1.2
MB04_S	594668	7390096	Aldebaran Sandstone	194.4	195.6	-1.2
MB05	593575	7401714	A Seam	191.1	193.9	-2.8
MB08_B	594956	7395372	Silty clay/Gravel	214.0	220.0	-6.0
MB09_T	600263	7396108	Sand	194.6	193.8	0.8
MB10_T	595642	7395113	Silt/gravel	184.6	188.6	-4.1
TAR016_CR	594586	7400197	Aldebaran Sandstone	189.4	200.9	-11.5
TAR040_C	598843	7398818	Aldebaran Sandstone	196.0	197.5	-1.5
TAR053	596635	7397000	Aldebaran Sandstone	189.1	201.1	-12.0
TAR176_C	595813	7395670	Aldebaran Sandstone - fine grained	193.0	194.2	-1.2
TAR177_C	596965	7395510	Tertiary Basalt?	189.4	194.7	-5.4
TAR189_C	598335	7395816	Aldebaran Sandstone	192.7	193.9	-1.2
TAR249_C	597227	7397143	Aldebaran Sandstone	189.2	196.9	-7.7

Note: *Coordinates in MGA 94 Zone 55*

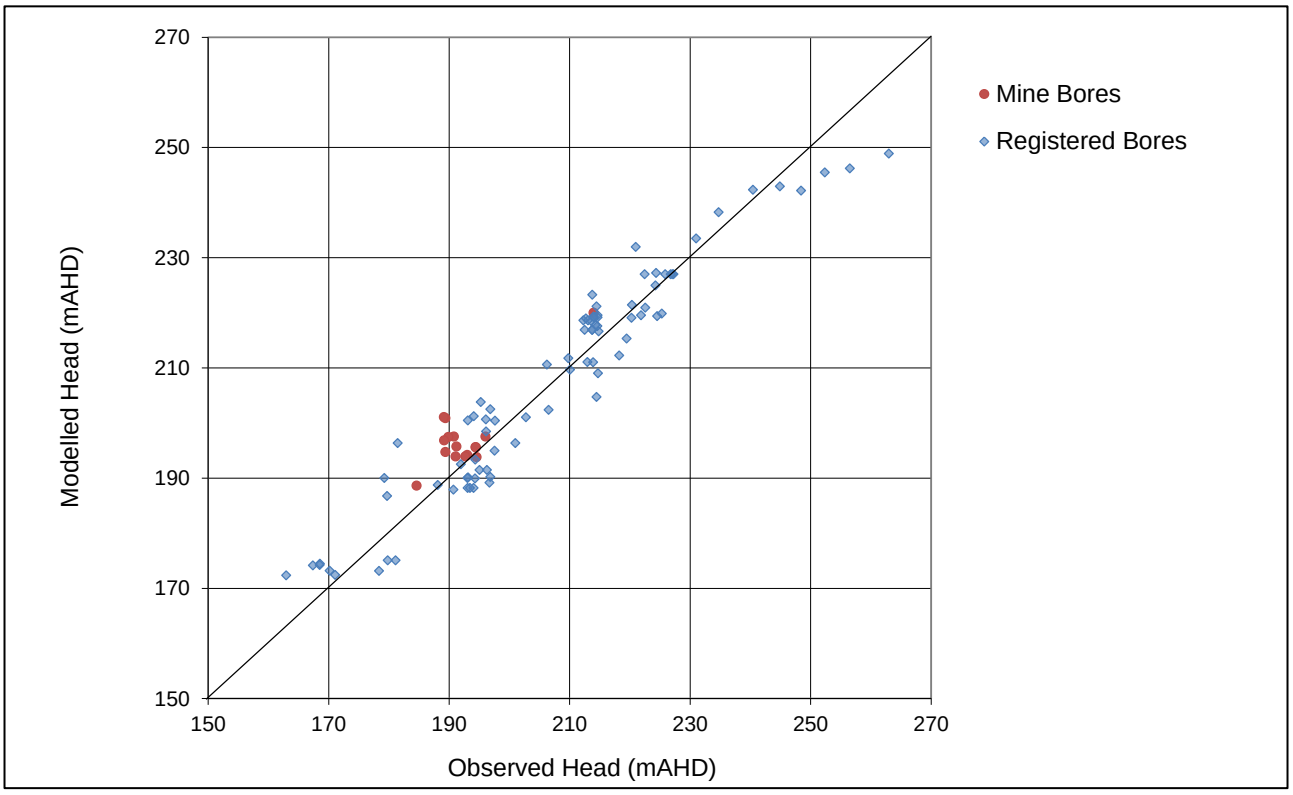


Figure B-5: Steady State Calibration – Modelled vs Observed Groundwater Levels

An objective method to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. One such method is by measurement of the error between the modelled and observed (measured) water levels. A root mean square (RMS), expressed as:

$$RMS = \left[1/n \sum (h_o - h_m)_i^2\right]^{0.5}$$

where: n = number of measurements
h_o = observed water level
h_m = simulated water level

is considered to be the best measure of error, if errors are normally distributed. The RMS error calculated for the calibrated model is 7.70 m.

The maximum acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head loss in the system is small, the errors are only a small part of the overall model response (Anderson and Woessner, 1992)[4]. Estimation of the error based on the population of observations is calculated as the scaled RMS, as follows:

$$Scaled\ RMS = \left[\frac{RMS}{range}\ x\ 100\right]$$

The steady state calibration recorded a scaled RMS of 7.70 %. This indicates a good calibration and is within the Australian guidelines (Barnett *et al.,* 2012) of 10% Scaled RMS.

2.1.2 Calibrated Steady State Water Budget

The mass balance error, that is, the difference between calculated model inflows and outflows at the completion of the steady state simulation (expressed as a percentage of discrepancy) was 0.04%. This value indicates that the model is stable and has good accuracy in the numerical solution. The model water budget is summarised in Table B-4.

Table B-4: WATER BUDGET – STEADY STATE MODEL

Parameter	Input (m^3/d)	Output (m^3/d)
Constant Head	81	2,139
Recharge	6,505	0
River Leakage	21,983	22,073
Totals	**28,569**	**24,212**

The water budget indicates that the long-term average of 28,569 m^3/day (29 ML/day) of water enters the groundwater system. A total of 21,983 m^3/day (22 ML/day) of river flow is predicted to enter the model, and 22,073 m^3/day (22 ML/day) leaves the system as baseflow.

[4] Anderson, M.P.; Woessner, W.W., (1992), *"Applied Groundwater Modelling: Simulation of Flow and Advective Transport",* (2nd Edition ed.). Academic Press.

2.1.3 Composite Sensitivities

PEST was used to automatically calculate the sensitivities at the end of each optimisation iteration. Figure B-6 presents the final composite parameter sensitivities within respect to the automated steady state calibration and model output. The composite sensitivity (unit less) of each parameter is the normalised (with respect to the number of observations, or population) magnitude of the column of the Jacobian matrix pertaining to that parameter. The use of composite sensitivity helps compare the effects that different parameters have on the parameter estimation process when these parameters are of a different type and magnitude (Doherty *et al.,* 1994).

The final sensitivity results show that the calibration simulation is most sensitive to changes in the hydraulic parameters of the upper units. The most sensitive parameters are recharge rates, hydraulic conductivity rates of the Tertiary Basalt, fine-grained Aldebaran Sandstone, and Tertiary gravels. The results indicate that parameters that show significant sensitivity to the calibration should be explored through sensitivity analysis.

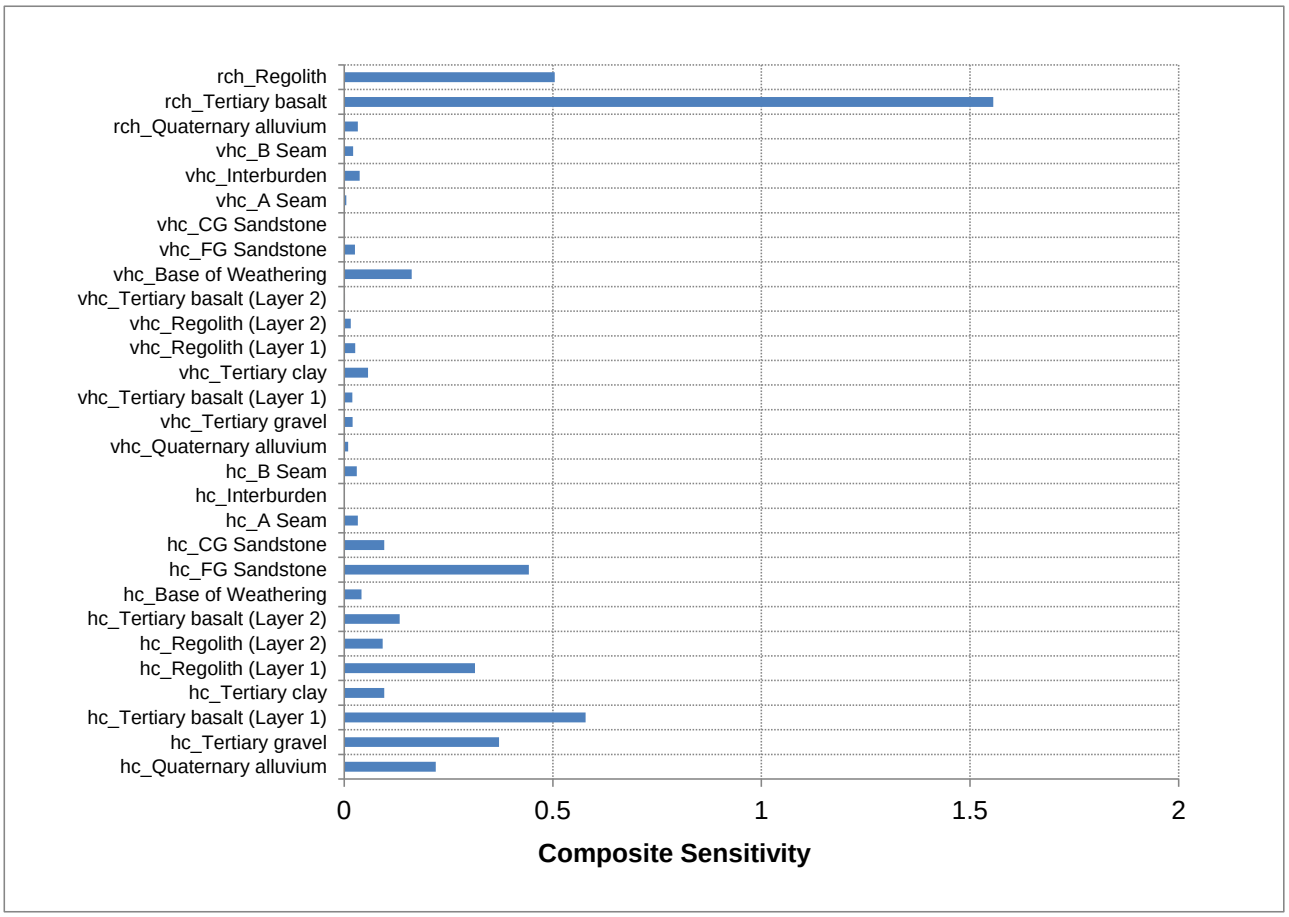
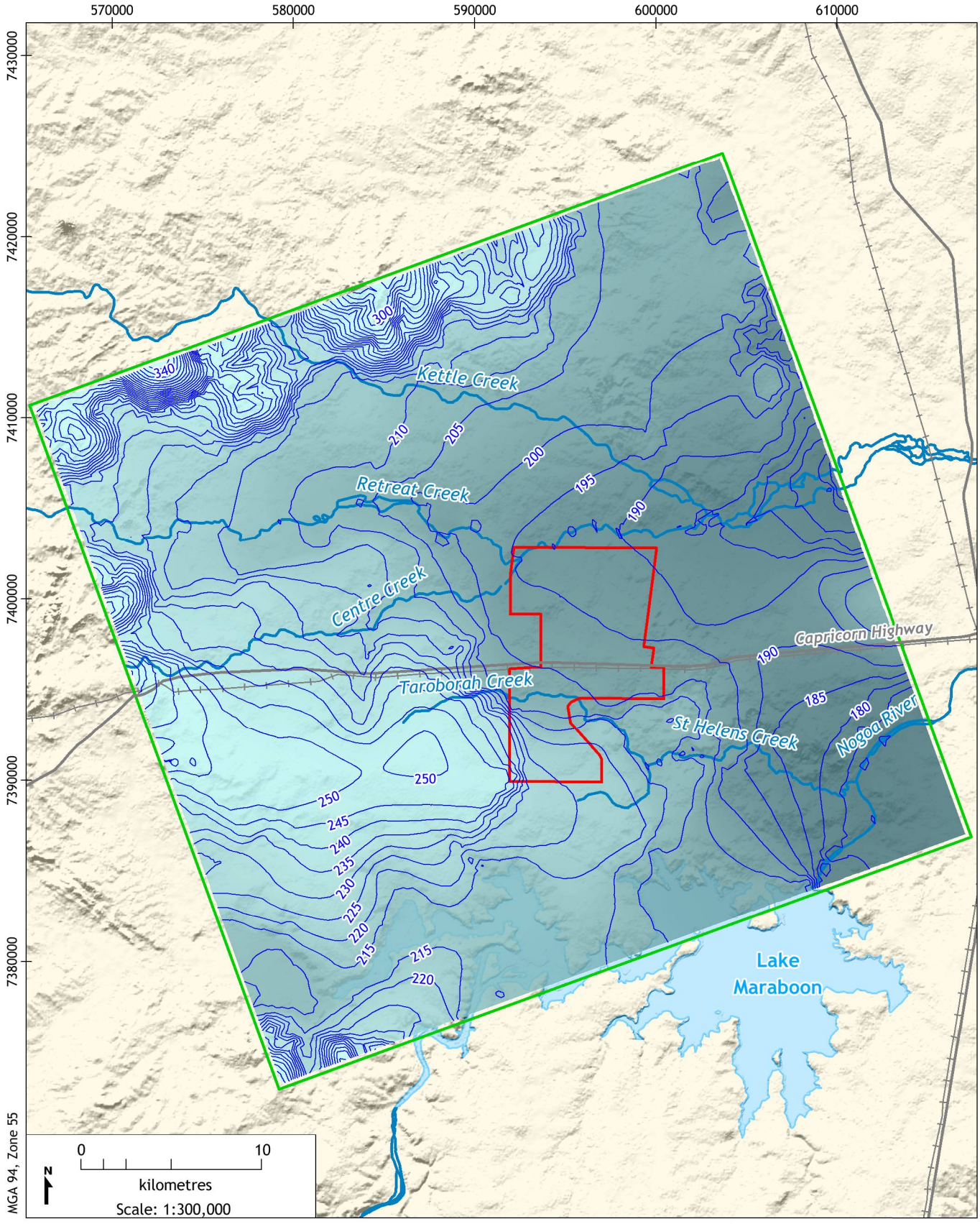


Figure B-6: Final Composite Parameter Sensitivities

2.1.4 Calibrated Steady State Heads

The calibrated starting heads from the steady state run are presented for Layers 1 and 7 in Figure B-7. The heads reflect the groundwater flow regime prior to commencement of any mining with the model domain, and indicate a general flow of groundwater towards the north-east. Groundwater gradients are relatively low, with higher gradients within the more hilly terrain at the northern and western edges of the model domain. Groundwater discharges from the model domain along the eastern edge of the model domain, from the Nogoa River and Retreat Creek.



LEGEND:

- MDL Boundary
- Model Boundary
- Highway
- Railway
- Groundwater Contour (mAHD)

Taroborah Coal Project
Groundwater Assessment (G1588)

Calibrated Heads - Steady State
Layer 1

DATE: 26/9/2014

FIGURE No: **B-7**

3 PREDICTIVE MODEL

3.1 Starting Conditions for Predictive Model

The calibrated steady state heads, based on pre-mining conditions, were used as the starting heads of the predictive model.

