RPS Aquaterra

HYDROGEOLOGICAL ASSESSMENT OF OREBODIES 29, 30 & 35 FOR MINING BELOW WATER TABLE APPROVALS

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Our ref: 1077K\Reports\009c
Date: 24 July 2013

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Document Status

	Issue Date	Purpose of Document
Revision C	24/07/13	Final Report

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Reviewer	Jon Hall	Principal Hydrogeologist		24/07/13

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FIGURES (compiled at end of report)

1. BACKGROUND

1.1 Introduction

BHP Billiton Iron Ore (BHPBIO) plans to mine below the water table at Orebodies 29, 30 and 35 (OB29, 30 and 35). To assist with obtaining the required below water table approvals for these deposits, RPS Aquaterra was commissioned by BHPBIO to provide a high level hydrogeological assessment of the potential impacts of mine dewatering operations.

This report summarises predicted dewatering requirements at OB29, 30 and 35 and the predicted water table drawdowns associated with dewatering. The potential impacts of drawdown on regional environmental receptors, flora and fauna are also considered.

1.2 Existing Mining Operations

OB29, 30 and 35 are in close proximity to the existing Whaleback Pit (Figure 1) where dewatering has been taking place for around 30 years. Mining in the Whaleback Pit is currently at approximately 380 mRL requiring the water table to have been drawn down by approximately 150 m to date. The final pit will require in excess of 300 m total drawdown from pre-mining water levels. It is also noted that western end of the Whaleback Pit (known as the West Pit) may well encapsulate OB30, requiring OB30 to be dewatered as part of the approved Whaleback mining.

To date OB29 and OB30 have been mined to just above pre-mining water levels. OB35 has been approved for above water table mining and BHPBIO are awaiting final Heritage sign-off.

OB23 and 25 are located approximately 15 km to the east of OB29, 30 and 25. OB23 has been mined below the water table for approximately 5 years with water levels being drawn down approximately 85 m to date. Dewatering commenced at OB25 Pit 3 in 2006 and is required to allow mining to a planned maximum pit depth of 373 mRL. Dewatering at OB25 Pit 1 commenced in 2010 and is required to draw water levels down below the proposed pit depth of 490 mRL.

1.3 Nearby Water Supply Schemes

The Ophthalmia Borefield is located approximately 15 km to the east of the study area, providing potable quality water to Newman and the nearby mining operations. The Ophthalmia Dam is located on the Fortescue River and was installed to capture surface water runoff for subsequent slow release to replenish the downstream aquifers which support the Ophthalmia Borefield (as part of a long term Aquifer Recharge Scheme).

1.4 Environmental Receptors

There are two identified environmental receptors within the Newman / Whaleback area – Cathedral Gorge located approximately 14 km to the northwest of OB29, 30 and 35 and Ethel Gorge located approximately 20 km to the northeast of OB29, 30 and 35.

Cathedral Gorge is recognised for its surface water pools and associated vegetation. Ethel Gorge is a regional outflow zone for the upper reaches of the Fortescue River Catchment, with the Homestead, Whaleback, Shovelanna and Warrawandu Creeks all converging with the Fortescue River just upstream of Ethel Gorge. A stygofauna community has been identified in the area, with its habitat is expected to be related to saturated shallow calcretes and gravels of an extensive Tertiary overburden sequence.

2. MINING AND WATER MANAGEMENT AT OB29, 30, 35

2.1 Proposed Below Water Table Mining

It is currently anticipated that dewatering will proceed to:

- 90 m below the water table at OB29
- 60 m below the water table at OB30
- 70 m below the water table at OB35

The area of disturbance for the below water table mining is slightly greater than that for above water table mining, due to the minor increase to pit crest areas and the requirement for additional overburden storage areas (OSAs). However, there is the potential to optimise ex-pit OSAs by making pit voids available for dumping.

2.2 Proposed Dewatering Requirements

To facilitate dry mining conditions, dewatering will be required. From preliminary hydrogeological assessments (RPS Aquaterra, 2012) and some earlier investigations into ore moisture content (Aquaterra, 2009), it was identified that the hydrogeology in the OB29, 30 and 35 area is complex with several potentially key hydrogeological controls (enhanced permeability and/or hydraulic connection via dolomite and known structures and faults etc) being unknown or poorly understood (particularly around OB29). To take account of these uncertainties, current dewatering estimates cover a large range of potential dewatering pumping rates. In addition to these hydrogeological uncertainties, the rate of mining of each pit and the mine sequencing of the three orebodies will also have a significant influence on the actual dewatering volumes and rates required to maintain dry mining conditions. As yet, the mining sequence and mine plans are not finalised, however, impacts outside the pit will be less sensitive to the final mine plan.

Subsequent hydrogeological drilling investigations have confirmed the hydrogeological complexity of the OB29 area and has highlighted that uncertainties with respect to dewatering requirements will remain until long-term groundwater abstraction commences and prediction models can be validated (and recalibrated as required) to measured performance data. For planning purposes (ie the design of the dewatering system), the upper ends of the ranges of predicted dewatering rates have been assumed, with the dewatering system at OB29 being designed for approximately 10 ML/d, but could be augmented if required.

2.3 Water Management

It is currently planned that dewatering volumes from OB29, 30 and 35 will be fed into the Whaleback process water supply system. However, at times, there may be surplus water (ie more than the processing water requirements) and this surplus will be directed, via the current Newman Joint Venture (NJV) water infrastructure, to the existing approved discharge locations at Ophthalmia Dam and the nearby Aquifer Recharge Scheme infiltration ponds.

3. ASSESSMENT OF GROUNDWATER CHANGE AND POTENTIAL IMPACTS

3.1 OB29, 30 and 35 Area

3.1.1 Groundwater Drawdown

The drawdown of the water table in the OB29, 30 and 35 area will commence with dewatering abstraction, with the rate of drawdown being driven by the sequence of mining the orebodies and the individual mine schedules. In the area of the pits the rate of drawdown is anticipated to be in the order of 10's of meters per year with the area of influence increasing over time until the ultimate drawdown cones of depression (i.e. maximum lateral and vertical extent of drawdown as a result of dewatering) are reached.

