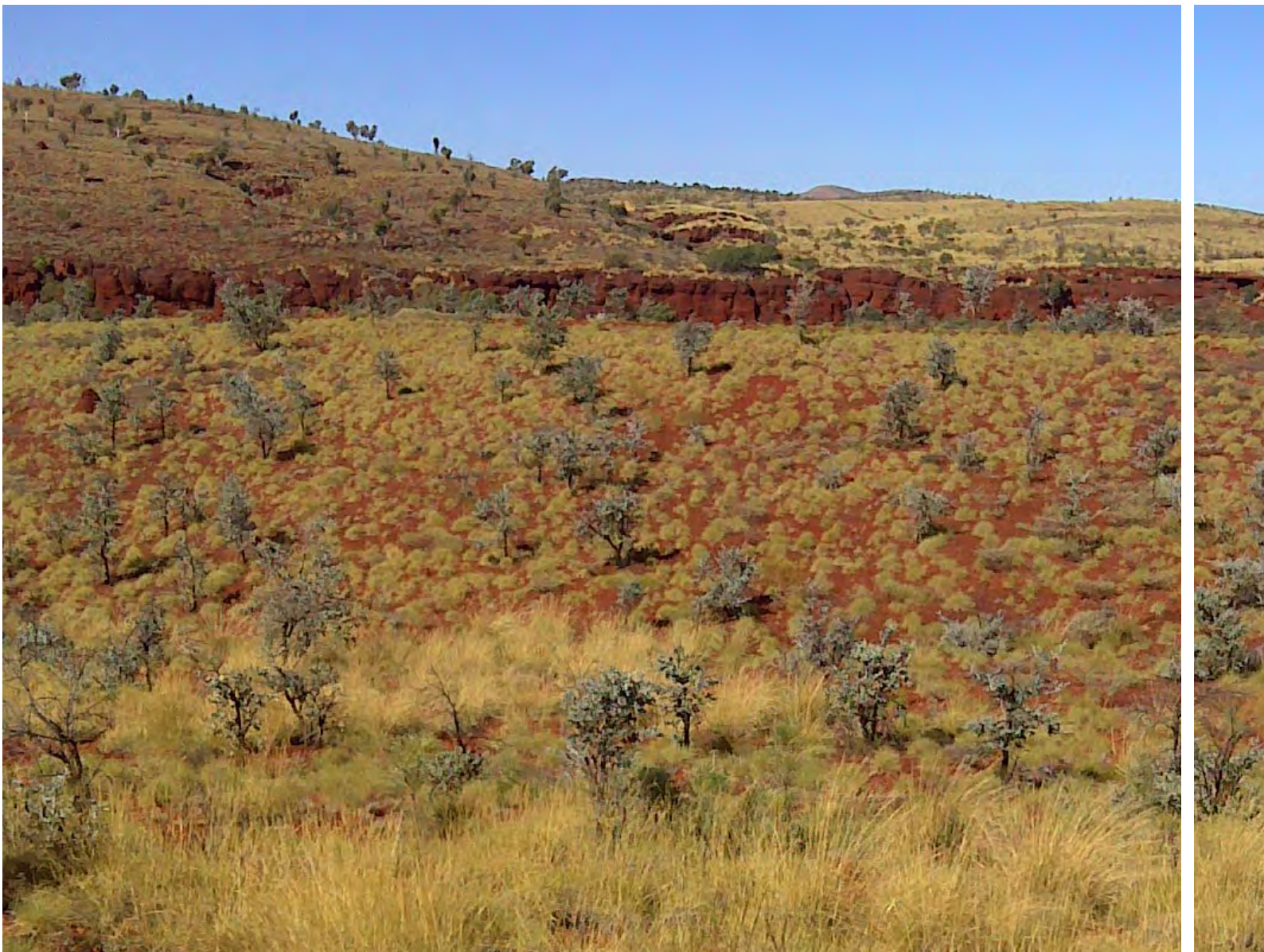




Eastern Ridge Revised Proposal Flora and Vegetation Impact Assessment

Prepared for BHP Billiton Iron Ore Pty Ltd
November 2015



Document Status						
Rev No.	Authors	Reviewer/s	Date	Approved for Issue		
				Name	Distributed To	Date
1	D.Brearley	J.Waters	17/06/15	D.Brearley	C.Pengelly, B.Menezies	17/06/15
2	D.Brearley	B.Menezies, C.Pengally, S.Williamson	16/07/15	D.Brearley	C.Pengelly, B.Menezies, S.Williamson	18/07/15
3	D.Brearley	C.Pengally	02/09/15	D.Brearley	C.Pengelly	14/09/15
4	D.Brearley	C.Pengally, M.McGowan, B.Menezies	16/10/15	D.Brearley	C.Pengelly, B.Menezies	30/10/15



ACN 095 837 120
 PO Box 227
 YALLINGUP WA 6282
 Telephone / Fax (08) 9756 6206
 E-mail: onshoreenv@westnet.com.au

COPYRIGHT: The concepts and information contained in this document are the property of Onshore Environmental Consultants Pty Ltd. Use or copying of this document in whole or in part without the written permission of Onshore Environmental Consultants Pty Ltd constitutes an infringement of copyright.

DISCLAIMER: This report has been undertaken solely for BHP Billiton Iron Ore Pty Ltd. No responsibility is accepted to any third party who may come into possession of this report in whatever manner and who may use or rely on the whole or any part of this report. If any such third party attempts to rely on any information contained in this report such party should obtain independent advice in relation to such information.

EXECUTIVE SUMMARY

BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore) is seeking environmental approval under Part IV of the *Environmental Protection Act 1986* (EP Act) for a revised proposal to manage Orebody (OB)24, OB25, OB32 and OB25 West under a single development envelope. A number of extensions to disturbance areas, pit areas and access to below water table ore for these existing approvals will be referred through this approvals process, along with approval for new mining operations at OB25 West. The three areas being reviewed as part of this impact assessment are summarised as:

- 1) OB24 Maximum Disturbance Boundary extension;
- 2) OB32 East Maximum Disturbance Boundary extension; and
- 3) OB25 West Operations.

Onshore Environmental Consultants Pty Ltd (Onshore Environmental) was commissioned by BHP Billiton Iron Ore to undertake an impact assessment on flora and vegetation for the three areas.

There are 12 flora and vegetation surveys that have been completed within, or partly within, the Development Envelope between June 1995 and June 2013, with survey effort spread across a variety of seasons. The most recent baseline survey was completed between April and July 2011 at Eastern Ridge (OB 23/24/25) (ENV Australia 2012). In addition comprehensive targeted significant flora surveys were completed at OB25 in July 2012 (Onshore Environmental 2012) and OB24 in June 2013 (Onshore Environmental 2013a).

Based on collated results from previous flora and vegetation surveys intersecting the Development Envelope, no plant taxon gazetted as Threatened Flora (T) pursuant to subsection (2) of Section 23F of the *Wildlife Conservation Act 1950* (WC Act) or listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has been recorded from the OB24 and OB32 East extension areas, or the OB25 West Operations area.

The Priority 2 flora taxon *Isotropis parviflora* was recorded as one plant from the northern sector of the OB24 Maximum Disturbance Boundary extension in May 2004. Despite good seasonal conditions follow-up targeted surveys completed in July 2011 and June 2012 failed to record any evidence of *Isotropis parviflora* at the previous location point or from the wider study area. *Isotropis parviflora* is a short-lived coloniser species that has been out-competed by the maturing vegetation cover at the site. The potential impact of the OB24 Maximum Disturbance Boundary extension on *Isotropis parviflora* was determined to be negligible.

The Priority 3 flora taxon *Eremophila magnifica* subsp. *velutina* occurs on hill crests, ridges, hill slopes and rocky drainage lines throughout the central sector of the proposed OB25 West Operations area; this represents the western sub-population. Plant density was variable ranging from one to 100 plants per 10 m². The eastern sub-population occurs approximately 500 m east of the proposed OB25 West Operations boundary on the northern side of the existing OB25 pit (within the approved Eastern Ridge Development Envelope). Approval of the proposed OB25 West Operations area would potentially result in the entire local population of *Eremophila magnifica* subsp. *velutina* being cleared. The local impact is therefore determined to be high. Given that *Eremophila magnifica* subsp. *velutina* occurs over a 300 km range extending from south-east of Newman to west of Tom Price, with two populations within this range known from Karijini National Park, the regional impact was determined to be low.

Based on fine-scale consolidated vegetation mapping of BHP Billiton Iron Ore's Pilbara

tenements (Onshore Environmental 2014c) twelve vegetation associations occur within the Development Envelope. The vegetation associations are not affiliated with Federal and State listed Threatened Ecological Communities (TECs), or State listed Priority Ecological Communities (PECs). Vegetation condition within the Development Envelope was rated as *pristine, excellent, or very good*, with smaller areas fringing the adjacent mining operations rated as *degraded or completely degraded (cleared)*.

The extent for nine of the twelve vegetation associations is less than one percent of the total representation within BHP Billiton Iron Ore's Pilbara consolidated vegetation mapping database (i.e. BHP Billiton Iron Ore's Pilbara tenure), and less than five percent for the remaining three vegetation associations. It is determined that direct clearing within the Development Envelope will not have any significant impact on the regional representation of the twelve vegetation associations.

Alterations to surface runoff and drainage from the Development Envelope should not adversely impact the existing surface water regimes, and as such downstream vegetation is not determined to be at risk.

A review of baseline groundwater depth at 2012 confirms *in situ* groundwater levels are within 25 m bgl at two major receptors surrounding the Eastern Ridge development Envelope; Homestead Creek (as well as adjacent floodplains and major tributaries), and a section of the Fortescue River (supporting the Ethel Gorge TEC). Considering the OB24 and OB25 West projects in isolation, i.e. non-cumulative impact, minor groundwater drawdown between 1 m and 5 m in depth is modelled to occur within one localised area along the northern branch of Homestead Creek supporting the facultative phreatophyre *Eucalyptus victrix*. The potential impact is determined to be low. For OB25 West, minor groundwater drawdown in the range 1 m to 2 m intersects sections of the Homestead Creek drainage system supporting both *Eucalyptus camaldulensis* subsp. *refulgens* and *Eucalyptus victrix*. This range is within natural seasonal variation and potential impacts on both *Eucalyptus camaldulensis* subsp. *refulgens* and *Eucalyptus victrix* are determined to be negligible.

Cumulative groundwater drawdown extending up to 65 m was modelled to intersect areas along Homestead Creek where baseline groundwater depth at 2012 was less than 25 m bgl and capable of providing a groundwater source for *Eucalyptus victrix* and/or *Eucalyptus camaldulensis* subsp. *refulgens*. The groundwater drawdown risk along the major length of Homestead Creek supports *Eucalyptus victrix* alone and is determined to be low. However, the risk for a localised section of Homestead Creek supporting *Eucalyptus camaldulensis* subsp. *refulgens* immediately west of OB25 West was determined to be moderate.

The cumulative groundwater drawdown was modelled to extend eastwards to Ethel Gorge on the Fortescue River. Groundwater drawdown along the main drainage channel supporting *Eucalyptus victrix* and *Eucalyptus camaldulensis* subsp. *refulgens* was within the range 10 m to 15 m, which has the potential for low to moderate impact on groundwater dependent vegetation, including the tree species *Eucalyptus victrix* and *Eucalyptus camaldulensis* subsp. *refulgens*.

Fire is a common disturbance that occurs throughout the Pilbara, and the twelve vegetation associations represented within the Development Envelope are not fire-sensitive. Fire is determined to be manageable and is unlikely to pose any significant risk to vegetation.

There were two common and widespread introduced (weed) species recorded as scattered plants within localised areas of the Development Envelope; **Bidens bipinnata* (Beggar's Ticks) and **Cenchrus ciliaris* (Buffel Grass). While clearing of native vegetation and increased vehicular access has the potential to introduce and/or spread weed species, the implementation of existing management strategies used at surrounding BHP Billiton Iron Ore

operations will ensure the potential for any impacts remains low.

Vegetation can be impacted by increased levels of airborne dust in instances where leaf transpiration is impeded. This could occur along unsealed roads and tracks supporting large volumes of traffic, and is pronounced during dry seasonal conditions. With appropriate management, the potential impact of increased levels of airborne dust is considered to be a low risk.

ABBREVIATIONS

Abbreviation	Definition
AWT	Above Water Table
BAM Act	<i>Biosecurity and Agriculture Management Act (2007)</i>
BHP Billiton Iron Ore	BHP Billiton Iron Ore Pty Ltd
BoM	Bureau of Meteorology
CID	channel iron deposit
DEWHA	Department of the Environment, Water, Heritage and the Arts
DoE	Department of Environment
DPaW	Department of Parks and Wildlife
EC	electrical conductivity
EIA	environmental impact assessment
EP Act	<i>Environmental Protection Act (1986)</i>
EPA	Environmental Protection Authority
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act (1999)</i>
EPS	Environmental Protection Statement
Ha	Hectares
HV	heavy vehicle
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
KCT	Key Characteristics Table
Km	Kilometre
LOM	Life of Mine
LV	light vehicle
M	Metre
MS	Ministerial Statement of Approval
Mt	million tonnes
Mtpa	million tonnes per annum
OB	Orebody
OSAs	Overburden Storage Areas
P1	Priority 1
P2	Priority 2
P3	Priority 3
P4	Priority 4
PECs	Priority Ecological Communities
SRE	short-range endemic
T	Threatened Flora
TECs	Threatened Ecological Communities
WA	Western Australia
WAH	Western Australian Herbarium
WC Act	<i>Wildlife Conservation Act (1950)</i>

TABLE OF CONTENTS

EXECUTIVE SUMMARY	I
ABBREVIATIONS	IV
TABLE OF CONTENTS	V
1 INTRODUCTION.....	1
1.1 PREAMBLE	1
1.2 APPROVALS HISTORY.....	1
1.3 PROPOSAL DESCRIPTION.....	1
2 EXISTING ENVIRONMENT	4
2.1 CLIMATE.....	4
2.2 BIOGEOGRAPHIC REGIONS	4
2.3 EXISTING LAND USE.....	5
2.4 LANDFORMS	5
2.5 SOILS.....	5
2.6 GEOLOGY.....	6
2.7 SURFACE WATER HYDROLOGY	6
2.8 FLORA AND VEGETATION	6
2.9 LAND SYSTEMS.....	7
3 SURVEY METHODOLOGY	12
3.1 LEGISLATION AND GUIDANCE STATEMENT	12
3.2 DESKTOP SEARCHES.....	12
3.3 FIELD SURVEY METHODOLOGY.....	12
3.3.1 Timing and Personnel.....	12
3.3.2 Sampling of Study Sites	16
3.3.3 Weed Survey and Mapping.....	16
3.3.4 Vegetation Association Mapping.....	16
3.3.5 Field Survey Constraints.....	17
3.3.6 Assessment of Conservation Significance.....	18
4 SUMMARY OF BASELINE ASSESSMENT	19
4.1 DESKTOP REVIEW	19
4.1.1 Previous Flora Surveys.....	19
4.1.2 Threatened Flora listed under the IUCN Red List database.....	27
4.1.3 Threatened Flora listed under the WA Wildlife Conservation (Rare Flora) Notice.....	27
4.1.4 Priority Flora recognised by the DpaW	27
4.1.5 TECs listed under State and Federal Legislation	28
4.1.6 PECs recognised by DpaW	29
4.2 CONSERVATION SIGNIFICANT FLORA.....	31
4.2.1 Threatened Flora listed under the WC Act and EPBC Act.....	31
4.2.2 Priority Flora	31
4.2.3 Flora of Interest.....	32
4.3 INTRODUCED FLORA	35
4.3.1 OB24 Maximum Disturbance Boundary Extension	35
4.3.2 OB32 East Maximum Disturbance Boundary Extension	35
4.3.3 OB25 West Operations	35
4.4 VEGETATION.....	38
4.5 VEGETATION CONDITION	39
4.6 SIGNIFICANCE OF VEGETATION.....	43
4.6.1 National Significance	43

4.6.2	State Significance	43
4.6.3	Local Significance on Basis of Specialised Landform.....	43
4.6.4	Local Significance on Basis of Supporting Significant Flora	44
5	EVALUATION OF THE POTENTIAL IMPACTS	45
5.1	DIRECT CLEARING	45
5.1.1	Vegetation.....	45
5.1.2	Impacts to Significant Flora	48
5.2	GROUND WATER DEPENDANT VEGETATION	51
5.2.1	Drawdown from OB24 and OB25 West Dewatering Only.....	52
5.2.2	Cumulative Drawdown.....	55
5.3	ALTERATION TO SURFACE WATER FLOWS.....	58
5.4	FIRE.....	60
5.5	INTRODUCED (WEED) SPECIES.....	60
5.6	DUST	60
6	SUMMARY	62
7	STUDY TEAM	64
8	REFERENCES.....	65
APPENDIX 1		
	Conservation Codes for Western Australian Flora	69
APPENDIX 2		
	Conservation categories for flora described under the EPBC Act	71
APPENDIX 3		
	Vegetation Classifications for the Pilbara based on Specht (1970), as modified by Aplin (1979) and Trudgen (2009)	73
APPENDIX 4		
	Vegetation condition scale (as developed by Keighery 1994)	75
LIST OF TABLES		
Table 1	Pre-European extent of the vegetation association covering the entire extent of the Development Envelope (Shepherd <i>et al.</i> 2002).	7
Table 2	Land systems occurring within the Development Envelope (descriptions from van Vreeswyk <i>et al.</i> 2004).	8
Table 3	Summary of previous flora and vegetation surveys completed within, or partly within, the Development Envelope.	14
Table 4	Relevance of constraints, as identified by EPA (2004), to the flora and vegetation survey.	17
Table 5	Summary of results from previous flora and vegetation surveys within, or in close proximity to, the Development Envelope.	20
Table 6	Significant flora taxa previously recorded from the Newman area; taken from Federal and State database searches, literature review and local knowledge.....	27
Table 7	Summary of Priority flora taxa recorded within the OB25 West Operations area and OB24 Maximum Disturbance Boundary extension.....	33
Table 8	Summary of introduced weed species recorded within the OB25 West Operations, OB24 Maximum Disturbance Boundary extension and OB32 East Maximum Disturbance Boundary extension.....	36
Table 9	Vegetation associations occurring within the Development Envelope (as per the consolidated mapping, Onshore Environmental 2014c).....	38

Table 10	Representation of vegetation condition categories within the Development Envelope.....	39
Table 11	Representation of twelve vegetation associations occurring within the Development Envelope (from Onshore Environmental 2014a). NOTE: Percentage values in brackets represent proportion of the vegetation association as mapped in BHP Billiton Iron Ore's consolidated database.	46
Table 12	Representation of vegetation condition categories within the Development Envelope.....	48
Table 13	Tree species dependence on groundwater.....	51
Table 14	Summary of five vegetation associations within the Development Envelope that support Mulga (<i>Acacia aptaneura</i> or <i>A. citrinoviridis</i>) or Coolibah (<i>Eucalyptus victrix</i>). NOTE: Percentage values in brackets represent proportion of the vegetation association as mapped in BHP Billiton Iron Ore's consolidated database.....	59

LIST OF FIGURES

Figure 1	Eastern Ridge Location Plan.....	3
Figure 2	Beard (1975) vegetation complexes represented within the Development Envelope.....	9
Figure 3	Previous flora and vegetation surveys completed within, and adjacent to, the Development Envelope.	10
Figure 4	Land systems occurring within the Development Envelope (descriptions from Van Vreeswyk <i>et al.</i> 2004).	11
Figure 5	Location of TECs and PECs within a 50 km radius of the Development Envelope.	30
Figure 6	Location of significant flora within and surrounding the Development Envelope.	34
Figure 7	Location of introduced weed species within the Eastern Ridge Development Envelope.....	37
Figure 8	Eastern Ridge Proposal - Vegetation associations occurring within the Development Envelope.	40
Figure 9	Eastern Ridge Proposal - Vegetation condition map for the Development Envelope.	42
Figure 10	Eastern Ridge Proposal - <i>Eremophila magnifica</i> subsp. <i>velutina</i> distribution and density.....	50
Figure 11	Eastern Ridge Proposal – Non-cumulative groundwater drawdown model for OB24 and OB25 West.	54
Figure 12	Eastern Ridge Proposal - Cumulative groundwater drawdown model for OB24 and OB25 West.....	56
Figure 13	Eastern Ridge Proposal – Hydrograph for monitoring bore within Ethel Gorge TEC.....	57

1 INTRODUCTION

1.1 Preamble

BHP Billiton Iron Ore's mining operations at Eastern Ridge including OB24, OB25 and OB32 are currently managed under three Ministerial Statements and BHP Billiton Iron Ore is proposing to amalgamate these existing Ministerial Statements and the new OB25 West mining operation under one new Ministerial Statement and a single Eastern Ridge Development Envelope. An Environmental Impact Assessment was required as part of the approvals process in order to assess the potential impacts of new developments presented under the revised proposal. In 2015 Onshore Environmental was commissioned by BHP Billiton Iron Ore to undertake an Environmental Impact assessment for the Eastern Ridge Proposal.

1.2 Approvals History

There are a number of existing approvals in the immediate surrounding area:

- Orebody 25 mining operations are operated under Ministerial Statement 834;
- Orebody 24 mining operations are operated under Ministerial Statement 712; and
- Orebody 32 East above water table mining operations are currently under assessment by the EPA.
- OB25 West: New mining operation to be included in this referral.

BHP Billiton Iron Ore is seeking environmental approval under Part IV of the *Environmental Protection Act 1986* (EP Act) for managing OB24, OB25, OB32 and OB25 West under a single development envelope.

1.3 Proposal Description

The Eastern Ridge mining operation is situated on Mineral Lease 244SA approximately 3 km north of the Newman town site in Western Australia (Figure 1). The existing operations include mining at OB24, OB25 OB32 (under assessment) and a new mining operation at OB25 West. Iron ore is extracted using conventional open pit methods and crushed at OB24 and OB25. The ore is railed to Port Hedland or the Newman hub based on business requirements.

As part of the new referral process BHP Billiton Iron Ore is seeking approval for changes to disturbance boundaries, pits areas and access to below water table mining for existing mining areas. Additionally this referral will include the new mining operations at OB25 West incorporating new infrastructure, haul roads, roads, stockpiles, and overburden storage areas (OSAs), as well as closure and rehabilitation requirements.

The following modifications for each area will be part of the current referral and assessed as part of this scope:

OB24

- Extension of the currently approved maximum disturbance boundary to the north in a number of areas; and
- Approval for below water table (BWT) mining.

OB25

- Revised water key characteristics for OB25; and
- Minor additional pit disturbance.

