RioTinto

Environmental Review Document

Mesa A Hub Revised Proposal

Assessment No. 2107

EPBC 2016/7843

Prepared for Rio Tinto by Eco Logical Australia

RTIO-HSE-0325438

Robe River Mining Co. Pty. Ltd.

December 2018

Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this Proposal.

Robe River Mining Co. Pty. Ltd proposes to extend the life of the Mesa A/Warramboo Iron Ore Project through further development of the existing Mesa A and Warramboo operations and development of nearby deposits: Highway, Tod Bore, Mesa B and Mesa C. The Environmental Review Document (ERD) has been prepared in accordance with the EPA's ***Procedures Manual (Part IV Divisions 1 and 2)***. The ERD is the report by the proponent on their environmental review which describes this Proposal and its likely effects on the environment.

The ERD is available for a public review period of two weeks from Monday 10 December, closing on Monday 24 December 2018.

Information on the Proposal from the public may assist the EPA to prepare an assessment report in which it will make recommendations on the Proposal to the Minister for Environment.

Why write a submission?

The EPA seeks information that will inform the EPA's consideration of the likely effect of the Proposal, if implemented, on the environment. This may include relevant new information that is not in the ERD, such as alternative courses of action or approaches.

In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information.

Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992*.

Why not join a group?

It may be worthwhile joining a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on information in the ERD.

When making comments on specific elements in the ERD:

- Clearly state your point of view and give reasons for your conclusions.
- Reference the source of your information, where applicable.
- Suggest alternatives to improve the outcomes on the environment.

What to include in your submission

Include the following in your submission to make it easier for the EPA to consider your submission:

- Your contact details – name and address.
- Date of your submission
- Whether you want your contact details to be confidential.
- Summary of your submission, if your submission is long.
- List points so that issues raised are clear, preferably by environmental factor.
- Refer each point to the page, section and if possible, paragraph of the ERD.
- Attach any reference material, if applicable. Make sure your information is accurate.

The closing date for public submissions is: Monday 24 December 2018.

The EPA prefers submissions to be made electronically via the EPA's Consultation Hub at https://consultation.epa.wa.gov.au.

Alternatively submissions can be:

- posted to: Chairman, Environmental Protection Authority, Locked Bag 33, Cloisters Square WA 6850, or
- delivered to: the Environmental Protection Authority, Level 4, The Atrium, 168 St Georges Terrace, Perth 6000.

If you have any questions on how to make a submission, please contact the EPA Services at the Department of Water and Environmental Regulation on 6364 7000.

Disclaimer and Limitation

This report has been prepared by Rio Tinto's Iron Ore group (**Rio Tinto**), on behalf of Robe River Mining Co. Pty. Ltd (the **Proponent**), specifically for the Mesa A Hub Revised Proposal. Neither the report nor its contents may be referred to without the express approval of Rio Tinto, unless the report has been released for referral and assessment of proposals.

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Acronyms

Abbreviation	Description
AH Act	*Aboriginal Heritage Act 1972*
AHD	Australian Height Datum
Air NEPM	National Environment Protection Measure for Ambient Air Quality
AMD	Acid and metalliferous drainage
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BHP	BHP Billiton
BWT	Below Water Table
CID	Channel Iron Deposit
CPI	Consumer Price Index
DAA	Department of Aboriginal Affairs
DBCA	Department of Biodiversity, Conservation and Attractions
DBP	Dampier Bunbury Pipeline
DEWHA	Department of the Environment, Water, Heritage and Art
DJTSI	Department of Jobs, Tourism, Science and Innovation
DMA	Decision Making Authorities
DMP	Department of Mines and Petroleum
DMIRS	Department of Mines, Industry Regulation and Safety
DoE	Department of the Environment
DotEE	Department of the Environment and Energy
DPC	Department of the Premier and Cabinet
DPLH	Department of Planning, Lands and Heritage
DRF	Declared Rare Flora
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
DWER	Department of Water and Regulation
EC	Electrical Conductivity
EMP	Environmental Management Plan
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPA Services	Environmental Protection Authority Services
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
ERD	Environmental Review Document
ESD	Environmental Scoping Document
EWR	Environmental Water Requirements
GDE	Groundwater Dependent Ecosystem
GIS	Geographical Information System

Abbreviation	Description
HTP	Hardcap Pisolite
IBRA	Interim Biogeographical Regionalisation for Australia
IUCN	International Union for Conservation of Nature
KMAC	Kuruma Marthudunera Aboriginal Corporation
KN	Nanutarra Formation
LIC	Local Implementation Committee
LoM	Life of Mine
MEZ	Mining Exclusion Zone
MNES	Matters of Environmental and National Significance
MS 756	Ministerial Statement 756
NGER Act	*National Greenhouse and Energy Reporting Act 2007*
NTU	Nephelometric Turbidity Unit
PAF	Potentially Acid Forming
Parks and Wildlife	Department of Biodiversity, Conservation and Atractions - Parks and Wildlife Service (Previously known as the Department of Parks and Wildlife)
PEC	Priority Ecological Community
PPV	Peak Particle Velocity
Proponent	Robe River Mining Co. Pty. Ltd.
RTIO	Rio Tinto
Sand Sheet PEC	Priority 3 Sand Sheet Vegetation (Robe Valley) Priority Ecological Community
SCARD	Spontaneous Combustion and Acid Rock Drainage
SRE	Short Range Endemics
TDS	Total dissolved solids
TEB	Terrestrial Ecosystems Branch
TEC	Threatened Ecological Community
the Fund	Pilbara Environmental Offsets Fund
TMP	Troglofauna Management Plan
TPB	Basal Pisolite
TPC	Pisolite Clay
TPH	Upper Pisolite
TPM	Mixed/Massive Pisolite
VIA	Visual Impact Assessment
WA	Western Australia
WA Museum	Western Australian Museum
WC Act	*Wildlife Conservation Act 1950*
WFSF	Waste Fines Storage Facility

EXECUTIVE SUMMARY

Robe River Mining Co. Pty. Ltd. (the Proponent) operates the existing Mesa A/Warramboo Iron Ore Project located approximately 43 kilometres (km) west of Pannawonica in the Pilbara region of Western Australia (Figure ES 1). The Proponent is seeking to extend the life of the Mesa A/Warramboo Iron Ore Project through further development of existing operations and development of new deposits nearby. This will sustain the Mesa A/Warramboo Iron Ore Project total ore feed at up to 25 million tonnes per annum. This sustaining proposal is referred to as the Mesa A Hub Revised Proposal (the Revised Proposal) and is contained within a Development Envelope which includes the existing approved Mesa A/Warramboo Iron Ore Project (Figure ES 2).

The Revised Proposal is a revision of the existing Mesa A/Warramboo Iron Ore Project. The Proposed Change includes extension of the existing above water table Mesa A mine pit, extension of the existing above water table Warramboo Mine pit both above and below water table, and development of new nearby deposits: Highway/Tod Bore (above water table), Mesa B (above water table) and Mesa C (above and below water table) in the mine operations area (Figure ES 3). The Proposed Change also includes development of associated infrastructure, water treatment facilities, extension of the existing Warramboo borefield, processing facilities, water management infrastructure and mineral waste dumps. The Proposed Change will be undertaken in the western portion of the Development Envelope (Figure ES 2).

Mining is anticipated to involve conventional drill, blast, load and haul techniques; with mine dewatering required at Mesa C and Warramboo to facilitate below water table mining. Surplus water generated from dewatering the Warramboo deposit will be used on-site and for wet processing or, where scheduling does not allow this, it will be discharged by controlled release to Warramboo Creek, south-west of the proposed operations. To assist in the management of surplus water discharge to Warramboo Creek, surplus water may also be discharged into existing mine pits at Warramboo enabling passive recharge of water back into the aquifer.

The existing Mesa A/Warramboo Iron Ore Project includes a Mining Exclusion Zone (MEZ) to protect the integrity of the Priority 3 *Sand Sheet Vegetation (Robe Valley) Priority Ecological Community* (Sand Sheet PEC); retain troglofauna habitat; protect the integrity of the Mesa A escarpment and its fauna habitat, landscape and heritage values. The existing Mesa A MEZ requires a small revision as part of the Proposed Change, to accommodate preferential mining of higher quality ore, additional access and other minor clearing, while still maintaining the values as described above.

The Western Australian Environmental Protection Authority (EPA) has determined that the Proposed Change requires assessment under Part IV of the *Environmental Protection Act 1986*, which provides for the EPA to undertake Environmental Impact Assessment of significant proposals, strategic proposals and land use planning schemes. The Commonwealth Department of the Environment and Energy determined that the Proposed Change is a Controlled Action for listed threatened species and therefore requires assessment under the *Environment Protection and Biodiversity Conservation Act 1999*. The EPA is assessing the Proposed Change on behalf of the Commonwealth under Section 87 of this Act as an accredited assessment.

The purpose of this Environmental Review Document is to provide a report on the environmental review for the Revised Proposal to the EPA. The scope of the

Environmental Review Document is to present an environmental review of the principal components of the Proposed Change, including a detailed impact assessment and description of proposed environmental management measures for the key environmental factors in accordance with the Environmental Scoping Document prepared by the EPA. This Environmental Review Document has been prepared in accordance with the Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA 2016a) to meet the requirements of Section 40(2)(b) of the *Environmental Protection Act 1986*.

The preliminary key environmental factors relevant to the Proposed Change are (as outlined in the Environmental Scoping Document):

- Flora and Vegetation
- Subterranean Fauna
- Terrestrial Fauna
- Hydrological Processes and Inland Waters Environmental Quality
- Landforms
- Social Surroundings.

During the course of preparation of the Environmental Review Document, 'Air Quality' was requested to be included as an ‘Other Environmental Factor’ by EPA Services.

The Development Envelope for the Revised Proposal lies within the western Pilbara region, where the key landscape features are the watercourses, with associated pools (Robe River), locally significant riparian vegetation communities (Robe River and Warramboo Creek); and mesa formations which host gorges and rocky hills/breakaway fauna habitats. These landscape features occur in the Development Envelope, providing shelter and foraging opportunities for fauna (in particular fauna that are Matters of National Environmental Significance), including aquatic and cave habitats; habitat for subterranean fauna (troglofauna and stygofauna), and have heritage and amenity values. The Development Envelope also contains three Priority Ecological Communities being: Priority 3 PEC; *Sand Sheet Vegetation* [*Robe Valley*], Priority 1 PEC; *the Subterranean invertebrate community of mesas in the Robe Valley region* and the Priority 1 PEC; the Subterranean invertebrate community of pisolitic hills in the Pilbara.

The main Proposal activities that involve interactions between preliminary key environmental factors, and have the potential to impact significant environmental values, are land disturbance, mine pit excavation, abstraction of groundwater and discharge of surplus water. The Proponent has applied the mitigation hierarchy in the *Western Australian Environmental Offsets Guidelines* (2014) for all proposed activities, to reduce the potential for significant impacts to environmental values as a result of the Proposed Change. The Proposed Change design has focussed on avoiding potentially significant impacts to the environment. After avoidance strategies have been considered, mitigation measures have then been investigated to reduce the remaining significant impacts to an acceptable level.

One of the key features of the Proposed Change design to achieve this outcome is the delineation of a MEZ, which ensures the preservation of the mesa escarpments, through limiting clearing in this area while allowing mining of the internal mesa plateau. This approach is expected to protect a number of key environmental, heritage and amenity values in particular:

- **Subterranean Fauna**
  - Retention of at least 50% by volume of connected pre-mining troglofauna habitat at Mesas A, B and C
- **Terrestrial Fauna**
  - Retention of key habitat features for significant fauna
- **Landforms**
  - Preservation of the prominence, scale and structural integrity of the mesas in the landscape
- **Social Surroundings**
  - Retention of key heritage sites.

An overview of the Proposed Change, including the key Proposal characteristics, is provided in Table ES 1 and Table ES 2, and a full summary of the Environmental Review including the potential impacts, proposed mitigation and avoidance and residual impacts for each key environmental factor is provided in Table ES 3. A brief summary of the key outcomes of the Environmental Review is provided below.

The Proposed Change will involve the unavoidable clearing of 3,000 hectares (ha) of Good to Excellent condition native vegetation. There will be no direct disturbance to the Sand Sheet PEC as part of this clearing. The Proposed Change also avoids almost all direct disturbance of riparian vegetation associated with the Robe River and Warramboo Creek. The effects of groundwater abstraction and dewatering have been modelled extensively and no irreversible impact on riparian vegetation is anticipated because of dewatering or surplus water discharge. Ongoing monitoring of key environmental values will be undertaken to ensure that no unforeseen impacts occur from dewatering and surplus water discharge and that the significant river and creek systems near the Development Envelope are protected.

The troglofauna and stygofauna habitat present within each deposit is well connected and extends beyond the proposed impact areas. The proposed mitigation strategies for the Proposed Change, including the continuation of the MEZ approach adopted at Mesa A, are expected to be effective in reducing the potential for impacts to subterranean fauna. They should ensure the proposed mining at each deposit can be conducted such that the ecological integrity of troglofauna and stygofauna habitat, as well as the diversity and ecological integrity of the troglofauna and stygofauna assemblages present, are unlikely to be significantly impacted.

The Proponent considers the residual impact associated with the unavoidable clearing of native vegetation in Good to Excellent condition and clearing of two subterranean fauna community PECs and riparian vegetation to be significant. The Proponent proposes the provision of an environmental offset ($750 per hectare) for the unavoidable clearing of native vegetation in Good to Excellent condition, and an environmental offset at the higher offset rate ($1,500 per hectare) for the unavoidable clearing of two subterranean fauna community PECs and riparian vegetation. Based on the proposed avoidance of significant areas, proposed mitigation strategies and the continued implementation of existing management strategies (including offsets for the three identified potentially significant residual impacts), the Proponent considers that the EPA objectives can be met for all environmental factors. The Proposed Change is environmentally acceptable and can be adequately managed through the draft Ministerial Statement for the Revised Proposal.





LEGEND

- Rio Tinto Mine
- Rio Tinto Port
- Deposit
- Town
- Rio Tinto Railway
- Highway
- Major Road
- National Park

Rio Tinto

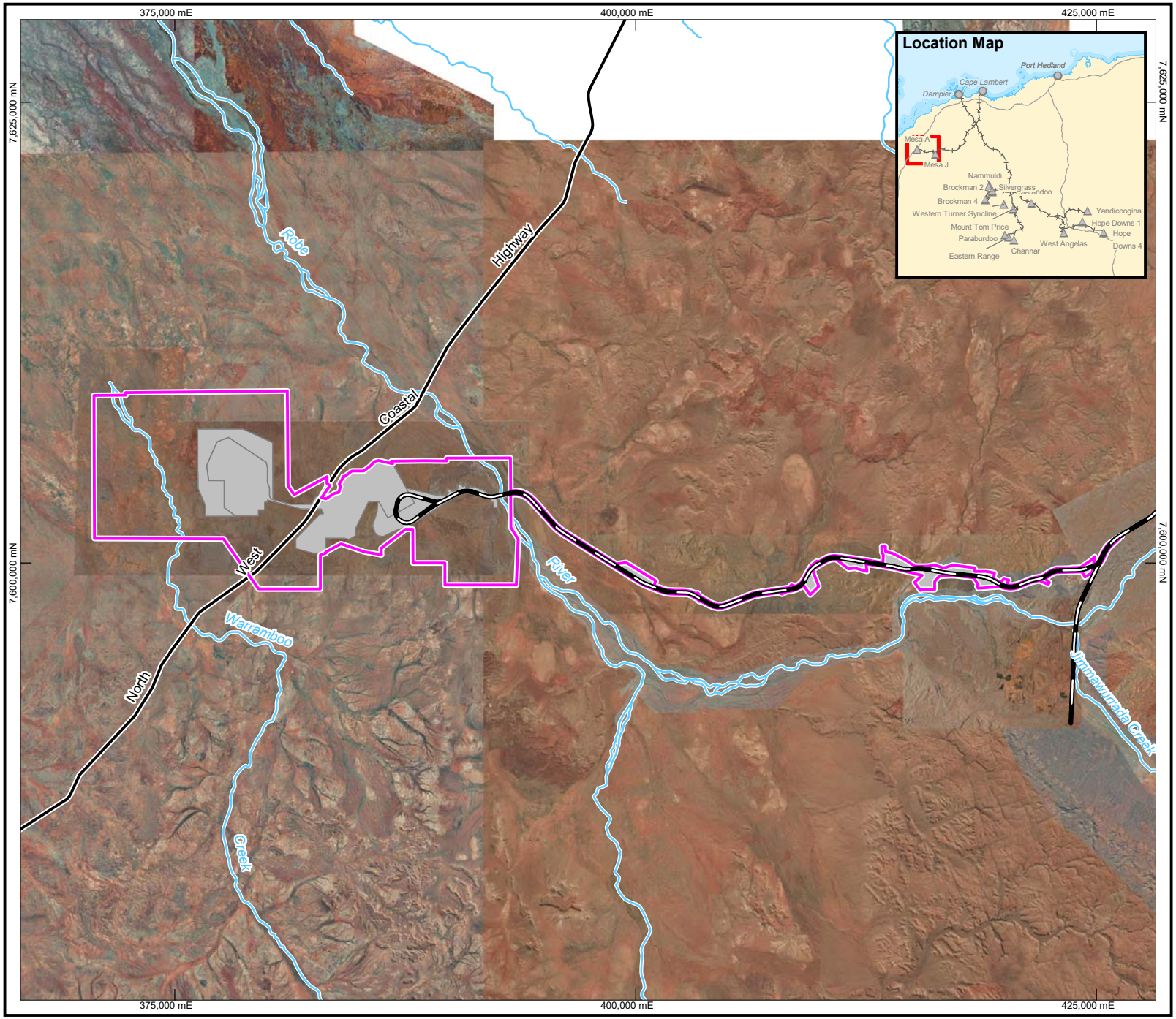
Iron Ore (WA)

Figure ES 1: Regional Location

Drawn: GIS Team
Date: July, 2018

Plan No: PDE0149312v2
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse

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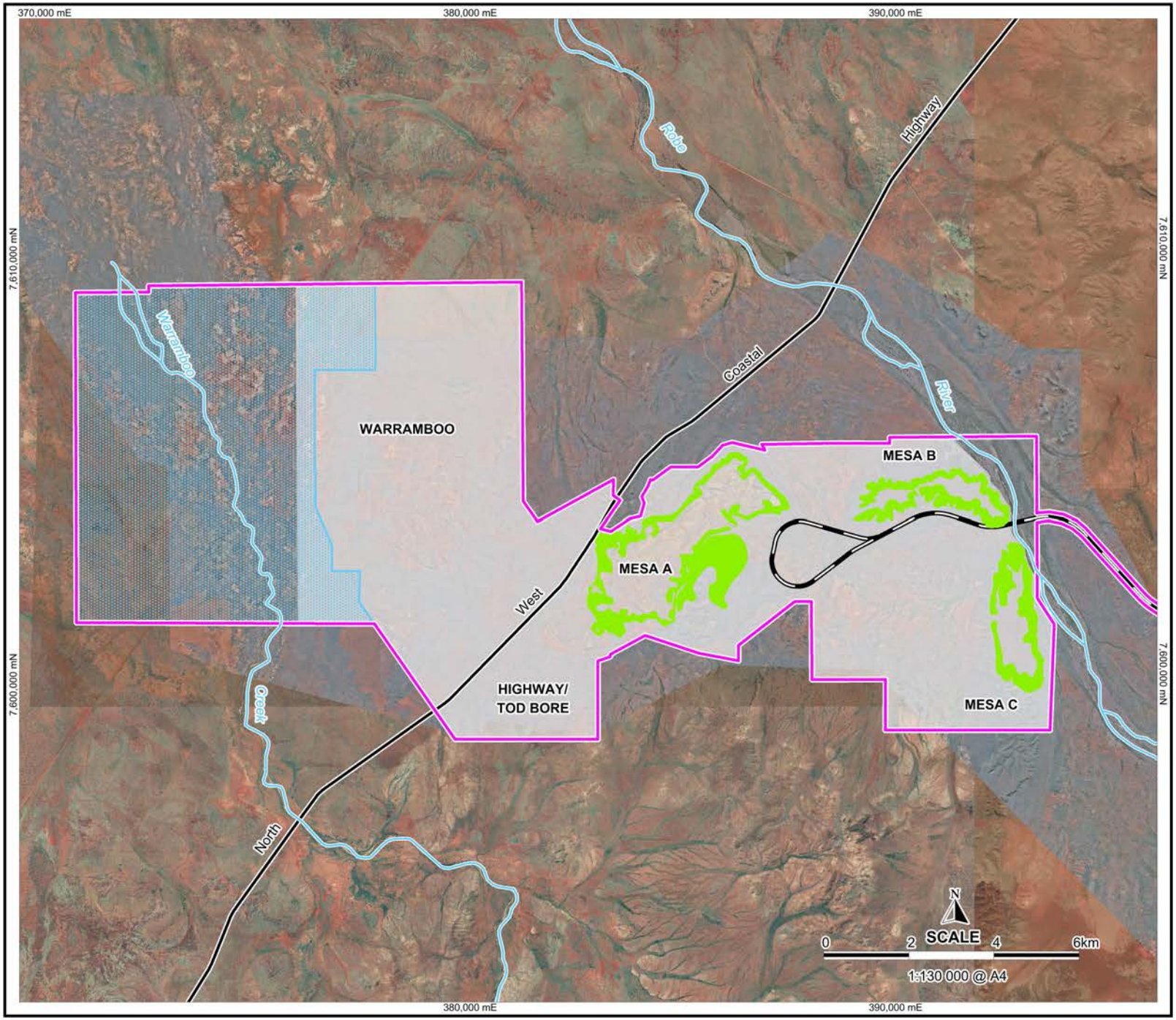
Iron Ore (WA)

Figure ES 2: Development Envelope

Drawn: T.Murphy
Date: Aug, 2018

Plan No: PDE0149313v5
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Proposed Mining Exclusion Zone
- Proposed mine operations area
- Proposed borefield extension area
- Rio Tinto Railway
- Highway
- Major Watercourse

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Iron Ore (WA)

Figure ES 3: Revised Proposal

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164288v1
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

Table ES 1: Summary of the Revised Proposal

Proposal title	Mesa A Hub Revised Proposal
Proponent name	Robe River Mining Co. Pty. Ltd.
Short description	The Revised Proposal includes the existing Mesa A/Warramboo Iron Ore Project and a revision which includes development of additional mine pits and associated infrastructure, water treatment facilities, processing facilities and water management infrastructure, as well as expansion of existing mine pits, waste dumps and associated infrastructure.

Table ES 2: Location and proposed extent of physical and operational elements

Element	Location	Existing approval (Ministerial Statement/s and other regulatory approvals)	Proposed Change	Proposed extent (Mesa A Hub Revised Proposal)
Physical elements				
Mine and associated infrastructure	Figure ES 2	Not more than 3,680 ha (with the exception of clearing in the MEZ, other than the approved portal and other infrastructure as per Figure 2 and Figure 4 of MS 756).	Clearing of no more than 3,000 ha of native vegetation within the Development Envelope of 16,834 ha. Disturbance in the defined Mesa A Mining Exclusion Zone limited to 42 ha, including mining (33 ha), widening of the existing escarpment cut (2 ha) and installation of infrastructure (7 ha). Clearing in the Mesa B and Mesa C Mining Exclusion Zones in accordance with the Environmental Management Plan.	Clearing of up to 6,680 ha within the Development Envelope of 16,834 ha. Disturbance in the Mesa A Mining Exclusion Zone limited to that for the portal and other infrastructure as approved under MS 756 plus additional disturbance limited to 42 ha, including mining (33 ha), widening of the escarpment cut (2 ha) and installation of infrastructure (7 ha). Clearing in the Mesa B and Mesa C Mining Exclusion Zones in accordance with the Environmental Management Plan.
Infrastructure corridor	Figure ES 2		No change	
Mining depth	Figure ES 3	Above water table.	Above water table at Mesa A, Mesa B and Highway/Tod Bore. Above and below water table at Warramboo and Mesa C.	Above water table at Mesa A, Mesa B, and Highway/Tod Bore. Above and below water table at Warramboo and Mesa C.
Operational elements				
Water supply and Warramboo dewatering	Figure ES 3	3 gigalitres per annum (GL/a) (licensed under *Rights in Water and Irrigation Act 1914*)	Abstraction of no more than 15 GL/a (including the current licensed abstraction of 3 GL/a) of groundwater from the Warramboo dewatering (excludes surface water inflow due to rainfall events) and water supply borefield.	Abstraction of no more than 15 GL/a of groundwater from the Warramboo dewatering (excludes surface water inflow due to rainfall events) and water supply borefield.

Element	Location	Existing approval (Ministerial Statement/s and other regulatory approvals)	Proposed Change	Proposed extent (Mesa A Hub Revised Proposal)
Mesa C dewatering	Figure ES 3	-	Abstraction of no more than 5 GL/a of groundwater from the Mesa C Channel Iron Deposit (CID) aquifer (excludes surface water inflow due to rainfall events).	Abstraction of no more than 5 GL/a of groundwater from the Mesa C CID Aquifer (excludes surface water inflow due to rainfall events).
Surplus water management	Figure ES 3	-	Use on-site, in processing, passive recharge via completed mine pits, and controlled surface discharge to Warramboo Creek. Controlled surface discharge from the Proposed Change to extend along Warramboo Creek no further than 8 km downstream of the discharge point under natural no-flow conditions.	Use on-site, in processing, passive recharge via completed mine pits, and controlled surface discharge to Warramboo Creek. Controlled surface discharge from the Revised Proposal to extend along Warramboo Creek no further than 8 km downstream of the discharge point under natural no-flow conditions.
Ore processing (waste)	Figure ES 3	-	In-pit disposal of waste fines at Warramboo.	In-pit disposal of waste fines at Warramboo.

Table ES 3: Summary of potential impacts, proposed mitigation and outcomes

Flora and Vegetation	
EPA Objective	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Policy and guidance	**EPA policy and guidance** • EPA Cumulative environmental impacts of development in the Pilbara region: Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the Environmental Protection Act 1986 (2014) • Department of Mines and Petroleum and EPA Guidelines for Preparing Mine Closure Plans (2015) • EPA Statement of Environmental Principles, Factors and Objectives (2016) • EPA Environmental Factor Guideline: Flora and Vegetation (2016) • EPA Environmental Factor Guideline - Inland Waters Environmental Quality (2016) • EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (2016) • EPA Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (2016). **Other policy and guidance** • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014).
Potential impacts	**Direct impacts** • Loss of vegetation due to clearing • Loss of conservation significant flora due to clearing. **Indirect impacts** • Loss or degradation of riparian vegetation as a result of groundwater drawdown • Loss or degradation of riparian vegetation as a result of surface water discharge • Degradation of vegetation due to ingress of weeds • Degradation of vegetation due to increased dust deposition.
Mitigation	**Avoid:** • The Proposed Change has been designed to avoid direct disturbance to the Sand Sheet PEC (excluding impacts within the buffer) • The Proposed Change has been designed to avoid known locations of Priority Flora as far as practicable

	• Clearing will only occur in approved ground disturbance areas • Strict hygiene procedures will be implemented to prevent introduction of new or additional populations of weed species into the Development Envelope. **Minimise:** • The clearing footprint has been reduced to the smallest practicable through project optimisation to reduce the extent of clearing required • Abstracted groundwater will be used on-site for processing and dust suppression to reduce the need for discharge. Hydrogeological modelling has been and will continue to be undertaken to facilitate understanding of current and future abstraction requirements • Groundwater abstraction will remain within licence limits and will be minimised to that required to access the below water table resource and meet water supply requirements • The *Melaleuca argentea* dominated communities and the *Melaleuca argentea* and *Eucalyptus camaldulensis* co-dominated community along the Robe River and the *Eucalyptus camaldulensis* dominated community along Warramboo Creek will be monitored to ensure no irreversible impacts to the health of riparian vegetation occur as a result of dewatering. If required, appropriate mitigation measures will be implemented in accordance with the EMP • Surplus water will be discharged at a rate that is not expected to cause bank erosion • Riparian vegetation within the discharge extent will be monitored to ensure there are no irreversible impacts to riparian vegetation health as a result of surplus water discharge. If required, appropriate mitigation measures will be implemented in accordance with the EMP • Weed control will be undertaken annually in the Development Envelope to minimise weed infestations • The Sand Sheet PEC will continue to be monitored to provide an indication of vegetation condition, community structure and diversity. If required, appropriate mitigation measures will be implemented in accordance with the EMP • The proposed haul road and construction haul road have been designed such that they are located as far from the Sand Sheet PEC as practicable to reduce potential for impacts of dust on the Sand Sheet PEC • The Proponent will implement dust controls including water sprays, dust suppressants and other measures to minimise the extent of dust deposition on vegetation. **Rehabilitate:** • Disturbed areas will be rehabilitated to create a safe, stable and non-polluting landscape revegetated with native species, to maximise environmental and cultural heritage outcomes and ensure the site does not adversely impact on the current surrounding land use. • The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA Guidelines for Preparing Mine Closure Plans. Indicative completion criteria include: o Seed used in rehabilitation works is of local provenance (except where seed pre-dates accurate recording of area) o Native plants within rehabilitated areas are observed to flower and/or fruit o Recruitment of native perennial plants is observed

	o Species richness of native perennial plants within rehabilitated areas is not less than reference sites o Any weed species recorded within rehabilitation areas are present within the local area o Erosion from landforms does not threaten surrounding significant natural ecosystems.
Outcomes	**Residual Impact**: The Proposed Change is expected to result in the unavoidable loss of up to 3,000 ha of vegetation. No disturbance will occur to the Sand Sheet PEC. Disturbance to five vegetation units of high local significance; ChAbAtrTw, EcEvMgAtrCv, AanAbAsyTP, AanAiAatAbTP and CcAanTe will be limited to between 1%-9% of the extent of each of these vegetation types in the western portion of the Development Envelope and disturbance of individuals of the four Priority Flora species will be limited to between 1% - 5% of records in the Rio Tinto database. The Proposed Change involves clearing of 8 ha of riparian vegetation along Warramboo Creek to facilitate installation of the surplus water discharge point. Drawdown of the Mesa C CID aquifer is not expected to result in observable changes to groundwater levels within the Robe River Alluvial Aquifer. Potential indirect impacts from dewatering and surface water discharge into Warramboo Creek may occur, however; no irreversible impact on riparian vegetation is anticipated. Although there may be impacts to the riparian vegetation along Warramboo Creek from both drawdown and discharge, the low flow channel and alluvial substrate will remain and the functionality of the community is expected to be maintained. Ongoing monitoring of key environmental values along the affected areas of Warramboo Creek will be undertaken to ensure that no unforeseen impacts occur. The Proponent considers that the residual impact from the direct clearing of up to 3,000 ha of native vegetation in Good to Excellent condition, including approximately 8 ha of riparian vegetation is significant and warrants an offset. After the mitigation hierarchy has been applied, including avoidance and minimisation of direct impacts to key flora and vegetation values and the proposed offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Flora and Vegetation. The proposed loss of vegetation is not expected to cause a loss of biological diversity at the local or regional scale and the ecological integrity of the area surrounding the footprint is expected to be maintained. **Offset:** The Proponent proposes the provision of an environmental offset ($750 per hectare) for the unavoidable clearing of native vegetation in Good to Excellent condition, and an environmental offset at the higher offset rate ($1,500 per hectare) for the unavoidable clearing of riparian vegetation.
Subterranean Fauna	
EPA Objective	To protect subterranean fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	**EPA Policy and guidance** • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) • EPA Statement of Environmental Principles, Factors and Objectives (2016) • EPA Environmental Factor Guideline: Subterranean Fauna (2016)

	• EPA Environmental Factor Guideline – Inland Waters Environmental Quality (2016) • EPA Technical Guidance: Sampling methods for Subterranean fauna (the content of this Guidance has not yet been updated from EPA Guidance Statement No. 54a: technical appendix to Guidance Statement No. 54) (2016) • EPA Technical Guidance: Subterranean fauna survey (2016) (the content of this Guidance has not yet been updated from EPA Guideline 12. Issued June 2013) • EPA Instructions on how to prepare an Environmental Review Document (2016) • EPA Instruction of how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (2016). **Other policy and guidance** • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014).
Troglofauna	
Potential impacts	**Direct impacts** • Reduction in troglofauna habitat due to mine pit development • Loss of individuals and changes to assemblages due to mine pit development. **Indirect impacts** • Clearing of vegetation and placement of mineral waste potentially leading to a reduction in organic inputs into the subterranean environment. Reduced organic inputs may diminish the quality of troglofauna habitat • Seepage from the WFSF will generate a saturated zone above the groundwater table, resulting in a temporary reduction in troglofauna habitat • Blasting may cause voids within the remnant mesa formations to collapse, resulting in a reduction in troglofauna habitat • Exposure of pit faces may cause changes to the temperature and humidity in the subterranean environment, potentially leading to degradation of troglofauna habitat • Hydrocarbon spills may result in a reduction in the quality of troglofauna habitat.
Mitigation	**Avoid:** • Single location and singleton troglofauna will be avoided as far as practicable and their ongoing avoidance will be ensured by the retention of a MEZ • Hydrocarbon storage and servicing and re-fuelling of plant and vehicles will not occur within the MEZs at Mesas A, B and C. **Minimise:** • The mine plan has been designed to retain at least 50% by volume of connected pre-mining troglofauna habitat at Mesas A, B and C by delineation of a MEZ (and pit floor in the case of Mesa A).

	• Clearing within the MEZs at Mesas A, B and C will be minimised and limited to infrastructure such as tracks, utilities, telecommunications, monitoring stations and abandonment bunds. • Mineral waste dumps required as part of the Proposed Change will be located either in-pit or off the mesa in order to minimise clearing in the MEZ. • The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement an EMP to ensure suitable troglofauna habitat is retained. • Troglofauna sampling will be conducted in the Warramboo and Highway/Tod Bore area and in the MEZs at Mesas A, B and C to verify persistence of troglofauna. **Rehabilitate:** • Pits will be backfilled with waste rock material where mine schedules allow and subterranean temperature and humidity at Mesa A will continue to be monitored. • The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA Guidelines for Preparing Mine Closure Plans. • The Closure Plan includes a closure objective to ensure that final landform is stable and considers ecological values and that vegetation is self-sustaining. Progressive rehabilitation will be undertaken which will assist in re-establishing nutrient flows into the subterranean environment.
Outcomes	**Residual Impact**: At least 50% by volume of connected pre-mining troglofauna habitat will be retained at Mesas A, B and C by delineation of a MEZ (and pit floor in the case of Mesa A). The mine plans for Mesas A, B and C have also been designed to avoid as many single location and singleton troglofauna as practicable and ensure their ongoing avoidance by the retention of the MEZ. The troglofauna habitat present within each deposit is well connected and extends beyond the proposed impact areas. Monitoring evidence also indicates that the Mesa A MEZ is functioning as intended, in protecting the ecological integrity of troglofauna habitat and assemblages. The proposed mitigation strategies, including the continuation of the MEZ approach adopted at Mesa A, will ensure the proposed mining at each deposit can be conducted such that the ecological integrity of troglofauna habitat, as well as the diversity and ecological integrity of the troglofauna assemblages present are unlikely to be impacted significantly. After the mitigation hierarchy has been applied, including retention of connected habitat through designation of a MEZ, the Proponent considers that the residual impact associated with the unavoidable clearing of the Priority 1 PECs is significant for the Troglofauna component of the Subterranean Fauna factor and warrants an offset. Given the proposed mitigation and offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Subterranean Fauna. **Offset:**

	The Proponent proposes the provision of an environmental offset at the higher offset rate ($1,500 per hectare) for the unavoidable clearing of areas with other environmental values: Priority Ecological Communities (the Subterranean invertebrate community of mesas in the Robe Valley region and the Subterranean invertebrate community of pisolitic hills in the Pilbara).
Stygofauna	
Potential impacts	**Direct impacts** • Reduction in stygofauna habitat due to below water table pit excavation at Warramboo and Mesa C (physical removal of habitat) • Reduction in stygofauna habitat due to groundwater abstraction resulting in groundwater drawdown at Warramboo and Mesa C • Loss of individuals and changes to assemblages due to groundwater abstraction and below water table mining at Warramboo and Mesa C. **Indirect impacts** • Seepage from in-pit disposal of waste fines and reverse osmosis effluent which has the potential to change groundwater chemistry and degrade stygofauna habitat • Hydrocarbon and wastewater spills which may result in a reduction in the quality of stygofauna habitat.
Mitigation	**Avoid:** • Additional water requirements will be sourced from an extension to the existing Warramboo borefield, avoiding the requirement for a new borefield impact area. • Placing waste fines in-pit at Warramboo avoids the need to disturb a previously undisturbed area. **Minimise:** • Dewatering will be minimised to that required to access the below water table resource. • Water from mine dewatering will be used on-site where possible to minimise the requirement for additional groundwater abstraction for operational water supply. • The Proponent will abstract groundwater within the licence limits and monitor groundwater levels to ensure impact remains within the predicted range of drawdown. If required, appropriate mitigation measures will be implemented in accordance with the EMP. • Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements. • Hydrocarbon storage will be inspected on a regular basis to identify any maintenance requirements. • Spill response procedures will be followed to contain and clean-up any hydrocarbon spills. **Rehabilitation:** • BWT pits will be backfilled and/or used for storage of waste fines material enabling recovery of groundwater levels and stygofauna habitats following cessation of groundwater abstraction. • Hydrocarbon storage and handling facilities will be decommissioned at closure.

Outcomes	**Residual impact:** The Proposed Change will result in some impacts to stygofauna habitat and communities; it is unlikely the stygofauna habitat or stygofauna assemblages will be significantly impacted primarily due to the habitat present within each deposit being well connected and extending beyond the proposed impact areas. At Warramboo, a small proportion of available habitat will be impacted by the proposed groundwater drawdown and pit excavation and there is a lack of potential barriers to dispersal of stygofauna to the west and north of the area. It is therefore considered that although the Proposed Change will result in the loss of individuals, it is unlikely to significantly affect the ecological integrity of the stygofauna habitat or the diversity and ecological integrity of the stygofauna assemblages in the Warramboo area. At Mesa C, very little of the deposit is below the water table (5%) and therefore suitable as stygofauna habitat. Studies indicate the Mesa C CID Aquifer is seasonally connected to the extensive stygofauna habitat present in the adjacent Robe River Alluvial Aquifer. Given the extent and connectivity with other primary habitats, such as the Robe River Alluvial Aquifer which is not expected to be impacted by the Proposed Change, it is considered that although the Proposed Change will result in the loss of individuals, it is unlikely to significantly affect the ecological integrity of stygofauna. After the mitigation hierarchy has been applied, including consideration of extensive, connected stygofauna habitat at Warramboo and Mesa C, the Proponent considers that the potential impacts can be managed to meet the EPA's objective for Subterranean Fauna. **Offset:** The Proponent considers that the potential impacts can be managed for stygofauna as a component of the Subterranean Fauna factor and the residual impact will not be significant enough to warrant application of offsets.
Terrestrial Fauna	
EPA Objective	To protect Terrestrial Fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	**EPA policy and guidance** • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) • EPA Environmental Factor Guideline: Terrestrial Fauna (2016) • EPA Statement of Environmental Principles, Factors and Objectives (2016) • EPA Technical Guidance: Sampling methods for terrestrial vertebrate fauna (the content in this Technical Guidance has not yet been updated from the technical report of the EPA and the then Department of Environment and Conservation issued in September 2010 and titled 'Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment') (2016)

	• EPA Technical Guidance: Terrestrial Fauna Surveys (the content in this Technical Guidance has not yet been updated from EPA Guidance Statement No. 56 issued in June 2004) (2016) • EPA Technical Guidance: Sampling of short range endemic invertebrate fauna (the content in this Technical Guidance has not yet been updated from EPA Guidance Statement No. 20 issued in May 2009) (2016) • EPA Environmental Factor Guideline: Inland Waters Environmental Quality (2016) • EPA Instructions on how to prepare an Environmental Review Document (2016) • EPA Instruction of how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (2016). **Other policy and guidance** • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014) • Department of the Environment, Water, Heritage and the Arts, Survey guidelines for Australia's Threatened Bats (2010) • Department of Sustainability, Environment, Water, Population and Communities Survey guidelines for Australia's threatened mammals (2011) • Department of Sustainability, Environment, Water, Population and Communities, Survey guidelines for Australia's threatened reptiles (2011) • Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand: Australian Water Quality Guidelines for Fresh and Marine Waters (2000).
Potential impacts	**Direct impacts** • Loss and/or fragmentation of fauna habitat including breeding, foraging and dispersal habitat due to clearing • Loss of individuals from increased vehicle strikes and collisions with fencing. **Indirect impacts** • Alteration of fauna habitat due to altered hydrology arising from groundwater abstraction and increased temporal availability of surface water from discharge of surplus water • Loss or degradation of habitat due to noise and vibration • Degradation of habitat due to dust and light emissions • Degradation of habitat due to altered fire regime, introduction or spread of weeds and changes to feral animal populations • Degradation of aquatic fauna habitat due to changes to water chemistry arising from discharge of surplus water.
Mitigation	**Avoid:** • The Proposed Change has been designed to avoid disturbance to Breakaways and Gullies habitat except where escarpment cuts are required to access the mesas (8 ha) • The Proposed Change will avoid direct impacts to all recorded potential diurnal/maternal Ghost Bat roosts

	• The Proposed Change will avoid direct disturbance to all but one known nocturnal Ghost Bat roost (one of the 24 caves/shelters recorded in the western portion of the Development Envelope as being used by Ghost Bats) • The use of barbed wire will be avoided except where legislated • The surplus water discharge point will be installed in Major River/Creek habitat of Warramboo Creek, not considered to be of significant value to conservation significant aquatic fauna • Lighting will be directed into the active pits to avoid the mesa escarpments. **Minimise:** • The clearing footprint has been minimised through project optimisation to reduce the extent of clearing required. Specifically, in-pit disposal of waste fines and reverse osmosis plant effluent is proposed rather than development of an external tailings storage facility and evaporation pond • The Proponent proposes to undertake annual monitoring of Northern Quoll within the Development Envelope. If required, appropriate mitigation measures will be implemented in accordance with the EMP. • The Proponent will abstract groundwater within the licence limits and monitor groundwater levels, responding appropriately, to ensure the extent of groundwater drawdown remains within the predicted range of impact. • Surplus groundwater will be utilised on-site for mine operations and processing, where practicable. Surplus water will only be discharged when supply exceeds demand for the duration of abstraction activities only • The MEZ around Ghost Bat roosts will minimise the potential impact of noise and vibration on roosting Ghost Bats and a Blast Management Framework will be implemented to limit vibration emissions • Monitoring of Ghost Bat roosts will include blast vibration monitoring for all blasts within 300 metres of the potential diurnal/maternal Ghost Bat roosts, and bi-annual collection and analysis (genetic and hormone) of scat samples from across the broader Robe Valley as part of the five year Ghost Bat study • Lighting will be installed only where required, that is, mainly in-pit and operational areas • Dust emissions will be managed through application of dust suppression methods including water sprays, where applicable • The Proponent has well established strategies for monitoring and management of the risk of weed ingress, feral animals and increase in fire at its Pilbara operations that will be implemented in the Development Envelope to manage these aspects. **Rehabilitate:** • The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA Guidelines for Preparing Mine Closure Plans.
Outcomes	**Residual Impact**: The Proposed Change will result in the unavoidable loss of fauna habitat (including habitats for conservation significant fauna species) as a result of clearing. None of the habitats recorded are restricted to the Development Envelope; all fauna habitats identified from the Development Envelope occur throughout the Robe Valley. The most significant habitat types in the Development Envelope are the Breakaways and Gullies habitat and Major

	River/Creek habitat which include habitat for Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Pilbara Olive Python, SREs and aquatic fauna species. Disturbance of the extent of Breakaways and Gullies habitat type present in the western portion of the Development Envelope will be limited to 6%, and disturbance of the extent of Major River/Creek habitat type in the western portion of the Development Envelope will be limited to 1%. There will be no direct disturbance to recorded potential diurnal/maternal Ghost Bat roosts. One recorded nocturnal Ghost Bat roost will be disturbed. The Proposed Change is not considered likely to result in significant impacts to local populations of conservation significant species, or affect the conservation status of species (including SREs and species of elevated conservation significance) given the retention of key habitat features and minimal impact to key habitat types. Groundwater abstraction for the Proposed Change is not predicted to result in significant changes to understorey vegetation (fauna habitat) along the majority of the defined flow channel of Warramboo Creek. Discharge of surplus water for the Proposed Change is not predicted to result in significant impacts to Major River/Creek habitat in Warramboo Creek as any potential impacts will be temporary and are expected to be limited to approximately 8 km from the point of discharge. The Proponent considers that the potential for loss of individuals from increased vehicle strikes and collisions with fencing as well as all potential indirect impacts (noise, vibration, dust, light, altered fire regime, introduction or spread of weeds and changes to feral animal populations) can be managed such that they are unlikely to result in a significant impact to fauna. After the mitigation hierarchy has been applied, including avoidance of direct impacts to key habitat and key habitat features, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Terrestrial Fauna; the proposed loss of habitat is not expected to cause a loss of biological diversity at the local or regional scale and the ecological integrity of the area surrounding the footprint is expected to be maintained. **Offset:** The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on terrestrial fauna and therefore offsets for Terrestrial Fauna values are not proposed.
Hydrological Processes and Inland Waters Environmental Quality	
EPA Objective	• To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected. • To maintain the quality of groundwater and surface water so that environmental values are protected.
Policy and guidance	**EPA Policy and Guidance** • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) • EPA Environmental Factor Guideline – Hydrological Processes (2016) • EPA Environmental Factor Guideline – Inland Waters Environmental Quality (2016) • EPA Inland Waters of the Pilbara Western Australia (Part 1) (1989)

	• EPA Inland Waters of the Pilbara Western Australia (Part 2) (1989) • EPA Statement of Environmental Principles, Factors and Objectives (2016) • EPA Instructions on how to prepare an Environmental Review Document (2016) • EPA Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans (2016). **Other policy and guidance** • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014) • Australian Water Quality Guidelines for Fresh and Marine Waters. (2000) • State Water Quality Management Strategy Document No.6. Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting (2001) • Pilbara Water in Mining Guideline. Report No 34 (2009) • Western Australian Water in Mining Guideline. Report No 12 (2013) • WRC Statewide Policy No 5 - Environmental Water Provisions Policy for Western Australia (2000) • Water Quality Protection Guidelines No. 1 to 11 and Water Quality Protection Note 22 (2000; 2008) • Strategic policy 2.09: Use of mine dewatering surplus (2013).
Potential impacts	**Direct** • Changes to groundwater levels as a result of groundwater abstraction • Changes to the hydrological regime of Warramboo Creek as a result of surplus water management. **Indirect** • Changes to surface and groundwater chemistry in Warramboo Creek and the Yarraloola Aquifer as a result of in-pit storage of waste fines, disposal of effluent from the reverse osmosis plant, surface water flows through operational areas and surplus water management.
Mitigation	**Avoid:** • Mine design will avoid exposure of potentially acid forming material (PAF) • During operations seepage from in-pit storage of waste fines and disposal of effluent from the reverse osmosis plant will mostly be captured by the water supply borefield and re-circulated in the wet plant. **Minimise:** • Hydrogeological modelling has been, and will continue to be, undertaken to facilitate understanding of current and future dewatering and water supply requirements to inform optimisation of groundwater abstraction to reduce impacts. • Abstraction will be minimised to that required to access the below water table resources and meet site water requirements.