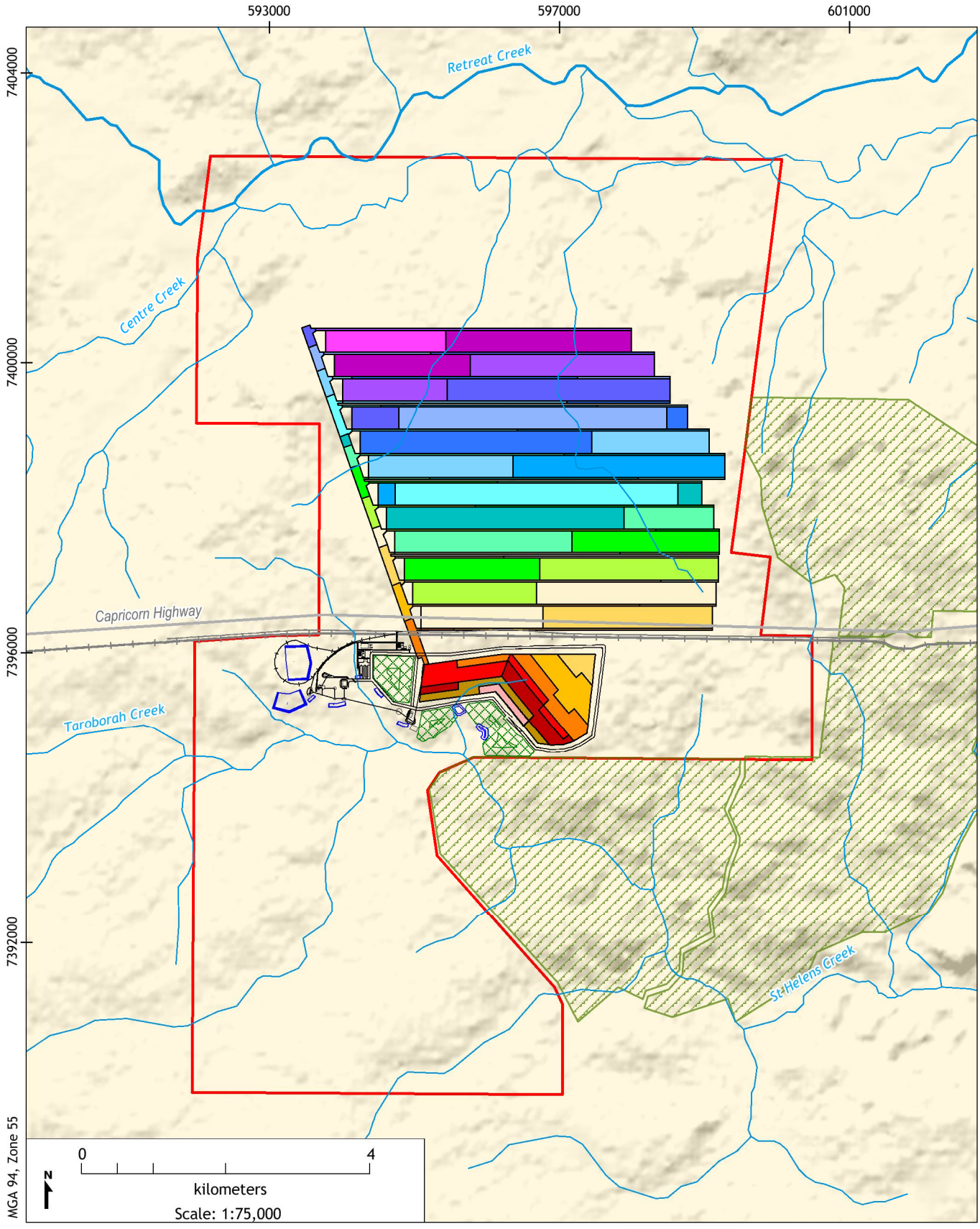
3.2 Mine Progression

The SURFACT Drain package (DRN) is used to represent the drainage of groundwater into the open-cut mining areas for the predictive model. Within the historical predictive model runs, drain cells were assigned a nominal conductance of 100 m^2/day to ensure complete dewatering to the base of the mined floor.

Mining within the predictive model was simulated in a varied staged approach, with mining commencing in 2018 (Year 1) within the open-cut mine area. The predictive mine progression for the Taroborah Mine area is shown in Figure B-8. Pit progression and the placement of spoil within the mining area was simulated progressively, with the mined areas backfilled with spoil immediately after excavation. A partial final void is proposed for the western and eastern extremities of the pits, which was simulated by assigning void parameters to the final void surface as mining progressed.

Longwall panels and development headings were simulated using drain cells. Drain cells grow at a quarterly rate according to the current mine schedule. Once each longwall panel is complete, the drain cells are removed; however, the main development heading was left active over the life of the underground mine to simulate the drainage and pumping from the workings. Subsidence cracking is applied to the overlying aquifer units at the end of each stage.

During the mining simulation, once the Western void is completed, drain cells remain to ensure water is not fed directly into the development headings portal.



LEGEND:

- MDL Boundary
- Longwall Panel
- Mine Infrastructure
- Waste Dump
- Wastewater Dam / Silt Trap
- Road
- Rail
- State Forest
- Watercourse

Mining Schedule

- Year 1
- Year 2
- Year 3
- Year 4
- Year 5
- Year 6
- Year 7
- Year 8
- Year 9
- Year 10
- Year 11
- Year 12
- Year 13
- Year 14
- Year 15
- Year 16
- Year 17
- Year 18
- Year 19
- Year 20
- Year 21

Taroborah Coal Project
Groundwater Assessment (G1588)

Mine Progression

DATE: 21/10/2014

FIGURE No: **B-8**

3.3 Recharge and Discharge

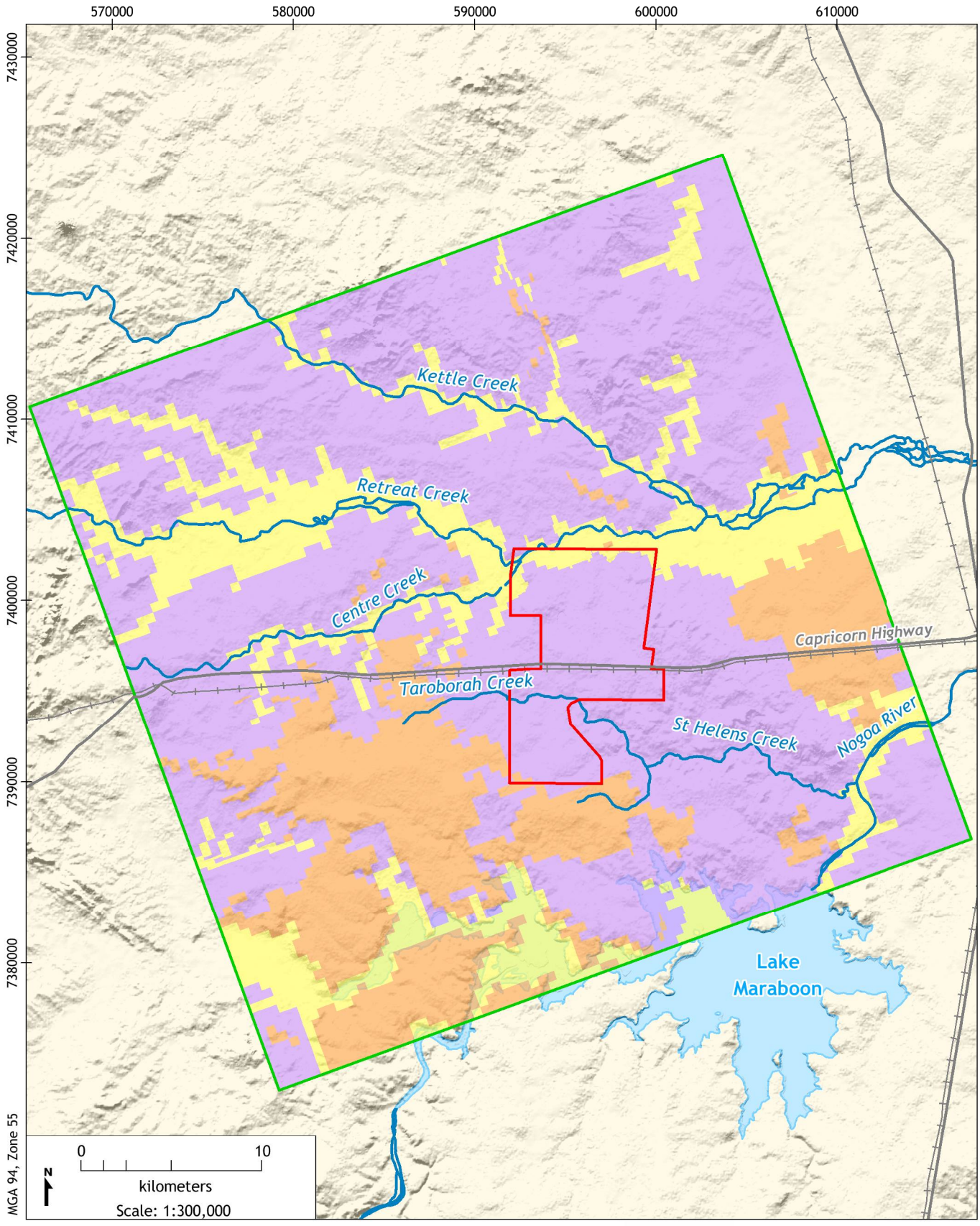
As detailed in Section 1.3.4, the recharge rates used within both the predictive model were:

- 0.05% annual rainfall (0.3 mm/year) for the alluvium;
- 0.8% of annual rainfall (4.8 mm/year) for the Tertiary basalt; and
- 0.1% of annual rainfall (0.7 mm/year) for the regolith material.

In addition, mined areas that were backfilled with spoil were assigned recharge values of 5.5% annual rainfall (34 mm/year), and the final void assigned a recharge rate of 80% of annual rainfall (497 mm/year). These values are based on findings by Mackie (2009), which are used as a standard practice for open-cut coal mines. Figure B-9 shows the model zonation used in the predictive model.

3.4 Evapotranspiration

Based on the BoM Gridded Average Evaporation Map (2005), the mean site annual pan evaporation rate is 1612.5 mm/year, and the mean annual evaporation exceeds mean annual rainfall. An evapotranspiration rate of 0.0004 L/day (90% pan evaporation) was applied within the proposed final voids at Taroborah. An extinction depth was applied in the SURFACT EVT package 2 m below the final backfilled land surface, to simulate the natural decline of evaporation with depth.



LEGEND:

- MDL Boundary
- Model Boundary
- Highway
- Railway

Modelled Recharge

- Alluvium 0.05% annual rainfall (0.31 mm/yr)
- Tertiary basalt 0.8% annual rainfall (4.8 mm/yr)
- Regolith 0.1% annual rainfall (0.7 mm/yr)

Taroborah Coal Project
Groundwater Assessment (G1588)

Modelled Recharge

DATE: 24/10/2014

FIGURE No: B-9

3.5 Hydraulic Parameters

The predictive model utilised the calibrated hydraulic parameters, which are detailed in Section 1.3.5. The parameters for spoil and the final voids were set as detailed in Table B-5.

In the underground extraction areas for the Project, the fracturing will depressurise the strata overlying the coal seam. The extent of the connective cracking typically varies depending on the coal seam thickness, the longwall panel width and the nature and strength of the overlying strata.

The model assumed the highly connective fracturing (goaf) above the coal seam extended to a height of 10 times the coal seam thickness, which was equivalent to a height of 40 m within these areas. The model also simulated the connective fracturing extending to a height of 30 times the coal seam thickness, which was equivalent to a height of 90 m. These heights were based on typical fracturing signatures observed in longwall mines in the Bowen Basin.

As the vertical conductivity of the Permian interburden calibrated to a relatively low rate, the goafing multiplication factor used in the unit was configured to result in a vertical conductivity value of 0.005 m/day. This was done to provide a conservative estimate of groundwater inflows and impact above the underground mine.

Table B-5: HYDRAULIC PARAMETERS – SPOIL, VOID AND GOAF

Model Layers	Lithology	Horizontal Hydraulic Conductivity (m/day)	Vertical Hydraulic Conductivity (m/day)	Specific Yield – Sy (%)	Specific Storage – Ss (m^{-1})
1 - 9	Spoil	1.0	1.0×10^{-1}	1.0×10^{-2}	1.0×10^{-3}
1 - 9	Void	100	100	1.0	$\frac{1}{\text{Layer thickness}}$
Goaf Height (m)					
0 - 5	Rubble	Background x 5 (0.005 in Layer 8)	Background x 50	0.5	-
5 - 20	Goaf	(0.005 in Layer 8)	Background x 20	-	-
20 - 40	Goaf	-	Background x 5	-	-
40 - 75	Fracture	-	Background x 2	-	-
75 - 90	Fracture	-	Background x 1.5	-	-

3.6 Predictive Model Results

3.6.1 Predicted Mine Inflows – Final Void Scenario

It is predicted that, on average, 2.6 ML/day of groundwater will be intercepted by the proposed Taroborah open-cut and underground mine, with peak inflows of 5.7 ML/day occurring around Year 19. Figure B-10 shows the rate of predicted mine water inflows over time for the open-cut and the underground mine. The maximum predicted inflows for the open-cut pit is 3.3 ML/day around Year 5 of the Project, while inflows to the underground peak at around 4.8 ML/day in Year 19 of the Project.

It is important to note that the predicted mine inflows do not represent the volume of water that will require pumping, rather the maximum loss from the groundwater systems. The estimates include 'unseen water', including moisture in coal, evaporation and humidity in mine ventilation air. Although it is difficult to quantify these components, the 'unseen water' can account for 10% of the model predicted volumes. Therefore, accounting for the 'unseen water', it is predicted that total groundwater inflows will be around 2.3 ML/day on average, with up to 3 ML/day entering the open-cut pit, and up to 4.3 ML/day entering the underground mine.

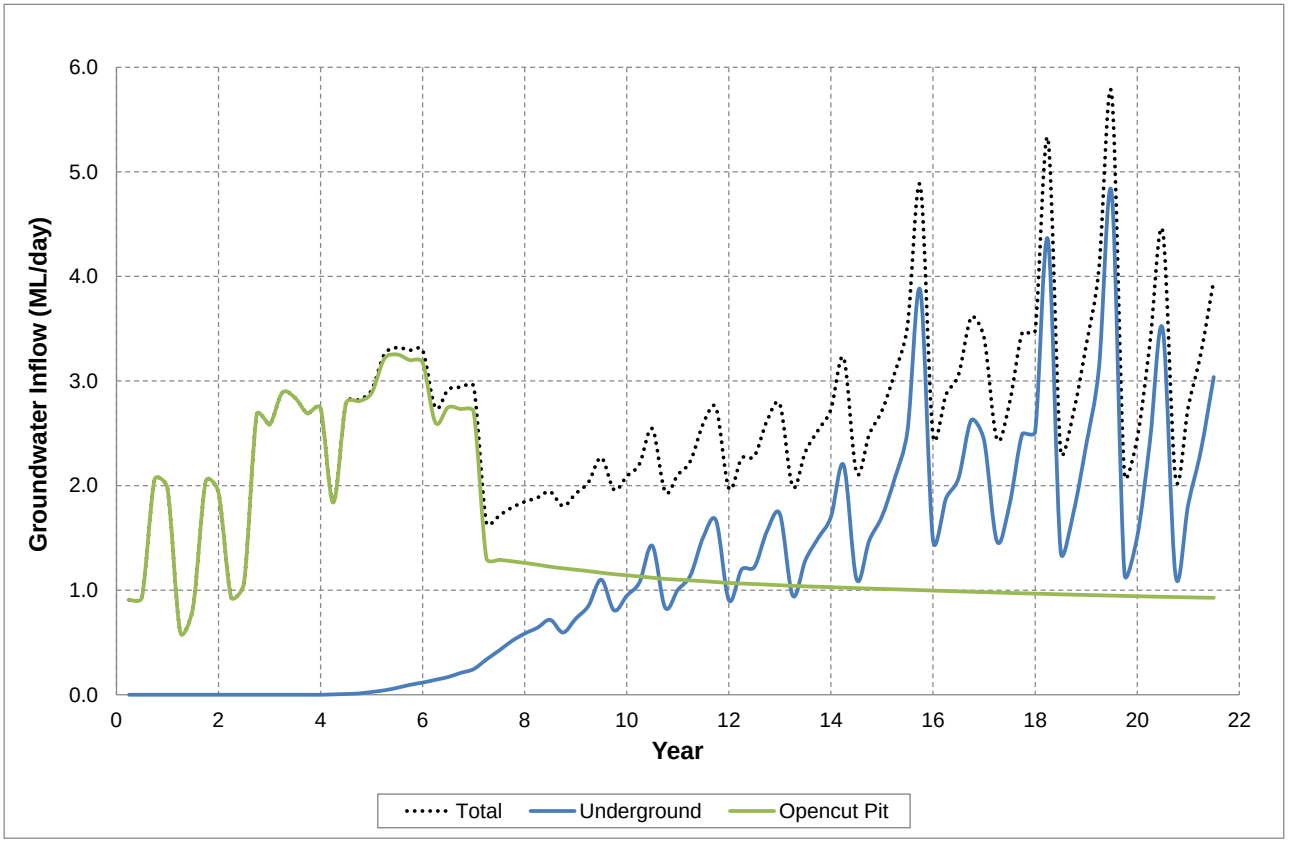


Figure B-10: Predicted Mine Inflows

As discussed above I Section 2, predicted groundwater inflows to the mine are not seasonally dependent.

3.6.2 Mining Phase Water Budget Summary

Figure B-11 shows the changes in key component water budgets over the staged timeframe for the model. Drains representing the Taroborah mine dewatering (open-cut and underground) are the main mechanism removing water from the model, with an average rate of groundwater extraction from the drain cells of 2.6 ML/day, and a maximum rate of up to 5.7 ML/day. Transpiration removes approximately 0.4 ML/day from the groundwater system, while recharge contributes approximately 0.3 ML/day to the groundwater system. An increase of up to 0.9 ML/day is reported for the change in river leakage across the full model domain, and a change of 0.9 ML/day in river drainage. This accounts for overall flow change and does not represent localised impacts for the individual change in river leakage for Retreat Creek.