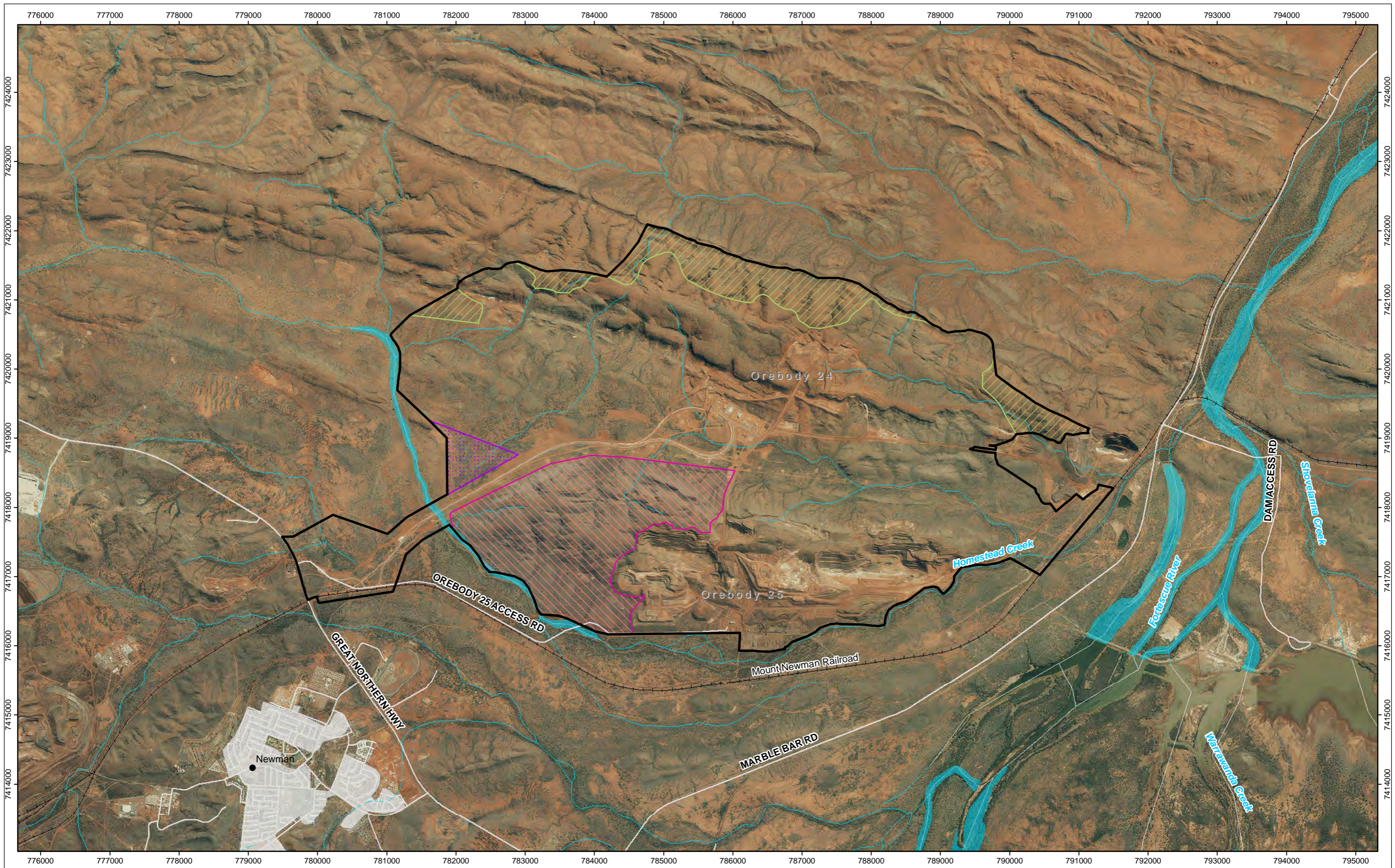
OB32 (currently under assessment in a separate approvals process)

- Extension to the pit area to the east (above water table); and
- Extensions to the approved development envelope to the south to accommodate future road alignment.

OB25 West (approval for a new mining operation)

- Mining of pits;
- Overburden storage in mined out voids and OSAs;
- Construction and use of haul and access roads;
- Out of pit topsoil, run of mine, low grade ore stockpiles;
- Ancillary infrastructure; and
- Closure and progressive rehabilitation.

The location for each of the areas and modifications are presented in Figure 1.



ONSHORE
ENVIRONMENTAL

ON SHORE ENVIRONMENTAL CONSULTANTS	Date:	22/05/2015
Sheet Size:	A3	Status: Final
Drawn by: GSM	Requested by: DB	GSM Reference: Eastern Ridge Location

N

0 500 1,000 1,500 2,000

Meters
1:50,000

Datum: GDA94
Projection: MGA Zone 50

FIGURE 1

EASTERN RIDGE LOCATION PLAN

Legend

- Eastern Ridge Development Envelope
- OB24 Maximum Disturbance Boundary extension
- OB25 West Operations
- OB32 East Maximum Disturbance Boundary extension

GRIFFIN
SPATIAL & MAPPING

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

2 EXISTING ENVIRONMENT

2.1 Climate

The Pilbara region is characterised by an arid-tropical climate resulting from the influence of tropical maritime and tropical continental air masses producing predominantly summer rainfall. Cyclones can occur during this period, bringing heavy rain and causing potential destruction to coastal and inland towns.

The nearest Bureau of Meteorology (BoM) weather station to the Eastern Ridge proposal is located approximately 12 km south-southeast at the Newman Airfield. Additional meteorological data is available from a former BoM weather station at Newman that was operational for 38 years between 1965 and 2003. Both of these weather stations have statistical records of temperature, rainfall, relative humidity and wind speed and direction for periods of greater than ten years.

Regional temperatures are warmest from October through to April, with average monthly maximum temperatures at both stations exceeding 30°C during this period. Temperatures are coolest from May to September with average monthly minimum temperatures below 12°C. The average daily maximum temperature in January is approximately 39°C, while average daily minimum temperatures reach as low as 5.7°C in July.

The total annual average precipitation is approximately 310 mm at Newman and 316 mm at Newman Airfield (BoM 2015). The majority of precipitation occurs between December and March, peaking in February with a monthly average of approximately 81 mm. The months of September and October exhibit the driest conditions with average rainfall less than 4 mm.

The Wittenoom BoM station is located approximately 190 km north-west of Newman and is the closest station that records evaporation. Annual average evaporation for Wittenoom is 3,142 mm per year, which exceeds annual rainfall by as much as 2,500 mm per year.

2.2 Biogeographic Regions

The latest version of the Interim Biogeographic Regionalisation for Australia (IBRA7) divides Australia into 89 bioregions based on climate, geology, landform, native vegetation and species information (DoE 2012) and includes 419 sub-regions. The bioregions and sub-regions are the reporting unit for assessing the status of native ecosystems and their level of protection in the National Reserve System.

The Eastern Ridge Proposal is located in the Pilbara bioregion, which consists of four sub-regions: Chichester, Fortescue, Hamersley and Roebourne. The Development Envelope is located in the Hamersley sub-region (PIL3), which is described as a mountainous area of Proterozoic sedimentary ranges and plateaux, dissected by gorges (basalt, shale and dolerite) (Kendrick 2001). It contains Mulga low woodland over bunch grasses on fine textured soils in valley floors, and *Eucalyptus leucophloia* over *Triodia brizoides* on skeletal soils of the ranges.

2.3 Existing Land Use

The current land use surrounding the Development Envelope is predominantly mineral exploration, iron ore mining and dry land agriculture, specifically pastoralism, cattle grazing and rangelands. Conservation lands amount to less than ten percent of the total area of the Pilbara Bioregion, with the major reserve being Karijini National Park (approximately 120 km to the north-west), supplemented by lesser conservation estates such as Cane River and Meentheena Conservation Parks. Wetlands of National Significance include the permanent pools of Millstream-Chichester and Karijini National Parks and the Fortescue Marsh (approximately 80 km to the north).

2.4 Landforms

The Development Envelope is located at the southern end of the Hamersley Plateau. The Hamersley Plateau is characterised by long strike ridges rising 300 m or more above valley floors and flats. Other characteristic landforms of the general area include stony plains and some alluvial plains and sand plains (Tille 2007). The entire region contains mainly rounded ranges and hills in contrast to the characteristic 'mesa form' hills that are located further north.

The Development Envelope is dissected by a series of steep ridges and rounded hill crests and hills slopes aligned roughly east-west and draining onto stony plains to the north and south. The ephemeral drainage line Homestead Creek is situated immediately south of the Development Envelope with surface drainage flowing to the east and into the Fortescue River.

2.5 Soils

The soils of the Pilbara Region have been defined and mapped at a scale of 1:2,000,000 by Bettanay *et al.* (1967). The Development Envelope is within an area dominated by coherent and porous loam soils with weak pedologic development. This soil type is most commonly present in areas of *Triodia* steppe with *Eucalyptus leucophloia*.

Tille (2006) collated the most recent and detailed mapping of Western Australia's rangelands and arid interior into a hierarchy of soil-landscape mapping units. The Development Envelope falls within the Fortescue Province, an area that occupies approximately 160,050 km² (6.3% of Western Australia) and includes the town of Newman. Soils and landforms for the Fortescue Province are described as "hills and ranges (with stony plains and some alluvial plains and sand plains) on the volcanic, granitic and sedimentary rocks of the Pilbara Craton. Stony soils with red loamy earths and red shallow loams (and some red/brown non-cracking clays, red deep sandy duplexes and red deep sands)" (Tille 2006). The Fortescue Province is divided into ten soil-landscape zones with the Development Envelope occurring within the Hamersley Plateaux Zone. The soils in this zone are described as "hills and dissected plateaux (with some stony plains and hardpan wash plains) on sedimentary and volcanic rocks of the Hamersley Basin (Ophthalmia Fold Belt). Stony soils with red shallow loams and some red/brown non-cracking clays and red loamy earths" (Tille 2006).

2.6 Geology

The Pilbara region makes up a portion of the Western Shield and consists of pre-Cambrian, Proterozoic and Archaean rocks. The area contains some of the earth's oldest rock formations, thought to be around 3.5 billion years old (ANRA 2008). Important mineral reserves, including iron ore, which is prevalent in the Pilbara, are associated with these rock formations.

The Pilbara Craton lies beneath the Proterozoic rocks of the Hamersley and Bangemall Basins. The Hamersley Basin covers the majority of the southern part of the Pilbara Craton and is separated into three stratigraphic groups; the Fortescue, Hamersley and Turee Creek rock groups. The Fortescue Group consists mainly of basalt with beds of siltstone, mudstone, shale, dolomite and jaspilite. These rocks form the Chichester Plateau, which lies beneath the Hamersley Plateau. The Turee Creek Group consists of interbedded mudstone, siltstone, sandstone, conglomerate and carbonate. These rocks are the youngest of the three groups and are exposed mainly in the Ashburton Valley.

The Hamersley Group is the most relevant to the Development Envelope as it contains both the Brockman Iron Formation and the Marra Mamba Iron Formation, which together provide most of the major iron ore deposits in the Pilbara (O'Brien and Associates 1992). This group forms the Hamersley Range and Plateau and consists of jaspilite and dolomite. The jaspilite produces deposits of haematite and limonite, which are mined for iron ore.

Eastern Ridge is a faulted outlier of the Brockman Iron Formation. The far north-western end is truncated by the Mt Whaleback Fault and the far eastern limit is truncated by the north north-east trending Fortescue River fault.

2.7 Surface Water Hydrology

Most creeks within the Pilbara are ephemeral with surface water only present following heavy rains as a result of storms or cyclones during the summer months. The Development Envelope is located just north of Homestead Creek an ephemeral drainage line which is a tributary of the larger Fortescue River. Homestead Creek runs in an easterly direction to join the Fortescue River just north of Ophthalmia Dam. The Fortescue River then flows north for approximately 80 km into the Fortescue Marsh.

2.8 Flora and Vegetation

The Development Envelope is located within the Hamersley Botanical District, which is part of the Eremaean Province (Beard 1990). It is dominated by tree and shrub - steppe communities consisting mainly of *Eucalyptus* and *Acacia* species. *Triodia pungens* and *Triodia wiseana* and some Mulga occur within valley areas and short grass plains occur on alluvia.

The original vegetation mapping was undertaken by Beard (1975) and refined by Shepherd *et al.* (2002). Two vegetation associations occur within the Eastern Ridge Development Envelope, 'Hamersley 82 and Hamersley 18 (Table 1, Figure 2). While the Pre-European extent for this vegetation association is approximately 100 percent,

less than ten percent of the association occurs within formal or informal reserves (Table 1).

Table 1 Pre-European extent of the vegetation association covering the entire extent of the Development Envelope (Shepherd *et al.* 2002).

Vegetation Sub-Association	Pre-Euro. Extent Remaining (ha)	Extent within Development Envelope (ha)	% Remaining Extent in IUCN Class I-IV Reserves
Hamersley 82: Hummock grasslands, low tree steppe; Snappy gum over <i>Triodia wiseana</i>	2,290,910 (100%)	755 (0.033%)	8.9
Hamersley 18: Low woodland; mulga (<i>Acacia aneura</i>)	24,675,970 (99.9%)	190 (<0.000%)	2.0

In recent years there has been numerous small-scale surveys completed throughout the Pilbara, predominantly associated with mining approvals. A literature review confirmed 12 previous flora and vegetation surveys occurring within the Development Envelope were completed between 1995 and 2013 (Figure 3). An additional 18 baseline surveys have been completed at surrounding BHP Billiton Iron Ore tenements.

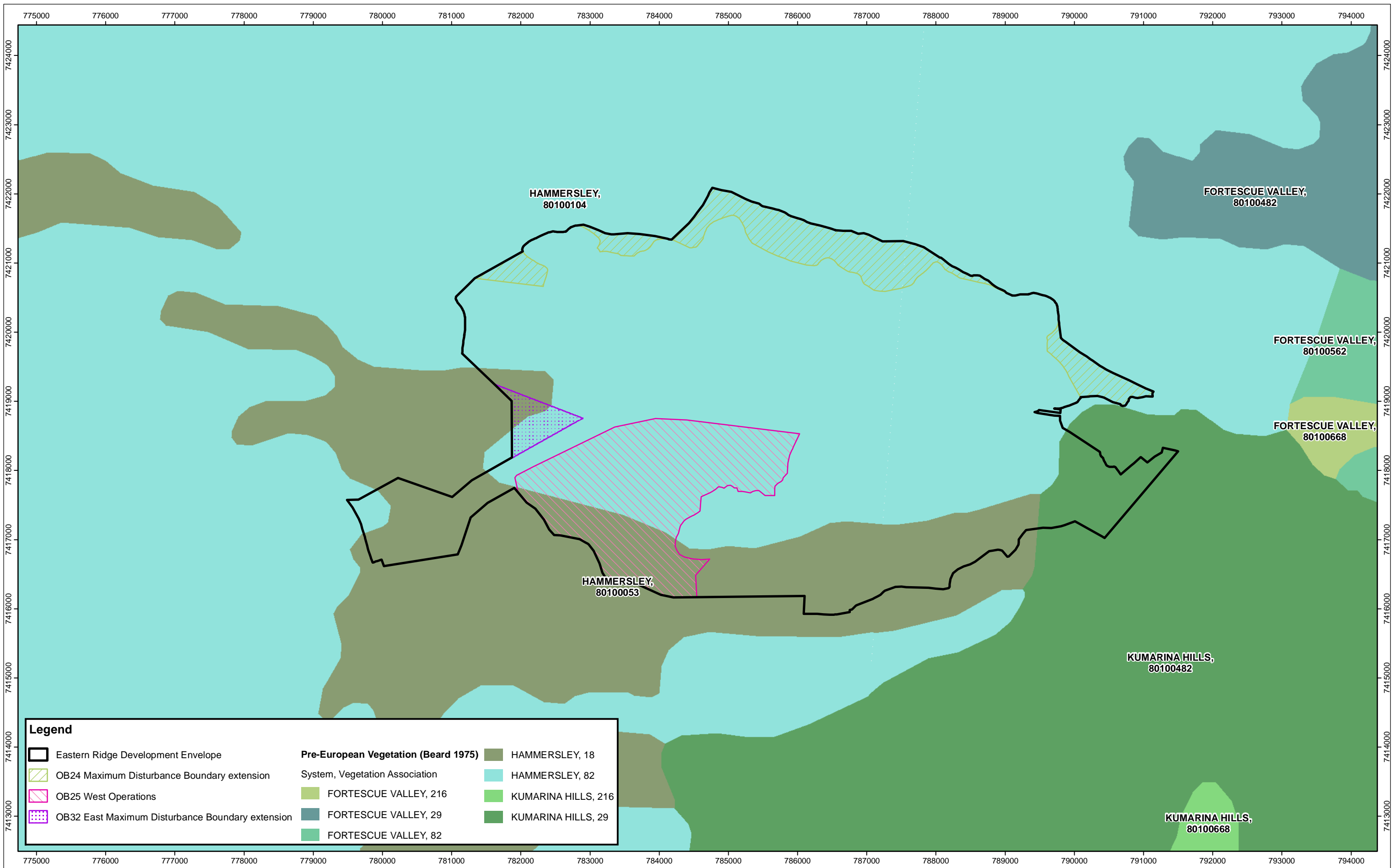
2.9 Land Systems

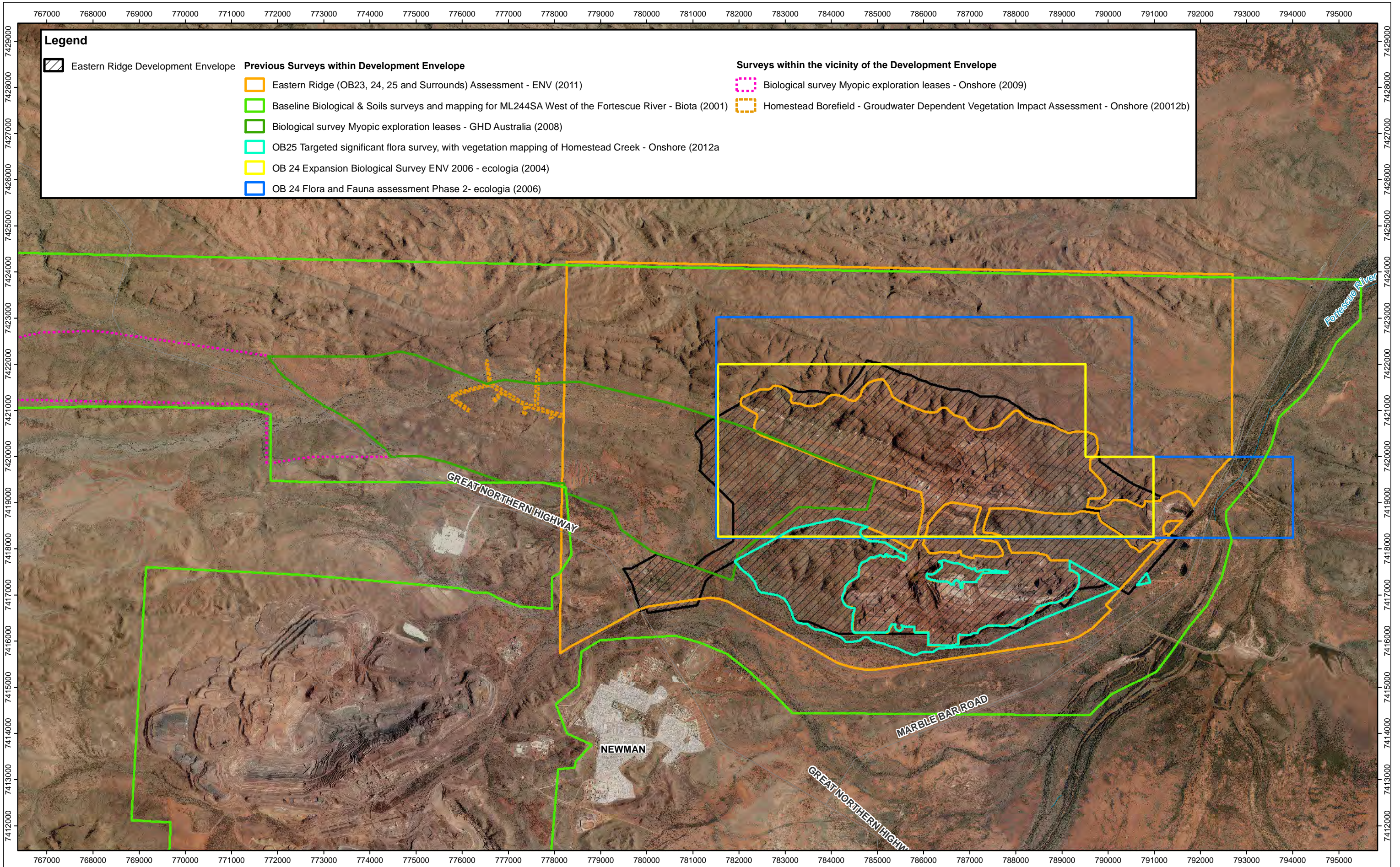
The Department of Agriculture has conducted inventory and condition surveys of the Pilbara (van Vreeswyk *et al.* 2004) using an integrated survey method involving the land system approach to rangeland description evaluation. The primary objective of the surveys was to provide comprehensive descriptions and mapping of the biophysical resources of the region as well as an evaluation on the condition of soils and vegetation. The mapping is based on patterns in topography, soils and vegetation.

A total of 102 land systems were defined in the Pilbara at a scale of 1:250,000 (van Vreeswyk *et al.* 2004), with three land systems occurring within the Development Envelope (Table 2, Figure 4). The Boolgeeda, Newman and Elimunna land systems represent 4.4 percent, 8.2 percent and 0.3 percent of the Pilbara IBRA respectively. The area within the Development Envelope is less than 0.1 percent for each of the three land systems.

Table 2 Land systems occurring within the Development Envelope (descriptions from van Vreeswyk *et al.* 2004).

Land System	Distribution in the Pilbara	Area in Development Envelope (km ²)	Area in Pilbara (km ²)	% of Land System in Development Envelope
Boolgeeda: Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands	Wide, common	1.29	7,748	0.017
Newman: Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands	Southern half, very common	7.85	14,580	0.054
Elimunna: Stony plains on basalt supporting sparse acacia and cassia shrublands and patchy tussock grasslands.	Central east and south, common	0.31	617	0.050





Legend











 Eastern Ridge Development Envelope	Previous Surveys within Development Envelope	Surveys within the vicinity of the Development Envelope
	 Eastern Ridge (OB23, 24, 25 and Surrounds) Assessment - ENV (2011)	 Biological survey Myopic exploration leases - Onshore (2009)
	 Baseline Biological & Soils surveys and mapping for ML244SA West of the Fortescue River - Biota (2001)	 Homestead Borefield - Groudwater Dependent Vegetation Impact Assessment - Onshore (20012b)
	 Biological survey Myopic exploration leases - GHD Australia (2008)	
	 OB25 Targeted significant flora survey, with vegetation mapping of Homestead Creek - Onshore (2012a)	
	 OB 24 Expansion Biological Survey ENV 2006 - ecologia (2004)	
	 OB 24 Flora and Fauna assessment Phase 2- ecologia (2006)	

	Figure: 3	Date: 22/05/2015
	Sheet Size: A3	Status: DRAFT
Drawn by: GSM	Requested by: GSM	GSM Reference: Eastern Ridge Survey_areas

N



0 1,000 2,000 3,000 4,000

Meters
1:75,000

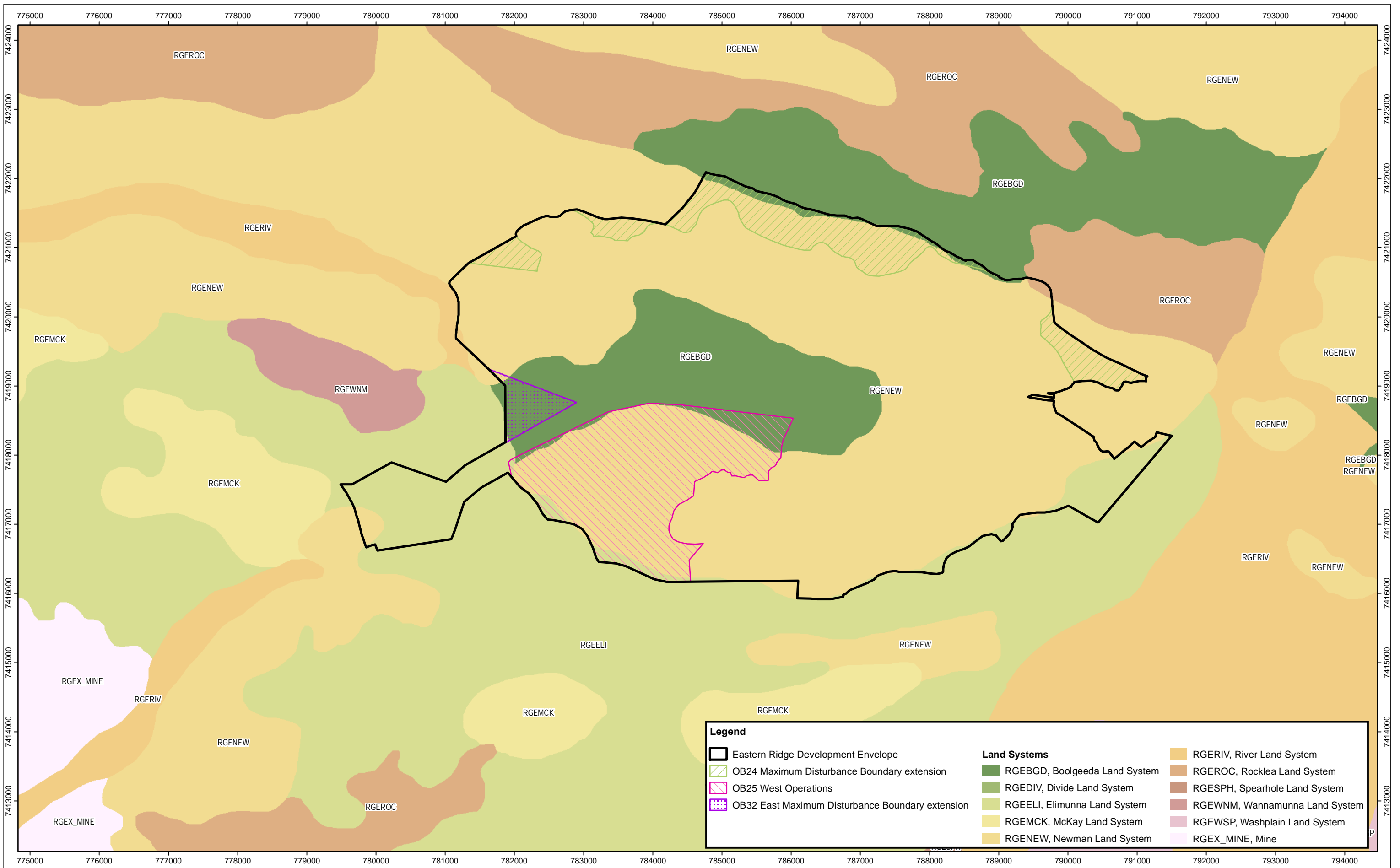
Datum: GDA94
Projection: MGA Zone 50

Previous flora and vegetation surveys completed within, and adjacent to, the Development Envelope

FIGURE 3

GRIFFIN
SPATIAL & MAPPING

PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213



Legend

Eastern Ridge Development Envelope	Land Systems	RGERIV, River Land System
OB24 Maximum Disturbance Boundary extension	RGEV, Divide Land System	RGEROC, Rocklea Land System
OB25 West Operations	RGEELI, Elimunna Land System	RGESPH, Spearhole Land System
OB32 East Maximum Disturbance Boundary extension	RGEMCK, McKay Land System	RGEWNM, Wannamunna Land System
	RGENEW, Newman Land System	RGEWSP, Washplain Land System
		RGEX_MINE, Mine

Figure:	4	Date:	22/05/2015
Sheet Size:	A3	Status:	DRAFT
Drawn by:	GSM	Requested by:	GSM
GSM Reference		Eastern_ridge_Land	

N

0 500 1,000 1,500 2,000 2,500
Meters
1:50,000
Datum: GDA94
Projection: MGA Zone 50

Land systems occurring within the Development Envelope (descriptions from Van Vreeswyk et al. 2004)

FIGURE 4

GRIFFIN
SPATIAL & MAPPING
PO Box 7215
Eaton WA 6232
admin@griffinspatial.com.au
+61 8 9725 3213

3 SURVEY METHODOLOGY

3.1 Legislation and Guidance Statement

The 12 previous flora and vegetation surveys completed within the Development Envelope and surrounds were carried out in a manner that was compliant with Environmental Protection Authority (EPA) requirements for the environmental surveying and reporting of flora and vegetation in Western Australia:

- Environmental Protection of Native Vegetation in Western Australia: Clearing of Native Vegetation with Particular Reference to Agricultural Areas. Position Statement No. 2 (EPA 2000);
- Terrestrial Biological Surveys as an Element of Environmental Protection. Position Statement No. 3 (EPA 2002); and
- EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No. 51 (EPA 2004).