	• Monitoring of riparian vegetation and groundwater levels will be undertaken along the Robe River adjacent to the predicted drawdown within the Mesa C CID Aquifer. If changes to groundwater levels and vegetation health are detected, then appropriate mitigation measures will be determined in accordance with the EMP. • Groundwater levels in the Warramboo borefield will be monitored to check that drawdown is occurring consistent with modelled predictions. • Dewatering water will be utilised on-site in the first instance to supply water for operational purposes. Only surplus water exceeding the operational requirement will be discharged to Warramboo Creek. • Monitoring of the location of the continuous surface water expression in Warramboo Creek under natural no-flow conditions, including surface water chemistry will be undertaken. If required, appropriate mitigation measures will be implemented in accordance with the EMP. • Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements. • Hydrocarbon storage facilities and all associated connections will be within appropriately contained areas and storm water will be collected from these areas and treated to remove hydrocarbons prior to discharge. • Hydrocarbon storage facilities and bunds will be inspected on a regular basis to identify any leaks or maintenance requirements. • The Proponent has well established management strategies for the management of PAF materials, While the likelihood of encountering significant quantities of PAF material is considered low; if PAF materials are encountered then existing management strategies within the Rio Tinto Iron Ore (WA) Mineral Waste Management Plan, and the Spontaneous Combustion and ARD (SCARD) Management Plan will be implemented to ensure waste material is adequately geochemically characterised and PAF material that poses an Acid Mine Drainage risk is appropriately managed. • Water management structures such as windrows around the base of waste dumps and sediment traps will be constructed in key areas to minimise discharge of sediment-laden run-off from the site. **Rehabilitate:** • The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA Guidelines for Preparing Mine Closure Plans. • Mine pits will be backfilled to appropriate levels to prevent the formation of pit lakes.
Outcomes	**Residual Impact**: The Proposed Change will result in unavoidable groundwater drawdown as a result of dewatering below water table resources and supplying water for processing requirements. Groundwater drawdown from dewatering at Mesa C is not expected to extend beyond the CID Aquifer. No observable changes are expected to surface water levels or surface water chemistry in the Robe River, groundwater levels in the Robe River Alluvial Aquifer, or surface water levels in the semi-permanent pools near Mesa B. Groundwater abstraction for dewatering and water supply from the Warramboo borefield will lower the groundwater table by up to 36 m and recovery of the groundwater table to 80% of pre-mining groundwater level will take approximately 40 years, with complete recovery of the groundwater level estimated to take up to 140 years. The 13 km section of the defined flow channel of Warramboo Creek within the

	estimated cone of depression of the Warramboo borefield extension will not be affected given the ephemeral nature of the creek and lack of permanent or semi-permanent pools identified in this section of the creek. Surplus water discharge will alter the seasonal occurrence of surface water in Warramboo Creek by increasing water availability up to 8 km downstream of the discharge point. No erosion is expected, however a temporary decline in vegetation health and localised impacts to fauna species may result along the extent of discharge due to alteration of surface water chemistry and sediment quality. No significant impacts to surface and groundwater quality are expected from hydrocarbons or PAF. After the mitigation hierarchy has been applied, no significant residual impact to hydrological processes and inland waters environmental quality values is anticipated and the Proponent considers that the Proposed Change can be managed to meet the EPA's objectives for these factors. **Offset:** The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on hydrological processes and inland waters environmental quality and therefore offsets for these values are not proposed.
Landforms	
EPA Objective	The EPA objective for landforms is to maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.
Policy and guidance	**EPA policy and guidance** • EPA Environmental Factor Guideline - Inland Waters Environmental Quality (2016) • EPA Environmental Factor Guideline: Landforms (2016) • EPA Statement of Environmental Principles, Factors and Objectives (2016) • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) • EPA Instructions on how to prepare an Environmental Review Document (2016) • EPA Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans (2016). **Other policy and guidance** • WA Environmental Offsets Policy (2011) • WA Environmental Offsets Guidelines (2014) • WAPC Visual Landscape Planning in Western Australia a manual for evaluation, assessment, siting and design (2007).

Potential impacts	**Direct impacts:** • Loss of variety due to removal or degradation of the mesa landforms • Loss of the integrity of the mesa landforms due to disturbance. **Indirect impacts** • Loss or degradation of the ecological values of the mesa landforms • Loss or degradation of the social values of the mesa landforms through loss of indigenous heritage and amenity values.
Mitigation	**Avoid:** • Sections of the escarpments with the highest ecological value; the locations and designs of the escarpment cuts for both Mesas B and C were selected to avoid disturbance to these areas • Potential loss of integrity of the mesa escarpments will be avoided by retaining an escarpment width of at least 30 metres at the top surface. • Direct impacts to potential diurnal/maternal Ghost Bat roosts at Mesas B and C will be avoided and direct impacts to all but one of the recorded nocturnal Ghost Bat roosts on Mesas A, B and C will be avoided. • Retention of the mesa escarpments will avoid impact to significant heritage sites located in the escarpments as well as reducing impacts to visual amenity of the landscape. • No direct disturbance to rock shelters is proposed, including the rock shelter site on Mesa B with spinifex matting. **Minimise:** • The most prominent feature of the mesas, the escarpments, will be retained excluding minor access cuts. • The widths required for the access cuts into the mesa escarpments have been minimised as far as possible. • The Proposed Change has been designed to retain connected troglofauna habitat of at least 50% of the pre-mining habitat volume on each mesa. • The implementation of the Blast Management Framework (including management of potential for flyrock) and retention of escarpments with an adequate width will minimise any potential impacts to the ecological value of the mesa escarpments, including the caves and rock shelters present on the mesa escarpment. • The location and layout of the mine and associated infrastructure has been designed to minimise impacts to Aboriginal heritage sites. Where impacts to heritage sites cannot be avoided, applications will be made under Section 18 of the *Aboriginal Heritage Act 1972* in consultation with the Kuruma Marthudunera People. • Waste dumps near Mesas B and C will remain lower than the surrounding mesas. **Rehabilitate:** • All disturbed surfaces will be rehabilitated including pit floors to maximise the ecological value

	• Visual impacts will be further minimised through construction of the waste dumps to be aesthetically compatible with the surrounding landscape and through rehabilitation of the waste dumps.
Outcomes	**Residual Impact**: The retention of the escarpments of the mesas, excluding access cuts, will, to a large extent, preserve the prominence and scale of the mesas in the landscape, and therefore the Proposed Change will retain the representation or 'variety' of Robe Pisolite mesas in the Robe Valley. The Warramboo and Highway/Tod Bore deposits are not associated with any elevated landforms and therefore no significant landform values will be affected by the Proposed Change in these areas. Given the most valuable feature of the mesa landform will remain largely intact and the structural integrity of the landform will be maintained through retention of an adequate escarpment width, it is considered the proposed loss of small proportions of the mesa escarpments is not expected to significantly impact the variety, integrity, ecological or social values of the landforms at a local or regional scale. After the mitigation hierarchy has been applied, including avoidance of direct disturbance to the majority of the mesa escarpments, including heritage and ecological values, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Landforms. **Offset:** The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on landforms and therefore offsets for the associated values are not proposed for this factor.
Social Surroundings	
EPA Objective	The EPA objective for social surroundings is to protect social surroundings from significant harm.
Policy and guidance	**EPA policy and guidance** • DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) • EPA Environmental Factor Guideline: Social Surroundings (2016) • EPA Instructions on how to prepare an Environmental Review Document (2016) • EPA Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans (2016). **Other policy and guidance** • Department of Aboriginal Affairs and Department of Premier and Cabinet Due Diligence Guidelines, Version 3.0 (2013).

Potential impacts	• Disturbance of sites of cultural significance • Prevention or change to access to a site • Changes to the physical and biological attributes of the environment (e.g. pools, creeks, mesa breakaways, bush tucker and bush medicine) which would impact on sites of heritage significance • The proposed intersection of the North West Coastal Highway with a mine pit.
Mitigation	**Avoid:** • The Proposed Change has been designed to avoid direct impacts to sites with high significance, including the Robe River, rock shelter site MBC15_36 on Mesa B with spinifex matting, Warramboo outstation, one ethnographic site and one archaeological site within the approved Warramboo pit footprint. **Minimise:** • The Proposed Change has been designed to minimise direct impacts to Yirrkawiya Gap and escarpments on Mesas A, B and C. • Further assessment of sites and salvaging of artefacts is expected to occur. Artefact salvage will ensure the retention of artefact values ex-situ. • The Proponent has established an internal system for managing all ground disturbing activities to ensure compliance with heritage commitments and regulatory requirements. • The Proponent is committed to consulting with the Kuruma Marthudunera People regarding the Proposed through Local Implementation Committee (LIC) meetings and heritage survey processes. **Rehabilitate:** • The Proponent has developed a Mine Closure Plan consistent with DMP and EPA Guidelines to ensure social surrounds are rehabilitated post closure.
Outcomes	**Residual Impact**: No disturbance will occur to the key heritage sites of Robe River and associated pools, rock shelter site MBC15_36, Warramboo outstation, one ethnographic site and one archaeological site within the current approved Warramboo Mine footprint, the traditional birthing place and the majority of the mesa escarpments. The Proposed Change has been designed to minimise impacts to Yirrkawiya Gap and the escarpments of Mesas A, B and C. Where impacts to heritage sites cannot be avoided, applications will be made under Section 18 of the *Aboriginal Heritage Act 1972* in consultation with the Kuruma Marthudunera People. The Proposed Change will result in direct disturbance to some artefact scatter sites, and may result in indirect disturbance to some rockshelter sites due to vibration. Approximately 51 Section 18 applications are anticipated. Additional surveys and mine planning are required to determine whether heritage sites at the Highway/Tod Bore deposits can be avoided. The Proponent will continue to work in close consultation with the Kuruma Marthudunera People in regards to avoidance and management of site disturbance.

	The Proposed Change will result in reduction in access to some traditional lands due to safety considerations associated with an operating mine site. There is also potential for temporary, localised changes to the availability of bush tucker and bush medicine due to abstraction of groundwater and discharge of surplus water. However, the flora and fauna that occur in the area that may be impacted occur more widely in the Robe Valley and the changes are not expected to impact any specific heritage sites. After the mitigation hierarchy has been applied, including avoidance of impacts to the most significant heritage sites in the western portion of the Development Envelope, minimisation of disturbance to other sites and the Proponent's commitment to continuing consultation with the Kuruma Marthudunera People regarding the Proposed Change through LIC meetings and heritage survey processes; the Proponent considers that the potential impacts can be managed to meet the EPA's objective for Social Surroundings. **Offset:** The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on Social Surroundings and therefore offsets for this factor are not proposed.

TERMINOLOGY

The following terminology is used throughout this document:

- **Proponent** – Robe River Mining Co. Pty. Ltd as manager and agent for the Robe River Iron Associates joint venture as set out in Section 1.2
- **Mesa A/Warramboo Iron Ore Project** – the Mesa A/Warramboo Iron Ore Project as approved under Ministerial Statement 756
- **Mesa A Hub Revised Proposal (the Revised Proposal)** – the existing Mesa A/Warramboo Iron Ore Project plus the proposed activities (as detailed in Section 2) that are additional to those approved under Ministerial Statement 756, incorporating development of additional mine pits and associated infrastructure, water treatment facilities, processing facilities and water management infrastructure as well as extension of existing mine pits, waste dumps and associated infrastructure.
- **Development Envelope** – the area encompassing the Revised Proposal, including the existing approved infrastructure corridor. The proposed activities will be undertaken in the western portion of the Development Envelope covering the mine pits, borefield and associated infrastructure. No additional disturbance is proposed within the existing infrastructure corridor approved under Ministerial Statement 756.
- **Mining Exclusion Zone** – the area where blasting and excavation of ore will not be undertaken.

1. INTRODUCTION

1.1 Purpose and Scope

Robe River Mining Co. Pty. Ltd. (the Proponent) operates the existing Mesa A/Warramboo Iron Ore Project located approximately 43 kilometres (km) west of Pannawonica in the Pilbara region of Western Australia (Figure 1-1). The current total ore feed from the Mesa A/Warramboo Iron Ore Project is up to 25 million tonnes per annum (Mt/a). The Proponent is seeking to extend the life of the Mesa A/Warramboo Iron Ore Project through further development of the existing Mesa A and Warramboo operations and development of nearby deposits: Highway, Tod Bore, Mesa B and Mesa C. This will sustain the Mesa A/Warramboo Iron Ore Project total ore feed at up to 25 Mt/a. This sustaining Proposal is referred to as the Mesa A Hub Revised Proposal (the Revised Proposal).

The purpose of this Environmental Review Document (ERD) is to provide a report on the environmental review for the Revised Proposal to the Western Australian Environmental Protection Authority (EPA).

The scope of the ERD is to present an environmental review that addresses the requirements outlined in sections 2 to 6 of the Environmental Scoping Document (ESD), including a detailed impact assessment and description of proposed environmental management measures for the key environmental factors in accordance with the ESD prepared by the EPA (Appendix 1).

1.2 Proponent

The Proponent for the Revised Proposal is Robe River Mining Co. Pty. Ltd. (ABN 71 008 694 246 / ACN 008 694 246) (a 100% owned Rio Tinto entity), which is the manager and agent for the Robe River Iron Associates joint venture. The joint venture is unincorporated and comprises the following participants:

- Robe River Mining Co. Pty. Ltd. (30 per cent share)
- North Mining Limited (35 per cent share)
- Mitsui Iron Ore Development Pty Ltd (20 per cent share)
- Pannawonica Iron Associates, a partnership carried on by Nippon Steel & Sumitomo Metal Australia Pty Ltd, Nippon Steel & Sumikin Resources Australia Pty Ltd (10 per cent share)
- Cape Lambert Iron Associates, a partnership carried on by Nippon Steel & Sumitomo Metal Australia Pty Ltd, Nippon Steel & Sumikin Resources Australia Pty Ltd and Mitsui Iron Ore Development Pty Ltd (5 per cent share).

The Rio Tinto key contact person in relation to this ERD is:

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LEGEND

- Rio Tinto Mine
- Rio Tinto Port
- Deposit
- Town
- Rio Tinto Railway
- Highway
- Major Road
- National Park

Rio Tinto

Iron Ore (WA)

Figure 1-1: Regional Location

Drawn: GIS Team
Date: February, 2018

Plan No: PDE0149312v1
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

1.3 Environmental Impact Assessment Process

The EPA determined that the Proposed Change requires assessment under Part IV of the EP Act which provides for the EPA to undertake Environmental Impact Assessment of significant proposals, strategic proposals and land use planning schemes. This ERD has been prepared in accordance with the Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA 2016a) to meet the requirements of Section 40(2)(b) of the EP Act.

The Commonwealth Department of the Environment and Energy (DotEE) determined that the Proposed Change is a Controlled Action and therefore requires assessment under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPA is assessing the Proposed Change on behalf of the Commonwealth under Section 87 of the EPBC Act as an accredited assessment.

The Revised Proposal is subject to the following State Agreement: *Iron Ore (Robe River) Agreement Act 1964*. A State Agreement is a legal contract between the Western Australian Government and a proponent of a major project within the boundaries of Western Australia (WA). A State Agreement details the rights, obligations, terms and conditions for development of a specific project.

1.4 Other Approvals and Regulation

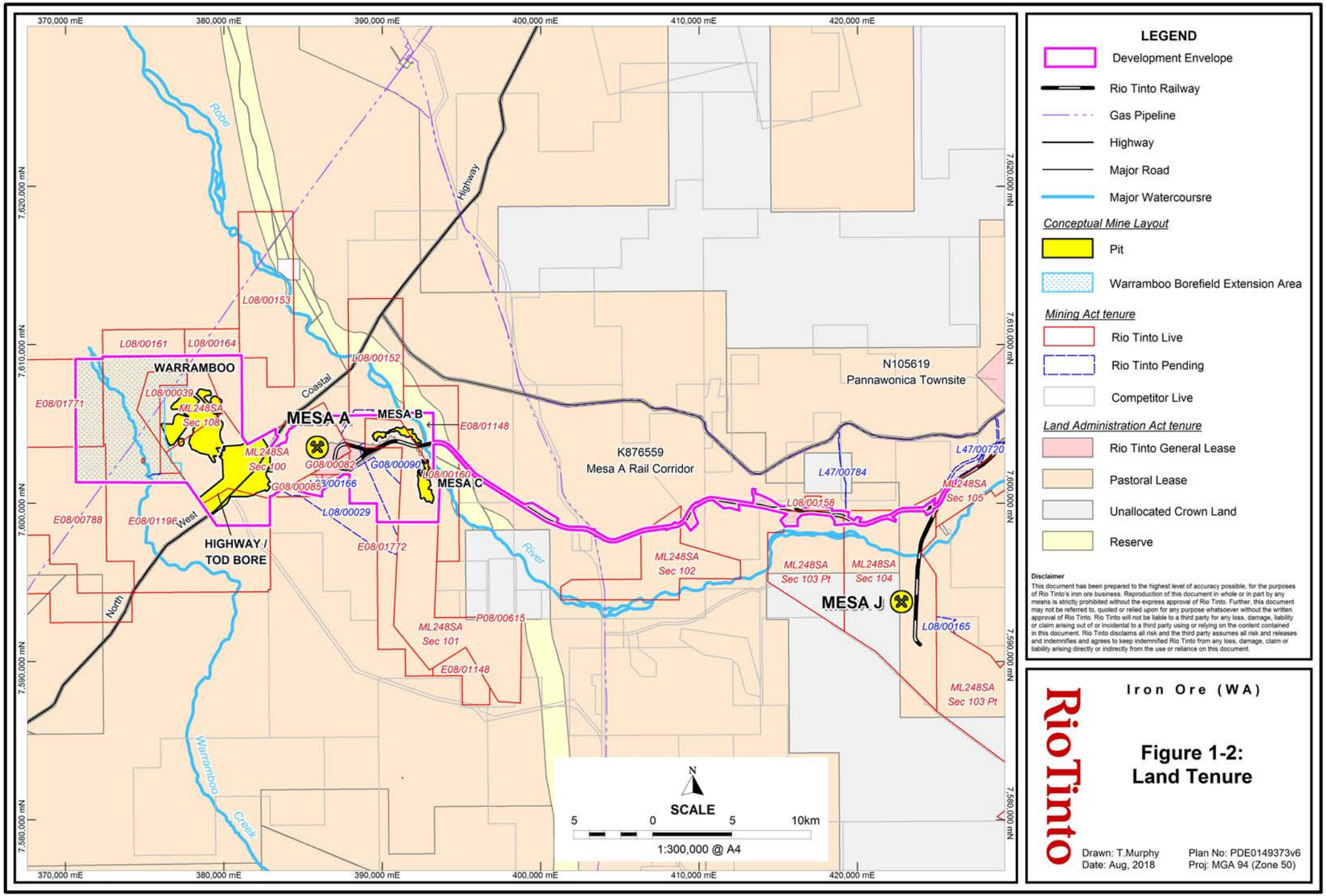
1.4.1 Land tenure

The Robe Valley mining operations, including the approved Mesa A/Warramboo Iron Ore Project, are primarily undertaken on the State Agreement Mineral Lease ML248SA granted pursuant to the *Iron Ore (Robe River) Agreement Act 1964*. ML248SA is held by Robe River Limited (a 100% owned Rio Tinto entity) and sub-leased to the Robe River Iron Associates, pursuant to Mineral Sub-lease No. 1H/79. ML248SA is considered appropriate tenure for mining and mining related infrastructure.

Existing tenure in and near the Development Envelope is shown in Figure 1-2. The deposits included in the Proposed Change are within ML248SA except for portions of the Mesas B and C deposits that extend into Exploration Licence E08/01148. Conversion of these areas into ML248SA will be required prior to development for mining.

The main co-existing *Land Administration Act 1997* tenure in the Development Envelope is the Yarraloola Pastoral Station (Lease N049500). This pastoral lease is held by the Yarraloola Station Partnership which comprises members of the Robe River Iron Associates joint venture. The main ancillary tenure is the Robe River Iron Associates joint venture *Land Administration Act 1997* lease for the approved Mesa A railway (Lease K876559). This lease runs between Mesas B and C and forms a tenure connection to the Mesa A mining operation.

Grant of additional tenure and/or conversion of tenure will be required for the development of *the* borefield, waste dumps, pipelines, haul roads and other infrastructure.



LEGEND

- Development Envelope
- Rio Tinto Railway
- Gas Pipeline
- Highway
- Major Road
- Major Watercoursre

Conceptual Mine Layout

- Pit
- Warramboo Borefield Extension Area

Mining Act tenure

- Rio Tinto Live
- Rio Tinto Pending
- Competitor Live

Land Administration Act tenure

- Rio Tinto General Lease
- Pastoral Lease
- Unallocated Crown Land
- Reserve

Disclaimer

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Rio Tinto

Iron Ore (WA)

Figure 1-2: Land Tenure

Drawn: T.Murphy
Date: Aug, 2018

Plan No: PDE0149373v6
Proj: MGA 94 (Zone 50)

1.4.2 Native title

The majority of the Development Envelope lies within the Kuruma Marthudunera Native Title Claim (WC99/012). The Proponent has a Participation Agreement and an Indigenous Land Use Agreement with the Kuruma Marthudunera People that include an established consultation framework for ongoing engagement on relevant aspects of the Proponent's operations. These Agreements set obligations for processes such as land access, tenure acquisition, heritage surveys, environmental management, mining benefit payments and reporting, consultation and communication between the parties.

1.4.3 Other approvals

Other environmental approvals that will be sought as part of the Proposed Change are listed in Table 1-1.

Table 1-1: Other approvals and regulations

Proposed activity	Land tenure/access	Type of approval	Legislation regulating the activity
Clearing of native vegetation in connection with activities outside the Proposed Change (e.g. activities as indicated in Section 2.3.15)	• ML248SA (*Mining Act 1978* pursuant to the *Iron Ore (Robe River) Agreement Act 1964*) • G08/00082 and G08/00085 (*Mining Act 1978)* • L08/00039, L08/00152, L08/00153 (*Mining Act 1978*) • K876559 (*Land Administration Act 1997*) • Additional/converted tenure.	Native Vegetation Clearing Permit	EP Act – Part V
Heritage	• ML248SA (*Mining Act 1978* pursuant to the *Iron Ore (Robe River) Agreement Act 1964*) • G08/00082 and G08/00085 (*Mining Act 1978)* • L08/00039, L08/00152, L08/00153 (*Mining Act 1978*) • K876559 (*Land Administration Act 1997*) • Additional/converted tenure.	Section 18 consent to disturb a protected site	*Aboriginal Heritage Act 1972* (AH Act)
Disturbance to bed and banks of water course	• ML248SA (*Mining Act 1978* pursuant to the *Iron Ore (Robe River) Agreement Act 1964*) • G08/00082 and G08/00085 (*Mining Act 1978)* • L08/00039, L08/00152, L08/00153 (*Mining Act 1978*) • K876559 (*Land Administration Act 1997*) • Additional/converted tenure.	Bed and Banks permit	*Rights in Water and Irrigation Act 1914*

Proposed activity	Land tenure/access	Type of approval	Legislation regulating the activity
Construction of well and groundwater abstraction	• ML248SA (*Mining Act 1978* pursuant to the *Iron Ore (Robe River) Agreement Act 1964*) • G08/00082 and G08/00085 (*Mining Act 1978)* • L08/00039, L08/00152, L08/00153 (*Mining Act 1978*) • K876559 (*Land Administration Act 1997*) • Additional/converted tenure.	Licence and Groundwater Operating Strategy	*Rights in Water and Irrigation Act 1914*
Construction and operation of plant, waste fines facility and waste water treatment facilities and discharge of surplus water	• ML248SA (*Mining Act 1978* pursuant to the *Iron Ore (Robe River) Agreement Act 1964*) • G08/00082 and G08/00085 (*Mining Act 1978)* • L08/00039, L08/00152, L08/00153 (*Mining Act 1978*) • K876559 (*Land Administration Act 1997*) • Additional/converted tenure.	Works Approval and Licence	EP Act – Part V

1.4.4 Decision making authorities

Based on the other approvals identified in Table 1-1, the Proponent has revised the list of decision making authorities (DMAs) identified in the ESD and their relevance to the Revised Proposal (Table 1-2).

The Minister for Lands is listed in the ESD as a DMA. However, the Proponent considers the Minister for Lands is unlikely to be a DMA for the Revised Proposal as the Proponent is not currently planning to seek additional tenure under the *Land Administration Act 1997*. Should it become necessary to seek additional tenure under the *Land Administration Act 1997*, the Proponent would consult with the Department of Planning Lands and Heritage (DPLH).

Main Roads WA are listed in the ESD as a DMA. However, the Proponent considers Main Roads WA is unlikely to be a DMA for the Revised Proposal as changes to public roads are not proposed. The section of the North West Coastal Highway that runs through the Highway/Tod Bore deposit will require re-alignment prior to mining of these deposits. It is anticipated that separate approval for the re-alignment of the Highway will be required. Consultation and investigations to determine the most appropriate alignment will be initiated well in advance of commencement of mining of the Highway/Tod Bore deposit.

Table 1-2: Revised decision making authorities and their relevance to the Revised Proposal

Revised list of DMAs	Relevant legislation
Minister for State Development	*Iron Ore (Robe River) Agreement Act 1964*
Minister for Mines and Petroleum	*Mining Act 1978*
Minister for Environment	*Wildlife Conservation Act 1950* (WC Act) *Environmental Protection Act 1986* (EP Act)
Chief Executive Officer Department of Water and Environmental Regulation (DWER) (formerly the Department of Environmental Regulation and the Department of Water)	*Environmental Protection Act 1986* *Rights in Water and Irrigation Act 1914*
Executive Director, Environment Department of Mines, Industry Regulation and Safety (DMIRS) (formerly the Department of Mines and Petroleum [DMP])	*Mining Act 1978*
State Mining Engineer DMIRS	*Mines Safety and Inspection Act 1994*
Minister for Aboriginal Affairs	*Aboriginal Heritage Act 1972*

2. THE REVISED PROPOSAL

2.1 Background

2.1.1 Assessment process

The Proposed Change was referred to the EPA under Section 38 of the EP Act on 21 November 2016. On 23 December 2016, the EPA determined that the Proposed Change required environmental assessment as a Revised Proposal at the level of 'Environmental Review – no public review'. The Proposed Change was also referred to the DotEE under the requirements of the EPBC Act on 12 December 2016. The DotEE determined that the Proposed Change is a Controlled Action on 8 February 2017 (EPBC 2016/7843). Following the Proposed Change being declared a Controlled Action under the EPBC Act, the EPA amended the level of assessment to 'Environmental Review – two week public review period' on 16 February 2017 to satisfy the EPBC Act public review requirements. The DotEE and EPA agreed impacts to Matters of National Environmental Significance (MNES) will be assessed by the EPA as an accredited assessment under Section 87 of the EPBC Act.

The EPA endorsed the ESD (Appendix 1) for the Mesa A Hub Revised Proposal on 16 March 2017. The ESD provides an outline of the key environmental factors, a description of the scope of the assessment of the Proposed Change and an indicative timeline for the assessment process.

Since endorsement of the ESD, refinement of the Proposed Change has occurred during the ongoing feasibility study (and more detailed technical studies undertaken). Required amendments to the Proposed Change were identified as listed in Table 2-1 and were approved under s43A of the EP Act on 9 July 2018.

Table 2-1: Amendments to the Proposed Change since referral

Proposed activity	Proposed Change as referred	Proposed Change as approved under s43A
Ground disturbance	Clearing of no more than 2,500 ha of native vegetation within a Development Envelope of 20,184 ha.	Clearing of no more than 3,000 ha of native vegetation within a Development Envelope of 16,834 ha.
Water supply and Warramboo dewatering	Abstraction of no more than 11 GL/a of groundwater from the Warramboo dewatering and water supply borefield (including the currently licensed abstraction rate of 3 GL/a).	Abstraction of no more than 15 GL/a of groundwater from the Warramboo dewatering and water supply borefield (including the current licensed abstraction rate of 3 GL/a).
Water treatment (waste)	Disposal of effluent from the reverse osmosis plant at Warramboo to an evaporation pond.	In-pit disposal of effluent from the reverse osmosis plant at Warramboo.

Should the Proposed Change be approved for implementation, the Proponent proposes that the Revised Proposal be subject to new conditions which replace those of MS 756. A draft Ministerial Statement is provided as Appendix 2. However, it is acknowledged that, the development of the final Ministerial Statement is the responsibility of the Minister.

2.1.2 Existing approval

The Mesa A/Warramboo Iron Ore Project was authorised to commence in November 2007 under Ministerial Statement 756 (MS 756); productive mining commenced at Mesa A in 2010 and at Warramboo in 2012.

The Mesa A/Warramboo Iron Ore Project (as amended[1]) includes:

- Above water table mining of two deposits: Mesa A and Warramboo
- Out-of-pit mineral waste dumps, low grade ore dumps, and topsoil and subsoil stockpiles
- Run of Mine pads, a crushing and screening plant, stackers, stockyards, train load-out and other materials handling infrastructure
- Support facilities including workshops, power supply infrastructure, hydrocarbon storage, explosives storage, vehicle wash-down areas, laydown areas, offices, laboratories, warehouses, potable water supply from the Warramboo borefield and waste water treatment plants
- Linear infrastructure including heavy vehicle and light vehicle access roads and railway, power and communications networks
- Infrastructure for surface water management including diversion drains and culverts.

The existing Mesa A/Warramboo Iron Ore Project includes a Mining Exclusion Zone (MEZ) across the Priority 3 Sand Sheet Vegetation (Robe Valley) Priority Ecological Community (Sand Sheet PEC) and along most of the length of the Mesa A escarpment and the south-western part of the deposit. The MEZ was established to protect the integrity of the Sand Sheet PEC, retain troglofauna habitat and protect the integrity of the mesa escarpment and its fauna habitat, landscape and heritage values. In addition to the MEZ, the Mesa A/Warramboo Iron Ore Project includes retention of a zone of troglofauna habitat beneath the pit floor (the sub-floor zone).

2.2 Justification

The Proposed Change is the only option suitable for development within the timeframe required to maintain both the type and production rate of iron ore product and efficient operation of the existing Mesa A/Warramboo Iron Ore Project. Robe Valley iron ore is supplied to many steel-producing companies in Japan, Korea and China. The unique technical properties of Robe Valley iron ore establish it as an important component of the iron ore blend in customers' blast furnace feedstock. The Revised Proposal will extend the life of the existing Mesa A/Warramboo Iron Ore Project for approximately ten years and is critical to sustain the Proponent's business activities in the region.

[1] Three amendments to the Mesa A/Warramboo Iron Ore Project have been approved under section 45C of the *Environmental Protection Act 1986* (WA) subsequent to the grant of Statement No. 756.

The Revised Proposal will result in economic benefits for Australia and Western Australia through:

- Contribution to the value of mineral exports
- Royalties and taxation payments
- Capital investment
- Increasing direct and indirect employment opportunities in the region
- Increasing demand for goods and services supporting the regional economy.

The ongoing activities of the Proponent, and more broadly Rio Tinto, in the Pilbara will continue to support social and economic development projects, including:

- Increasing the education, training, employment and business options for local people, including local Aboriginal people
- Funding a range of organisations in the region, including sporting and cultural groups.

The Revised Proposal will continue to make use of Rio Tinto's existing infrastructure, including ports and railway, power, communications and road networks. This will reduce the extent of new infrastructure required and result in a smaller disturbance footprint than would otherwise be required for a project of this scale.

A number of design options have been considered for specific aspects of the Proposed Change. Preferred options have been selected on the basis that they meet project requirements while minimising potential environmental impacts. Options for water supply, surplus water management, haul road routes, waste fines disposal, revision of the Mesa A MEZ and the rationale for the selection of preferred options are discussed as part of the assessment of impacts for relevant environmental factors.

2.3 Revised Proposal Description

2.3.1 Summary of the Revised Proposal

The Revised Proposal is a revision of the existing Mesa A/Warramboo Iron Ore Project, to extend the existing above water table Mesa A mine pit, extend the existing above water table Warramboo Mine pit both above and below water table, and develop four new nearby deposits: Highway (above the water table), Tod Bore (above the water table), Mesa B (above the water table) and Mesa C (above and below the water table) in the mine operations area (Table 2-2; Table 2-3).

The Revised Proposal includes the approved Mesa A/Warramboo Iron Ore Project as approved under Ministerial Statement 756 and the Proposed Changes that are described in this ERD. The Proposed Change to the approved Mesa A/Warramboo Iron Ore Project includes:

- Mine pits:
  - Extension of the approved above water table Mesa A mine pit, including a revision of the Mesa A MEZ to accommodate preferential mining of higher quality ore
  - Extension of the approved above water table Warramboo Mine pits both above and BWT
  - Development of new above water table mine pits at Mesa B
  - Development of new above and BWT mine pits at Mesa C
  - Development of new above water table mine pits at Highway/Tod Bore
- Additional mineral waste management including but not limited to backfilling, out-of-pit waste dumps, low grade ore dumps, topsoil and subsoil stockpiles and extensions to existing waste dumps
- Processing facilities including but not limited to a wet processing plant, in-pit waste fines storage facility (WFSF), reverse osmosis plant and disposal of reverse osmosis plant effluent
- Additional support facilities including but not limited to workshops, power supply infrastructure, explosives storage, hydrocarbon storage, laydown areas, laboratory, offices and waste water treatment plants
- Installation of infrastructure such as tracks, utilities, telecommunications, monitoring stations and abandonment bunds in the Mesa A MEZ and the proposed MEZs at Mesas B and C
- Additional surface water management infrastructure including but not limited to diversion drains, levees and culverts
- Additional linear infrastructure including but not limited to heavy vehicle and light vehicle haul and access roads, pipelines and power (including sub-stations) and communications distribution networks
- Warramboo borefield extension
- Dewatering infrastructure including extension to the approved Warramboo borefield and pipelines at Warramboo and new dewatering infrastructure at Mesa C
- Management of surplus water including use in processing, use on-site, passive recharge via completed mine pits and controlled discharge to Warramboo Creek.

In this ERD, the assessment of environmental impacts associated with the Revised Proposal relates to the Proposed Change to the approved Mesa A/Warramboo Iron Ore Project. The impacts of the approved activities will be considered as part of the cumulative impact assessment. The new elements of the Revised Proposal listed above are referred to as the 'Proposed Change' and the activities associated with the existing Mesa A/Warramboo Iron Ore Project as approved under MS 756 will be referred to as 'approved activities'.

The Development Envelope for the Revised Proposal is shown in Figure 2-1. The Proposed Change will be undertaken in the western portion of the Development Envelope covering the mine pits, borefield and associated infrastructure. No additional disturbance is proposed within the existing infrastructure corridor approved under Ministerial Statement 756. A conceptual layout for the Revised Proposal that may be subject to some change in implementation, is shown in Figure 2-2.

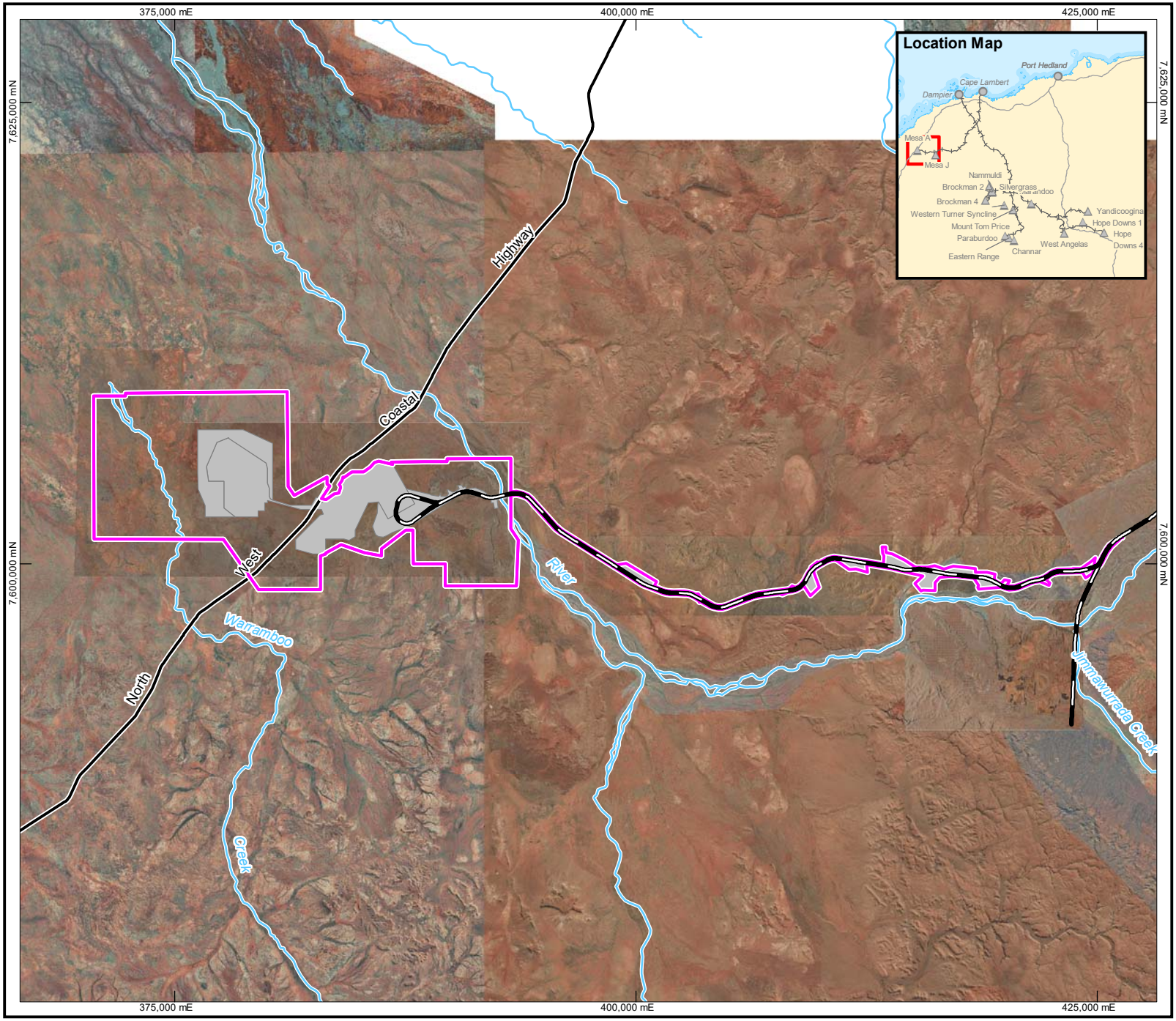
Table 2-2: Summary of the Revised Proposal

Proposal title	Mesa A Hub Revised Proposal
Proponent name	Robe River Mining Co. Pty. Ltd.
Short description	The Revised Proposal includes the existing Mesa A/Warramboo Iron Ore Project and a revision which includes development of additional mine pits and associated infrastructure, water treatment facilities, processing facilities and water management infrastructure, as well as expansion of existing mine pits, waste dumps and associated infrastructure.