In assessing the potential impact of dewatering, the rate of drawdown and the progression of the individual drawdown cones around each pit contribute to a combined maximum potential drawdown around all pits (i.e. the interference drawdown). Figure 2 presents a preliminary assessment of the maximum potential drawdown associated with the dewatering at OB29, 30 and 35 assuming that the water table at each orebody will be drawn down to below the proposed maximum mining depth at the same time. These drawdown contours were developed based on the conceptual hydrogeological model for the area which is based on the existing geological and hydrogeological information available for the specific OB29, 30 and 35 and Whaleback area, combined with knowledge and experience gained from the dewatering of other orebodies in the Pilbara region. Consistent with the conceptual hydrogeological model, dewatering induced drawdowns are largely restricted to the immediate vicinity of the pits (and orebody aquifers) with the lateral spread of drawdown away from the pits being constrained by low permeability basement rocks. This is shown in Figures 3 and 4 which show NW-SE and SW-NE sections through the OB29 pit.

Figure 3 (NW-SE section), shows minimal drawdown to the south of the pit, while drawdown to the north shows the interference effects of dewatering from both OB29 and the Whaleback pits. There is drawdown within the alluvium of Whaleback Creek between the pits, but this is limited to the immediate mine area. Figure 4 (NE-SW section) shows minimal drawdown away from the pit and no drawdown in the saturated alluvium to the NE of Newman town site.

The orebodies themselves are believed to be in hydraulic connection therefore significant interference drawdown has been assumed in the area between OB29, 30 and 35.

The drawdown to the north, towards Whaleback Pit is anticipated to be minimal due to limited hydraulic connection in this direction (through the low-permeability Mt Sylvia and McRae Shale Formations). This is supported by the evidence that there has been minimal drawdown in the OB29, 30 and 35 area in response to the significant Whaleback dewatering to date.

The potential drawdown shown to the east, west and south of the OB29, 30 and 35 area (Figure 2) is considered to provide conservative overestimates of drawdown. There is the potential for each of the orebodies to be in hydraulic connection with permeable dolomite of the Wittenoom Formation. Should this be the case, there is the potential for the water table to be drawdown along strike in the dolomite (i.e. to the northeast of OB29 and the west of OB30) and potentially along the southwestern side of the OB35 Pit. The OB29, 30 and 35 area is also known to be structurally complex, therefore there is the potential for the drawdown to extend along zones of secondary permeability (i.e. faulting and fracturing) through stratigraphic units which are generally known to be of lower permeability (i.e. the MacLeod and Nummuldi Members of the Marra Mamba Formation). This has been partially accounted for in Figure 2 by the potential drawdown extending to the south and east of OB29 and the south of OB30.

It is noted that the potential drawdown from the proposed OB29, 30 and 35 dewatering is not anticipated to extend anywhere near the identified environmental receptors or water supply schemes in the region.

3.1.2 Groundwater Dependent Vegetation

Predicted water table drawdown due to dewatering was used as input to an assessment of impacts on vegetation in the OB29, 30 and 35 area completed by Onshore Environmental (2013).

3.1.3 Stygofauna

Stygofauna are generally found in groundwater habitats with substantial fissures or voids. Within the Newman area this includes saturated Tertiary alluvium as well as orebody, dolomite and fractured rock aquifers. In the OB29, 30 and 35 area, the Tertiary deposits (Whaleback Creek detritals) are generally not saturated and, as yet, the dolomite in the area has not been confirmed as permeable. As such, this leaves the orebody aquifers and potentially the fault / fracture systems as the main stygofauna habitats in the study area.

Proposed mining will remove the majority of the orebody aquifer in the area and therefore the majority of the local stygofauna habitat. There may also be some dewatering of potential habitat in surrounding Wittenoom Formation. However, nearly all dolomite encountered in the field investigation was fresh with no permeable zones. There were some intersections of fractured dolomitic shales and BIF, interpreted to be Wittenoom Formation, located on the northern margin of OB29. These zones were rare and likely to be hydraulically isolated. Extensive dewatering of the Wittenoom Formation dolomite is not expected.

Predicted water table drawdown due to dewatering was used as input to an assessment of impacts on stygofauna in the OB29, 30 and 35 area by Bennelongia (2013).

3.2 Ophthalmia Dam / Ethel Gorge Area

3.2.1 Groundwater Levels

Groundwater level monitoring in the Ethel Gorge area has been conducted since 1971, prior to the construction of Ophthalmia Dam. As such there is substantial data available to have developed a good hydrogeological understanding of the area. Historical data (Figure 5) clearly show declining groundwater levels in response to the water supply abstraction from the Ophthalmia Borefield and the recovering trends associated with the construction of the Ophthalmia Dam and its associated recharge basins in late 1981. In addition, the response to rainfall recharge is evident, particularly in 1999 and 2000. More recent data (Figure 6) also show response to rainfall recharge events, despite the influence of dewatering at the nearby OB23 and 25 Pits.

Surplus dewatering water from OB23 and 25 is already being discharged to Ophthalmia Dam and the Aquifer Recharge Scheme infiltration ponds. However, any influence on downstream groundwater levels is masked by the drawdown impacts of dewatering close to the pits, and by seasonal fluctuations away from the pits.

There are expected to be no direct impacts of dewatering of OB29, 30 and 35 on groundwater levels in the Ophthalmia Dam/Ethel Gorge area. As outlined in Section 3.1.1 and shown on Figure 4, drawdown is expected to be confined to the immediate area of the pits by low permeability basement rocks. The discharge of surplus dewatering from OB29, 30 and 35 to Ophthalmia Dam will result in some minor rise in dam water levels and minor increased seepage from the dam which will, in turn, have some influence on groundwater levels immediately downstream of the dam. An impact assessment for possible surplus dewatering discharge to Ophthalmia Dam was undertaken previously for the Jimblebar Iron Ore Project (RPS Aquaterra, 2010). Water and salt balance modelling was conducted to assess the potential impact of discharging surplus dewatering water (generally ranging between approximately 9 and 21 ML/d) from South Jimblebar into the dam. The water/salt balance outcomes for the 9 ML/d case would closely reflect the influence of excess dewatering discharge from OB29, 30 and 35 (where dewatering is expected to be less than 10 ML/d).

The water balance modelling indicated that (for 8.9 ML/d excess discharge to the dam):

- The average dam level would rise by 0.2 m.
- The average overflow from the dam would increase by less than 1% (2 ML/d).
- The average seepage (to groundwater) from the dam would increase by 11% (5 ML/d).