The most recent surveys were also conducted in accordance with BHP Billiton Iron Ore's Guidance for Flora and Vegetation Surveys in the Pilbara (BHP Billiton Iron Ore 2010).

3.2 Desktop Searches

Desktop searches of three databases were completed for information relating to significant flora (DPaW 2014a, see Appendix 1), TECs and PECs (DPaW 2014b) previously collected or described within, or in close proximity to, the Development Envelope. The search was extended beyond the immediate envelope to place flora values into a local and regional context. The search co-ordinate used was a 50 km radius around the point location 782618 mE 7419843 mN (50K GDA94). The State database search investigated three DPaW databases (DPaW 2014a):

1. The Threatened (Declared Rare) Flora Database;
2. The Threatened (Declared Rare) and Priority Flora List; and
3. The Western Australian Herbarium (WAH) Specimen Database for Priority flora species opportunistically collected in the area of interest.

A search of the EPBC Act Protected Matters database was undertaken (Department of Environment, DoE) 2015, see Appendix 2), as well as a search of the International Union for Conservation of Nature (IUCN) database (IUCN 2015). A comprehensive literature review of surveys previously completed within or in close proximity to the tenement boundary was also undertaken.

3.3 Field Survey Methodology

3.3.1 Timing and Personnel

There are 12 flora and vegetation surveys that have been completed within, or partly within, the Development Envelope between June 1995 and June 2013, with survey effort spread across a variety of seasons (Figure 3, Table 3). The surveys are described further in Section 3.

The most recent Level 2 flora and vegetation survey encompassing the entire Development Envelope was completed by ENV Australia (2012) under good to average seasonal conditions and included a review of all previous survey data. Onshore Environmental (2011, 2013) recently completed comprehensive targeted significant flora surveys at OB25 and OB24.

Table 3 Summary of previous flora and vegetation surveys completed within, or partly within, the Development Envelope.

Report	Survey Field Date	Survey Intensity	Area Covered	OB25 West	OB24 North Ext.	OB32 East Ext.
Onshore Environmental (2013a) Targeted Flora and Vegetation Survey Orebody 24	5-14 th June 2013	Targeted significant flora survey	Northern part of the DE		✓	
Onshore Environmental (2012) OB25 Targeted Significant Flora Survey and Vegetation Mapping of Homestead Creek	4 th -8 th July 2012 23 rd July - 1 st August 2012	Targeted significant flora survey	Southern section of the DE, includes proposed new OB25 West area	✓		
ENV Australia (2012) Eastern Ridge (OB23/24/25) Flora and Vegetation Report	8-19 th April 2011 29-31 st July 2011	51 quadrats (22 quadrats in DE)	Covered the entire DE and extended in to surrounding areas. Operational areas of OB23, OB24 and OB25 excluded.	✓	✓	✓
ENV Australia (2009a) Orebody 25 to Newman Flora and Vegetation Assessment	14-17 th July 2009	33 quadrats (13 quadrats in DE)	Southern parts of the DE	✓		
GHD (2008) Biological survey of Myopic exploration leases	26 th May - 4 th June 2008	119 quadrats (17 within DE)	Western part of the development area. Covers OB32 and the proposed extension			✓
ENV Australia (2006a) OB24 Flora and Fauna Assessment Phase II	16 th March - 10 th April 2006	48 quadrats (predominately within the DE)	Covers the northern extent of the DE, including the extension areas for OB32 and OB24. Also covers a small area in the north of OB25 west. Extends to the north of the DE	✓	✓	✓
Ecologia Environment (2005) Orebody 25 Biological Review and Environmental Impact Assessment	No field survey component	Desktop Survey	Desktop review of OB25	✓		
Ecologia Environmental (2004a) Orebodies 18, 23 and 25 Flora and Fauna Review	No field survey component	Desktop survey	Within the DE and surrounds	✓	✓	✓

Report	Survey Field Date	Survey Intensity	Area Covered	OB25 West	OB24 North Ext.	OB32 East Ext.
Ecologia Environmental (2004b) OB24 Expansion Biological Survey	14 th -27 th May 2004 5 th -9 th August 2004	50 quadrats (48 quadrats in DE)	Covers the northern extent of the DE, including the extension areas for OB32 and OB24. Also covers a small area of OB25 west	✓	✓	✓
Biota Environmental Sciences (2001) Baseline Biological and Soil Surveys and Mapping for ML244SA West of the Fortescue River	28 th September - 8 th October 2000	60 quadrats (0 quadrats in DE)	Covers the entire DE and much of the surrounding area	✓	✓	✓
BHP Billiton Iron Ore Environment Department (2000) Orebody 25 Priority Flora Species Survey	June 2000	Targeted searches	Within the southern part of the DE at OB25	✓		
Ecologia Environment (1995) Orebody 25 Biological Assessment Survey	6-15 June 1995	Targeted searches	Within the southern part of the DE at OB25	✓		

3.3.2 Sampling of Study Sites

Field surveys completed within the Development Envelope involved systematic sampling using quadrats. Although a number of different consultancy groups have completed the previous flora and vegetation surveys the methodology implemented is relatively consistent.

Quadrats were generally 50 m by 50 m in dimensions or an equivalent area (2,500 m²) along narrow associations such as minor drainage lines. This area is standard for the Pilbara bioregion. The survey of ML244SA by Biota (2001) employed different sampling methods using additional line and belt transects to provide information on cover and the shrub and tree component. In most surveys, relevé vegetation descriptions were made to increase the accuracy of vegetation mapping and at locations where conservation significant flora was recorded. Targeted searches were completed in areas supporting significant plant taxa, or within habitats where it was anticipated significant flora might occur.

The sampling sites were assessed to provide a list of the total flora occurring within the area and a description of the vegetation structure. Data collected covered a range of environmental parameters including:

- Landform and habitat;
- Aspect;
- Soil colour and soil type;
- Rock type;
- Slope (angle);
- Percentage of bare ground, logs, twigs and leaves;
- Vegetation condition;
- Disturbance (caused by fire, clearing, grazing etc.);
- Age since fire;
- Broad floristic formation;
- Vegetation association description; and
- Height and percentage ground cover provided by individual plant taxa.

Other parameters recorded for each study site were:

- Study site number and date of assessment;
- Names of the botanists undertaking the assessment;
- Location (waypoint) - GPS coordinate (GDA94) using a handheld GPS; and
- Photograph number.

3.3.3 Weed Survey and Mapping

The location of introduced weed species within the Development Envelope was identified from previous flora and vegetation surveys. Introduced weed species were recorded from formal quadrats assessed within the Development Envelope and surrounds. Opportunistic collections were also made while moving between study sites and targeted weed searches were completed in high moisture habitats, including drainage lines and floodplains.

3.3.4 Vegetation Association Mapping

Onshore Environmental has previously completed consolidated mapping of BHP Billiton Iron Ore leases including the central, eastern and mainline rail tenements of the Pilbara (Onshore Environmental 2014c). A total of 162 baseline flora and vegetation surveys commissioned by BHP Billiton Iron Ore at its Pilbara based

tenements between 2004 and 2013 were reviewed by Onshore Environmental as part of the consolidation of regional vegetation mapping.

Numerous previous baseline flora and vegetation surveys intersecting the Development Envelope have included a vegetation mapping component. During the consolidated mapping project, Onshore Environmental rated the integrity of vegetation association mapping datasets overlapping the Development Envelope and selected the most recent dataset (ENV Australia 2012) for incorporation into the consolidated database as 'fine scale' mapping. The consolidated mapping dataset (Onshore Environmental 2014c) was utilised for the Eastern Ridge proposal.

Description of vegetation structure follows the height, life form and density classes of Specht (1970) as modified by Alpin (1979) and Trudgen (2009) (see Appendix 3). This is largely a structural classification suitable for broader scale mapping, but taking all ecologically significant strata into account. Vegetation condition for each of the sampling sites was determined using a recognised rating scale (based on Keighery 1994, see Appendix 4).

3.3.5 Field Survey Constraints

The EPA Guidance Statement No. 51 for Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004) list twelve potential constraints that field surveys may encounter. These constraints are addressed in Table 4.

Table 4 Relevance of constraints, as identified by EPA (2004), to the flora and vegetation survey.

Constraint	Relevance
Scope	The scope of work for baseline flora and vegetation surveys was established by BHP Billiton Iron Ore in compliance with relevant EPA Guidance Statements.
Proportion of flora collected and identified	Given that 12 flora and vegetation surveys have been conducted within the Development Envelope it is anticipated that a large proportion of the total flora present is likely to have been recorded. The previous surveys have been completed by five consultancies over a range of seasons extending between 1995 and 2013.
Sources of information	A total of 12 previous flora and vegetation surveys have been completed within all, or part of, the Development Envelope. Numerous additional surveys have been undertaken in close proximity, providing an extensive local database.
The proportion of the task achieved and further work which might be needed	There has been a high level of survey intensity over an extended period (1995 to 2013) within and surrounding the Development Envelope. All required tasks relating to compliance with Level 2 flora and vegetation survey have been achieved and there are no recommendations for any further survey work.
Timing / weather / season / cycle	A total of 12 flora and vegetation surveys have been completed at different times of the year between 1995 and 2013. Five of these surveys were completed under good seasonal conditions.
Disturbances, e.g. fire, flood	Minor disturbances related to fire, mine exploration and grazing by domestic stock were noted within the tenement boundary, but did not impact on survey results.
Intensity	Numerous previous surveys have been completed at survey intensity that is required for the Pilbara bioregion, with vegetation mapping completed at a scale of 1:20,000. Targeted significant flora surveys were completed at OB25 in July 2012 (Onshore Environmental 2012) and OB24 in June 2013 (Onshore Environmental 2013a).

Constraint	Relevance
Completeness	All required tasks associated with a multi-season Level 2 flora and vegetation survey have been completed within the Development Envelope.
Resources	Appropriate resources have been applied to the baseline and targeted flora and vegetation surveys and there were no limitations to survey outcomes identified.
Access problems	The entire Development Envelope is accessible on foot walking from established tracks.
Availability of contextual information	A total of 23 flora and vegetation surveys have previously been completed within a 25 km radius of the Development Envelope, with 12 surveys occurring all or partly within the Development Envelope, providing an extensive local database.
Experience levels	No constraints relating to the experience of personnel were identified from previous surveys of the Development Envelope.

3.3.6 Assessment of Conservation Significance

The conservation significance of flora and ecological communities are classified on a Commonwealth, State and Local level on the basis of various Acts and Agreements (EPA Guidance Statement No. 51, EPA 2004), including:

Commonwealth Level:

- EPBC Act: DoE lists Threatened Flora and Ecological Communities, which are determined by the Threatened Species Scientific Committee according to criteria set out in the Act. The Act lists flora that are considered to be of conservation significance under one of six categories (Appendix 2).

State Level:

- WC Act: At a State level native flora species are protected under the WC Act - Wildlife Conservation (Rare Flora) Notice. A number of plant species are assigned an additional level of conservation significance based on a limited number of known populations and the perceived threats to these locations. Species of the highest conservation significance are gazetted Threatened Flora (T) under subsection 2 of section 23F of the Act. It is an offence to take or damage Threatened flora without Ministerial approval. Section 23F of the Act defines 'to take' as "to gather, pick, cut, pull up, destroy, dig up, remove or injure the flora or to cause or permit the same to be done by any means".
- DPaW Priority list: DPaW produces a list of Priority species and ecological communities (PECs) that have not been assigned statutory protection under the WC Act. Priority Flora are under consideration for declaration as 'Rare Flora', classified as in urgent need of further survey (Priority One to Three), require monitoring every 5-10 years (Priority Four) or require a specific conservation program to prevent the taxon becoming threatened within five years (Priority 5), see Appendix 1. The list of PECs identifies those that need further investigation before nomination for TEC status.

Local Level:

- Species may be considered of local conservation significance because of their patterns of distribution and abundance. Although not formally protected by legislation, such species are acknowledged to be in decline as a result of threatening processes, primarily habitat loss through land clearing.

4 SUMMARY OF BASELINE ASSESSMENT

4.1 Desktop Review

4.1.1 Previous Flora Surveys

There are at least 23 previous flora and vegetation surveys that have been completed within a 25 km radius of the Development Envelope, including 12 surveys that together provide entire coverage of the Development Envelope (Figure 3). Table 5 summarises findings of the literature review, tabulating survey timing, survey intensity, and the main results including total flora and presence of conservation significant flora and introduced weeds.

Flora and vegetation values within the Development Envelope were determined using the 12 baseline and targeted flora and vegetation surveys that intersect the Development Envelope.

Table 5 Summary of results from previous flora and vegetation surveys within, or in close proximity to, the Development Envelope.

Report	Proximity to Development Envelope	Survey Timing, Type and Conditions	Vegetation Associations and Landform	Floristics	Significant Flora
<i>Surveys wholly or partly within the Development Envelope (DE)</i>					
Onshore Environmental (2013a) Targeted Flora and Vegetation Survey Orebody 24	Northern part of the DE	5-14 th June 2013 Targeted Survey Fair seasonal conditions (study area was also impacted by fire)	Not assessed	Not assessed	<i>Goodenia nuda</i> (Priority 4)
Onshore Environmental (2012) OB25 Targeted Significant Flora Survey and Vegetation Mapping of Homestead Creek	Southern parts of the DE	4 th -8 th July 2012, 23 rd July - 1 st August 2012 Targeted survey and vegetation mapping Average seasonal conditions	7 vegetation associations	Not assessed	<i>Eremophila magnifica</i> subsp. <i>velutina</i> (Priority 3)
ENV Australia (2012) Eastern Ridge (OB 23/24/25) Flora and Vegetation Report	Survey area overlaps the entire DE, with the exception of excluded operational areas.	8-19 th April, 29-31 st July 2011 Good-average seasonal conditions	13 vegetation associations	422 taxa from 52 families and 170 genera 18 weed species: * <i>Cenchrus ciliaris</i> , * <i>Cenchrus setiger</i> , * <i>Acetosa vesicaria</i> , * <i>Aerva javanica</i> , * <i>Vachellia farnesiana</i> , * <i>Tamarix aphylla</i> , * <i>Cynodon dactylon</i> , * <i>Lactuca serriola</i> , * <i>Malvastrum americanum</i> , * <i>Solanum nigrum</i> , * <i>Symphotrichum squamatum</i> , * <i>Echinochloa colona</i> , * <i>Agave americana</i> , * <i>Cyperus involucreatus</i> , * <i>Setaria verticillata</i> , * <i>Bidens bipinnata</i> , * <i>Cucumis melo</i> subsp. <i>agrestis</i> , * <i>Flaveria trinervia</i>	<i>Calotis latiuscula</i> (Priority 3), <i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (Priority 1) ¹ , <i>Goodenia nuda</i> (Priority 4), <i>Eremophila magnifica</i> subsp. <i>velutina</i> (Priority 3), <i>Isotropis parviflora</i> (Priority 2)

¹ Confirmed to be *Aristida burbridgeae* (not threatened or Priority flora) by Onshore Environmental (2012).

Report	Proximity to Development Envelope	Survey Timing, Type and Conditions	Vegetation Associations and Landform	Floristics	Significant Flora
ENV Australia (2009a) Orebody 25 to Newman Flora and Vegetation Assessment	Corridor extending from Mt Whaleback to OB25. Several locations within the southern part of the study area	14-17 th July 2009 Poor seasonal conditions		Seven weed species: * <i>Acetosa vesicaria</i> , * <i>Bidens bipinnata</i> , * <i>Cenchrus ciliaris</i> , * <i>Cynodon dactylon</i> , * <i>Enteropogon ramosus</i> , * <i>Malvastrum americanum</i> , * <i>Setaria verticillata</i>	<i>Rostellularia adscendens</i> var. ? <i>latifolia</i> (Could not be identified to variant level, possibly a Priority 3 species)
GHD (2008) Report for Myopic Project Area, Newman	Overlaps the western parts of the DE including OB32 and extension areas.	26 th May – 4 th June 2008 Poor seasonal conditions	9 vegetation associations	321 taxa from 52 families Thirteen weed species: * <i>Cenchrus ciliaris</i> , * <i>Cynodon dactylon</i> , * <i>Vachellia farnesiana</i> , * <i>Malvastrum americanum</i> , * <i>Citrullus sp.</i> , * <i>Merremia dissecta</i> , * <i>Cylindropuntia sp.</i> , * <i>Aerva javanica</i> , ?* <i>Arundo donax</i> , * <i>Cenchrus setaceus</i> , * <i>Acetosa vesicaria</i> , * <i>Tamarix aphylla</i> , * <i>Tribulus terrestris</i>	None
ENV Australia (2006a) OB24 Flora and Fauna Assessment Phase II	Overlaps the northern half of the DE and extends further north	16 th March - 10 th April 2006 Level 2 baseline Good seasonal conditions	6 vegetation associations	413 taxa from 53 families and 156 genera Eight weed species: * <i>Acetosa vesicaria</i> , * <i>Bidens bipinnata</i> , * <i>Cenchrus ciliaris</i> , * <i>Cynodon dactylon</i> , * <i>Echinochloa colona</i> , * <i>Malvastrum americanum</i> , * <i>Setaria verticillata</i> , * <i>Solanum nigrum</i>	<i>Eremophila magnifica</i> subsp. <i>velutina</i> (Priority 3), <i>Gymnanthera cunninghamii</i> (Priority 3)
Ecologia Environment (2005) Orebody 25 Biological Review and Environmental Impact Assessment	Desktop review of OB25, within the DE	September 2005 Desktop survey	12 vegetation associations	Three weed species: * <i>Acetosa vesicaria</i> , * <i>Cenchrus ciliaris</i> , * <i>Sonchus oleraceus</i>	<i>Eremophila magnifica</i> ²

² The subspecies is not provided in the report and could be either *Eremophila magnifica* subsp. *magnifica* (Priority 4) or *Eremophila magnifica* subsp. *velutina* (Priority 3)

Report	Proximity to Development Envelope	Survey Timing, Type and Conditions	Vegetation Associations and Landform	Floristics	Significant Flora
Ecologia Environmental (2004a) Orebodies 18, 23 and 25 Flora and Fauna Review	Within the DE Review report only (no field survey work)	May 2004 Desktop survey	11 vegetation associations	Five weed species; * <i>Sonchus oleraceus</i> (OB18, OB 23, OB 25), * <i>Acetosa vesicaria</i> (OB 18,OB 23, OB 25), * <i>Bidens bipinnata</i> (OB18), * <i>Cenchrus ciliaris</i> (OB23), * <i>Cenchrus echinatus</i> (OB23)	<i>Rhodanthe frenchii</i> ³ (Priority 2 from OB18), <i>Eremophila magnifica</i> ⁸ (from OB25)
Ecologia Environmental (2004b) OB24 Expansion Biological Survey	Overlaps the northern half of the DE	14 th -27 th May 2004, 5 th -9 th August 2004 Level 2 baseline Good seasonal conditions	6 vegetation associations based on topographic features	258 taxa from 45 families and 108 genera Four weed species: * <i>Acetosa vesicaria</i> , * <i>Bidens bipinnata</i> , * <i>Cenchrus ciliaris</i> , * <i>Malvastrum americanum</i>	<i>Isotropis winnecke</i> ⁴ (Priority 1)
Biota Environmental Sciences (2001) Baseline Biological and Soil Surveys and Mapping for ML244SA West of the Fortescue River	Covers the entire ML244SA mining lease of which the DE forms a small area (broad scale)	28th September - 8th October 2000 Level 2 baseline Poor seasonal conditions	27 vegetation associations	380 taxa from 98 families and 168 genera Fourteen weed species: * <i>Acetosa vesicaria</i> , * <i>Cenchrus ciliaris</i> , * <i>Cenchrus echinatus</i> (OB23), * <i>Cenchrus setiger</i> (Whaleback), * <i>Cynodon dactylon</i> , * <i>Sisymbrium erysimoides</i> , * <i>Malvastrum americanum</i> (OB30, OB35, OB23, Whaleback), * <i>Solanum nigrum</i> (Whaleback), * <i>Argemone ochroleuca</i> (Whaleback), * <i>Bidens bipinnata</i> (OB30/35, Whaleback), * <i>Conyza bonariensis</i> (Whaleback), * <i>Hypochaeris glabra</i> (Whaleback), * <i>Helichrysum luteoalbum</i> , * <i>Sonchus oleraceus</i> (OB23, Whaleback, OB25)	<i>Eremophila magnifica</i> ⁵ , <i>Lepidium catapycnon</i> (Threatened)

³ Likely to be a mis-identification (not previously recorded at Eastern Ridge or surrounds)

⁴ Now confirmed to be *Isotropis parviflora* (Priority 2)

⁵ subspecies not recorded, could be either *Eremophila magnifica* subsp. *magnifica* (Priority 4) or *Eremophila magnifica* subsp. *velutina* (Priority 3)