Table 2-3: Location and proposed extent of physical and operational elements

Element	Location	Existing approval (Ministerial Statement/s and other regulatory approvals)	Proposed change	Proposed extent (the Mesa A Hub Revised Proposal)
Physical elements				
Mine and associated infrastructure	Figure 2-2	Not more than 3,680 hectares (ha) (with the exception of clearing in the MEZ, other than the approved portal and other infrastructure as per Figure 2 and Figure 4 of MS 756).	Clearing of no more than 3,000 ha of native vegetation within the Development Envelope of 16,834 ha. Disturbance in the defined Mesa A MEZ limited to 42 ha, including mining (33 ha), widening of the existing escarpment cut (2 ha) and installation of infrastructure (7 ha). Clearing in the Mesa B and Mesa C MEZs in accordance with the Environmental Management Plan.	Clearing of up to 6,680 ha within the Development Envelope of 16,834 ha. Disturbance in the Mesa A MEZ limited to that for the portal and other infrastructure as approved under MS 756 plus additional disturbance limited to 42 ha, including mining (33 ha), widening of the escarpment cut (2 ha) and installation of infrastructure (7 ha). Clearing in the Mesa B and Mesa C MEZs in accordance with the Environmental Management Plan.
Infrastructure corridor	Figure 2-1		No change	
Mining depth	Figure 2-2	Above water table.	Above water table at Mesa A, Mesa B and Highway/Tod Bore. Above and below water table at Warramboo and Mesa C.	Above water table at Mesa A, Mesa B, and Highway/Tod Bore. Above and below water table at Warramboo and Mesa C.
Operational elements				
Water supply and Warramboo dewatering	Figure 2-2	3 gigalitres per annum (GL/a) (licensed under *Rights in Water and Irrigation Act 1914*)	Abstraction of no more than 15 GL/a (including the current licensed abstraction of 3 GL/a) of groundwater from the Warramboo dewatering (excludes surface water inflow due to rainfall events) and water supply borefield.	Abstraction of no more than 15 GL/a of groundwater from the Warramboo dewatering (excludes surface water inflow due to rainfall events) and water supply borefield.

Element	Location	Existing approval (Ministerial Statement/s and other regulatory approvals)	Proposed change	Proposed extent (the Mesa A Hub Revised Proposal)
Mesa C dewatering	Figure 2-2	-	Abstraction of no more than 5 GL/a of groundwater from the Mesa C CID Aquifer (excludes surface water inflow due to rainfall events).	Abstraction of no more than 5 GL/a of groundwater from the Mesa C CID Aquifer (excludes surface water inflow due to rainfall events).
Surplus water management	Figure 2-2	-	Use on-site, in processing, passive recharge via completed mine pits and controlled surface discharge to Warramboo Creek. Controlled surface discharge from the Proposed Change to extend along Warramboo Creek no further than 8 km downstream of the discharge point under natural no-flow conditions.	Use on-site, in processing, passive recharge via completed mine pits and controlled surface discharge to Warramboo Creek. Controlled surface discharge from the Revised Proposal to extend along Warramboo Creek no further than 8 km downstream of the discharge point under natural no-flow conditions.
Ore processing (waste)	Figure 2-2	-	In-pit disposal of waste fines at Warramboo.	In-pit disposal of waste fines at Warramboo.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse

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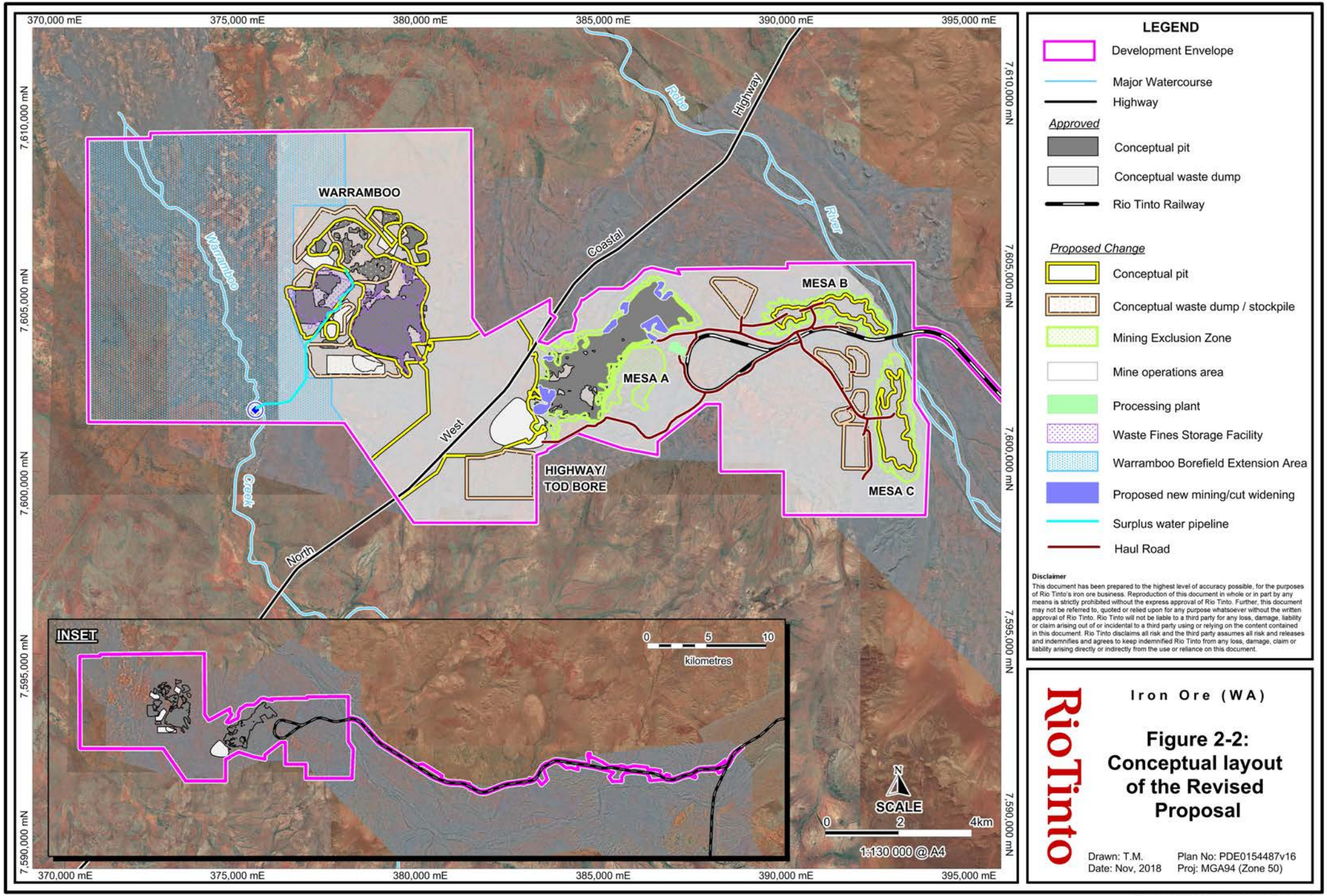
Iron Ore (WA)

Figure 2-1: Development Envelope

Drawn: T.Murphy
Date: May, 2018

Plan No: PDE0149313v4
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Major Watercourse
- Highway

Approved

- Conceptual pit
- Conceptual waste dump
- Rio Tinto Railway

Proposed Change

- Conceptual pit
- Conceptual waste dump / stockpile
- Mining Exclusion Zone
- Mine operations area
- Processing plant
- Waste Fines Storage Facility
- Warramboo Borefield Extension Area
- Proposed new mining/cut widening
- Surplus water pipeline
- Haul Road

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Iron Ore (WA)

Figure 2-2: Conceptual layout of the Revised Proposal

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0154487v16
Proj: MGA94 (Zone 50)

2.3.2 Description of the resource

The deposits between Mesa C and Warramboo are believed to have formed as part of the Robe River palaeochannel in the late Mesozoic to early Tertiary period. The Warramboo and Highway/Tod Bore deposits form part of the buried downstream continuation of the Robe Pisolite deposit present at Mesas A, B and C.

2.3.3 Vegetation clearing and topsoil removal

A maximum of 3,000 ha (in addition to the currently approved 3,680 ha) within the Development Envelope of 16,834 ha will be subject to vegetation clearing.

Clearing of vegetation will occur during pre-strip activities to develop the mine pits and associated infrastructure. Fill for construction purposes will be sourced from the escarpment cuts at Mesas B and C, borrow pits and existing waste dumps in-pit at Mesa A and on the southern side of Mesa A.

Topsoil, subsoil and overburden will be removed during the bulk earthworks phase. Topsoil is an important resource in rehabilitation as it contains a natural seed bank and typically contains significant quantities of organic material and nutrients (required for successful rehabilitation) relative to subsoil or overburden material. Topsoil layers in the Pilbara are highly variable in thickness, ranging from minimal soil development on rocky areas to approximately 300 millimetres (mm) in valley areas. Stripped topsoil, subsoil and cleared vegetation will be stored in out-of-pit stockpiles for later use in areas being rehabilitated.

2.3.4 Mining

The Proposed Change includes development of new open cut mine pits at the Mesa B, Mesa C and Highway /Tod Bore deposits. The mine pits at Mesa B and Highway/Tod Bore will be above the water table; the mine pit at Mesa C will be approximately 90% above and 10% BWT.

The Proposed Change also includes an above water table extension of the existing mine pit at Mesa A and an above and BWT extension of the existing mine pits at Warramboo. Together with current approved mine pits at Warramboo, mining at Warramboo will be approximately 89% above and 11% BWT following implementation of the Proposed Change.

Dewatering of up to 15 GL/a at Warramboo will be required to enable BWT mining of the Warramboo deposit. Dewatering of 5 GL/a at Mesa C will be required to enable BWT mining of the Mesa C deposit.

Mining is anticipated to involve conventional drill, blast, load and haul techniques whereby the blasted material will be excavated and loaded into haul trucks (i.e. bulk mining methods).

2.3.5 Revision of the Mesa A Mining Exclusion Zone

The Mesa A MEZ requires revision to accommodate preferential mining of higher quality ore, additional access and other minor clearing. Proposed disturbance in the current Mesa A MEZ will be limited to 42 ha of which 33 ha is proposed for mining. The proposed mine pit shell has been designed to retain a substantial proportion of troglofauna habitat, maintaining interconnectivity between the material beneath the pit floor and the MEZ and avoiding singleton troglofauna records.

The proposed pit design will continue to meet the requirements of MS 756, Condition 8-1 and will result in retention of at least 50% of estimated total pre-mining material suitable as troglobitic fauna habitat (compared with 52% habitat retention with the current approved pit design). The proposed changes to the pit design will also result in decommissioning of one of the troglobitic fauna habitat monitoring stations; 11 monitoring stations will remain accessible.

The Proposed Change will require 2 ha of additional disturbance in the Mesa A MEZ in order to widen the existing escarpment cut. An additional 7 ha of clearing will be required to allow access to the proposed additional mining areas and retain access to infrastructure, including troglofauna monitoring stations, utilities, telecommunications, and abandonment bunds; such infrastructure is variously required to meet legal obligations and because of lack of alternative suitable locations.

2.3.6 Waste rock and low grade ore handling

Overburden and mineral waste will be used to progressively backfill mine pits where sequencing and schedules allow. Where sequencing and scheduling do not allow waste to be used for backfilling, out-of-pit waste dumps will be utilised. Out-of-pit storage will also be required for low grade ore.

2.3.7 Ore handling, processing and transport

Ore from all deposits will be hauled to Mesa A to tie-in with existing operations. Ore will be crushed at the existing primary crusher at Mesa A and then either directly transported to port or further processed using a wet beneficiation process (wet processing) at a wet processing plant to be constructed near Mesa A as part of the Proposed Change.

2.3.8 Waste fines residue handling

Waste fines will be generated by the wet processing plant and will be pumped from the wet processing plant to an in-pit WFSF to be developed at Warramboo as part of the Proposed Change. In-pit storage of waste fines will occur in an area of the pit that has previously been completely mined out of all ore.

2.3.9 Water supply and management

2.3.9.1 Water supply

Water will be required at the new deposits as part of the Proposed Change for construction and general mining activities, dust suppression on haul roads, and potable water supply. This water will be sourced from existing and new local bores or reticulated from the existing Mesa A header tanks.

Water will also be required for wet processing where not available from mine dewatering activities. This water will be sourced from the Warramboo borefield extension (the existing Warramboo borefield supplies water to the existing Mesa A/Warramboo Iron Ore Project). A reverse osmosis plant may be required for water sourced from the Warramboo borefield, to ensure suitable water chemistry for wet processing. Effluent generated by the reverse osmosis plant will be disposed of in-pit at Warramboo.

Peak water demand for the Revised Proposal is estimated to be up to 15 GL/a.

2.3.9.2 Surplus dewater management

All surplus water generated from dewatering the Mesa C deposit will be used on-site and for wet processing.

Where scheduling allows, surplus water generated from dewatering the Warramboo deposit will be used on-site and for wet processing. Where scheduling does not allow this, the surplus water will be discharged by controlled release to Warramboo Creek, south-west of the proposed operations. To assist in the management of surplus water discharge to Warramboo Creek, surplus water may also be discharged into existing mine pits at Warramboo enabling passive recharge of water back into the aquifer.

This proposed water management approach is consistent with the "Pilbara Water in Mining Guideline" (Government of Western Australia 2009) which identifies options for use and/or release of dewatering discharge as:

- Efficient on-site use, including mitigation of any impacts
- Used for fit-for-purpose activities (such as processing and dust suppression)
- Transferred to meet other demand including other proponents in the area and public water supply
- Injection back into the aquifer
- Controlled release to the environment where the dewater release is allowed to flow (either through a pipe or overland) into a designated water course or wetland.

There is no other mine or water user in close enough proximity to the Development Envelope to make transfer to another proponent feasible and local aquifers are not considered suitable for active re-injection (see Section 8.6.1).

2.3.9.3 Surface water management infrastructure

Operations are located on the fringes of floodplain areas and are mainly outside modelled critical flood levels. Some flood protection for mine pits and ore processing facilities will be installed to minimise production loss due to water ingress or erosion. These will be designed to largely direct water past operational areas within existing flow networks. Local water management may include interception and re-direction of surface flows and is expected to include diversion drains and culverts where required.

2.3.10 Power supply

Power supply for the Proposed Change will include sub-stations and diesel-power generation units. The existing overhead power line between the Pannawonica switchyard and the Mesa A/Mesa J tee-off will be duplicated to provide power for the Proposed Change. Duplication of this section of overhead power line is excluded from the Proposed Change and will be subject to relevant provisions under Part V (Land Clearing and Works Approval/Licensing) of the EP Act.

2.3.11 Road access and infrastructure

New haul roads will be established between Mesas A, B and C (Figure 2-2). Mesa escarpment cuts will be required at Mesas B and C to allow ore to be hauled from the proposed Mesas B and C mine pits to Mesa A. The existing mesa escarpment cut at Mesa A will be widened by approximately 100 m, to allow haul trucks from Mesas B and C to access the primary crusher at Mesa A. Existing tracks at Mesas B and C will be widened by approximately 1 m (including use of rock-breakers if required) to provide temporary access to the tops of the mesas so that the permanent escarpment cuts can be formed.

2.3.12 Workforce and accommodation

Existing fly-in fly-out accommodation at Mesa A will be utilised for the ongoing operations workforce for the Revised Proposal. The existing Mesa A/Warramboo Iron Ore Project workforce will transition as required from Mesa A/Warramboo to the deposits included in the Proposed Change. It is anticipated that the operational workforce will increase by approximately 50 roles with the development of the new deposits and the addition of the wet plant and associated facilities (refer Section 2.3.14).

Additional temporary accommodation will be required to support the construction phase of the Proposed Change. Establishment and operation of a construction camp is excluded from the Proposed Change and will be subject to relevant provisions under Part V (Land Clearing and Works Approval/Licensing) of the EP Act.

2.3.13 Non-mineral waste disposal

The Proponent has existing systems and procedures to collect and recycle waste streams such as hydrocarbon wastes (oil, drums, rags, filters, etc.), tyres, batteries, scrap metal and conveyor belting. These existing systems will be used for the Revised Proposal. Hazardous wastes will be collected and removed for treatment by licensed contractors. General waste from the Mesa A/Warramboo Iron Ore Project is disposed of at the existing Deepdale Landfill. General waste from the Revised Proposal will continue to be disposed of at the Deepdale Landfill. Some inert waste may be disposed of at the Mesa A Hub site.

2.3.14 Other ancillary mining facilities

Existing communications systems will be extended, including installation of fibre optic cables, to support new (proposed) mining areas. Other facilities such as waste water treatment plants, explosive storage, fuel storage, diesel-power generation units, laboratory, workshops, offices and laydown areas will also be required.

2.3.15 Exclusions from the Proposed Change

The scope of the Proposed Change specifically excludes:

- Activities that are part of the existing Mesa A/Warramboo Iron Ore Project as approved under Ministerial Statement 756
- Low impact activities, including drilling and associated activities (such as upgrades to existing roads/tracks) for resource evaluation, geotechnical assessment and hydrogeological investigations to support the environmental assessment of the Proposed Change (to be subject to relevant provisions under Part V [Land Clearing] of the EP Act)

- Essential environmental, heritage and other studies/investigations involving fieldwork
- Duplication of a 9 km section of overhead power line between the Pannawonica switchyard and the Mesa A/Mesa J tee-off (to be subject to relevant provisions under Part V [Land Clearing and Works Approval/Licensing] of the EP Act)
- Establishment of a construction camp to support the construction phase of the Proposed Change (to be subject to relevant provisions under Part V [Land Clearing and Works Approvals/Licensing] of the EP Act)
- Establishment of temporary services (communications, water supply and power), temporary concrete batch plant, site offices, access roads and laydown areas to support establishment of a construction camp (to be subject to relevant provisions under Part V [Land Clearing and Works Approval/Licensing] of the EP Act)
- Establishment of borrow pits/quarry to provide suitable material for construction of any items excluded from assessment under Part IV of the EP Act (to be subject to relevant provisions under Part V [Land Clearing] of the EP Act).
- Re-alignment of the North West Coastal Highway to allow access to the Highway/Tod Bore deposit. Separate approval will be sought for this aspect (see Section 2.4).

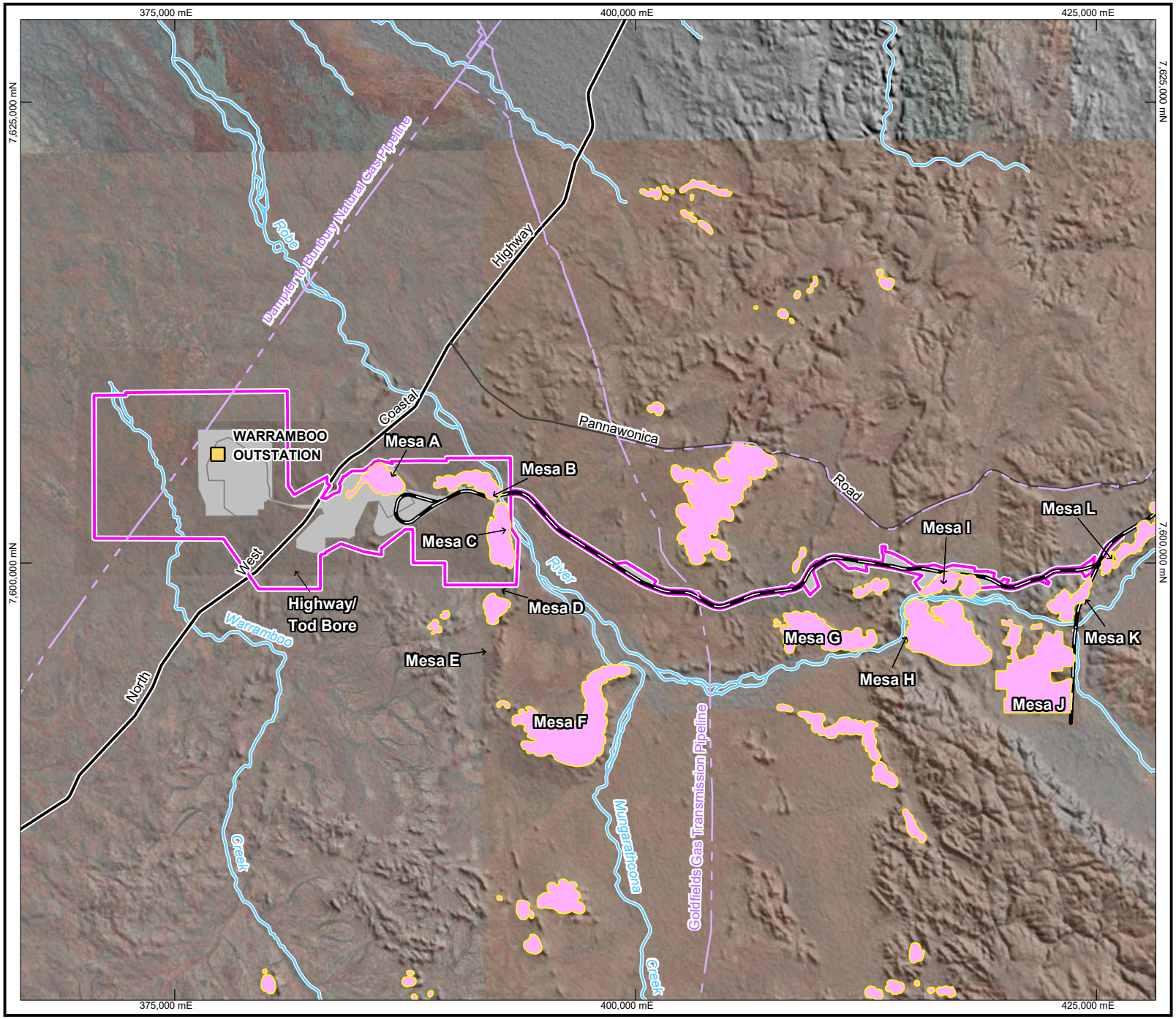
2.4 Local and Regional Context

The Revised Proposal is located in the Robe Valley within the Pilbara region of Western Australia, in the Shire of Ashburton (Figure 1-1). The Robe Valley is traversed by the Robe River, which is one of several major river systems in the Pilbara and flows generally westward over approximately 190 km. The Robe River intersects the Development Envelope and passes approximately 50 m to the east of Mesas B and C at its closest point (Figure 2-2). For the majority of its course, the Robe River is ephemeral with a wide, shallow floodplain. During the dry season, surface water is restricted to a series of permanent or semi-permanent pools along sections of the Robe River that are maintained by sub-surface flow.

Warramboo Creek also intersects the Development Envelope and passes approximately 1 km to the west of the Warramboo deposit (Figure 2-2). Warramboo Creek is ephemeral and drains generally from south-east to north-west. It is well-defined for much of its course before it discharges onto the poorly defined scrubland of the coastal plain.

Throughout the Robe Valley, on both sides of the Robe River, numerous mesa formations occur and are comprised primarily of Robe Pisolite[2] (Figure 2-3). The Robe Valley mesas are mostly elevated areas of land that protrude above the surrounding landscape and have relatively flat tops and steep sides or escarpments. The escarpments of some of the Robe Valley mesas contain deep gullies and/or caves. The Robe Pisolite is believed to have been deposited in the palaeochannels of the ancestral Robe River system and, as a result of regional uplift and subsequent erosion, to have been exposed along the Robe Valley as a series of mesas. The Warramboo and Highway/Tod Bore deposits form part of the buried downstream continuation of the Robe Pisolite deposit present at Mesas A, B and C.

[2] Pisolitic ore consists primarily of a mixture of iron minerals with minor clay and silica. The majority of the pisolite is made up of spherical accretions of iron minerals called pisoliths.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Mesa
- Rio Tinto Railway
- Highway
- Major road
- Major Watercourse
- Natural gas pipeline

N

SCALE

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1:300 000 @ A4

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Rio Tinto

Iron Ore (WA)

Figure 2-3: Local context

Drawn: T.M.
Date: Aug, 2018

Plan No: PDE0159820v4
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

The most significant environmental values within and directly adjacent to the Development Envelope include the escarpments of Mesas B and C contain deep gullies that represent significant habitat features for terrestrial fauna. A semi-permanent pool present in the Robe River adjacent to Mesa B, and the riparian vegetation of the Robe River and Warramboo Creek also represent significant habitat features for terrestrial fauna. Vegetation associated with riparian habitat along the Robe River and the Sand Sheet PEC located at the base of the south-eastern side of Mesa A (see Section 5.4) are of high local significance.

Existing land uses in the Development Envelope include pastoral activities (Yarraloola Station and Yalleen Station), mineral exploration, mining activities and Traditional Owner activities such as camping, fishing and hunting (refer to Figure 1-2 for land tenure). The mesa profiles are also used by Traditional Owners as navigational landmarks. The Dampier to Bunbury natural gas pipeline runs to the north-west of the Warramboo deposit, within the Development Envelope and the Goldfields Gas Transmission Pipeline also crosses over the existing Mesa A/Warramboo Iron Ore Project infrastructure corridor (Figure 2-3). The North West Coastal Highway runs between the Mesa A and Warramboo deposits, directly through the Highway/Tod bore deposit (Figure 2-3). This section of the Highway will require re-alignment prior to mining the Highway/Tod Bore deposit. It is anticipated that separate approval for the re-alignment of the Highway will be required. Consultation and investigations to determine the most appropriate alignment will be initiated well in advance of commencement of mining of the Highway/Tod Bore deposit.

3. STAKEHOLDER ENGAGEMENT

3.1 Key Stakeholders

Key stakeholders for the Revised Proposal were identified based on the Proponent's experience in recent and similar project developments in the Pilbara. The following key stakeholders were identified:

- Department of Jobs, Tourism, Science and Innovation (DJTSI) (formerly the Department of State Development)
- Department of Mines, Industry Regulation and Safety (DMIRS) (formerly the DMP)
- DWER, specifically:
  - Environmental Protection Authority Services (EPA Services) (formerly the Office of the Environmental Protection Authority)
  - Regulatory Services: Water (formerly the Department of Water)
- Department of Biodiversity, Conservation and Attractions (DBCA), specifically Parks and Wildlife Service (formerly the Department of Parks and Wildlife)
- Dampier Bunbury Pipeline (DBP)
- Kuruma Marthudunera People.

3.2 Stakeholder Engagement Process

Consultation on the Proposed Change commenced in 2015 and has included discussions with a number of key stakeholders (Table 3-1). The timing of the consultation program has enabled topics raised to be considered in the early design phase of the Proposed Change, during determination of mitigation measures and as part of the preparation of the ERD.

A draft version of this document was provided to the Kuruma Marthudunera People on 19 July 2018 and the final version will be provided as soon as practicable.

3.3 Stakeholder Consultation

The most common topics/issues raised by stakeholders as part of the stakeholder engagement program (Table 3-1) were:

- Subterranean fauna, including maintenance of adequate troglofauna retention zones and contextual information on presence/absence of subterranean fauna species across the Robe Valley mesas
- Mine closure, including early consideration of abandonment bund placement and installation
- Warramboo outstation (Figure 2-3), particularly exclusion of the outstation from the mining footprint and maintenance of access to the outstation.

Table 3-1: Stakeholder consultation

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Kuruma Marthudunera People	24 March 2015	The Proponent provided an overview of the scope of the Proposed Change. The Proponent advised the Kuruma Marthudunera People that biological surveys were scheduled and provided maps of the proposed survey locations. The Proponent requested heritage surveys. The Kuruma Marthudunera People sought clarification regarding current access to Warramboo outstation and the proposed mine development schedule.	The Proponent confirmed that access to Warramboo outstation is available provided the drill and blast team is contacted prior to any visit.
Kuruma Marthudunera People	2 September 2015	The Proponent provided an update on the status of biological surveys and provided preliminary results from biological surveys. The Kuruma Marthudunera People discussed mining near the Warramboo outstation.	The Proponent confirmed that the Warramboo outstation will be excluded from mining and that access to the site will be maintained subject to safety constraints. A procedure is in place to allow safe access.
Kuruma Marthudunera People	4 April 2016	The Proponent provided a summary of results from biological surveys and provided information regarding the planned 2016 biological survey work.	No specific response or further action required from the Proponent.
EPA Services[3]	10 May 2016	The Proponent provided an overview of the scope of the Proposed Change and a summary of the biological survey results and likely key environmental factors for the environmental assessment of the Proposed Change. EPA Services advised that the Proponent would need to show that the Proposed Change will meet the EPA objective for subterranean fauna. EPA Services recommended a meeting with the Terrestrial Ecosystems Branch (TEB) to discuss the proposed troglofauna habitat retention zones.	The Proponent has completed additional troglofauna studies to demonstrate that the Proposed Change will meet the EPA objective for subterranean fauna (refer Section 6.7). The Proponent met with the TEB on 1 May 2017 following additional troglofauna sampling (refer to entry below).

[3] Formerly the Office of the EPA

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
DMIRS[4]	30 June 2016	The Proponent provided an overview of the scope of the Proposed Change, the tenure context and tenure requirements and a summary of the likely key environmental factors for the environmental assessment of the Proposed Change. The DMIRS advised that abandonment bund placement and installation need to be considered early in mine planning and mine development to ensure these structures are not precluded from being installed at closure. The DMIRS sought clarification on whether different subterranean fauna species have been recorded on each mesa and whether contextual work had been undertaken on remaining mesas.	The Proponent acknowledged that the Mine Closure Plan will reflect current closure requirements. The Proponent confirmed that different troglofauna species are generally recorded on different mesas and that contextual subterranean fauna survey work has been undertaken on other mesas in the Robe Valley.
DJTSI[5]	25 August 2016	The Proponent provided an overview of the scope of the Proposed Change.	The Proponent confirmed a Proposal requesting approval for the development will be submitted to the DJTSI following funding approval and approval under Part IV of the EP Act.
Kuruma Marthudunera People	5-6 October 2016	The Proponent discussed tenure requests and cultural heritage management and provided an update on the Life of Mine studies. The Kuruma Marthudunera People agreed that seeking Section 18 consent under the AH Act for potential disturbance to all the rock shelters at Mesas B and C is a logical pathway forward.	The Proponent will work with the Kuruma Marthudunera Aboriginal Corporation to confirm the outcomes required for Section 18 consent for the rock shelters.

[4] Formerly the Department of Mines and Petroleum

[5] Formerly the Department of State Development

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
DWER[6]	15 November 2016	The Proponent provided an overview of the scope of the Proposed Change. The DWER requested technical engagement prior to development of numerical hydrogeological models. The DWER requested that details of surplus water disposal options be presented during the Environmental Impact Assessment process.	The Proponent conducted technical engagement with the DWER on 14 February 2017 and 15 February 2018 (refer to entries below).
Kuruma Marthudunera People	Eight separate consultation sessions between December 2016 and November 2017	Eight separate consultation sessions were held, the majority of which were part of the Heritage Sub-Committee meetings or the Heritage Advisory Committee meetings. Discussion items included general project design updates, upcoming Section 16 and Section 18 work related to the Proposed Change, the mesa landforms and the hydrology and vegetation of the Robe River.	The Proponent addressed any queries as they arose during the consultation sessions. Regular updates regarding the Proposed Change were requested. Regular updates have been and will continue to be provided.
DMIRS	24 January 2017	The Proponent provided an overview of the Mesa A Hub Closure Plan that is in preparation. The DMIRS commended the fact that abandonment bund design and consideration is incorporated into study outputs. The DMIRS agreed that the Plan can contain some knowledge gaps as long as there is a process to close-out the gaps before the final Closure Plan for the site is submitted.	The Closure Plan will be submitted with the ERD (refer Appendix 3).
DWER	14 February 2017	The Proponent presented a summary of the hydrogeological drilling and monitoring program in the Robe Valley and conceptual hydrogeological models for Mesa C and Warramboo. The DWER queried the lack of evapotranspiration in the Warramboo conceptual model and whether there are likely to be any issues with PAF material. The DWER noted that consideration of cumulative impact assessment for the lower Robe River will be expected as part of the Environmental Impact Assessment.	The Proponent explained that the lack of evapotranspiration in the Warramboo conceptual model is because there is little vegetation along Warramboo Creek that is likely to be utilising groundwater. The Proponent explained that no PAF issues are anticipated based on geology and geochemical

[6] Formerly the Department of Water

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		The proposed consultant to peer review the hydrogeological model was discussed. The Proponent offered to arrange a site visit which was accepted by the DWER.	assessment undertaken to date (refer Section 8.6.3).
Parks and Wildlife Service	24 March 2017	The Proponent provided an outline of the scope of the Proposed Change. The Proponent provided a status update and overview of survey results. Parks and Wildlife Service indicated that the full context for flora and vegetation should be included in the ERD. That is, all available data should be used when discussing species distribution. Parks and Wildlife Service asked if the Sand Sheet PEC is monitored and indicated that the current data should be included in the ERD. Parks and Wildlife Service advised that Ghost Bat roost context needs to be provided including locations of, and information about, roosts outside the Development Envelope, whether the potential diurnal/maternal roost at Mesa A is currently being used by Ghost Bats. Parks and Wildlife Service queried whether the North West Coastal Hwy will remain in the same location once the Highway/Tod Bore deposit is mined. Parks and Wildlife noted that this is a complex Proposal so two weeks for DMA to sign-off isn't really enough. Parks and Wildlife Service suggested a technical consultation session on sub-fauna and possibly bats (depending on the information provided in the ERD) soon after submission of the ERD would be useful.	The Proponent agreed to provide full vegetation/species context in the ERD (refer Sections 5.4, 5.5 and 1.1). The Proponent agreed to include relevant Sand Sheet PEC monitoring information in the ERD (refer Section 5.4). The Proponent indicated that additional work to assess Ghost Bat roosts is underway (refer Section 7.4). The Proponent indicated that the North West Coastal Highway will require re-alignment prior to mining the Highway/Tod Bore deposit (refer Sections 1.4.4, 2.4 and 9.6). The Proponent agreed to initiate technical consultation after ERD submission.
Kuruma Marthudunera People	4 April 2017	The Proponent provided an update on Life of Mine planning and provided an overview of mine design to minimise heritage impacts. The Proponent also provided an update on the progress of environmental approvals.	No specific response or action required from the Proponent.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
DWER	11, 12 April 2017	The Proponent provided an outline of the Proposed Change during a site visit. Discussions were around current understanding and conceptualisation of the hydrology and hydrogeology for all of the Robe Valley existing operations and proposed developments. Items raised by the DWER included: • Discussions around the detail of hydrogeological conceptualisations, gaps in knowledge, and assumptions and how these are being addressed, including how this informs the impact assessment and approach to managing water • Asked what fish species are found in the Robe River • Indication that they would like to see consideration of cumulative impacts both at the local scale of the Proposed Change and also on the broader catchment (Robe Valley) scale • What suite of hydro and environmental monitoring is currently undertaken and frequency, including subterranean fauna • Asked whether there are any significant environmental receptors including any pools in the vicinity • Asked what the extent of the cones of depression would be and if any stygofauna are restricted to the borefield groundwater drawdown area • Asked how much of Warramboo Creek would be impacted by the proposed discharge and for what duration • Asked if there are baseline data for the riparian vegetation of Warramboo Creek • Asked what the discharge water quality into Warramboo Creek would be • Asked what the proposed closure approach for BWT pits is and whether there would be pit lakes.	The queries and requests for technical information have been addressed as far as possible in this ERD. Please refer to the following sections which correspond to each dot point: • Section 8 • Section 7.4.7.5 • Section 8.6.4 • Section 8 and Section 6.4.1.2 • Section 8.4 • Section 8.5.1and 6.5.3.1 • Section 8.6.2.2 • Section 5.6.2 • Section 8.6.3.4 • Section 8.7
EPA Services	18 April and 8 June 2017	Discussion of requirements of the ESD, including discussion of some work requirements that aren't technically feasible.	Clarification of the requirements of the ESD was provided by the EPA.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
EPA Services (TEB)	1 May 2017	The Proponent provided an outline of the Proposed Change. The Proponent provided a summary of troglofauna sampling and results. The Proponent presented the troglofauna habitat assessment modelling for Warramboo and Highway/Tod Bore deposits. The Proponent also presented conceptual troglofauna habitat retention areas and singleton avoidance areas for Mesas B and C. The EPA Services advised the Proponent to provide justification for the areas, volumes and widths selected as MEZ in terms of suitability for troglofauna. The EPA Services advised that data from troglofauna sampling at Mesa A and analysis of downhole humidity and temperature data should be used to justify selected areas. The EPA Services asked whether the same troglofauna species are present inside and outside the Warramboo impact zone and whether additional sampling will be done. The EPA Services requested that null results through the broader Warramboo area are shown. The proposed changes to the Mesa A MEZ were discussed. The EPA Services advised that the EPA Board would like to do a site visit to see how the Mesa A MEZ is managed. Suggested timing is after submission of the draft ERD.	Justification for selection of the MEZs, including outcomes from analysis of data from Mesa A is provided in Section 6.4.4 of the ERD. The Proponent supports an EPA Board visit to the Development Envelope; this is to be progressed following submission of the ERD. Additional troglofauna sampling has been undertaken in the broader Warramboo area; results are included in the ERD. Further sampling is underway; results are anticipated to become available during the Environmental Impact Assessment process.
DBP	21 August 2017	DBP requirements for installation of infrastructure that will cross the Dampier to Bunbury Natural Gas Pipeline easement were discussed.	The Proponent noted the DBP requirements and has designed the infrastructure accordingly. The Proponent will seek Section 41 approval under the *Dampier to Bunbury Pipeline Act 1997* as advised by the DBP.
DWER	12 October 2017	An overview of the Proposed Change and required EP Act Part V approvals was provided.	No specific response or additional action required from the Proponent other than standard application procedures.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Kuruma Marthudunera People	17 October 2017	An update of the Proposed Change design was provided describing how the Proposed Change has been designed to avoid direct impacts to rock shelters and how Yirrkawiya Gap will be protected. The Proponent stated that Section 16 and Section 18 applications will still be required for the majority of rock shelters at Mesas B and C due to the potential for indirect impacts. The Kuruma Marthudunera People requested further consultation about the rock shelters at Mesa B with spinifex matting (field ID MBC15_36) and the feasibility of protecting these sites.	The Proponent has undertaken further on-site consultation with the Kuruma Marthudunera People regarding site MBC15_36. In agreement with the Kuruma Marthudunera People, the Proponent plans to lodge Section 16 applications for investigation of the spinifex matting. The Proposed Change will avoid disturbance to site MBC15_36.
DJTSI	21 November 2017	The Proponent advised that tenure applications have been made to support the Proposed Change.	The Proponent will provide a full overview of tenure applications to DJTSI once the full footprint of the area off current tenure is known.
Kuruma Marthudunera Aboriginal Corporation (KMAC)	15 December 2017	The Proponent presented a 3-dimensional hydrogeological visualisation program for areas in the Robe Valley.	KMAC were pleased with the program and requested the iOS and Android links.
DJTSI	30 January 2018	The Proponent discussed current and proposed tenure applications relating to the Proposed Change.	No specific response or further action required from the Proponent.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
DWER	15 February 2018	The Proponent provided an update on hydrogeological modelling and the Environmental Impact Assessment for the Proposed Change. DWER queried whether isolated pockets of stygofauna habitat will be created by the proposed drawdown at Warramboo. DWER queried whether the interaction between surface discharge to Warramboo Creek and beneath Warramboo Creek was considered in the hydrogeological modelling.	The Proponent explained that isolated pockets of stygofauna habitat are unlikely to be created at Warramboo as there are no known barriers to stygofauna dispersion and stygofauna habitat will continue to be present below the cone of depression and outside the lateral extent of drawdown. The Proponent explained that the modelling does not consider interaction between discharged surplus water and drawdown because discharge and maximum drawdown are proposed to occur at different times.
Yarraloola Pastoral Station	11 April 2018	The Proponent provided an overview of the Proposed Change. Yarraloola Pastoral Station indicated that the Proposed Change will have only limited impact on the pastoral operation. Yarraloola Station noted three water bores that may dry up as they are not deep enough.	The Proponent will investigate how deep the bores are. The Proponent will update the Pastoral Station updated on changes to infrastructure and progress of the Proposed Change.
DotEE	18 October 2018	The Proponent provided an overview of the Proposal. The Proponent also provided an overview of the most recent survey results on Ghost Bat utilisation of caves in previously mined areas and adjacent to existing Mesa J and A operations and the latest preliminary information on broader Pilbara Leaf-nosed Bat range extents. Potential offset mechanisms were broadly discussed for iron ore projects in the Pilbara.	No specific response required from the Proponent. The Proponent indicated willingness to provide additional information to DotEE as part of the assessment process.

4. ENVIRONMENTAL PRINCIPLES AND FACTORS

4.1 EP Act Principles

Table 4-1 provides details on how the EP Act principles have been considered in relation to the Proposed Change. The assessment of the impacts on each environmental factor from the Proposed Change is presented in Sections 5 to 13.

Table 4-1: EP Act principles

Principle	Consideration
The precautionary principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by: a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and b) an assessment of the risk-weighted consequences of various options.	Comprehensive biological surveys have been undertaken for the Proposed Change. The results of the biological surveys have been used to guide the design phase of the Proposed Change. Where significant potential environmental impacts have been identified, the relative risk has been evaluated and measures have been, and will continue to be, incorporated into the design and management of the Proposed Change to avoid or minimise these impacts where practical.
The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.	The Proposed Change will make a long-term contribution to the economic prosperity of Western Australia. The Proposed Change will not compromise current or foreseeable future land use options in the area. The Proposed Change can be effectively managed through avoidance, management and mitigation measures to ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.
Principles relating to improved valuation, pricing and incentive mechanisms (1) Environmental factors should be included in the valuation of assets and services. (2) The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement. (3) The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution.	Comprehensive biological surveys have been undertaken for the Proposed Change and have identified aspects of the environment that are of conservation significance. Where significant potential environmental impacts have been identified, measures have been, and will continue to be, incorporated into the design and management of the Proposed Change to avoid or minimise these impacts where practical. The Proponent's Health, Safety, Environment, Community and Quality Management System has established rehabilitation procedures for restoring disturbed environments.

Principle	Consideration
The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	The results from comprehensive biological surveys have been used to guide the design of the Proposed Change. The Proposed Change has been designed to avoid or minimise disturbance to high value habitats in order to maintain biological diversity and ecological integrity. The Proposed Change will be subject to a Mine Closure Plan prepared in accordance with the DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) and the Rio Tinto Closure Standard. This will provide the basis for ensuring that post-mining land use objectives are identified (through a consultative process) and can be met. The Proponent will undertake land rehabilitation activities to underpin the mine closure process.
The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Application of the Proponent's management policies, systems and procedures, in combination with the Mine Closure Plan, will provide the basis for minimising the generation of waste and its discharge into the environment. Mine planning objectives to minimise stripping ratios, thereby reducing mineral waste materials volumes, will assist in meeting the aims of this principle.

4.2 EPA environmental factors

The preliminary key environmental factors relevant to the Proposed Change are (as outlined in the ESD):

- Flora and Vegetation
- Subterranean Fauna
- Terrestrial Fauna
- Hydrological Processes and Inland Waters Environmental Quality
- Landforms
- Social Surroundings.

During the course of preparation of the ERD, 'Air quality' was requested to be included as an 'Other Environmental Factor' by EPA Services.

5. FLORA AND VEGETATION

This section describes the flora and vegetation that occur within the western portion of the Development Envelope and provides an assessment of the potential impacts of the Proposed Change to conservation significant flora and vegetation, proposed mitigation measures and the predicted outcome for this key environmental factor.

5.1 EPA Objective

The EPA's objective for flora and vegetation is to protect flora and vegetation so that biological diversity and ecological integrity are maintained.

5.2 Policy and Guidance

The following policy and guidance documents have been considered in the assessment of flora and vegetation.

5.2.1 EPA policy and guidance

- Cumulative environmental impacts of development in the Pilbara region: Advice of the Environmental Protection Authority to the Minister for Environment under Section 16(e) of the *Environmental Protection Act 1986* (EPA 2014)
- DMP and EPA Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015)
- Statement of Environmental Principles, Factors and Objectives (EPA 2018a)
- EPA Environmental Factor Guideline: Flora and Vegetation (EPA 2016b)
- Environmental Factor Guideline - Inland Waters Environmental Quality (EPA 2016c)
- EPA Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016d)
- Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (EPA 2016e).

