



Breanne Menezies  
Senior Ecologist - Environmental Approvals  
BHP Billiton Iron Ore  
PO Box 7122, Cloisters Square  
Perth WA 6850

1<sup>st</sup> February 2013

## **Orebody (OB) 29, 30, 35 – Groundwater Dependent Vegetation Impact Assessment**

### **1 INTRODUCTION**

Onshore Environmental Consultants Pty Ltd (Onshore Environmental) was commissioned by BHP Billiton Iron Ore (BHPBIO) to undertake an assessment of groundwater dependent vegetation at Orebody (OB) 29, OB30 and OB35 in the Eastern Pilbara (hereafter referred to as the study area).

The study area is located in the Eastern Pilbara region of Western Australia and situated immediately south of BHPBIO's Mount Whaleback mining operations, approximately 5 km west of the Newman town site (Figure 1). The study area represents satellite deposits of the existing Mount Whaleback mining operation approved for mining above watertable. Above watertable mining at OB29 and OB30 has been undertaken since 1974 and 1999 respectively, while OB35 is planned to commence mining in 2013. The development of these satellite deposits below watertable is required to sustain existing operations at Mount Whaleback. The mining activities involve conventional open pit iron ore mining below watertable and mine dewatering (with supporting infrastructure), and will be campaign mined on an 'as needs basis' to provide ore to blend with Brockman Formation ores from Mount Whaleback.

The assessment will be used to inform environmental approvals of impacts (if any) to groundwater dependent vegetation resulting from below groundwater mining (i.e. mine dewatering) within the study area.

### **2 BACKGROUND**

#### **2.1 Geology**

OB29, OB30 and OB35 are located in the Newman Hub area immediately south of the Whaleback Pit. All three orebodies are predominantly hosted by the upper members of the Marra Mamba Iron Formation (Mount Newman and MacLeod) although mineralisation does extend into the lower Marra Mamba (Nammuldi Member) and into the overlying West Angela Member of the Wittenoom Formation. Overlying detritals, where present, may also be mineralised and enriched to ore grade. OB29 and OB30 have been and continue to be mined above the water table (RPS Aquaterra, 2012).

## 2.2 Hydrogeology

From preliminary hydrogeological assessments (RPS Aquaterra, 2012) it was identified that the hydrogeology in the OB29, OB30 and OB35 area is complex with several potentially key hydrogeological controls (enhanced permeability and/or hydraulic connection via dolomite and known structures and faults) being unknown or poorly understood (particularly around OB29). 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. As a reflection of this uncertainty, conservatively large drawdown zone of influence information was provided for impact assessment purposes.

OB29, OB30 and OB35 are in close proximity to the existing Whaleback Pit 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. Studies to date indicate that the Whaleback Pit is hydrogeologically separate from the OB29, OB30 and OB35 pits. To date OB29 and OB30 have been mined to above pre-mining water levels. OB35 above water table mining is due to commence in 2013.

## 2.3 Flora and Vegetation Surveys

The study area is situated in the Hamersley Plateau which forms part of the Fortescue Botanical District in the Eremaean Botanical Province of Western Australia (Beard 1975). The flora of the Pilbara has been recorded at a broad scale by Burbidge (1959) and Beard (1975). More recently, the Department of Agriculture (van Vreeswyk *et al.* 2004) compiled an inventory and condition survey of the Pilbara. In recent years an increase in the number of regional resource development projects has resulted in a significant amount of site-specific biological survey work being completed in the region for the purpose of formal environmental assessment. The site-specific survey reports most relevant to the study area are summarised in Table 1, with results from the two most relevant surveys outlined below.

### OB35 and Surrounds Flora and Vegetation Survey (GHD 2011)

A Level 2 flora and vegetation survey of OB35 and surrounding exploration areas of Mt Helen, Silver Knight, Eastern Syncline and Adjacent Miscellaneous Licence, was conducted in two stages from 20<sup>th</sup> - 28<sup>th</sup> May 2010 and 2<sup>nd</sup> - 6<sup>th</sup> August 2010. The survey covered an area of approximately 6,100 ha (61 km<sup>2</sup>), which included the OB30 and OB35 project areas.

A total of 88 quadrats and 35 relevé sites were assessed within the study area. The total flora comprised 347 plant taxa (including subspecies and varieties) representing 159 genera and 48 plant families, including 334 native taxa and 13 introduced (weed) species. A total of 29 taxa in the collection could not be identified to species level due to the absence of adequate collection material. The dominant plant families were Fabaceae (77 taxa), Poaceae (41 taxa), Malvaceae (35 taxa), Chenopodiaceae (19 taxa) and Scrophulariaceae (19 taxa). The dominant Genus was *Acacia* (36 taxa). Species richness was consistent with previous surveys undertaken at or near the study area. However, lower diversity within the annual and ephemeral flora resulted from below average rainfall during the three months preceding the field survey.

There were no Threatened (Declared Rare Flora - DRF) or *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed plant taxa recorded from the study area. The following three Priority flora taxa, as listed by the Department of Environment and Conservation (DEC), were recorded:

- *Gymnanthera cunninghamii* (Priority 3);

- *Indigofera gilesii* subsp. *gilesii* ms (Priority 4); and
- *Goodenia nuda* (Priority 4).

A total of thirteen introduced weed species were recorded from the study area. None of these species are listed as Declared Plants pursuant to section 37 of the *Agricultural and Related Resources Protection Act 1976* (ARRP Act). \**Cenchrus ciliaris* and \**Bidens bipinnata* were the most dominant weed species recorded within the study area.

A total of 22 vegetation associations from ten broad floristic formations was described and mapped within the study area:

1. *Acacia* Low Open Forest;
2. *Acacia* Low Open Shrubland;
3. *Acacia* Low Open Woodland;
4. *Acacia* Low Woodland;
5. *Acacia* Open Scrub;
6. *Acacia* Open Shrubland;
7. *Eucalyptus* Low Open Woodland;
8. *Eucalyptus* Low Woodland;
9. *Themeda* Open Tussock Grasslands, and
10. *Triodia* Hummock Grassland to Open Hummock Grassland.

None of the vegetation associations were determined to be Threatened Ecological Communities (TECs) as defined by the EPBC Act or the DEC, or Priority Ecological Communities (PECs) as listed by the DEC.

Vegetation condition ranged from Pristine to Completely Degraded. The majority of the study area was considered in Excellent to Very Good condition with the exception of previously cleared tracks, exploration drilling areas, creek lines and the north eastern corner of the study area where the tailings storage facility and several topsoil and borrow pit sites are located. The main disturbances noted were impacts from fire and introduced weeds.

*Mt Whaleback AML 7/244 Flora and Vegetation and Vertebrate Fauna Review (Onshore Environmental 2013)*

In early 2013 there was a comprehensive review of all previous flora and vegetation surveys and vertebrate fauna and fauna habitat assessments completed within mining lease AML 7/244 at Mount Whaleback. The study area covered approximately 6,650 ha (66.50 km<sup>2</sup>) which included the OB29 project area.