To put the surplus dewatering discharges and likely influences on dam overflow and seepage, into context:

- Any surplus discharge from OB29, 30 and 35 (which will be less than the expected maximum dewatering of 10 ML/d) will be less than is currently discharge to the dam from OB23 and OB25 dewatering (up to 23 ML/d since 2007 – BHPBIO, 2012).
- The volume of the dam at the main spillway level is 22,000 ML. The peak volume is 100,000 ML (Parsons Brinkerhoff, 2013);
- The estimated volume of groundwater in storage downstream of the dam within the Tertiary detritals down to Ethel Gorge is over 20,000 ML;
- Groundwater inflow to the area downstream of the dam (including recharge from Homestead/Shovelanna Creeks) is around 12 ML/d (RPS Aquaterra, 2013)

It is expected that any influence of increased seepage from the dam as a result of surplus dewatering discharge will be masked by both the drawdown impacts of dewatering (close to pits) and by seasonal fluctuations away from the pits.

3.2.2 Water Quality

The water/salt balance modelling results for the Jimblebar Iron Ore Project (RPS Aquaterra, 2010) referred to in Section 3.2.1 are also applicable to the potential influence of surplus dewatering discharge to the dam from OB29, 30 and 35 as the salinity of any surplus (expected to be in the range 500mg/L to 1080mg/L) are also comparable with the adopted salinity in the Jimblebar modelling (1040mg/L). The modelling results indicated that the salinity of the dam water would increase marginally with the proposed surplus water discharge. In terms of possible downstream impacts, the key outcomes of the modelling were that:

- The average salinity in dam overflow would increase from 40 mg/L (TDS) to 47 mg/L.
- The average salinity in dam seepage increase from 65 mg/L to 225 mg/L.

By comparison, existing downstream groundwater quality ranges from 600 to 1500 mg/L (TDS - recorded in Ophthalmia Borefield pumping bores). Taking into account the relative volumes of the predicted increases in dam overflow, dam seepage and the groundwater throughflow and storage (refer Section 3.2.1), it was concluded that dam seepage and overflow would have minimal impact on downstream groundwater quality due to dilution.

3.2.3 Vegetation

Riverine vegetation has opportunistically established around the dam since the dam's construction in 1981 (Astron, 2009). The discharge of surplus dewatering from OB29, 30 and 35 will have some minor influence on dam water levels. Expected maximum annual excess dewatering discharges are less than 5% of the full volume of the dam and are predicted to result in a rise in average dam water levels of around 0.2 m, well within the ranges of water level rises that naturally occur as a result of seasonal and longer term fluctuation in catchment runoff. The riverine vegetation downstream of the dam is supported by groundwater. The discharge of surplus dewatering to the dam will result in some increased overflow and seepage from the dam, but with only minimal influence on groundwater levels or salinity.

The potential for surplus water disposal to Ophthalmia Dam to impact on terrestrial vegetation is assessed in Astron (2009).

3.2.4 Stygofauna

As outlined in 3.2., there is expected to be no direct change in groundwater levels in the Ophthalmia Dam/Ethel Gorge area from dewatering of OB29, 30 and 35, and the effects of surplus discharge are expected to be minor and masked by other influences (natural fluctuation and dewatering of nearer orebodies).

Similarly, as outlined in Section 3.2.2, there is expected to be no measureable change in groundwater quality in the Ethel Gorge area as a result of surplus dewatering discharge to Ophthalmia Dam.

In summary, no significant change is expected to the stygofauna habitat in the Opthalmia Dam / Ethel Gorge area.

3.3 Post-Mining Impacts

The potential impacts of the OB29, 30 and 35 Pits on the local and regional groundwater and surface water resources, and key environmental receptors are dependent on the closure options adopted for the final pit voids.

BHPBIO approach to closure planning, including key groundwater and surface water considerations, are outlined in the OB29, 30, 35 Preliminary Mine Closure Plan (BHPBIO, 2013)

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Based on the current hydrogeological understanding of the OB29, 30 and 35 area, the drawdown resulting from the required dewatering is anticipated to extend approximately 4 to 5 km to the east and west of the study area and potentially 3 to 4 km to the south, with negligible drawdown anticipated to the north, towards the existing Whaleback Pit. The predicted drawdown is not expected to reach the regional environmental receptors, Cathedral Gorge and Ethel Gorge, which are approximately 14 and 20 km respectively from the study area.

The potential impact on stygofauna and groundwater dependent vegetation, resulting from the predicted drawdown is expected to be minimal.

Dewatering discharge is proposed to be used as a water supply at Whaleback, with any surplus water to be discharged into the Ophthalima Dam and associated Aquifer Recharge Scheme ponds at existing approved discharge points.

The proposed discharge will result in a very minor increase in water levels within the dam and a very minor increase in the salinity of the dam water. This will have some minor influence on downstream groundwater levels. It is expected that any such influences will be masked by natural (seasonal) fluctuations in groundwater levels. The increased salinity of the seepage (and overflow) from the dam is not expected to have any significant effect on downstream groundwater quality and no impact on the overall quality of supply from the Ophthalmia Borefield.

4.2 Recommendations

While it is clear that the impacts of dewatering at OB29, 30 and 35 will be largely restricted to the immediate mining area, the local hydrogeology is typical of the area and is complex. As such there remain uncertainties in some of the details of the conceptual hydrogeological model. These uncertainties largely relate to the possible presence of aquifers in the dolomite adjacent to the orebodies and any hydraulic connection between the orebodies and these, or any other local fracture zone aquifers. These uncertainties will mainly affect predictions of dewatering rates and volumes, but may also have some influence on the prediction of drawdowns in the immediate areas of the pits.

It is recommended that these uncertainties are resolved as follows:

- Initiate pumping from existing bores (as a hydrodynamic trial) with all abstraction used to supplement mine water supplies.
- Review monitored drawdowns and revise the conceptual hydrogeological model (and validate/calibrate numerical groundwater models) based on results.
- Revise predictions of dewatering requirements and local/regional drawdowns.

This approach could be managed (licensing and reporting) through the 5C GWL process.