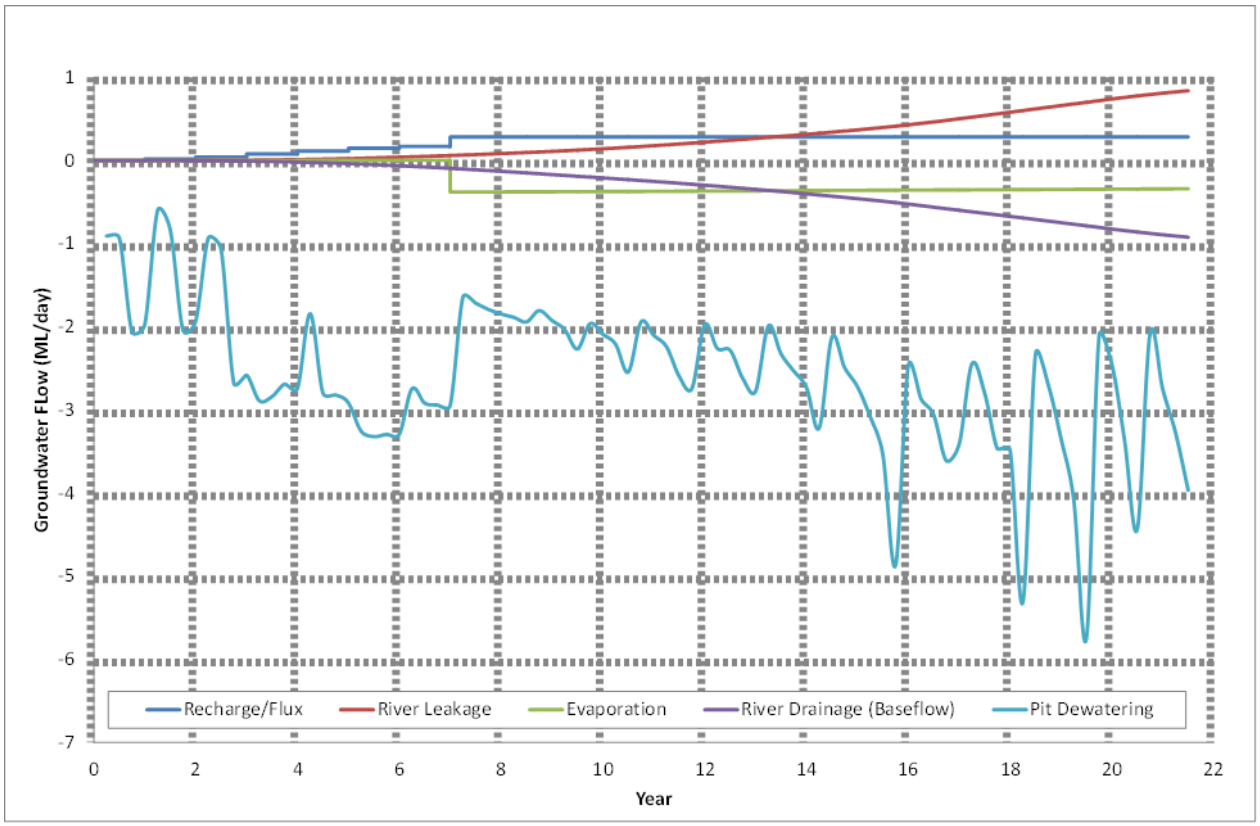


Figure B-11: Predicted Water Budget

3.7 Groundwater Drawdown

Figure B-12 to Figure B-15 show the predicted change in groundwater levels in Layer 1 (Quaternary and Tertiary alluvium and Tertiary basalt) and Layer 9 (Seam B) for Years 5, 10, 15 and 21 of the proposed mine schedule. The results show the extent and degree of groundwater level drawdown within areas modelled as having a saturated thickness prior to mining.

Figure B-16 shows that groundwater level drawdown within the alluvium could extend up to 3.5 km east (down-stream) of the MDL 467 boundary. The extent of drawdown north of the Project area is limited by the presence of Retreat Creek, which acts as a recharge source and buffers the effects of the predicted drawdown. Drawdown within the Tertiary basalts (Layer 1) are also mapped as extending up to 3 km south of the ML boundary.

The predicted drawdown within Seam B (Layer 9) is largely contained within the MDL 467 boundary. Due to the presence of underground mining, Seam B (Layer 9) is the model layer most affected by drawdown or depressurisation. The Layer 9 contours represent the worst case or maximum predicted drawdown within the model, and the drawdown or depressurisation predicted within other model layers will be less than that shown in Figure B-12 to Figure B-15.

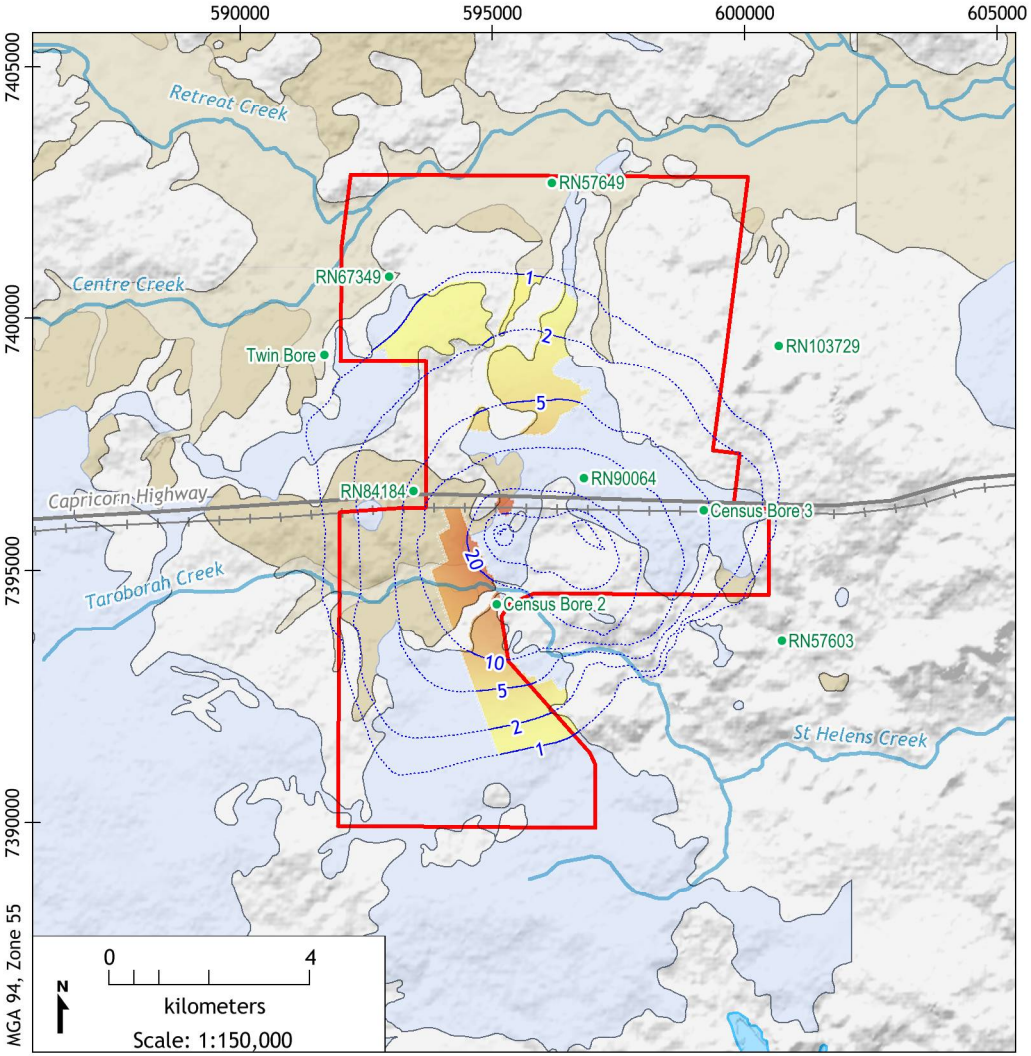
The hydrostratigraphic units above the longwall panels do not completely depressurise, as groundwater drawdown is a function of the vertical hydraulic conductivity of the goaf and the fracture zone. As detailed under Section 1.3.2, the model structure was based on the Taroborah Mine geological model, as well as government exploration drill logs and geological reports.

At the completion of each longwall panel, drain cells are removed from the simulation and water levels are allowed to recover. Unconfined storage properties of the mined longwall panel are increased to reflect additional void space in the rubble left behind following goafing due to the removal of the coal. The numerical model predicts groundwater levels recover to within 80% of their pre-mining levels after just 91 days. This is primarily due to the high storage within the Aldebaran Sandstone overlying the longwall mining area, which is not completely desaturated and allows rapid drainage of groundwater into the mined out areas. This high storage effectively buffers the groundwater systems adjacent to the Aldebaran Sandstone aquifer from impacts. Steep vertical hydraulic gradients form in the model and result in high groundwater flows towards the desaturated area within the coal seam, which causes groundwater levels to recover quickly. This occurs in the model because depressurisation is not extensive above the longwall mining area, and a high yielding aquifer exists adjacent to active mining.

AGE explored a scenario whereby the permeability of the fracture zone was increased to allow the vertical depressurisation to extend further above the longwall. The results are summarised in Section 4.2.

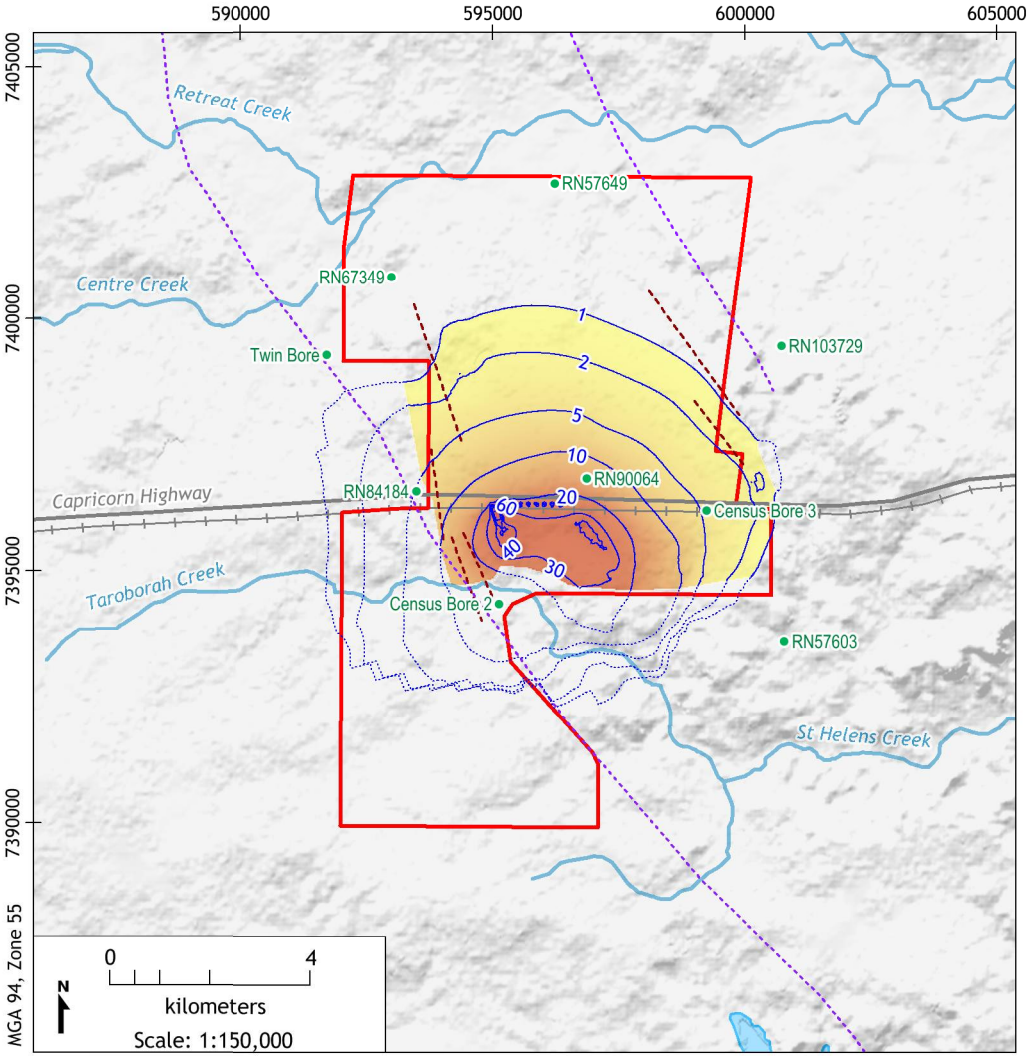
Predicted Drawdown Layer 1 (Qa/TQa/Tb) Year 5

Qa/TQa/Tb dry where no drawdown colour fill



Predicted Drawdown Layer 9 (Seam B) Year 5

Coal seam not present where no drawdown colour fill



LEGEND:

- Drawdown Contour (m)
- MDL Boundary
- Highway
- Railway
- Main Watercourse
- Landholder bore
- IMC Inferred Fault
- Bowen Basin Fault

1:100,000 Geology (Anakie & Rubyvale)

- Qa - Quaternary Alluvium
- TQa - Tertiary/Quaternary Alluvium
- Tb - Tertiary Basalt

Drawdown (m)

- 1
- 10
- 20
- 50
- 170

Taroborah Coal Project
Groundwater Assessment (G1588)

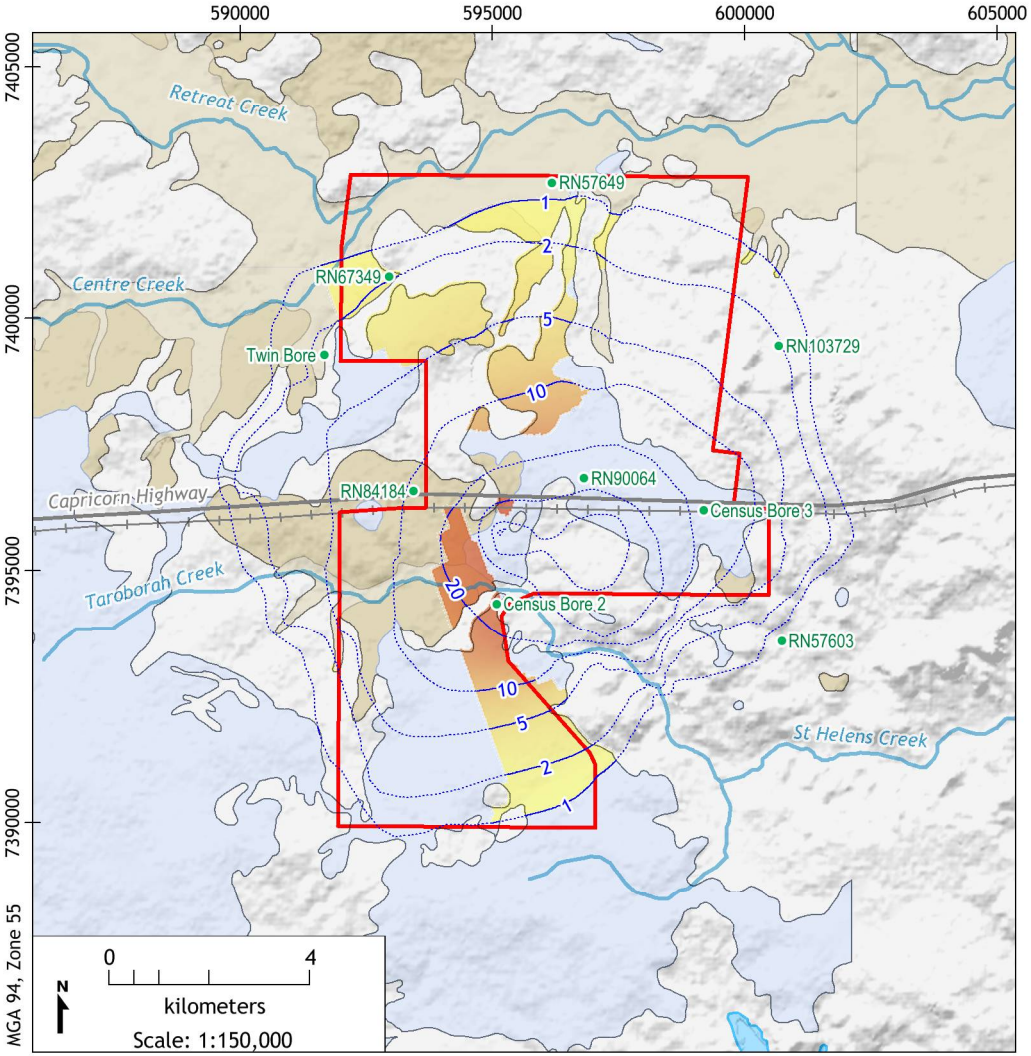
Predicted Drawdown Layer 1 (Qa/TQa/Tb) and Layer 9 (Seam B) Year 5