Report	Proximity to Development Envelope	Survey Timing, Type and Conditions	Vegetation Associations and Landform	Floristics	Significant Flora
BHP Billiton Iron Ore Environment Department (2000) Orebody 25 Priority Flora Species Survey	Within the DE Targeted survey of previous significant flora locations around OB25	June 2000 Targeted survey Good seasonal conditions	Not assessed	One weed species recorded; * <i>Acetosa vesicaria</i>	<i>Eremophila magnifica</i> ⁶
Ecologia Environment (1995) Orebody 25 Biological Assessment Survey	Within the southern part of the DE	6 th -15 th June 1995 Level 2 baseline Good seasonal conditions	4 vegetation associations	211 taxa from 41 families and 93 genera	<i>Eremophila magnifica</i> ⁸
<i>Surveys adjacent to the Development Envelope (DE) at Eastern Ridge</i>					
BHP Billiton Iron Ore (2011) OB25 Gatehouse Vegetation and Flora Survey	2 km west	5 th January 2011	3 vegetation associations	87 taxa and 22 families Seven weed species: * <i>Cenchrus ciliaris</i> , * <i>Cenchrus setiger</i> , * <i>Malvastrum americanum</i> , * <i>Vachellia farnesiana</i> , * <i>Cucumis melo</i> subsp. <i>agrestis</i> , * <i>Conyza bonariensis</i> , * <i>Symphotrichum squamatum</i>	<i>Rhagodia</i> sp. Hamersely (M. Trudgen 17794) (Priority 3) ⁷
Onshore Environmental (2011) Targeted Survey for <i>Rhagodia</i> sp. Hamersley at OB25 Gatehouse	3 km south-west	6 th March 2011 Targeted survey Good seasonal conditions	Not assessed	Not assessed	None

⁶ The subspecies is not provided in the report and could be either *Eremophila magnifica* subsp. *magnifica* (Priority 4) or *Eremophila magnifica* subsp. *velutina* (Priority 3)

⁷ Confirmed to be *Rhagodia eremaea* (not threatened or priority) by Onshore Environmental (2011)

Report	Proximity to Development Envelope	Survey Timing, Type and Conditions	Vegetation Associations and Landform	Floristics	Significant Flora
Onshore Environmental (2009) Biological Survey Myopic Exploration Leases	West of the Great Northern Highway	8 th -14 th June 2009 15-18 th June 2009 Level 2 baseline Good seasonal conditions	17 vegetation associations	274 taxa from 48 families and 123 genera. Eight weed species: * <i>Bidens bipinnata</i> , * <i>Cenchrus ciliaris</i> , * <i>Cenchrus setiger</i> , * <i>Malvastrum americanum</i> , * <i>Setaria verticillata</i> , * <i>Solanum nigrum</i> , * <i>Stylosanthes hamata</i> , * <i>Tribulus terrestris</i>	<i>Aristida lazaridis</i> (Priority 2), <i>Goodenia nuda</i> (Priority 4), <i>Lepidium catapycnon</i> (Threatened)
ENV Australia (2007) RGP4 Orebody 25 Rail Spur Siding Declared Rare and Priority Flora Survey	Adjacent to the southern boundry DE	27 th November - 1 st December 2006 Targeted survey Poor seasonal conditions	Not assessed	One weed species: * <i>Cenchrus ciliaris</i>	None
Ecologia (2004c) Eastern Ophthalmia Range Biological Survey	~3km east, extends east along the Ophthalmia Range	18 th March-7 th April 2004 Level 2 baseline Good seasonal conditions	8 vegetation associations	248 taxa from 41 families and 94 genera. The most speciose families were Poaceae (33 taxa), Mimosaceae (27 taxa) and Malvaceae (22 taxa). Two weed species: * <i>Cenchrus ciliaris</i> , * <i>Bidens bipinnata</i>	<i>Isotropis winnecke</i> ⁸ (Priority 1)
Ecologia Environment (1998) Orebody 23 Extension Biological Assessment Survey	Adjacent to the DE to the east	17-22 nd June 1997 Level 2 baseline Excellent seasonal conditions	7 vegetation associations	304 taxa from 47 families and 128 genera Four weed species recorded; * <i>Acetosa vesicaria</i> , * <i>Cenchrus ciliaris</i> , * <i>Cenchrus echinatus</i> , * <i>Sonchus oleraceus</i>	None

⁸ Now confirmed to be *Isotropis parviflora* (Priority 2)

Report	Proximity to Development Envelope	Survey Timing, Type and Conditions	Vegetation Associations and Landform	Floristics	Significant Flora
<i>Surveys at Whaleback, OB29, OB30 and OB35</i>					
Onshore Environmental (2014a) Mt Whaleback OB29/30/25 Targeted Flora Survey Assessment	~5km west-south west	16 th -23 rd February 2014 Targeted survey Excellent seasonal conditions	Not assessed	Not assessed	<i>Lepidium catapycnon</i> (Threatened), <i>Calotis latiuscula</i> (Priority 3), <i>Gymnanthera cunninghamii</i> (Priority 3), <i>Eremophila magnifica</i> subsp. <i>magnifica</i> (Priority 4), <i>Goodenia nuda</i> (Priority 4)
Onshore Environmental (2014b) Western Ridge Flora and Vegetation and Vertebrate Fauna Survey	~11km south west	21 st -24 th June Level 2 baseline Good seasonal conditions	17 vegetation associations	194 plant taxa from 34 families and 89 genera Seven introduced weed species: * <i>Aerva javanica</i> , * <i>Bidens bipinnata</i> , * <i>Cenchrus ciliaris</i> , * <i>Cenchrus setiger</i> , * <i>Malvastrum americanum</i> , * <i>Setaria verticillata</i> , * <i>Vachellia farnesiana</i>	<i>Aristida jerichoensis</i> var. <i>subspinulifera</i> (Priority 3), <i>Calotis latiuscula</i> (Priority 3)
Onshore Environmental and Biologic Environmental Surveys (2009) Flora and Vegetation Survey and Fauna Mt Whaleback Mine Site	~8 km south west	22 nd -25 th June 2009 Level 2 baseline Good seasonal conditions	9 vegetation associations	201 plant taxa from 40 families and 100 genera 15 weed species: * <i>Aerva javanica</i> , * <i>Argemone ochroleuca</i> , * <i>Bidens bipinnata</i> , * <i>Cenchrus ciliaris</i> , * <i>Cenchrus setigera</i> , * <i>Chloris barbata</i> , * <i>Cucumis melo</i> , * <i>Cynodon dactylon</i> , * <i>Echinochloa colona</i> , * <i>Malvastrum americanum</i> , * <i>Setaria verticillata</i> , * <i>Sisymbrium orientale</i> , * <i>Solanum nigrum</i> , * <i>Sonchus oleraceus</i> , * <i>Vachellia farnesiana</i>	None

Report	Proximity to Development Envelope	Survey Timing, Type and Conditions	Vegetation Associations and Landform	Floristics	Significant Flora
ENV Australia (2006b) Mt Whaleback Flora and Vegetation Assessment - Phase 3 Summary Report	~8 km south west	2-13 th August 2006, 20 th September 2006 Level 2 baseline Average seasonal conditions	9 vegetation associations	240 taxa Seven weed species: * <i>Aerva javanica</i> , * <i>Acetosa vesicaria</i> , * <i>Bidens bipinnata</i> , * <i>Cenchrus ciliaris</i> , * <i>Malvastrum americanum</i> , * <i>Solanum nigrum</i> , * <i>Librium orientale</i>	<i>Lepidium catapycnon</i> (Threatened)

4.1.2 Threatened Flora listed under the IUCN Red List database

There were no Threatened Flora records identified from a search of the International Union for Conservation of Nature (IUCN) database (IUCN 2015).

4.1.3 Threatened Flora listed under the WA Wildlife Conservation (Rare Flora) Notice

The DPaW search identified one Threatened Flora taxon occurring within a 50 km radius of the Development Envelope, *Lepidium catapycnon* (Table 6).

4.1.4 Priority Flora recognised by the DpaW

The DPaW database search (DPaW 2014a) identified 21 Priority flora taxa as potentially occurring within a 50 km search radius of the Development Envelope. Priority flora taxa recorded during the database search are listed in Table 6, along with a general habitat description and the likelihood of habitat occurring within the Development Envelope.

Table 6 Significant flora taxa previously recorded from the Newman area; taken from Federal and State database searches, literature review and local knowledge.

Taxon	Cons. Code	Life Form	Habitat Preference	Suitable Habitat Present	Likelihood in the Development Envelope
<i>Acacia bromilowiana</i>	P4	Perennial	Red skeletal stony loam, laterite, banded ironstone, basalt. Rocky hills, breakaways, scree slopes, gorges, creek beds.	Yes	Possible
<i>Acacia subtiliformis</i>	P3	Perennial	Rocky calcrete plateaus.	No	Unlikely
<i>Amaranthus centralis</i>	P3	Annual	River banks. Sand plains. Mulga woodlands.	No	Unlikely
<i>Aristida jerichoensis</i> var. <i>subspinulifera</i>	P3	Perennial	Hard pan plains.	No	Unlikely
<i>Calotis latiuscula</i>	P3	Perennial	Sand, loam. Rocky hillsides, floodplains, rocky creeks or river beds.	Yes	Likely
<i>Crotalaria smithiana</i>	P3	Annual	Regeneration site on floodplain.	No	Unlikely
<i>Dampiera metallorum</i>	P3	Perennial	Skeletal red-brown gravelly soil over banded ironstone. Steep slopes, summits of hills.	No	Unlikely
<i>Eremophila magnifica</i> subsp. <i>magnifica</i>	P4	Perennial	Skeletal soils over ironstone. Rocky screes.	Yes	Likely

Taxon	Cons. Code	Life Form	Habitat Preference	Suitable Habitat Present	Likelihood in the Development Envelope
<i>Eremophila magnifica</i> subsp. <i>velutina</i>	P3	Perennial	Skeletal soils over ironstone. Summits.	Yes	Likely
<i>Eremophila rigida</i>	P3	Perennial	Hard pan plains.	No	Unlikely
<i>Eremophila</i> sp. West Angelas (S van Leeuwen 4068)	P1	Perennial	High in the landscape. Rocky hill summits.	No	Unlikely
<i>Euphorbia inappendiculata</i> var. <i>inappendiculata</i>	P2	Annual	Broken rocky scree slopes.	Yes	Possible
<i>Goodenia</i> sp. East Pilbara (A.A. Mitchell PRP 727)	P3	Biennial	Low undulating plain, swampy plains.	No	Unlikely
<i>Goodenia nuda</i>	P4	Annual	Plains and floodplains.	Yes	Likely
<i>Gymnanthera cunninghamii</i>	P3	Perennial	Sandy soils.	Yes	Possible
<i>Indigofera</i> sp. Gilesii (M.E. Trudgen 15869)	P3	Perennial	Pebbly loam amongst boulders and outcrops. Hills.	Yes	Possible
<i>Isotropis parviflora</i>	P2	Annual	Rocky hills.	Yes	Likely
<i>Lepidium catapychnon</i>	T	Perennial	Skeletal soils. Hillsides.	Yes	Possible
<i>Oxalis</i> sp. Pilbara (M. E Trudgen 12725)	P2	Annual	Gullies. Base of cliffs. Shady areas associated with high ironstone cliffs.	No	Unlikely
<i>Rhagodia</i> sp. Hamersley (M. Trudgen 17794)	P3	Perennial	Clay plains. Mulga woodlands.	No	Unlikely
<i>Rostellularia adscendens</i> var. <i>latifolia</i> (R.Br.) R.M.Barker	P3	Annual	Ironstone soils. Near creeks, rocky hills.	Yes	Possible
<i>Themeda</i> sp. Hamersley Station (M.E. Trudgen 11431)	P3	Perennial	Clay pan, grass plain.	No	Unlikely

Likely - suitable habitat, close (<10 km) records and/or field survey completed in sub-optimal season, suggest species is likely to occur

Possible - sub-optimal habitat, close (<10 km) records and/or field survey completed in sub-optimal season, suggests species possibly occurs

Unlikely - lack of suitable habitat, no records (<50 km) and/or field survey completed in optimal season, suggest species is unlikely to occur

4.1.5 TECs listed under State and Federal Legislation

A search of the DPaW communities database (DPaW 2014b) confirmed there was one TEC record within a 50 km radius of the Development Envelope; the Ethel Gorge Aquifer Stygobiont Community TEC (Figure 5). It is listed as Endangered under the EPBC Act Protected Matters Database (DoE 2014). The TEC is a subterranean community and has no relationship with flora and vegetation and will not be discussed further.

4.1.6 PECs recognised by DpaW

A search of the State communities database (DPaW 2014c) confirmed that one PEC was located approximately 40 km north of the Development Envelope (Figure 5). The Priority 3iii PEC 'Vegetation of sand dunes of the Hamersley Range/Fortescue Valley' (previously 'Fortescue Valley Sand Dunes') is described as red linear sand dune communities that lie on the Divide Land system at the junction of the Hamersley Range and Fortescue Valley. A small number are vegetated with *Acacia dictyophleba* scattered tall shrubs over *Crotalaria cunninghamii*, *Trichodesma zeylanicum* var. *grandiflorum* open shrubland. They are regionally rare, small and fragile and highly susceptible to threatening processes such as weed invasion, especially buffel grass, and erosion (DPaW 2014c). The PEC was not recorded within the Eastern Ridge Development Envelope.

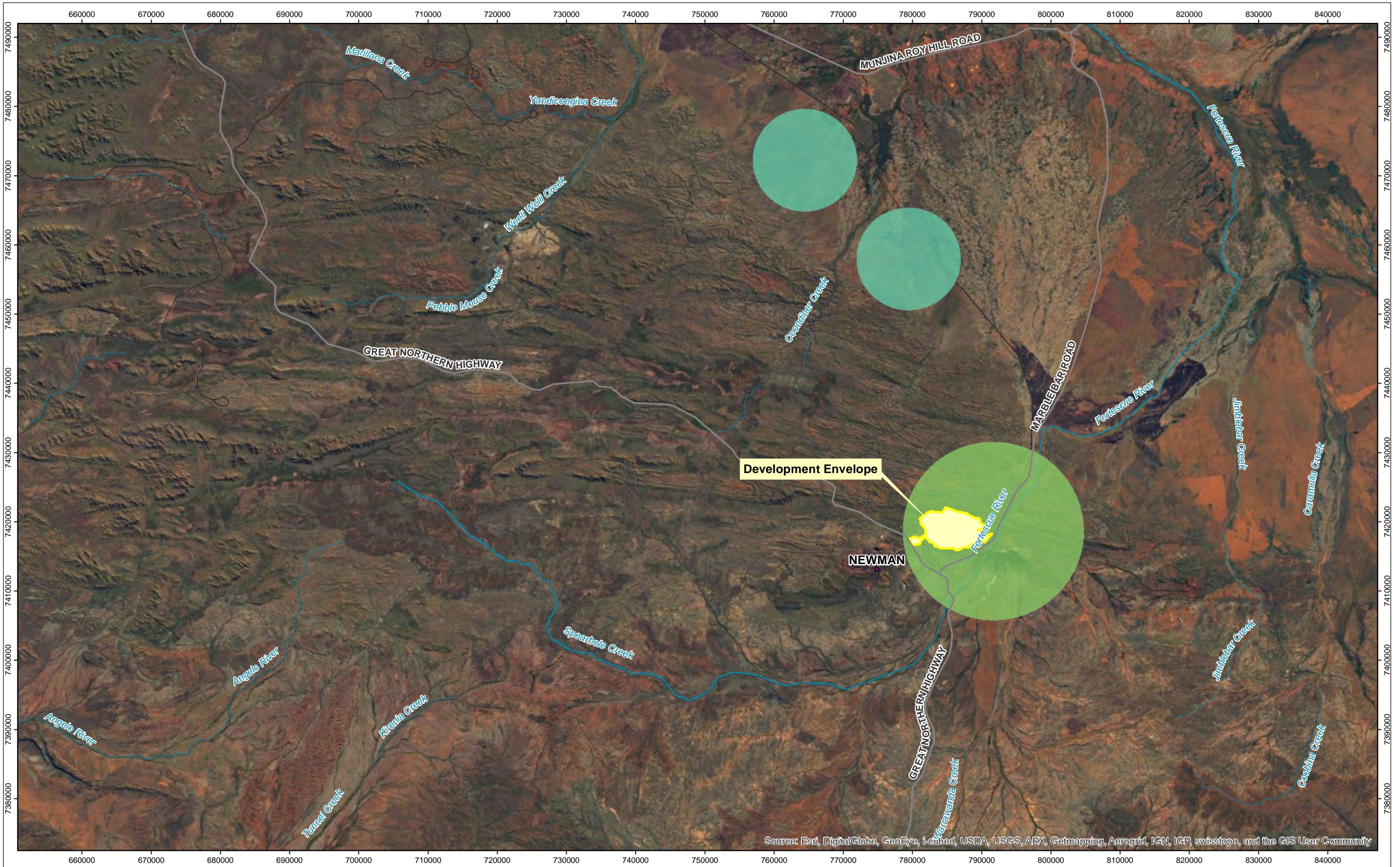


Figure: 5 **Date:** 22/05/2015
Sheet Size: A3 **Status:** FINAL
 Drawn by: GSM Requested by: DB GSM Reference: Eastern Ridge_TecPec

N

0 2.5 5 10 15 20
 Kilometers
 1:500,000
 Datum: GDA94
 Projection: MGA Zone 50

**Location of TECs and PECs within a
 50 km radius of the
 Development Envelope**

FIGURE 5

Legend

- Eastern Ridge Development Envelope
- PEC Locations**
- Ethel Gorge aquifer stygobiont community
- Fortescue Valley Sand Dunes

PO Box 7215
 Eaton WA 6232
 admin@griffinspatial.com.au
 +61 8 9725 3213

4.2 Conservation Significant Flora

4.2.1 Threatened Flora listed under the WC Act and EPBC Act

No plant taxon gazetted as Threatened Flora (T) pursuant to subsection (2) of Section 23F of the WC Act or listed under the EPBC Act was recorded from within the Development Envelope.

4.2.2 Priority Flora

Two Priority flora taxa have previously been recorded from within the Development Envelope; *Isotropis parviflora* (Priority 2) and *Eremophila magnifica* subsp. *velutina* (Priority 3). Descriptions for both species and their distribution within the Development Envelope are summarised in Table 7.

OB24 Maximum Disturbance Boundary Extension

The Priority 2 flora taxon *Isotropis parviflora* was recorded as one plant from a single location point in the northern sector of the OB24 Maximum Disturbance Boundary Extension (Ecologia 2004b, Figure 6).

Isotropis parviflora is a low perennial herb or shrub to 0.1 m in height flowering white to pink during March. It occurs on ironstone hills in the south-east Pilbara region of Western Australia, and is also known from the Tanami Desert. It is known to be a short lived disturbance species that responds to fire and is often recorded along the berms of access tracks.

Despite good seasonal conditions targeted surveys completed in July 2011 (ENV Australia 2012) and June 2012 (Onshore Environmental 2013) failed to record any evidence of *Isotropis parviflora* at the previous location point or across the wider study area. *Isotropis parviflora* is a known short lived colonising species and the plant recorded in the northern sector of the OB24 Maximum Disturbance Boundary Extension in May 2004 (Ecologia 2004b) has been outcompeted by the maturing vegetation cover.

OB32 East Maximum Disturbance Boundary Extension

No Priority flora taxa occur within the OB32 East Maximum Disturbance Boundary extension.

OB25 West Operations

The Priority 3 flora taxon *Eremophila magnifica* subsp. *velutina* occurs within the OB25 West Operations.



Eremophila magnifica subsp. *velutina* is a shrub reaching 1.5 m in height. It flowers blue between August and November and grows in skeletal soils on ironstone hill slopes and rocky screes. It has been recorded during previous baseline and targeted surveys at OB25 (BHPBIO 2000; Ecologia 1995, 2004; ENV Australia 2006, 2012). The most recent targeted field survey completed in July 2012 (Onshore Environmental 2012) recorded large numbers of *Eremophila magnifica* subsp. *velutina* plants distributed along the entire length of the range within the southern sector of the OB25 West Operations (Figure 6). Plant density at recorded waypoints ranged from one to 100 plants per 10 m². It was recorded on upper hill slopes, rocky ravines, hill crests, foot slopes, ironstone ridges, breakaways, rocky drainage lines

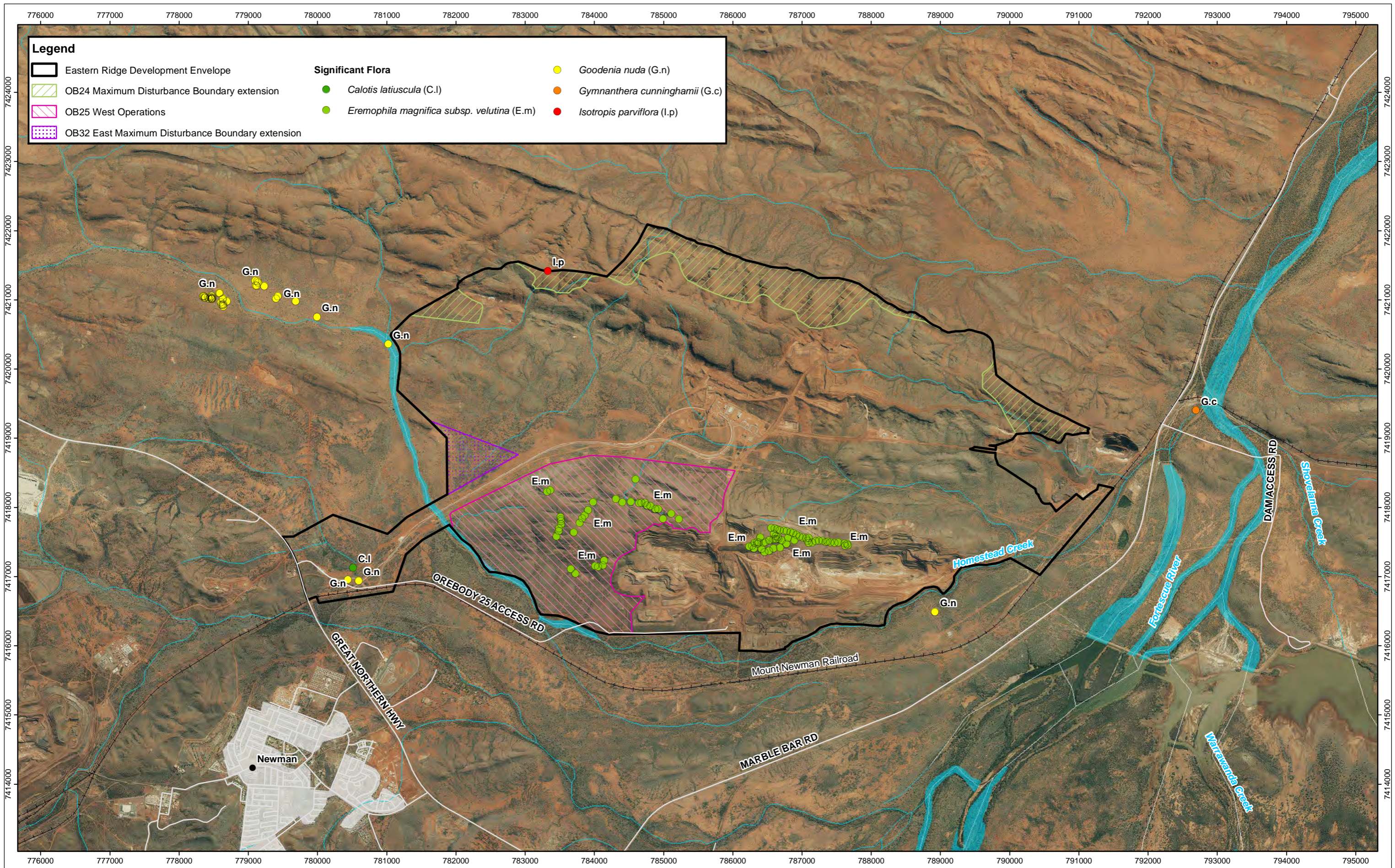
and cliff faces. It occurred across a number of vegetation associations with the characteristic species including *Triodia pungens*, *Triodia* sp. Shovelanna Hill, *Eucalyptus leucophloia* subsp. *leucophloia*, *Corymbia ferriticola*, *Hakea chordophylla*, *Acacia pruinocarpa*, *Acacia hamersleyensis*, *Petalostylis labicheoides*, *Grevillea wickhamii* and *Grevillea berryana*.