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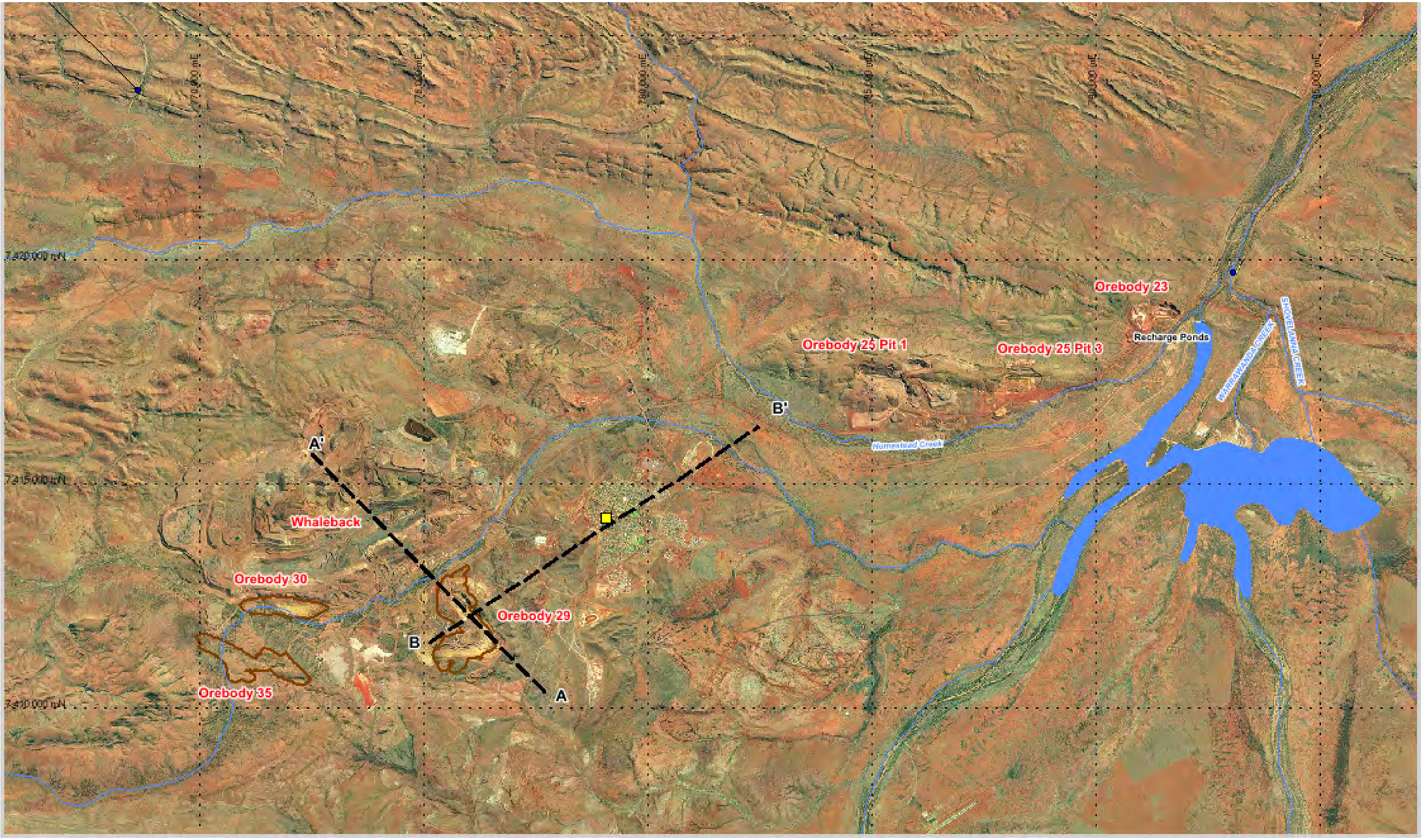
FIGURES



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GDA 1994 Zone 50

AUTHOR: EB/JH	REPORT NO: 009
DRAWN: MR/GB	REVISION: b
DATE: 11/07/2013	JOB NO: 1077K

LEGEND

- Environmental Receptor
- River/ Stream
- Dam
- Orebody Outline
- Cross Section Line

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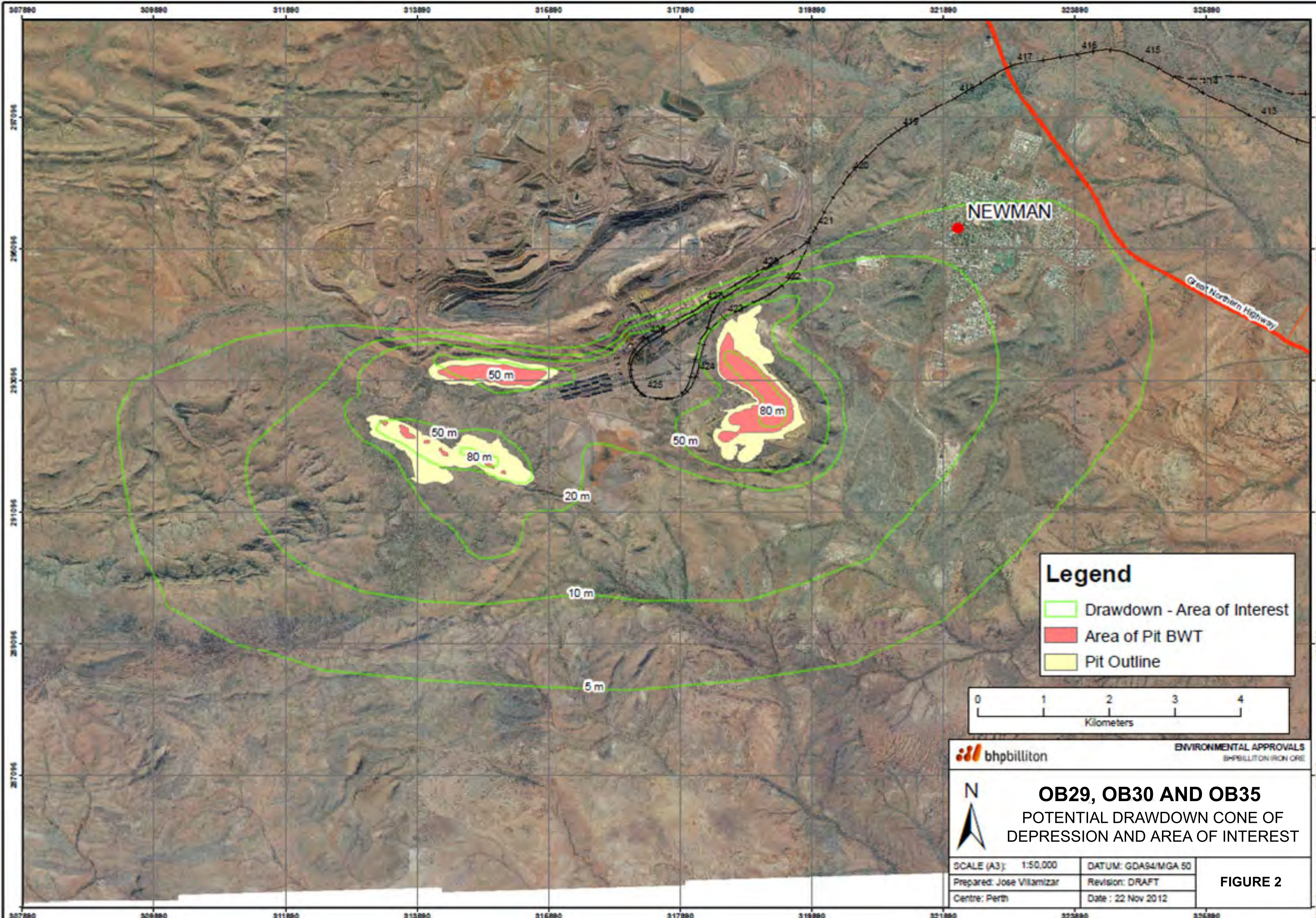
FIGURE 1