DATE: 14/10/2014

FIGURE No: **B-12**

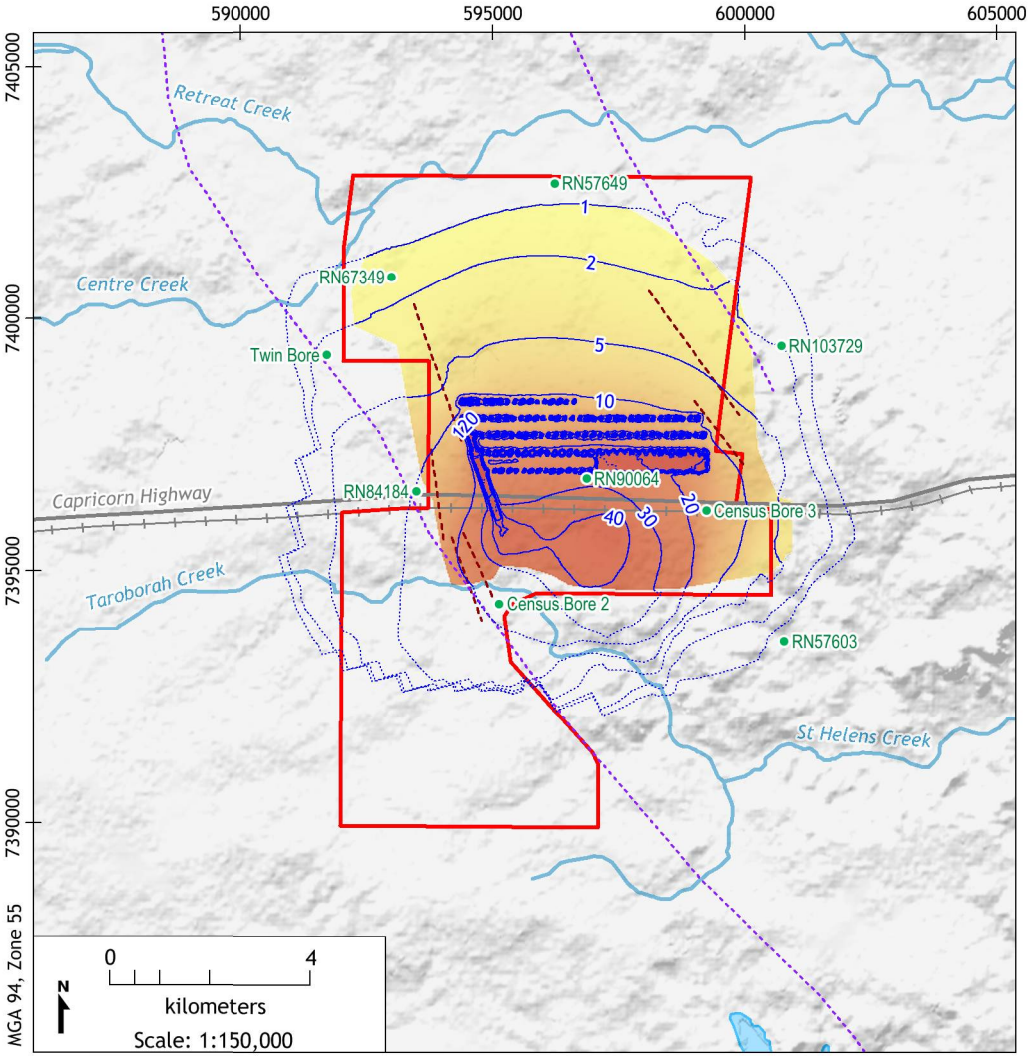
Predicted Drawdown Layer 1 (Qa/TQa/Tb) Year 10

Qa/TQa/Tb dry where no drawdown colour fill



Predicted Drawdown Layer 9 (Seam B) Year 10

Coal seam not present where no drawdown colour fill



LEGEND:

- Drawdown Contour (m)
- MDL Boundary
- Highway
- Railway
- Main Watercourse
- Landholder bore
- IMC Inferred Fault
- Bowen Basin Fault

1:100,000 Geology (Anakie & Rubyvale)

- Qa - Quaternary Alluvium
- TQa - Tertiary/Quaternary Alluvium
- Tb - Tertiary Basalt

Drawdown (m)

- 1
- 10
- 20
- 50
- 170

Taroborah Coal Project
Groundwater Assessment (G1588)

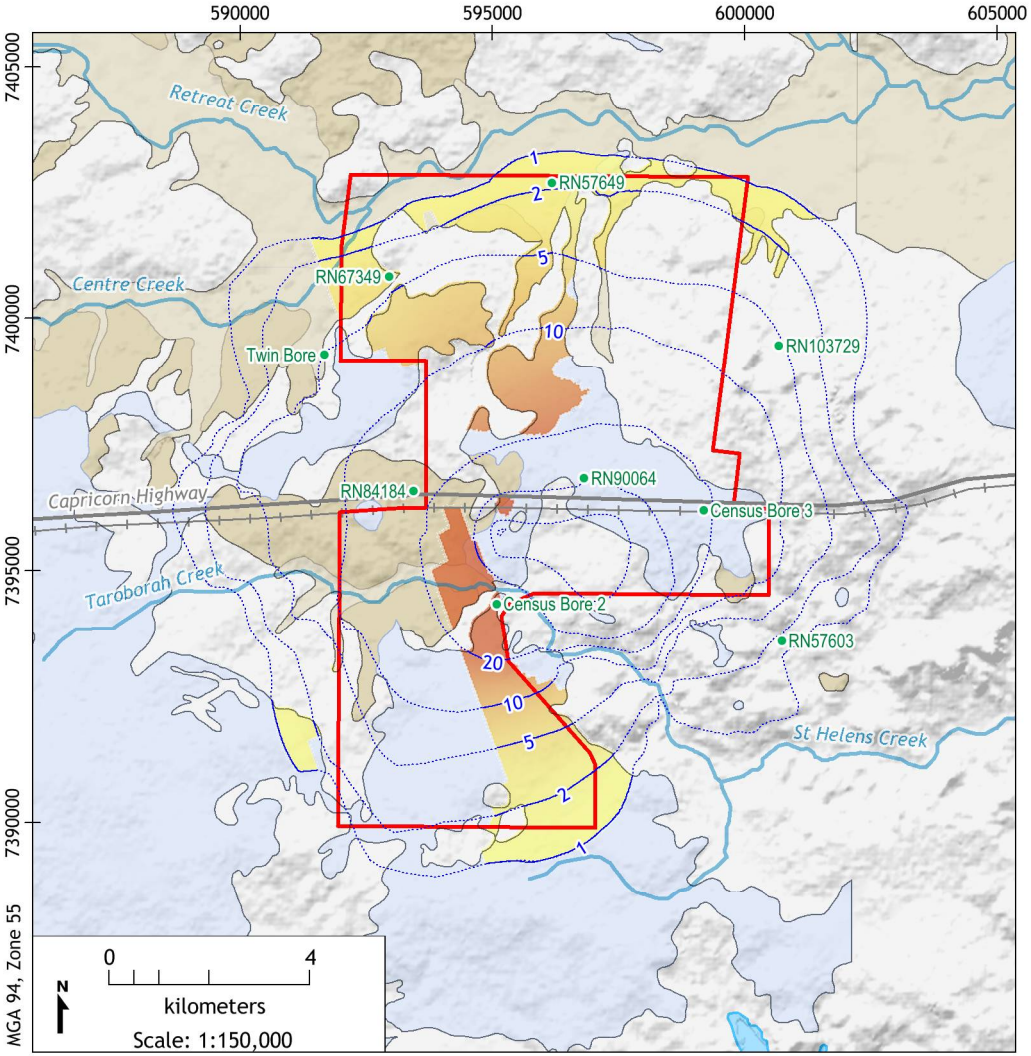
Predicted Drawdown Layer 1 (Qa/TQa/Tb) and Layer 9 (Seam B) Year 10

DATE: 14/10/2014

FIGURE No: **B-13**

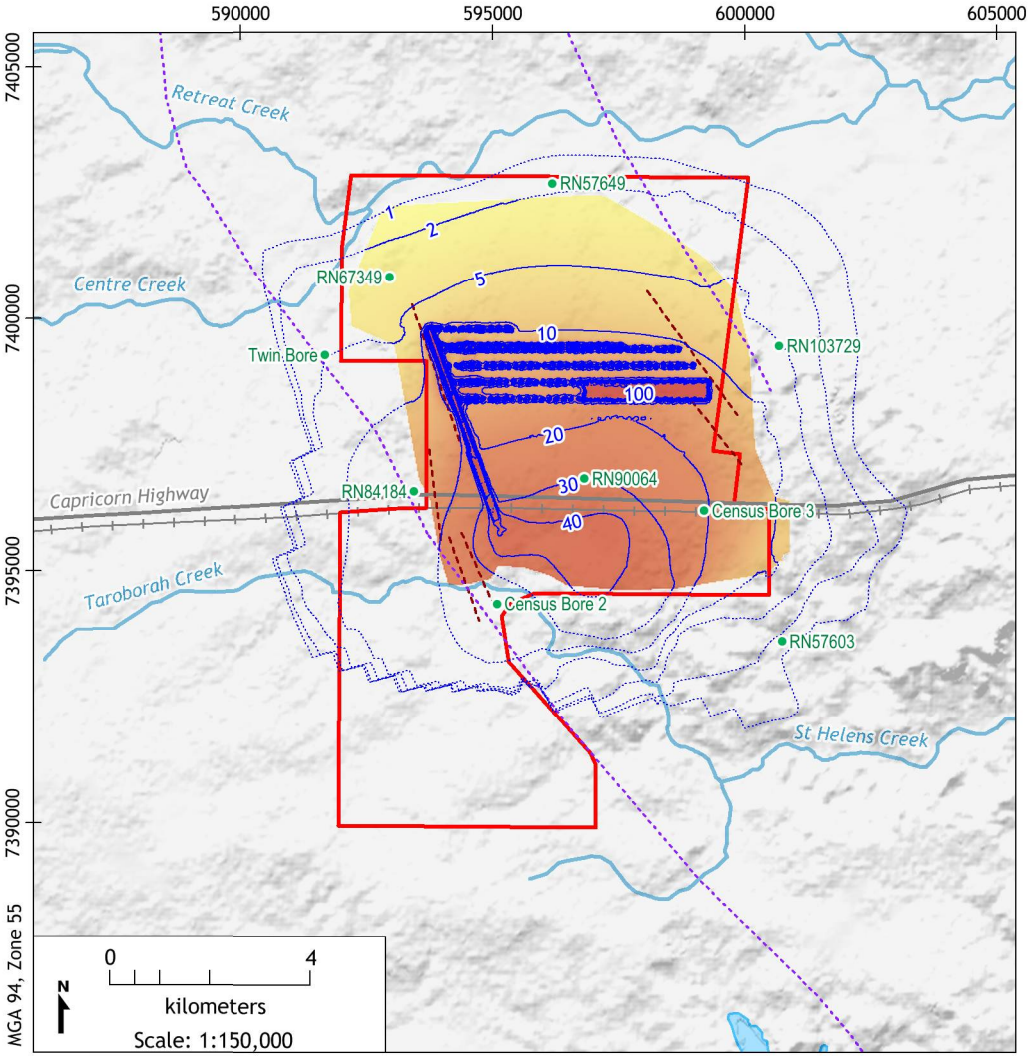
Predicted Drawdown Layer 1 (Qa/TQa/Tb) Year 15

Qa/TQa/Tb dry where no drawdown colour fill



Predicted Drawdown Layer 9 (Seam B) Year 15

Coal seam not present where no drawdown colour fill



LEGEND:

- Drawdown Contour (m)
- MDL Boundary
- Highway
- Railway
- Main Watercourse
- Landholder bore
- IMC Inferred Fault
- Bowen Basin Fault

1:100,000 Geology (Anakie & Rubyvale)

- Qa - Quaternary Alluvium
- TQa - Tertiary/Quaternary Alluvium
- Tb - Tertiary Basalt

Drawdown (m)

- 1
- 10
- 20
- 50
- 170

Taroborah Coal Project
Groundwater Assessment (G1588)

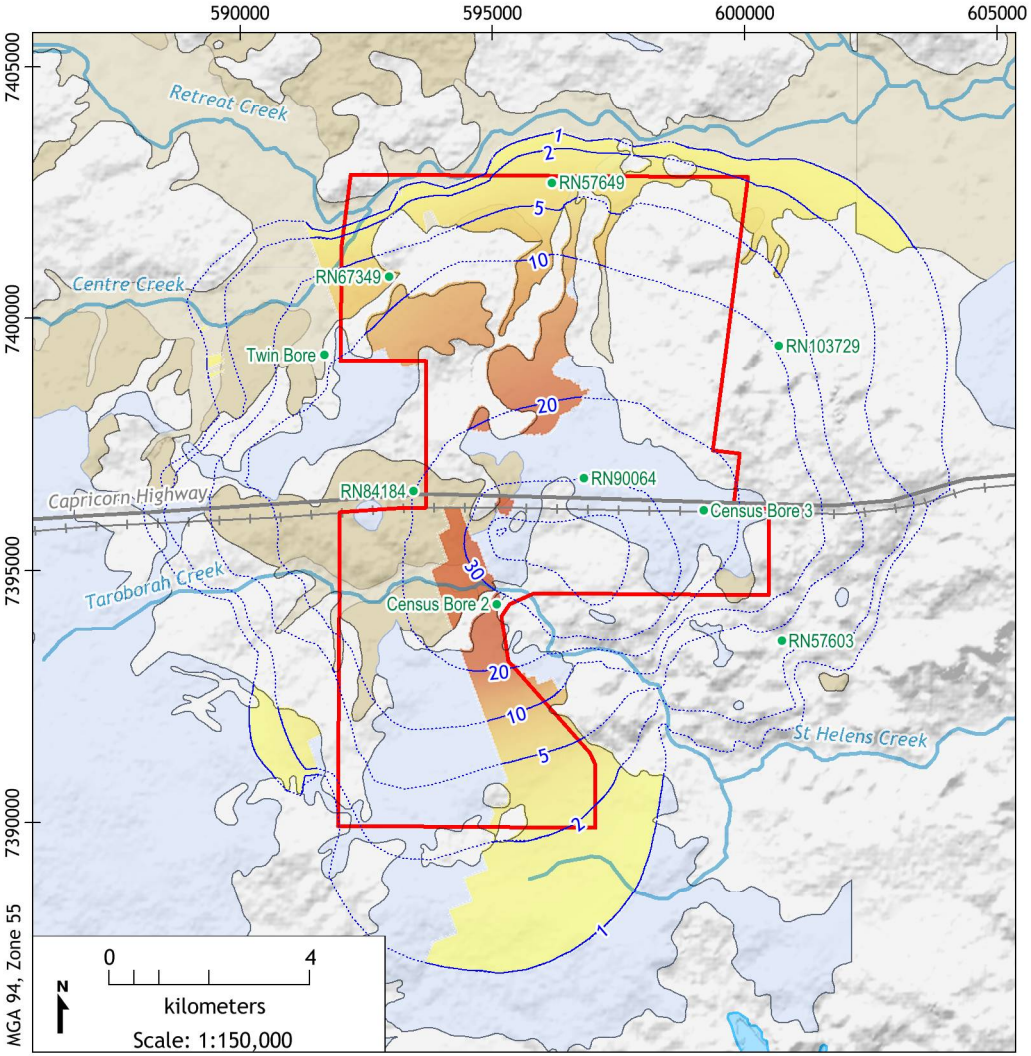
Predicted Drawdown Layer 1 (Qa/TQa/Tb) and Layer 9 (Seam B) Year 15