5.2.2 Other policy and guidance

- WA Environmental Offsets Policy (Government of Western Australia 2011)
- WA Environmental Offsets Guidelines (Government of Western Australia 2014).

5.3 Environmental Scoping Document

Table 5-1 summarises where the requirements of the ESD are addressed in this Section.

Table 5-1: Requirements of the ESD for flora and vegetation

Task number	Requirement of ESD	Comments
1	Identify and characterise flora and vegetation in accordance with the requirements of Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment, December 2016. The survey should take into account areas that are likely to be directly or indirectly impacted as a result of the Proposal. For surveys previously undertaken of the Proposal and adjacent areas, demonstrate how these surveys are relevant and representative of the Development Envelope and if they are consistent with EPA Policy, and summarise their findings.	Section 5.4
2	Undertake baseline mapping of weed affected areas in any area likely to be directly or indirectly impacted by the Proposal.	Section 5.4.6
3	Provide an analysis of the vegetation and significant flora species present and likely to be present within the Development Envelope and indirect disturbance areas outside of the Development Envelope. Include an assessment of the relevance of any vegetation and significant flora species in a local and regional context. Include a quantitative assessment of levels of impact on conservation significant species, communities or vegetation units. For species, this includes numbers and proportions of individuals for the species in a local and regional context, and numbers and proportions of populations directly or potentially indirectly impacted. For communities and vegetation units this includes the area (in hectares) and proportions directly or potentially indirectly impacted.	Sections 5.5 and 1.1
4	Provide a clear set of data that shows the impact (direct, indirect and secondary) from the existing approved project to date against the currently approved footprint and proposed additional impact (direct, indirect and secondary) for the expanded Proposal.	Section 5.5, 1.1, 5.4.4.1
5	Provide information on the current status and outcomes of current activities to ensure that no significant adverse effects through direct or indirect impacts to the Sand Sheet PEC have occurred from the implementation of the Proposal as required by Condition 7-1 in Ministerial Statement 756.	Section 5.4.4.1
6	Review and revise the current Flora and Vegetation management plan in relation to the requirements of Condition 7 in Ministerial Statement 756, to apply to the entire Proposal. The following should be addressed in the plan:	Appendix 4 The draft EMP includes monitoring of the regionally significant Sand Sheet PEC and riparian vegetation

Task number	Requirement of ESD	Comments
	• Invasive species control – control of weeds, in particular through the infrastructure corridor, other transport and/or entry and exit points and in areas of native vegetation including the Sand Sheet PEC and vegetation units considered to have high local significance (e.g. rare units, habitat for conservation significant species) • Monitoring program – to monitor the health of significant flora species and vegetation identified, including (but not limited to) the Sand Sheet PEC, *Triodia* sp. Robe River (M. E. Trudgen et al. MET 12367) P3, *Rhynchosia bungarensis* P4 and *Goodenia nuda*.	considered to be of high and moderate local significance. The mitigation hierarchy has been considered in the design of the Proposed Change. As detailed in Sections 5.5.1 and 5.6.1, the Proposed Change will avoid disturbance to Priority Flora such that the Proposed Change is unlikely to result in significant impacts to Priority Flora. As the Proposed Change is unlikely to result in significant impacts to Priority Flora, monitoring of Priority Flora is not considered warranted. This is consistent with other mining operations.
7	Provide an analysis of any additional potential impacts from the Proposal in relation to dewatering and discharge activities.	Section 5.6.2
8	Provide a detailed description of the cumulative impacts associated with the Proposal, including direct impacts from clearing, and indirect impacts such as groundwater drawdown, altered drainage, changes in water quality, spread of weeds, fragmentation of vegetation, altered fire regime, and dust.	Section 5.6.3
9	Provide tables and maps of the proposed clearing and predicted indirect impact to vegetation and significant flora species, including but not limited to threatened and/or Priority Ecological Communities, threatened flora, Priority Flora, unnamed or new flora species.	Sections 5.5 and 1.1
10	Discuss, and determine significance of, potential direct, indirect (such as dust downstream impacts, weed invasion, etc.) and cumulative impacts (including in relation to the existing project) to flora and vegetation as a result of the Proposal at a local and regional level.	Sections 1.1, 0 and 5.8
11	Demonstrate that all practicable measures have been taken to reduce both the area of the proposed disturbance footprint and the Development Envelope based on progress in the Proposal design and understanding of the environmental impacts.	Section 5.8 and 5.6.1
12	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to flora and vegetation.	Section 5.8
13	Discuss management measures, outcomes/objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	Section 5.8

Task number	Requirement of ESD	Comments
14	Prepare a Mine Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015), which includes methodologies and criteria to ensure progressive rehabilitation of disturbed areas with vegetation composed of native species of local provenance.	Appendix 3
15	Describe the residual impacts for the Proposal and analyse these impacts to identify and detail any that are significant	Section 5.8 and 13
16	Create an offsets position following application of the 'mitigation hierarchy'.	Section 5.8 and 13
17	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 5.8 and 13

5.4 Receiving Environment

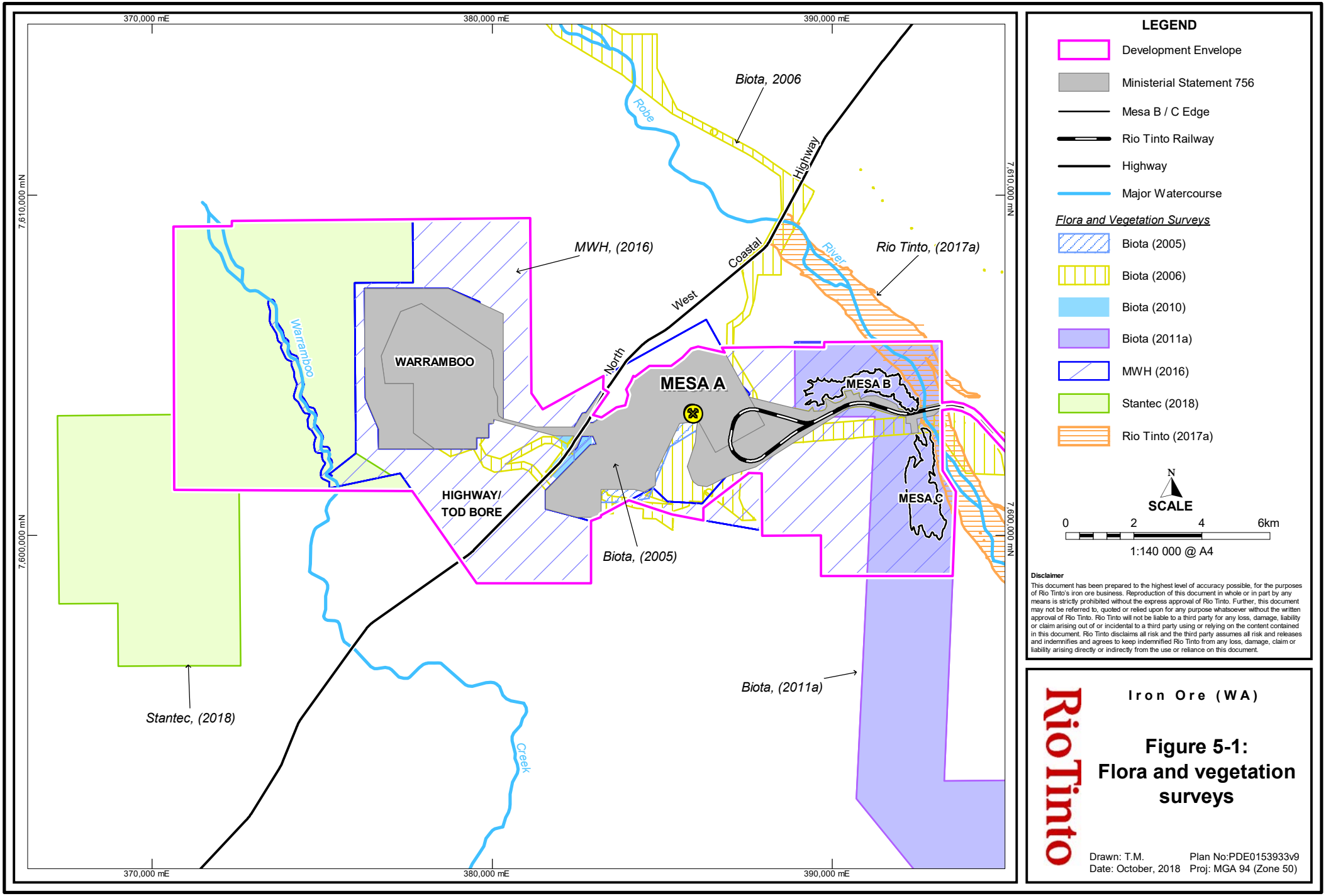
5.4.1 Flora and vegetation studies

Numerous flora and vegetation surveys have been conducted within the western portion of the Development Envelope and the wider Mesa A locality (Biota 2005a, 2006a, 2010a, 2011a, MWH 2016, Stantec 2018). Rio Tinto also conducted a broader study of riparian vegetation communities throughout the Robe Valley to identify the distribution of potential groundwater dependent ecosystems (GDEs) present (Rio Tinto 2017a). A consolidated list of flora and vegetation surveys completed to date is provided in Table 5-2. The most recent survey reports are attached in Appendix 5. Figure 5-1 shows the locations of surveys relevant to the Proposed Change and Figure 5-2 shows flora and vegetation survey sites in the western portion of the Development Envelope.

Table 5-2: Summary of supporting flora and vegetation studies

Report	Summary	Survey date
Flora and vegetation assessment Proposed Warramboo Borefield Area Stantec (2018)	A flora and vegetation survey of the Warramboo borefield was undertaken, including review of aerial photography, review of previous mapping, and sampling of quadrats and relevés, mapping of vegetation types, targeted searches for conservation significant flora, vegetation condition assessment and identification of introduced species.	May 2016
Assessment of Groundwater Dependent Vegetation distribution on the Robe River – Targeted Riparian Vegetation Survey – Stage 1 Rio Tinto (2017a)	A survey of Groundwater Dependent Vegetation as an indicator for the presence of terrestrial GDEs. The survey mapped the nature and distribution of Robe River Groundwater Dependent Vegetation, including obligate phreatophytic vegetation communities, assessed significance of the vegetation and interpreted sensitivity to hydrological change.	December 2016 and January 2017
Level 2 Flora and vegetation survey: Mesa B-C, Warramboo BWT, Highway to Tod Bore and Mesa A extension MWH (2016)	A level 2 flora and vegetation survey was conducted across various locations in the western portion of the Development Envelope. The survey included quadrats, relevés, mapping of vegetation units, targeted searches for conservation significant flora, vegetation condition assessment and identification of introduced species.	June and September 2015
Desktop Flora, Vegetation and Fauna Habitat Assessment at Robe Valley Native Vegetation Clearing Permit – Supporting Report Eco Logical Australia (2015)	A desktop assessment to summarise vegetation, flora and fauna assessments in the Robe Valley was undertaken covering a 3,723.5 ha area to address the 10 Clearing Principles to support a Native Vegetation Clearing Permit application process.	May 2015
Warramboo Extension Section 45C Biological Assessment Biota (2012a)	A biological survey of the Warramboo Mine extension area, including a desktop review and a flora and vegetation field survey. The field survey included sampling of quadrats, vegetation mapping and description of vegetation types.	May 2012

Report	Summary	Survey date
Flora, vegetation and fauna assessment of the Warramboo/Yarraloola access track ENV (2012)	A single season Level 2 Flora and Vegetation assessment and a Level 1 Fauna assessment of Warramboo/Yarraloola access track was undertaken. The survey included vegetation condition mapping, sampling of quadrats, list of vascular plant species present, targeted surveys for Threatened and Priority Flora, Declared Rare Flora (DRF), Threatened Ecological Communities (TECs), Priority Ecological Communities (PECs) and declared and environmental weeds. It also included a review of the survey area to determine conservation significant fauna presence.	July 2012
Baseline Flora and Vegetation Assessment of Robe Valley Mesas (Mesas B, C, D, E, F, H and I) Biota (2011a)	A baseline flora and vegetation survey was conducted including quadrats and relevés of representative areas, mapping of vegetation types and opportunistic records of Priority Flora and weeds.	October 2010
A Vegetation and Flora Survey of Warramboo Summary Report Biota (2010a)	A flora and vegetation survey was conducted in the Warramboo area. This included database searches, review of relevant reports, sampling of quadrats, description and mapping of vegetation types, opportunistic searches for Priority Flora and weeds.	August 2009
A vegetation and flora survey of the proposed Mesa A Transport Corridor, Warramboo Deposit and Yarraloola Borefield Biota (2006a)	A flora and vegetation survey of the Mesa A Transport Corridor, Warramboo Deposit and Yarraloola borefield. The survey included quadrats, mapping of vegetation types and systematic searches for DRF across the entire area and opportunistic records of weed species.	July and September 2005
Vegetation and Flora Survey of Mesa A and G, near Pannawonica Biota (2005a)	A baseline flora and vegetation survey of Mesa A and G was conducted and included a review of other previous botanical work conducted at Mesa A. The survey included survey of drill lines and quadrats on both Mesa A and Mesa G and identified vegetation types, Priority Flora and introduced species.	August 2003 and May 2004



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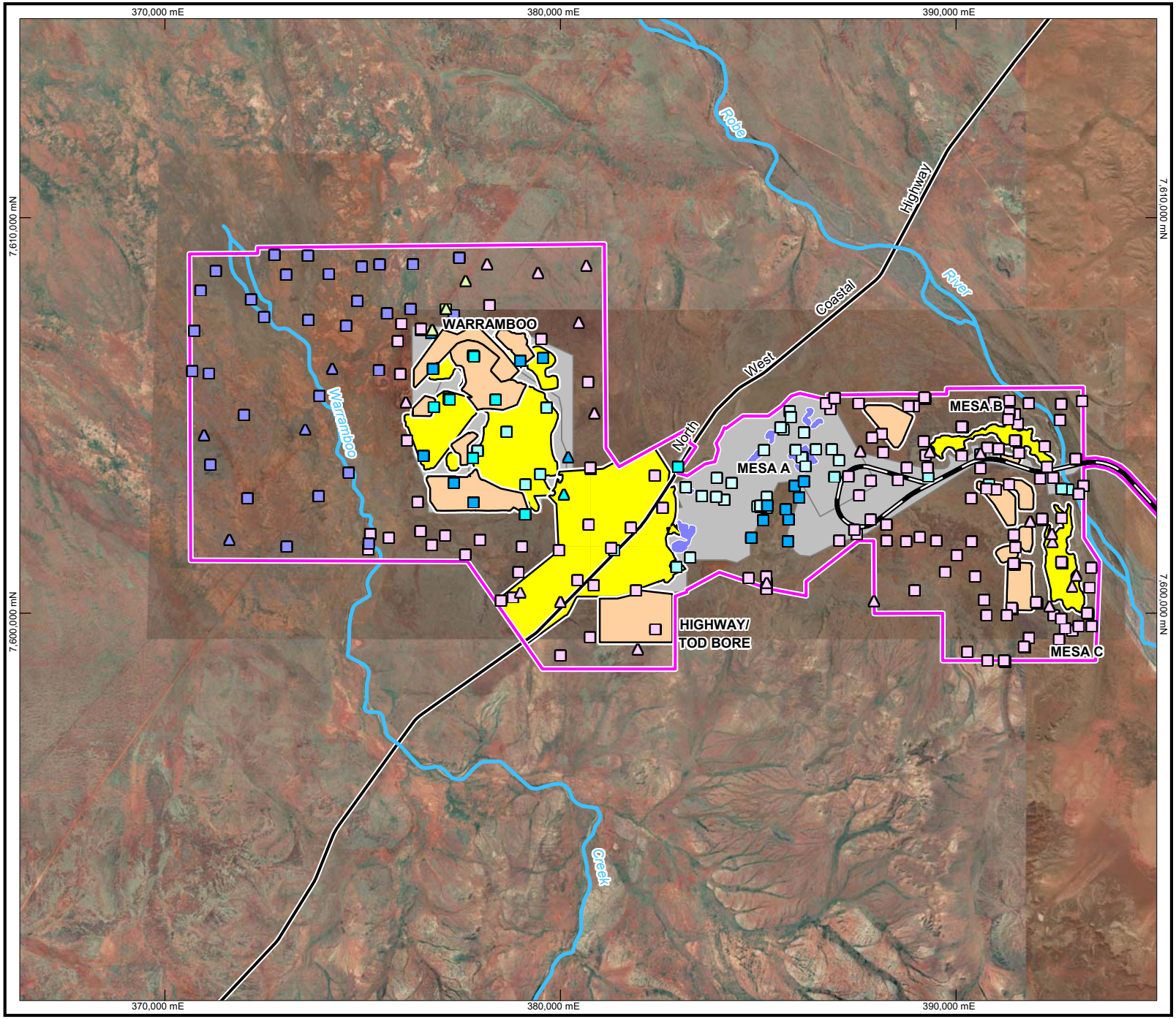
Rio Tinto

Iron Ore (WA)

Figure 5-1: Flora and vegetation surveys

Drawn: T.M.
Date: October, 2018
Plan No:PDE0153933v9
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Railway
- Highway
- Major Watercourse

Conceptual Mine layout

- Mine Pit
- Waste Dump / Stockpile
- Proposed new mining/cut widening

Flora and vegetation sites

Releve	*Quadrat*
Biota (2010)	Biota (2005)
Biota (2012)	Biota (2006)
ENV (2012)	Biota (2010)
MWH (2016)	Biota (2011a)
Stantec (2018)	Biota (2012)
	ENV (2012)
	MWH (2016)
	Stantec (2018)

N

SCALE

2 0 2 4 6km

1:140 000 @ A4

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Rio Tinto

Iron Ore (WA)

Figure 5-2: Flora and Vegetation survey sites

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0152055v8
Proj:MGA94 Zone50

Geospatial Information and Mapping

5.4.2 Regional context

The Interim Biogeographical Regionalisation for Australia (IBRA) Version 7 recognises 89 geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information. The 89 bioregions are further defined into 419 subregions, which are more localised and homogenous geomorphological units within each bioregion.

The Revised Proposal is located within the Pilbara IBRA bioregion, in the north of Western Australia. The Pilbara bioregion is divided into four subregions which include Chichester, Roebourne, Fortescue Plains, and Hamersley. The western portion of the Development Envelope lies within the Hamersley (PIL03) and Roebourne (PIL04) subregions.

The Development Envelope lies within the Eremaean Botanical Province (Beard 1975a) and intersects ten vegetation units defined by Beard (1975a, 1975b), as follows:

- Hammersley 82
- Hammersley 609
- Onslow Coastal Plain 600
- Onslow Coastal Plain 604
- Onslow Coastal Plain 605
- Stuart Hills 29
- Stuart Hills 93
- Stuart Hills 583
- Stuart Hills 603
- Stuart Hills 609.

Each vegetation unit has at least 98% of their pre-European extent remaining.

5.4.3 Vegetation units

A total of 76 vegetation units have been mapped in the western portion of the Development Envelope (Figure 5-3; Table 5-3). Some of the surveys undertaken in the western portion of the Development Envelope overlap one another therefore an amalgamation exercise was undertaken to generate a consolidated set of vegetation mapping and associated vegetation unit descriptions. The vegetation unit descriptions generally align with MWH (2016, 2018) which supersede the previous Biota work. The Rio Tinto (2017a) riparian vegetation mapping is much finer in scale, comprising a small area of the western portion of the Development Envelope and was therefore excluded from the broader list of vegetation units. However, this finer scale mapping has been considered in relation to the assessment of impacts to obligate phreatophytic vegetation (Section 5.6.2).

The dominant vegetation units represented by >500 ha each within the western portion of the Development Envelope are as follows:

- **AbAanAatTw** – *Acacia bivenosa*, *Acacia ancistrocarpa*, *Acacia atkinsiana* tall to mid sparse shrubland over *Triodia wiseana* mid open hummock grassland (1,949 ha)
- **AatCtTw** – *Acacia atkinsiana* tall to mid open shrubland over *Corchorus tectus* low sparse shrubland over *Triodia wiseana* hummock grassland (936 ha)

- **AanAbAsyTP** – *Acacia ancistrocarpa* and *Acacia bivenosa* tall to mid sparse shrubland with occasional *Acacia synchronicia* mid shrubs over *Triodia* sp. Peedamulla (A.A. Mitchell PRP 1636) mid open hummock grassland (868 ha)
- **CcAsyAanTe –** *Corymbia candida* isolated low trees over *Acacia synchronicia* and *Acacia ancistrocarpa* tall sparse to isolated shrubland over *Triodia epactia* mid open hummock grassland (755 ha)
- **CcAanAsyTe –** *Corymbia candida* isolated low trees over *Acacia synchronicia* and *Acacia ancistrocarpa* tall sparse to isolated shrubland over *Triodia epactia* mid open hummock grassland (610 ha)
- **AatAanCtTw** – *Acacia atkinsiana* and *Acacia ancistrocarpa* mid to low open to sparse shrubland over *Corchorus tectus* low open to sparse shrubland over *Triodia wiseana* sparse hummock grassland (592 ha)
- **AanAiAatAbTP** - *Acacia ancistrocarpa*, *Acacia inaequilatera*, *Acacia atkinsiana* and *Acacia bivenosa* tall to mid sparse shrubland over *Triodia* sp. Peedamulla (A.A. Mitchell PRP 1636) mid open to sparse hummock grassland (581 ha)
- **AatAiAarAbTw** – *Acacia atkinsiana*, *Acacia inaequilatera* (*Acacia arida*) tall open shrubland over *Acacia bivenosa* open shrubland over *Triodia wiseana* hummock grassland (535 ha).

Table 5-3: Description of vegetation units

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
AanAbAsyTe	*Acacia ancistrocarpa*, *Acacia bivenosa* and *Acacia synchronicia* tall to mid open/sparse shrubland over *Triodia epactia* open hummock grassland	4	
AanAbAsyTP	*Acacia ancistrocarpa* and *Acacia bivenosa* tall to mid sparse shrubland with occasional *Acacia synchronicia* mid shrubs over *Triodia* sp. Peedamulla (A.A. Mitchell PRP 1636) mid open hummock grassland	4	
AanAbSspTe	*Acacia ancistrocarp*a and *Acacia bivenosa* mid open shrubland over *Sida* sp. Pilbara (A.A. Mitchell PRP 1543) low sparse shrubland over *Triodia epactia* open hummock grassland.	6	
AanAiAatAbTP	*Acacia ancistrocarpa*, *Acacia inaequilatera*, *Acacia atkinsiana* and *Acacia bivenosa* tall to mid sparse shrubland over *Triodia* sp. Peedamulla (A.A. Mitchell PRP 1636) mid open to sparse hummock grassland	3	
AanAsyAteTwTe	*Acacia ancistrocarpa*, *Acacia synchronicia* and *Acacia tetragonophylla* mid open to sparse shrubland over *Triodia wiseana* and/or *Triodia epactia* hummock grassland to open hummock grassland.	8	
AanAsyTe	*Acacia ancistrocarpa* and *Acacia synchronicia* mid sparse shrubland over *Triodia epactia* open to sparse hummock grassland.	4	
AarAbTw	*Acacia arida* and *Acacia bivenosa* mid open shrubland over *Triodia wiseana* hummock grassland	5	
AarTw	*Acacia arida* mid open shrubland over *Triodia wiseana* hummock grassland	10	

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
AarTwTRR	*Acacia arida* mid open shrubland over *Triodia wiseana* and *Triodia* sp. Robe River (M.E. Trudgen et al. MET 12367) hummock grassland	0	This unit is outside the indicative footprint and considered to be very similar to vegetation unit AarTw which had ten quadrats established in it.
AatAanCtTw	*Acacia atkinsiana* and *Acacia ancistrocarpa* mid to low open to sparse shrubland over *Corchorus tectus* low open to sparse shrubland over *Triodia wiseana* sparse hummock grassland	3	
AatAbAanTl	*Acacia atkinsiana*, *Acacia bivenosa* and *Acacia ancistrocarpa* tall to mid, open to sparse shrubland over *Triodia lanigera* hummock grassland to open hummock grassland	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.
AatAiAarAbTw	*Acacia atkinsiana*, *Acacia inaequilatera* tall open shrubland over *Acacia arida*, *Acacia bivenosa* open shrubland over *Triodia wiseana* hummock grassland	11	
AatCtTw	*Acacia atkinsiana* tall to mid open shrubland over *Corchorus tectus* low sparse shrubland over *Triodia wiseana* hummock grassland	6	Four of the quadrat areas had been recently burned.
AbAanAatTw	*Acacia bivenosa*, *Acacia ancistrocarpa*, *Acacia atkinsiana* and *Acacia arida* mid open to sparse shrubland over *Triodia wiseana* hummock grassland	26	
AbAanAiTw	*Acacia inaequilatera* scattered tall shrubs over *Acacia ancistrocarpa*, *Acacia bivenosa* open shrubland to shrubland over *Triodia wiseana* hummock grassland	10	
AbAanAsyTw	*Acacia bivenosa*, *Acacia ancistrocarpa* and *Acacia synchronicia* tall to mid sparse shrubland over *Triodia wiseana* mid open hummock grassland	3	

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
AbTw	*Acacia bivenosa* mid sparse to open shrubland over *Triodia wiseana* hummock grassland	12	
AiAaAbTw	*Acacia inaequilatera* scattered tall shrubs over *Acacia ancistrocarpa*, *Acacia bivenosa* open shrubland to shrubland over *Triodia wiseana* hummock grassland	11	
AiAbTw	*Acacia inaequilatera* scattered tall shrubs over *Acacia bivenosa* scattered low shrubs over *Triodia wiseana* hummock grassland	7	
AsyAbAanTw	*Acacia synchronicia*, *Acacia bivenosa* and *Acacia ancistrocarpa* low to mid sparse shrubland over *Triodia wiseana* open hummock grassland	3	
AsyAbTlo	*Acacia synchronicia*, *Acacia bivenosa* open shrubland over *Triodia longiceps* hummock grassland	0	This unit was mapped in 2005 based on mapping notes, with an extent of 2.6 ha all of which is outside the indicative footprint.
AxBp	*Acacia xiphophylla* mid isolated shrubs over *Brachyachne prostrata* and *Sclerolaena costata* open herbland with *Triodia epactia* isolated hummock grasses	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.
AxSaoEf	*Acacia xiphophylla* tall sparse shrubland over *Senna artemisioides* subsp. *oligophylla* mid sparse shrubland over *Eriachne flaccida* mid tussock grassland	4	
AxTe	*Acacia xiphophylla* tall open shrubland over *Triodia epactia* open hummock grassland	5	
AxTeCHfEb	*Acacia xiphophylla* tall open shrubland over *Triodia epactia* scattered hummock grasses over *Chrysopogon fallax*, *Eriachne benthamii* scattered tussock grasses	0	This unit was described from two relevés. The mapped extent of this unit is approximately 0.5 ha and is entirely within the western portion of the Development Envelope approved under Ministerial Statement 756.
AxTP[1]	*Acacia xiphophylla* tall open to sparse shrubland over *Triodia* sp. Peedamulla (A.A. Mitchell PRP 1636) mid open hummock grassland	5	

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
AxTw	*Acacia xiphophylla* tall open to sparse shrubland over *Triodia wiseana* open hummock grassland	6	
CcAaAbAsyTeTw	*Corymbia candida* scattered low trees over *Acacia ancistrocarpa*, *Acacia bivenosa*, *Acacia synchronicia* open shrubland over *Triodia epactia*, *Triodia wiseana* hummock grassland	4	
CcAanAbTe	*Corymbia candida* low open woodland over *Acacia ancistrocarpa* and *Acacia bivenosa* tall to mid open to sparse shrubland over *Triodia epactia* with occasional *Triodia wiseana* hummock grassland to open hummock grassland	13	
CcAanAiAsyTe	*Corymbia candida* low open woodland over *Acacia ancistrocarpa*, *Acacia inaequilatera* and *Acacia synchronicia* mid sparse shrubland over *Triodia epactia* hummock to open hummock grassland	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.
CcAanAsyTe	*Corymbia candida* isolated low trees over *Acacia synchronicia* and *Acacia ancistrocarpa* tall sparse to isolated shrubland over *Triodia epactia* mid open hummock grassland	5	
CcAanTe	*Corymbia candida* isolated patches of low trees over *Acacia ancistrocarpa* mid sparse shrubland over *Triodia epactia* open hummock grassland with occasional *Triodia* sp. Peedamulla (A.A. Mitchell PRP 1636)	4	
CcAarCAoTeCHf	*Corymbia candida* subsp. *candida* scattered trees over *Acacia arida*, *Cassia oligophylla* open shrubland over *Triodia epactia* hummock grassland and *Chrysopogon fallax* scattered tussock grasses	1	The mapped extent of this unit is entirely within the western portion of the Development Envelope approved under Ministerial Statement 756.

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
CcAatTtTl	*Corymbia candida* low open woodland over *Acacia atkinsiana* and *Acacia inaequilatera* tall shrubland over *Triodia lanigera* open hummock grassland and *Themeda triandra* open tussock grassland	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. The mapped extent of this unit is approximately 6 ha.
CcAlTe	*Corymbia candida* subsp. *candida* scattered low trees over *Acacia ligulata* scattered shrubs over *Triodia epactia* very open hummock grassland	2	This unit was mapped in 2012 and 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. Mapping notes were also used to describe the unit in the 2012 survey (Biota 2012a). The mapped extent of this unit is entirely within the western portion of the Development Envelope approved under Ministerial Statement 756.
CcAsyAanAssTe	*Corymbia candida* isolated low trees over *Acacia synchronicia*, *Acacia ancistrocarpa* and *Acacia sclerosperma* subsp. *sclerosperma* tall to mid sparse shrubland over *Triodia epactia* sparse to open hummock grassland	7	
CcAsyAanTe	*Corymbia candida* isolated low trees over *Acacia synchronicia* and *Acacia ancistrocarpa* tall sparse to isolated shrubland over *Triodia epactia* mid open hummock grassland	12	
CcChAatAaTe	*Corymbia hamersleyana*, *Corymbia candida* scattered low trees to low open woodland over *Acacia atkinsiana*, *Acacia ancistrocarpa* scattered tall shrubs to tall open shrubland over *Triodia epactia* open hummock grassland	0	This unit was described from two relevés. The majority of the mapped extent of this vegetation unit is within the Mesa A MEZ.

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
CcSaTeCc	*Corymbia candida* subsp. *candida* scattered trees over *Acacia ancistrocarpa* tall shrubland over *Acacia arida*, *Cassia oligophylla* open shrubland over *Triodia epactia* hummock grassland and *Chrysopogon fallax* scattered tussock grasses	0	This unit is considered to have insufficient extent in the western portion of the Development Envelope (0.4 ha) to warrant quadrats. Also mapped as CcAarCAoTeCHf from one quadrat.
ChAanTe	*Corymbia hamersleyana* low open woodland over *Acacia ancistrocarpa* mid sparse shrubland over *Triodia epactia* open hummock grassland	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.
ChAarTw	*Corymbia hamersleyana* scattered low trees over *Acacia arida* shrubland over *Triodia wiseana* open hummock grassland	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. The mapped extent of this unit in the western portion of the Development Envelope is approximately 5 ha.
ChAbAtrTw	*Corymbia hamersleyana* low isolated trees over *Acacia bivenosa* and *Acacia trachycarpa* mid sparse to open shrubland over *Triodia wiseana* hummock grassland to open hummock grassland	4	
ChAtpAanTe	*Corymbia hamersleyana* isolated to low open woodland over *Acacia tumida* var. *pilbarensis* and *Acacia ancistrocarpa* mid sparse shrubland over *Triodia epactia* mid open hummock grassland with occasional *Chrysopogon fallax* and *Eragrostis cumingii* tussock grassland	3	
ChAtuGwAatAarTw	*Acacia tumida* var. *pilbarensis*, *Acacia pruinocarpa*, *Grevillea wickhamii* tall open shrubland to open scrub over *Acacia atkinsiana*, *Acacia arida* open shrubland to tall open shrubland over *Triodia wiseana* open hummock grassland and *Eriachne mucronata* scattered tussock grasses	3	

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
ChAtuTwTe	*Corymbia hamersleyana* scattered low trees over *Acacia tumida* tall closed scrub over *Triodia wiseana*, *Triodia epactia* open hummock grassland	4	
ChCcAanAatAsTe	*Corymbia hamersleyana* and *Corymbia candida* low open woodland over *Acacia ancistrocarpa*, *Acacia atkinsiana* and *Acacia sericophylla* over tall to mid sparse shrubland over *Triodia epactia* open hummock grassland with occasional *Triodia wiseana* and *Triodia* sp. Peedamulla (A.A. Mitchell PRP 1636) over isolated patches of tussock grasses dominated by *Chrysopogon fallax*	5	
ChCcAiAatAbTe	*Corymbia hamersleyana*, *Corymbia candida* subsp. *Candida* scattered low trees over *Acacia inaequilatera*, *Acacia atkinsiana*, *Acacia bivenosa* open shrubland over *Triodia epactia* closed hummock grassland	4	
ChCfEcTe	*Corymbia hamersleyana* low open woodland over *Acacia ancistrocarpa* mid open shrubland over *Chrysopogon fallax* and *Eragrostis cumingii* tussock grassland over with *Triodia epactia* sparse hummock grassland	3	
ChCzAanAtrAtuAatTlTe	*Corymbia hamersleyana* and *Corymbia zygophylla* low open woodland over *Acacia ancistrocarpa*, *Acacia trachycarpa*, *Acacia tumida* var. *pilbarensis* and *Acacia atkinsiana* mid open shrubland over *Triodia lanigera* and *Triodia epactia* hummock grassland	2	This unit was mapped in 2005 and 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.
ChCzAtuAtrCE	*Corymbia hamersleyana*, *Corymbia zygophylla* low open woodland over *Acacia tumida* (*Acacia trachycarpa*) tall open scrub over **Cenchrus* spp.[2] closed tussock grassland	0	This unit was mapped in 2005 and is a degraded version of ChCzAtuAtrTe Biota (2006a) which was partially re-mapped by MWH (2016) as ChCzAanAtrAtuAatTlTe, which was described from two quadrats.

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
ChElAiAatAarTw	*Corymbia hamersleyana*, *Eucalyptus leucophloia* subsp. *leucophloia* scattered trees over *Acacia atkinsiana*, *Acacia inaequilatera*, *Acacia arida* open shrubland over *Triodia wiseana* hummock grassland	2	This unit was mapped in 2009 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. Two mapping notes were also used to describe this unit. The mapped extent of this unit is entirely within the western portion of the Development Envelope approved under Ministerial Statement 756.
ChGrTuTwTe	*Corymbia hamersleyana* low open woodland over *Gossypium robinsonii* tall sparse shrubland over *Tephrosia uniovulata* and *Hibiscus sturtii* var. *campylochlamys* low sparse shrubland over *Triodia wiseana* and *Triodia epactia* open hummock grassland	5	
ChGwAtuAiTw	*Corymbia hamersleyana* low open woodland over *Acacia tumida* var. *pilbarensis*, *Acacia inaequilatera* and *Grevillea wickhamii* subsp. *macrodonta* mid open shrubland over *Triodia wiseana* sparse shrubland	1	This unit was also described from one relevé.
ChGwTe	*Corymbia hamersleyana* low open woodland over *Grevillea wickhamii* subsp. *Macrodonta* tall sparse shrubland over *Triodia epactia* open hummock grassland	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.
CODcAbAatTw	*Codonocarpus cotinifolius* scattered low trees over *Acacia atkinsiana*, *Acacia bivenosa* low open shrubs over *Triodia wiseana* very open hummock grassland	0	Two vegetation mapping notes were used to describe this unit. The mapped extent of this unit (6.7 ha) is entirely within the western portion of the Development Envelope approved under Ministerial Statement 756.
CzAanTl	*Corymbia zygophylla* low isolated trees over *Acacia ancistrocarpa* tall to mid open shrubland over *Triodia lanigera* hummock grassland	3	

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
CzAtGeTs	*Corymbia zygophylla* scattered low trees over *Acacia tumida* var. *pilbarensis*, *Grevillea eriostachya* high shrubland over *Triodia schinzii* hummock grassland	18	
CzEf	*Corymbia zygophylla* scattered low trees over *Acacia tumida* var. *pilbarensis*, *Grevillea eriostachya* high shrubland over *Triodia schinzii* hummock grassland	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.
EcAanAtrAbAtuTe	*Eucalyptus camaldulensis* subsp. *refulgens* low open woodland over *Acacia ancistrocarpa*, *Acacia trachycarpa*, *Acacia bivenosa* and *Acacia tumida* var. *pilbarensis* tall to mid open shrubland over *Triodia epactia* open to sparse hummock grassland	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. This unit has been subsequently described as EcrAtAanTe from five quadrats.
EcCcAanTe	*Eucalyptus camaldulensis* subsp. *refulgens* and *Corymbia candida* low open woodland over *Acacia ancistrocarpa* mid open shrubland over *Triodia epactia* open hummock grassland	1	This unit was also described from transects and mapping notes. This unit has been subsequently described as EcrAtAanTe from five quadrats.
EcEvMgAtrCv	*Eucalyptus camaldulensis* subsp. *refulgens* and *Eucalyptus victrix* low open woodland over *Melaleuca glomerata* and *Acacia trachycarpa* tall to mid open shrubland over *Cyperus vaginatus* sparse sedgeland	5	
EcrAtAanTe	*Eucalyptus camaldulensis* subsp. *refulgens* mid open woodland to isolated mid trees over *Acacia trachycarpa* and *Acacia ancistrocarpa* tall open shrubland over *Triodia epactia* mid open hummock grassland	5	

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
EcrEvCcAtAssTe	*Eucalyptus camaldulensis* subsp. *refulgens*, *Eucalyptus victrix* and *Corymbia candida* mid to low woodland over *Acacia trachycarpa* and *Acacia sclerosperma* subsp. *sclerosperma* tall to mid sparse shrubland over *Triodia epactia* open hummock grassland over **Cenchrus ciliaris*[2], *Eulalia aurea* and *Eriachne benthamii* sparse tussock grassland	3	
ElAarAbAtuTwEm	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia arida*, *Acacia bivenosa* and *Acacia tumida* var. *pilbarensis* tall to mid open shrubland over *Triodia wiseana* open hummock grassland and *Eriachne mucronata* sparse tussock grassland	2	This unit was mapped in 2015 to meet EPA Guidance Statement No. 51 (2004) Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.
ElAarTw	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia arida* low open shrubland over *Triodia wiseana* open hummock grassland	8	
ElAatAarTw	*Eucalyptus leucophloia* scattered low trees over *Acacia atkinsiana* (*Acacia arida*) open shrubland to tall shrubland over *Triodia wiseana* hummock grassland	3	
ElAatAtuGwTw	*Eucalyptus leucophloia* subsp. *leucophloia* low woodland over *Acacia atkinsiana*, *Acacia tumida*, *Grevillea wickhamii* tall shrubland over *Triodia wiseana* hummock grassland	1	This unit was mapped in 2005, 2009 and 2012. One relevé and mapping notes were also used to describe this unit.
ElAbAsyTw	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia bivenosa* and *Acacia synchronicia* mid sparse shrubland over *Triodia wiseana* hummock grassland	3	
ElAiAbTw	*Eucalyptus leucophloia* scattered low trees over *Acacia inaequilatera* scattered tall shrubs over *Acacia bivenosa* scattered shrubs to open shrubland over *Triodia wiseana* hummock grassland	0	This unit was re-mapped by MWH (2016) as ElAbAsyTw which has three quadrats.

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
ElAprAatAarTw	*Eucalyptus leucophloia* scattered low tress over *Acacia pruinocarpa* scattered tall shrubs over *Acacia atkinsiana*, *Acacia arida* shrubland over *Triodia wiseana* open hummock grassland	0	The mapped extent of this unit (0.8 ha) is entirely within the western portion of the Development Envelope approved under Ministerial Statement 756.
ElAtuAbTwERIm	*Eucalyptus leucophloia* scattered low trees over *Acacia pruinocarpa*, *Acacia atkinsiana* tall open shrubland over *Triodia wiseana* open hummock grassland	2	The mapped extent of this unit (37.1 ha) is entirely within the western portion of the Development Envelope approved under Ministerial Statement 756.
ElAtuTw	*Eucalyptus leucophloia* subsp. *leucophloia* low open woodland over *Acacia tumida* var. *pilbarensis* tall open shrubland over *Triodia wiseana* sparse hummock grassland	0	This unit was described from four relevés and was recorded from five small areas (extent between 0.2 ha and 2.2 ha).
ElCcAtuAarTw	*Eucalyptus leucophloia* subsp. *leucophloia*, *Corymbia candida* subsp. *candida* scattered low trees over *Acacia tumida* scattered tall shrubs to tall open shrubland over *Acacia arida* scattered shrubs over *Triodia wiseana* scattered hummock grasses	1	The mapped extent of this unit (4.4 ha) is entirely within the western portion of the Development Envelope approved under Ministerial Statement 756.
EvCcAtpAccAanEb	*Eucalyptus victrix* and *Corymbia candida* mid to low open woodland with occasional *Eucalyptus camaldulensis* subsp. *refulgens* over *Acacia tumida* var. *pilbarensis*, *Acacia colei* var. *colei* and *Acacia ancistrocarpa* tall sparse shrubland over *Eriachne benthamii*, **Cenchrus ciliaris*[2], *Eulalia aurea* and *Dichanthium fecundum* mid tussock grassland	7	

Vegetation Unit	Vegetation Description	Number of quadrats surveyed	Comment
R	River or creek beds	Not applicable	
Te	*Triodia epactia* very open hummock grassland	0	The mapped extent of this unit in the western portion of the Development Envelope is 8.6 ha and is described from a mapping note. The extent of this unit is entirely within the western portion of the Development Envelope approved under Ministerial Statement 756.

[1] This vegetation unit was initially recorded as including *Triodia pungens*. Previously *Triodia epactia* and *Triodia pungens* were used inter-changeably. *Triodia pungens* is now generally considered to occur in the east Pilbara.

[2] The Proponent has well established strategies for monitoring and management of the risk of weeds at its Pilbara operations which will continue to be implemented. See Table 5-16 for information on invasive species control.

5.4.4 Significant vegetation

None of the vegetation units within the western portion of the Development Envelope are associated with any TECs currently listed under the EPBC Act or listed by the DBCA. One vegetation unit in the western portion of the Development Envelope, the Sand Sheet PEC, is considered to be of regional significance (CzAtGeTs). A total of five vegetation units in the western portion of the Development Envelope are considered to be of high local significance; two riparian units that are associated with the Robe River (ChAbAtrTw and EcEvMgAtrCv) and three units that support a restricted Priority 1 species (AanAbAsyTP, AanAiAatAbTP and CcAanTe). Twenty vegetation units in the western portion of the Development Envelope are considered to be of moderate local significance. The extent of one of these vegetation types; ElAatAtuGwTw is already approved to be cleared under MS 756 so is not considered further in the assessment of impacts in this ERD. Potential impacts to the remaining 19 vegetation units of moderate local significance are described in Section 5.6.1.1.