LOCATION MAP



NEWMAN
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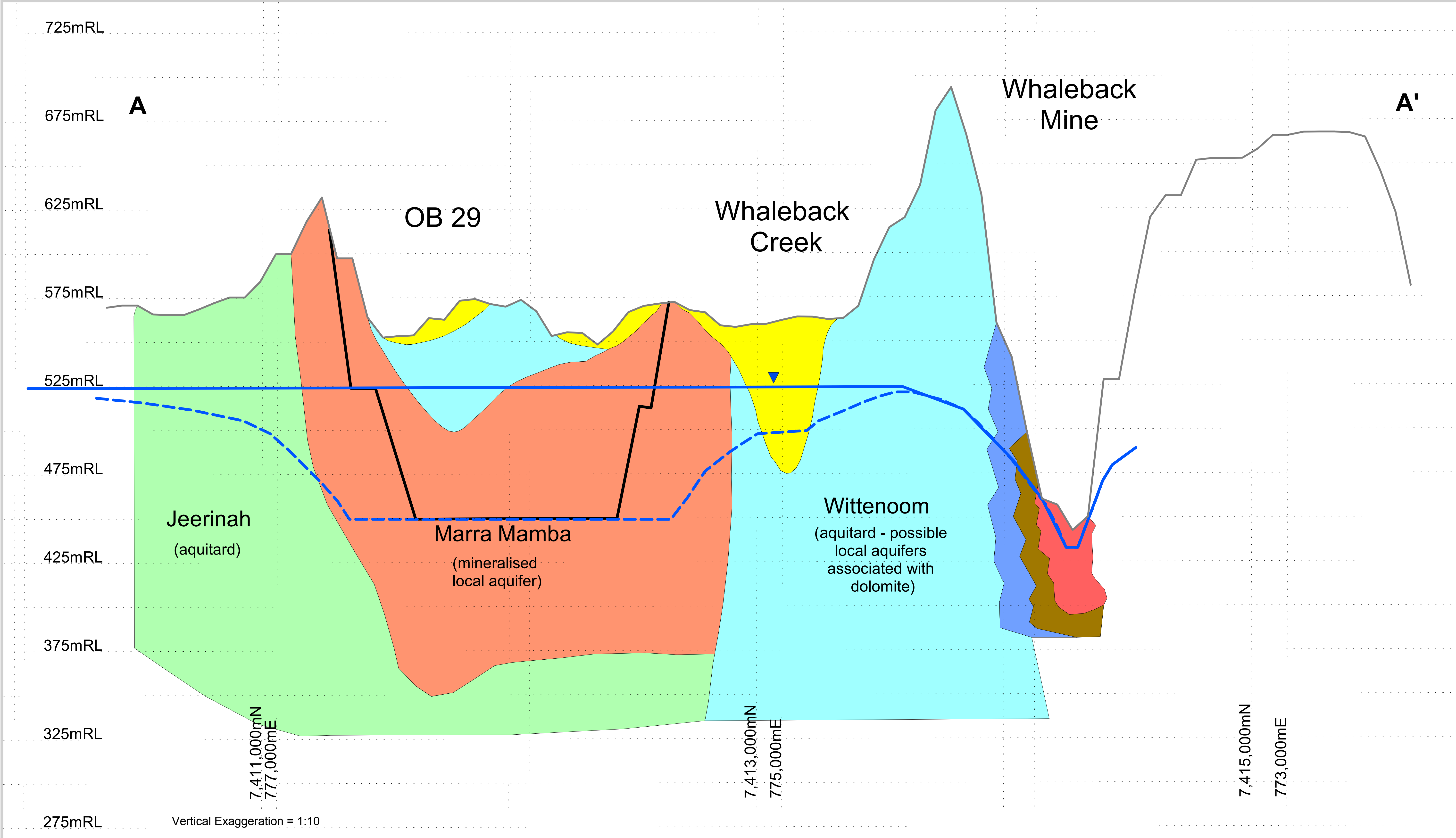
50 m
50 m
80 m
50 m
80 m
50 m
20 m
10 m
5 m
417
416
415
414
413
418
419
420
421
422
423
424
425
Legend
Drawdown - Area of Interest
Area of Pit BWT
Pit Outline
0
1
2
3
4
Kilometers
bhpbilliton
ENVIRONMENTAL APPROVALS
BHPBILLITON IRON ORE
N
OB29, OB30 AND OB35
POTENTIAL DRAWDOWN CONE OF DEPRESSION AND AREA OF INTEREST
SCALE (A3): 1:50,000
DATUM: GDA94/MGA 50
Prepared: Jose Villamizar
Revision: DRAFT
Centre: Perth
Date : 22 Nov 2012
FIGURE 2



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MGA 94 Zone 50

AUTHOR: JH / GB	REPORT NO: 009
DRAWN: GB	REVISION: b
DATE: 11/07/2013	JOB NO: 1077K

LEGEND

- Current Water Table
- Drawn Down Water Table
- OB29 Pit
- Alluvium / Detritals
- Dales Gorge Member
- Mt McRae Shale
- Mt Sylvia Formation
- Wittenoom Formation
- Marra Mamba Formation
- Jeerinah Formation

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FIGURE 3

CROSS SECTION A-A'