The review investigated 20 previous flora and vegetation surveys completed within, or partly within, the study area since commencement of mining at Mount Whaleback in the 1960s. Nine of the surveys were completed to Level 2 standard (EPA 2004) and had one or more formal quadrats established and assessed within the boundary of the study area. There were a total of 183 quadrats and 24 releve plots previously assessed within the study area. However, raw data could only be sourced for 103 quadrats; data for the remaining 80 quadrats had not been supplied to BHPBIO in GIS databases and/or were not presented in the appendices of reports.

A combined total number of 352 plant taxa (including varieties and subspecies) from 48 families and 147 genera were recorded from the study area inclusive of all previous available survey data. Species representation was greatest among the Fabaceae, Poaceae, Malvaceae, Chenopodiaceae, Asteraceae and Amaranthaceae families, which is typical for the Pilbara Bioregion.

The total flora included one Threatened flora species (*Lepidium catapycnon*), three Priority flora species (*Calotis latiuscula* Priority 3, *Euphorbia inappendiculata* Priority 3 and *Eremophila magnifica* subsp. *magnifica* Priority 4), and 19 introduced weed species. *Lepidium*

*catapycnon*, is listed as Vulnerable under the EPBC Act and gazetted as DRF under the WC Act. None of the 19 introduced weed species were listed as Declared Plants under the ARRP Act.

A total of 20 vegetation associations from six Broad Floristic Formations were described and mapped from the study area. The six Broad Floristic Formations recorded were:

1. *Acacia* Low Open Forest;
2. *Acacia* Low Woodland
3. *Triodia* Hummock Grassland
4. *Triodia* Open Hummock Grassland
5. *Themeda* Tussock Grassland
6. \**Cenchrus* Open Tussock Grassland

None of the vegetation associations were listed as TECs as defined by the EPBC Act or the DEC, or PECs as listed by the DEC.

Vegetation condition was highly variable ranging from Excellent to Completely Degraded. Native vegetation has been cleared across 3,095.2 ha within the study area, primarily associated with the Mount Whaleback mining operation and associated infrastructure. These disturbed areas were rated as Completely Degraded and were largely devoid of native vegetation cover. Condition for the majority of remnant native vegetation was rated as Excellent and included nine of the 20 vegetation associations described and mapped. These vegetation associations were typically situated at upland sites where foraging value for domestic cattle is low. Vegetation condition declined around active areas of the Mount Whaleback mining operation, and particularly on landform features with higher soil moisture status such as drainage lines, alluvial plains and lower hill slopes. Contributing factors were grazing by cattle, presence of introduced weed species, fire, and positioning of infrastructure including clearing for access tracks, roads, power line corridors and rail alignments.

Table 1 Summary of Main Findings from Previous Surveys within and surrounding the Study Area.

Project	Survey time	Season	Method	Study Area (ha)	Number of Sites	Number of Taxa Recorded	Conservation Significant Flora	No. Introduced Flora
Mt Whaleback AML 7/244 Flora and Vegetation and Vertebrate Fauna Review (Onshore Environmental 2013)	Review	Not Relevant	Review	6,650	103	352	<i>Lepidium catapycnon</i> (DRF-T), <i>Calotis latiuscula</i> (P3), <i>Euphorbia inappendiculata</i> (P3), <i>Eremophila magnifica</i> subsp. <i>magnifica</i> (P4)	19
Mt Whaleback East Flora, Vegetation and Fauna Survey (ENV 2011)	January 2011	Poor	Single Season Level 2	703	15	127	None	6
Mt Whaleback TSF Flora, Vegetation and Fauna Assessment (Astron 2010)	March 2010	Poor	Single Season Level 2	23.5	7	71	None	2
Newman to Jimblebar Transmission Line and Newman Town Substation Flora and Vegetation Assessment (ENV 2009a)	April 2009	Poor	Single Season Level 2	-	67	365	<i>Goodenia nuda</i> (P4)	15
Mount Whaleback Power station Flora and Vegetation Assessment (ENV 2009b)	April 2009	Poor	Single Season Level 2	-	10	124	None	5
Biological Survey - Myopic Exploration Leases (Onshore 2009)	June 2009	Poor	Single Season Level 1	-	75	274	<i>Goodenia nuda</i> (P4) <i>Tephrosia</i> sp. Cathedral Gorge (F.H. Mollemans 2420) <sup>2</sup> <i>Lepidium catapycnon</i> (DRF-T) <i>Aristida lazaridis</i> (P2)	8
Orebody 25 to Newman Flora and Vegetation Assessment (ENV 2009c)	July 2009	Poor	Single Season Level 2	603	33	214	None	7
Homestead Creek Culvert Flora and Vegetation Assessment (ENV 2009d)	July 2009	Poor	Single Season Level 1	35	-	80	None	6
Newman Power Network, Level 2 Flora and Level 1 Fauna Survey (Biologic 2009)	July 2009	Poor	Targeted Search	-	-	319	<i>Goodenia nuda</i> (P4)	14
Whaleback Flora and Vegetation Survey and Fauna Assessment (Onshore/Biologic 2009)	June 2009	Poor	Single Season Level 2	2609	30	201	None	17
Orebody 35 VCP area Flora and Fauna Assessment (ENV 2010)	December 2009	Poor	Single Season Level 2	844	29	189	<i>Tephrosia</i> sp. Cathedral Gorge (FH Mollemans 2420) <sup>2</sup>	3
Newman Water Pipeline Enhancement Project: Flora and Vegetation Assessment (Ecologia 2008)	April 2008	Good	Single Season Level 1	-	69	353	<i>Themeda</i> sp. Hamersley Station (M.E. Trudgen 11431) (P3)	16
Rail RGP5 Summary of Important Findings from RGP5 Railway Project Biological Assessments (ENV 2008a)	April 2008	Good	Single Season Level 2	-	159	-	<i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3)	10
RPG5 Jimblebar Junction to Yandi Junction Railway Reserve (ENV 2008b)	April 2008	Good	Single Season Level 2	960	137	353	<i>Eremophila margarethae</i> <sup>2</sup> <i>Bulbostylis burbridgeae</i> (P4) <i>Goodenia nuda</i> (P4)	11
Rail RGP5 Repeater 9 Access Road Flora and Vegetation Assessment (ENV 2008c)	June 2008	Good	Single Season Level 2	12	7	163	<i>Eremophila margarethae</i> <sup>2</sup> <i>Rostellularia adscendens</i> var. <i>latifolia</i> (P3)	14
Report for Myopic Project Area Newman, Flora and Fauna Assessment (GHD 2008)	May to June 2008	Good	Single Season Level 2	3,600	141	321	<i>Triumfetta leptacantha</i> <sup>2</sup> <i>Brunonia</i> sp. Long hairs (D.E. Symon 2440) (P1)	3
Newman Ammonium Nitrate Storage Facility - Conservation Significant Flora Survey (Ecologia 2006a)	January 2006	Very Good	Targeted Searches	10	-	64	None	1
Orebody 24 Flora and Fauna Assessment Phase II (ENV 2006a)	March-April 2006	Very Good	Single Season Level 2	-	84	413	<i>Abutilon trudgenii</i> <sup>2</sup> <i>Eremophila magnifica</i> subsp. <i>velutina</i> (P3) <i>Gymnanthera cunninghamii</i> (P3) <i>Triumfetta leptacantha</i> <sup>2</sup> <i>Tephrosia</i> sp. Cathedral Gorge (FH Mollemans 2420) <sup>2</sup>	8
Newman Ammonium Nitrate Storage Facility - Phase II conservation significant flora survey (Ecologia 2006b)	April 2006	Very Good	Targeted Searches	76.3	-	122	None	3
BHPBIO Western Ridge Exploration Project Biological Survey (Ecologia 2006c)	August 2006	Very Good	Single Season Level 2	-	36	152	<i>Calotis latiuscula</i> (P3)	3
Mount Whaleback Flora and Vegetation Assessment Phase III Summary Report (ENV 2006f)	August 2006	Very Good	Single Season Level 2	-	81	345	<i>Lepidium catapycnon</i> (DRF-T) <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (P1) <sup>6</sup>	9
Newman Hub RGP4 Infrastructure Area Flora and Vegetation Assessment (ENV 2006b)	September 2006	Good	Single Season Level 2	250	10	168	None	8
Newman Hub Rail Corridor Declared Rare and Priority Flora Survey (ENV 2006d)	September 2006	Good	Targeted Searches	17.8	-	-	<i>Abutilon trudgenii</i> <sup>2</sup>	1
Mount Whaleback Newman Kurra Village Extension Area Flora and Vegetation Assessment (ENV 2006e)	September 2006	Good	Single Season Level 2	30	9	117	None	7
Newman Hub RGP4 Topsoil Stockpile and Borrow Areas for Construction Flora and Vegetation Assessment (ENV 2006c)	October 2006	Good	Single Season Level 2	220	45	285	<i>Acacia kenneallyi</i> (P3) <sup>5</sup>	13