4.2.3 Flora of Interest

None of the plant taxa recorded from within the Development Envelope are determined to be species of interest or represent significant range extensions. The flora is considered to be well represented locally and regionally.

Table 7 Summary of Priority flora taxa recorded within the OB25 West Operations area and OB24 Maximum Disturbance Boundary extension.

Taxon (Common Name)	Photograph	Description	Occurrence in Development Envelope	OB25 West	OB24 MDB	OB32 East MDB
<i>Isotropis parviflora</i> (Priority 2)		Low coloniser shrub to 0.1 m in height occurring on ironstone valley slopes in the Pilbara region of Western Australia. It has white or pink flowers and flowering is in March. It is known from further south in the Rawlinson Range and has also been collected from the Hamersley Range, Hope Downs and two locations at BHP Billiton Iron Ore's Marillana (Yandi) Mine.	Recorded in 2004 as one plant from the northern fringe of the OB24 Maximum Disturbance Boundary Extension (Figure 6) (Ecologia 2004b). Follow-up targeted surveys have failed to record from same location.		✓	
<i>Eremophila magnifica</i> subsp. <i>velutina</i> (Priority 3)		Shrub reaching 1.5 m in height. Flowers blue between August and November, growing in skeletal soils on ironstone hill slopes and rocky screes. Occurs over a range of approximately 300 km extending from south-east of Newman to west of Tom Price, with two populations within this range known from Karijini National Park.	Recorded as large numbers of plants distributed along the entire length of the range within the central sector of the OB25 West Operations (Figure 6). Plant density ranges from one to 100 plants per 10 m ² . Found on upper hill slopes, rocky ravines, hill crests, foot slopes, ironstone ridges, breakaways, rocky drainage lines and cliff faces.	✓		




Legend

Eastern Ridge Development Envelope	Significant Flora	<i>Goodenia nuda</i> (G.n)
OB24 Maximum Disturbance Boundary extension	<i>Calotis latiuscula</i> (C.l)	<i>Gymnanthera cunninghamii</i> (G.c)
OB25 West Operations	<i>Eremophila magnifica subsp. velutina</i> (E.m)	<i>Isotropis parviflora</i> (I.p)
OB32 East Maximum Disturbance Boundary extension		



ON SHORE ENVIRONMENTAL CONSULTANTS
 Date: 22/05/2015
 Sheet Size: A3 Status: Final
 Drawn by: GSM Requested by: DB
 GSM Reference: Eastern Ridge Sig Flora

N



0 500 1,000 1,500
 Meters
 1:50,000
 Datum: GDA94
 Projection: MGA Zone 50

FIGURE 6
 Location of significant flora within and surrounding the Development Envelope



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

4.3 Introduced Flora

A total of 14 introduced weed species have been recorded from the Development Envelope during previous flora and vegetation surveys (Figure 7). However only two of these introduced weeds occur within expansion areas assessed as part of this referral, **Bidens bipinnata* and **Cenchrus ciliaris* (Table 8).

None of the introduced weed species are listed as a Declared Pest under the BAM Act.

4.3.1 OB24 Maximum Disturbance Boundary Extension

One introduced weed species was recorded from the OB24 Maximum Disturbance Boundary Extension, **Bidens bipinnata* (Figure 7).



4.3.2 OB32 East Maximum Disturbance Boundary Extension

One introduced weed species was recorded from the OB32 East Maximum Disturbance Boundary Extension, **Cenchrus ciliaris* (Figure 7).

4.3.3 OB25 West Operations

Two introduced weed species were recorded from the OB25 West Operations; **Cenchrus ciliaris* and **Bidens bipinnata* (Figure 7).

Table 8 Summary of introduced weed species recorded within the OB25 West Operations, OB24 Maximum Disturbance Boundary extension and OB32 East Maximum Disturbance Boundary extension.

Taxon (Common Name)	Photograph	Description	Occurrence in Development Envelope	OB25 West	OB24 MDB	OB32 East MDB
* <i>Bidens bipinnata</i> (Bipinnate Beggars Tick)		Erect annual herb that grows up to 1 m in height. Widespread in the northern parts of Western Australia from Shark Bay up to the Northern Territory border. It has three pronged barbs on its seeds so it is easily spread by livestock and other animals. In the Pilbara it is common in moist habitats such as drainage lines, flood plains and gorges, and responds vigorously following rainfall.	Recorded from one point location on the northern fringe of the OB24 Maximum Disturbance Boundary Extension and OB25 West Operations respectively.	✓	✓	
* <i>Cenchrus ciliaris</i> (Buffel Grass)		Tufted perennial grass originating from the Middle East as a fodder species by pastoralists. It grows in dense tussocks up to 1 m tall and typically occurs in monospecific stands on loamy plains and creekline levee banks. It is an aggressive colonizing species that has become well established throughout the Pilbara, Gascoyne and Murchison regions of Western Australia, and is continuing to spread in the south-west (Hussey <i>et al.</i> 1997).	Recorded from three point locations on the northern fringe of the OB25 West Operations and three point locations on the northern and eastern fringe of the OB32 East Maximum Disturbance Boundary extension	✓		✓

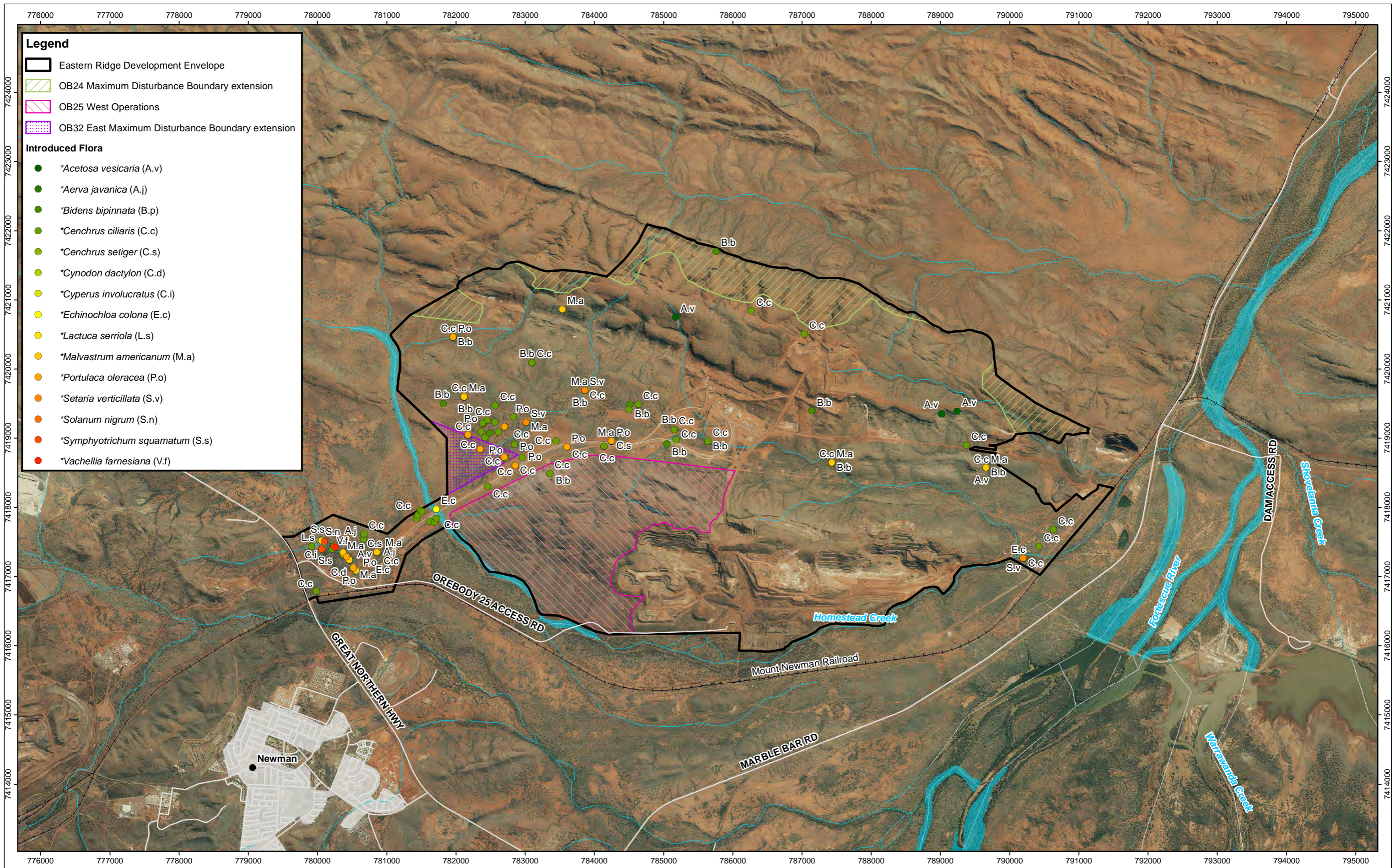


FIGURE 7
Location of introduced weed species within the Eastern Ridge Development Envelope

4.4 Vegetation

Vegetation mapping for the Development Envelope was collated and standardised by Onshore Environmental as part of the consolidated mapping of BHP Billiton Iron Ore's Pilbara tenements. The vegetation association polygon detail was sourced from the 'Eastern Ridge (OB23/24/25) Flora and Vegetation Assessment' (ENV Australia 2012). The consolidated mapping defined twelve vegetation associations occurring within the Development Envelope (Table 9, Figure 8).

Table 9 Vegetation associations occurring within the Development Envelope (as per the consolidated mapping, Onshore Environmental 2014c).

Vegetation Code	Vegetation Description
GG Tp CfeFbAca DpaAh	Open Hummock Grassland of <i>Triodia pungens</i> with Low Open Woodland of <i>Corymbia ferritcola</i> , <i>Ficus brachypoda</i> and <i>Acacia catenulata</i> subsp. <i>occidentalis</i> over High Open Shrubland of <i>Dodonaea pachyneura</i> and <i>Acacia hamersleyensis</i> on red sandy clay loam in gullies and on breakaways
GG Tp EICfe Dpa	Hummock Grassland of <i>Triodia pungens</i> with Low Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and <i>Corymbia ferritcola</i> over Open Shrubland of <i>Dodonaea pachyneura</i> on red brown sandy clay loam in gullies
HC TpTs EI AaAkAsi	Hummock Grassland of <i>Triodia pungens</i> and <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) with Scattered Low Trees of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over Scattered Tall Shrubs of <i>Acacia aptaneura</i> , <i>Acacia kempeana</i> and <i>Acacia sibirica</i> on red brown loam on hill crests, hill slopes and breakaway slopes
HC TwTbrTp EICh AmaGwAb	Hummock Grassland of <i>Triodia wiseana</i> , <i>Triodia brizoides</i> and <i>Triodia pungens</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and <i>Corymbia hamersleyana</i> over High Open Shrubland of <i>Acacia maitlandii</i> , <i>Grevillea wickhamii</i> subsp. <i>hispidula</i> and <i>Acacia bivenosa</i> on red brown sandy loam on hill crests and upper hill slopes
HS TsTwTp EICh AhiAad	Hummock Grassland of <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835), <i>Triodia wiseana</i> and <i>Triodia pungens</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and <i>Corymbia hamersleyana</i> over Low Open Shrubland of <i>Acacia hilliana</i> and <i>Acacia adoxa</i> var. <i>adoxo</i> on red brown sandy loam on hill slopes
HS Tw EIChHc AanAbAa	Hummock Grassland of <i>Triodia wiseana</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> , <i>Corymbia hamersleyana</i> and <i>Hakea chordophylla</i> and Open Shrubland of <i>Acacia ancistrocarpa</i> , <i>Acacia bivenosa</i> and <i>Acacia aptaneura</i> on red sandy loam on hill slopes
MA CcCs EvAciAh	Tussock Grassland * <i>Cenchrus ciliaris</i> and * <i>Cenchrus setiger</i> with Low Woodland of <i>Eucalyptus victrix</i> , <i>Acacia citrinoviridis</i> and <i>Atalaya hemiglauc</i> a on brown sandy loam on major drainage lines and adjacent flood plains
ME TtEaEte ApyAtpPI EvCh	Tussock Grassland of <i>Themeda triandra</i> , <i>Eulalia aurea</i> and <i>Eriachne tenuiculmis</i> with High Shrubland of <i>Acacia pyrifolia</i> var. <i>pyrifolia</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Petalostylis labicheoides</i> and Open Woodland of <i>Eucalyptus victrix</i> and <i>Corymbia hamersleyana</i> on red brown silty loam on medium drainage lines and flood plains
MI AmoAanPI ChEI TtAin	Shrubland of <i>Acacia monticola</i> , <i>Acacia ancistrocarpa</i> and <i>Petalostylis labicheoides</i> with Scattered Low Trees of <i>Corymbia hamersleyana</i> and <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over Open Tussock Grassland of <i>Themeda triandra</i> and <i>Aristida inaequiglumis</i> on red loamy sand on minor drainage lines
MI CcAa CcCs Tb	Low Open Woodland of <i>Corymbia candida</i> subsp. <i>dipsodes</i> and <i>Acacia aptaneura</i> over Open Tussock Grassland of * <i>Cenchrus ciliaris</i> and * <i>Cenchrus setiger</i> and Very Open Hummock Grassland of <i>Triodia basedowii</i> on red brown loam on floodplains and minor drainage lines

Vegetation Code	Vegetation Description
SA Tb ChEg SpBeKp	Hummock Grassland of <i>Triodia basedowii</i> with Low Open Woodland of <i>Corymbia hamersleyana</i> and <i>Eucalyptus gamophylla</i> over Low Open Shrubland of <i>Scaevola parviflora</i> , <i>Bonamia erecta</i> and <i>Kennedia prorepens</i> on red loamy sand on sand plains
SP Ts Ai	Hummock Grassland of <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) with High Open Shrubland of <i>Acacia inaequilatera</i> on red brown loamy sand on hill slopes and stony plains

4.5 Vegetation Condition

Vegetation condition within the OB24 Maximum Disturbance Boundary and OB32 East Maximum Disturbance Boundary was predominantly rated as *excellent*, with smaller areas rated as *very good* and *completed degraded* (Table 10, Figure 9).

For the OB25 West Operations vegetation condition was predominantly rated as *pristine*, *excellent* and *very good*. Disturbed areas were rated as *degraded* (0.8 ha) or *completely degraded* (117.1 ha) (Table 10, Figure 9).

The high proportion of condition classes rated as *excellent* or better reflects the position of vegetation in the landscape, i.e. predominantly associated with uplands supporting non-palatable plant taxa that were not under grazing pressure by domestic stock. Reduced vegetation condition was recorded for vegetation occurring on stony plains and drainage lines, or associated with exploration and mining activities at OB25.

Table 10 Representation of vegetation condition categories within the Development Envelope.

Vegetation Condition	OB24 MDB extension	OB25 West Operations	OB32 East MDB extension
Pristine	0	112.69	0
Excellent	288.94	230.44	46.01
Very Good	24.54	112.82	3.33
Good	0	0	0
Degraded	0	0.83	0
Completely Degraded (Cleared)	5.92	117.11	2.51
Total	319.40	573.88	51.85

Legend

Consolidated Vegetation Types

Acacia Shrubland

MI AmoAnPI ChEI TtAin Shrubland of *Acacia monticola*, *Acacia ancistrocarpa* and *Petalostylis labicheoides* with Scattered Low Trees of *Corymbia hamersleyana* and *Eucalyptus leucophloia* subsp. *leucophloia* over Open Tussock Grassland of *Themeda triandra* and *Aristida inaequilatera* on red loamy sand on minor drainage lines

*Cenchrus Tussock Grassland

MA CcCs EvAciAh Tussock Grassland **Cenchrus ciliaris* and **Cenchrus setiger* with Low Woodland of *Eucalyptus victrix*, *Acacia citrinoviridis* and *Atalaya hemiglauca* on brown sandy loam on major drainage lines and adjacent flood plains

Corymbia Low Open Woodland

MI CcAa CcCs Tb Low Open Woodland of *Corymbia candida* subsp. *dipsodes* and *Acacia aptaneura* over Open Tussock Grassland of **Cenchrus ciliaris* and **Cenchrus setiger* and Very Open Hummock Grassland of *Triodia basedowii* on red brown loam on floodplains and minor drainage lines

Eucalyptus Low Woodland

ME TtEaEte ApyAtpPI EvCh Tussock Grassland of *Themeda triandra*, *Eulalia aurea* and *Eriachne tenuiculmis* with High Shrubland of *Acacia pyrifolia* var. *pyrifolia*, *Acacia tumida* var. *pilbarensis* and *Petalostylis labicheoides* and Open Woodland of *Eucalyptus victrix* and *Corymbia hamersleyana* on red brown silty loam on medium drainage lines and flood plains

Triodia Hummock Grassland

GG Tp EICfe Dpa Hummock Grassland of *Triodia pungens* with Low Woodland of *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia ferritcola* over Open Shrubland of *Dodonaea pachyneura* on red brown sandy clay loam in gullies

HC TpTs EI AaAkAsi Hummock Grassland of *Triodia pungens* and *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) with Scattered Low Trees of *Eucalyptus leucophloia* subsp. *leucophloia* over Scattered Tall Shrubs of *Acacia aptaneura*, *Acacia kempeana* and *Acacia sibirica* on red brown loam on hill crests, hill slopes and breakaway slopes

HC TwTbrTp EICH AmaGwAb Hummock Grassland of *Triodia wiseana*, *Triodia brizoides* and *Triodia pungens* with Low Open Woodland of *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* over High Open Shrubland of *Acacia maitlandii*, *Grevillea wickhamii* subsp. *hispidula* and *Acacia bivenosa* on red brown sandy loam on hill crests and upper hill slopes

HS TsTwTp EICH AhiAad Hummock Grassland of *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835), *Triodia wiseana* and *Triodia pungens* with Low Open Woodland of *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* over Low Open Shrubland of *Acacia hilliania* and *Acacia adoxa* var. *adoxo* on red brown sandy loam on hill slopes

HS Tw EICHhc AanAbAa "Hummock Grassland of *Triodia wiseana* with Low Open Woodland of *Eucalyptus leucophloia* subsp. *leucophloia*, *Corymbia hamersleyana* and *Hakea chordophylla* and Open Shrubland of *Acacia ancistrocarpa*, *Acacia bivenosa* and *Acacia aptaneura* on red sandy loam on hill slopes

SA Tb ChEg SpBeKp Hummock Grassland of *Triodia basedowii* with Low Open Woodland of *Corymbia hamersleyana* and *Eucalyptus gamophylla* over Low Open Shrubland of *Scaevola parvifolia*, *Bonamia erecta* and *Kennedia prorepens* on red loamy sand on sand plain

SP Ts Ai Hummock Grassland of *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) with High Open Shrubland of *Acacia inaequilatera* on red brown loamy sand on lower hill slopes and stony plains

Triodia Open Hummock Grassland

GG Tp CfeFbAca DpaAh Open Hummock Grassland of *Triodia pungens* with Low Open Woodland of *Corymbia ferritcola*, *Ficus brachypoda* and *Acacia catenulata* subsp. *occidentalis* over High Open Shrubland of *Dodonaea pachyneura* and *Acacia hamersleyensis* on red sandy clay loam in gullies and on breakaway slopes

Cleared

Grey Cleared

FIGURE 8
Eastern Ridge Proposal Vegetation
associations occurring within the
Development Envelope



ON SHORE ENVIRONMENTAL CONSULTANTS	Date:	05/06/2015
Sheet Size:	A3	Status: Final
Drawn by GSM	Requested by DB	GSM Reference Eastern Ridge Intro Flora



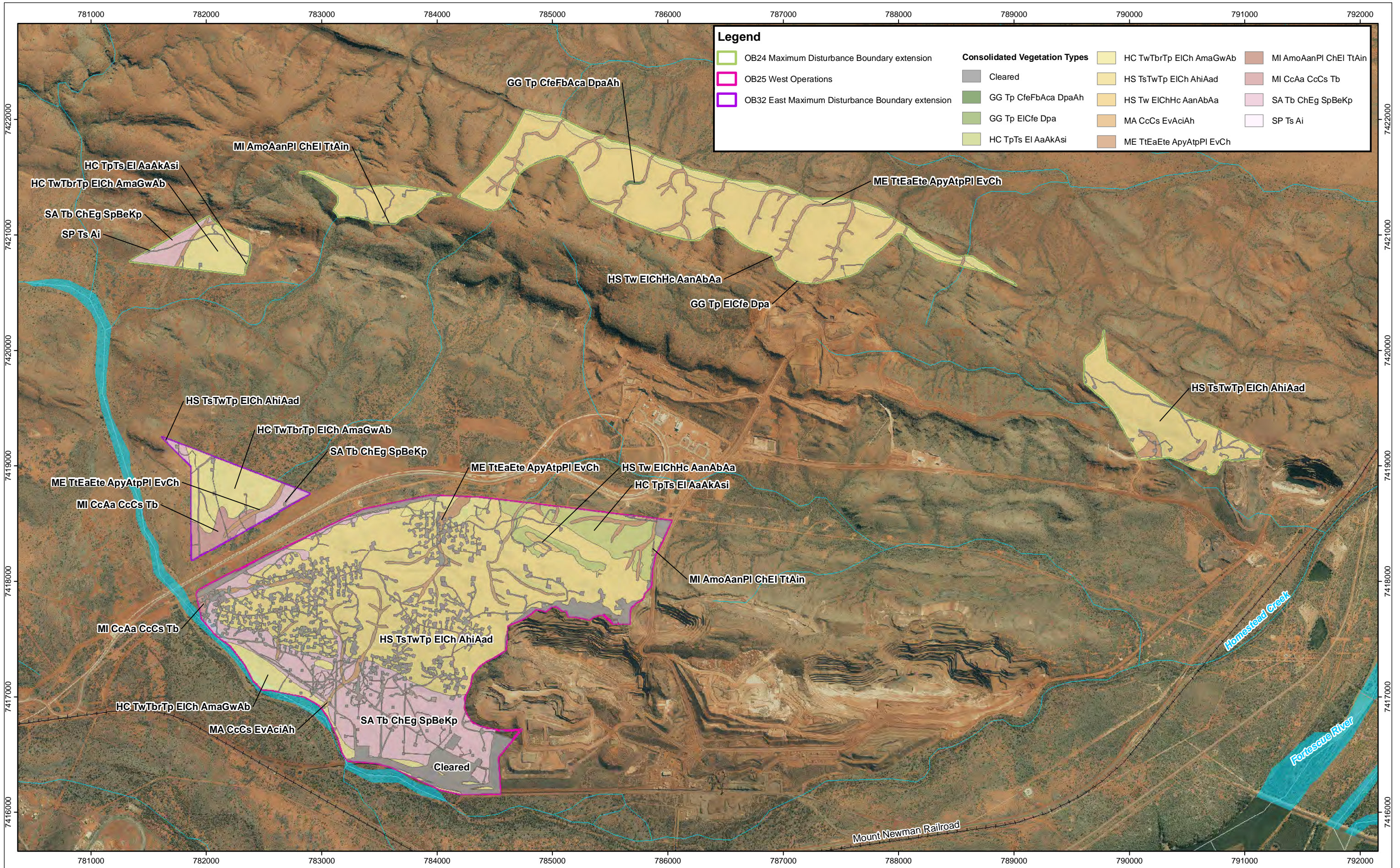
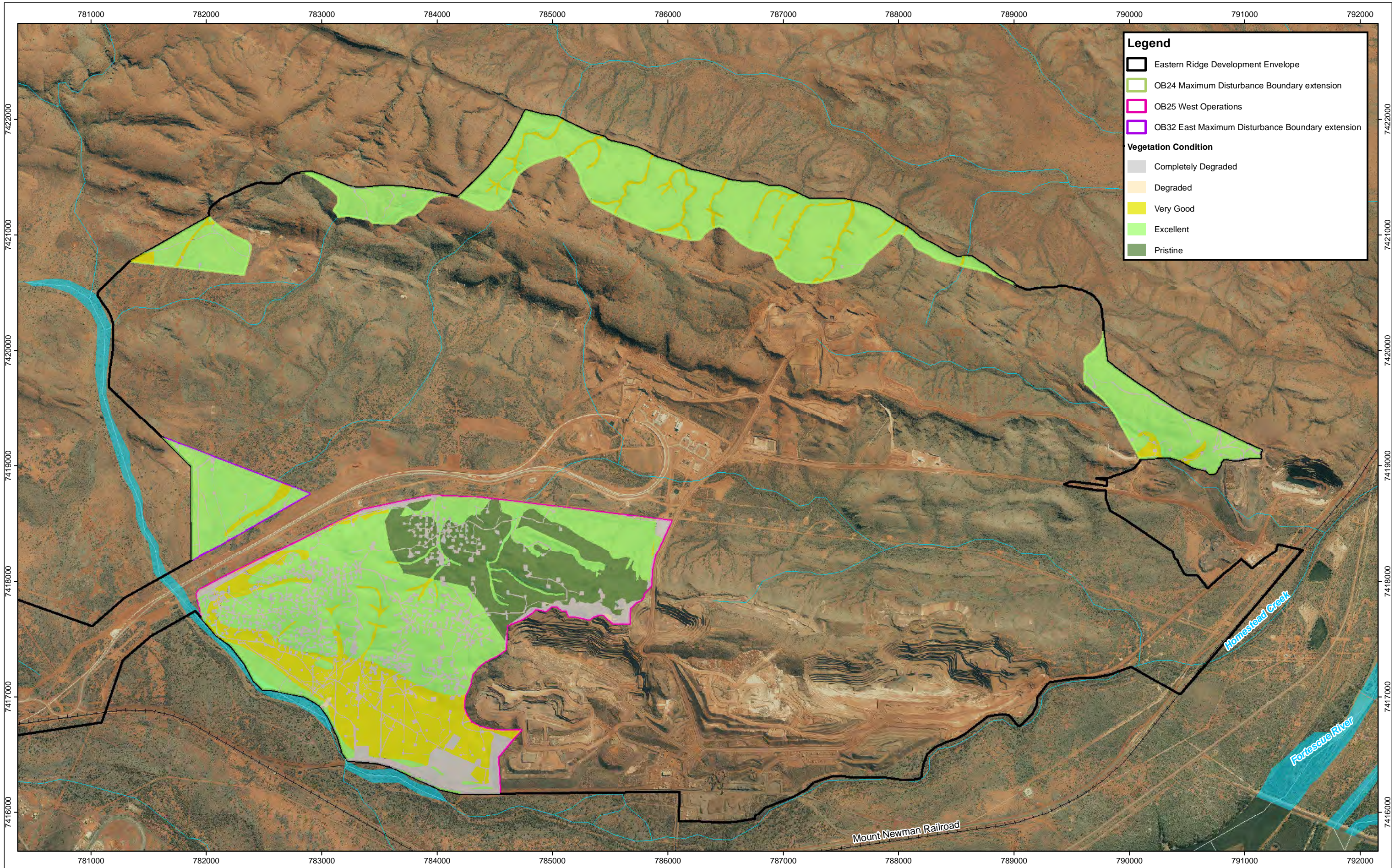