The vegetation units of regional significance and high local significance recorded in the western portion of the Development Envelope are summarised in Table 5-4 and are described further below. The vegetation units of moderate local significance are summarised in Appendix 6, and are generally considered to be common in the Mesa A/Warramboo area or have been recorded throughout the Robe Valley. The remaining vegetation units were considered to be of either low local significance (12 vegetation units) or negligible local significance (38 vegetation units) based on the definitions below from information presented by MWH (2016, 2017, 2018):

- **High local significance**: supports Threatened Flora; supports Priority 1 flora; associated with listed TECs or PECs; or associated with major drainage systems supporting riparian vegetation
- **Moderate local significance:** supports Priority 2 flora, or high density of Priority 3 flora and associated habitat; associated with local drainage systems supporting riparian vegetation; or has limited local representation
- **Low significance:** supports scattered records of Priority 3 flora, or locally common Priority 4 flora; associated with minor local drainage systems supporting riparian vegetation
- **Negligible significance:** supports Priority 4 flora that are regionally common; or associated with vegetation common across the Pilbara region.

Table 5-4: Significant vegetation units

Code	Description	Location	Significance
Regional Significance			
CzAtGeTs	*Corymbia zygophylla* scattered low trees over *Acacia tumida* var. *pilbarensis*, *Grevillea eriostachya* high shrubland over *Triodia schinzii* hummock grassland	Adjacent to the south-eastern side of Mesa A	This vegetation unit is representative of the Sand Sheet PEC and is a habitat and vegetation type that is atypical for the locality. It is the most northern expression of this vegetation type in the Carnarvon Basin and is poorly represented in the Pilbara region and unrepresented in the reserve system. It supports many species at their northern limits or which exist as disjunct populations including species restricted to the deep red sands of this habitat type (Parks and Wildlife 2014)
High Local Significance			
ChAbAtrTw	*Corymbia hamersleyana* low isolated trees over *Acacia bivenosa* and *Acacia trachycarpa* mid sparse to open shrubland over *Triodia wiseana* hummock grassland to open hummock grassland	Robe River in the vicinity of Mesas B and C	Supports riparian habitat and associated phreatophytic vegetation of the Robe River major drainage system.
EcEvMgAtrCv	*Eucalyptus camaldulensis* subsp. *refulgens* and *Eucalyptus victrix* low open woodland over *Melaleuca glomerata* and *Acacia trachycarpa* tall to mid open shrubland over *Cyperus vaginatus* sparse sedgeland	Robe River in the vicinity of Mesas B and C	Supports riparian habitat and GDEs and associated phreatophytic vegetation of the Robe River major drainage system. It also supports *Rhynchosia bungarensis* (Priority 4).
AanAbAsyTP	*Acacia ancistrocarpa*, *Acacia bivenosa* and *Acacia synchronicia* tall to mid open/sparse shrubland over *Triodia epactia* open hummock grassland	Warramboo borefield extension area	Supports *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61) (Priority 1).

Code	Description	Location	Significance
AanAiAatAbTP	*Acacia ancistrocarpa*, *Acacia inaequilatera*, *Acacia atkinsiana* and *Acacia bivenosa* tall to mid sparse shrubland over *Triodia* sp. Peedamulla (A.A. Mitchell PRP 1636) mid open to sparse hummock grassland	Warramboo borefield extension area	Supports *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61) (Priority 1).
CcAanTe	*Corymbia candida* isolated patches of low trees over *Acacia ancistrocarpa* mid sparse shrubland over *Triodia epactia* open hummock grassland with occasional *Triodia* sp. Peedamulla (A.A. Mitchell PRP 1636)	Warramboo borefield extension area	Supports *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61) (Priority 1).

5.4.4.1 Sand Sheet PEC

The Sand Sheet PEC is located immediately adjacent to the south-eastern boundary of the existing Mesa A/Warramboo Iron Ore Project. This PEC is considered to be of regional conservation significance as both a habitat and vegetation type that is atypical for the locality. It is the most northern expression of this vegetation type in the Carnarvon Basin and is poorly represented in the Pilbara region and unrepresented in the reserve system. It supports many species at their northern limits or which exist as disjunct populations including species restricted to the deep red sands of this habitat type (Parks and Wildlife 2014).

Two representations of the Sand Sheet PEC occur within the western portion of the Development Envelope; one of approximately 147 ha and one of 7 ha. These representations each have a mapped buffer of 411 ha and 136 ha respectively (Figure 5-4)[7]. Approximately 64 ha of the Sand Sheet PEC is within the area approved under MS756, of which approximately 3 ha was approved for disturbance. The remainder of the Sand Sheet is within the MEZ and will not be directly impacted.

Monitoring of the Sand Sheet PEC has been conducted since 2008 and is designed to assess the effects of mining operations from the Mesa A/Warramboo Iron Ore project on the Sand Sheet Vegetation Community in order to report on the abundance of weeds and the influence of dust, fire and clearing within the community. The monitoring involves assessing permanent flora quadrats, documenting flora species occurring in the PEC, locating flora of conservation significance, recording introduced species and mapping vegetation condition and other disturbance. The most recent results available are from 2017 (Astron 2017a; Appendix 5).

The condition of the Sand Sheet PEC vegetation in 2017 ranged from Excellent to Poor. Senescence was observed in several species in 2017, and previous years and it was particularly prevalent in *Acacia tumida* var. *pilbarensis* and *Triodia schinzii*. The presence of 'medium' or 'medium' – 'low' dust cover, introduced species (principally Buffel Grass, **Cenchrus ciliaris*), signs of cattle and historical clearing were responsible for the lower condition rating in some areas of the Sand Sheet PEC.

Vegetation condition did not generally differ between the Sand Sheet PEC and the reference areas, which were established south of the Sand Sheet PEC in 2017. The exception was dust scores which tended to be 'medium' to 'low' in the Sand Sheet PEC and 'low' to 'none' at the reference areas. Analysis of remotely sensed imagery indicated that the Sand Sheet PEC vegetation condition was overall relatively stable between 2012 and 2017; the condition of some areas had declined, while the condition of other areas had improved. The main area of decline in condition was along the north-western edge of the Sand Sheet PEC in the period 2016 to 2017. There was no clear evidence that dust loads were affecting plant health within the period of monitoring. Astron (2017a) suggested changes in soil moisture and altered surface water flow may be a driver of vegetation condition in the Sand Sheet PEC and worthy of further investigation.

Astron (2017a) noted that on-ground monitoring results showed a decline in the vegetation cover in the Sand Sheet PEC since the initial 2008 monitoring and specifically, widespread senescence of *Acacia tumida* var. *pilbarensis* (and other species) has been

[7] PEC buffers are shown on the map rather than PEC boundaries as the Conditions for supply of PEC location information allow only buffers to be shown in public reports.

noted during monitoring within the Sand Sheet PEC since 2015 (Biota 2016, Astron 2017a). Analysis of the data showed that the decline in cover amongst the monitored quadrats does not appear to be associated with proximity to the mine footprint. The decline in vegetation cover corresponded with a transition within the Robe Valley from above average rainfall conditions to more average rainfall between 2012 and 2016. However, analysis of the data does not show a direct correlation between vegetation cover and rainfall in the 12 months prior to each survey. This may be due to the presence of local groundwater retaining clay layers beneath parts of the Sand Sheet which undergo periodic cycles of replenishment and decline, allowing some species intermittent access to retained water. If groundwater anomalies are at least partially driving the observed changes in the Sand Sheet PEC, then the observed inter-annual to decadal scale changes in rainfall patterns are likely to be responsible for a substantial proportion of the changes observed. In addition, altered surface water flow patterns and altered fire regime (i.e. excluding fire driven reductions in biomass) as a result of the Mesa A/Warramboo Iron Ore Project may have contributed to the observed decline in vegetation cover. Monitoring conducted in 2016 following above average rainfall in the four months prior to the survey noted recruitment of *Acacia tumida* var. *pilbarensis* (Biota 2016). Seedlings and saplings of *Acacia tumida* var. *pilbarensis* were also noted in the majority of monitoring quadrats in 2017 (Astron 2017a).

Buffel Grass was the only introduced species recorded during the 2017 monitoring survey. Five introduced species were recorded in the Sand Sheet PEC during the 2016 monitoring, including two species not previously recorded in the Sand Sheet PEC; Speedy Weed (**Flaveria trinervia*) and Spiked Malvastrum (**Malvastrum americanum*) which were both recorded along the northern boundary of the PEC close to the approved activities. It is not clear whether the approved activities contributed to these records however it is likely the increase in the number of species recorded in 2016 was due to increased monitoring effort since commencement of mining operations at the Mesa A/Warramboo Iron Ore Project. Weed infestation areas in the PEC are treated by the Proponent which is the likely reason these weed species were not all recorded again in 2017. Buffel Grass is the most common introduced species, and is most prevalent in the south-east section of the PEC (Biota 2016). As Buffel Grass is known to be an aggressive competitor, the more favourable climatic conditions in 2009, 2011, 2013, 2015 and 2016 would likely have contributed to the spread of this weed within the Sand Sheet PEC (Biota 2016).

5.4.4.2 Riparian vegetation

Riparian ecosystems occur along the Robe River and along Warramboo Creek in and adjacent to the Development Envelope. The riparian vegetation in the vicinity of the Robe River includes GDEs (Figure 5-5).

GDEs are characterised by the presence of species that rely on groundwater, known as phreatophytic species. Such species only inhabit areas where they have access to groundwater in order satisfy at least some proportion of their environmental water requirements (EWR) (Eamus *et al.* 2006 in Rio Tinto 2017a). Phreatophytic species may be classified as either obligate or facultative phreatophytes depending on their reliance on groundwater. Obligate phreatophytes are species for which access to groundwater is critically important to their presence in the landscape. Facultative phreatophytes are those species that opportunistically utilise groundwater to satisfy a proportion of their EWR but, if required (i.e. during extended dry periods), may also satisfy their EWR via stored soil water reserves (Eamus *et al.* 2006 in Rio Tinto 2017a). The tree species *Melaleuca argentea* (obligate phreatophyte), *Eucalyptus camaldulensis* subsp. *refulgens*

(facultative phreatophyte) and *Eucalyptus victrix* (facultative phreatophyte or vadophyte [plants that primarily take up water only from the unsaturated soil above the water table]) are the three most common phreatophytic species within riparian systems of the Pilbara bioregion. Due to its dependence on groundwater, the obligate phreatophyte *Melaleuca argentea* is considered the best indicator of consistently shallow groundwater or permanent (perennial) surface water and as such, this species is also widely considered the best indicator of a GDE. *Eucalyptus camaldulensis* is one of the most broadly distributed Eucalyptus species in Australia and commonly occurs along ephemeral creeklines in the Pilbara.

Riparian vegetation communities associated with the Robe River in the western portion of the Development Envelope are represented by the vegetation units ChAbAtrTw and EcEvMgAtrCv as mapped by MWH (2016) and are considered to be of high local significance. Subsequent detailed mapping of the riparian vegetation of the Robe River from the North West Coastal Highway to near Pannawonica recorded *Melaleuca argentea*, *Eucalyptus camaldulensis* subsp*. refulgens* and *Eucalyptus victrix* adjacent to Mesas B and C (Figure 5-5). The detailed mapping showed that obligate phreatophytic vegetation is relatively common along the Robe River and not restricted to the area adjacent to Mesas B and C (Rio Tinto 2017a).

The pre-mining depth to groundwater along Warramboo Creek throughout the proposed zone of drawdown (Section 8.6.2) is historically approximately 7-26 m below ground level (with the depth as shallow as 7 m in the coastal plain area in the northern extent of the drawdown zone and the depth up to 26 m in the south of the drawdown extent). Warramboo Creek represents a low to moderate sized Pilbara Creek system and generally supports facultative phreatophytic vegetation. Three vegetation units as mapped by MWH (2016) (EcAanAtrAbAtuTe, EcCcAanTe, EcrAtAanTe and EcrEvCcAtAssTe) associated with Warramboo Creek in the western portion of the Development Envelope are considered to be of moderate local significance as they support the facultative phreatophytic species, *Eucalyptus camaldulensis* subsp. *refulgens*, and the facultative (and potentially vadophytic) species, *Eucalyptus victrix* (Appendix 6).

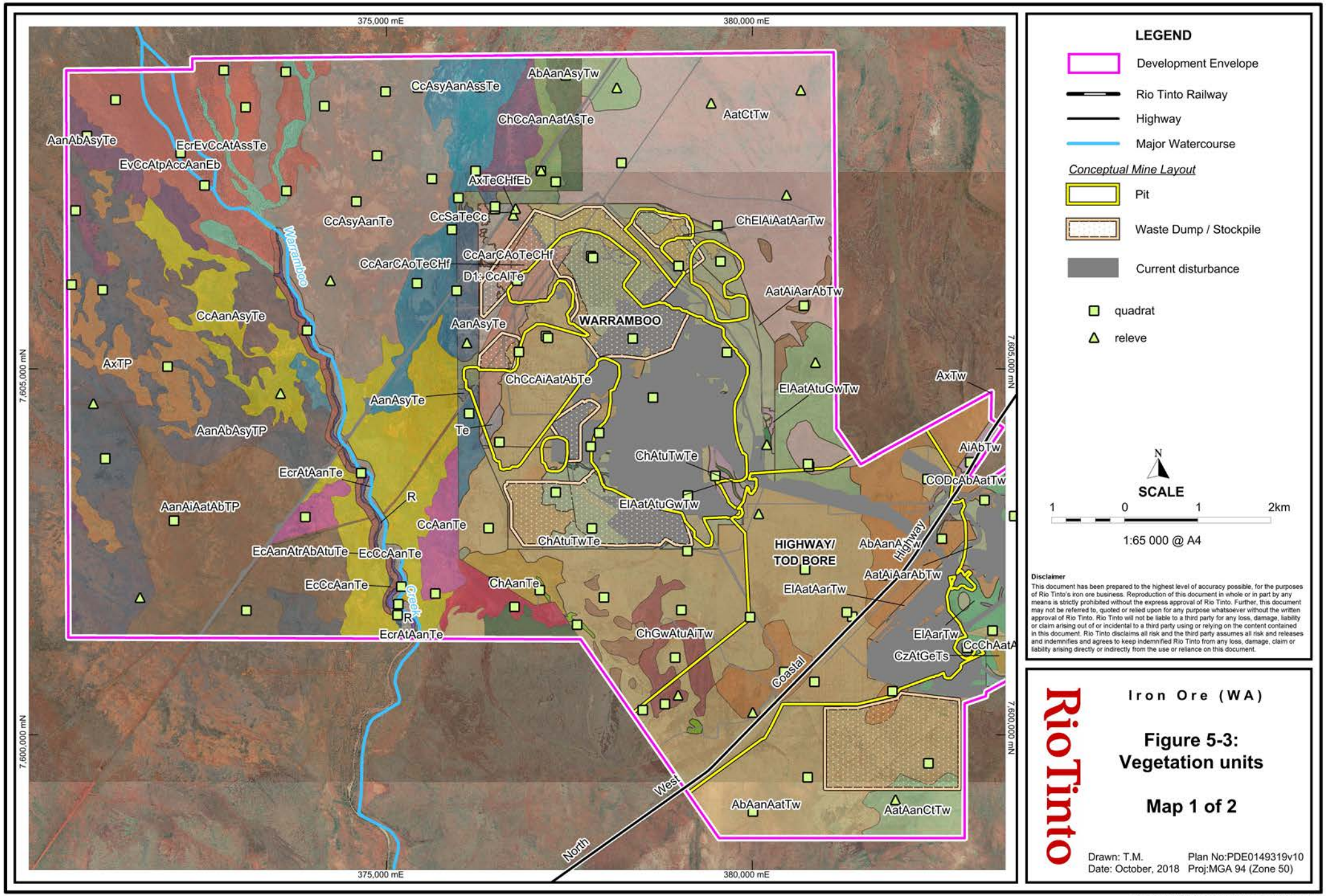
Subsequent additional mapping of the riparian vegetation along Warramboo Creek has been undertaken using high resolution aerial photography. With the advent of digital image sensors with higher resolutions and more stable colour reproduction capabilities, the high resolution aerial photography produced is increasingly recognised as able to allow species recognition. In areas such as the Pilbara where riparian over storeys are generally relatively simple, this has enabled the use of suitable aerial photography to map the distribution of key phreatophytes and delineate areas where more sensitive phreatophytes are present, dominant or co-dominant. The additional mapping of Warramboo Creek delineated five vegetation units (considered to be of moderate local significance) listed in Table 5-5 and shown in Figure 5-6 and provides further definition of, and confidence in, the distribution and extent of phreatophytic communities, particularly the extent of communities in which *Eucalyptus camaldulensis* subsp. *refulgens* is dominant or co-dominant. The vegetation units of this more detailed mapping generally align with those of the most recent flora and vegetation assessment of the Warramboo area (Stantec 2018). The more detailed mapping is used for impact assessment throughout this document.

Table 5-5: Description of riparian vegetation units along Warramboo Creek (detailed mapping)

Vegetation Unit	Vegetation Description
EvCcAtpAccA	*Eucalyptus victrix* and *Corymbia candida* mid to low open woodland with scattered *Eucalyptus camaldulensis* subsp. *refulgens, Acacia tumida* var. *pilbarensis*, *Acacia colei* var. *colei* and *Acacia ancistrocarpa* tall sparse shrubland, over *Eriachne benthamii*, **Cenchrus ciliaris*, *Eulalia aurea* and *Dichanthium fecundum* mid tussock grassland
EcrEvCcAtAs	*Eucalyptus camaldulensis* subsp. *refulgens*, *Eucalyptus victrix* and *Corymbia candida* mid to low woodland, over *Acacia trachycarpa* and *Acacia sclerosperma* subsp. *sclerosperma* tall to mid sparse shrubland, over *Triodia epactia* open hummock grassland over **Cenchrus ciliaris*, *Eulalia aurea* and *Eriachne benthamii* sparse tussock grassland
EcrAtAanTe	*Eucalyptus camaldulensis* subsp. *refulgens* mid woodland over *Acacia trachycarpa* and *Acacia ancistrocarpa* tall open shrubland over *Triodia epactia* mid open hummock grassland
EcAanAtrAbAtuTe	*Corymbia candida* and *Eucalyptus victrix* low open woodland (with scattered *Eucalyptus camaldulensis* subsp. *refulgens*), over *Acacia ancistrocarpa*, *Acacia trachycarpa*, *Acacia bivenosa* and *Acacia tumida* var. *pilbarensis* tall to mid open shrubland, over *Triodia epactia* open to sparse hummock grassland
EcrAtAanAtTe	*Eucalyptus camaldulensis* subsp. *refulgens* mid woodland over *Acacia trachycarpa, Acacia ancistrocarpa* and *Acacia tumida* var. *pilbarensis* tall open shrubland over *Triodia epactia* mid open hummock grassland

5.4.4.3 Vegetation units AanAbAsyTP, AanAiAatAbTP and CcAanTe

These vegetation units are of high local significance given they support three populations of the Priority 1 taxon *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61). These vegetation types extends over 1,500 ha within the western portion of the Development Envelope (Figure 5-3) and also extend outside the Development Envelope to the north-west.



LEGEND

- Development Envelope
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Current disturbance
- quadrat
- releve

N

SCALE

1 0 1 2km

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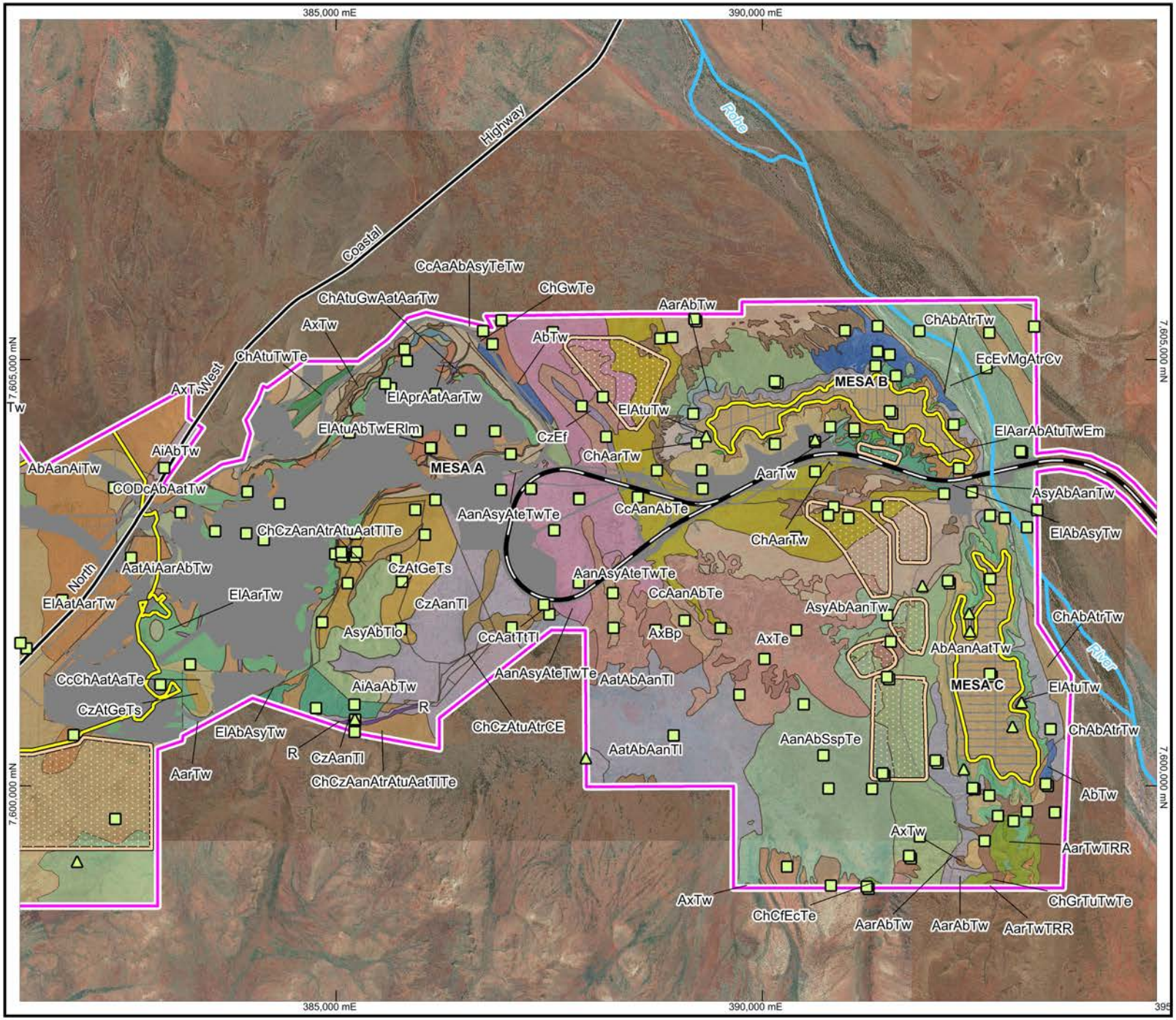
Iron Ore (WA)

Figure 5-3: Vegetation units

Map 1 of 2

Drawn: T.M. Plan No:PDE0149319v10
Date: October, 2018 Proj:MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Current disturbance
- quadrat
- releve

N

SCALE

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Iron Ore (WA)

Figure 5-3: Vegetation units

Map 2 of 2

Drawn: T.M.
Date: October, 2018

Plan No:PDE0149319v10
Proj:MGA 94 (Zone 50)

Geospatial Information and Mapping



AanAbAsyTe — Acacia ancistrocarpa, Acacia bivenosa and Acacia synchronicia tall to mid open/sparse shrubland over Triodia epactia open hummock grassland



AanAbAsyTP — Acacia ancistrocarpa and Acacia bivenosa tall to mid sparse shrubland with occasional Acacia synchronicia mid shrubs over Triodia sp. Peedamulla (A.A. Mitchell PRP 1636) mid open hummock grassland



AanAbSspTe — Acacia ancistrocarpa and Acacia bivenosa mid open shrubland over Sida sp. Pilbara (A.A. Mitchell PRP 1543) low sparse shrubland over Triodia epactia open hummock grassland



AanAiAatAbTP — Acacia ancistrocarpa, Acacia inaequilatera, Acacia atkinsiana and Acacia bivenosa tall to mid sparse shrubland over Triodia sp. Peedamulla (A.A. Mitchell PRP 1636) mid open to sparse hummock grassland



AanAsyAteTwTe — Acacia ancistrocarpa, Acacia synchronicia and Acacia tetragonophylla mid open to sparse shrubland over Triodia wiseana and/or Triodia epactia hummock grassland to open hummock grassland



AanAsyTe — Acacia ancistrocarpa and Acacia synchronicia mid sparse shrubland over Triodia epactia open to sparse hummock grassland



AarAbTw — Acacia arida and Acacia bivenosa mid open shrubland over Triodia wiseana hummock grassland



AarTw — Acacia arida mid open shrubland over Triodia wiseana hummock grassland



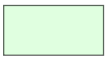
AarTwTRR — Acacia arida mid open shrubland over Triodia wiseana and Triodia sp. Robe River (M.E. Trudgen et al. MET 12367) hummock grassland



AatAanCtTw — Acacia atkinsiana and Acacia ancistrocarpa mid to low open to sparse shrubland over Corchorus tectus low open to sparse shrubland over Triodia wiseana sparse hummock grassland



AatAbAanTl — Acacia atkinsiana, Acacia bivenosa and Acacia ancistrocarpa tall to mid, open to sparse shrubland over Triodia lanigera hummock grassland to open hummock grassland



AatAiAarAbTw — Acacia ancistrocarpa, A. atkinsiana, A. inaequilatera tall open shrubland over A. arida, A. bivenosa open shrubland over Triodia wiseana hummock grassland



AatCtTw — Acacia atkinsiana tall to mid open shrubland over Corchorus tectus low sparse shrubland over Triodia wiseana hummock grassland



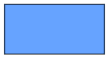
AbAanAatTw — Acacia bivenosa, Acacia ancistrocarpa, Acacia atkinsiana and Acacia arida mid open to sparse shrubland over Triodia wiseana hummock grassland



AbAanAiTw — Acacia inaequilatera scattered tall shrubs over Acacia ancistrocarpa, A. bivenosa open shrubland to shrubland over Triodia wiseana hummock grassland



AbAanAsyTw — Acacia bivenosa, Acacia ancistrocarpa and Acacia synchronicia tall to mid sparse shrubland over Triodia wiseana mid open hummock grassland



AbTw — Acacia bivenosa mid sparse to open shrubland over Triodia wiseana hummock grassland



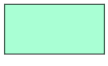
AiAaAbTw — Acacia inaequilatera scattered tall shrubs over Acacia ancistrocarpa, A. bivenosa open shrubland to shrubland over Triodia wiseana hummock grassland



AiAbTw — Acacia inaequilatera scattered tall shrubs over A. bivenosa scattered low shrubs over Triodia wiseana hummock grassland



AsyAbAanTw — Acacia synchronicia, Acacia bivenosa and Acacia ancistrocarpa low to mid sparse shrubland over Triodia wiseana open hummock grassland



AsyAbTlo — Acacia synchronicia, A. bivenosa open shrubland over Triodia longiceps hummock grassland



AxBp — Acacia xiphophylla mid isolated shrubs over Brachyachne prostrata and Sclerolaena costata open herbland with Triodia epactia isolated hummock grasses



AxSaoEf — Acacia xiphophylla tall sparse shrubland over Senna artemisioides subsp. oligophylla mid sparse shrubland over Eriachne flaccida mid tussock grassland



AxTe — Acacia xiphophylla tall open shrubland over Triodia epactia open hummock grassland



AxTeCHfEb — Acacia xiphophylla tall open shrubland over Triodia epactia scattered hummock grasses over Chrysopogon fallax, Eriachne benthamii scattered tussock grasses



AxTP — Acacia xiphophylla tall open to sparse shrubland over Triodia sp. Peedamulla (A.A. Mitchell PRP 1636) mid open hummock grassland



AxTw — Acacia xiphophylla tall open to sparse shrubland over Triodia wiseana open hummock grassland



CcAaAbAsyTeTw — Corymbia candida scattered low trees over Acacia ancistrocarpa, A. bivenosa, A. synchronicia open shrubland over Triodia epactia, T. wiseana hummock grassland



CcAanAbTe — Corymbia candida low open woodland over Acacia ancistrocarpa and Acacia bivenosa tall to mid open to sparse shrubland over Triodia epactia with occasional Triodia wiseana hummock grassland to open hummock grassland



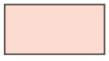
CcAanAiAsyTe — Corymbia candida low open woodland over Acacia ancistrocarpa, Acacia inaequilatera and Acacia synchronicia mid sparse shrubland over Triodia epactia hummock grassland



CcAanAsyTe — Corymbia candida isolated patches of low trees over Acacia ancistrocarpa and Acacia synchronicia tall to mid sparse shrubland over Triodia epactia mid hummock grassland



CcAanTe — Corymbia candida isolated patches of low trees over Acacia ancistrocarpa mid sparse shrubland over Triodia epactia open hummock grassland with occasional Triodia sp. Peedamulla (A.A.Mitchell PRP 1636)



CcAarCAoTeCHf — Corymbia candida subsp. candida scattered trees over Acacia arida, Cassia oligophylla open shrubland over Triodia epactia hummock grassland and Chrysopogon fallax scattered tussock grasses



CcAatTtTl — Corymbia candida low open woodland over Acacia atkinsiana and Acacia inaequilatera tall shrubland over Triodia lanigera open hummock grassland and Themeda triandra open tussock grassland



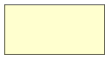
CcAlTe — Corymbia candida subsp. candida scattered low trees over Acacia ligulata scattered shrubs over Triodia epactia very open hummock grassland



CcAsyAanAssTe — Corymbia candida isolated low trees over Acacia synchronicia, Acacia ancistrocarpa and Acacia sclerosperma subsp. sclerosperma tall to mid sparse shrubland over Triodia epactia sparse to open hummock grassland



CcAsyAanTe — Corymbia candida isolated low trees over Acacia synchronicia and Acacia ancistrocarpa tall sparse to isolated shrubland over Triodia epactia mid open hummock grassland



CcChAatAaTe — Corymbia hamersleyana, C. candida scattered low trees to low open woodland over Acacia atkinsiana, A. ancistrocarpa scattered tall shrubs to tall open shrubland over Triodia epactia open hummock grassland



CcSaTeCc — Corymbia candida subsp. candida scattered trees over Acacia ancistrocarpa tall shrubland over A. arida, Cassia oligophylla open shrubland over Triodia epactia hummock grassland and Chrysopogon fallax scattered tussock grasses



ChAanTe — Corymbia hamersleyana low open woodland over Acacia ancistrocarpa mid sparse shrubland over Triodia epactia open hummock grassland



ChAarTw — Corymbia hamersleyana scattered low trees over Acacia arida shrubland over Triodia wiseana open hummock grassland

Rio Tinto

Iron Ore (WA)

Figure 5-3:

Legend 1 of 3

Drawn: T.M.
Date: October, 2018

Plan No: PDE0149319v8
Proj: MGA94 (Zone 50)



ChAbAtrTw

Corymbia hamersleyana low isolated trees over Acacia bivenosa and Acacia trachycarpa mid sparse to open shrubland over Triodia wiseana hummock grassland to open hummock grassland



ChAtpAanTe

Corymbia hamersleyana isolated to low open woodland over Acacia tumida var. pilbarensis and Acacia ancistrocarpa mid sparse shrubland over Triodia epactia mid open hummock grassland with occasional Chrysopogon fallax and Eragrostis cumingii tussock grassland



ChAtuGwAatAarTw

Acacia tumida var .pilbarensis, A. pruinocarpa, Grevillea wickhamil tall open shrubland to open scrub over Acacia atkinsiana, A. arida open shrubland to tall open shrubland over Triodia wiseana open hummock grassland and Eriachne mucronata scattered tussock grasses



ChAtuTwTe

Corymbia hamersleyana scattered low trees over Acacia tumida tall closed scrub over Triodia wiseana, T. epactia open hummock grassland



ChCcAanAatAsTe

Corymbia hamersleyana and Corymbia candida low open woodland over Acacia ancistrocarpa, Acacia atkinsiana and Acacia sericophylla over tall to mid sparse shrubland over Triodia epactia open hummock grassland with occasional Triodia wiseana and Triodia sp. Peedamulla (A.A. Mitchell PRP 1636) over isolated patches of tussock grasses dominated by Chrysopogon fallax



ChCcAiAatAbTe

Corymbia hamersleyana, C. candida subsp. candida scattered low trees over Acacia inaequilatera, A. atkinsiana, A. bivenosa open shrubland over Triodia epactia closed hummock grassland



ChCfEcTe

Corymbia hamersleyana low open woodland over Acacia ancistrocarpa mid open shrubland, over Chrysopogon fallax and Eragrostis cumingii tussock grassland with Triodia epactia sparse hummock grassland



ChCzAanAtrAtuAatTlTe

Corymbia hamersleyana and Corymbia zygophylla low open woodland over Acacia ancistrocarpa, Acacia trachycarpa, Acacia tumida var. pilbarensis and Acacia atkinsiana mid open shrubland over Triodia lanigera and Triodia epactia hummock grassland



ChCzAtuAtrCE

Corymbia hamersleyana, C. zygophylla low open woodland over Acacia tumida (A. trachycarpa) tall open scrub over *Cenchrus spp. closed tussock grassland



ChElAiAatAarTw

Corymbia hamersleyana, Eucalyptus leucophloia subsp. leucophloia scattered trees over Acacia atkinsiana, A. inaequilatera, A. arida open shrubland over Triodia wiseana hummock grassland



ChGrTuTwTe

Corymbia hamersleyana low open woodland over Gossypium robinsonii tall sparse shrubland over Tephrosia uniovulata and Hibiscus sturtii var. campylochlamys low sparse shrubland over Triodia wiseana and Triodia epactia open hummock grassland



ChGwAtuAiTw

Corymbia hamersleyana low open woodland over Acacia tumida var. pilbarensis, Acacia inaequilatera and Grevillea wickhamii subsp. macrodonta mid open shrubland over Triodia wiseana sparse shrubland



ChGwTe

Corymbia hamersleyana low open woodland over Grevillea wickhamii subsp. macrodonta tall sparse shrubland over Triodia epactia open hummock grassland



CODcAbAatTw

Codonocarpus cotinifolius scattered low trees over Acacia atkinsiana, A. bivenosa low open shrubs over Triodia wiseana very open hummock grassland



CzAanTl

Corymbia zygophylla low isolated trees over Acacia ancistrocarpa tall to mid open shrubland over Triodia lanigera hummock grassland



CzAtGeTs

Corymbia zygophylla scattered low trees over Acacia tumida var. pilbarensis, Grevillea eriostachya high shrubland over Triodia schinzii hummock grassland



CzEf

Corymbia zygophylla scattered low trees over Acacia tumida var. pilbarensis, Grevillea eriostachya high shrubland over Triodia schinzii hummock grassland



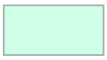
EcAanAtrAbAtuTe

Eucalyptus camaldulensis subsp. refulgens low open woodland over Acacia ancistrocarpa, Acacia trachycarpa, Acacia bivenosa and Acacia tumida var. pilbarensis tall to mid open shrubland over Triodia epactia open to sparse hummock grassland



EcCcAanTe

Eucalyptus camaldulensis subsp. refulgens and Corymbia candida low open woodland over Acacia ancistrocarpa mid open shrubland over Triodia epactia open hummock grassland



EcEvMgAtrCv

Eucalyptus camaldulensis subsp. refulgens and Eucalyptus victrix low open woodland over Melaleuca glomerata and Acacia trachycarpa tall to mid open shrubland over Cyperus vaginatus sparse sedgeland



EcrAtAanTe

Eucalyptus camaldulensis subsp. refulgens mid open woodland to isolated mid trees over Acacia trachycarpa and Acacia ancistrocarpa tall open shrubland over Triodia epactia mid open hummock grassland



EcrEvCcAtAssTe

Eucalyptus camaldulensis subsp. refulgens, Eucalyptus victrix and Corymbia candida mid to low woodland over Acacia trachycarpa and Acacia sclerosperma subsp. sclerosperma tall to mid sparse shrubland over Triodia epactia open hummock grassland over *Cenchrus ciliaris, Eulalia aurea and Eriachne benthamii sparse tussock grassland



ElAarAbAtuTwEm

Eucalyptus leucophloia subsp. leucophloia low open woodland over Acacia arida, Acacia bivenosa and Acacia tumida var. pilbarensis tall to mid open shrubland over Triodia wiseana open hummock grassland and Eriachne mucronata sparse tussock grassland



ElAarTw

Eucalyptus leucophloia subsp. leucophloia low open woodland over Acacia arida low open shrubland over Triodia wiseana open hummock grassland



ElAatAarTw

Eucalyptus leucophloia scattered low trees over Acacia atkinsiana (A. arida) open shrubland to tall shrubland over Triodia wiseana hummock grassland



ElAatAtuGwTw

Eucalyptus leucophloia subsp. leucophloia low woodland over Acacia atkinsiana, A. tumida, Grevillea wickhamii tall shrubland over Triodia wiseana hummock grassland



ElAbAsyTw

Eucalyptus leucophloia subsp. leucophloia low open woodland over Acacia bivenosa and Acacia synchronicia mid sparse shrubland over Triodia wiseana hummock grassland



ElAiAbTw

Eucalyptus leucophloia scattered low trees over Acacia inaequilatera scattered tall shrubs over Acacia bivenosa scattered shrubs to open shrubland over Triodia wiseana hummock grassland



ElAprAatAarTw

Eucalyptus leucophloia scattered low tress over Acacia pruinocarpa scattered tall shrubs over Acacia atkinsiana, A. arida shrubland over Triodia wiseana open hummock grassland



ElAtuAbTwERIm

Eucalyptus leucophloia scattered low trees over Acacia pruinocarpa, A. atkinsiana tall open shrubland over Triodia wiseana open hummock grassland



ElAtuTw

Eucalyptus leucophloia subsp. leucophloia low open woodland over Acacia tumida var. pilbarensis tall open shrubland over Triodia wiseana sparse hummock grassland



ElCcAtuAarTw

Eucalyptus leucophloia subsp. leucophloia, Corymbia candida subsp. candida scattered low trees over Acacia tumida scattered tall shrubs to tall open shrubland over A. arida scattered shrubs over Triodia wiseana scattered hummock grasses

Iron Ore (WA)

Figure 5-3:

Legend 2 of 3

Drawn: T.M.
Date: October, 2018

Plan No: PDE0149319v8
Proj: MGA94 (Zone 50)

	EvCcAtpAccAanEb	Eucalyptus victrix and Corymbia candida mid to low open woodland with occasional Eucalyptus camaldulensis subsp.refulgens over Acacia tumida var.pilbarensis, Acacia colei var. colei and Acacia ancistrocarpa tall sparse shrubland over Eriachne benthamii, *Cenchrus ciliaris, Eulalia aurea and Dichanthium fecundum mid tussock grassland
	R	River or creek beds
	Te	Triodia epactia very open hummock grassland

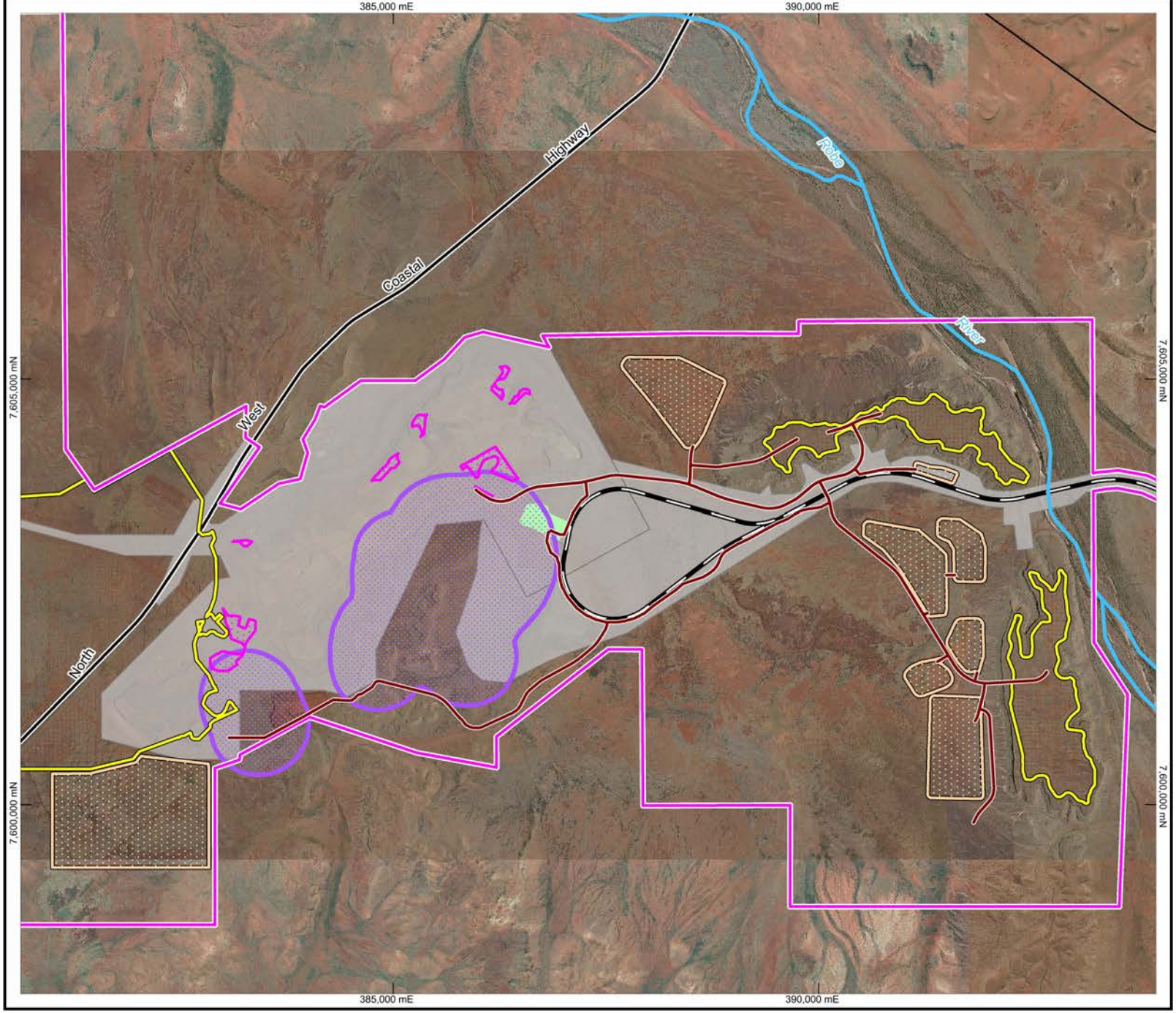
Iron Ore (WA)

Figure 5-3:

Legend
3 of 3

Drawn: T.M.
Date: October, 2018

Plan No: PDE0149319v8
Proj: MGA94 (Zone 50)



LEGEND

- Development Envelope
- Ministerial Statement 756
- Sand Sheet Vegetation PEC Buffer
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Processing plant
- New mining/cut widening at Mesa A
- Haul road