Project	Survey time	Season	Method	Study Area (ha)	Number of Sites	Number of Taxa Recorded	Conservation Significant Flora	No. Introduced Flora
OB25 Rail Spur Siding Declared rare and Priority Flora Survey (ENV 2007)	November to December 2006	Good	Targeted Search	121.1	-	-	None	1
Western Ridge Exploration Project Biological Survey (Ecologia 2005)	May 2005	Very Good	Single Season Level 2	-	7	152	None	0
Newman BHP Billiton Ongoing Works - Newman Hub Final Report (Ecologia 2004b)	June 2004	Poor	Targeted Search	-	-	-	None	4
Newman Village Declared Rare and Priority Flora and Weed Survey (Ecologia 2004c)	June- July 2004	Poor	Targeted Search	-	-	-	None	1
Orebody 24 Expansion Biological Survey (Ecologia 2004d)	May 2004	Poor	Single Season Level 2	5200	50	258	<i>Tephrosia</i> sp. Cathedral Gorge(F.H. Mollemans 2420) <i>Triumfetta leptacantha</i> <sup>2</sup> <i>Isotropis winneckeii</i> (P1) <sup>1</sup>	4
Orebody 25 Priority Flora Species Survey (BHPBIO 2000a)	June 2000	Very Good	Targeted Search	-	-	2	<i>Eremophila magnifica</i> <sup>3</sup> <i>Triumfetta leptacantha</i> <sup>2</sup>	0
Mt Whaleback Priority Flora Species Survey (BHPBIO 2000b)	July 2000	Good	Targeted Search	-	-	-	<i>Triumfetta leptacantha</i> <sup>2</sup>	0
Baseline Biological and Soil Surveys Mapping for ML244SA West of the Fortescue River (Biota 2000)	September to October 2000	Very Good	Single Season Level 2	17, 060	60	380	<i>Eriachne tenuiculmis</i> <sup>2</sup>	14
Field Search and Observations of <i>Lepidium catapycnon</i> Population Near Mt Whaleback, Newman (BHPBIO 1999a)	June-August 1999	Good	Targeted Search	-	-	1	<i>Lepidium catapycnon</i> (DRF-T)	0
Regional Search for <i>Lepidium catapycnon</i> in the greater Newman Area (Pilbara), Western Australia (BHPBIO 1999b)	June-November 1999	Good	Targeted Search	-	-	1	<i>Lepidium catapycnon</i> (DRF-T)	0
Orebody 23 Extension - Biological Survey Assessment (Ecologia 1998)	June 1997	Good	Single Season Level 2	650	20	233	<i>Scaevola acacioides</i> <sup>2</sup>	2
Mt Whaleback Soil and Vegetation Mapping (HGM 1997)	November 1996	Poor	Targeted Search	-	-	-	<i>Lepidium catapycnon</i> (DRF-T)	0
Follow-Up Survey of Mt Whaleback <i>Lepidium catapycnon</i> population (HGM 1999)	May 1999	Good	Targeted Search	10.5	-	-	<i>Lepidium catapycnon</i> (DRF-T)	0
Newman Lease Environmental Appraisal (Maunsell and Partners 1984)	October 1984	Poor	Review	36,100	-	-	None	0

<sup>1</sup> *Isotropis winneckeii* is now identified as *Isotropis parviflora* (P2)

<sup>2</sup> Since been delisted (WAH 2011)

<sup>3</sup> *Eremophila magnifica* at the time of ID was not divided into the two subspecies

<sup>4</sup> Formerly known as *Euphorbia drummondii* subsp. *inappendiculata*

<sup>5</sup> Likely to be erroneous record from the Kimberley

<sup>6</sup> Recently re-identified as *Aristida burbridgeae*.

### 3 Groundwater Dependent Vegetation

Onshore Environmental considers any vegetation that uses groundwater as potentially at risk if it occurs in a location where the groundwater would be lowered beyond assumed natural groundwater variation. However, the impact on vegetation from lowering the groundwater table is likely to be relative to the species' dependence on groundwater. For example, plants that rely on water sourced directly from the groundwater table (phreatophytes) are more likely to show signs of decline or be lost than those that use soil moisture (vadophytes), because vadophytes may be sustained by precipitation. An assessment of the species' dependence on groundwater within the study area is informed by a desktop literature review, with specific reference to previous vegetation association mapping and an understanding of the underlying groundwater environment.

The phreatophytic<sup>1</sup> tree species *Melaleuca argentea* is determined to be the highest risk plant taxon within the Eastern Pilbara. It relies on the existence of shallow groundwater for survival and is considered to be at high risk from groundwater drawdown. *Melaleuca argentea* has not previously been recorded within, or in the vicinity of, the study area (GHD 2011; ENV Australia 2006a, 2006b, 2010; Onshore Environmental 2009, 2013) and there are no defined occurrences of shallow groundwater within the study area (RPS Aquaterra 2012). It is therefore determined that none of the vegetation associations occurring within the study area are at high risk from groundwater drawdown (Table 2).