DATE: 14/10/2014

FIGURE No: **B-14**

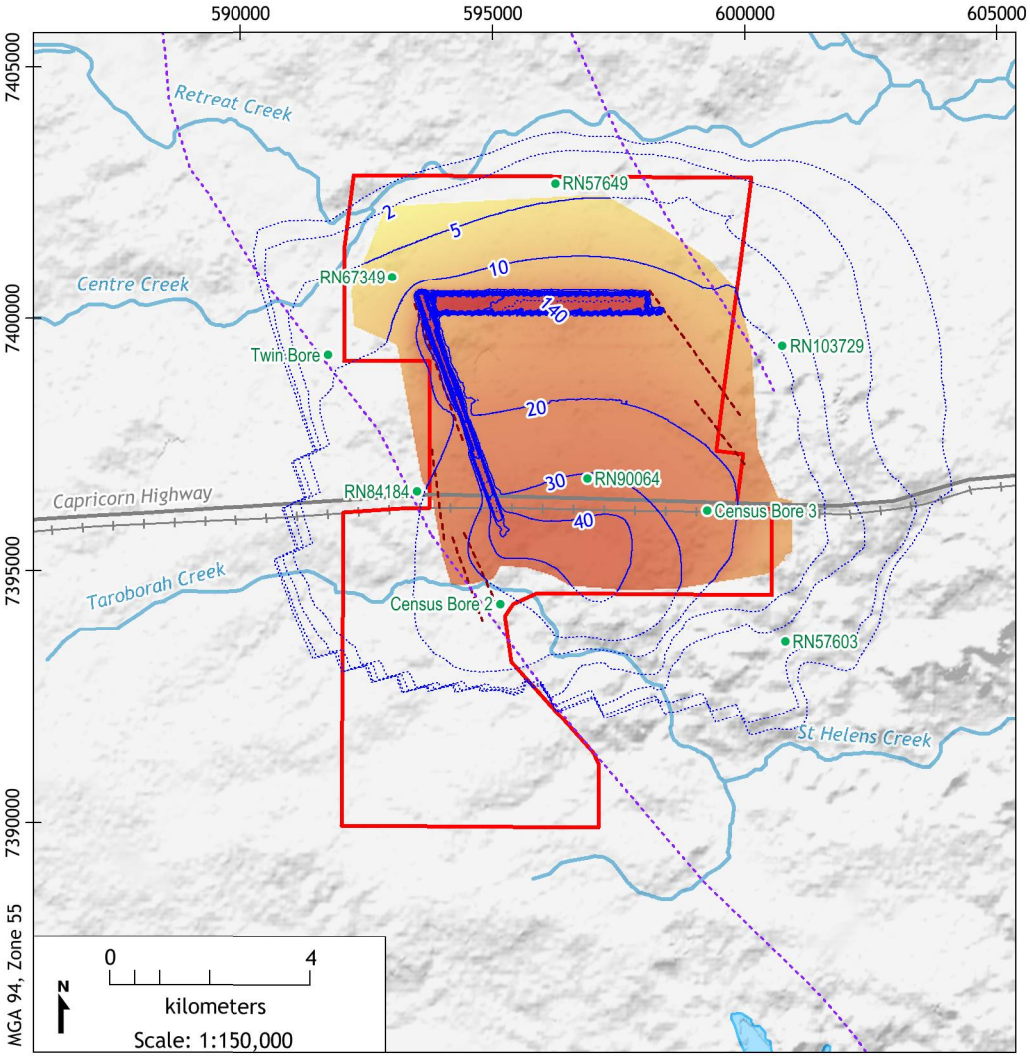
Predicted Drawdown Layer 1 (Qa/TQa/Tb) Year 21

Qa/TQa/Tb dry where no drawdown colour fill



Predicted Drawdown Layer 9 (Seam B) Year 21

Coal seam not present where no drawdown colour fill



LEGEND:

- Drawdown Contour (m)
- MDL Boundary
- Highway
- Railway
- Main Watercourse
- Landholder bore
- IMC Inferred Fault
- Bowen Basin Fault

1:100,000 Geology (Anakie & Rubyvale)

- Qa - Quaternary Alluvium
- TQa - Tertiary/Quaternary Alluvium
- Tb - Tertiary Basalt

Drawdown (m)

- 1
- 10
- 20
- 50
- 170

Taroborah Coal Project
Groundwater Assessment (G1588)

Predicted Drawdown Layer 1 (Qa/TQa/Tb) and Layer 9 (Seam B) Year 21

DATE: 24/10/2014

FIGURE No: **B-15**

3.8 Impact on Groundwater Users

Table B-6 lists the private landholder bores where groundwater levels may decline by greater than 2 m. Overall, eight active bores may record groundwater level declines by over 2 m as a result of the proposed mine, they include:

- one bore used for stock water supply with a predicted decline of less than five metres;
- two bores used for stock water supply with a predicted decline of between five to ten metres;
- four bores used for stock and farm water supply with a predicted decline of over ten metres; and
- one bore used for stock, farm and drinking water supply with a predicted decline of over ten metres.

The model results also recorded a decline in groundwater levels of over 2 m at five additional bore locations; however, four of the bores have been abandoned or destroyed, with one bore (RN 57649) currently dry and not in use.

Table B-6: PREDICTED DRAWDOWN IN PRIVATE BORES

Bore ID	Easting	Northing	Stratigraphy	Use	Bore Depth (mbgl)	Status*	SWL mbgl (Dec 2011)	Predicted Drawdown (m)	Impact on Bore Use
RN57603	600739	7393663	Aldebaran Sandstone	Stock	80.0	EX	equipped (unable to read)	-2.5	2 m - 5 m drawdown
RN67349	592950	7400883	Tertiary Basalt	Stock	32.0	EX	7.83	-7.2	5 m - 10 m drawdown
Twin Bore	591671	7399335	Tertiary Basalt / Aldebaran Sandstone	Stock - Not currently in use	46	EX	19	-8.5	5 m - 10 m drawdown
Census Bore 2	595087	7394403	Aldebaran Sandstone & Tertiary Basalt	Exploration Hole - used for stock	137	EX	equipped (unable to read)	-20.3	> 10 m drawdown
RN84184	593437	7396628	Aldebaran Sandstone	Stock	76.5	EX	equipped (unable to read)	-17.3	> 10 m drawdown
RN90064	596819	7396888	Aldebaran Sandstone / Coal	Stock & farm water	92.0	EX	equipped (unable to read)	-29.7	> 10 m drawdown
RN103729	600681	7399512	Aldebaran Sandstone	Stock	121.5	EX	equipped (unable to read)	-10.1	> 10 m drawdown
Census Bore 3	599193	7396249	Aldebaran Sandstone	Stock, farm & drinking water	123	EX	equipped (unable to read)	-23.6	> 10 m drawdown
RN57649	596184	7402744	Alluvium	Stock - Not currently in use	16.0	AU	reported dry	-3.8	Dry bore and currently not in use

Note: *Coordinates in MGA 94 Zone 55*
Status - Status of the bore is based on bore census findings (see Appendix A – Field Investigation)*
EX – Existing bore
AU – Abandoned bore that is dry but in a usable condition

Figure B-16 shows the change in groundwater levels over the Project life for the three private landholder bores with a potential 2 m to 10 m decline in Tertiary groundwater levels. Figure B-17 shows the change in groundwater levels over the Project life for the five private landholder bores with a potential decline in groundwater levels of over 10 m. This occurs within the Aldebaran Sandstone. Both hydrographs generally show a gradual decline in groundwater levels over time. An exception to this are bore RN 90064 and Community Bore, which record a more rapid decline in groundwater levels within the initial seven years of open-cut mining.

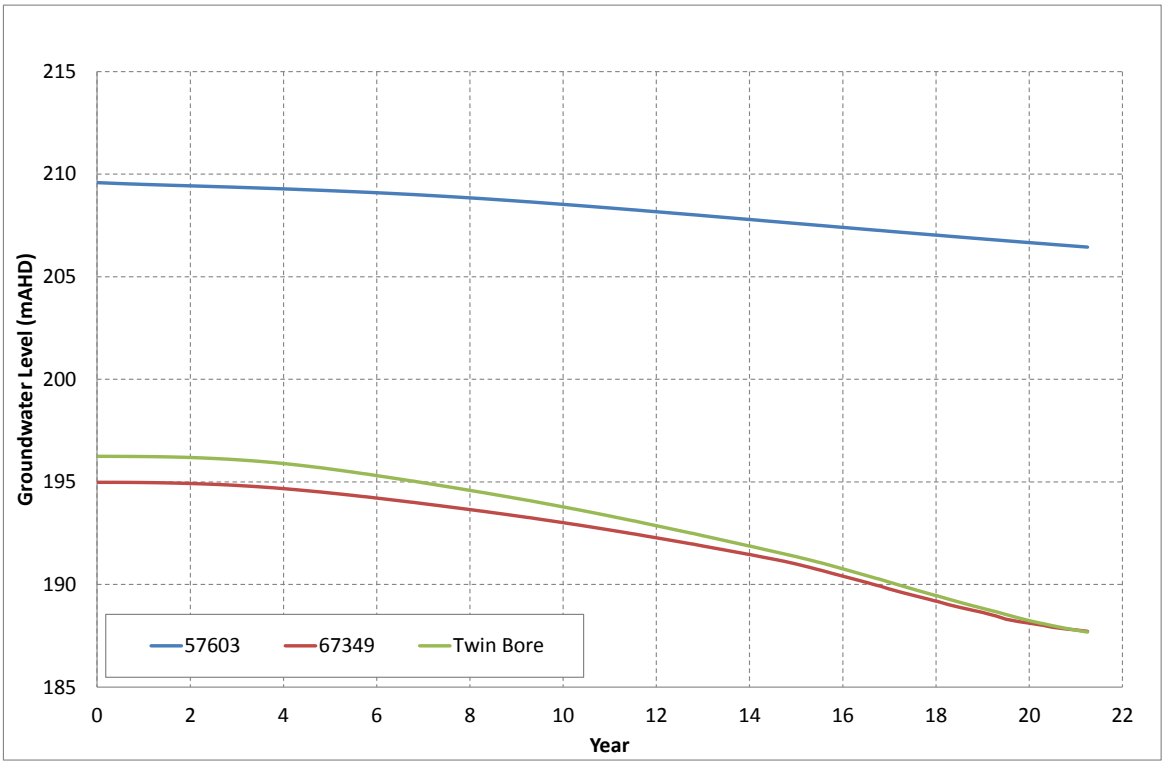


Figure B-16: Predicted Drawdown in Landholder Bores – 2 m to 10 m Drawdown

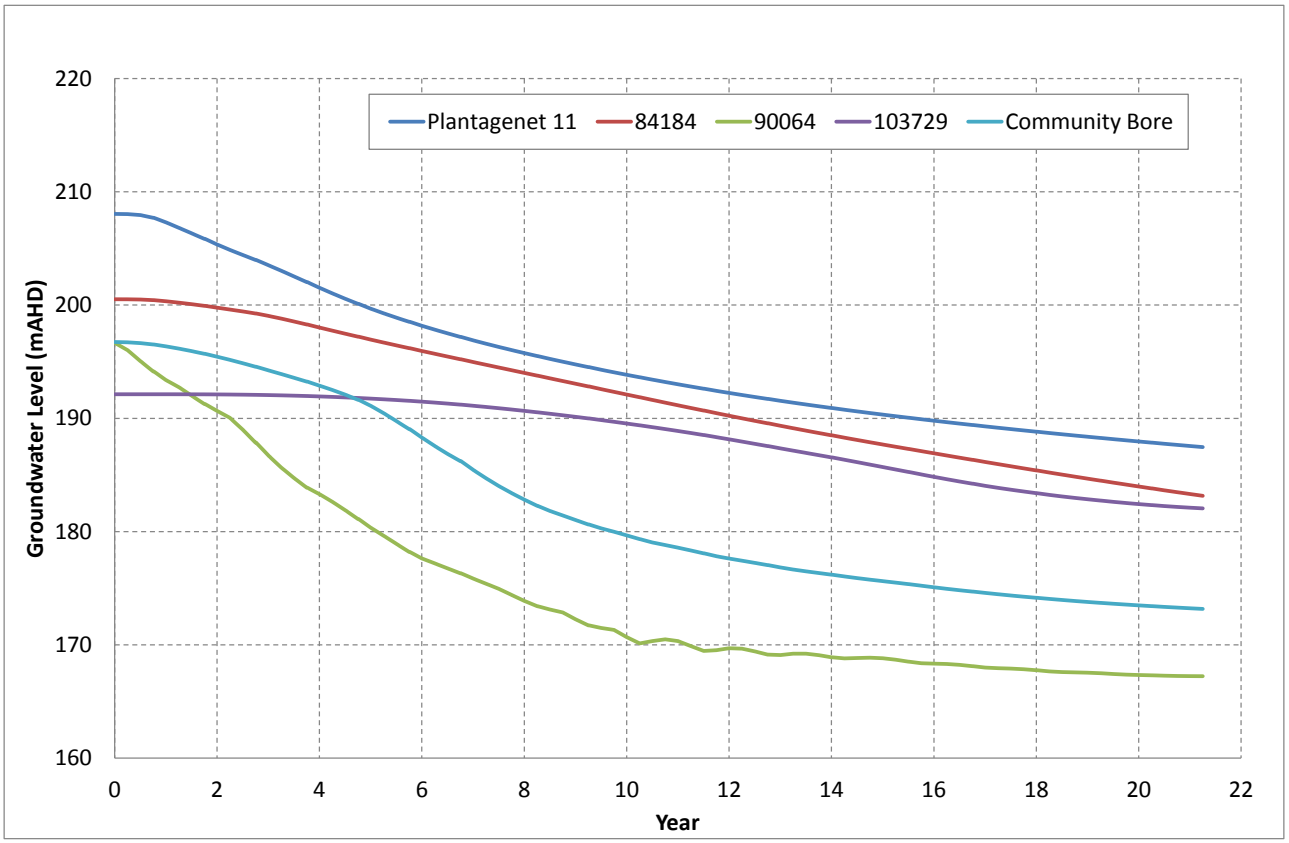


Figure B-17: Predicted Drawdown in Landholder Bores – 10 m + Drawdown

The predicted drawdown at the private landholder bores has been carried out using a number of assumptions regarding not only the numerical model (Section 1.3) but also the construction and integrity of the private landholder bores. Outside of the mine area, the geology is not as well understood and the model layering and parameterisation has been simplified to suit a conservative understanding, that is a hydraulic connection across the structural features that separate the mine area and areas further to the east, west and north (see Section 8 in the main text of the groundwater report).

Where possible, the location and usage of the bores were verified in the bore census (Appendix A-4); however, subsurface information relating to bore construction and lithology is often not available or not able to be verified. The model therefore makes assumptions regarding the model layers in which these bores are constructed, primarily by interpreting from the drilled depth of the bore. As a result, the model and its predictions are conservative in nature. The drawdown predicted by the model is considered to be a worst case scenario and the magnitude of predicted drawdown is unlikely. Where possible, groundwater levels within the private landholder bores should be monitored to verify modelled predictions.

Any loss of groundwater supply in affected bores will be compensated by the Proponent. Mitigation measures may entail:

- deepening of the bore;
- deepening of the pump; and
- constructing a replacement bore; or supplementation of supply with the groundwater extracted as a requirement of the mining process.

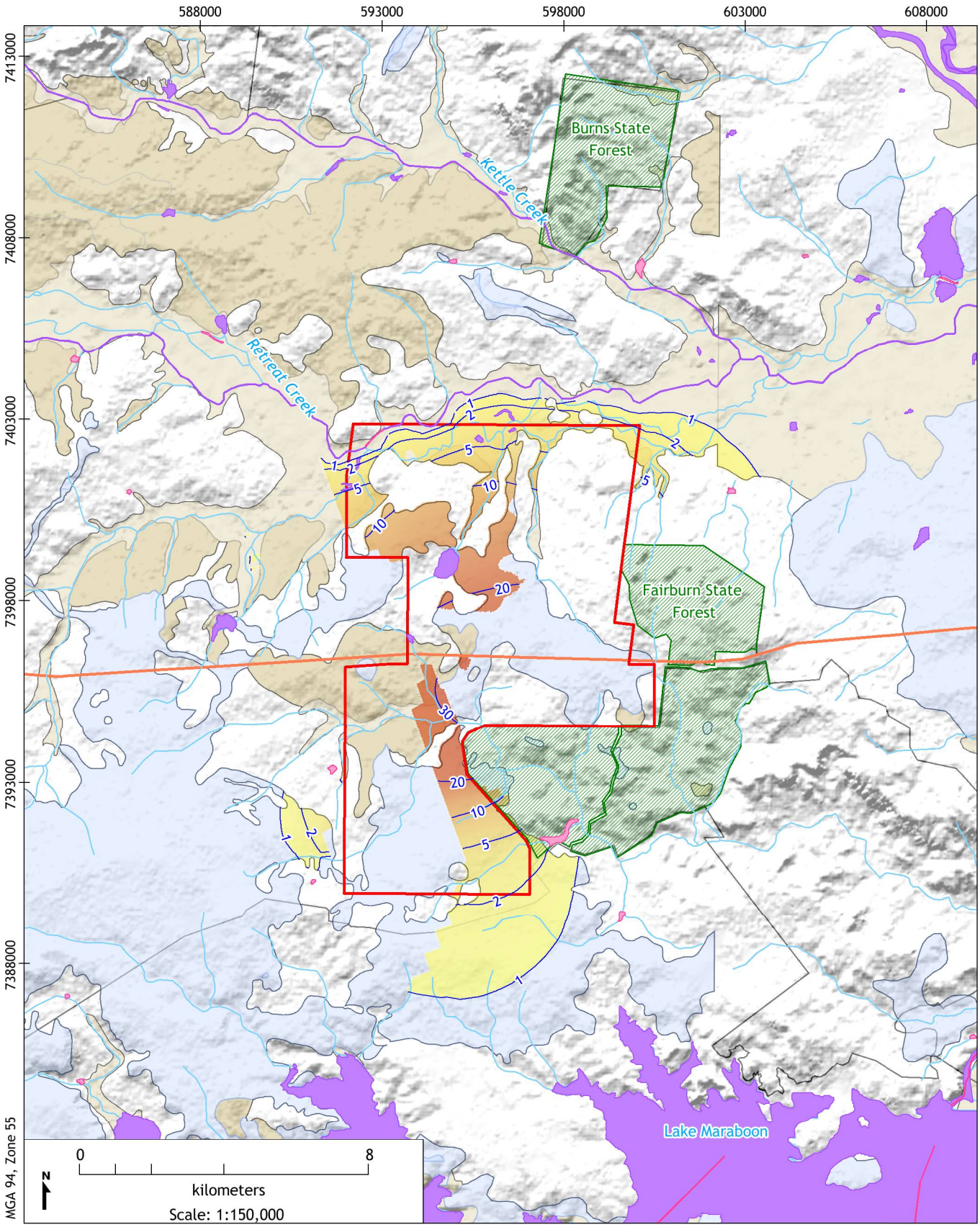
Details of the mitigation measures will be developed in agreement with the landholder at the appropriate time.