FIGURE 8
Eastern Ridge Proposal Vegetation associations occurring within the Development Envelope



Legend

- Eastern Ridge Development Envelope
- OB24 Maximum Disturbance Boundary extension
- OB25 West Operations
- OB32 East Maximum Disturbance Boundary extension

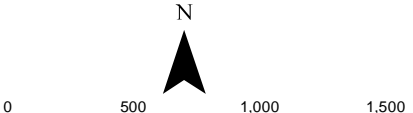
Vegetation Condition

- Completely Degraded
- Degraded
- Very Good
- Excellent
- Pristine



ON SHORE ENVIRONMENTAL CONSULTANTS	Date: 10/09/2015
Sheet Size: A3	Status: Final
Drawn by: GSM	Requested by: DB
GSM Reference: Eastern Ridge Veg Cond	

N



0 500 1,000 1,500
Meters
1:30,000
Datum: GDA94
Projection: MGA Zone 50

FIGURE 9
Eastern Ridge Proposal Vegetation condition map for the Development Envelope



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

4.6 Significance of Vegetation

4.6.1 National Significance

A search of the DPaW communities database (DPaW 2014b) confirmed there was one TEC record within a 50 km radius of the study area; the Ethel Gorge Aquifer Stygobiont Community TEC (Figure 5). It is listed as Endangered under the EPBC Act Protected Matters Database (DoE 2014). However the TEC is a subterranean community and is not has no relationship with flora and vegetation and therefore is not considered to be of significance.

A search of the EPBC Act Protected Matters database (DoE 2014) confirmed there were no Threatened Ecological Communities (TECs) recorded within, or adjacent to, the Development Envelope. This has been confirmed during previous field survey work.

4.6.2 State Significance

A search of DPaWs communities database (DPaW 2013b) confirmed that one PEC was located approximately 40 km north of the study area (Figure 5). The Priority 3iii PEC 'Vegetation of sand dunes of the Hamersley Range/Fortescue Valley' (previously 'Fortescue Valley Sand Dunes') is described as red linear sand dune communities that lie on the Divide Land system at the junction of the Hamersley Range and Fortescue Valley. No sand dunes exist within the Development Envelope and the vegetation associations recorded within the Development Envelope are not considered to be affiliated with any PECs or vegetation of significance.

4.6.3 Local Significance on Basis of Specialised Landform

Local significance can be determined where a plant taxon or vegetation association is confined to a specialised habitat that is not common in the local area. Beard (1975) vegetation associations within each subregion were ranked as Low, Medium or High priority for reservation in the conservation estate (Kendrick 2001). For the two Beard vegetation associations represented within the Development Envelope, Hamersley 82 was rated as being of low reservation priority while Hamersley 18 was rated as medium reservation priority (Kendrick 2001).

Additionally a list of ecosystems considered to be 'at risk' within each IBRA subregion was identified during the biodiversity audit of Western Australia's biogeographical subregions (McKenzie *et al.* 2003). According to the audit, the Development Envelope occurs within the Pilbara 3 - Hamersley Subregion. Kendrick (2001) lists the following communities within the Hamersley Subregion as being 'Ecosystems at risk':

- Grove-intergrade Mulga communities, eastern Hamersley Range;
- Valley floor mulga;
- Lower slopes mulga;
- Marillana Station dunefields, adjacent to the Hancock Ranges (dunes support some desert fauna elements such as *Ningui ridei* and *Ctenotus quattuordecimlineatus*);
- Coolibah Swamp, Mount Bruce, Karijini National Park;
- Munjina Claypan and associated mulga community;
- Hilltop floras, Hamersley Range;
- All major ephemeral water courses;
- Wetland community, Weeli Wolli Spring;

- Wetland community, Palm Spring, Duck Creek;
- Stygofauna communities, OB23;
- Other stygofauna associated with aquifers near mining below water table;
- Lake Robinson-Coondewanna Flats;
- West Angelas Cracking-Clays; and
- Coolibah-Lignum Flats.

There are two vegetation associations within the Eastern Ridge Development Envelope determined to be of local significance. These vegetation associations are described in further detail below.

Vegetation of Homestead Creek

All major ephemeral water courses in the Hamersley subregion are listed as 'ecosystems at risk' by the DPaW due to threats from grazing and weed invasion as described by Kendrick (2003). Homestead Creek occurs immediately south and west of the Development Envelope. During the establishment of the Development Envelope a 50 metre buffer was applied to Homestead Creek.

One vegetation association within the OB25 West Operations extension extends into the major drainage line of Homestead Creek:

- MA CcCs EvAciAh - Tussock Grassland **Cenchrus ciliaris* and **Cenchrus setiger* with Low Woodland of *Eucalyptus victrix*, *Acacia citrinoviridis* and *Atalaya hemiglauca* on brown sandy loam on major drainage lines and adjacent flood plains.

This association is a minor component of the vegetation represented at the OB25 West Operations extension, occurring over 0.45 ha.

Gorges

The vegetation of gorges within the Development Envelope were identified as areas of significance by ENV Australia (2012). Gorges are considered significant as they may contain permanent or temporary waterholes and provide refugia for fire intolerant species and humidophiles (Kendrick 2001).

One vegetation association within the OB24 Maximum Disturbance Boundary extension was associated with gorges:

- GG Tp CfeFbAca DpaAh - Open Hummock Grassland of *Triodia pungens* with Low Open Woodland of *Corymbia ferritcola*, *Ficus brachypoda* and *Acacia catenulata* subsp. *occidentalis* over High Open Shrubland of *Dodonea pachyneura* and *Acacia hamersleyensis* on red sandy clay loam in gullies and on breakaways.

This association is a minor component of the vegetation represented at the OB24 Maximum Disturbance Boundary extension, occurring over 0.39 ha.

4.6.4 Local Significance on Basis of Supporting Significant Flora

The two Priority flora taxa recorded from the Development Envelope occur within the same vegetation association, 'HS TsTwTp EICH AhiAad - Hummock Grassland of *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835), *Triodia wiseana* and *Triodia pungens* with Low Open Woodland of *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* over Low Open Shrubland of *Acacia hilliana* and *Acacia adoxa* var. *adoxo* on red brown sandy loam on hill slopes'. Under the criteria listed in 4.3.6 this vegetation association is considered to be of local significance. However, it is noted that it has a wide distribution throughout the Pilbara bioregion and is considered to be well distributed.

5 EVALUATION OF THE POTENTIAL IMPACTS

The following potential flora and vegetation impacts have been identified within the Development Envelope:

- Direct removal of vegetation during clearing and earthworks;
- Alteration to groundwater levels;
- Alteration to the volume of surface water flows;
- Altering the frequency or intensity of wildfire;
- Increased diversity and cover of introduced (weed) species; and
- Increased levels of airborne dust reducing leaf transpiration and causing vegetation decline.

These potential impacts are addressed below.

5.1 Direct Clearing

5.1.1 Vegetation

The Development Envelope is located within the Hamersley Botanical District within the Pilbara IBRA region, which is part of the Eremaean Province (Beard 1990). Broad scale vegetation mapping undertaken by Beard (1975) and refined by Shepherd *et al.* (2002) show two vegetation complexes within the Development Envelope; Hamersley 82 and Hamersley 18 (Figure 2). The Pre-European extent remaining for these two vegetation complexes is estimated at close to 100 percent (Table 1). At a regional scale the area within the Development Envelope represents less than 0.03 percent of the total extent for each complex, which is considered to be a negligible impact.

Based on fine-scale consolidated vegetation mapping of BHP Billiton Iron Ore's Pilbara tenements (Onshore Environmental 2014c) twelve vegetation associations are represented within the Development Envelope (Figure 8, Table 11). Clearing of vegetation will represent disturbance to less than one percent of the total representation within the consolidated vegetation mapping database (BHP Billiton Iron Ore Pilbara tenements only) for nine of the twelve associations, and less than five percent for the remaining three vegetation associations (Table 11).

It is determined that direct clearing within the Development Envelope will not have any significant impact on regional representation of the twelve vegetation associations.

Table 11 Representation of twelve vegetation associations occurring within the Development Envelope (from Onshore Environmental 2014a). NOTE: Percentage values in brackets represent proportion of the vegetation association as mapped in BHP Billiton Iron Ore's consolidated database.

Vegetation Code	Vegetation Description	Consolidated Mapping Area (ha)	OB24 MDB extension	OB25 West Operations	OB32 East MDB extension
GG Tp CfeFbAca DpaAh	Open Hummock Grassland of <i>Triodia pungens</i> with Low Open Woodland of <i>Corymbia ferritcola</i> , <i>Ficus brachypoda</i> and <i>Acacia catenulata</i> subsp. <i>occidentalis</i> over High Open Shrubland of <i>Dodonea pachyneura</i> and <i>Acacia hamersleyensis</i> on red sandy clay loam in gullies and on breakaways	196.14	0.389 (0.198%)		
GG Tp EICfe Dpa	Hummock Grassland of <i>Triodia pungens</i> with Low Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and <i>Corymbia ferritcola</i> over Open Shrubland of <i>Dodonea pachyneura</i> on red brown sandy clay loam in gullies	53.81	0.055 (0.102%)		
HC TpTs EI AaAkAsi	Hummock Grassland of <i>Triodia pungens</i> and <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) with Scattered Low Trees of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over Scattered Tall Shrubs of <i>Acacia aptaneura</i> , <i>Acacia kempeana</i> and <i>Acacia sibirica</i> on red brown loam on hill crests, hill slopes and breakaway slopes	952.34	0.136 (0.014%)	35.172 (3.693%)	
HC TwTbrTp EICh AmaGwAb	Hummock Grassland of <i>Triodia wiseana</i> , <i>Triodia brizoides</i> and <i>Triodia pungens</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and <i>Corymbia hamersleyana</i> over High Open Shrubland of <i>Acacia maitlandii</i> , <i>Grevillea wickhamii</i> subsp. <i>hispidula</i> and <i>Acacia bivenosa</i> on red brown sandy loam on hill crests and upper hill slopes	9,186.80	37.786 (0.411%)	28.529 (0.311%)	32.646 (0.355%)
HS TsTwTp EICh AhiAad	Hummock Grassland of <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835), <i>Triodia wiseana</i> and <i>Triodia pungens</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and <i>Corymbia hamersleyana</i> over Low Open Shrubland of <i>Acacia hilliiana</i> and <i>Acacia adoxa</i> var. <i>adoxo</i> on red brown sandy loam on hill slopes	42,184.16	248.799 (0.590%)	321.85 (0.763%)	0.018 (<0.000%)
HS Tw EIChHc AanAbAa	Hummock Grassland of <i>Triodia wiseana</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> , <i>Corymbia hamersleyana</i> and <i>Hakea chordophylla</i> and Open Shrubland of <i>Acacia ancistrocarpa</i> , <i>Acacia bivenosa</i> and <i>Acacia aptaneura</i> on red sandy loam on hill slopes	3,631.58	0.013 (<0.000%)	1.884 (0.052%)	

Vegetation Code	Vegetation Description	Consolidated Mapping Area (ha)	OB24 MDB extension	OB25 West Operations	OB32 East MDB extension
MA CcCs EvAciAh	Tussock Grassland * <i>Cenchrus ciliaris</i> and * <i>Cenchrus setiger</i> with Low Woodland of <i>Eucalyptus victrix</i> , <i>Acacia citrinoviridis</i> and <i>Atalaya hemiglauca</i> on brown sandy loam on major drainage lines and adjacent flood plains	2,198.48		0.448 (0.020%)	
ME TtEaEte ApyAtpPI EvCh	Tussock Grassland of <i>Themeda triandra</i> , <i>Eulalia aurea</i> and <i>Eriachne tenuiculmis</i> with High Shrubland of <i>Acacia pyrifolia</i> var. <i>pyrifolia</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Petalostylis labicheoides</i> and Open Woodland of <i>Eucalyptus victrix</i> and <i>Corymbia hamersleyana</i> on red brown silty loam on medium drainage lines and flood plains	1,032.77	23.626 (2.288%)	24.976 (2.418%)	2.443 (0.237%)
MI AmoAanPI ChEI TtAin	Shrubland of <i>Acacia monticola</i> , <i>Acacia ancistrocarpa</i> and <i>Petalostylis labicheoides</i> with Scattered Low Trees of <i>Corymbia hamersleyana</i> and <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over Open Tussock Grassland of <i>Themeda triandra</i> and <i>Aristida inaequiglumis</i> on red loamy sand on minor drainage lines	609.40	0.138 (0.023%)	0.149 (0.024%)	
MI CcAa CcCs Tb	Low Open Woodland of <i>Corymbia candida</i> subsp. <i>dipsodes</i> and <i>Acacia aptaneura</i> over Open Tussock Grassland of * <i>Cenchrus ciliaris</i> and * <i>Cenchrus setiger</i> and Very Open Hummock Grassland of <i>Triodia basedowii</i> on red brown loam on floodplains and minor drainage lines	774.68		2.469 (0.319%)	10.245 (1.322%)
SA Tb ChEg SpBeKp	Hummock Grassland of <i>Triodia basedowii</i> with Low Open Woodland of <i>Corymbia hamersleyana</i> and <i>Eucalyptus gamophylla</i> over Low Open Shrubland of <i>Scaevola parviflora</i> , <i>Bonamia erecta</i> and <i>Kennedia prorepens</i> on red loamy sand on sand plains	5,954.30	8.279 (0.139%)	124.108 (2.084%)	6.511 (0.109%)
SP Ts Ai	Hummock Grassland of <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) with High Open Shrubland of <i>Acacia inaequilatera</i> on red brown loamy sand on hill slopes and stony plains	1,441.38	0.179 (0.012%)		
Cleared			34.285		
TOTAL		68,215.84	353.685	539.585	51.863

Vegetation condition within the Development Envelope was rated as *pristine*, *excellent* or *very good*, with small areas fringing the existing OB25 mining operation rated as *degraded* or *completely degraded (cleared)* (Table 12). The high proportion of condition classes at excellent or better reflects the position of vegetation in the landscape, i.e. predominantly associated with uplands supporting non-palatable plant taxa that were not under grazing pressure by domestic stock. Reduced vegetation condition was recorded for vegetation occurring on sand plains and drainage lines.

Table 12 Representation of vegetation condition categories within the Development Envelope.

Vegetation Condition	OB24 MDB extension	OB25 West Operations	OB32 East MDB extension
Pristine	0	112.69 (20%)	0
Excellent	288.94 (90%)	230.44 (40%)	46.01 (89%)
Very Good	24.54 (10%)	112.82 (20%)	3.33 (6%)
Good	0	0	0
Degraded	0	0.83 (0%)	0
Completely Degraded (Cleared)	5.92	117.11 (20%)	2.51 (5%)
Total	319.40	573.88	51.85

5.1.2 Impacts to Significant Flora

There was no Federal or State listed Threatened Flora recorded from the Development Envelope. Impacts to the Priority flora occurring within each of the new extension areas are discussed below.

OB24 Maximum Disturbance Boundary extension

The Priority 2 flora taxon *Isotropis parviflora* was recorded as one plant from a single location point in the northern sector of the OB24 Maximum Disturbance Boundary extension in 2004 (Ecologia 2004b, Figure 6). Despite good seasonal conditions targeted surveys completed in July 2011 (ENV Australia 2012) and June 2012 (Onshore Environmental 2013) failed to record any evidence of *Isotropis parviflora* at the previous location point or across the wider study area. *Isotropis parviflora* is a known short lived colonising species and the plant recorded in the northern sector of the OB24 Maximum Disturbance Boundary Extension in May 2004 (Ecologia 2004b) has been outcompeted by the maturing vegetation cover.

The impact of the OB24 Maximum Disturbance Boundary extension on *Isotropis parviflora* was considered to be negligible.

OB32 East Maximum Disturbance Boundary extension

No Priority flora taxa occur within the OB32 East Maximum Disturbance Boundary extension and hence there will be no impact on significant flora.

OB25 West Operations

One Priority flora taxon, *Eremophila magnifica* subsp. *velutina* (Priority 3), occurs throughout the central sector of the proposed OB25 West Operations; this represents the western sub-population for the mapped extent within the Development Envelope and vicinity (Figure 10). It occurs on hill crests, ironstone ridges, breakaway slopes, cliff faces, upper hillslopes, rocky ravines, foot slopes and rocky drainage lines. *Eremophila magnifica* subsp. *velutina* was recorded at variable density ranging from

one to 100 plants per 10 m². The distribution was mapped as 'scattered plants' (low density) versus 'dense plants' (high density) across the extent of the area surveyed (Figure 10). Within the OB25 West Operations boundary (the western sub-population) *Eremophila magnifica* subsp. *velutina* occurred at low density over 144.2 ha and at high density over 130.1 ha (Figure 10).

The eastern sub-population occurs approximately 500 m east of the proposed OB25 West Operations boundary on the northern side of the existing OB25 pit (within the approved Eastern Ridge Development Envelope) (Figure 6). *Eremophila magnifica* subsp. *velutina* occurred at low density over 32.4 ha within the eastern sub-population (Figure 10).

Approval of the proposed OB25 West Operations would potentially result in the entire local population of *Eremophila magnifica* subsp. *velutina* being cleared. The local impact is therefore determined to be high.

Eremophila magnifica subsp. *velutina* occurs over a range of approximately 300 km extending from south-east of Newman to west of Tom Price, with two populations within this range known from Karijini National Park, i.e. it occurs within a formal conservation reserve.

Eremophila magnifica subsp. *velutina* has previously been recorded as an estimated 1,536 individuals from ten populations at Parallel Ridge within BHP Billiton Iron Ore's Tandanya tenements (ENV Australia 2010). It was recorded on north facing hill slopes and gorge walls with the following two vegetation associations:

- Hummock Grassland of *Triodia wiseana* with Low Open Woodland of *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia hamersleyana* with Scattered Shrubs of *Acacia bivenosa*, *Acacia maitlandii* and *Acacia hamersleyensis* on red-brown loam on hill slopes; and
- Open Hummock Grassland of *Triodia wiseana* and *Triodia melvillei* with Low Open Woodland of *Eucalyptus leucophloia* subsp. *leucophloia* and *Corymbia deserticola* subsp. *deserticola* with Very Open Tussock Grassland of *Cymbopogon ambiguus*, *Eriachne mucronata* and *Cymbopogon procerus* on skeletal red-brown loam in gorges.

Given the relatively large known distribution range and occurrence of at least two populations within this range occurring within Karijini National Park, the regional impact of disturbing the population at the OB25 West Operations is determined to be low.

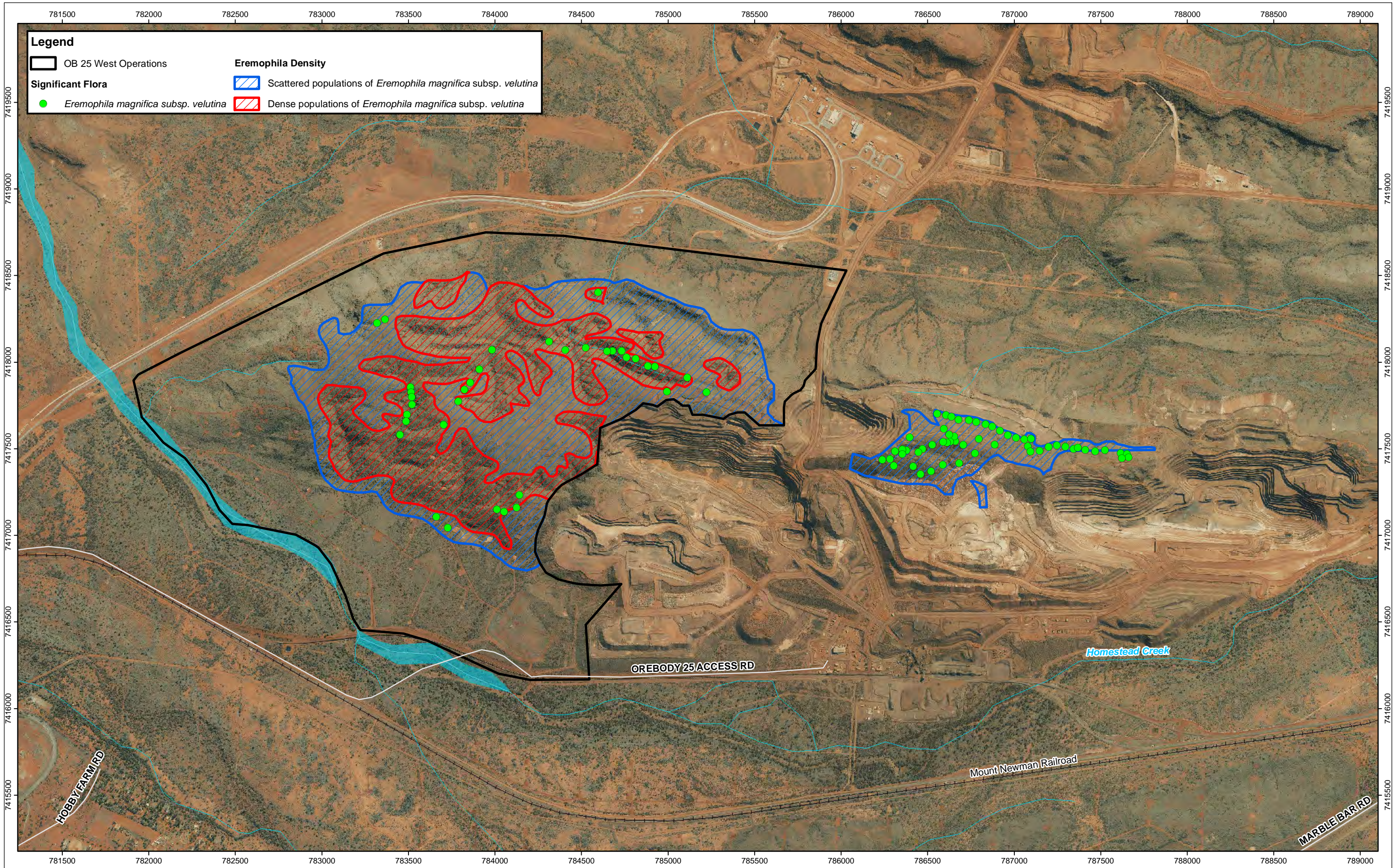


Figure 10
Eastern Ridge Proposal - *Eremophila magna subsp. velutina* distribution and density.