Vegetation associations occurring along the main drainage channel and associated flood plains within the study area support three native tree species that are considered to be at moderate risk from groundwater drawdown; *Eucalyptus camaldulensis* subsp. *refulgens*, *Eucalyptus victrix* and *Eucalyptus xerothermica* (Figure 2). These tree species are classified as vadophytes<sup>2</sup> or facultative phreatophytes<sup>3</sup>. *Eucalyptus camaldulensis* subsp. *refulgens* is the most widespread of Australian *Eucalyptus* species and is known to tolerate a wide range of water regimes. It typically occurs along inland rivers and may be dependent on shallow groundwater for survival, although the root system may penetrate deeper than 10 m. Studies in the Pilbara indicate that *E. camaldulensis* occurring along the larger drainage lines may have access to groundwater up to 21 m below the surface. Investigations at Marillana Creek found the vigour of large *E. camaldulensis* trees (>10 m tall) declined in response to lower groundwater levels caused by test pumping of water, while the vigour of smaller *E. camaldulensis* remained unchanged (Australian Groundwater Consultants 1981). This observation suggests that the species is capable of being both a vadophyte and a phreatophyte, using the former strategy when young and the latter strategy when mature (Halpern Glink Maunsell 1999). *Eucalyptus victrix* and *Eucalyptus xerothermica* are vadophytes being relatively drought tolerant but susceptible to decline when groundwater becomes limiting (Muir Environmental 1995).

---

<sup>1</sup> Phreatophytes are plant species that rely on water sourced directly from the watertable.

<sup>2</sup> Vadophytes primarily use water held in the vadose (unsaturated) zone that occurs above the watertable.

<sup>3</sup> Facultative Phreatophytes are capable of functioning as both a vadophyte and a phreatophyte

Table 2 Tree species dependence on groundwater.

Species Dependence on Groundwater	Plant Physiology / Water Use	Indicator Species
High	Phreatophyte	<i>Melaleuca argentea</i> (not recorded from the study area)
Moderate	Facultative Phreatophyte or Vadophyte	<i>Eucalyptus camaldulensis</i> subsp. <i>refulgens</i> , <i>Eucalyptus victrix</i> , <i>Eucalyptus xerothermica</i>
Low-None	Xerophyte	All remaining tree species within the study area

#### 4 Assessment of Potential Impacts

The presence of groundwater dependent vegetation can be inferred on the basis of vegetation association mapping in combination with pre-abstraction groundwater levels. The RPS Aquaterra Hydrological Report (RPS Aquaterra 2012) indicates that pre-abstraction groundwater levels within the study area are in the range of 15 m below ground level (bgl) to 115 m bgl, averaging 40-50 mbgl (Figure 3). It is noted that the shallower groundwater levels occur within previously mined areas of the pit void and were not taken from natural ground level.

On the basis of previous studies in the Pilbara, tree roots have been confirmed to a maximum depth of 21 m bgl (Muir Environmental 1995). A conservative threshold of 30 m bgl has been established by Onshore Environmental, below which it is determined unlikely that any tree species in the Pilbara would be utilising the groundwater resource. Vegetation associations occurring along the main drainage channel and associated flood plains that support the facultative phreatophyte *Eucalyptus camaldulensis* subsp. *refulgens* and/or vadophytic trees species *Eucalyptus victrix* and *Eucalyptus xerothermica*, are determined to be at moderate risk from groundwater drawdown impacts associated with proposed abstraction at OB29, OB30 and OB35 (Table 2). Mapping of the vegetation associations supporting facultative phreatophyte species confirms the majority of the area considered at moderate risk overlays pre-abstraction groundwater levels in excess of 30 m bgl (Figure 2), and vegetation is therefore unlikely to have access to the groundwater resource. The remaining vegetation associations support xerophytic species and are determined to be at low to nil risk of being impacted from groundwater drawdown. Vegetation mapping of these areas confirms the vegetation associations comprise xerophytic<sup>4</sup> plant forms that have no reliance on groundwater (Table 2).

Predicted groundwater drawdown is estimated to range between a maximum of 50 m to 80 m close to abstraction operations within and adjacent to the pits, decreasing to 20 m for the area between the three pits. Predicted groundwater drawdown levels decrease sharply outside the outer perimeter of the three pits (Figure 4).

Predicted drawdown confirms that altered groundwater levels within the study area will range from 55-185 m bgl (Figure 5). There are two localised areas within the OB29 and OB30 pits where predicted drawdown would increase groundwater depth from 15-25 m bgl to >30 m bgl, and hence pose a potential risk to the health of groundwater dependent vegetation (Figure 2). However, both areas have been extensively cleared of native vegetation.

<sup>4</sup> Xerophytes are plants that have no reliance on groundwater for survival.



## 5 Groundwater Dependent Vegetation within the Study Area

### Vegetation at High Risk from Groundwater Drawdown

None of the vegetation associations recorded within the study area are considered to be at a high risk from groundwater drawdown, with pre-abstraction groundwater levels exceeding 15 m bgl and no previous record of the phreatophyte *Melaleuca argentea*.

### Vegetation with a Moderate Risk from Groundwater Drawdown

Vegetation associations within the study area at moderate risk from groundwater drawdown were defined as those supporting the vadophytic tree species *Eucalyptus victrix* and *Eucalyptus xerothermica*, and facultative phreatophyte *Eucalyptus camaldulensis* subsp. *refulgens*. These taxa occur along the main drainage channel and adjacent floodplains, described as Vegetation associations 1b, 2a and 5b by Onshore Environmental (2013) and as Vegetation associations 3a, 4a, 5a and 7b by GHD (2011). Pre-abstraction groundwater levels below these vegetation associations is greater than 30 m bgl and therefore they are not considered to be groundwater dependent, or at risk from groundwater drawdown (Figure 2).

### Vegetation with Low to No Risk from Groundwater Drawdown

The majority of vegetation occurring in the study area and surrounds comprise xerophytic species that have no interaction with groundwater and hence would not be impacted by groundwater drawdown.