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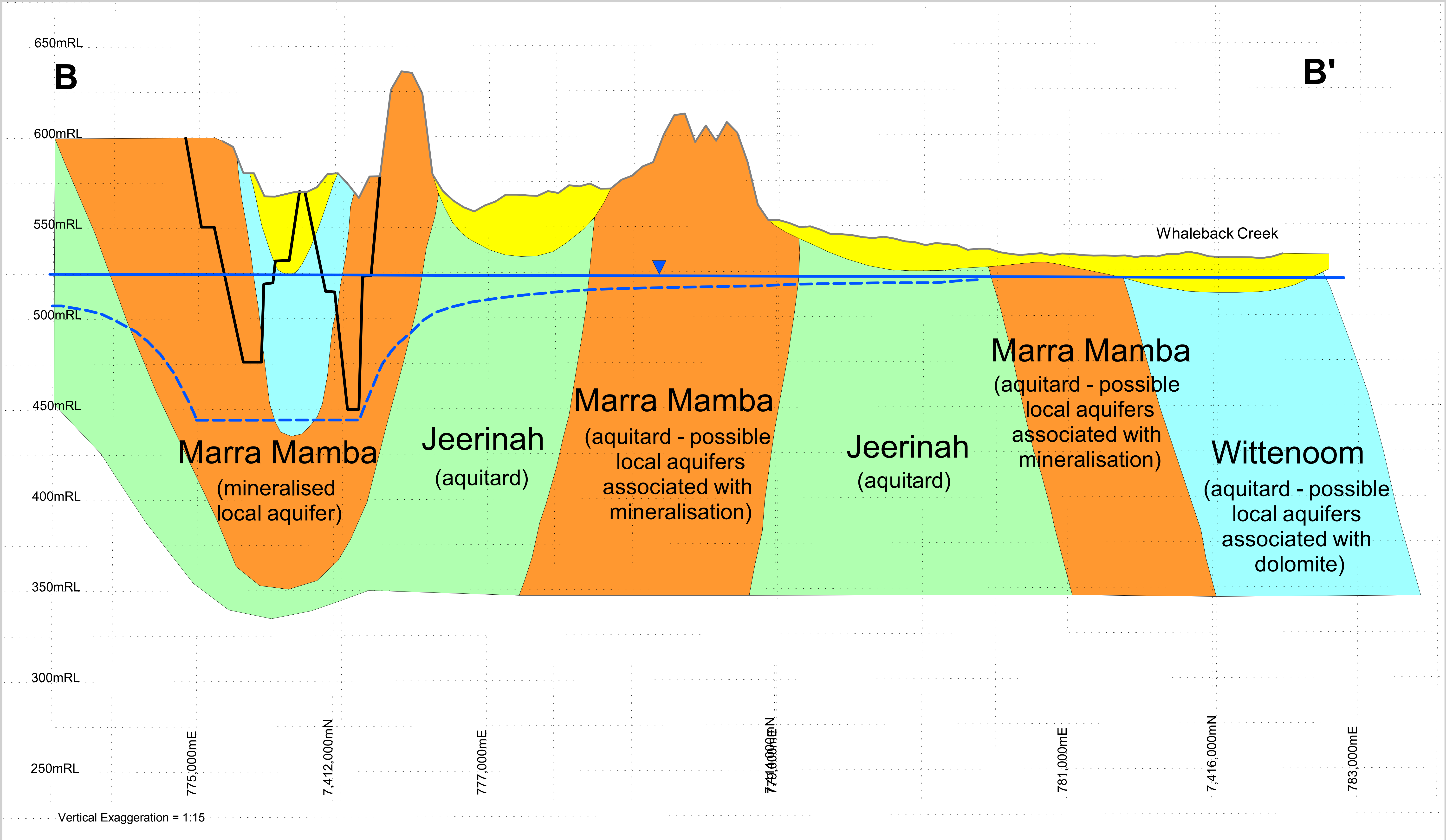

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MGA 94 Zone 50

AUTHOR: JH / GB	REPORT NO: 009
DRAWN: GB	REVISION: b
DATE: 11/07/2013	JOB NO: 1077K

LEGEND

- Current Water Table
- Drawn Down Water Table
- OB29 Pit
- Alluvium / Detritals
- Wittenoom Formation
- Marra Mamba Formation
- Jeerinah Formation

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FIGURE 4

CROSS SECTION B-B'

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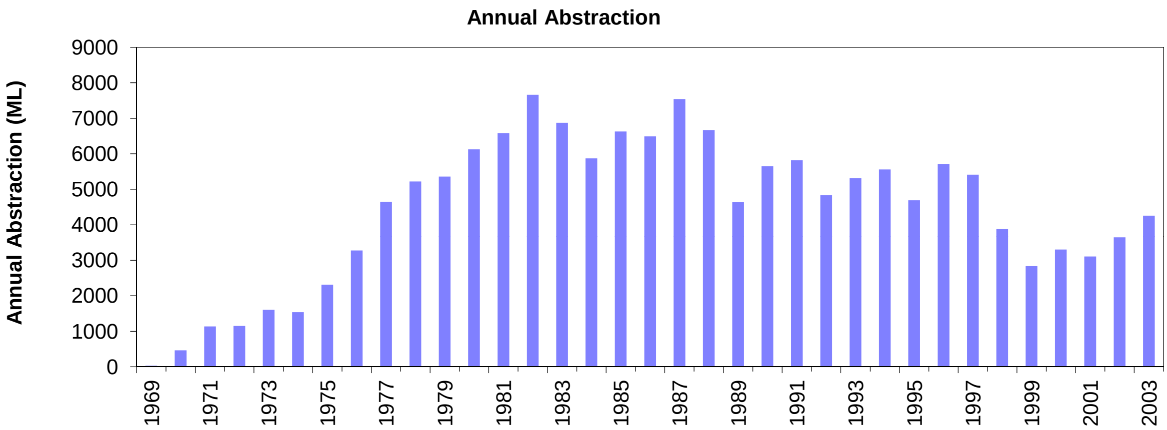