5.2 Ground Water Dependant Vegetation

The Eastern Ridge Revised Proposal includes below water table (BWT) approvals for the OB24 Maximum Disturbance Boundary and OB25 West Operations.

A numerical groundwater model was used to estimate baseline depth to groundwater at 2012. Areas where *in situ* groundwater depth was less than 25 m bgl were plotted (see green contour lines in Figures 11 and 12) to represent zones that may potentially support groundwater dependent vegetation. The 25 m bgl threshold followed findings from previous studies in the Pilbara where *Eucalyptus camaldulensis* trees occurring along major ephemeral drainage lines were accessing groundwater up to 21 m bgl (Muir Environmental 1995).

Onshore Environmental considers any vegetation that uses groundwater is potentially at risk if it occurs at a location where the groundwater would be lowered beyond assumed natural groundwater variation. However, the impact on vegetation from lowering of the groundwater table is also likely to be relative to the species' dependence on groundwater. For example, plants that rely solely on water sourced directly from the groundwater table (obligate phreatophytes) are more likely to show signs of decline or be lost compared to plants that use soil moisture (vadophytes) or intermittently utilise groundwater, i.e during periods of extended drought (facultative phreatophytes).

An assessment of the species' dependence on groundwater was informed by a desktop literature review and an understanding of the groundwater environment from BHP Billiton Iron Ore (2015), including the estimated depth of the groundwater below natural ground level (Table 13).

Table 13 Tree species dependence on groundwater.

Species Dependence on Groundwater	Plant Physiology / Water Use	Indicator Species
High	Obligate Phreatophyte	<i>Melaleuca argentea</i> (not recorded at OB24 OB25 West and surrounds)
Moderate	Facultative Phreatophyte or Vadophyte	<i>Eucalyptus camaldulensis</i> subsp. <i>refulgens</i>
Low	Facultative Phreatophyte or Vadophyte	<i>Eucalyptus victrix</i>
None	Xerophyte	All remaining tree species at OB24 OB25 West and surrounds

The obligate phreatophytic⁹ tree species *Melaleuca argentea* is determined to be the highest risk plant taxon within the central and south-east Pilbara. It relies on the existence of shallow groundwater for survival (<3 m bgl) 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 OB24 Maximum Disturbance Boundary or the OB25 West Operations (including the adjacent stretch of Fortescue River). It is

⁹ Phreatophytes are plant species that rely on water sourced directly from the watertable.

therefore determined that none of the vegetation associations occurring within the cumulative drawdown areas are at high risk.

Vegetation associations occurring within the cumulative drawdown areas along Homestead Creek and Fortescue River, support one native tree species that is considered to potentially be at moderate risk from groundwater drawdown (*Eucalyptus camaldulensis* subsp. *refulgens*), and a second species that is potentially at low risk from groundwater drawdown (*Eucalyptus victrix*). These tree species are classified as facultative phreatophytes¹⁰, noting that *Eucalyptus victrix* may also function in some environments as a vadophyte¹¹. *Eucalyptus camaldulensis* 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 up to 21 m below the surface. *Eucalyptus victrix* is relatively drought tolerant but may be susceptible to decline where groundwater is limited during extended dry periods (Muir Environmental 1995).

5.2.1 Drawdown from OB24 and OB25 West Dewatering Only

A numerical groundwater model was used to estimate the potential drawdown associated with proposed dewatering operations at OB24 and OB25 West in isolation, i.e. non-cumulative (Figure 11). Areas where depth to groundwater at 2012 was less than 25 m bgl were highlighted (see green contour lines, Figure 11) to represent zones where groundwater dependent vegetation may potentially occur (and hence be at risk from drawdown).

Groundwater levels are expected to be lowered by a maximum of 35 m due to dewatering at OB24, with the 1 m drawdown contour extending out radially for approximately 2 km from the base of the pit (see red contour lines, Figure 11). The only vegetation identified as being potentially at risk within the drawdown footprint, i.e. occurring within areas where existing groundwater levels are less than 25 m bgl, is a section along the northern branch of Homestead Creek (Figure 11). The modelled groundwater drawdown within this area ranges between 1 m and 5 m, which is within the range of natural seasonal variation. Given that *Eucalyptus victrix* occurs alone along this section of Homestead Creek, potential impacts are determined to be low.

The drawdown remains outside of the designated Ethel Gorge TEC boundary, and therefore there are no potential impacts to groundwater dependant vegetation at Ethel Gorge and the associated Fortescue River. The limited drawdown extent is the result of lower permeability strata surrounding OB24 as well as the relatively small magnitude of drawdown that is required at OB24.

For OB25 West, groundwater levels are modelled to be lowered by up to 45 m. In general the zone of drawdown was confined to a radius of approximately 1 km from the base of the pit, an area where existing groundwater levels are greater than 25 m bgl and hence unlikely to support groundwater dependent vegetation. The modelled drawdown at OB25 West extends in a westerly direction out to a distance of 4 km due to the occurrence of relatively high permeability Witenoom Formation. This includes the Homestead Creek drainage system where existing groundwater levels are less than 25 m bgl, and both *Eucalyptus camaldulensis* subsp. *refulgens* and *Eucalyptus victrix* are known to occur. However, modelled drawdown within the

¹⁰ Facultative Phreatophytes are capable of functioning as both a vadophyte and a phreatophyte

¹¹ Vadophytes primarily use water held in the vadose (unsaturated) zone that occurs above the watertable.

4 km westerly extension is estimated to range between 1 m and 2 m. This range is within natural seasonal variation and potential impacts on both *Eucalyptus camaldulensis* subsp. *refulgens* and *Eucalyptus victrix* are determined to be negligible.

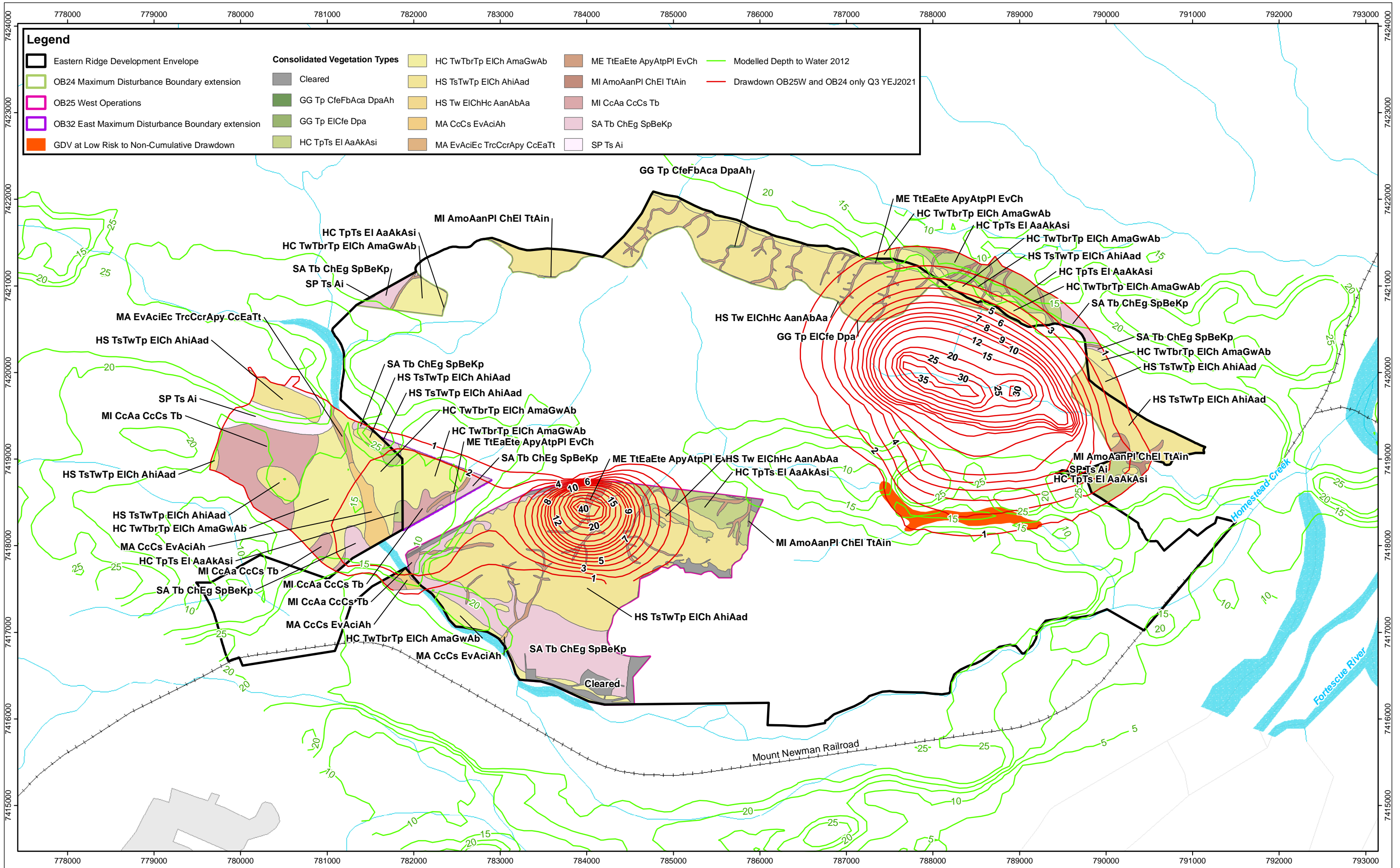


FIGURE 11
 Eastern Ridge Proposal – Non-cumulative groundwater drawdown model for OB24 and OB25 West.

5.2.2 Cumulative Drawdown

The hydrogeologic system at Eastern Ridge is complex and water levels in certain areas have fluctuated over a relatively wide range during the past 40 years due to water supply pumping from the Ophthalmia and Homestead borefields, dewatering at OB23 and OB25, and from significant natural recharge associated with high rainfall events and the installation of Ophthalmia Dam. Groundwater data has been compiled and reviewed to assess potential cumulative impacts to the hydrologic system taking into account currently approved operations within Eastern Ridge, as well as delineating the relative contribution that the proposed operations at OB24 and OB25 West would have to any cumulative change.

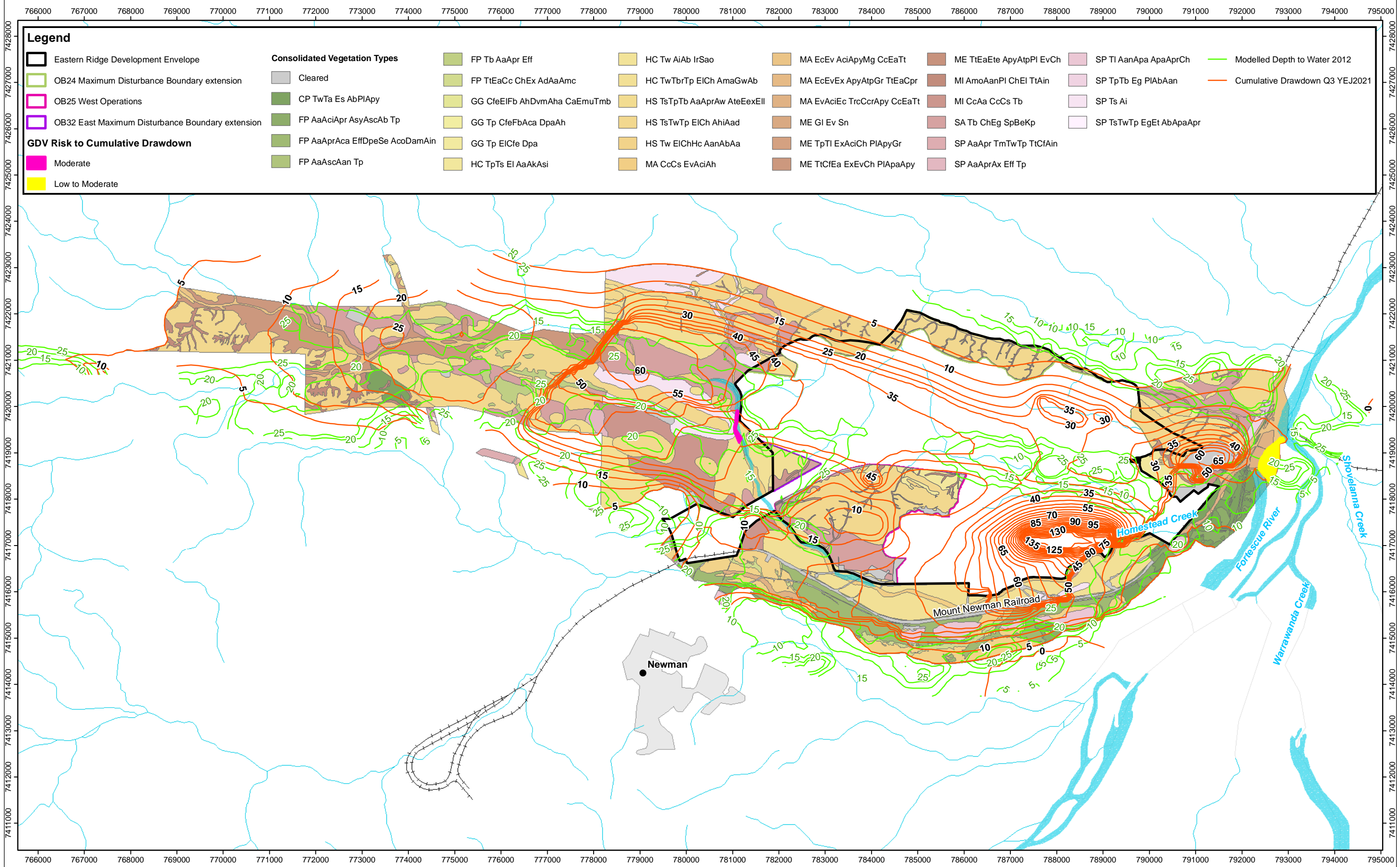
A review of baseline groundwater depth at 2012 confirms *in situ* groundwater levels are within 25 m bgl at two major receptors surrounding the Eastern Ridge development Envelope; Homestead Creek (as well as adjacent floodplains and major tributaries), and a section of the Fortescue River (supporting the Ethel Gorge TEC) (see green contour lines, Figure 12). The cumulative impact area has been modelled to extend approximately 24 km east-west and 9 km north-south (see red contour lines, Figure 12).

None of the vegetation associations occurring within the cumulative groundwater drawdown areas surrounding the Eastern Ridge Development Envelope are at high risk owing to the absence of obligate phreatophytic flora, including the tree species *Melaleuca argentea*. However, vegetation along the main drainage channel of Homestead Creek and adjacent floodplains, and the northern tributary of Homestead Creek, supports *Eucalyptus victrix*, with a smaller area along the main drainage channel supporting *Eucalyptus camaldulensis* subsp. *refulgens*. The cumulative groundwater drawdown for this area is modelled to range between 5 m and 65 m. The risk from cumulative groundwater drawdown along the major length of Homestead Creek supporting *Eucalyptus victrix* is determined to be low, noting a sparse stocking rate of trees and relatively deep groundwater resource in the range of 18-20 m bgl. A localised section of Homestead Creek situated immediately west of OB25 West supporting *Eucalyptus camaldulensis* subsp. *refulgens* (approximately 6 ha in area) is determined to be at moderate risk from cumulative groundwater drawdown (Figure 12).

The cumulative groundwater drawdown is modelled to extend eastwards to Ethel Gorge, situated along the major drainage channel of Fortescue River. The baseline groundwater depth at 2012 along Fortescue River ranges from 5 m bgl to 25 m bgl, and cumulative drawdown is modelled to be within the range 10 m to 15 m. Hydrographs of selected monitoring bores located within the Ethel Gorge TEC confirm that water levels since the mid-1970's have fluctuated by up to 15 m in response to the construction of Ophthalmia Dam and significant rainfall events (Figure 13). On this basis potential impacts at Ethel Gorge are determined to be low to moderate for groundwater dependent vegetation, including the tree species *Eucalyptus victrix* and *Eucalyptus camaldulensis* subsp. *refulgens*.

The remaining vegetation associations occurring in areas where existing groundwater levels are greater than 25 m bgl are determined to have negligible risk from groundwater drawdown as they comprise a mixture of vadophytic and xerophytic¹² plant forms that have no reliance on groundwater.

¹² Xerophytes are plants that have no reliance on groundwater for survival.



Legend	Consolidated Vegetation Types	FP Tb AaApr Eff	HC Tw AiAb IrSao	MA EcEv AciApyMg CcEaTt	ME TtEaEte ApyAtpPI EvCh	SP Tl AanApa ApaAprCh	Modelled Depth to Water 2012
Eastern Ridge Development Envelope	Cleared	FP TtEaCc ChEx AdAaAmc	HC TwTbrTp ElCh AmaGwAb	MA EcEvEx ApyAtpGr TtEaCpr	MI AmoAanPI ChEl TtAin	SP TpTb Eg PIAbAan	Cumulative Drawdown Q3 YEJ2021
OB24 Maximum Disturbance Boundary extension	CP TwTa Es AbPIApy	GG CfeEIFb AhDvmAha CaEmuTmb	HS TsTpTb AaAprAw AteExEII	MA EvAciEc TrcCcrApy CcEaTt	MI CcAa CcCs Tb	SP Ts Ai	
OB25 West Operations	FP AaAciApr AsyAscAb Tp	GG Tp CfeFbAca DpaAh	HS TsTwTp ElCh AhIAad	ME GI Ev Sn	SA Tb ChEg SpBeKp	SP TsTwTp EgEt AbApaApr	
OB32 East Maximum Disturbance Boundary extension	FP AaAprAca EffDpeSe AcoDamAin	GG Tp EICfe Dpa	HS Tw ElChHc AanAbAa	ME TpTI ExAciCh PIAPyGr	SP AaApr TmTwTp TtCfAin		
GDV Risk to Cumulative Drawdown	FP AaAscAan Tp	HC TpTs El AaAkAsi	MA CcCs EvAciAh	ME TtCfEa ExEvCh PIAPaApy	SP AaAprAx Eff Tp		
Moderate							
Low to Moderate							

ONSHORE
ENVIRONMENTAL CONSULTANTS

ON SHORE ENVIRONMENTAL CONSULTANTS Date: 30/10/2015

Sheet Size: A3 Status: Final

Drawn by: GSM Requested by: DB GSM Reference: Eastern Ridge Cumm_gdv

N

0 1 2 3
Kilometers
1:75,000

Datum: GDA94
Projection: MGA Zone 50

FIGURE 12
Eastern Ridge Proposal - Cumulative groundwater drawdown model for OB24 and OB25 West

GRIFFIN
SPATIAL & MAPPING

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

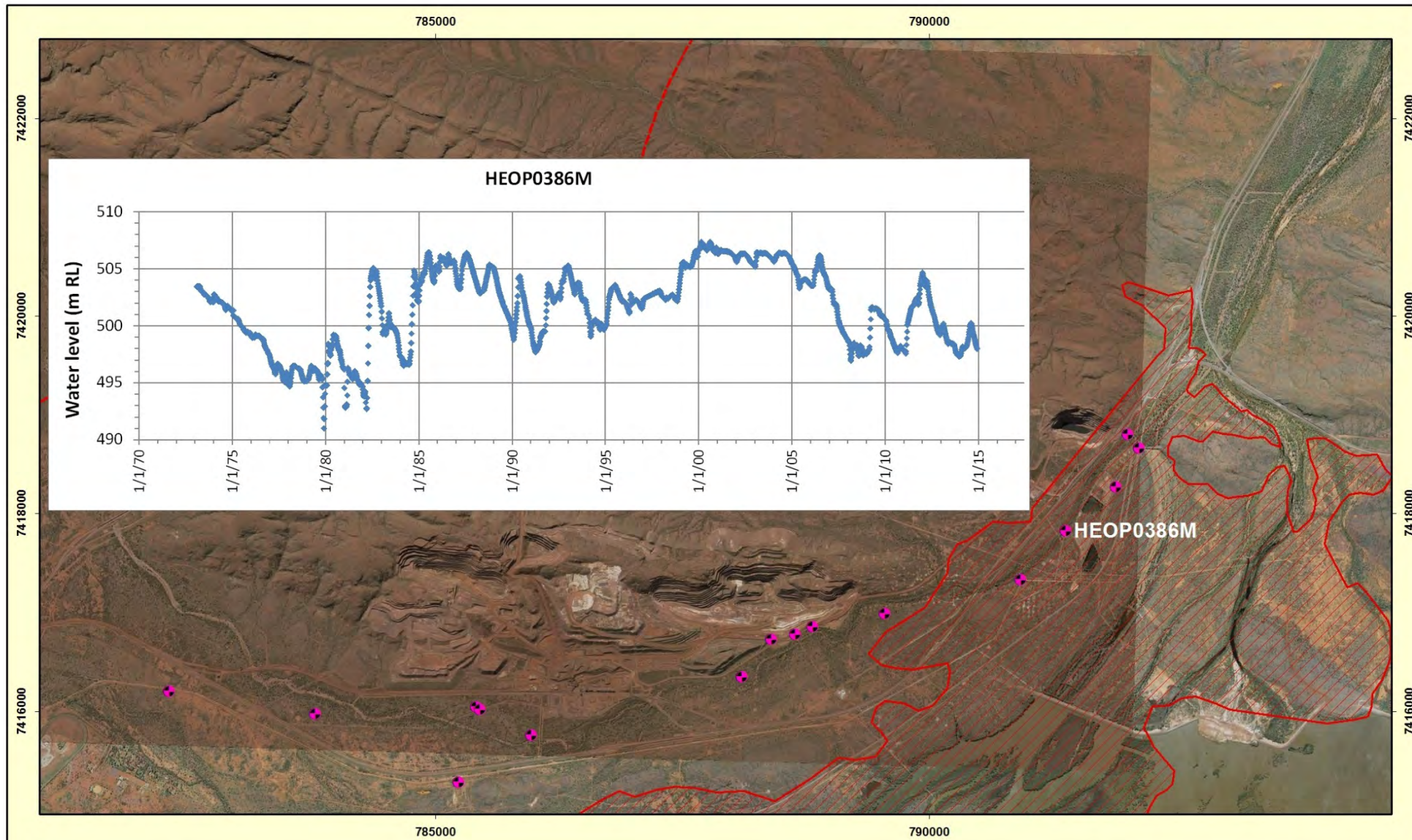


Figure 13 Eastern Ridge Proposal – Hydrograph for monitoring bore within Ethel Gorge TEC



- Monitoring Bore
- ▭ Threated Ecological Community Boundary



**HEOP0386M
Hydrograph**

Scale 1:50,000	Plotted: 12/7/2015	FIGURE 3
MAP GRID & DATUM GDA94, ZONE 50	Drawn: M. McGowan	
File Name:		

5.3 Alteration to Surface Water Flows

Surface drainage within the Development Envelope is ephemeral and follows characteristic high intensity summer rainfall events. The Development Envelope occurs at the western end of Eastern Ridge, which is characterised by large hills with prominent ironstone ridges. The range is dissected by a series of minor and medium drainage lines that flow north and south from the Development Envelope into Homestead Creek and then east into Fortescue River.

The majority of the Development Envelope is covered by upland vegetation associations supporting flora that will not be affected by alteration to surface water flows.