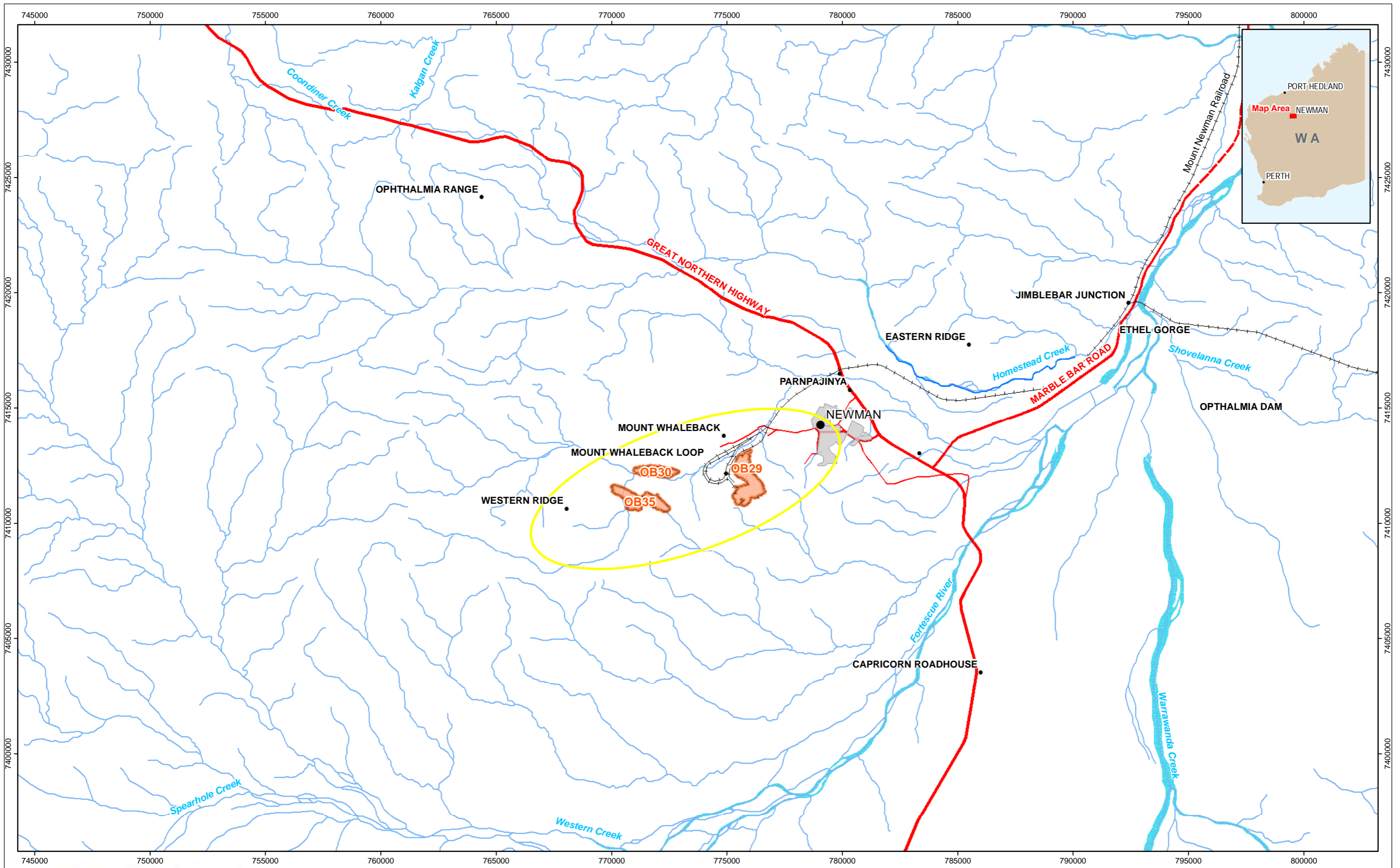
## 6 SUMMARY

There are no areas of groundwater dependent vegetation within the study area identified to be at high risk from groundwater drawdown associated with proposed mining below groundwater levels at OB29, OB30 and OB35.

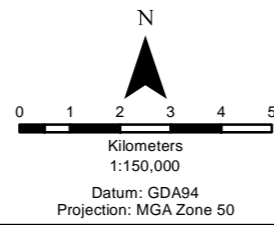
Vegetation associations occurring along the main drainage channel and adjacent floodplains support the facultative tree species *Eucalyptus camaldulensis* subsp. *refulgens* and/or vadophytic trees species *Eucalyptus victrix* and *Eucalyptus xerothermica*. The vegetation associations supporting these three tree species are determined to be at moderate risk from groundwater drawdown (Figure 2). However, pre-abstraction groundwater levels below these areas of moderate risk vegetation, and within the majority of the study area, are in excess of 30 m bgl, and groundwater at this depth is unlikely to be accessible for plant uptake.

The remaining vegetation associations within the study area are identified as xerophytic plant species with no reliance on groundwater and are determined to be at low to nil risk from being impacted from groundwater drawdown. Additionally, pre-abstraction groundwater levels are in the range 35-115 m bgl and groundwater is therefore not accessible to vegetation.

On the basis of predicted groundwater drawdown data provided by RPS Aquaterra, it is unlikely there will be any impact on native vegetation resulting from proposed dewatering activities during mining below existing groundwater levels at OB29, OB30 and OB35.



ON SHORE ENVIRONMENTAL CONSULTANTS	Date:	10/01/2013
Sheet Size:	A3	Status: Final
Drawn by GSM	Requested by DB	GSM Reference ob 29 30 35 gw location



### OREBODY 29, 30 and 35

Location of the study area, showing mining infrastructure and local ephemeral drainage lines