3.9 Impact on Groundwater Dependent Ecosystems

The Federal Government has established the National Atlas of Groundwater Dependent Ecosystems (GDEs)[5], based on the current knowledge of GDEs across Australia. The atlas shows known GDEs and ecosystems that potentially use groundwater, and is considered the most comprehensive inventory of the location and characteristics of GDEs in Australia. Ecosystems with a potential dependence on the surface expression of groundwater are shown on Figure B-18, along with the predicted groundwater drawdowns within the unconsolidated stratigraphy (Layer 1) at the end of mining (Year 21). Figure B-18 shows a number of ecosystems identified as having a low to moderate potential for groundwater dependence within the Project area. These are generally localised along the creeks and tributaries, as well as one region (within the MDL 467 boundary), which corresponds with a man-made dam.

Figure B-19 indicates that some areas identified as having a potential dependence on groundwater are within the drawdown contours predicted for the unconsolidated stratigraphy (Layer 1). For information on the impact of groundwater drawdown on GDEs the reader is referred to the EIS Ecology Report.

[5] http://www.bom.gov.au/water/groundwater/gde/index.shtml



LEGEND:

- Drawdown Contour (m)

Drawdown (m)

- 1
- 10
- 20
- 50
- 170
- MDL Boundary
- State Forest
- Watercourse

GDE Atlas (BOM)
(Surface Expression of Groundwater)

- High potential for GW interaction
- Moderate potential for GW interaction
- Low potential for GW interaction

1:100,000 Geology (Anakie & Rubyvale)

- Qa - Quaternary Alluvium
- TQa - Tertiary/Quaternary Alluvium
- Tb - Tertiary Basalt

Taroborah Coal Project
Groundwater Assessment (G1588)

GDEs and Groundwater Drawdown
Layer 1 - Year 21

DATE: 14/10/2014

FIGURE No: **B-18**

3.10 Groundwater Recovery

The baseline model simulated recovery of the groundwater system for 1,000 years post mining (Year 1021). The simulation utilised the predicted groundwater levels and hydraulic properties at the end of the mining period. The drain cells used to simulate dewatering from the coal seam were removed, allowing the groundwater levels in geological units above and beneath the coal seams to recover (gradual return to pre mine dewatering conditions). The main development headings were changed to void parameters within the previously existing coal seam layer, to simulate the filling up of the excavation road area once mining ceases. The drain cells used in the western void were also removed and changed to include void, recharge and evaporation rates.

Figure B-19 illustrates the recovery of groundwater levels within the western and eastern pit voids, as well as the pit crest elevations. The results indicate that groundwater levels within both pit voids will begin to stabilise approximately 500 years following active mining. However, within 100 years groundwater levels have recovered to within 60 % to 70% of post mining levels. Groundwater levels within the western pit void will be maintained at around 194 mAHD, while groundwater levels within the eastern pit void will be maintained at around 190 mAHD (consistent with pre-mining water levels). Both pit lake levels fall well below the pit crest, indicating that the voids will not over-top and will act as 'sinks'.

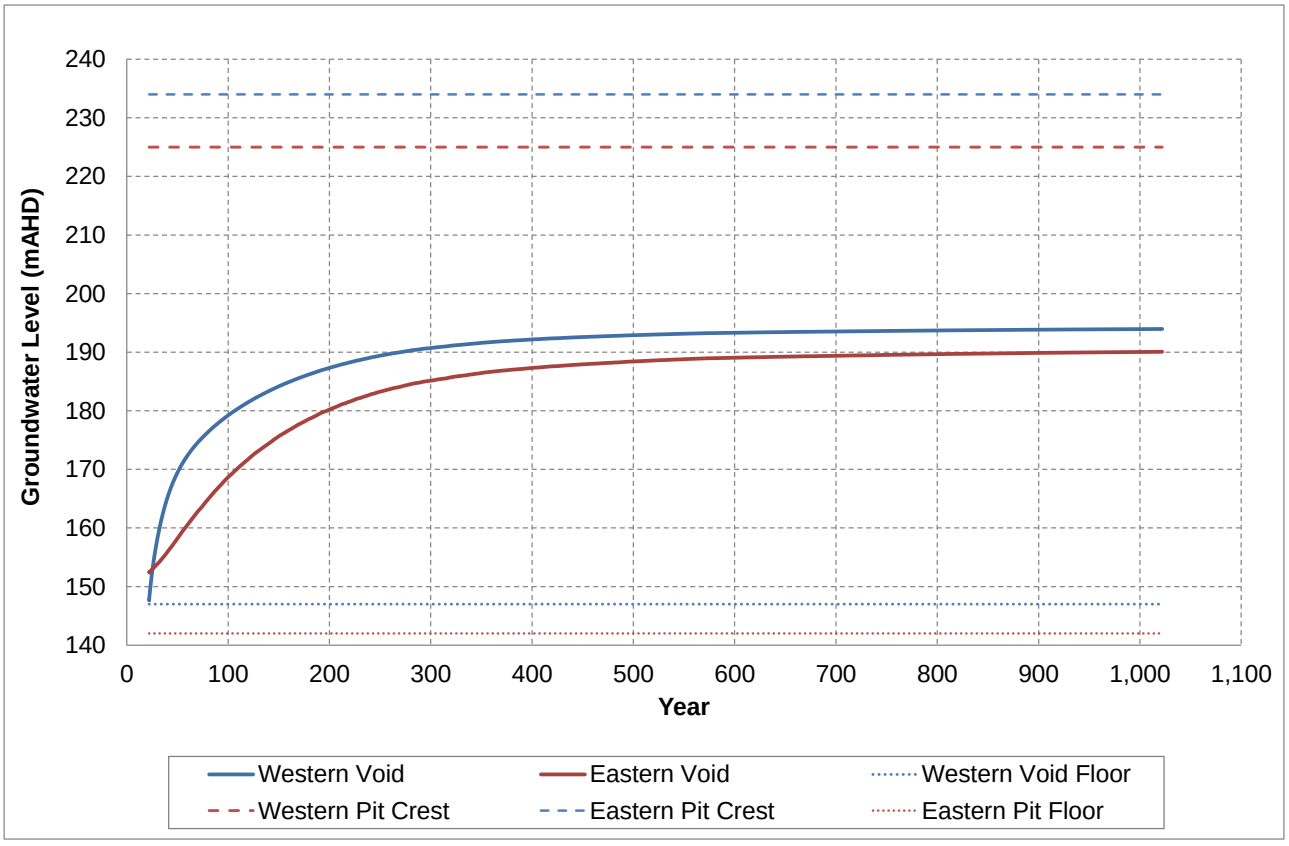
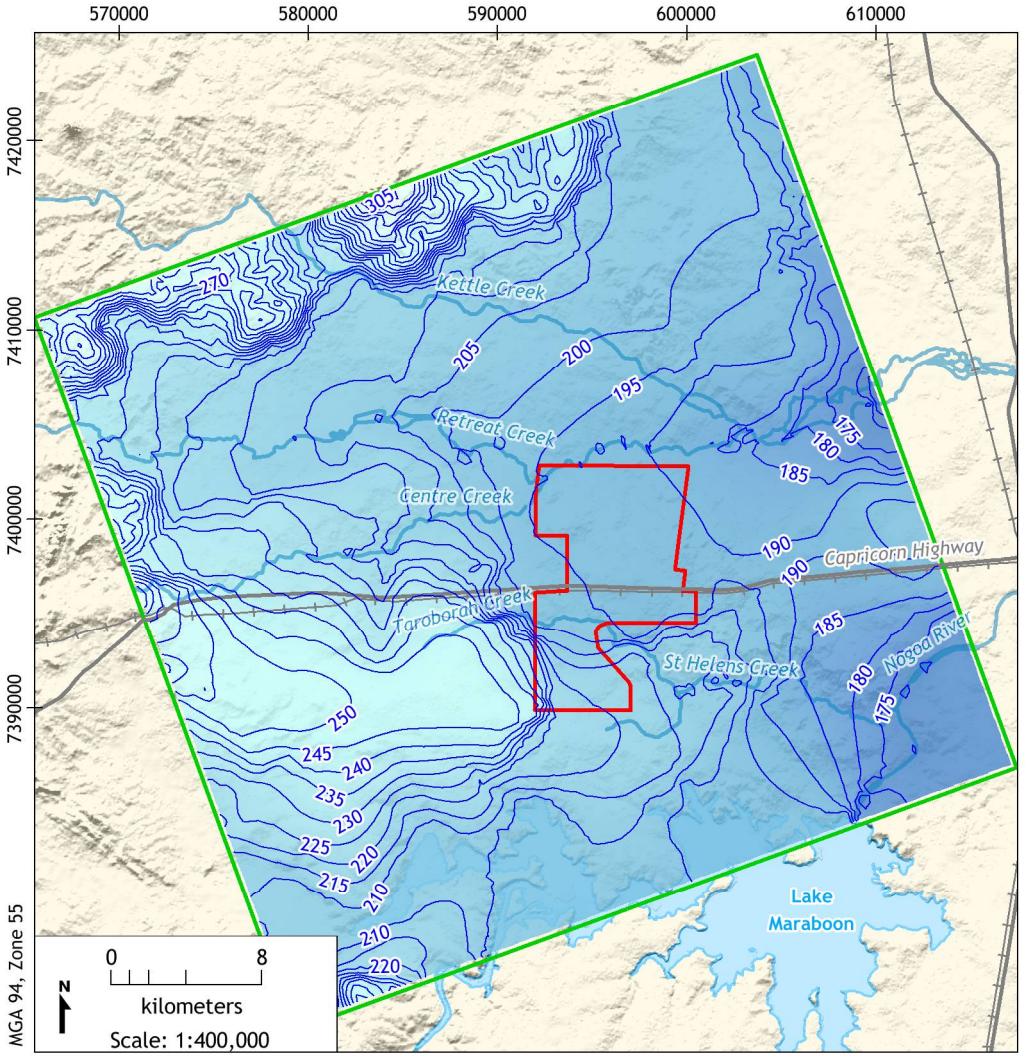


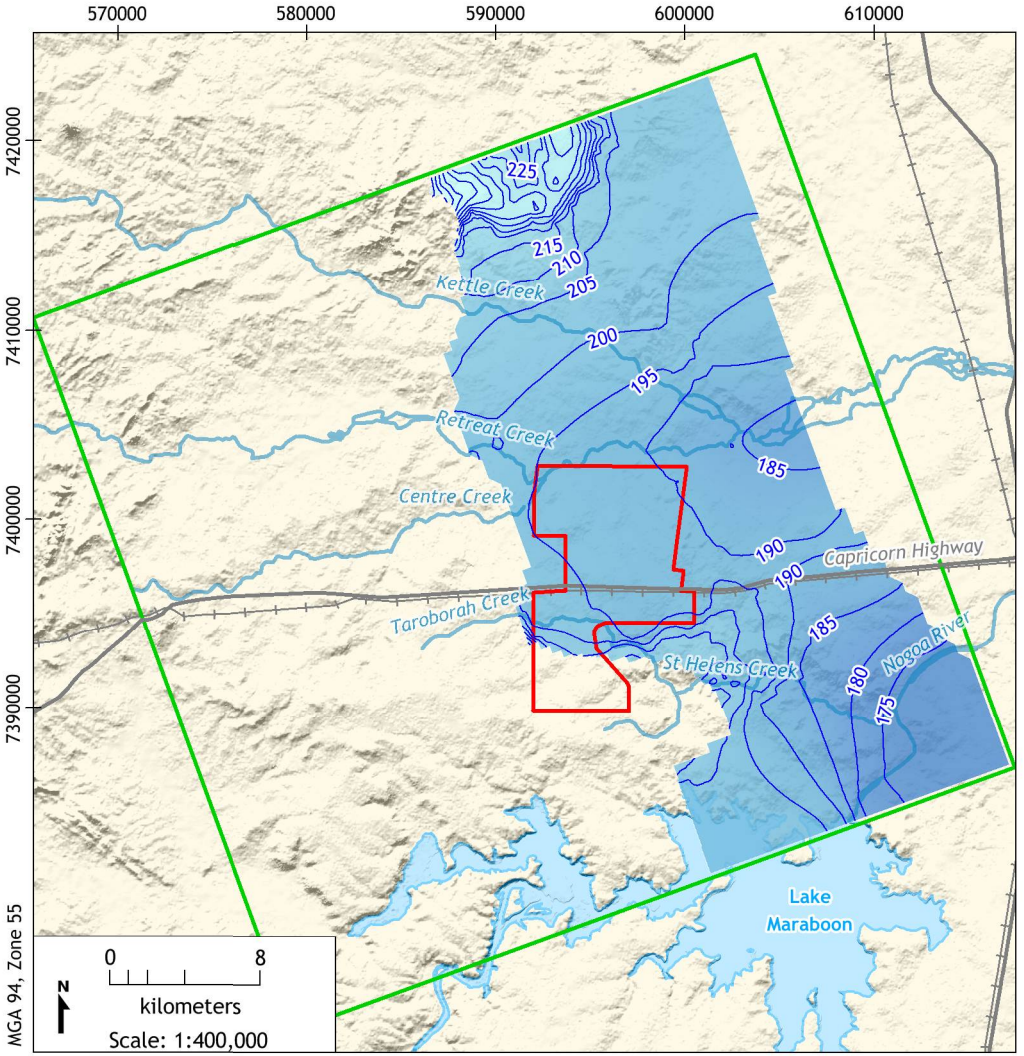
Figure B-19: Pit Lake Level Recovery over time

Figure B-20 presents the predicted recovered groundwater levels within the unconsolidated stratigraphy (Layer 1) approximately 1,000 years following mining (Year 1021).

Recovered Alluvial Groundwater Levels Layer 1 (Qa/TQa/Tb) 1000 Years Post-Mining



Recovered Groundwater Levels Aldebaran SS 1000 Years Post-Mining



LEGEND:

- MDL Boundary
- Model Boundary
- Highway
- Railway
- Main Watercourse
- Groundwater Contour (mAHD)

Taroborah Coal Project
Groundwater Assessment (G1588)

Recovered Alluvial Groundwater Levels Layer 1 (Qa/TQa/Tb) and Aldebaran SS 1000 Years Post-Mining

DATE: 15/10/2014

FIGURE No: **B-20**

4 MODEL SENSITIVITY ANALYSIS

Parameter sensitivity on predictions was explored through additional model scenario runs and varying key parameters values. These parameters were considered potentially sensitive to the model with impacts on predictive inflows and model fluxes. The sensitivity analysis assesses the following parameter ranges:

- a ±50% change in horizontal and vertical hydraulic conductivity of all model layers displaying low sensitivity to calibration (excluding void, spoil, and goaf);
- a ±1 order of magnitude change in recharge (excluding void and spoil);
- a ±1 order of magnitude change in specific storage layers (excluding the void and spoil); and
- a ± 1 order of magnitude change in specific yield of all model layers (excluding the void and spoil).

In addition to these sensitivity analyses, the sensitivity of the model output was explored in relation to the method used to model subsidence induced fracturing. This is summarised in Section 4.2.

4.1 Predictive Mine Inflow Rates

Sensitivity of the predicted pit inflow rates to changes in the model parameters is summarised in Table B-7 and shown in Figure B-21. Table B-7 shows that increasing the hydraulic conductivity by 50% and the storage by an order of magnitude raises the overall maximum predicted inflow by 128% (7.4 ML/day) and 125% (7.2 ML/day), respectively. The other parameters are less sensitive, with the change in inflow results, when compared to baseline values, ranging between 111% and 118%.

Table B-7: SUMMARY OF SENSITIVITY ANALYSIS

Parameter	Average Daily Inflow		Maximum Daily Inflow	
Unit	**ML/day**	**%**	**ML/day**	**%**
Baseline	2.6	100	5.7	100
HC_VHC + 50 %	3.1	120%	7.4	128%
HC_VHC – 50 %	2.3	87%	4.3	75%
RCH + 1 x OM	3.3	128%	6.5	114%
RCH – 1 x OM	2.5	96%	6.6	115%
SS + 1 x OM	3.9	148%	7.2	125%
SS – 1 x OM	2.1	81%	4.6	80%
SY + 1 x OM	2.7	104%	6.4	111%
SY – 1 x OM	2.7	103%	6.8	118%

Notes: hc – Horizontal and Vertical Hydraulic Conductivity
SY – Specific Yield
SS – Specific Storage
OM – Order of Magnitude (x10)
% – percentage compared to baseline model scenario

Figure B-22 shows the change in sensitivity with time and mine progression. Figure B-22 indicates that the predicted mine inflow seepages to the open-cut pits (initial 7 years) are most sensitive to changes in storage (ss) and recharge (rech). The underground mining inflows are most sensitive to changes in hydraulic conductivity (hc) and storage (ss).