N

SCALE

1 0 1 2km

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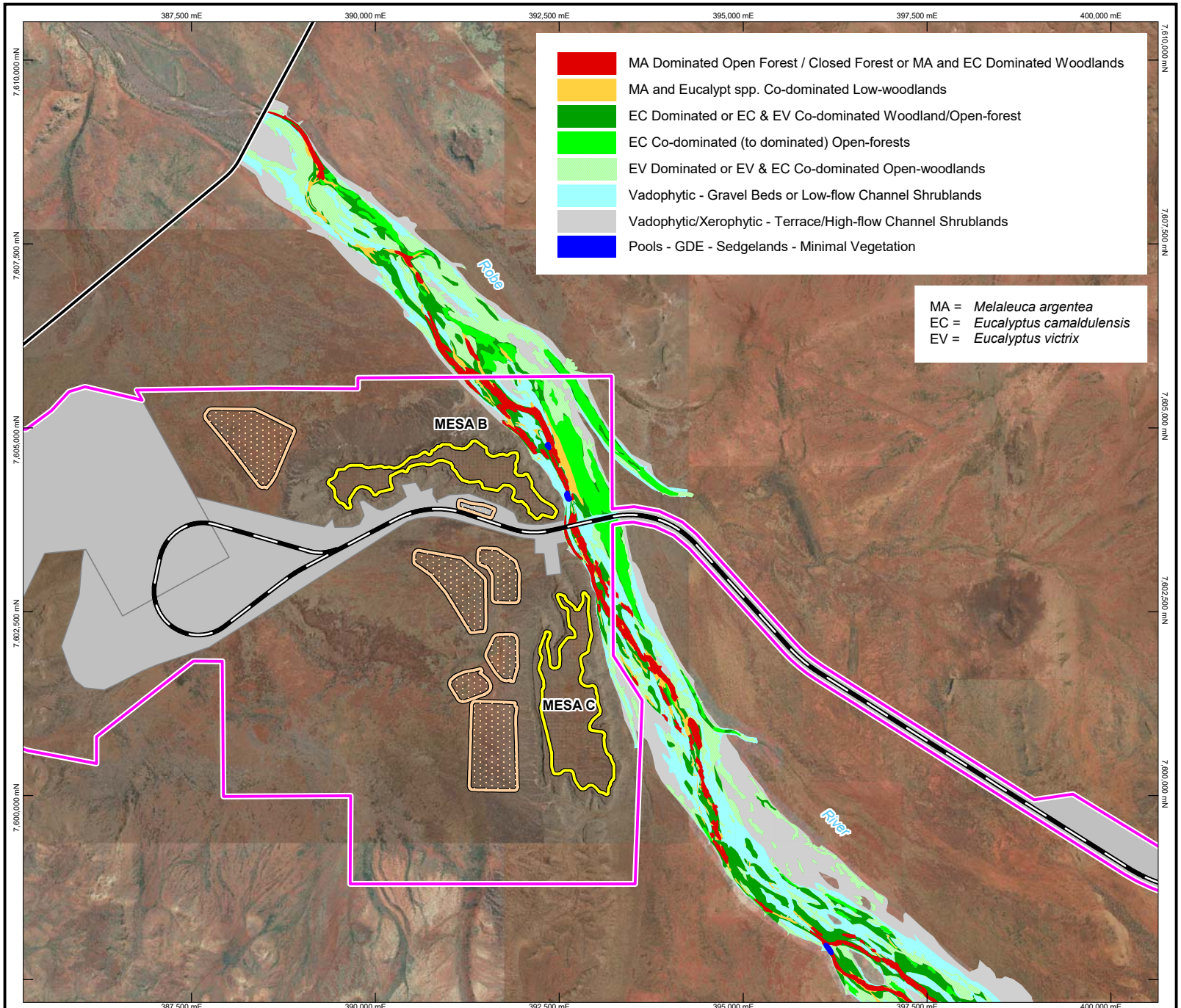
Iron Ore (WA)

Figure 5-4: Location of the Sand Sheet PEC buffer

Drawn: T.Murphy
Date: Aug, 2018

Plan No: PDE0153953v6
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile

N

SCALE

0 1 2 3 4km

1:50 000 @ A4

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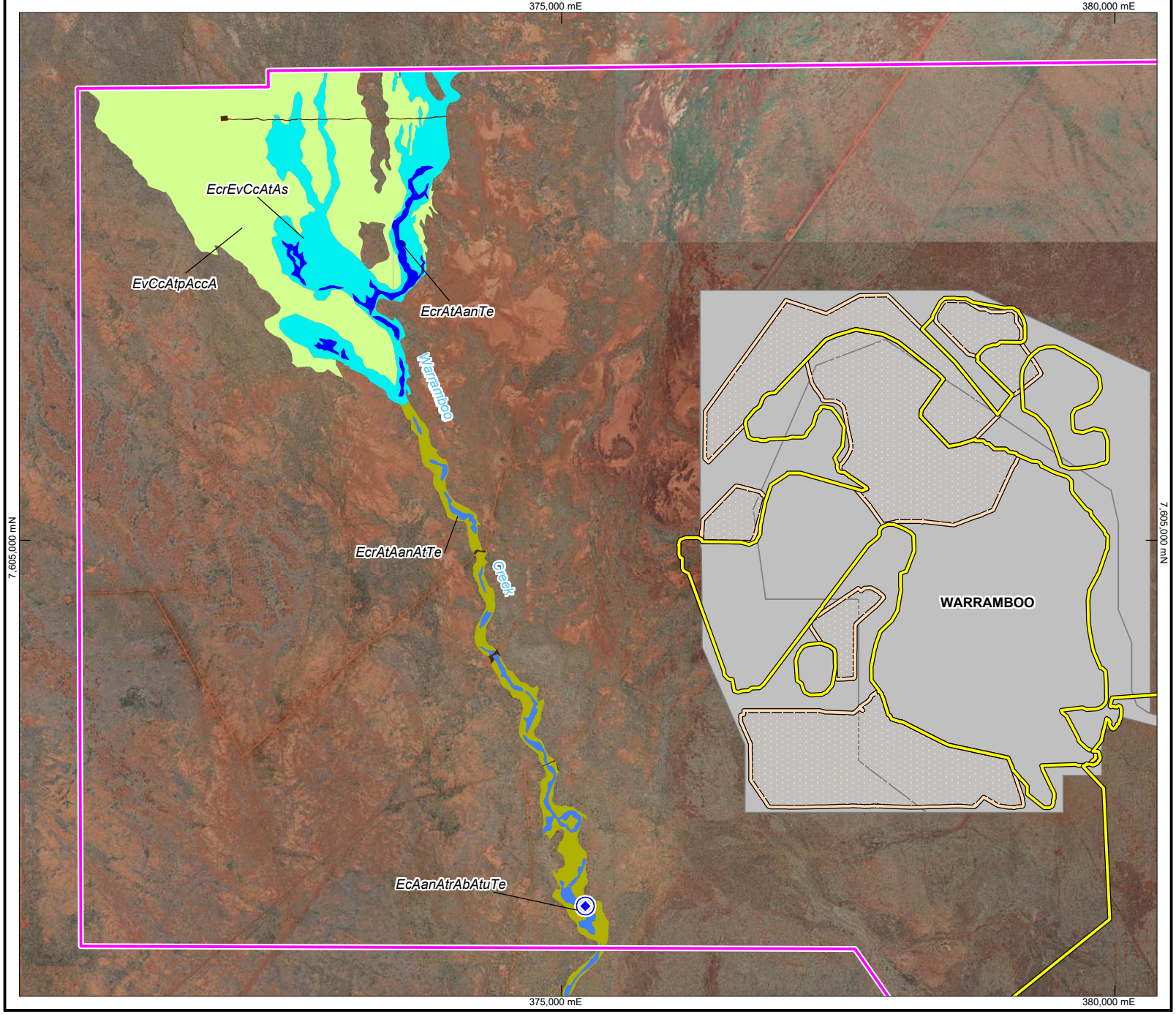
Iron Ore (WA)

Figure 5-5: Riparian Vegetation and GDEs of the Robe River

Drawn: T.M.
Date: Aug, 2018

Plan No: PDE0157907v4
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Proposed Discharge point

N

SCALE

0.5 0 0.5 1 1.5km

1:50 000 @ A4

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Iron Ore (WA)

Figure 5-6: Riparian vegetation of Warramboo Creek

Drawn: T.M.
Date: Aug, 2018

Plan No: PDE0159856v3
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

5.4.5 Significant flora

A total of 392 vascular flora taxa have been recorded within the western portion of the Development Envelope, comprising 375 native flora taxa and 17 introduced flora taxa (weeds). These flora taxa represent 49 families and 143 genera. No Threatened Flora have been recorded in the western portion of the Development Envelope (MWH 2016; Stantec 2018), nor were any identified in any desktop studies as likely to occur.

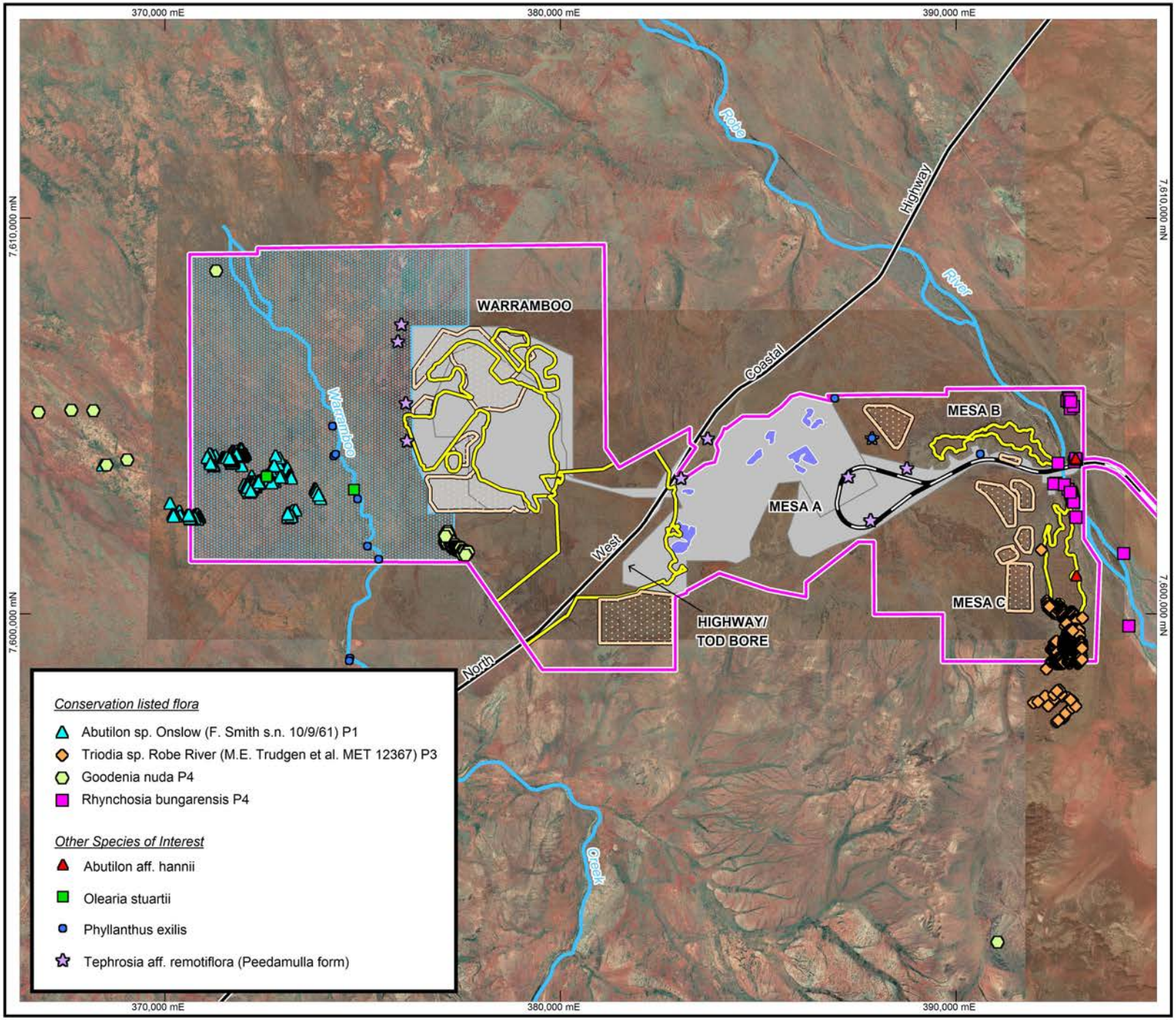
Four Priority Flora species have been recorded in the western portion of the Development Envelope; these are identified in Table 5-6 and their recorded locations shown on Figure 5-7.

Table 5-6: Priority species recorded (Biota 2011a; MWH 2016; Stantec 2018).

Taxon	Conservation status	No. of individuals	Number of locations
Abutilon sp. Onslow (F. Smith s.n. 10/9/61)	Priority 1	1,241	242
Triodia sp. Robe River (M.E. Trudgen et al. Met 12367)	Priority 3	34,324	1,218
Goodenia nuda	Priority 4	368	67
Rhynchosia bungarensis	Priority 4	760	29

Two other taxa recorded in the western portion of the Development Envelope are considered range extensions. *Olearia stuartii* was recorded in Warramboo Creek, outside of its recorded range which includes south Pilbara, Murchison and Central Ranges. In addition, *Phyllanthus exilis* was recorded at Warramboo Creek but is more commonly recorded in the Kimberley with only scattered records in the Pilbara. An additional species recorded in the Warramboo area, *Sida platycalyx*, was not considered to be a true range extension, but rather a new population record representing a gap in the current knowledge and distribution (Stantec 2018). Therefore, *Sida platycalyx* is not considered further. Locations of *Olearia stuartii* and *Phyllanthus exilis* records are shown in Figure 5-7.

Two other taxa were recorded with anomalous features; *Abutilon* aff. *hannii* and *Tephrosia* aff. *remotiflora* (Peedamulla Form) and represent taxa that have been collected previously, but have not yet been officially assigned a scientific name or described by taxonomists (MWH 2016; Stantec 2018) (Figure 5-7, Table 5-7). The two taxa have been recorded previously from the immediate area and sporadically in the Pilbara region (MWH 2016). Both species have been recorded from a variety of habitats and do not appear to be restricted to a particular landform. Given it is likely these taxa have distributions that extend further than current records show, these species are considered unlikely to be assigned conservation significant status and therefore have not been considered further in the assessment of impacts from the Proposed Change.



Conservation listed flora

- Abutilon sp. Onslow (F. Smith s.n. 10/9/61) P1
- Triodia sp. Robe River (M.E. Trudgen et al. MET 12367) P3
- Goodenia nuda P4
- Rhynchosia bungarensis P4

Other Species of Interest

- Abutilon aff. hannii
- Olearia stuartii
- Phyllanthus exilis
- Tephrosia aff. remotiflora (Peedamulla form)

LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Warramboo Borefield Extension Area
- Proposed new mining/cut widening

N

SCALE

2 0 2 4km

1:140 000 @ A4

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Rio Tinto

Iron Ore (WA)

Figure 5-7: Records of conservation significant flora

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0152057v7
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

Table 5-7: Other flora species of potential interest recorded (MWH 2016; Stantec 2018)

Taxon	Nearest Known Location	Information
Olearia stuartii	185 km east	*Olearia stuartii* was recorded on the banks of Warramboo Creek. This species is known to occur in a wide variety of habitats including creek beds and is commonly recorded in the south Pilbara, Murchison and the Central Ranges.
Phyllanthus exilis	140 km east, north-east	*Phyllanthus exilis* was recorded on creek banks, flat drainage areas and floodways, which is typical for the species. The species is more common in the Kimberley region but scattered locations are present in the Pilbara.
Abutilon aff. *hannii*	n/a	*Abutilon* aff. *hannii* was recorded in the vicinity of Mesas B and C. Pilbara collections of this species are limited and it is likely that *Abutilon* aff. *hannii* is a distinct taxon (Mike Hislop, pers comm 21/7/2015, MWH 2016).
Tephrosia aff. *remotiflora* (Peedamulla form)	n/a	*Tephrosia* aff. *remotiflora* (Peedamulla form) was recorded in the vicinity of Mesas A, B and C and also in the proposed Warramboo borefield extension area, and is under consideration to be classified as a distinct taxon (Mike Hislop, pers comm 31/7/2015, MWH 2016).

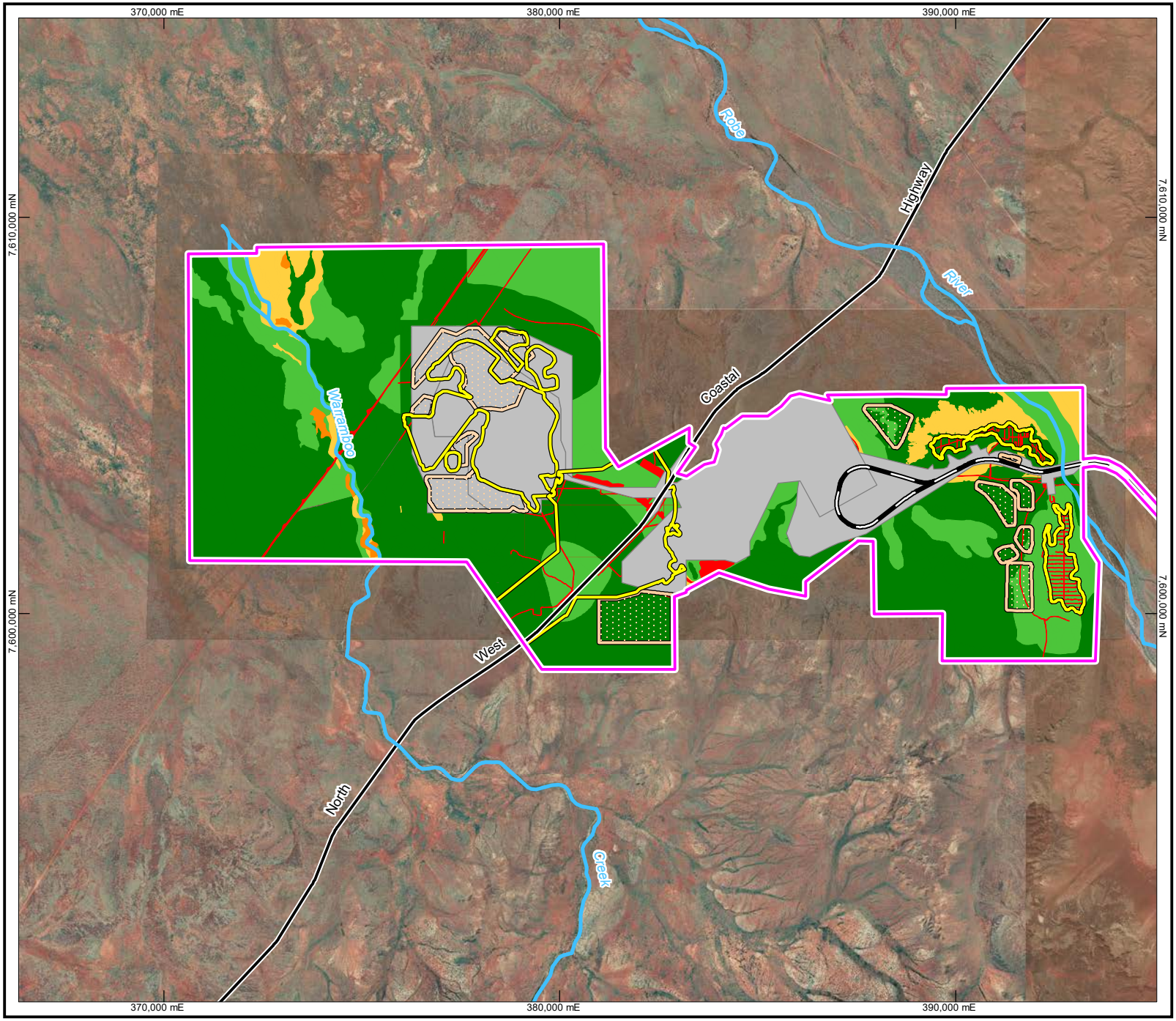
5.4.6 Vegetation condition

Vegetation within the western portion of the Development Envelope was recorded as ranging from Excellent to Completely Degraded (MWH 2016, 2017; Stantec 2018; Figure 5-8). Overall, the majority of vegetation in the western portion of the Development Envelope was in Excellent (58%) or Very Good (27%) condition. Approximately 10% of the western portion of the Development Envelope was considered to be in Completely Degraded condition. This was generally due to high weed infestation, cattle grazing and trampling, mining operations and infrastructure including rail line and previous drill pads and vehicle tracks.

Seventeen introduced flora species have been recorded within the western portion of the Development Envelope as shown in Figure 5-9 and listed in Table 5-8. None of these are Weeds of National Significance or Declared Plant Pests. The majority of weeds recorded in the western portion of the Development Envelope were found in drainage areas, damp areas on stony plains, disturbed areas, inside and surrounding the existing rail loop, historical drilling sites and rehabilitation areas. **Cenchrus ciliaris* (Buffel Grass) was the most abundant weed species, recorded across all sites, with the understorey almost replaced by this species in some locations at the southern end of Warramboo Creek (MWH 2016).

Table 5-8: Introduced flora taxa (MWH 2016; Stantec 2018)

Family	Taxon (Common Name)	Record Location
Amaranthaceae	**Aerva javanica* (Kapok Bush)	Mesa B and C
Asteraceae	**Flaveria trinervia* (Speedy Weed)	Mesa B and C
	**Bidens bipinnata*	Mesa A
Cucurbitaceae	**Citrullus colocynthis* (Colocynth)	Mesa B and C
	**Citrullus lanatus* (Pie Melon)	Mesa B and C
Fabaceae	**Vachellia farnesiana* (Mimosa Bush)	Mesa B and C, Warramboo Borefield
Malvaceae	**Malvastrum americanum* (Spiked Malvastrum)	Mesa B and C, Highway to Tod Bore, Warramboo BWT, Warramboo Borefield
Papaveraceae	**Argemone ochroleuca* subsp. *ochroleuca* (Mexican Poppy)	Mesa B and C
Passifloraceae	**Passiflora foetida* var. *hispida* (Stinking Passion Flower)	Mesa B and C, Warramboo Borefield
Poaceae	**Cenchrus ciliaris* (Buffel Grass)	Mesa B and C, Highway to Tod Bore, Wararmboo BWT, Mesa A extension, Warramboo Creek, Warramboo Borefield
	**Cenchrus setiger* (Birdwood Grass)	Mesa B and C, Highway to Tod Bore, Mesa A extension, Warramboo Creek, Warramboo Borefield
	**Chloris barbata* (Purpletop Chloris)	Mesa B and C
	**Cynodon dactylon* (Couch)	Mesa B
	**Digitaria ciliaris* (Southern Crabgrass)	Mesa A
	**Echinochloa colona* (Awnless Barnyard Grass)	Warramboo Creek, Warramboo Borefield
	**Setaria verticillata* (Whorled Pigeon Grass)	Mesa B and C, Warramboo BWT, Warramboo Creek, Warramboo Borefield
Portulacaceae	**Portulaca pilosa*	Mesa C and north of Warramboo BWT
Zygophyllaceae	**Tribulus terrestris*	Warramboo Borefield



LEGEND

- Development Envelope
- Ministerial Statement 756
- Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Waste Dump / Stockpile

Vegetation Condition

- Excellent
- Very Good
- Good
- Poor
- Completely degraded

N

SCALE

0 2 4 6km

1:140 000 @ A4

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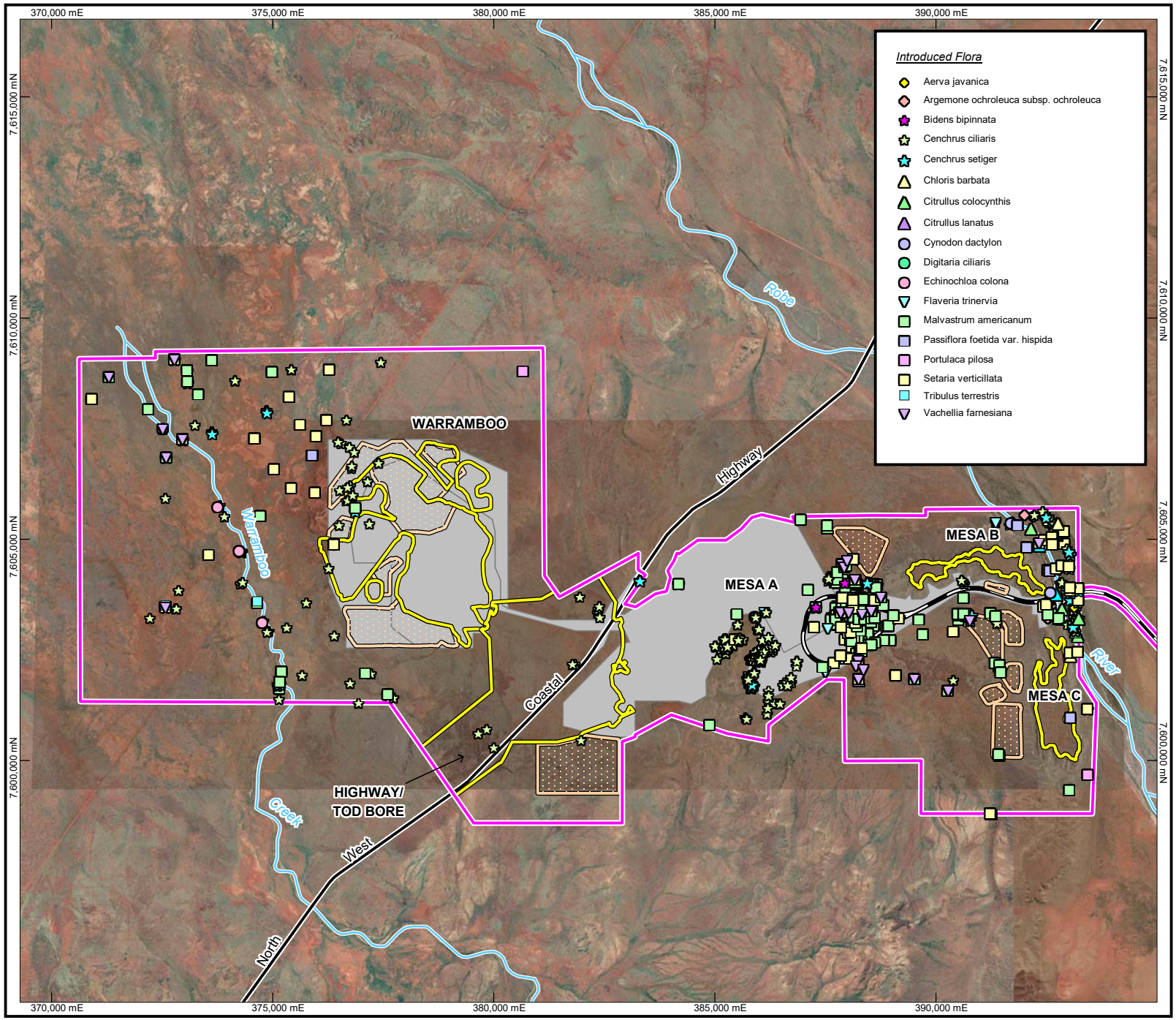
Iron Ore (WA)

Figure 5-8: Vegetation condition

Drawn: T.M.
Date: Sept, 2018

Plan No: PDE0150810v7
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile

N

SCALE

0 2 4 6km

1:125 000 @ A4

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Iron Ore (WA)

Figure 5-9: Distribution of introduced flora

Drawn: T.M.
Date: October, 2018

Plan No: PDE0158807v6
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

5.5 Potential Impacts

A number of potential impacts are identified in the ESD. The potential direct, indirect and cumulative impacts identified for the Proposed Change on the basis of biological surveys and flora and vegetation assessments are described in Sections 5.5.1 to 5.5.3. The significance of these potential impacts is discussed in Section 5.5.

5.5.1 Direct impacts

Potential direct impacts of the Proposed Change to flora and vegetation have been identified as:

- Loss of vegetation due to clearing
- Loss of conservation significant flora due to clearing.

Significant vegetation units are described in Section 5.4.4. The significant vegetation units that will potentially be impacted by clearing are presented in Table 5-9. Assessment of potential impacts to these units is provided in Section 5.6.1.

Table 5-9: Potential direct impact to significant vegetation

Code	Significance	Extent within western portion of the Development Envelope (ha)	Proposed extent of new activities (ha)	Proposed extent of disturbance (%)
Regional significance				
CzAtGeTs	Representative of the Sand Sheet PEC.	143	0	0
High local significance				
ChAbAtrTw	Supports riparian habitat and associated phreatophytic vegetation of the Robe River major drainage system.	88	1.5	2%
EcEvMgAtrCv	Supports riparian habitat, GDEs and associated phreatophytic vegetation of the Robe River major drainage system.	229	2	<1%
AanAbAsyTP	Supports *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61) (Priority 1).	868	30	3.5%
AanAiAatAbTP	Supports *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61) (Priority 1).	581	11	1.9%
CcAanTe	Supports *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61) (Priority 1).	116	10.5	9%

Section 5.4.5 identifies the Priority Flora species recorded in the western portion of the Development Envelope. Potential direct impacts to Priority Flora species are presented in Table 5-10. Assessment of potential direct impacts to Priority Flora species is provided in Section 5.6.1.

Table 5-10: Potential direct impacts to known populations of Priority Flora

Taxon	Conservation status	No. of individuals	No. of individuals in Rio Tinto database	No. of individuals proposed to be disturbed	Proposed disturbance (% of records in the western portion of the Development Envelope)	Proposed disturbance (%of records in the Rio Tinto database)	Range on Naturemap (km)
Abutilon sp. Onslow (F. Smith s.n. 10/9/61)	Priority 1	1,241	1,284	70	6%	5%	135
Triodia sp. Robe River (M.E. Trudgen et al. Met 12367)	Priority 3	34,324	288,681	1,774	5%	<1%	180
Goodenia nuda	Priority 4	368	10,627	114	31%	1%	880
Rhynchosia bungarensis	Priority 4	760	12,736	38	5%	<1%	430

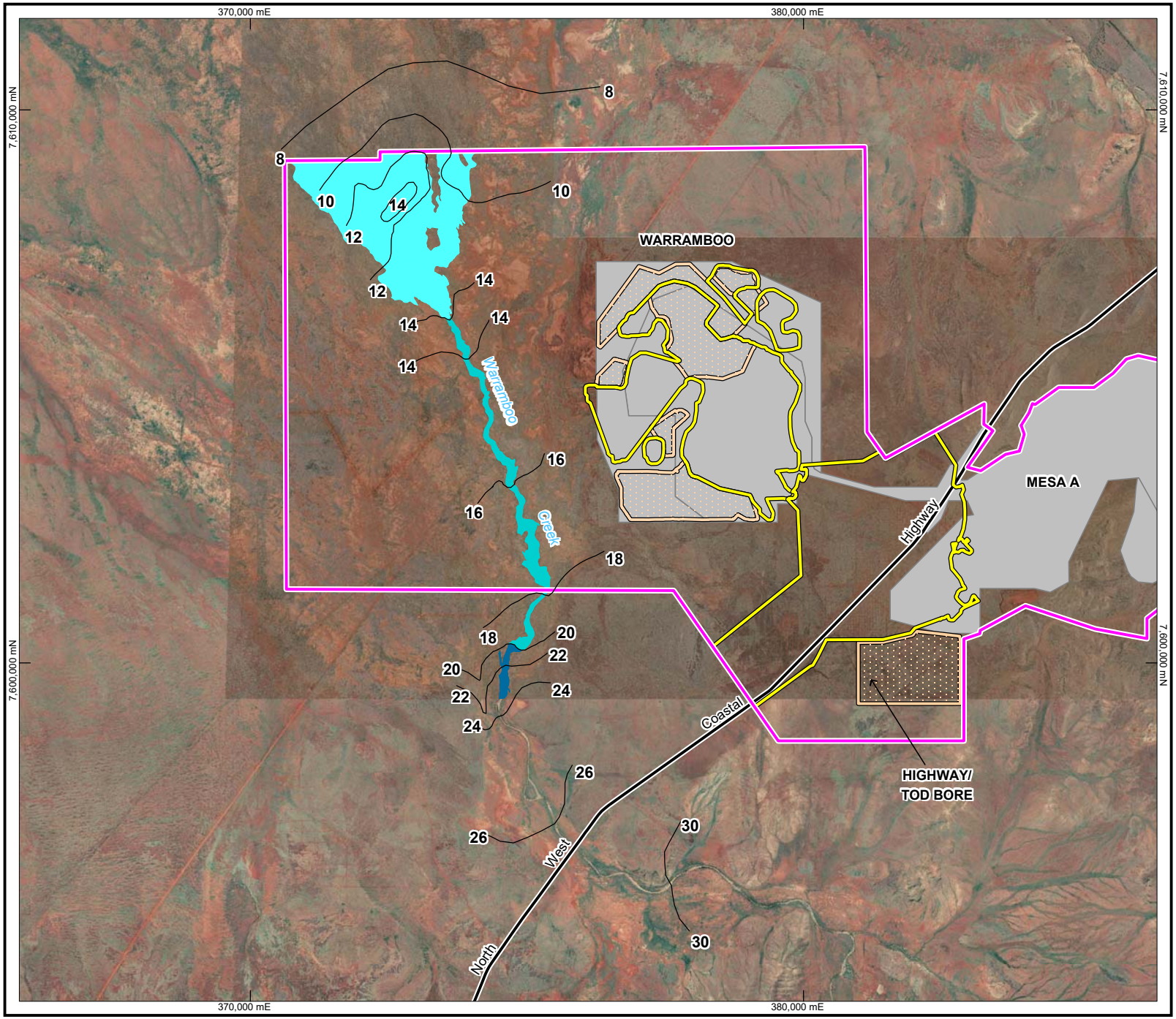
5.5.2 Indirect impacts

Potential indirect impacts of the Proposed Change to flora and vegetation have been identified as:

- Loss or degradation of riparian vegetation as a result of groundwater drawdown
- Loss or degradation of riparian vegetation as a result of surface water discharge
- Degradation of vegetation due to ingress of weeds
- Degradation of vegetation due to increased dust deposition.

The vegetation units recorded in the western portion of the Development Envelope, including units associated with Warramboo Creek, are described in Sections 5.4.3 and 5.4.4. Hydrogeological modelling indicates there is limited hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvium. Consequently, drawdown of groundwater levels within the Mesa C CID Aquifer is not expected to result in observable changes to groundwater levels within the adjacent Robe River Alluvial Aquifer.

Groundwater drawdown in the Yarraloola Aquifer beneath the ephemeral Warramboo Creek has the potential to impact vegetation units. Three potential impact zones were delineated based on depth to groundwater, available literature on facultative phreatophytes and Rio Tinto's experience with these species within the Pilbara (Section 5.6.2.1, Figure 5-10). Potential impacts to vegetation units in each of the zones were then identified based on the proposed drawdown in each zone as shown in Table 5-11.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile

Warramboo Creek Zone

- Zone 1 - facultative phreatophytes - low/moderate potential groundwater use
- Zone 2 - facultative phreatophytes - low potential groundwater use
- Zone 3 - facultative phreatophytes - negligible groundwater use
- Estimated existing groundwater depth contour (m below ground level)

N

SCALE

1 0 1 2 3km

1:100 000 @ A4

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Rio Tinto

Iron Ore (WA)

Figure 5-10: Groundwater depen -dence zones along Warramboo Creek

Drawn: T.M.
Date: Aug, 2018

Plan No: PDE0160394v4
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

Table 5-11: Potential indirect impacts on vegetation from groundwater drawdown in the Yarraloola Aquifer

Zone	Zone description	Vegetation unit	Extent (ha)	Estimated current local depth to groundwater (m below ground level)	Modelled drawdown (m below pre-mining groundwater level)	Potential impact where riparian vegetation is able to access the broader groundwater table rather than shallow, small scale aquifers	
						Overstorey – phreatophytic species	Understorey
Zone 1 Low to Moderate potential for phreatophytes to access groundwater	The distribution of phreatophytes with increasing lateral spread from channels and general proliferation on the floodplain indicates an increased potential for phreatophytes to access groundwater from the CID/Yarraloola Aquifers. However, some of these distributional characteristics also indicate reliance upon surface water regimes within the Warramboo Creek system (rather than on groundwater). Seasonal rainfall is expected to continue to provide the majority of riparian water requirements through surface water inputs, soil pore moisture stores and associated small scale, shallow aquifers. Substantial Clay formations that contribute to seasonal water storage are likely to occur throughout the floodplain. Understorey vegetation cover is relatively low and generally impacted by cattle and weed species. The understorey species present are unlikely to have root depth greater than 5-10 m and are highly unlikely to directly access groundwater.	EcrAtAanTe	19	10-14	12-22	• Likely reduction in canopy cover, particularly during extended dry periods • Potential increase in mortality of phreatophytic species • Potential structural changes due to the longer term influence of increased mortality within phreatophytic populations • Some potential for compositional changes within associated species assemblages, but dominant components of the community are unlikely to experience compositional change.	Some potential for minor changes to abundance of understorey species due to changes in shading of understorey and changes to vadose soil water resources (as a result of changes to the proximity of groundwater)
		EcrEvCcAtAs	148	9-14	9-22	• Likely reduction in canopy cover during extended dry periods • Potential increase in mortality of phreatophytic species • Potential structural changes, particularly in denser woodland representations of this community, due to the longer term influence of increased mortality within phreatophytic populations • Some potential for compositional changes within associated species assemblages but dominant components of the riparian community are unlikely to experience compositional change.	
		EvCcAtpAccA	368	9-14	6-22	• Likely reduction in canopy cover during extended dry periods • Some potential minor increases in mortality of phreatophytic species • Structural changes unlikely • Compositional change unlikely as baseline composition and structure suggest relatively low potential for reliance on groundwater.	
Zone 2 Low potential for phreatophytes to access groundwater	The depth to groundwater and minimal lateral distribution of phreatophytes away from the low flow channel of Warramboo Creek indicate that phreatophytes may access groundwater but any access is minimal and likely to represent only a small proportion of their water requirements. Longitudinal distribution patterns of *E. camaldulensis* along the local groundwater height gradient (i.e. decreasing depth to groundwater trends not mirrored by a trend of increasing abundance of *E. camaldulensis*) suggest that surface water inputs are likely to play a more important role than groundwater from the CID/Yarraloola aquifers. Compositional data for understorey vegetation indicate understorey components are highly unlikely to access groundwater, or be indirectly influenced by decreasing groundwater proximity.	EcrAtAanAtTe	22	14-20	6-26	• Some potential for reduction in canopy cover during extended dry periods • Potential increase in mortality of phreatophytic species • Structural and compositional changes unlikely.	Changes to understorey vegetation unlikely
		EcAanAtrAbAtuTe	74	14-20	6-26	• Some potential for reduction in canopy cover during extended dry periods • Some potential for individual tree deaths • Structural and compositional changes unlikely.	

Zone	Zone description	Vegetation unit	Extent (ha)	Estimated current local depth to groundwater (m below ground level)	Modelled drawdown (m below pre-mining groundwater level)	Potential impact where riparian vegetation is able to access the broader groundwater table rather than shallow, small scale aquifers	
						Overstorey – phreatophytic species	Understorey
Zone 3 Negligible potential for phreatophytes to access groundwater	Depth to groundwater and lack of lateral spread of phreatophytes away from the low flow channel indicates a low probability that riparian vegetation is dependent on groundwater from the CID/Yarraloola aquifers. If groundwater access is occurring, it is likely that phreatophytes are accessing small alluvial aquifers which are likely to operate independently of the CID/Yarraloola aquifers.	EcrAtAanAtTe	7	>20m	<6m	• Changes to canopy cover, structure and composition are unlikely.	Changes to understorey vegetation unlikely
		EcAanAtrAbAtuTe	8	>20m	<6m	• Changes to canopy cover, structure and composition are highly unlikely.	

Discharge of surplus water to the ephemeral Warramboo Creek has the potential to impact riparian vegetation along Warramboo Creek as summarised in Table 5-12.

Table 5-12: Potential indirect impacts from surplus water discharge

Component	Modelled discharge rate (GL/a)	Modelled total discharge volume (GL)	Extent of potential impact to vegetation	Predicted potential impact to vegetation
Discharge to Warramboo Creek	2 to 7	9	Up to 8 km downstream from the discharge point	Temporary changes in structure, cover and health of riparian vegetation

5.5.3 Cumulative impacts

Potential cumulative impacts of the Proposed Change to flora and vegetation are the clearing of vegetation and Priority Flora species in the Robe Valley. Table 5-13 shows approved, current and proposed clearing for the approved activities and the Proposed Change.

Table 5-13: Approved, current and proposed clearing

Approved activities		Proposed Change	Revised Proposal
Clearing approved under Ministerial Statement 756 (ha)	Clearing to end 2017 (ha)	Proposed additional clearing (ha)	Proposed total clearing (ha)
3,680	1,914	3,000	6,680

Detailed mapping at the scale undertaken for the Development Envelope is not broadly available for the Pilbara region. Identification and assessment of potential cumulative impacts to vegetation, therefore, requires broader vegetation mapping such as that completed by Beard (1975a, 1975b) to be used.

Table 5-14 shows the pre-European extent of vegetation units in the Pilbara as defined by Beard (1975a, 1975b), the proposed clearing and the total cumulative clearing taking into account the following historical, proposed and reasonably foreseeable clearing:

- Existing and historical mining projects: Mining operations (Mesa A/Warramboo, Mesa J, Mesa K, East Deepdale and Middle Robe)
- Existing clearing from other infrastructure: Mesa J and Mesa A Railways, borrow pits, power lines, roads and tracks
- Reasonably foreseeable projects: the Proposed Change and the Mesa H Proposal (currently being assessed).

Assessment of cumulative impacts to vegetation is provided in Section 5.6.3.

Table 5-14: Cumulative impacts to vegetation units defined by Beard (1975a, 1975b)

Vegetation unit	Pre-European extent in Pilbara (ha)	Robe Valley historical clearing (% of pre-European extent)	Mesa A Hub proposed clearing (% of pre-European extent)	Total cumulative clearing[1] (% of pre-European extent)
Hammersley 82	2,169,360	<1%	<1%	<1%
Hammersley 609	74,130	2%	<1%	3%
Onslow Coastal Plain 600	67,100	<1%	<1%	<1%
Onslow Coastal Plain 604	15,660	2%	3%	5%
Onslow Coastal Plain 605	88,350	<1%	<1%	<1%
Stuart Hills 29	17,220	1%	2%	3%
Stuart Hills 93	55,610	<1%	<1%	<1%
Stuart Hills 583	242,300	<1%	1%	1%
Stuart Hills 603	54,800	2%	<1%	2%
Stuart Hills 605	25,730	<1%	<1%	<1%

[1] Total cumulative clearing = historical + proposed + reasonably foreseeable

Table 5-15 shows potential cumulative impacts on Priority Flora in the Robe Valley. The existing disturbance provided is the disturbance from implementation of the approved Mesa A/Warramboo Iron Ore Project. Baseline flora surveys for other disturbed areas in the Robe Valley pre-date the Rio Tinto database. Total cumulative disturbance includes disturbance from the approved activities, proposed disturbance for the Proposed Change and reasonably foreseeable disturbance that may occur as part of the Mesa H Proposal. Assessment of cumulative impacts to Priority Flora is provided in Section 5.6.3.