Figure 1

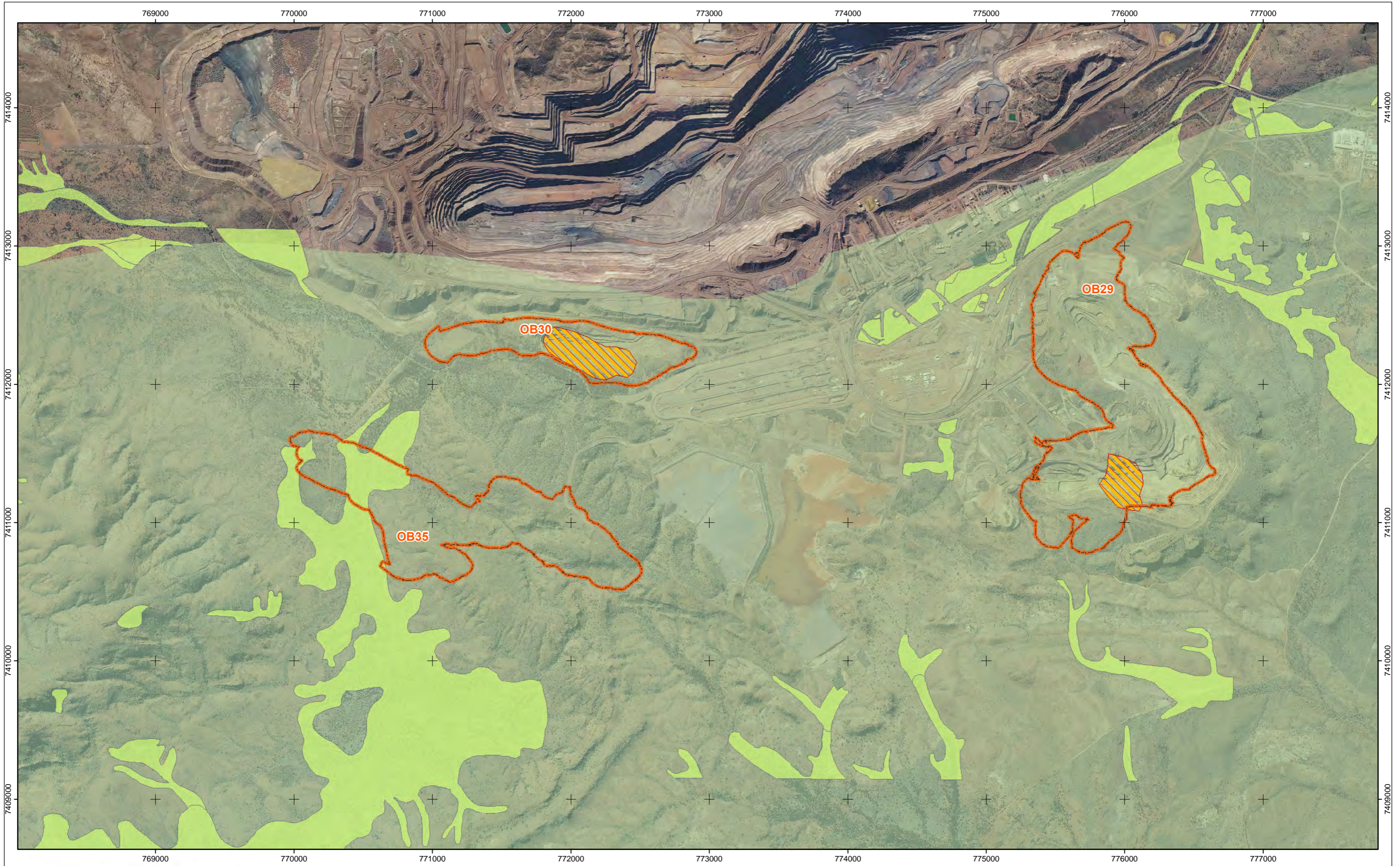
#### Legend

- Study Area
- Pit Outline

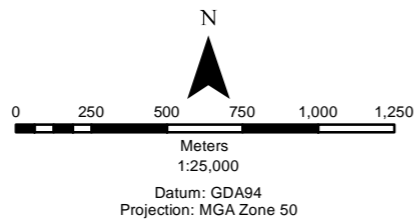


PO Box 7215  
Eaton WA 6232  
admin@griffinspatial.com.au  
Ph/Fax +61 (0) 8 9725 3213  
Mob 0487 337 226





ON SHORE ENVIRONMENTAL CONSULTANTS	Date:	12/07/2013
Sheet Size:	A3	Status: Final
Drawn by GSM	Requested by DB	GSM Reference Orebody_29_30_35_water_levels



### OREBODY 29, 30, 35

Groundwater drawdown risk rating map for vegetation within the study area, highlighting vegetation associations considered to be at 'moderate' risk from proposed groundwater drawdown.

Figure 2

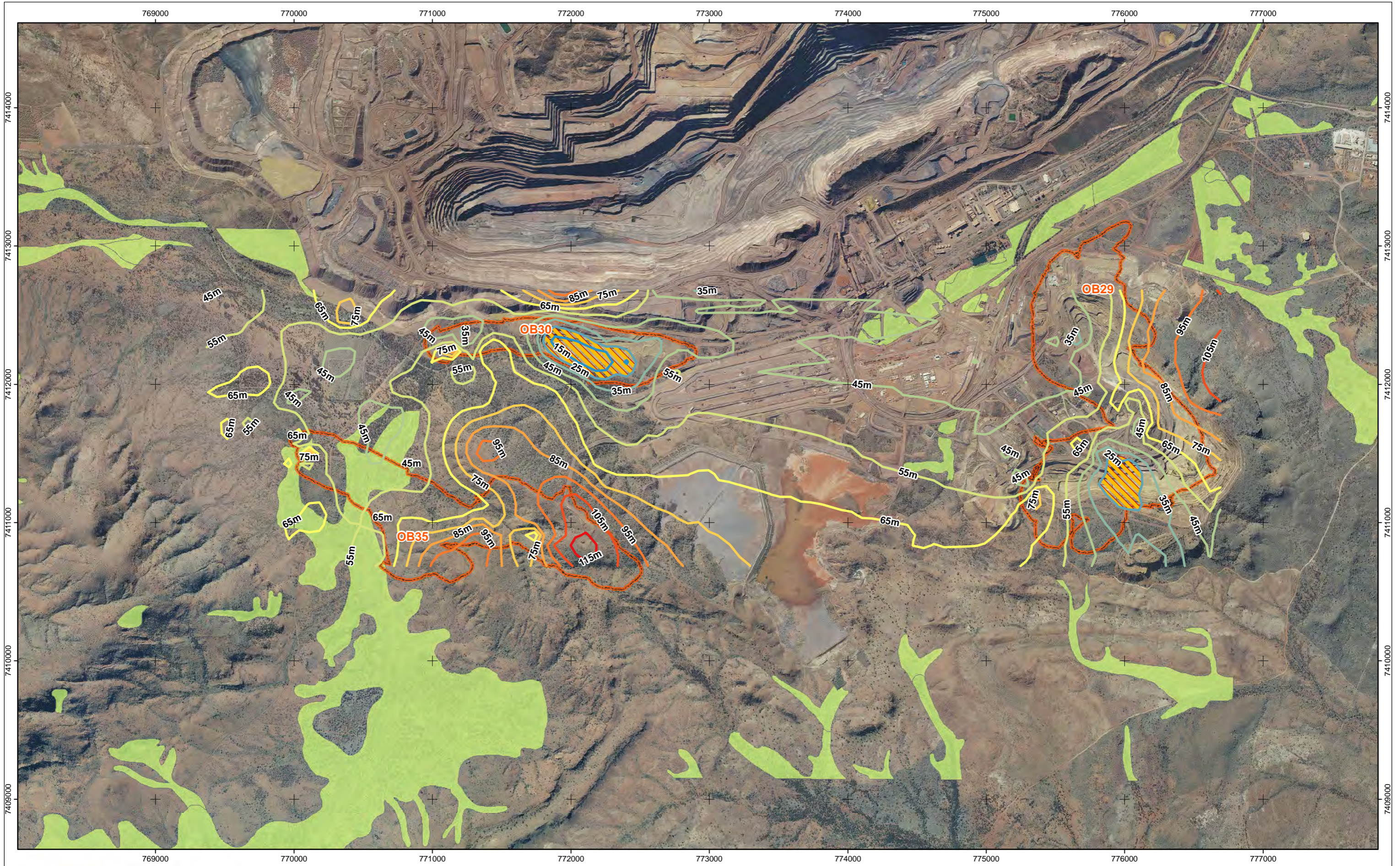
#### Legend

- Pit Outline
- Drawdown less than 30m
- Areas of Depth Increase <30m bgl to >30m bgl
- Vegetation Risk**
- Moderate Risk

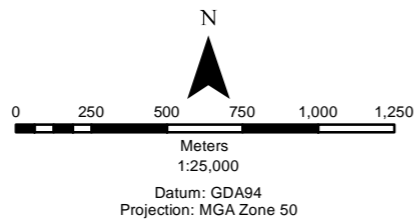


PO Box 7215  
Eaton WA 6232  
admin@griffinspatial.com.au  
Ph/Fax +61 (0) 8 9725 3213  
Mob 0487 337 226





ON SHORE ENVIRONMENTAL CONSULTANTS  
 Date: 12/07/2013  
 Sheet Size: A3 Status: Final  
 Drawn by: GSM Requested by: DB  
 GSM Reference: Orebody\_29\_30\_35\_water\_levels