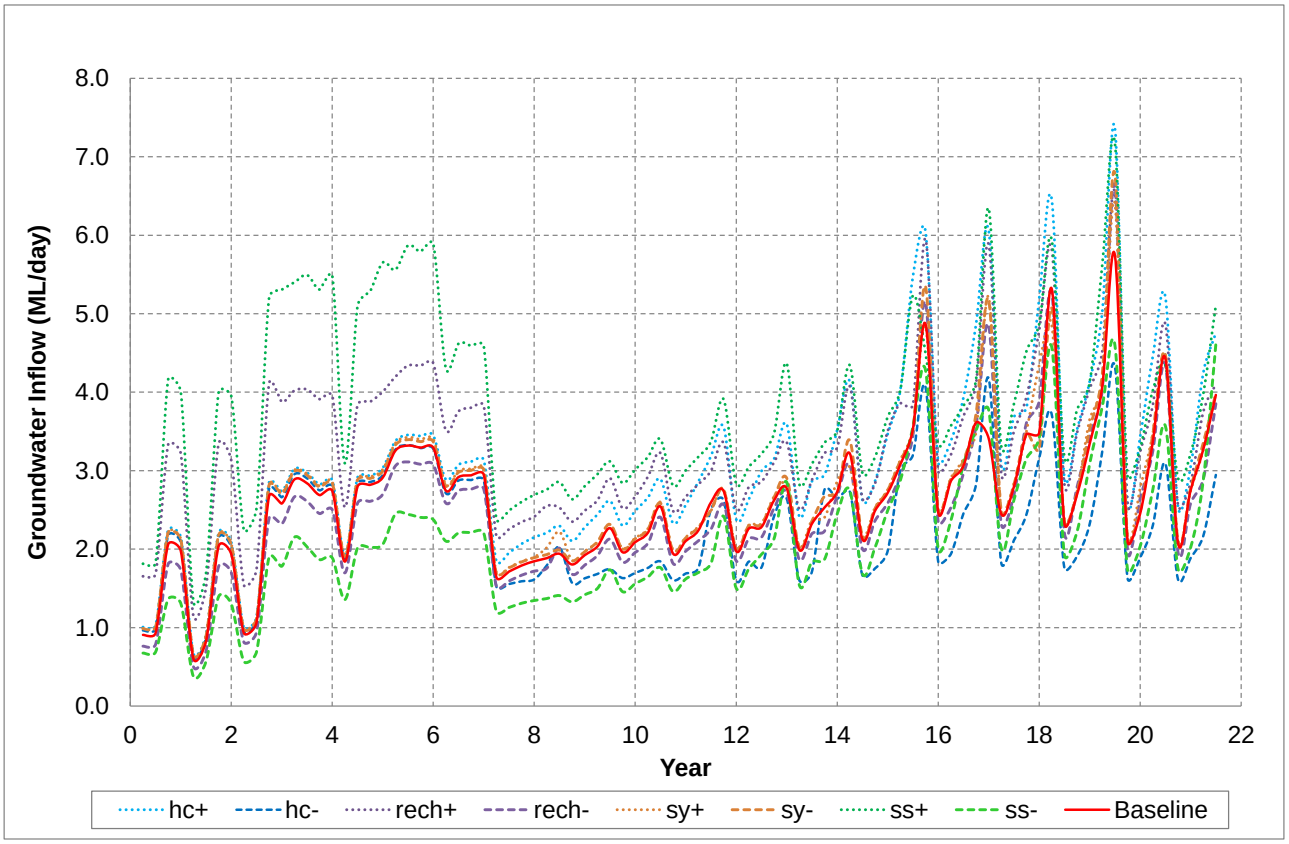
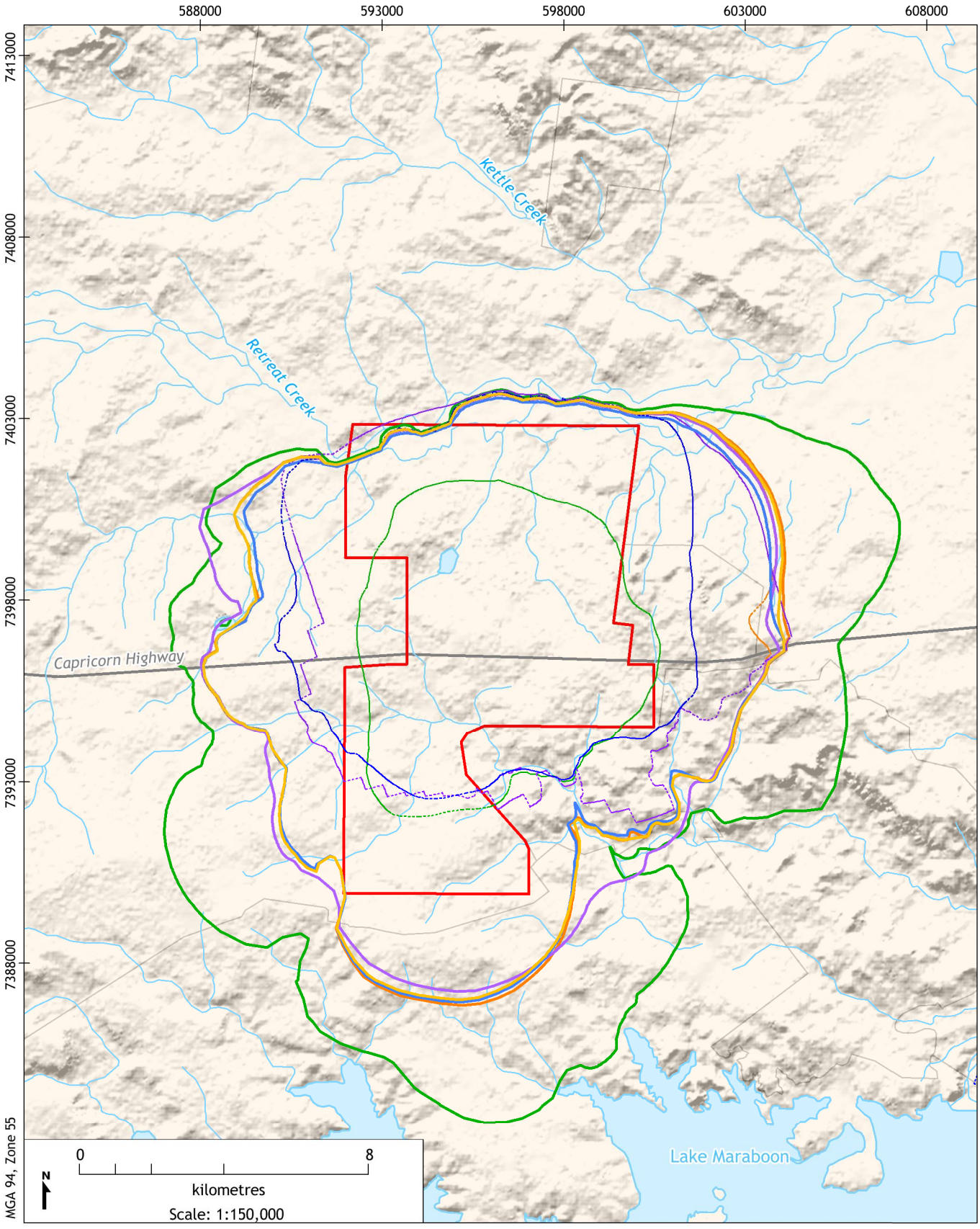


Figure B-21: Sensitivity Analysis – Pit Inflows

4.1.1 Predictive Drawdowns

Figure B- 22 shows the maximum extent of 1 m water table drawdown within the model for the baseline and sensitivity analysis. The 1 m drawdown contours encompass drawdown within all model layers, as it represents the maximum extent of drawdown within the uppermost saturated aquifer. Therefore the extent of drawdown is not representative of one aquifer (i.e. alluvium) and has only been used to identify the sensitivity of the model to different hydraulic parameters.

Figure B- 22 indicates that the extent of drawdown predicted by the model is most sensitive to changes in storage (ss). The parameters used within the model were based on field results (Appendix A) and standard hydraulic parameters within the Bowen Basin. The drawdown extent as a result of a one order of magnitude reduction in storage is not considered likely, as conservative values for storage have already been applied to the baseline model (see Section 1.3.5).



LEGEND:

Drawdown Extent (1m Contour)

- Baseline
- HC/VHC + 50 Percent
- HC/VHC - 50 Percent
- Recharge + 1 OM
- Recharge - 1 OM
- SY + 1 OM
- SY - 1 OM
- SS + 1 OM
- SS - 1 OM

- MDL Boundary
- Watercourse
- Highways

Taroborah Coal Project
Groundwater Assessment (G1588)

Predicted Drawdown Extent
Sensitivity Analysis - 1m Contour
Year 21

DATE: 26/9/2014

FIGURE No: **B-22**

4.2 Subsidence Induced Fracturing

The sensitivity of the model output was explored in relation to the conceptual approach used to represent subsidence induced fracturing and the parameters used in the method.

4.2.1 Representation of Subsidence Induced Fracturing

Within the basecase model, the longwall mine was represented by applying a series of drains to each longwall panel. These drains remained active for the entire mining strip of the longwall panel. Once mining of the longwall panel is complete, the drains were then switched off and the material above the mined coal seam was simulated to be goafed or affected by subsidence induced fracturing (see Table B-8).

An alternative method of representing the longwall panel was explored as a sensitivity analysis. In the alternative approach, the drains are not active for the entire mining strip of the longwall panel but switched off progressively in conjunction with the active mining face. The overburden material above and behind the mined strip is also progressively goafed or fractured.

Whilst neither conceptual approach is perfectly representing physical reality, it provides an alternative approach to compare against the baseline.

4.2.2 Height of Subsidence Induced Fracturing

The height of fracturing in the baseline model used a 30 times multiplier (30 t) above the mined B seam (equivalent to 90 m) as postulated by the 1993 model of Kendorski (2006) and commonly used in the industry. In this context, the assumption of 30 t could be perceived as optimistic and not representing a possible worst case scenario.

Investigations of Australian experience, as well as groundwater modelling of other Bowen Basin longwall proposals, support the 1993 Kendorski model of strata behaviour and the assumption made for the project. For example:

- Adhikary and Wilkins (ACARP C18016, 2012): Extensive monitoring of longwall caving at Springvale and Dendrobium in NSW indicate the height of the fractured zone extends 100 m to 105 m (~30 t) above the mine workings.
- MESC (2012): This subsidence modelling report for Moranbah South sites experience of undermining surface waters (Isaac River) at Moranbah North, where longwall extraction at 4.5 m height showed no discernible increased inflow into the mine workings at depths from 110 m to 200 m (i.e. 25 t - 50 t).
- Guo *et al*. (ACARP C14033, 2007): Provides a summary of practical hydrogeological models of longwall mining proposed by various authors, and concludes that the fractured / disturbed zone, where the strata sag downwards resulting in bending, fracturing, joint opening and bed separation, is indicated to be 15 to 40 times the seam thickness.
- Gale (ACARP C13013, 2008): In the Hunter Valley, at Wollombi Creek Mine, stream flow was lost when mining occurred at a depth of approximately 90 m but not at depths greater than 120 m. Subsidence was estimated to be approximately 1.4 m to 1.6 m. The site at Wambo under Wollombi Creek also indicated stream loss at depths of 90 m to 95 m but not at depths of 110 m to 210 m. It is noted that subsidence of 1.4 m to 1.6 m at Wollombi Creek suggests an extraction thickness of 2.3 m to 2.7 m, or a thickness of the fractured zone of 33 t to 39 t.

Gale goes on to suggest that the height of fracturing is more a function of extraction width rather than extraction height, with a typical ratio of height of fractures forming being 1 to1.5 times the extraction width. However, the creation of these fractures alone does not necessarily imply that a direct hydraulic connection exists over this zone. In order for mine inflow to occur, the fractures created must form a connected and conductive network to allow significant volumes of inflow.

- Frith (ACARP C10023, 2003): Investigation of subsurface fracturing above longwall panels using vertical boreholes at a number of Queensland and NSW mines indicated that the height above the workings where total loss of drilling fluid occurred (which is considered analogous to the fractured zone) ranged from 18 m to 63 m (6.4 to 31.5 t).

With this information, the sensitivity model was generated with the assumption that the height of fracturing is equivalent to 40 times the thickness of the B coal seam (equivalent to 120 m). This multiplier would appear to be at the upper end of predictions. This height extends the fractured zone to the base of layer 3, which represents the base of weathering in the Aldebaran Sandstone and base of Tertiary in some parts of the model.

4.2.3 Vertical Hydraulic Conductivity of the Goaf

Model sensitivity was also explored in terms of the vertical hydraulic conductivity values applied to the strata impacted by subsidence induced fracturing. The vertical hydraulic conductivity values applied to the fractured strata representing layers 4 to 9 were increased in comparison with the baseline model. Table B-8 shows the changes to the vertical hydrualic conducitivty within the goaf/fracture zone.

Table B-8: Sensitivity of longwall induced changes to Kz

Layer	Baseline fractured Kz (m/day)	Sensitivity fractured Kz (m/day)	Percent change
4	6.02×10^{-3}	1.09×10^{-2}	82%
5	7.70×10^{-3}	3.50×10^{-2}	355%
6	1.00×10^{-1}	1.00	900%
7	2.30×10^{-2}	4.60×10^{-2}	100%
8	5.0×10^{-4}	1.00×10^{-3}	100%
9	8.4×10^{-3}	2.12×10^{-2}	150%

4.2.4 Summary

The predicted inflows from the sensitivity analyses are shown in Figure B- 23. The analyses show that by modifying the representation of the longwall mine and by increasing the height of subsidence induced fracturing (from 30 t to 40 t), the inflows are generally higher, in the order of 4 ML/day to 5 ML/day. There are two peaks of short duration toward the end of mining in the order of 8 ML/day.

By also modifying the vertical hydraulic conductivity of layers 7, 8 and 9, the predicted inflows increase between 0.5 ML/day and 2 ML/day. The inflows are generally between 4 ML/day and 6 ML/day. The two inflow peaks of short duration toward the end of mining increase up to 10 ML/day.

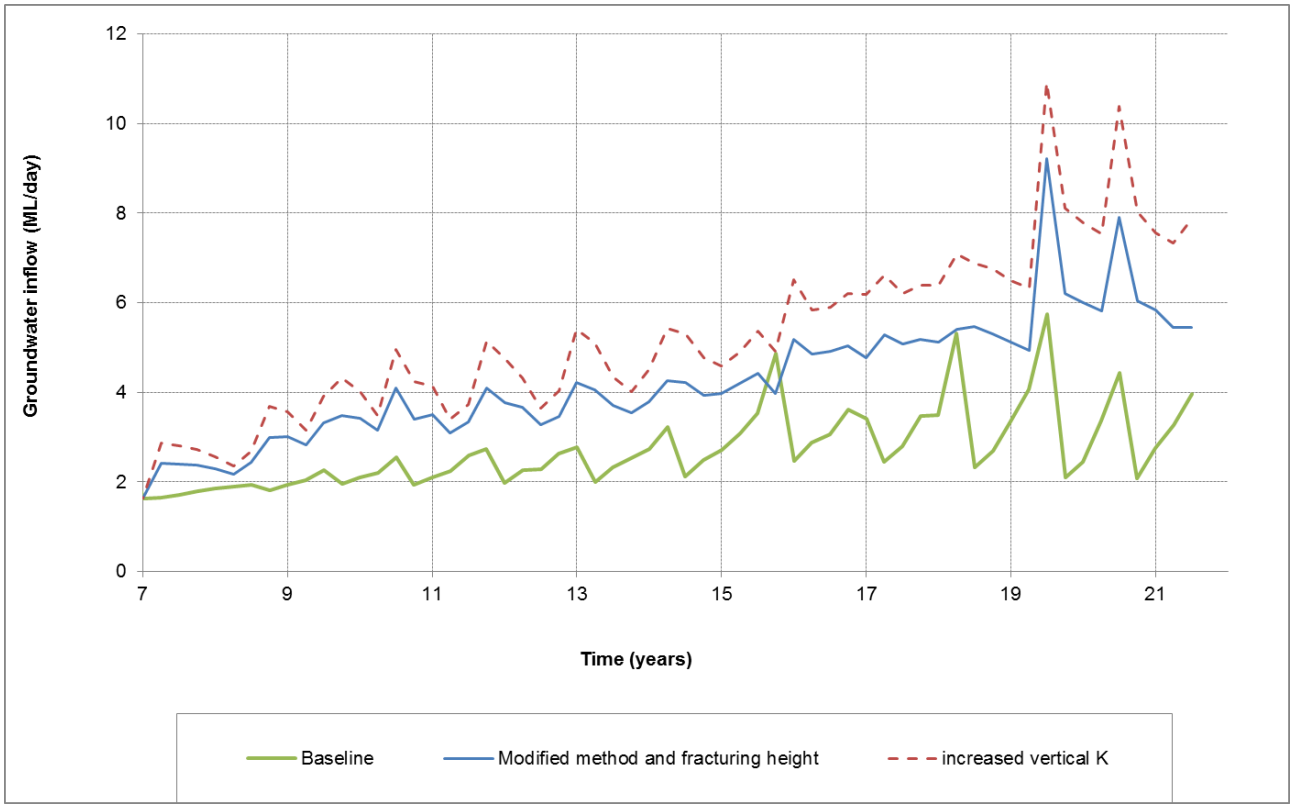


Figure B- 23: Subsidence induced fracturing sensitivity analysis – predicted inflows

The sensitivity analysis shows that during the later stages of mining, groundwater inflows in the order of 8 ML/day to 10 ML/day are predicted. This inflow occurs when the longwall mine progression is in the northern portion of the mine, directly under a thick sequence of Tertiary material, which in the model is represented as having relatively high hydraulic conductivity and direct connection via the increased subsidence fracturing. This predicted high inflow is not considered realistic for the reasons outlined below.