Table 5-15: Cumulative impacts on Priority Flora in the Robe Valley

Taxon	Conservation status	Individuals in Rio Tinto database	Individuals (% of total Rio Tinto records)			
			Disturbance from other approved activities	Disturbance from proposed activities (Mesa H)	Disturbance from Proposed Change	Total cumulative disturbance[1]
Abutilon sp. Onslow (F. Smith s.n. 10/9/61)	Priority 1	1,284			70 (5%)	70 (5%)
Triodia sp. Robe River (M.E. Trudgen et al. Met 12367)	Priority 3	288,681	1 (<1%)	28,293 (10%)	1,774 (<1%)	30,068 (10%)
Goodenia nuda	Priority 4	10,627			114 (1%)	114 (1%)
Rhynchosia bungarensis	Priority 4	12,736	12 (<1%)	121 (1%)	38 (<1%)	171 (1%)

[1] Total cumulative disturbance = Mesa A/Warramboo + proposed + reasonably foreseeable

5.6 Assessment of Impacts

5.6.1 Direct impacts

5.6.1.1 Loss of vegetation due to clearing

The Proposed Change involves the clearing of up to 3,000 ha of vegetation to enable construction of the mine and associated infrastructure including mine pits, mineral waste dumps, wet processing plant, borefield and haul roads. During development of the Proposed Change, water supply, haul road route and waste fines disposal options were examined. Preferred options have been selected to meet project requirements while minimising clearing of vegetation, particularly significant vegetation, as described below:

- **Water supply**: Options considered included an extension to the current borefield at Warramboo, a new borefield at Jimmawurrada (located approximately 40 km south-east of Mesa C) or a combination of the two. Extension of the current borefield at Warramboo was selected as the preferred water supply option as hydrogeological test work showed an extension to the borefield would be able to meet the increased water demand, and the proximity of the existing borefield and proposed extension to the Mesa A Hub will result in less clearing than development of a new borefield at Jimmawurrada
- **Haul road routes:** Haul road routes have been designed to avoid direct disturbance to the Sand Sheet PEC. The closest proposed disturbance to the main Sand Sheet PEC vegetation will be for the operational and construction haul roads. These roads are proposed to be located to the north and south of the Sand Sheet approximately 120 m from the closest point of the main Sand Sheet. No new disturbance is proposed in the vicinity of the smaller Sand Sheet PEC. An existing track located approximately 55 m south of the closest point of the smaller Sand Sheet PEC will be used as a temporary construction haul road
- **Waste fines disposal:** WFSF options considered included in-pit at Warramboo, in-pit at Mesa A and out-of-pit. In-pit storage at Warramboo was selected as the preferred option based upon environmental, operational and closure considerations. One of the key reasons for selecting the in-pit option at Warramboo is that it requires no significant additional clearing.

Clearing will result in loss of vegetation, including loss of vegetation units of conservation significance. The majority of vegetation that may be impacted by the Proposed Change is considered to be in Good to Excellent condition. The majority of vegetation types within the western portion of the Development Envelope are representative of those found on similar landforms in the region (MWH 2016). It is noted that the vegetation types associated with the Stony Plains landform have a flora composition that reflects both the semi-arid vegetation of the Hamersley subregion and the more coastal vegetation of the Roebourne subregion (MWH 2016), consistent with the western portion of the Development Envelope straddling two IBRA subregions. Over 7,000 ha of the vegetation types associated with the Stony Plains landform has been recorded in the western portion of the Development Envelope, representing over 47% of the western portion of the Development Envelope.

No clearing will occur within the Sand Sheet PEC (vegetation type CzAtGeTs). The nearest proposed clearing will be approximately 120 m from the closest point on the Sand Sheet PEC. Clearing will disturb up to 40 ha within the buffer area around the Sand Sheet PEC (representing approximately 7% of the total PEC buffer area of both occurrences). The majority of clearing within the PEC buffer will occur within vegetation units AbAanAatTw, AbAanAiTw and AatAanCtTw, none of which are considered to have any level of conservation significance.

The Proposed Change may impact five vegetation types of high local significance (Table 5-9):

- **ChAbAtrTw**: Approximately 1.5 ha of this vegetation type may be disturbed in the western portion of the Development Envelope, equating to 2% of the extent of this unit in the western portion of the Development Envelope. Vegetation type ChAbAtrTw is common on the terraces of the Robe River; Rio Tinto has recorded approximately 1,200 ha of this unit along the banks of the river. The proposed disturbance would therefore equate to less than 0.2% of the recorded extent of this vegetation type in the Robe Valley
- **EcEvMgAtrCv**: Approximately 2 ha of this vegetation type may be disturbed, equating to less than 1% of the extent of this vegetation type in the western portion of the Development Envelope.
- **AanAbAsyTP, AanAiAatAbTP and CcAanTe**: Approximately 30 ha, 11 ha and 10.5 ha of these vegetation types may be disturbed respectively, equating to 3.5%, 1.9% and 9% of the extent of these vegetation types in the western portion of the Development Envelope respectively. These vegetation types are considered to be of high local significance because they support the Priority 1 flora taxon, *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61). Based on analysis of available aerial imagery and previous records of *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61), vegetation with the potential to support this priority taxon extends to the north-west for greater than 10 km (Stantec 2018). However, *Abutilon* sp. Onslow is considered to be restricted to the coastal plains from Onslow (located 51 km west) to the Development Envelope so it is unlikely that the entire mapped extent of these vegetation types support *Abutilon* sp. Onslow; the significance of the vegetation types would thus be lower in areas where they does not support *Abutilon* sp. Onslow. Based on the avoidance of direct impact to the Sand Sheet PEC and the limited proportion of high local significance vegetation types that may be directly impacted by the proposed clearing, the proposed impact to high local significance vegetation types is not expected to be significant at a local or regional level.

Approximately 9% of the vegetation mapped in the western portion of the Development Envelope is considered to be of moderate local significance. The vegetation units of moderate local significance are summarised in Appendix 6 and are generally considered to be common in the Mesa A/Warramboo area or have been recorded throughout the Robe Valley. The Proposed Change will result in the total loss of up to 13% of the mapped extent of these vegetation units in the western portion of the Development Envelope, affecting 15 of the 19 vegetation units. The majority of vegetation units of moderate local significance affected will be subject to clearing of less than 30% of their mapped extent in the western portion of the Development Envelope. Three of the vegetation units will be subject to up to approximately 50% of their mapped extent in the western portion of the Development Envelope being cleared; ElAtuAbTwERIm (~33%), ChAtuTwTe (~48%) and CcAaAbAsyTeTw (~48%). ElAtuAbTwERIm is considered to be

common in the Mesa A/Warramboo area (Biota 2005a) and ChAtuTwTe and CcAaAbAsyTeT have both been recorded elsewhere in the Robe Valley based on Rio Tinto's internal database. Therefore, the proposed loss of portions of these units within the western portion of the Development Envelope is not considered to be significant.

Two of the five vegetation units associated with Warramboo Creek that are considered to be of moderate local significance will be impacted by the Proposed Change; EcAanAtrAbAtuTe (approximately 7 ha to be cleared totalling 8% of the mapped extent within the western portion of the Development Envelope) and EcrAtAanAtTe (approximately 1 ha to be cleared totalling 4% of the mapped extent within the western portion of the Development Envelope). Warramboo Creek extends for approximately 51 km, with approximately 12 km of the creek within the Development Envelope. The associated vegetation types are likely to extend beyond the Development Envelope (based on aerial photography) and are not considered to be locally restricted. Therefore, the proposed impact to these vegetation types is not expected to be significant.

5.6.1.2 Loss of conservation significant flora due to clearing

No flora listed as threatened under the WC Act or the EPBC Act will be impacted by the Proposed Change.

The proposed locations of pits, waste dumps and infrastructure are still conceptual. A range of conceptual disturbance footprints have, therefore, been considered during the Environmental Impact Assessment and the maximum disturbance to Priority Flora is presented in this ERD. This approach has been taken in order to limit disturbance to significant environmental values while maintaining some flexibility for development within the Development Envelope. The Proposed Change will preferentially avoid known locations of Priority Flora as far as practicable however clearing will result in the direct loss of some individuals (limited to the maximum disturbance presented in this ERD) of the following conservation significant flora species:

- ***Abutilon* sp. Onslow (F. Smith s.n. 10/9/61) (P1):** This species has a range of approximately 135 km on Naturemap (DBCA 2018a). The Rio Tinto database currently contains records of 1,284 individuals and it is likely this species is under-collected and its distribution extends further outside the Development Envelope than current records show. The Proposed Change may disturb up to 5% of records of this species in the Rio Tinto database. Given the low proportion of records to be disturbed and that the species is likely under-collected, it is unlikely that the Proposed Change will result in a significant impact to this species at a local or regional level
- ***Triodia* sp. Robe River (M.E. Trudgen et al. MET 12367) (P3):** This species has a range of approximately 180 km on Naturemap (DBCA 2018a). The Rio Tinto database currently contains records of over 280,000 individuals of this species, with 34,324 of those recorded in the western portion of the Development Envelope. In addition, API recorded 24 populations of this species, estimated to contain almost 60 million individuals across a 90,000 ha survey area at their West Pilbara Iron Ore Project (API 2011). The API project is located approximately 80 km south-east of the Development Envelope. The Proposed Change will disturb less than 1% of Rio Tinto records of this species. Given the high number of records, large range of the species and the small proportion of records to be disturbed, it is unlikely that the Proposed Change will result in a significant impact to this species at a local or regional level

- ***Goodenia nuda* (P4):** Although restricted to the Pilbara region, *Goodenia nuda* occurs extensively throughout the Pilbara in a variety of habitats. This species has a range of approximately 880 km on Naturemap (DBCA 2018a). The Rio Tinto database currently contains records of over 10,000 individuals of this species, with 368 of those recorded in the Development Envelope. Although the Proposed Change will disturb up to 31% of the records of this species in the western portion of the Development Envelope, this represents only 1% of records of this species in the Rio Tinto database. This species has been recorded in the local area outside the Development Envelope, namely 3 km to the west (five populations, consisting of over 20 individuals in total), 7 km to the north (four populations, consisting of five individuals in total) and 7-10 km south (two populations, consisting of 12 individuals in total). Given the range of the species and the small proportion of records to be disturbed, it is unlikely that the Proposed Change will result in a significant impact to this species at a local or regional level
- ***Rhynchosia bungarensis* (P4):** This species has a range of approximately 430 km on Naturemap (DBCA 2018a). The Rio Tinto database currently contains records of over 12,736 individuals of this species, with 760 of those recorded in the western portion of the Development Envelope. The Proposed Change will disturb less than 1% of records of this species in the Rio Tinto database. Given the range of the species and the small proportion of records to be disturbed, it is unlikely that the Proposed Change will result in a significant impact to this species at a local or regional level.

The Proposed Change may disturb taxa recorded in the western portion of the Development Envelope that are considered range extensions as they are more commonly recorded in other regions. Up to 3% and 1% of records in the Rio Tinto database of *Olearia stuartii* and *Phyllanthus exilis*, respectively may be disturbed. However, both species have numerous records in the Pilbara region and given the small proportion of records to be disturbed it is unlikely that the Proposed Change will result in a significant impact to these species at a local or regional level.

5.6.2 Indirect impacts

5.6.2.1 Loss or degradation of riparian vegetation as a result of groundwater drawdown

Detailed vegetation mapping recorded obligate phreatophytic vegetation along the Robe River adjacent to Mesas B and C (Rio Tinto 2017a). Hydrogeological modelling indicates there is limited hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvium. Consequently, drawdown of groundwater level within the Mesa C CID Aquifer is not expected to result in observable changes to groundwater levels within the adjacent Robe River Alluvial Aquifer. Should there be greater hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvium than current modelling and hydrogeological investigations indicate, there is potential for stress to individual trees and changes to understorey vegetation along the Robe River within the extent of drawdown. Monitoring of groundwater levels in the alluvial aquifer and vegetation health will be undertaken to confirm the hydrological predictions. If unexpected impacts occur, mitigation will be implemented (Section 5.8).

Approximately 13 km of the defined channel of the ephemeral Warramboo Creek is expected to be inside the modelled cone of depression that will result from abstraction of groundwater from the Warramboo borefield extension. No permanent or semi-permanent pools have been identified in this section of Warramboo Creek. Warramboo Creek

supports facultative phreatophytic vegetation. Abstraction of groundwater from the Warramboo borefield extension may impact the five vegetation units identified during additional mapping as supporting facultative phreatophytic vegetation along Warramboo Creek and onto the flood plain beyond the defined flow channel; EvCcAtpAccA, EcrEvCcAtAs, EcrAtAanTe, EcAanAtrAbAtuTe and EcrAtAanAtTe.

For Australian systems, evidence suggests that reliance on groundwater by terrestrial vegetation is greatly reduced in areas where the water table exceeds a threshold depth, likely to lie between 7 m and 12 m (Benyon *et al.* 2006; DoW 2009; O'Grady *et al.* 2010; Zolfaghar *et al.* 2014), with 10 m suggested as a general threshold (Eamus *et al.* 2006). Vegetation may potentially access groundwater when the water table is between 10 m and 20 m depth, although it is thought to be negligible in terms of contribution to total plant water use (Zencich *et al.* 2002). Beyond 20 m depth, the probability of groundwater as a water source for vegetation is regarded as being low. The pre-mining depth to groundwater along Warramboo Creek, throughout the modelled cone of depression, is historically 7-26 m below ground level (with the depth as shallow as 7 m in the coastal plain area in the northern extent of the drawdown zone and the depth up to 26 m in the south of the drawdown extent). *Eucalyptus camaldulensis* which become established under relatively deep groundwater conditions (i.e. 10 m below ground level and deeper) have been observed to exhibit substantial resilience to changes in groundwater availability. In such situations, exceedance of impact thresholds have been observed leading to canopy decline (without detectable increases in mortality) and removal of selective weaker branches (likely through cavitation and vascular failure), until water demand is reduced to a level where the available root system is better matched to vadose soil resources.

Considering the available literature and Rio Tinto's experience with facultative phreatophytes within the Pilbara, three riparian vegetation impact zones were delineated for Warramboo Creek (Section 5.5.2) enabling assessment of the likely current access of phreatophytic species to groundwater and assessment of potential impacts from changes to groundwater levels Figure 5-10.

The distribution of phreatophytes with increasing lateral spread from channels and general proliferation on the floodplain indicates an increased potential for phreatophytes in Zone 1 to access groundwater from the CID/Yarraloola Aquifers. However, some of these distributional characteristics also indicate reliance upon surface water regimes within the Warramboo Creek system (rather than on groundwater). Therefore, for vegetation units EcrAtAanTe, EcrEvCcAtAs and EvCcAtpAccA in Zone 1, a reduction in canopy cover is likely; particularly during extended dry periods, and mortality of phreatophytic species has potential to increase. There is also potential for structural changes, and some potential for compositional changes, to vegetation units EcrAtAanTe and EcrEvCcAtAs. The vegetation types in Zone 1 are likely to extend beyond the Development Envelope (based on aerial photography) and are not considered to be locally restricted. Therefore, the proposed impact to these vegetation types is not expected to be significant.

Facultative phreatophytic species in Zone 2 may access groundwater but any access is likely to be minimal and represent only a small proportion of their EWR. As noted above, *Eucalyptus camaldulensis* which become established under relatively deep groundwater conditions (i.e. 10 m below ground level as in Zone 2) have been observed to exhibit substantial resilience to changes in groundwater availability. In this Zone surface water inputs are likely to play a more important role than groundwater. Although changes to

groundwater access in Zone 2 may result in a reduction in canopy cover and potentially an increase in mortality of phreatophytic species in vegetation units EcrAtAanAtTe and EcAanAtrAbAtuTe, structural and compositional changes are considered unlikely. As the low flow channel and alluvial substrate will remain, the functionality of the community is expected to be maintained.

Based on depth to groundwater and a lack of lateral spread of phreatophytes away from the low flow channel, it is considered to be a low probability that riparian vegetation in Zone 3 (vegetation types EcrAtAanAtTe and EcAanAtrAbAtuTe) is dependent on groundwater from the CID/Yarraloola aquifers. Changes to canopy cover, structure and composition are considered unlikely in vegetation type EcrAtAanAtTe and highly unlikely in vegetation type EcAanAtrAbAtuTe.

5.6.2.2 Loss or degradation of riparian vegetation as a result of surface water discharge

The controlled discharge of surplus water to Warramboo Creek will change the water availability in a section of Warramboo Creek (up to 8 km) downstream from the discharge point. Surface water discharge will not be continuous during the life of the Revised Proposal. Modelling of discharge shows that continuous flow could extend up to 8 km downstream during periods of discharge. The change in hydrological regime is likely to result in temporary changes to riparian vegetation along Warramboo Creek. It is anticipated that vegetation adaptation to the altered hydrological regime could include new growth and changes in structure and cover. Specifically, it is likely there will be a change of dominance and cover with an increase in the sedges and rushes genera of *Bulbostylis, Cyperus, Fimbristylis* and *Lipocarpha* that are currently present at 16 locations and/or quadrats (Scott Walker, MWH, pers. comm. 7 September 2015). It is also possible that Melaleuca species may recruit at these locations due to the available surface water. Changes in dominance cover and richness may be recorded over time; however, the functioning of the community is still likely to be satisfactory (Scott Walker, MWH, pers. comm. 7 September 2015). The vegetation along the creek may also be temporarily affected by cattle and other introduced fauna being attracted to the available water during periods of discharge. The proposed discharge is not continuous and is not expected to have any long-term adverse effects on the riparian vegetation community. Following cessation of discharge, vegetation that has become established as a result of discharge may be affected by a loss of available water. However, it is anticipated that the riparian vegetation will revert to that adapted to an ephemeral system.

The proposed discharge of surplus groundwater via the proposed discharge point at Warramboo Creek may alter surface water chemistry and sediment quality downstream of the discharge point during natural no-flow conditions. Changes to water chemistry and sediment quality may result in short-term changes to vegetation health.

The surface and groundwater chemistry of Warramboo Creek is described in Section 8.4.4 and 8.6.3. Surface water samples collected from Warramboo Creek after rainfall events show the water to be fresh with a neutral to mildly alkaline pH. Total nitrogen levels in Warramboo Creek are generally elevated compared with the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 95% aquatic ecosystem protection level (ANZECC/ARMCANZ 2000). Aluminium, total chromium, copper, iron, nitrates, total phosphorus and zinc also show some degree of elevation compared with ANZECC 95% aquatic ecosystem protection levels.

Groundwater chemistry data for samples collected from bores most likely to represent the proposed surplus water discharge were compared with data from surface water samples and ANZECC guidelines. The chemistry of the groundwater proposed for discharge has a neutral to mildly alkaline pH and is considered fresh to brackish. Median concentrations of boron, nitrate, NOx and total nitrogen and also electrical conductivity (EC) in the groundwater are elevated compared with both the surface water in Warramboo Creek and the ANZECC guidelines.

Under natural no-flow conditions, discharged surplus water has the potential to increase salt and some metal concentrations within Warramboo Creek and result in accumulation of salts and metals within sediments for the duration of discharge, potentially causing temporary vegetation stress and decline in vegetation health in an 8 km section of Warramboo Creek. However, during natural flow conditions which occur during rainfall events, discharged surplus groundwater will be diluted and the system flushed (Scott Walker, MWH, pers. comm. 7 September 2015). This will mitigate the potential impacts of short-term increases in salinity on vegetation in the 8 km of Warramboo Creek that may be affected by the proposed discharge.

In regards to potential erosion impacts, discharge of excess groundwater is predicted to occur at a rate which is significantly less than the flow rates generated during flood events and on this basis, discharge is unlikely to overtop the creek bank. Discharge velocities are predicted to be less than 1 m/s which are considered unlikely to result in channel erosion within Warramboo Creek (Rio Tinto 2015a).

5.6.2.3 Degradation of vegetation due to ingress of weeds

Historically, weeds in the Pilbara have been introduced through pastoral activities (EPA 2014). However, weeds are often also able to rapidly invade locations subject to disturbance, land clearing and/or altered hydrological regimes. This can result in replacement of native species and simplification of natural ecosystems.

Most weed species recorded in the western portion of the Development Envelope were recorded in drainage lines, disturbed areas or on the Stony Plains. Movement of cattle and natural drainage represent the major sources of weed distribution in the region.

Limited clearing will occur in drainage lines. Clearing at Warramboo Creek for installation of the discharge point may intersect an existing population of the dominant weed in the western portion of the Development Envelope; **Cenchrus ciliaris*, contributing to seed spread. Weed species have the potential to spread further downstream with altered hydrological regimes, specifically, discharge to Warramboo Creek.

The Proponent has well established strategies for the management of weeds at its Pilbara operations to ensure that risks of weed ingress are minimised. This includes management of weeds associated with discharge of surplus water in creeklines. Weed monitoring and management strategies have been and will continue to be implemented to minimise the risk of weed ingress.

5.6.2.4 Degradation of vegetation due to increased dust deposition

Construction and operation of the Proposed Change is likely to increase airborne dust, which in turn may result in increased dust deposition on native vegetation in the western portion of the Development Envelope.

Due to the significance of the Sand Sheet PEC and its proximity to the mining operations, infrastructure has been designed to avoid being in close proximity to the Sand Sheet PEC as far as practicable. Two construction haul road options were considered, a northern route and a southern route. While the northern construction haul route is within existing tenure and represents a shorter haul distance, this route would require new disturbance within 50 m of the Sand Sheet PEC, potentially leading to increased dust deposition on the Sand Sheet PEC. The southern construction haul route is separated by topography from the Sand Sheet PEC and is 120 m away at its closest point so is not expected to result in a significant change in dust deposition on the Sand Sheet PEC.

The wet processing plant is proposed to be located approximately 250m from the northern edge of the main Sand Sheet PEC at its closest point. The wet processing plant is not expected to significantly increase airborne dust as the moisture content of the ore will increase during the beneficiation process.

Winds in the Development Envelope are predominantly southerly to south-easterly (Envall 2017) so dust deposition as a result of the proposed haul road will be higher to the north of the road than to the south of the road where the Sand Sheet PEC lies. Northerly winds which would transport dust from the haul road to the Sand Sheet PEC are relatively infrequent (Envall 2017). Dust monitoring conducted on the Sand Sheet PEC at the point closest to the proposed haul road shows current dust deposition varies between 1.5 g/m^2/month and 9.1 g/m^2/month with an average of 5.7 g/m^2/month. Dust modelling predicts monthly dust deposition will increase by 1.1 g/m^2/month at the closest point on the Sand Sheet PEC due to activity on the proposed haul road (Envall 2017). Dust modelling indicates that dust deposition due to activity on the proposed haul road will be below 0.5 g/m^2/month 500 m away from the haul road.

Matsuki *et al*. (2016) conducted a study examining the impacts of dust on plant health in semi-arid environments. The study found no evidence of negative impacts on plant health for dust deposition rates up to 77 g/m^2/month. Dust deposition monitoring conducted at Mesa A in 2016 approximately 340 m from the current Mesa A mine pit and approximately 100m from the Mesa A plant showed a maximum dust deposition rate of 9.4 g/m^2/month (Envall 2017). Based on dust and vegetation monitoring to date, modelled dust deposition for the Proposed Change and the study by Matsuki *et al.* (2016), any decline in vegetation health due to dust deposition is likely to be limited to the area immediately adjacent to the proposed mining operation.

The Proponent has well established strategies for the management of dust emissions at its Pilbara operations. These strategies will continue to be implemented to manage dust emissions. Strategies to manage dust emissions include:

- Minimising exposed surfaces by minimising clearing and rehabilitating disturbed areas no longer in use
- Applying water (or other dust suppressants) to roads, working surfaces and stockpiles as required
- Restricting vehicle access to designated roads and tracks and implementing speed limits to minimise dust generation from roads.

Monitoring will enable dust management performance to be assessed and strategies to manage dust emissions refined where necessary.

The Proposed Change may result in a minor, temporary increase in localised dust deposition on vegetation but is not expected to significantly impact vegetation.

5.6.3 Cumulative impacts

The Proposed Change will result in the clearing of up to 3,000 ha of vegetation, in addition to the 3,680 ha approved under Ministerial Statement 756 for the existing Mesa A/Warramboo Iron Ore Project.

Ten vegetation units as mapped by Beard occur in the Development Envelope. Historical clearing in the Robe Valley has resulted in disturbance to these units with the greatest disturbance being to Hammersley 609 (2% of Pre-European extent), Onslow Coastal Plain 604 (2% of Pre-European extent) and Stuart Hills 603 (2% of pre-European extent) as presented in Table 5-14. The Proposed Change will increase cumulative impacts to vegetation in the Robe Valley. Considering historical, proposed and reasonably foreseeable impacts, cumulative clearing of each vegetation unit will remain low, with the greatest contribution of the Proposed Change to cumulative impacts being to Onslow Coastal Plain 604 and Stuart Hills 29, with proposed clearing for the Proposed Change representing 3% and 2% of the Pre-European extent of these units respectively. The resultant cumulative clearing to these units would be 5% of the pre-European extent of the Onslow Coastal Plain 604 unit and 3% of the pre-European extent of the Stuart Hills 29 unit. Given the small (5% or less) proportion of cumulative disturbance to the vegetation units in the Development Envelope, the Proposed Change is considered unlikely to result in significant impacts to vegetation in the Pilbara region.

Approximately 4 km of Warramboo Creek falls within the current drawdown extent from groundwater abstraction for water supply from the Warramboo borefield to the existing Mesa A/Warramboo Iron Ore Project. Current drawdown in this area is approximately 1-2.5 m. Significant impacts to riparian vegetation in this area as a result of the current drawdown were not expected and have not been observed. It is likely the groundwater in this area represents a small proportion of the EWR of the phreatophytes present, given depth to groundwater in this area (approximately 14-16 metres below ground level) and a generally negligible degree of lateral spread of phreatophytes away from the low flow channel. In addition, flora and vegetation monitoring transects recently established along Warramboo Creek [RTIO CK 4-I, RTIO CK 5-I and RTIO CK 6-I in MWH (2016)] have not demonstrated any areas of reduced vegetation condition deemed to potentially be from drawdown. The areas of poorer vegetation condition in the transects were concluded to be due to cattle, erosion and the presence of weeds.

The Proposed Change will not result in cumulative impacts to riparian vegetation in Warramboo Creek from surplus water discharge as the approved activities do not involve discharge of surplus groundwater. Tracking of the disturbance footprint for the approved activities shows that only two recorded populations of Priority Flora have been disturbed by the existing operation:

- *Triodia* sp. Robe River (M.E. Trudgen et al. Met 12367): one individual, representing <1% of the records in the Rio Tinto database
- *Rhynchosia bungarensis:* 12 individuals, representing <1% of the records in the Rio Tinto database.

Considering historical disturbance from the Mesa A/Warramboo Iron Ore Project, the proposed disturbance and reasonably foreseeable disturbance in the Robe Valley, cumulative impacts to Priority Flora species will be 10% or less (Table 5-15). Cumulative impacts to Priority Flora are estimated to be:

- 5% of Rio Tinto records of *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61)
- 10% of Rio Tinto records of *Triodia* sp. Robe River (M.E. Trudgen et al. Met 12367)
- 1% of Rio Tinto records of *Goodenia nuda*
- 1% of Rio Tinto records of *Rhynchosia bungarensis*.

The greatest contribution of the Proposed Change to cumulative impacts is 5% of Rio Tinto records of *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61) and 1% of Rio Tinto records of *Goodenia nuda*. It is, therefore, considered that the Proposed Change will have only a limited contribution to cumulative impacts on Priority Flora in the Robe Valley.

Prior to commencement of mining at the Mesa A/Warramboo Iron Ore Project weed species were relatively widespread, but typically at low densities (Biota 2006a). Various weed species were recorded in the vicinity of Mesas A, B and C during the two-phase survey conducted by Biota 2006a), however none were recorded from Warramboo or the Sand Sheet PEC. Since commencement of the approved activities, six weed species have been recorded in the Sand Sheet PEC, with records subsequently eradicated. None of the recorded species are Weeds of National Significance or declared pests (Biota 2016). The increase in the number of species recorded and locations is likely to be due to increased monitoring effort since commencement of mining operations at the Mesa A/Warramboo Iron Ore Project. Favourable climatic conditions in 2009, 2011, 2013, 2015 and 2016 are likely to have contributed to the recorded spread of Buffel Grass (Biota 2016). The Proposed Change has the potential to increase the spread of weeds within and in the vicinity of the western portion of the Development Envelope due to ground disturbance and increased vehicle movements. This will be managed in accordance with established Rio Tinto weed management and monitoring programs.

The Proposed Change may contribute further dust deposition to a portion of the Sand Sheet PEC located to the south-east of Mesa A. Modelling of dust deposition from a new haul road from the Mesa A/Warramboo Iron Ore Project to Mesa B and Mesa C demonstrates that northerly winds are required to carry dust from the haul road to the Sand Sheet PEC and these are relatively infrequent. The predicted monthly dust deposition from the haul road at the closest point of the Sand Sheet PEC is 1.1 g/m^2/month, which is within the standard deviation of the current month to month depositions (Envall 2017).

No other existing or proposed mining operations occur in the vicinity of the Proposed Change that would contribute to cumulative impacts on flora and vegetation.

5.7 Closure

The Mesa A Hub Closure Plan (Rio Tinto 2017b) is the updated closure plan for the Mesa A, B, C, Warramboo, Highway/Tod Bore operations and supersedes previous closure plans for the approved project. It is applicable to mine developments and associated infrastructure, excluding rail and road infrastructure, within the Development Envelope. A summary of the approach to closure of the Revised Proposal and how it relates to the flora and vegetation factor is provided below.

The proposed final land use assumes that the site will be rehabilitated to create a safe, stable and non-polluting landscape revegetated with native species, to maximise environmental and cultural heritage outcomes and ensure the site does not adversely impact on the current surrounding land use. Due to the nature of the mining activity undertaken, the final landform will include large voids and waste dumps, and will therefore be unlikely to support pastoral activities in the immediate vicinity of the mining areas. The final land use will be determined prior to closure during final planning phases and in consultation with relevant stakeholders.

The Mesa A Hub is a relatively new mining area, rehabilitation to date has been limited to areas associated with construction, however encouraging results have been received during monitoring to date. Progressive backfill of pits to meet closure commitments and other opportunistic rehabilitation will be undertaken during operations; however, the majority of rehabilitation will be completed at closure. Rehabilitation areas from other sites in the Robe Valley (Mesa J and Mesa K) are used to guide planned rehabilitation at the Mesa A Hub and to determine likely rehabilitation outcomes. Examples of rehabilitation areas from other sites in the Robe Valley are provided in Section 13 of the Mesa A Hub Closure Plan (Appendix 3).

The key objective for vegetation on rehabilitated land is that it is self-sustaining and compatible with the final land use. This will be measured via rehabilitation monitoring/site inspections and analysis of historical monitoring data. Seed used in rehabilitation works will be of local provenance. Weeds in rehabilitation are managed under the company's Weed Management Strategy which has control measures such as periodic spraying and equipment hygiene procedures.

The additional surface flow of water discharged to Warramboo Creek may result in temporary changes to riparian vegetation during mining. Following cessation of discharge, vegetation that has become established as a result of discharge may be affected by a loss of available water. It is anticipated that the riparian vegetation will revert to that adapted to an ephemeral system following cessation of discharge. As such, the proposed discharge is not expected to have any long-term adverse effects on the riparian vegetation community and management post closure is, therefore, not expected to be required.

5.8 Mitigation

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 5-16.

The Mesa A Hub Environmental Management Plan (EMP) (Appendix 4) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa A Hub. The EMP identifies:

- Mitigation strategies proposed to minimise impacts to significant environmental values
- The environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met
- Trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach
- The management actions that will be implemented in response to monitoring results.

Table 5-16: Mitigation measures and predicted outcomes for flora and vegetation

Potential impacts	Mitigation to address potential impacts	Predicted outcome
EPA Objective: To protect flora and vegetation so that biological diversity and ecological integrity are maintained.		
Direct Impact: loss of vegetation and conservation significant flora due to clearing Clearing will remove up to 3,000 ha of native vegetation including vegetation units of local significance and Priority Flora.	The following key management strategies will be implemented to manage the loss of flora and vegetation as a result of clearing: **Avoid:** The Proposed Change has been designed to avoid direct disturbance to the Sand Sheet PEC (excluding impacts within the buffer). Specifically, all roads avoid interaction with the Sand Sheet PEC. Development of infrastructure avoids interaction with the Robe River riparian zone. The Proposed Change has been designed to avoid known locations of Priority Flora as far as practicable. Priority Flora are also flagged with restriction zones in Rio Tinto's internal GIS system. The Proponent will ensure clearing only occurs in approved ground disturbance areas through continued implementation of the Proponent's Approvals Request system **Minimise:** The clearing footprint has been minimised through project optimisation to reduce the extent of clearing required. Specifically, in-pit disposal of waste fines and reverse osmosis plant effluent is proposed rather than development of an external tailings storage facility and evaporation pond. The Proponent proposes that clearing be subject to a new Ministerial Statement for the Revised Proposal (Appendix 2). Schedule 1 of the Ministerial Statement shall authorise	The Proposed Change is expected to result in the unavoidable loss of up to 3,000 ha of vegetation. The Proposed Change is expected to impact five vegetation units of high local significance; ChAbAtrTw, EcEvMgAtrCv, AanAbAsyTP, AanAiAatAbTP and CcAanTe. The Proponent has conservatively estimated disturbance to <10%of the mapped extent of each of these vegetation types within the western portion of the Development Envelope. Some minor clearing of riparian vegetation will be required to facilitate installation of the discharge point on Warramboo Creek and monitoring points along the Robe River (8 ha). The Proposed Change is expected to impact four Priority Flora species: • *Abutilon* sp. Onslow (P1) • *Triodia* sp. Robe River (P3) • *Goodenia nuda* (P4) • *Rhynchosia bungarensis* (P4). Predicted impacts to individuals of these species range between 1%-5% of records in the Rio Tinto database being cleared by the Proposed Change. Each species is considered to be generally well represented in the Robe Valley or Pilbara region and/or have large known ranges. Given this, and the small predicted loss of individuals relative to those known to occur across Rio Tinto sites

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	clearing of no more than 6,680 ha within the Development Envelope of 16,834 ha. **Rehabilitate:** The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA *Guidelines for Preparing Mine Closure Plans* (2015). The Closure Plan (Appendix 3) includes a closure objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use. Indicative completion criteria include: • Seed used in rehabilitation works is of local provenance (except where seed pre-dates accurate recording of area) • Native plants within rehabilitated areas are observed to flower and/or fruit • Recruitment of native perennial plants is observed • Species richness of native perennial plants within rehabilitated areas is not less than reference sites • Any weed species recorded within rehabilitation areas are present within the local area • Erosion from landforms does not threaten surrounding significant natural ecosystems. **Offset:** The Proponent proposes the provision of an environmental offset ($750 per hectare) for the unavoidable clearing of native vegetation in Good to Excellent condition, and an environmental offset at the	more broadly, the impacts to these species are unlikely to result in a significant decline in their regional representation. Significant residual impacts will be addressed via the provision of an offset in accordance with EPA requirements.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	higher offset rate ($1,500 per hectare) for the unavoidable clearing of riparian vegetation. **Other legislation:** The Proponent will adhere to the requirements of the WC Act.	
Indirect impact: loss or degradation of riparian vegetation as a result of groundwater drawdown.	The following key management strategies will be implemented to manage the potential loss of flora and vegetation as a result of groundwater drawdown **Minimise**: Hydrogeological modelling has been and will continue to be undertaken to facilitate understanding of current and future abstraction requirements. Groundwater abstraction will be minimised to that required to access the BWT resource and meet water supply requirements. Groundwater abstraction will remain within licence limits to minimise impacts to the local aquifer. The Proponent proposes to monitor the health of the *M. argentea* dominated communities and the *M. argentea* and *E. camaldulensis* co-dominated community along the Robe River and the *E. camaldulensis* dominated community along Warramboo Creek to ensure no irreversible impact to the health of riparian vegetation of the Robe River and Warramboo Creek as a result of groundwater abstraction for the Proposed Change. The Proponent proposes that groundwater abstraction be subject to a new Ministerial Statement for the Revised Proposal (Appendix 2). The conditions of the new Ministerial Statement shall require the Proponent to implement an EMP (Appendix 4) to manage groundwater abstraction such that there is no irreversible impact to the health of riparian vegetation of the Robe River and	Current hydrogeological data and modelling indicate limited to no hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvial aquifer. Consequently, drawdown in groundwater levels within the Mesa C CID Aquifer is not expected to result in observable changes to obligate phreatophytic species. Should there be greater hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvium than current modelling and hydrogeological investigations indicate, there is potential for stress to individual trees along the Robe River in the extent of drawdown. Groundwater drawdown may affect availability of groundwater to facultative phreatophytic vegetation along the 13 km section of the defined flow channel of Warramboo Creek and into the flood plain downstream of the defined channel. In Zone 1 (refer Section 5.5.2) the following may occur: • Likely reduction in canopy cover during extended dry periods and potential increase in mortality of phreatophytic species in vegetation units EcrAtAanTe, EcrEvCcAtAs and EvCcAtpAccA • Potential structural and compositional changes to vegetation units EcrAtAanTe and EcrEvCcAtAs.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	Warramboo Creek as a result of groundwater abstraction for the Proposed Change. **Other legislation:** Groundwater abstraction has been and will continue to be managed in accordance with the existing Groundwater Licence issued under the *Rights in Water and Irrigation Act 1914* and associated Groundwater Operating Strategy, and any amendments as required.	In Zone 2 there is potential for a reduction in canopy cover during extended dry periods increase in mortality of phreatophytic species in vegetation units EcrAtAanAtTe and EcAanAtrAbAtuTe; however, structural and compositional changes are considered unlikely. In Zone 3 potential changes to canopy cover, structure and composition are considered unlikely in vegetation type EcrAtAanAtTe and highly unlikely in vegetation type EcAanAtrAbAtuTe. Although there may be impacts to the riparian vegetation along Warramboo Creek, the low flow channel and alluvial substrate will remain and the functionality of the community is expected to be maintained. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant, therefore no offset is proposed.
Indirect impact: loss or degradation of riparian vegetation as a result of surface water discharge Discharge of surplus water into Warramboo Creek is expected to change the hydrological regime of Warramboo Creek from an ephemeral system to one with permanent water available for the duration of discharge. The change to the hydrological regime may impact riparian vegetation. Alteration of sediment quality and surface water chemistry in Warramboo Creek from discharge of surplus water may result in decline in vegetation health.	The following key management strategies will be implemented to manage the impacts to riparian vegetation as a result of discharge of surplus water: **Minimise:** Abstracted groundwater will be used on-site for processing and dust suppression to avoid discharge as far as practicable. Surplus water will be discharged at a rate which is not expected to cause bank erosion. The Proponent proposes to monitor the health of the riparian vegetation within the discharge extent to ensure there is no irreversible impact[1] to the health of riparian vegetation of Warramboo Creek as a result of surplus water discharge from the Proposed Change.	The Proposed Change is expected to result in temporary changes to riparian vegetation as a result of increased water availability during discharge. Continuous flow may extend up to approximately 8 km downstream of the discharge point during peak discharge conditions. It is anticipated that vegetation adaptation to increased water availability will include new growth and changes in structure and cover. Specifically, it is likely there will be a change of dominance and cover with an increase in the sedges and rushes genera of *Bulbostylis, Cyperus, Fimbristylis* and *Lipocarpha*. Once discharge ceases, it is anticipated that the riparian vegetation will revert to that adapted to an ephemeral system.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	The Proponent proposes that the discharge of surplus water be subject to a new Ministerial Statement for the Revised Proposal (Appendix 2). The conditions of the Ministerial Statement shall require the Proponent to implement an EMP (Appendix 4) to ensure that discharge of surplus water does not have an irreversible impact on the health of riparian vegetation of Warramboo Creek. **Other legislation:** The Proponent will adhere to the requirements of the WC Act. Discharge of surplus dewatering water will be managed in accordance with an amended Operating Licence issued under Part V of the EP Act.	Changes to sediment quality and surface water chemistry from surplus water discharge may result in a temporary decline in vegetation health along an 8 km section of Warramboo Creek for the duration of discharge. Natural flow conditions following rainfall events will mitigate the potential impacts of increases in salinity on vegetation in the 8 km section of Warramboo Creek that may be impacted by the proposed discharge. The Proponent considers the potential impacts can be managed and residual impact will not be significant enough to warrant application of offsets.
Indirect impact: degradation of vegetation due to ingress of weeds Ground disturbance and change to the hydrological regime of Warramboo Creek as a result of discharge may introduce or spread weed species within the Development Envelope.	The Proponent has well established strategies for monitoring and management of the risk of weed ingress at its Pilbara operations. The following key management strategies will continue to be implemented to manage weeds: **Avoid:** The Proponent will implement strict hygiene procedures to prevent introduction of new or additional populations of weed species into the western portion of the Development Envelope. **Minimise:** The Proponent will undertake annual weed control to minimise weed infestations in the Development Envelope. The Proponent proposes to continue to monitor the Sand Sheet PEC. Monitoring will provide an indication of vegetation condition, community structure and diversity. The Proponent proposes that clearing and discharge of surplus dewatering water be subject to a new Ministerial	The Proposed Change is expected to result in a minor increase in the potential for weed infestation; however, this is not expected to significantly alter the condition of vegetation in the western portion of the Development Envelope. The Proponent considers that the potential impact from weeds can be managed and the residual impact will not be significant enough to warrant application of offsets.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	Statement for the Revised Proposal (Appendix 2). Schedule 1 of the Ministerial Statement shall authorise clearing of no more than 6,680 ha within the Development Envelope of 16,834 ha. The conditions of the Ministerial Statement for the Revised Proposal shall require the Proponent to implement an EMP (Appendix 4) to ensure that discharge of surplus water does not have an irreversible impact on the health of riparian vegetation of Warramboo Creek. **Rehabilitate:** The Proponent proposes that closure be subject to a new Ministerial Statement for the Revised Proposal (Appendix 2). The Ministerial Statement shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA *Guidelines for Preparing Mine Closure Plans* (2015). The Closure Plan (Appendix 3) includes a closure objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use. **Other legislation:** Weed management will be in accordance with the requirements of the *Biosecurity and Agriculture Management Act 2007*.	
Indirect impact: degradation of vegetation due to increased dust deposition Dust emissions may impact vegetation within the western portion of the Development Envelope including the Sand Sheet PEC.	The following key management strategies will continue to be implemented to manage dust emissions: **Minimise:** The Proponent will minimise exposed surfaces by minimising clearing. The Proponent has designed the proposed haul road and construction haul road such that they are located as far from the Sand Sheet PEC as practicable to reduce potential impacts of dust on the Sand Sheet PEC.	The Proposed Change is expected to result in a minor increase in dust deposition on vegetation, including the Sand Sheet PEC; however, this is not expected to significantly alter the condition of vegetation in the western portion of the Development Envelope. The Proponent considers that the potential impact can be managed and the residual impact will not be significant enough to warrant application of offsets.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	The Proponent will implement dust controls including water sprays, dust suppressants and other measures to minimise the extent of dust deposition on vegetation. **Rehabilitate:** The Proponent will rehabilitate disturbed areas that are no longer in use.	

[1] Where 'irreversible impact' is defined as, 'an impact resulting in a permanent loss of environmental value(s); or where intensive, and/or un-proven management intervention, potentially over a long timeframe, would be required to restore the environmental value(s)'.

5.9 Predicted outcome

The Flora and Vegetation values identified in the western portion of the Development Envelope that are considered relevant to the Proposed Change, and the key predicted outcomes for those values are outlined below.

Significant vegetation

- The Sand Sheet PEC
- Riparian vegetation
    - Groundwater Dependent Vegetation along the Robe River (dominated by obligate phreatophytic vegetation - *Melaleuca Argentea*) adjacent to Mesas B and C
    - Riparian vegetation of Warramboo Creek (dominated by facultative phreatophytic vegetation - *Eucalyptus camaldulensis* and *Eucalyptus victrix*)
- Vegetation unit AanAbTP which supports two populations of the Priority 1 taxon *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61).

Priority listed flora species

- *Abutilon* sp. Onslow (F. Smith s.n. 10/9/61) (Priority 1)
- *Triodia* sp. Robe River (M.E. Trudgen et al. Met 12367) (Priority 3)
- *Goodenia nuda* (Priority 4)
- *Rhynchosia bungarensis* (Priority 4).