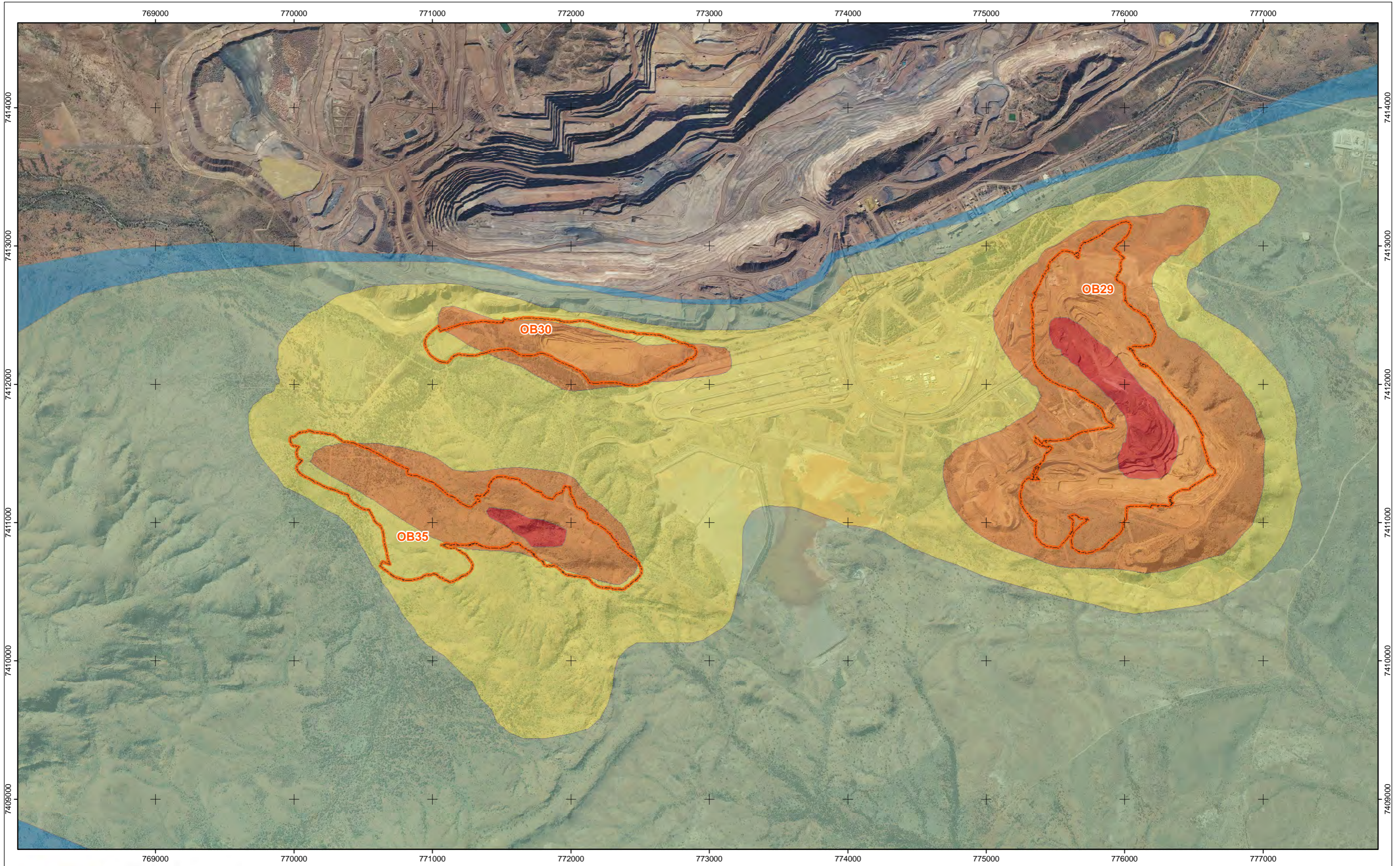
**OREBODY 29, 30, 35**  
 Pre-abstraction groundwater levels within the study area  
**Figure 3**

**Legend**

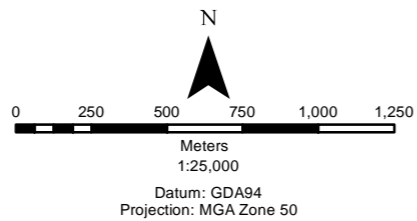
- Pit Outline
  - Areas of Depth Increase <30m bgl to >30m bgl
  - Moderate Risk Vegetation
- | Water Level Contours |      |
|----------------------|------|
| 15m                  | 85m  |
| 25m                  | 55m  |
| 35m                  | 65m  |
|                      | 75m  |
|                      | 85m  |
|                      | 95m  |
|                      | 105m |
|                      | 115m |

**GRIFFIN**  
 SPATIAL & MAPPING  
 PO Box 7215  
 Eaton WA 6232  
 admin@griffinspatial.com.au  
 Ph/Fax +61 (0) 8 9725 3213  
 Mob 0487 337 226





ON SHORE ENVIRONMENTAL CONSULTANTS	Date:	30/04/2013
Sheet Size:	A3	Status: Final
Drawn by GSM	Requested by DB	GSM Reference Orebody_29_30_35_drawdown