The experience of subsurface fracturing with regard to weak sediments (i.e. mudstones, claystones and weathered siltstones) and clays is that these units do not generally form continuous open fractures due to their plasticity, and the fractures that do form tend to be self-healing over a relatively short period of time due to swelling from moisture. Gale (2008) states "*the presence of clay in the overburden is considered to constrain the fracture network through fracture healing by expansion or its ability to strain without fracturing*".

The overburden in the project area includes a significantly thick sequence of weak Tertiary strata and weathered Permian, ranging in thickness from 45 m to 90 m. Included are numerous, often times thick, layers of clay and weathered claystone, which lie beneath the scattered basalt occurrences and alluvial gravels in the north near Retreat Creek. Based on experience elsewhere, it is expected that these units will not be highly fractured from subsidence where they occur more than 60 m to 70 m above the mine workings and therefore, will continue to act as an aquiclude to the overlying groundwater and surface waters.

Therefore, whilst the sensitivity analysis predicts high inflows to the underground mine, it is unlikely that these flow rates would eventuate due to the nature of the overlying sediments.

Figure B- 24 shows the 1 m drawdown extent for the subsidence sensitivity analysis. Figure B- 24 indicates that the extent of drawdown predicted by the sensitivity model is comparable to the other sensitivities presented in Figure B- 22.

Table B-9 shows that by changing the representation of the goaf and increasing the height of fracturing from 30 t to 40 t, it increases the average predicted inflow by 41%. By further increasing the vertical hydraulic conductivities, the inflows increase by 67%. As discussed above, the maximum inflows are considered unlikely due to the nature of the weathered Permian and Tertiary material above the longwall mine.

Table B-9: SUMMARY OF SUBSIDENCE SENSITIVITY ANALYSIS

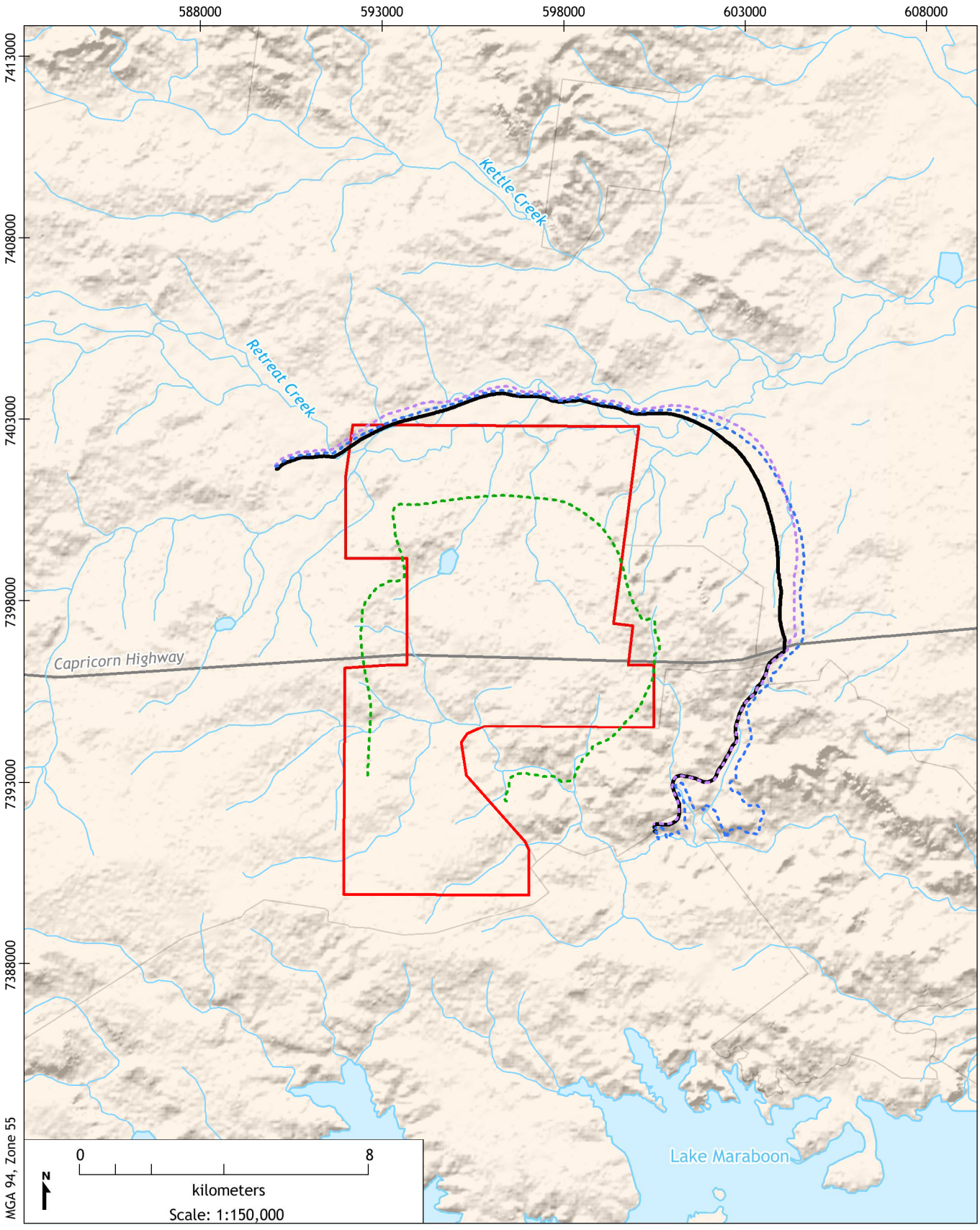
Parameter	**Average Daily Inflow**		**Maximum Daily Inflow**	
Unit	**ML/day**	**%**	**ML/day**	**%**
Baseline	2.6	100	5.7	100
Modified method and fracturing height	3.6	141	9.2	161
Increased vertical K	4.3	167	10.9	190

Figure B- 25 shows the predicted drawdown for the subsidence sensitivity analysis within layer 9 after 21 years. The figure shows that with the change in longwall representation, the predicted depressurisation within the model layers is sustained and is of greater magnitude. This magnitude is greatest within layer 9 and decreases with height above the underground mine.

The greater drawdown as a result of this change in the modelling approach is only present during mining. Post mining, the recovery within the underground and open pit will be comparable to the baseline model.

Groundwater drawdown caused by underground mining in the layers overlying the longwall panel is more extensive in this scenario. This is because the vertical hydraulic conductivity of the fracture zone is increased, which further enhances hydraulic connection to the overlying groundwater system when compared to the baseline model presented in the EIS. The model results show water levels depressurise by up to 30m within the Aldebaran Sandstone, immediately above the active underground mining.

Whilst this scenario increased the hydraulic connection between the longwall mining area and the Aldebaran sandstone, the results show the majority of the Aldebaran Sandstone is not sully desaturated. Following the completion of each longwall mining area, groundwater levels in Layer 9 (rubble zone) respond similar to the basecase (see Section 3.7); however, residual drawdown occurs in the overlying layers for approximately six months following longwall completion.



LEGEND:

Maximum Drawdown Extent (1m contour)

- Baseline
- HC+
- SS+
- Fracture

- MDL Boundary
- Watercourse
- Highways

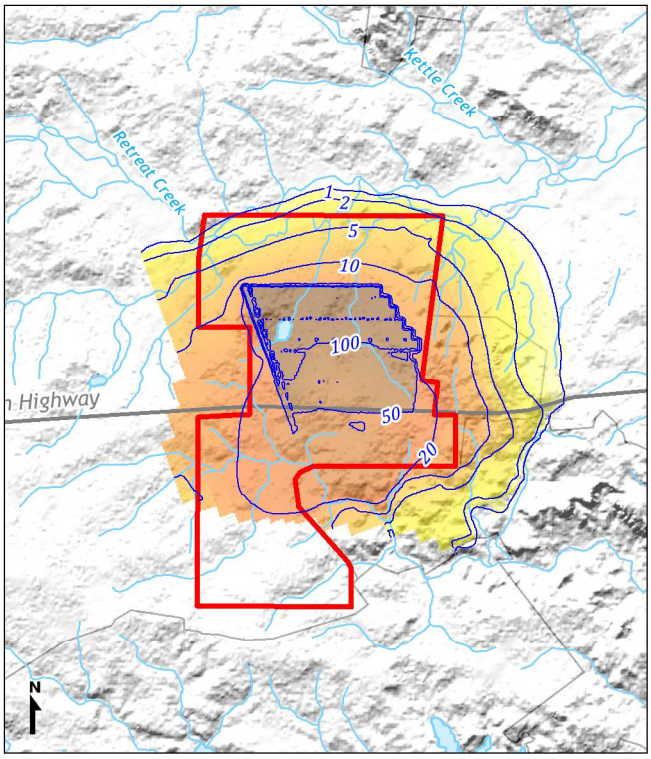
Taroborah Coal Project
Groundwater Assessment (G1588)

Subsidence induced fracturing sensitivity analysis - maximum drawdown extent

DATE: 14/10/2014

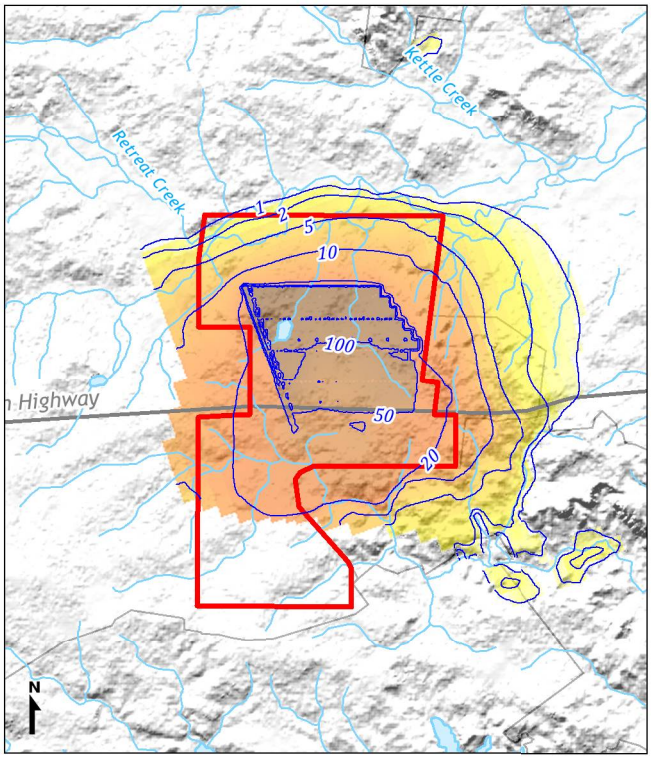
FIGURE No: **B-24**

Base Case



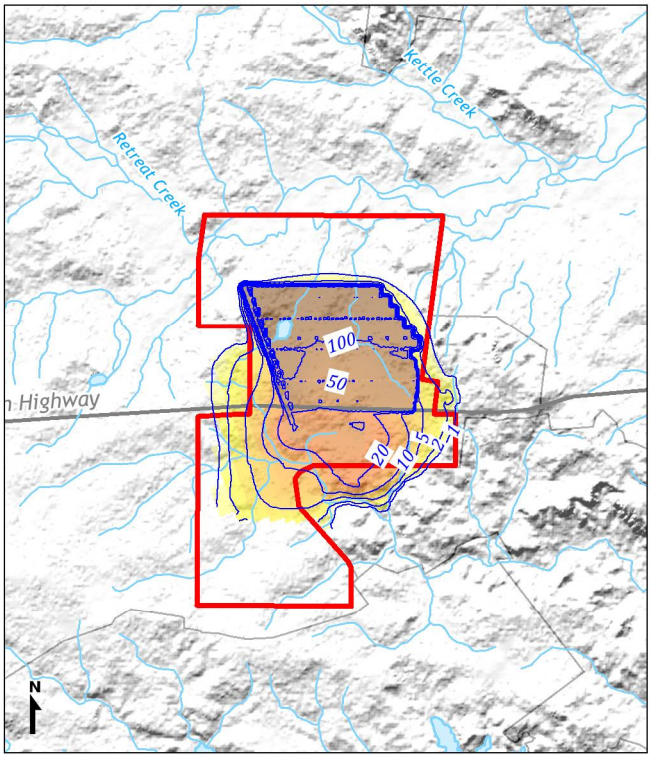
GDA 94, Zone 55

HC+



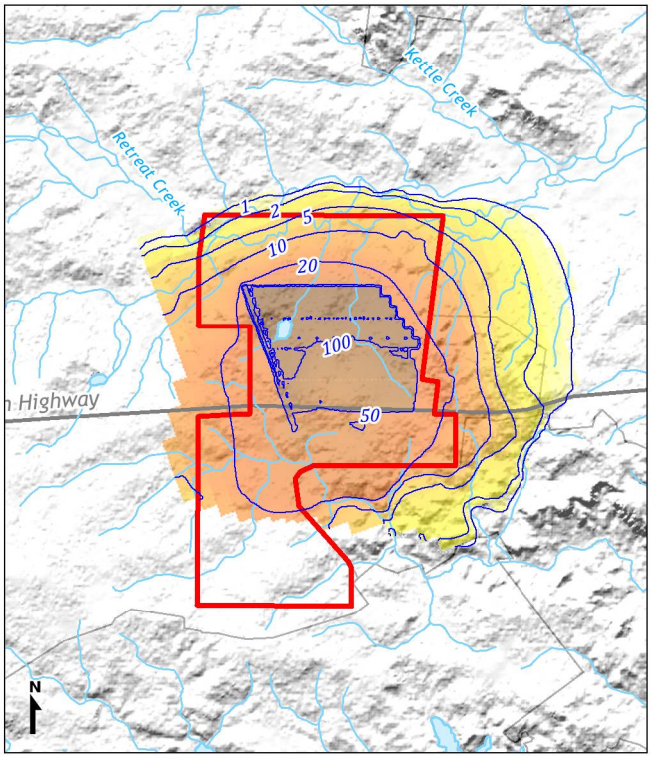
GDA 94, Zone 55

SS+



GDA 94, Zone 55

Fracture



GDA 94, Zone 55

LEGEND:

- Drawdown contour (m)
- MDL Boundary
- Watercourse
- Highways

Taroborah Coal Project
Groundwater Assessment (G1588)

Subsidence induced fracturing sensitivity analysis - magnitude of drawdown

DATE: 26/9/2014

FIGURE No: **B-25**

4.3 Limitations

Development, calibration and the results of predictive simulations from any groundwater model are based on available data characterising the groundwater system under investigation. It is not possible to collect all the data characterising the whole aquifer system in detail, and therefore various assumptions are made during development of all groundwater models. A number of assumptions were made during development of the groundwater model. This report presents these assumptions and their impact on the simulation results are discussed. Where an assumption was necessary, a conservative approach was taken, such as adopting model parameters from plausible ranges, so that the model would likely over-predict changes and impacts and therefore be representative of the worst-case scenario.

As discussed in Section 3.8, the predicted drawdown at the private landholder bores has been carried out using a number of assumptions regarding not only the numerical model but also the construction and integrity of the private landholder bores. Outside of the mine area, the geology is not as well understood and the model layering and parameterisation has been simplified to suit a conservative understanding. The model assumes a hydraulic connection across the structural features that separate the mine area and areas further to the east, west and north.

Where possible, the location and usage of the bores were verified; however, subsurface information relating to bore construction and lithology is often not available or not able to be verified. The model therefore makes assumptions regarding the model layers in which these bores are constructed. As a result, the model and its predictions are conservative in nature. The drawdown predicted by the model is considered to be a worst case scenario and the magnitude of predicted drawdown is unlikely.

It is important for the reader to understand that models can only approximate natural phenomenon that occurs in groundwater systems. Although it is calibrated, there remain limitations for long-term predictive use. As with all models, the Taroborah model should follow an evolutionary path and be updated as more data (particularly in the areas proposed for mining) becomes available.

The numerical model has been developed as a conservative impact assessment tool and is not required to include complex geological structure. The model adopts a conservative approach and is based upon a sound conceptual model and a suitable steady state calibration. The model is considered to be suitable for predicting impacts of the proposed mine upon local groundwater systems.

5 REFERENCES

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