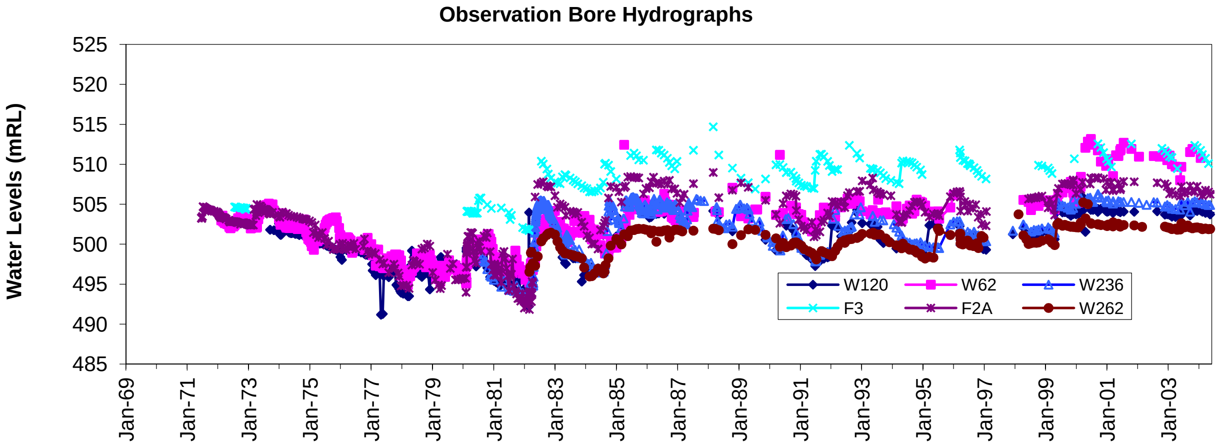

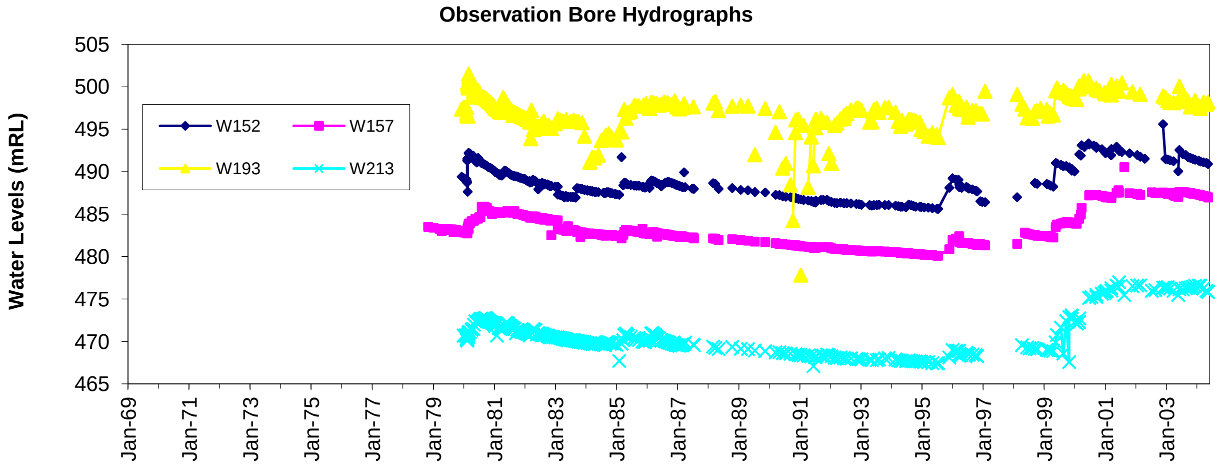

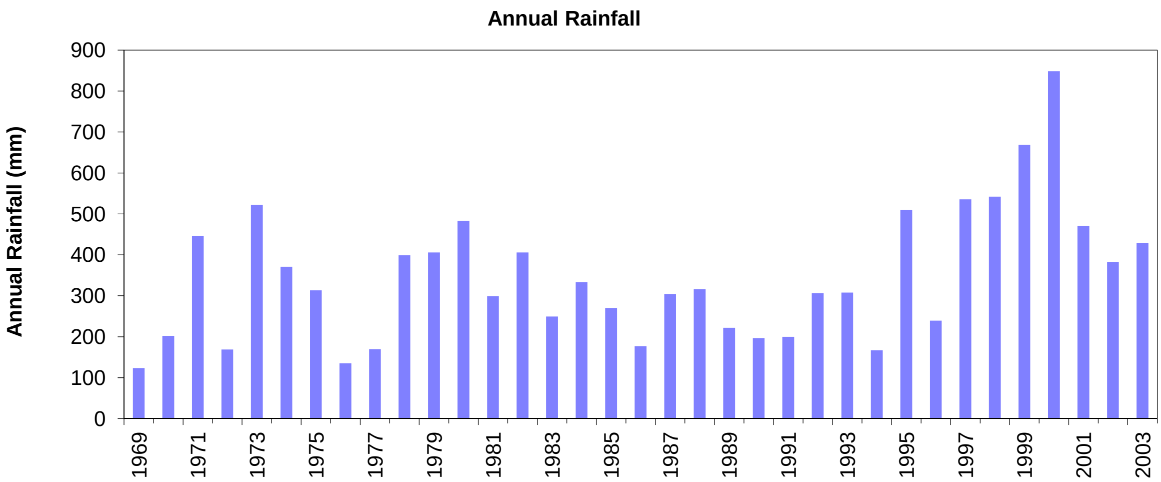

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Monitoring Summary - Ophthalmia Wellfield