It is widely accepted that Mulga vegetation occurring on floodplains in the Pilbara can be susceptible to altered surface water flows owing to the dense lateral rooting habit and the absence of a tap root. Kendrick (2001) lists three Mulga communities within the Hamersley Subregion as 'Ecosystems at risk':

1. Grove-intergrade Mulga communities, eastern Hamersley Range;
2. Valley floor mulga; and
3. Lower slopes mulga.

There are four vegetation associations recorded from the Development Envelope that support Mulga (*Acacia aptaneura* or *Acacia citrinoviridis*):

- 1) HC TpTs EI AaAkAsi - Hummock Grassland of *Triodia pungens* and *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) with Scattered Low Trees of *Eucalyptus leucophloia* subsp. *leucophloia* over Scattered Tall Shrubs of *Acacia aptaneura*, *Acacia kempeana* and *Acacia sibirica* on red brown loam on hill crests, hill slopes and breakaway slopes;
- 2) HS Tw EIChHc AanAbAa - Hummock Grassland of *Triodia wiseana* with Low Open Woodland of *Eucalyptus leucophloia* subsp. *leucophloia*, *Corymbia hamersleyana* and *Hakea chordophylla* and Open Shrubland of *Acacia ancistrocarpa*, *Acacia bivenosa* and *Acacia aptaneura* on red sandy loam on hill slopes;
- 3) MI CcAa CcCs Tb - Low Open Woodland of *Corymbia candida* subsp. *dipsodes* and *Acacia aptaneura* over Open Tussock Grassland of **Cenchrus ciliaris* and **Cenchrus setiger* and Very Open Hummock Grassland of *Triodia basedowii* on red brown loam on floodplains and minor drainage lines; and
- 4) MA CcCs EvAciAh - Tussock Grassland **Cenchrus ciliaris* and **Cenchrus setiger* with Low Woodland of *Eucalyptus victrix*, *Acacia citrinoviridis* and *Atalaya hemiglauca* on brown sandy loam on major drainage lines and adjacent flood plains.

The first two vegetation associations listed (HC TpTs EI AaAkAsi and HS Tw EIChHc AanAbAa) do not correspond to 'Ecosystems at risk' due their elevated position in the landscape. These vegetation associations have no reliance on surface water flows. The remaining two vegetation associations (MI CcAa CcCs Tb and MA CcCs EvAciAh) occur along minor and major drainage lines at OB25 West Operations and OB32 East MDB extension (Table 14). These drainage lines capture and redirect surface water flows across the Development Envelope and into Homestead Creek.

Table 14 Summary of five vegetation associations within the Development Envelope that support Mulga (*Acacia aptaneura* or *A.citrinoveridis*) or Coolibah (*Eucalyptus victrix*). NOTE: Percentage values in brackets represent proportion of the vegetation association as mapped in BHP Billiton Iron Ore’s consolidated database.

Vegetation Description	Consolidated Mapping Area (ha)	OB24 MDB extension	OB25 West Operations	OB32 East MDB extension
HC TpTs EI AaAkAsi Hummock Grassland of <i>Triodia pungens</i> and <i>Triodia</i> sp. Shovelanna Hill (S. van Leeuwen 3835) with Scattered Low Trees of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over Scattered Tall Shrubs of <i>Acacia aptaneura</i> , <i>Acacia kempeana</i> and <i>Acacia sibirica</i> on red brown loam on hill crests, hill slopes and breakaway slopes	952.34	0.136 (0.014%)	35.172 (3.693%)	
HS Tw EICHc AanAbAa Hummock Grassland of <i>Triodia wiseana</i> with Low Open Woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> , <i>Corymbia hamersleyana</i> and <i>Hakea chordophylla</i> and Open Shrubland of <i>Acacia ancistrocarpa</i> , <i>Acacia bivenosa</i> and <i>Acacia aptaneura</i> on red sandy loam on hill slopes	3,631.58	0.013 (<0.000%)	1.884 (0.052%)	
MI CcAa CcCs Tb Low Open Woodland of <i>Corymbia candida</i> subsp. <i>dipsodes</i> and <i>Acacia aptaneura</i> over Open Tussock Grassland of <i>*Cenchrus ciliaris</i> and <i>*Cenchrus setiger</i> and Very Open Hummock Grassland of <i>Triodia basedowii</i> on red brown loam on floodplains and minor drainage lines	774.68		2.469 (0.319%)	10.245 (1.322%)
MA CcCs EvAciAh Tussock Grassland <i>*Cenchrus ciliaris</i> and <i>*Cenchrus setiger</i> with Low Woodland of <i>Eucalyptus victrix</i> , <i>Acacia citrinoveridis</i> and <i>Atalaya hemiglauca</i> on brown sandy loam on major drainage lines and adjacent flood plains	2,198.48		0.448 (0.020%)	
ME TtEaEte ApyAtpPI EvCh Tussock Grassland of <i>Themeda triandra</i> , <i>Eulalia aurea</i> and <i>Eriachne tenuiculmis</i> with High Shrubland of <i>Acacia pyrifolia</i> var. <i>pyrifolia</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> and <i>Petalostylis labicheoides</i> and Open Woodland of <i>Eucalyptus victrix</i> and <i>Corymbia hamersleyana</i> on red brown silty loam on medium drainage lines and flood plains	1,032.77	23.626 (2.288%)	24.976 (2.418%)	2.443 (0.237%)

The planned mining development works within the Development Envelope are estimated to result in a 6.8 percent cumulative loss to the Homestead Creek catchment, of which the new additional extension areas contribute up to 0.5 percent equivalent catchment loss (RPS 2015). It is assumed the loss in catchment area

produces the same proportionate loss in runoff volume. This potential runoff volume loss lies within the overall seasonal variation of Homestead Creek flows and makes up a minimal portion of the runoff to environmental receptors such as Ethel Gorge and Fortescue Marsh (RPS 2015). RPS (2015) conclude that the Eastern Ridge Development Envelope proposal and associated alterations to surface runoff and drainage should not adversely impact the existing surface water regime and ecosystems.

Based on the RPS (2015) model, Mulga vegetation situated downstream of the Development Envelope will not be impacted by alterations to surface runoff. It is also noted that both vegetation associations are well represented regionally and occur within the area that would be approved for clearing.

A fifth vegetation association occurs along medium drainage lines forming Homestead Creek and support larger trees of *Eucalyptus victrix* (Coolibah) forming Open Woodland with *Corymbia hamersleyana*. Given the low density of trees within the drainage lines it is expected that vegetation should be resilient to any alteration to surface water flows. *Eucalyptus victrix* is also recognised as a facultative phreatophyte with the ability to utilise water sourced directly from the water table during extended dry periods.

Alterations to surface runoff and drainage from the Development Envelope should not adversely impact the existing surface water regimes, and as such downstream vegetation is not determined to be at risk.

5.4 Fire

Fire age within the Development Envelope at July 2011 was rated as moderate (3-5 years) to old (≥ 6 years) (ENV Australia 2012). Fire is a common disturbance that occurs throughout the Pilbara, and the twelve vegetation associations represented within the Development Envelope are not recognized as being fire-sensitive.

Fire within the Development Envelope is determined to manageable and is unlikely to pose any significant risk to vegetation.

5.5 Introduced (Weed) Species

The previous baseline flora and vegetation surveys recorded two introduced (weed) species as scattered plants within localised areas of the Development Envelope; **Bidens bipinnata* (Beggar's Ticks) and **Cenchrus ciliaris* (Buffel Grass). Both taxa are common and widespread weed species in the Pilbara. While clearing of native vegetation and increased vehicular access has the potential to introduce and/or spread weed species, the current risk is determined to be low. Existing management strategies used at surrounding BHP Billiton Iron Ore operations will be important tools for reducing weed risks.

5.6 Dust

Vegetation can be impacted by increased levels of airborne dust in instances where leaf transpiration is impeded. This could occur along unsealed roads and tracks supporting large volumes of traffic, and is pronounced during dry seasonal conditions. Dust control measures such as road watering, use of sprays on the main

ore transfer points, and progressive rehabilitation of disturbed areas would be used to minimise dust generation from the site.

With appropriate management implemented, the potential impact of increased levels of airborne dust is considered to be a low risk.

6 SUMMARY

Key findings from the Eastern Ridge flora and vegetation impact assessment are listed below:

- No Threatened Flora have been recorded from within the Eastern Ridge Development Envelope;
- The Priority 2 flora taxon *Isotropis parviflora* is a short lived coloniser that was recorded as one plant from the northern sector of the OB24 Maximum Disturbance Boundary extension in May 2004. Despite targeted surveys over the eleven year period since the initial record was made, this species has not been recorded at the location or surrounds. Given that *Isotropis parviflora* is a disturbance species, the impact of the OB24 Maximum Disturbance Boundary extension on this taxon was determined to be negligible;
- A western sub-population of the Priority 3 flora taxon *Eremophila magnifica* subsp. *velutina* occurs throughout the central sector of the proposed OB25 West Operations. The eastern sub-population occurs approximately 500 m east of the proposed OB25 West Operations boundary within the approved Eastern Ridge Development Envelope. Approval of the proposed OB25 West Operations area would potentially result in the entire population of *Eremophila magnifica* subsp. *velutina* being cleared. The local impact was therefore determined to be high. However, given that *Eremophila magnifica* subsp. *velutina* occurs over a 300 km range extending from south-east of Newman to west of Tom Price, with two populations within this range known from Karijini National Park, the regional impact on *Eremophila magnifica* subsp. *velutina* was determined to be low;
- The twelve vegetation associations are not affiliated with either Federal and State listed TECs, or State listed PECs for the Pilbara;
- Vegetation condition within the Development Envelope was rated as *pristine*, *excellent*, or *very good*, with smaller areas fringing the adjacent mining operations rated as *degraded* or *completely degraded (cleared)*;
- New proposed clearing of vegetation within the Development Envelope will represent disturbance to less than one percent of the total representation within BHP Billiton Iron Ore's consolidated vegetation mapping database for nine of the twelve vegetation associations, and less than five percent for the remaining three vegetation associations;
- It is determined that new proposed direct clearing within the Development Envelope will not have any significant impact on the regional representation of the twelve vegetation associations;
- Alterations to surface runoff and drainage from the Development Envelope should not adversely impact the existing surface water regimes, and as such downstream vegetation is not determined to be at risk;
- A review of baseline groundwater depth at 2012 confirms *in situ* groundwater levels are within 25 m bgl at two major receptors surrounding the Eastern Ridge development Envelope; Homestead Creek (as well as adjacent floodplains and major tributaries), and a section of the Fortescue River (supporting the Ethel Gorge TEC);
- Considering the OB24 and OB25 West projects in isolation, i.e. non-cumulative impact, minor groundwater drawdown between 1 m and 5 m in depth is modelled to occur within one localised area along the northern branch of Homestead Creek supporting the facultative phreatophyte *Eucalyptus victrix*. The potential impact is determined to be low. For OB25

West, minor groundwater drawdown in the range 1 m to 2 m intersects sections of the Homestead Creek drainage system supporting both *Eucalyptus camaldulensis* subsp. *refulgens* and *Eucalyptus victrix*. This range is within natural seasonal variation and potential impacts on both *Eucalyptus camaldulensis* subsp. *refulgens* and *Eucalyptus victrix* are determined to be negligible;

- Cumulative groundwater drawdown extending up to 65 m was modelled to intersect areas along Homestead Creek where baseline groundwater depth at 2012 was less than 25 m bgl and capable of providing a groundwater source for *Eucalyptus victrix* and/or *Eucalyptus camaldulensis* subsp. *refulgens*. The groundwater drawdown risk along the major length of Homestead Creek supports *Eucalyptus victrix* alone and is determined to be low. However, the risk for a localised section of Homestead Creek supporting *Eucalyptus camaldulensis* subsp. *refulgens* immediately west of OB25 West was determined to be moderate;
- The cumulative groundwater drawdown was modelled to extend eastwards to Ethel Gorge on the Fortescue River. Groundwater drawdown along the main drainage channel supporting *Eucalyptus victrix* and *Eucalyptus camaldulensis* subsp. *refulgens* was within the range 10 m to 15 m, which has the potential for low to moderate impact on groundwater dependent vegetation, including the tree species *Eucalyptus victrix* and *Eucalyptus camaldulensis* subsp. *refulgens*.

8 REFERENCES

- 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.
- Aplin T.E.H. (1979). The Flora. Chapter 3 in O'Brien, B.J. (ed.) (1979). *Environment and Science*. University of Western Australia Press.
- Australian Groundwater Consultants (1981) *Study of Tree / Groundwater Relations: Yandicoogina Iron Ore Deposit*. CSR Limited, Sydney (unpublished).
- Australian Soil Resource Information System (ASRIS) (2014) Available at <http://www.asris.csiro.au/mapping>
- Beard J. S. (1990) *Plant Life of Western Australia*. Kangaroo Press, Perth.
- Beard, J. S. (1975). Pilbara. Explanatory Notes and Map Sheet 5, 1:1 000 000 series Vegetation Survey of Western Australia. University of Western Australia Press: Nedlands.
- BHP Billiton Iron Ore (2010) *Guidance for Vegetation and Flora Surveys in the Pilbara Region*. Unpublished guidance statement prepared by BHP Billiton Iron Ore.
- BHP Billiton Iron Ore (2011) *OB25 Gatehouse Vegetation and Flora Survey*. Report prepared for BHP Billiton Iron Ore.
- BHP Iron Ore Environment Department (2000) *Orebody 25 Priority Flora Species Survey*. Report prepared for BHP Billiton Iron Ore.
- Biota Environmental Sciences (2001) *Baseline Biological and Soil Surveys and Mapping for ML244SA West of the Fortescue River*. Report prepared for BHP Billiton Iron Ore.
- Bureau of Meteorology (2015), *Climate Statistics for Australian Locations: Newman*.
- Department of Environment (DoE) (2012) *Interim Biogeographic Regionalisation for Australia, Revision 7*. Online at: <http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html#ibra>
- Department of Environment (DoE) (2015) *Interactive Environmental Database Reporting Tool Search*. www.environment.gov.au
- Department of Parks and Wildlife (DPaW) (2014a) *Threatened and Priority Flora Database Search*.
- Department of Parks and Wildlife (DPaW) (2014b) *List of Threatened Ecological Communities on the Department of Parks and Wildlife's Threatened Ecological Community (TEC) Database endorsed by the Minister for the Environment*. WA Threatened Species and Communities Unit, Department of Parks and Wildlife.
- Department of Parks and Wildlife (DPaW) (2014c) *List of Priority Ecological Communities on the Department of Parks and Wildlife's PEC Database endorsed by the Minister for the Environment*. WA Threatened Species and Communities Unit, Department of Parks and Wildlife.
- Ecologia Environment (1995) *Orebody 25 Biological Assessment Survey*. Report prepared for BHP Billiton Iron Ore.

- Ecologia Environment (1998) *Orebody 23 Extension Biological Assessment Survey*. Report prepared for BHP Billiton Iron Ore.
- Ecologia Environment (2004a) *Orebodies 18, 23 and 25 Flora and Fauna Review*. Report prepared for BHP Billiton Iron Ore.
- Ecologia Environment (2004) *Eastern Ophthalmia Range Biological Survey*. Report prepared for BHP Billiton Iron Ore.
- Ecologia Environment (2004) *OB24 Expansion Biological Survey*. Report prepared for BHP Billiton Iron Ore.
- Ecologia Environment (2005) *Orebody 25 Biological Review and Environmental Impact Assessment*. Report prepared for BHP Billiton Iron Ore.
- ENV Australia (2006a) *OB24 Flora and Fauna Assessment Phase II*. Report prepared for BHP Billiton Iron Ore.
- ENV Australia (2006b) *Mt Whaleback Flora and Vegetation Assessment – Phase 3 Summary Report*. Report prepared for BHP Billiton Iron Ore.
- ENV Australia (2007) *RGP4 Orebody 25 Rail Spur Siding Declared Rare and Priority Flora Survey*. Report prepared for BHP Billiton Iron Ore.
- ENV Australia (2009a) *Orebody 25 to Newman Flora and Vegetation Assessment*. Report prepared for BHP Billiton Iron Ore.
- ENV Australia (2009b) *Homestead Creek Culvert Flora and Vegetation Assessment*. Report prepared for BHP Billiton Iron Ore.
- ENV Australia (2010) *Area C West NVCP Flora, Vegetation and Fauna Assessment*. Report prepared for BHP Billiton Iron Ore.
- ENV Australia (2012) *Eastern Ridge (OB 23/24/25) Flora and Vegetation Report*. Report prepared for BHP Billiton Iron Ore.
- Environmental Protection Authority (EPA) (2000) *Environmental Protection of Native Vegetation in Western Australia: Clearing of Native Vegetation with Particular Reference to Agricultural Areas, Position Statement No. 2*, EPA, Perth.
- Environmental Protection Authority (EPA) (2002) *Terrestrial Biological Surveys as an Element of Biodiversity Protection, Position Statement No. 3*, EPA, Perth.
- Environmental Protection Authority (EPA) (2004) *EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia, No. 51*, EPA, Perth.
- GHD (2008) *Report for Myopic Project Area, Newman Flora and Fauna Assessment*. Report prepared for BHP Billiton Iron Ore.
- Hussey, B. M. J., Keighery, G. J., Cousens, R. D., Dodd, J. and Lloyd, S. G. (1997) *Western Weeds*. The Plant Protection Society of Western Australia and Agriculture Western Australia. Kensington, W.A.
- International Union for Conservation of Nature (IUCN) (2015) *Interactive Environmental Database Reporting Tool Search*, performed February 2014. www.iucn.org
- Keighery, B. J. (1994) *Bushland Plant Survey: a Guide to Plant Community Survey for the Community*. Wildflower Society of WA (Inc.), Nedlands, Western Australia.

- Kendrick (2001) Bioregion: Pilbara 3 Subregion (PIL3). Department of Conservation and Land Management, Perth.
- McKenzie, N.L., May, J.E. and McKenna, S. (2003) *Bioregional Summary of the 2002 Biodiversity Audit for Western Australia*, The National Land and Water Resources Audit and the Western Australian Department of Conservation and Land Management, Perth, Western Australia.
- Muir, B. (1995) *Field Monitoring of Vegetation Health*. In *Management of Groundwater Dependent Vegetation in the Central Pilbara Iron Ore Mining Province*, ed. The University of Western Australia.
- O'Brien, B.J. and Associates Pty. Ltd. (1992) Marandoo Iron ore Mine and Central Pilbara Railway. Environmental Review and Management Programme. Report to Hamersley Iron Pty. Ltd.
- Onshore Environmental (2009) *Biological Survey Myopic Exploration Leases*. Report prepared for BHP Billiton Iron Ore.
- Onshore Environmental (2011) *Targeted Survey for Rhagodia sp. Hamersley (Priority 3) OB25 Gatehouse*. Report prepared for BHP Billiton Iron Ore.
- Onshore Environmental (2012) *Targeted Significant Flora Survey and Vegetation Mapping of Homestead Creek*. Report prepared for BHP Billiton Iron Ore.
- Onshore Environmental (2013a) *Targeted Flora and Vegetation Survey Orebody 24*. Report prepared for BHP Billiton Iron Ore.
- Onshore Environmental (2013b) *OB19 Level 2 Flora and Vegetation Survey*. Report prepared for BHP Billiton Iron Ore.
- Onshore Environmental (2014a) *Mt Whaleback OB29/30/25 Targeted Flora Survey Assessment*. Report prepared for BHP Billiton Iron Ore.
- Onshore Environmental (2014b) *Western Ridge Flora and Vegetation and Vertebrate Fauna Survey*. Report prepared for BHP Billiton Iron Ore.
- Onshore Environmental (2014c) Consolidation of Regional Vegetation Mapping BHP Billiton Iron Ore Pilbara Tenure. Prepared for BHP Billiton Iron Ore.
- Onshore Environmental and Biologic Environmental Surveys (2009) *Flora and Vegetation Survey and Fauna Mt Whaleback Mine Site*. Report prepared for BHP Billiton Iron Ore.
- RPS (2015) Eastern Ridge Mining Operations Amalgamation: Surface Water Environmental Impact Assessment. Report prepared for BHP Billiton Iron Ore.
- Shepherd, D.P., Beeston, G.R., and Hopkins, A.J.M. (2002) Native Vegetation in Western Australia. Technical Report 249. Department of Agriculture, Western Australia, South Perth.
- Specht R.L. (1970) Vegetation. In *The Australian Environment*. 4th edn (Ed. G.W. Leeper). Melbourne.
- Tille, P. (2007) Soil-landscapes of Western Australia's rangelands and arid interior. Resource management technical report 313. Department of Agriculture and Food.
- Trudgen, M.E. (2009) BHP Billiton Iron Ore – Vegetation classification system for utilisation in the Pilbara Bioregion. Professional advice provided to BHP Billiton Iron Ore.

- Tyler IM, Hunter WM & Williams IR (1991) Geological Survey of Western Australia 1:250000 Geological Series – Explanatory Notes Newman, Perth Western Australia
- 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.
- Western Australian Herbarium (WAH) (2015) *Florabase – Information on the Western Australian flora*. Department of Parks and Wildlife. Online: <http://florabase.dpaw.wa.gov.au> [February 2015].

APPENDIX 1

Conservation Codes for Western Australian Flora

T: Threatened (Declared Rare) Flora - Extant Taxa

Taxa which have been adequately searched for, and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.

1: Priority One - Poorly Known Taxa

Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.

2: Priority Two - Poorly Known Taxa

Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.

3: Priority Three - Poorly Known Taxa

Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.

4: Priority Four - Rare, Near Threatened and other taxa in need of monitoring

- (a) **Rare.** Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.
- (b) **Near Threatened.** Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.
- (c) Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

5: Priority Five - Conservation Dependent taxa

Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxa becoming threatened within five years.

APPENDIX 2

Conservation categories for flora described
under the EPBC Act

Category	Description
Extinct	A species is extinct if there is no reasonable doubt that the last member of the species has died.
Extinct in the Wild	A species is categorised as extinct in the wild if it is only known to survive in cultivations, in captivity, or as a naturalised population well outside its past range; or if it has not been recorded in its known/expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered	The species is facing an extremely high risk of extinction in the wild and in the immediate future.
Endangered	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival, or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Conservation Dependent	The species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

APPENDIX 3

Vegetation Classifications for the Pilbara based on Specht (1970), as modified by Aplin (1979) and Trudgen (2009)

Height Class	Canopy Cover				
	100 - 70%	70 - 30%	30 - 10%	10 - 2%	< 2%
Trees > 30 m	High Closed Forest	High Open Forest	High Woodland	High Open Woodland	Scattered Tall Trees
Trees 10-30 m	Closed Forest	Open Forest	Woodland	Open Woodland	Scattered Trees
Trees < 10 m	Low Closed Woodland	Low Open Forest	Low Woodland	Low Open Woodland	Scattered Low Trees
Mallee	Closed Mallee	Mallee	Open Mallee	Very Open Mallee	Scattered Mallees
Shrubs > 2 m	Closed Scrub	Open Scrub	High Shrubland	High Open Shrubland	Scattered Tall Shrubs
Shrubs 1-2 m	Closed Heath	Open Heath	Shrubland	Open Shrubland	Scattered Shrubs
Shrubs < 1 m	Low Closed Heath	Low Open Heath	Low Shrubland	Low Open Shrubland	Low Scattered Shrubs
Hummock Grass	Closed Hummock Grassland	Hummock Grassland	Open Hummock Grassland	Very Open Hummock Grassland	Scattered Hummock Grass
Tussock Grass	Closed Tussock Grassland	Tussock Grassland	Open Tussock Grassland	Very Open Tussock Grassland	Scattered Tussock Grass
Bunch Grass	Closed Bunch Grassland	Bunch Grassland	Open Bunch Grassland	Very Open Bunch Grassland	Scattered Bunch Grass
Sedges	Closed Sedges	Sedges	Open Sedges	Very Open Sedges	Scattered Sedges
Herbs	Closed Herbs	Herbs	Open Herbs	Very Open Herbs	Scattered Herbs

Source: S. Van Leeuwen (DPaW)

APPENDIX 4

Vegetation condition scale
(as developed by Keighery 1994)

Condition	Code	Description
Pristine	1	Pristine or nearly so, no obvious signs of disturbance.
Excellent	2	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	3	Vegetation structure altered; obvious signs of disturbance.
Good	4	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it.
Degraded	5	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching Very Good condition without intensive management.
Completely Degraded	6	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species.