### OREBODY 29, 30, 35

Estimated groundwater drawdown contours for within the study area

Figure 4

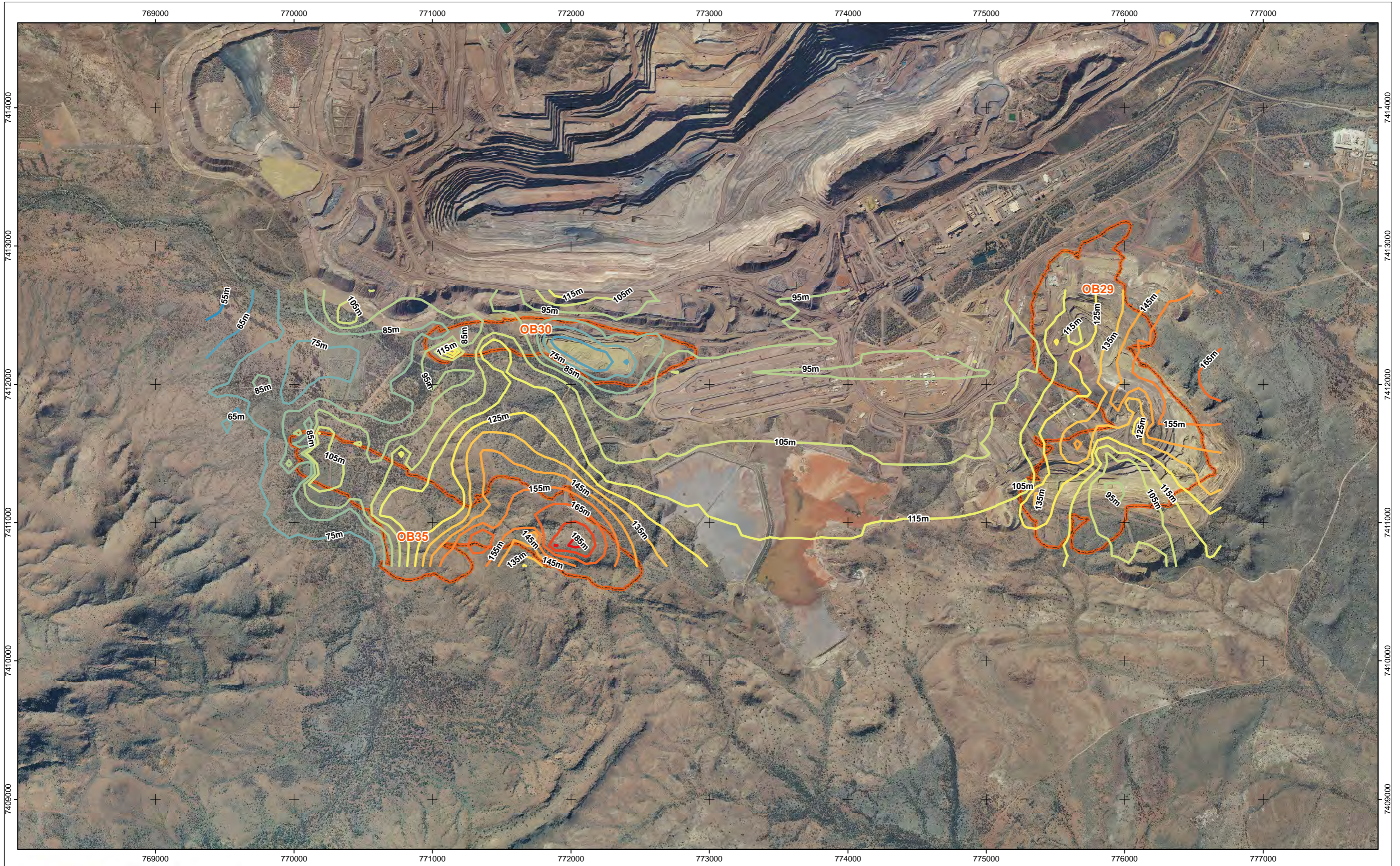
#### Legend

- Pit Outline
- Drawdown**
- 0-1m
- 2 - 5m
- 6 - 20m
- 21 - 50m
- 51 - 80m

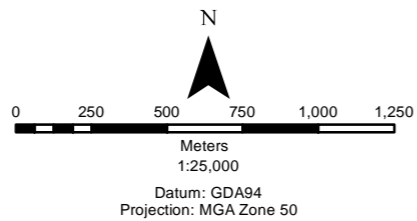


PO Box 7215  
Eaton WA 6232  
admin@griffinspatial.com.au  
Ph/Fax +61 (0) 8 9725 3213  
Mob 0487 337 226





ON SHORE ENVIRONMENTAL CONSULTANTS  
 Date: 30/04/2013  
 Sheet Size: A3 Status: Final  
 Drawn by: GSM Requested by: DB  
 GSM Reference: Orebody\_29\_30\_35\_total\_drawdown



**OREBODY 29, 30, 35**  
 Estimated groundwater levels within the study area,  
 with the proposed drawdown applied  
**Figure 5**

**Legend**

Pit Outline

**Est. Total Drawdown Water Level (m)**

- |    |     |     |     |
|----|-----|-----|-----|
| 55 | 95  | 135 | 175 |
| 65 | 105 | 145 | 185 |
| 75 | 115 | 155 |     |
| 85 | 125 | 165 |     |



PO Box 7215  
 Eaton WA 6232  
 admin@griffinspatial.com.au  
 Ph/Fax +61 (0) 8 9725 3213  
 Mob 0487 337 226



## 7 Bibliography

- AGC Woodward-Clyde 1992. *Review of Available Information on Groundwater Related Environmental Impacts of Iron Ore Mining along Marillana Creek: Project No. 2544/1*, Unpublished report for BHPIO.
- Beard, JS (1975). *Vegetation Survey of Western Australia: Sheet 5 Pilbara*, University of Western Australia Press, Perth, Western Australia.
- BHP Billiton Iron Ore [BHPBIO] (2000). *OB25 Priority Flora Species Survey*. BHP Billiton Iron Ore, Perth, Western Australia.
- BHP Billiton Iron Ore [BHPBIO] (2011). *OB25 Gatehouse Vegetation and Flora Survey*. BHP Billiton. BHP Billiton Iron Ore, Perth, Western Australia.
- Biologic (2009). *Newman Power Network, level 2 Flora and Level 1 Fauna Survey*. Unpublished report for BHPBIO.
- Burbidge, NT (1959). *Notes on Plants and Plant Habitats Observed in the Abydos-Woodstock Area, Pilbara District, Western Australia*. CSIRO Div. Plant Ind. Tech. Paper 12.
- Ecologia Environment (2004a) *Orebody 24 Expansion Biological Survey*. Unpublished report for MPD JV.
- Ecologia Environment (2004b) *Orebodies 18, 23 & 25 Flora and Fauna Review*. Unpublished report for BHP Billiton Iron Ore Pty Ltd.
- Ecologia Environment (2005). *OB25 Biological Review and Environmental Impact Assessment*. Unpublished report for BHP Billiton Iron Ore Pty Ltd.
- ENV.Australia (2006). *OB24 Flora and Fauna Assessment Phase II*. Unpublished report for BHP Billiton Iron Ore Pty Ltd.
- ENV.Australia (2009). *OB25 to Newman Flora and Vegetation Assessment*. Unpublished report for BHP Billiton Iron Ore Pty Ltd
- ENV.Australia (2012). *Eastern Ridge (OB23/24/25) Flora and Vegetation Assessment*. Unpublished report for BHP Billiton Iron Ore Pty Ltd.
- GHD (2008). *Flora and Fauna Assessment – Report for Myopic Project Area*. Unpublished report for BHP Billiton Iron Ore Pty Ltd.
- Halpern, Glink Maunsell 1998. *Marillana Creek Tree Stress Monitoring 1997*. Unpublished Report for BHPIO.
- Halpern, Glink Maunsell 1999. *Marillana Creek Western Access Corridor – Biological Assessment*. Unpublished Report for BHPIO.
- Muir Environmental 1994. *Marillana Creek: 1993 Dry Season Vegetation Monitoring*. Unpublished Report for BHPIO.
- Muir Environmental 1995. *Possible Long Term Impacts of the Yandicoogina Iron Ore Project on Riverine Species along Marillana Creek*. Report for BHPIO.
- Onshore Environmental (2009) *Biological Survey, Myopic Exploration Leases*. Confidential Report to BHP Billiton Iron Ore.
- Onshore Environmental (2011). *Targeted Survey for Rhagodia sp. Hamersley (Priority 3) OB25 Gatehouse Study Area*. Unpublished Report for BHP Billiton Iron Ore Pty Ltd.
- Onshore Environmental (2012). *Targeted significant flora searches at OB25 and vegetation mapping along Homestead Creek*. Unpublished Report for BHP Billiton Iron Ore Pty Ltd.



- Onshore Environmental (2013). *Mt Whaleback AML7/244 Flora and Vegetation and Vertebrate Fauna Review*. Unpublished Report for BHP Billiton Iron Ore Pty Ltd.
- RPS Aquaterra (2012). *Preliminary Hydrogeological Review of OB29, OB30 and OB35*. Unpublished report for BHPBIO.
- Van Vreeswyk et al. 2004. An inventory and condition survey of the Pilbara region, Western Australia. Western Australian Department of Agriculture Technical Bulletin No. 92.
- Weston, A. and Trudgen, M. 1995. *Vegetation and Flora Survey Marillana/Weeli Wollie Creeks and Palaeochannel*. Unpublished Report for BHPBIO.