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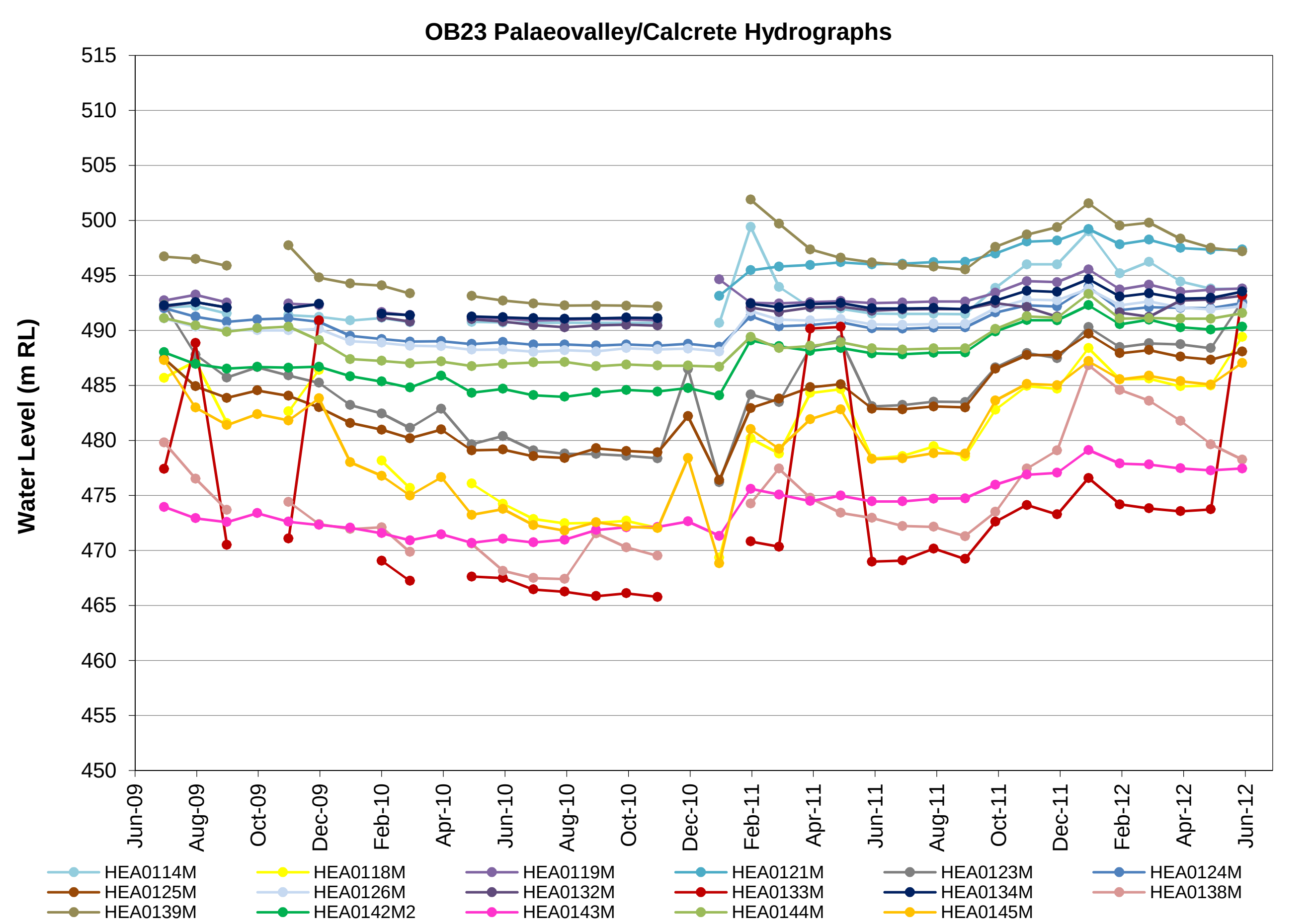
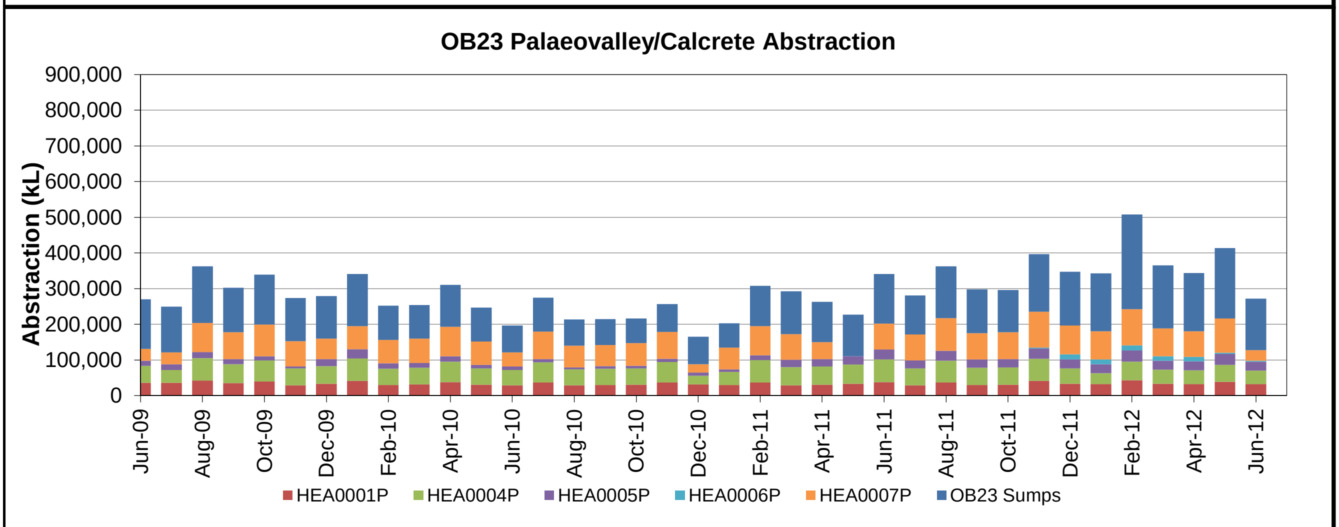
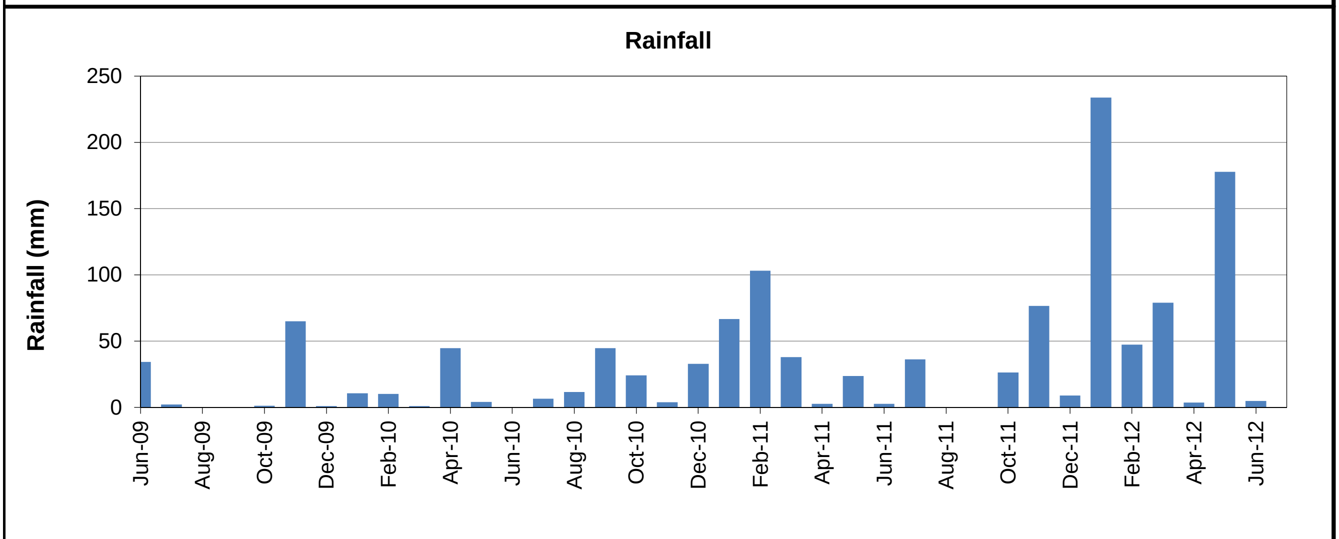
Figure 5







Monitoring Summary - Near OB23 Figure 6

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