The key predicted outcomes for the Flora and Vegetation values outlined above are:

- The unavoidable loss of up to 3,000 ha of vegetation.
- No direct disturbance to the Sand Sheet PEC.
- Direct clearing of riparian vegetation along Warramboo Creek as a result of the Proposed Change will be limited to 8 ha
- Disturbance of the vegetation unit of high local significance; AanAbTP as a result of the Proposed Change will be limited to 3% of the extent of this vegetation type in the western portion of the Development Envelope
- Disturbance of individuals of the four Priority Flora species as a result of the Proposed Change will be limited to between 1%-5% of records in the Rio Tinto database
- Groundwater drawdown may affect availability of groundwater to facultative phreatophytic vegetation along the 13 km section of the defined flow channel of Warramboo Creek and into the flood plain downstream of the defined channel. The potential for impact depends on the existing depth to groundwater and vegetation present:
    - In Zone 1 (low to moderate potential for groundwater dependence) there is potential for reduction in canopy cover and increased mortality in vegetation units EcrAtAanTe, EcrEvCcAtAs and EvCcAtpAccA as well as potential for structural and compositional changes to vegetation units EcrAtAanTe and EcrEvCcAtAs
    - In Zone 2 (low potential for groundwater dependence) there is potential for a reduction in canopy cover and individual tree deaths in vegetation units EcrAtAanAtTe and EcAanAtrAbAtuTe
    - In Zone 3 (negligible potential for groundwater dependence) potential impacts to vegetation are unlikely

- Temporary changes to riparian vegetation (including new growth and changes in structure and cover) as a result of increased water availability during discharge up to 8 km downstream of the discharge point during peak discharge conditions. Once discharge ceases, it is anticipated that the riparian vegetation will revert to that adapted to an ephemeral system
- Temporary decline in vegetation health up to 8 km downstream of the discharge point due to potential changes to sediment quality and surface water chemistry from surplus water discharge.

The Proponent considers that the residual impact from the direct clearing of up to 3,000 ha of native vegetation in Good to Excellent condition, including approximately 8 ha of riparian vegetation is significant and warrants an offset. The proposed offset is discussed in Section 13. After the mitigation hierarchy has been applied (Table 5-16), including avoidance and minimisation of direct impacts to key flora and vegetation values and the proposed offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Flora and Vegetation. The proposed loss of vegetation is not expected to cause a loss of biological diversity at the local or regional scale and the ecological integrity of the area surrounding the footprint is expected to be maintained.

6. SUBTERRANEAN FAUNA

This section describes the subterranean fauna that occur within the western portion of the Development Envelope and provides an assessment of the potential impacts of the Proposed Change to conservation significant subterranean fauna, proposed mitigation measures and the predicted outcome for this key environmental factor.

6.1 EPA Objective

The EPA objective for subterranean fauna is to protect subterranean fauna so that biological diversity and ecological integrity are maintained.

6.2 Policy and Guidance

The following policy and guidance documents have been considered in the assessment of subterranean fauna.

6.2.1 EPA policy and guidance

- DMP and EPA Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015)
- Statement of Environmental Principles, Factors and Objectives (EPA 2018a)
- Environmental Factor Guideline: Subterranean Fauna (EPA 2016f)
- Environmental Factor Guideline – Inland Waters Environmental Quality (EPA 2016c)
- Technical Guidance: Sampling methods for Subterranean fauna (the content of this Guidance has not yet been updated from EPA Guidance Statement No. 54a: technical appendix to Guidance Statement No. 54) (EPA 2016g)
- Technical Guidance: Subterranean fauna survey (the content of this Guidance has not yet been updated from EPA Guideline 12. Issued June 2013) (EPA 2016h)
- Instructions on how to prepare an Environmental Review Document (EPA 2016i)
- Instruction of how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans (EPA 2016e).

6.2.2 Other policy and guidance

- WA Environmental Offsets Policy (Government of Western Australia 2011)
- WA Environmental Offsets Guidelines (Government of Western Australia 2014).

6.3 Environmental Scoping Document

Table 6-1 summarises where the requirements of the ESD are addressed in this Section.

Table 6-1: Requirements of the ESD for subterranean fauna

Task number	Requirement	Comments
18	Provide a desktop study of all surveys of the Proposal area undertaken in accordance with EPA Policy. The study should include: • Justification of how those surveys are relevant and representative of the Development Envelope and if they were carried out using methods consistent with EPA Policy • A comprehensive listing of all subterranean fauna known or likely to occur in the habitats present, and identification of conservation significant fauna species likely to occur in the area.	Section 6.4.1 and 6.5.1
19	Conduct Level 2 subterranean fauna surveys in areas not previously surveyed that are likely to be directly or indirectly impacted as a result of the Proposal. Surveys are to be undertaken in accordance with EPA Policy. The surveys should also consider other areas outside the proposed impact footprint as reference areas.	Section 6.4.1.1 and 6.5.1.1
20	Present a review of previous survey information and operational monitoring, and the results of the subterranean fauna surveys and discuss the potential for direct, indirect and cumulative impacts to subterranean fauna (species, populations and assemblages) and habitat including consideration of altered water regimes and water quality (e.g. nutrient flows) as a result of the Proposal.	Sections 6.4.1, 6.4.2, 6.4.4, 6.5.1, 6.5.2, 6.5.3
21	Assess the impacts to subterranean fauna with reference to relevant impacts from the proposed action (including taking into consideration any relevant guidelines, policies and plans and statutory provisions). For species' which are likely to be impacted, provide information, including maps of habitat extent and an appropriate explanation of the likely distribution of species within those habitats including evidence to demonstrate whether there is habitat connectivity.	Sections 6.4.4 and 6.5.3
22	Provide a detailed description of the potential direct, indirect and cumulative impacts to conservation significant and other species within the Proposal area and on a regional scale.	Sections 6.4.2, 6.5.2, 6.4.4 and 6.5.3
23	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to subterranean fauna.	Section 6.4.6 and 6.5.5
24	Discuss management measures, outcomes/objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	Section 6.4.6 and 6.5.5
25	Review the current Mesa A Subterranean Fauna management plan in relation to the requirements of conditions 5 (Troglobitic fauna monitoring) and 6 (Troglofauna habitat retention) in Ministerial Statement 756, to apply to the entire Proposal including but not limited to areas depicted in Ministerial Statement 756, and how these areas are proposed to change.	Section 6.6

Task number	Requirement	Comments
	The Plan(s) should link to the outcomes of the Subterranean Fauna Peer Review. The following should be addressed in the review, consistent with reviews but not limited to: • Subterranean fauna species and populations and assemblages • Key habitat parameters for subterranean fauna, including humidity within the underground spaces which form the habitat of the troglobitic fauna and water quantity and quality for stygofauna • Studies on the impacts of blasting and mining on the integrity of troglobitic fauna habitat • The effectiveness of re-creating troglobitic fauna habitat through such measures as replacement of waste rock, supported by evidence, including reference to previous trials.	
26	Revise the current Subterranean Fauna management plan to apply to the entire Proposal.	Section 6.5.5
27	Prepare a Mine Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) which considers: • The use of Mining Exclusion Zones (MEZ) to protect troglofauna habitat • The use of waste rock to maximise survival of, and possible re-colonisation by, troglobitic fauna; and • The need to retain intact material suitable for troglobitic fauna habitat under the pit floor after mining to facilitate movement of troglobitic fauna between the material below the pit floor and the MEZ.	Sections 6.4.5 and 6.5.4
28	Describe the residual impacts for the Proposal and analyse these impacts.	Sections 6.4.4, 6.5.3, 6.4.6, 6.5.5 and 6.7
29	Create an offsets position following application of the mitigation hierarchy.	Sections 6.7 and 13
30	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Sections 6.4.6, 6.5.5 and 6.7

6.4 Troglofauna

6.4.1 Receiving environment

6.4.1.1 Surveys and studies

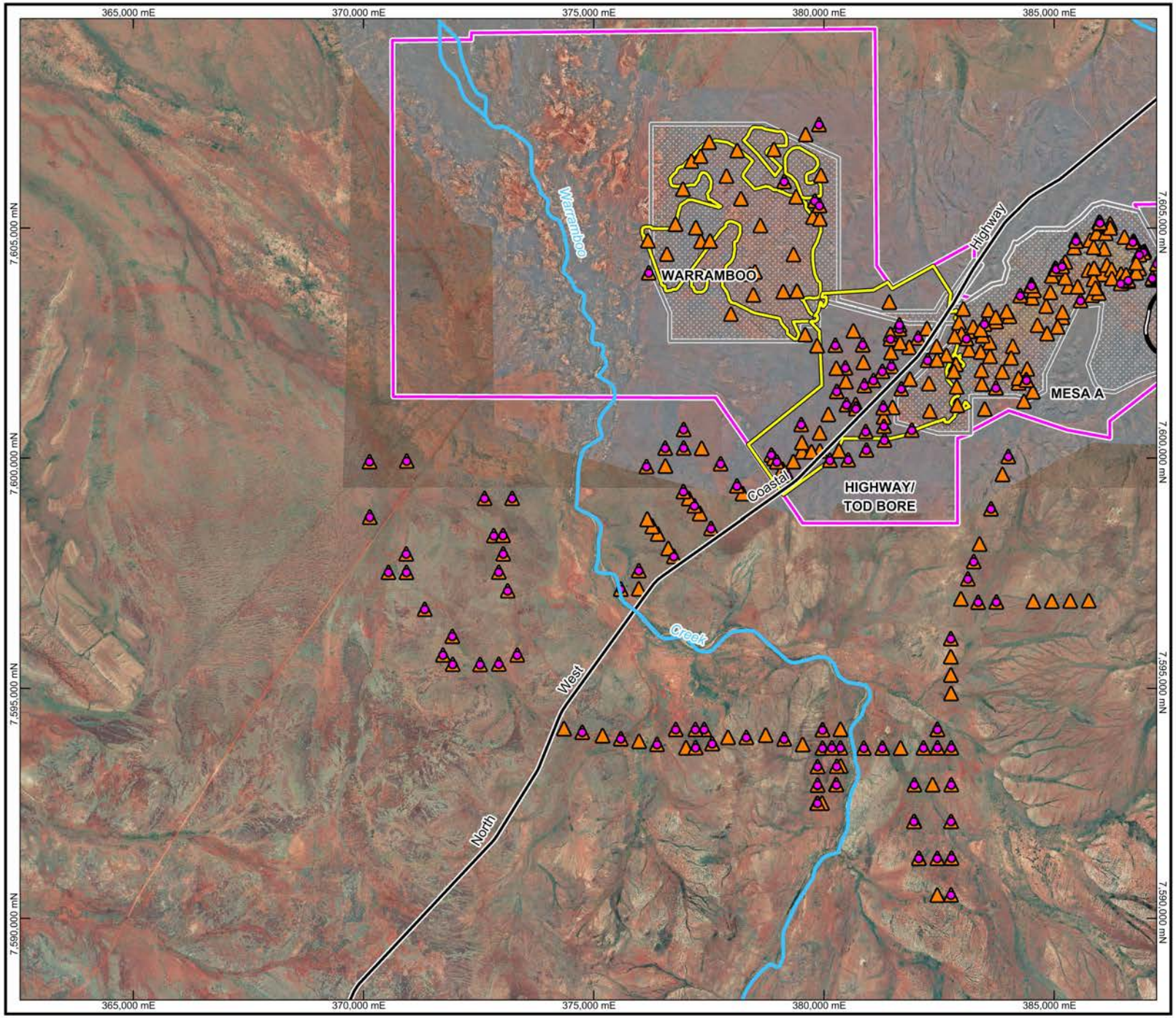
Troglofauna were first recorded at Mesa A in 2003 as by-catch of stygofauna sampling. Since 2003 numerous troglofauna surveys and assessments have been undertaken across the Robe Valley. The combined coverage of these surveys provides a considerable knowledge base of the troglofauna present in the western portion of the Development Envelope. It should be noted that the average sampling intensity per site has increased since the commencement of sampling in 2003 and that the seasonality of surveys has varied between sampling events. Caution must, therefore, be exercised when comparing results from surveys conducted at different times. The surveys are summarised in Table 6-2 and Figure 6-1 to Figure 6-3 show the troglofauna sampling sites in the western portion of the Development Envelope.

Table 6-2: Summary of supporting troglofauna studies

Report	Summary	Survey date
Comparison of Downhole Optical Image Logs in Troglofauna Assessment Holes 2017: Rio Tinto Mesa A, Mesa B and Mesa K Kinetic (2018)	Optical image surveys were conducted at Mesa A, B and K to determine if there was a detectable change in the structure of the boreholes used to monitor troglofauna that may have been induced by mining activities. In 2017, 19 previously monitored holes (ten, three and six holes at Mesa A, B and K respectively) were logged with an optical imaging tool and the images compared with previous monitoring results.	December 2017
Troglofauna habitat data analysis Astron (2017b)	Astron (2017b) undertook a statistical analysis of a set of downhole temperature and relative humidity data from uncased drill holes at Mesa A, Mesa B and Mesa K recorded by Rio Tinto from 2013-2017. The aim of this analysis was to test for impacts of mining at Mesa A on variables which may delimit troglofauna habitat (down hole temperature and relative humidity).	June 2017
Mesa A and Mesa B Annual Compliance Troglofauna Survey 2016 Bennelongia (2017)	Troglofauna sampling in the Mesa A and Mesa B between July and September 2016. A total of 39 drillholes were sampled using 44 traps and 37 net scrapes at Mesa A, and six drillholes were sampled using six traps and five net scapes at Mesa B.	July to September 2016
Mesa A Hub: Warramboo Troglobitic Fauna Assessment Biota (2017a)	Biota (2017a) conducted a two-phase troglofauna survey across the Warramboo deposit between June and September 2015 in accordance with relevant EPA guidance and policies. The survey included a desktop review, habitat characterisation and systematic sampling of troglofauna. Survey effort included the deployment of a total of 128 troglofauna traps across 33 drill holes and scraping at eight drill holes. Habitat characterisation was undertaken, initially using a combination of regional information and site specific geological data. The habitat units identified were assigned a prospectivity to support troglofauna which was then revisited on completion of the field survey sampling component of this study. The prospectivity of the geological units for troglofauna within the study area were categorised as Low, Moderate and High.	June and October 2015

Report	Summary	Survey date
Mesa A Hub: Mesas B and C Troglobitic Fauna Assessment Biota (2017b)	Biota (2017b) conducted a four-phase troglofauna fauna survey across the Mesa B and Mesa C survey areas between June 2015 – September 2016 in accordance with relevant EPA guidance and policies. Over the four sampling phases, 196 traps were installed at Mesa B and 233 at Mesa C. Ninety sites were also sampled using the scraping method. A total of 113 sites were sampled during the study, comprising 50 sites from Mesa B and 63 from Mesa.	April, June, August and October 2015 January, March, July and September 2016
Mesas A and K Targeted Troglofauna Survey Biota (2017c)	Biota (2017c) conducted a two-phase troglofauna survey in disturbed areas at Mesas A and K. A total of 14 sites were sampled at Mesa A and five sites at Mesa K. A total of 86 troglofauna traps were installed with 79 traps recovered. Haul net scraping was also completed for 16 of the 19 sites.	December 2016 to January 2017 February 2017 to March 2017
Mesa A and Warramboo Troglofauna Alignment Bennelongia (2015a)	Taxonomic alignment of troglofauna specimens recorded from Mesa A and Warramboo through further molecular work.	June 2015
Alignment of troglofauna – *Ideoblothrus* sp. 'Mesa A2' Bennelongia (2015b)	Taxonomic alignment of pseudoscorpions belonging to the genus *Ideoblothrus* recorded from Mesa A and Mesa B through further molecular work.	August 2015
Mesa A Troglofauna Biennial Compliance Monitoring: 2014 MWH (2014)	Troglofauna sampling at Mesa A and Mesa B between June and September 2014. A total of 41 drillholes were sampled using 132 traps and 40 net scrapes at Mesa A, and ten drillholes were sampled using 26 traps and ten net scapes at Mesa B.	June and September 2014
Mesa A Troglobitic Fauna Compliance Monitoring 2012 Biota (2012b)	Troglofauna sampling in the Mesa A MEZ and Mesa B between May and July 2012. A total of 36 drillholes were sampled using 105 traps at Mesa A, and ten drillholes were sampled using 30 traps at Mesa B.	May and July 2012

Report	Summary	Survey date
Mesa A Troglofauna Compliance Report 2010 Biota (2011b)	Troglofauna sampling in the Mesa A MEZ between July and October 2010. A total of 41 drillholes were sampled using 112 traps.	July and October 2010
Mesa A Troglobitic Fauna Studies Update Biota (2007)	Consolidates Mesa A troglofauna sampling data from six sampling phases conducted between 2004 and 2007. Over the six phases of sampling a total of 134 drillholes were sampled using trapping.	December 2006 and February 2007 April and May 2007



LEGEND

- Development Envelope
- Ministerial Statement 756
- Highway
- Major Watercourse

Sampling Method

- Scraping
- Trapping

Conceptual Mine Layout

- Mine Pit

N

SCALE

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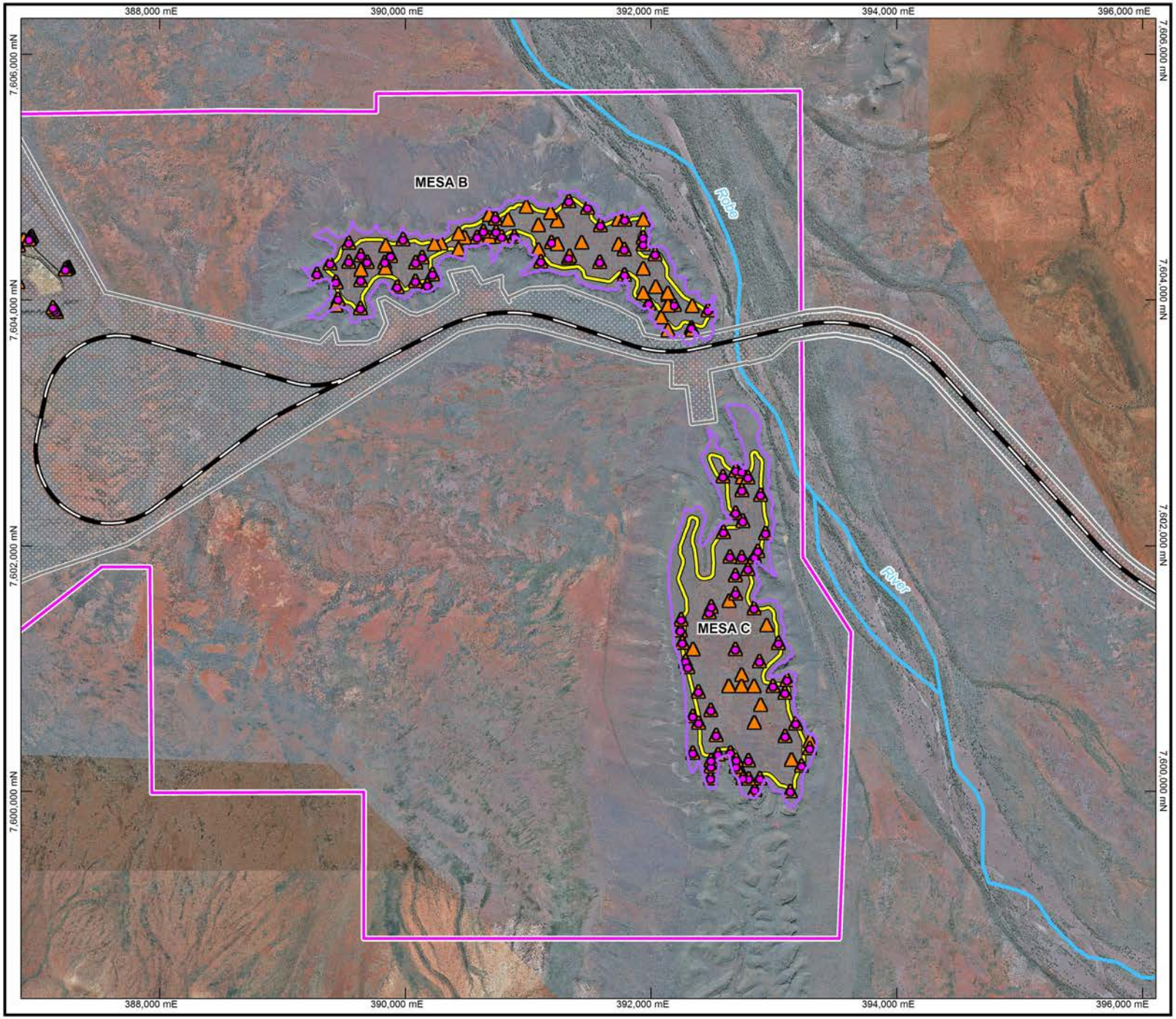
Iron Ore (WA)

Figure 6-1: Troglofauna sampling effort Warramboo, Highway/Tod Bore and surrounds

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0154714v5
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Railway
- Major Watercourse
- Top of mesa escarpment

Sampling Method

- Scraping
- Trapping

Conceptual Mine Layout

- Mine Pit

N

SCALE

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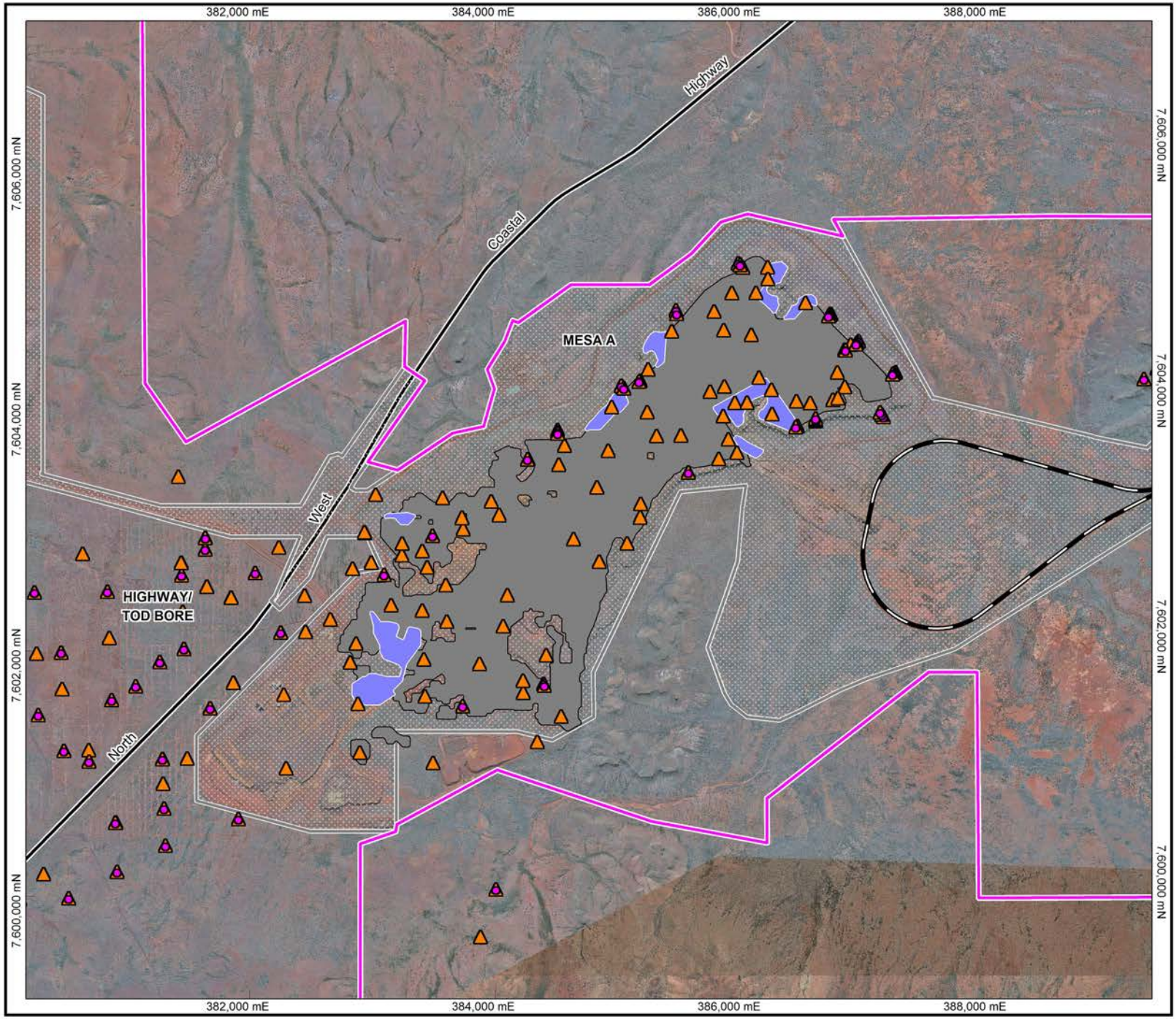
Iron Ore (WA)

Figure 6-2: Troglofauna sampling effort Mesa B and Mesa C

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0154720v7
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Railway

Sampling Method

- Scraping
- Trapping
- Approved Pit
- Proposed new mining/cut widening

N

SCALE

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Iron Ore (WA)

Figure 6-3: Troglofauna sampling effort Mesa A

Drawn: MS
Date: Nov, 2018

Plan No:PDE0161052v3
Proj:MGA94 Zone50

Geospatial Information and Mapping

6.4.1.2 Current monitoring and management at the Mesa A/Warramboo Iron Ore Project

The Mesa A/Warramboo Iron Ore Project is managed in accordance with MS 756 and includes a MEZ. The MEZ was established around the periphery of Mesa A, encompassing the escarpments and the south-western part of the deposit where a mesa escarpment is not present. The MEZ was established to protect a number of environmental values including troglofauna habitat and is comprised of CID. In addition to the MEZ, the Mesa A/Warramboo Iron Ore Project includes retention of a zone of troglofauna habitat beneath the pit floor (the sub-floor zone). The sub-floor zone provides connected CID habitat at least 15 m in thickness along the length of the mesa and connects with the MEZ. Together the MEZ and the sub-floor zone provide for retention of approximately 52% by volume of the pre-mining troglofauna habitat.

A Troglobitic Fauna Monitoring Program has been developed and implemented in accordance with Condition 5 of MS 756. The Monitoring Program includes periodic sampling of troglofauna and monitoring of down hole temperature and humidity in the retained habitat in the MEZ. The Monitoring Program also provides for studies on the impacts of blasting on the integrity of troglofauna habitat and the effectiveness of re-creating troglofauna habitat through replacement of waste rock. Where relevant to the Proposed Change, the results of troglofauna sampling and habitat monitoring conducted for the Mesa A/Warramboo Iron Ore Project are discussed in Section 6.4.2. Conditions 6 and 8 of MS 756 require mining to be managed to ensure that the actual pit shell contours are within the agreed parameters and that waste rock material is placed to protect and support any projecting ‘fingers’ of rock in the MEZ. These requirements have been adapted and incorporated into the Mesa A Hub draft EMP and the Mesa A Hub Closure Plan respectively.

6.4.1.3 Habitat

The likely habitats for troglobitic fauna in the study area were characterised using a combination of regional surface geological mapping and site specific data including mapping of thickness above water table of prospective geological units, stratigraphic logging, images and information from drill holes and troglofauna survey results (Biota 2017a, 2017b). The mapping of habitat prospectivity is a comprehensive approach to assessing troglofauna habitat using the collation and integration of all available datasets, including 2D and 3D geological / geophysical data, geological modelling outputs (e.g. using software similar to Leapfrog modelling software) and the physical features of geological formations. This approach is more comprehensive than the often simplistic approach using only 2D surface geological mapping to simply define ‘habitat’. A more detailed description of the habitat modelling methodology followed is provided in Appendix 7.

Geological units within the survey areas were categorised as Low, Moderate and High prospectivity for troglofauna based on the following characteristics (Biota 2017a, 2017b; Table 6-3):

A. Presence of mesocaverns, vugs and interstitial spaces.
B. Known hydration, weathering or significant cavity zones.
C. Presence of clay lenses or impeding layers to maintain stable humidity.
D. The known occurrence of troglofaunal communities from equivalent rock types during past Pilbara surveys.
E. Occurs above water table within the survey area.

Table 6-3: Troglofauna habitat prospectivity definitions (Biota 2017a, 2017b)

Prospectivity	Definition
High	Majority (four or five) categories confirmed for the geological unit, including E. Troglofauna routinely recorded from same rock type (D).
Medium	Suitable geology likely or known to occur above the water table in the survey area (E). Geology known to have interstices or vugs (A) and troglofauna have occasionally been detected in similar rock types previously (D). Geology may be subject to seasonal inundation (e.g. alluvium and colluvium). Where known, units of high prospectivity were categorised as medium if less than 5 m in thickness.
Low	Suitable geology only occurs B in the survey area. Rock type may have (B), (C) and (E) characteristics but locally lacking suitable habitat space. Troglofauna not known from previous studies sampling of the same geology.

Habitat prospectivity is determined by intrinsic features of the geological strata. Based on the characteristics listed above, three geological units were identified as high and medium troglofauna habitat prospectivity in the western portion of the Development Envelope:

- Robe Pisolite
  - greater than 5 m thickness (High prospectivity)
  - less than 5 m thickness (Medium prospectivity)
- Alluvium (Qr) (Medium prospectivity)
- Colluvium (Qg) (Medium prospectivity).

Robe Pisolite (or CID), alluvium and colluvium have been recognised by the EPA as potential troglofauna habitat during past assessments (Biota 2017b). The Robe Pisolite is likely to be the primary habitat for troglofauna in the western portion of the Development Envelope. The 5 m thickness threshold for designating Robe Pisolite as high or medium prospectivity was selected as a conservative threshold based on consideration of:

- The physical dimensions of troglofauna relative to the volume of habitat represented by habitat that is laterally connected with a thickness of 5 m
- Sampling results from the Warramboo and Highway/Tod Bore area where troglofauna have been recorded in areas with Robe Pisolite thickness of less than 5 m and in some areas with Pisolite thickness less than 2 m
- Expert opinion regarding suitable habitat.

Robe Pisolite with thickness >5 m is considered to represent high prospectivity troglofauna habitat. Figure 6-4 shows a plan view of the pre-mining extent and thickness of the troglofauna habitat (Robe Pisolite) at Mesas B and C in relation to the proposed mine pit outlines. Figure 6-5 to Figure 6-8 show typical cross-sections of the Robe Pisolite within Mesas B and C. The figures show that Robe Pisolite is present across the entirety of each mesa formation and there are no known geological barriers or faults within Mesas B and C.

The Priority 1 PEC, the Subterranean invertebrate community of pisolitic hills in the Pilbara, occurs in the Warramboo and Highway/Tod Bore area while the Priority 1 PEC,

the Subterranean invertebrate community of mesas in the Robe Valley region, occurs at Mesas B and C (Figure 6-9)[8]. The locations of these PECs broadly align with the occurrence of pisolite in the area.

The remaining geological units in the western portion of the Development Envelope (Lacustrine deposits (Qi), Eluvium (Qp), Alluvium (Qpt), Conglomerate (Kn and Kny), Ashburton (Wa), Warramboo Sandstone (Ma), Kiangi Creek Formation (Mk) and Granite (Pg)) were identified as low troglofauna habitat prospectivity. Troglofauna have been recorded in these units, however, the physical characteristics of the units suggest they are unlikely to provide core troglofauna habitat Biota (2017a).

Figure 6-10, Figure 6-11 and Figure 6-12 show the modelled troglofauna habitat prospectivity for Warramboo, Highway/Tod Bore and surrounds and Mesas B and C respectively. The figures show the habitat prospectivity as determined from regional surface geology and site specific data including mapping of thickness of prospective geological units, stratigraphic logging, images and information from drill holes and troglofauna surveys. The figures also identify the limit of high confidence habitat modelling, the area over which the Proponent has a high density of drill holes and thus high confidence in the data.

Habitat prospectivity mapping was verified by overlaying specimen results and null records on the habitat prospectivity mapping. Further details of the troglofauna habitat modelling methodology are provided in Appendix 7.

Warramboo, Highway/Tod Bore

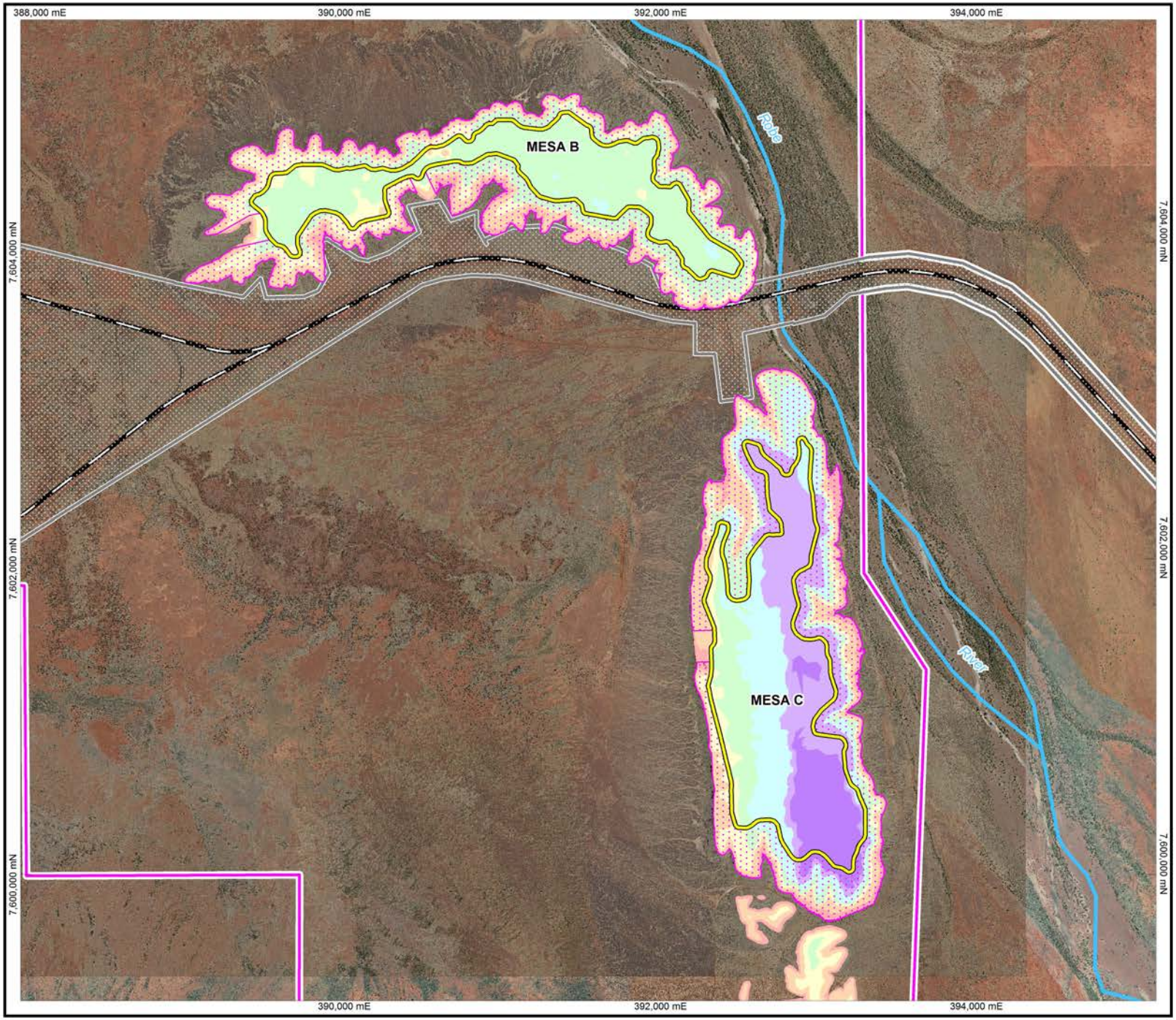
Figure 6-13 shows troglofauna records overlaid on modelled troglofauna habitat prospectivity in the vicinity of Warramboo and Highway/Tod Bore. The survey results support the habitat model described above with 87% of conservation significant and potential SRE species recorded in modelled high prospectivity habitat.

As the habitat model was developed partly from two-dimensional mapping layers, the model can provide a two-dimensional estimate of habitat, that is, an area estimate. The habitat model indicates that the following areas of troglofauna habitat prospectivity currently exist within the limit of high confidence habitat modelling:

- Approximately 6,136 ha of high prospectivity habitat
- Approximately 9,620 ha of medium prospectivity habitat
- Approximately 54 ha of modelled low prospectivity habitat.

The above area estimates exclude modelled high and medium suitability habitat currently mined under MS 756.

[8] PEC buffers are shown on the map rather than PEC boundaries as the Conditions for supply of PEC location information allow only buffers to be shown in public reports.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Railway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Mining Exclusion Zone

Robe Pisolite (CID) Thickness Above Water Table

- 1-5m
- 5-15m
- 15-25m
- 25-35m
- 35-45m
- 45-55m
- >=55m

N

SCALE

0.5 0 0.5 1km

1:35 000 @ A4

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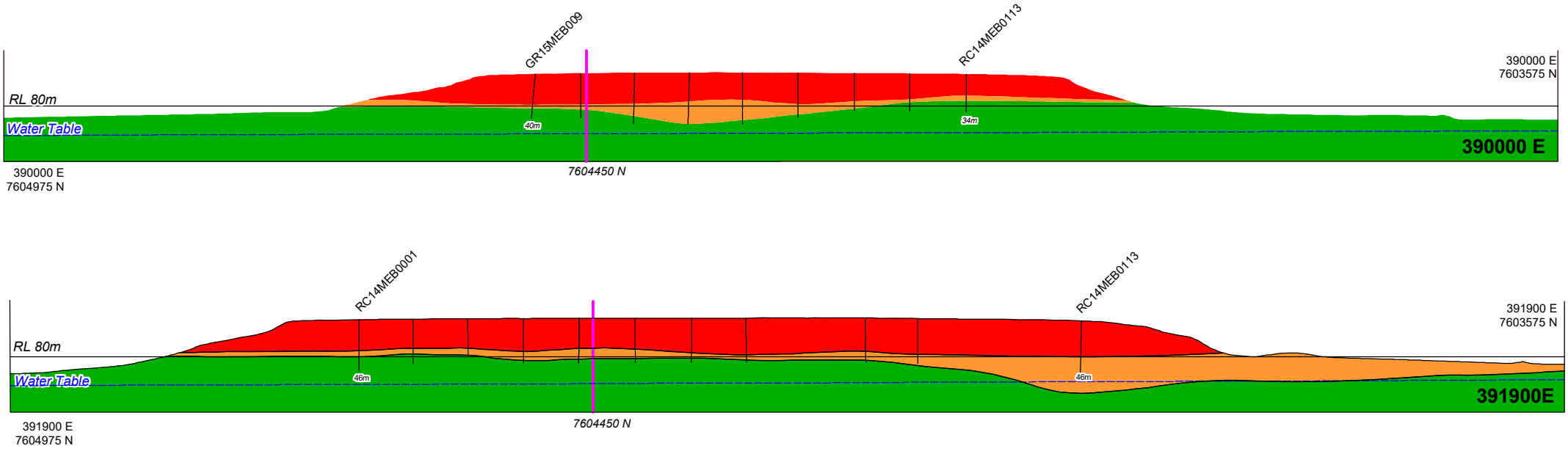
Iron Ore (WA)

Figure 6-4: Pre-mining troglofauna habitat at Mesas B and C

Drawn:T.M.
Date: Aug, 2018

Plan No:PDE0158179v5
Proj:MGA94 Zone50

Geospatial Information and Mapping



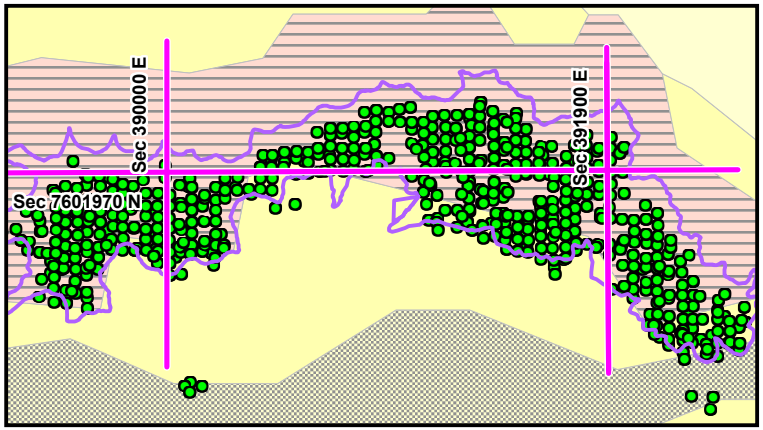
Horizontal scale 1:3000
Vertical scale 1:1000

LEGEND

100 0 100m

A4 scale 1:5000
MGA94 Zone 50

- Robe Pisolite
- Basal Tertiary Pisolite
- Ashburton Formation
- Drill hole



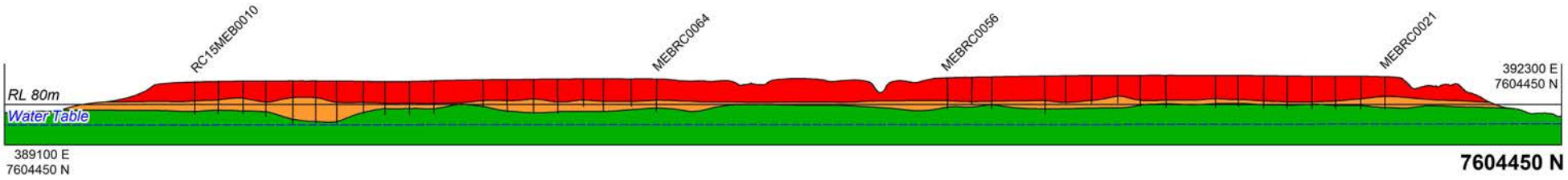
- Drill hole
- Section line
- Top of mesa escarpment
- Elluvium and Alluvium
- Robe Pisolite
- Colluvium
- Alluvium

Iron Ore (WA)

Figure 6-5: Typical schematic cross-sections of Mesa B

Drawn:T.M.
Date:July, 2018

Plan No:PDE0157531v3
Proj: GDA94 Zone 50

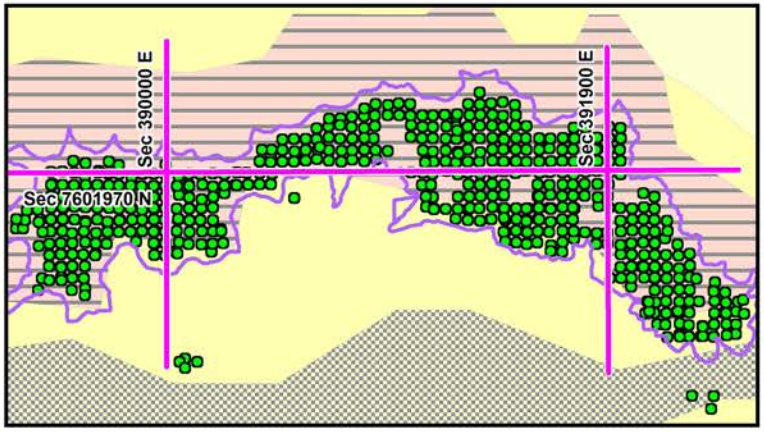


Horizontal scale 1:3000
Vertical scale 1:1000

LEGEND

100 0 100m
A4 scale 1:7 500
MGA94 Zone 50

- Robe Pisolite
- Basal Tertiary Pisolite
- Ashburton Formation
- Drill hole



- Drill hole
- Section line
- Top of mesa escarpment
- Elluvium and Alluvium
- Robe Pisolite
- Colluvium
- Alluvium

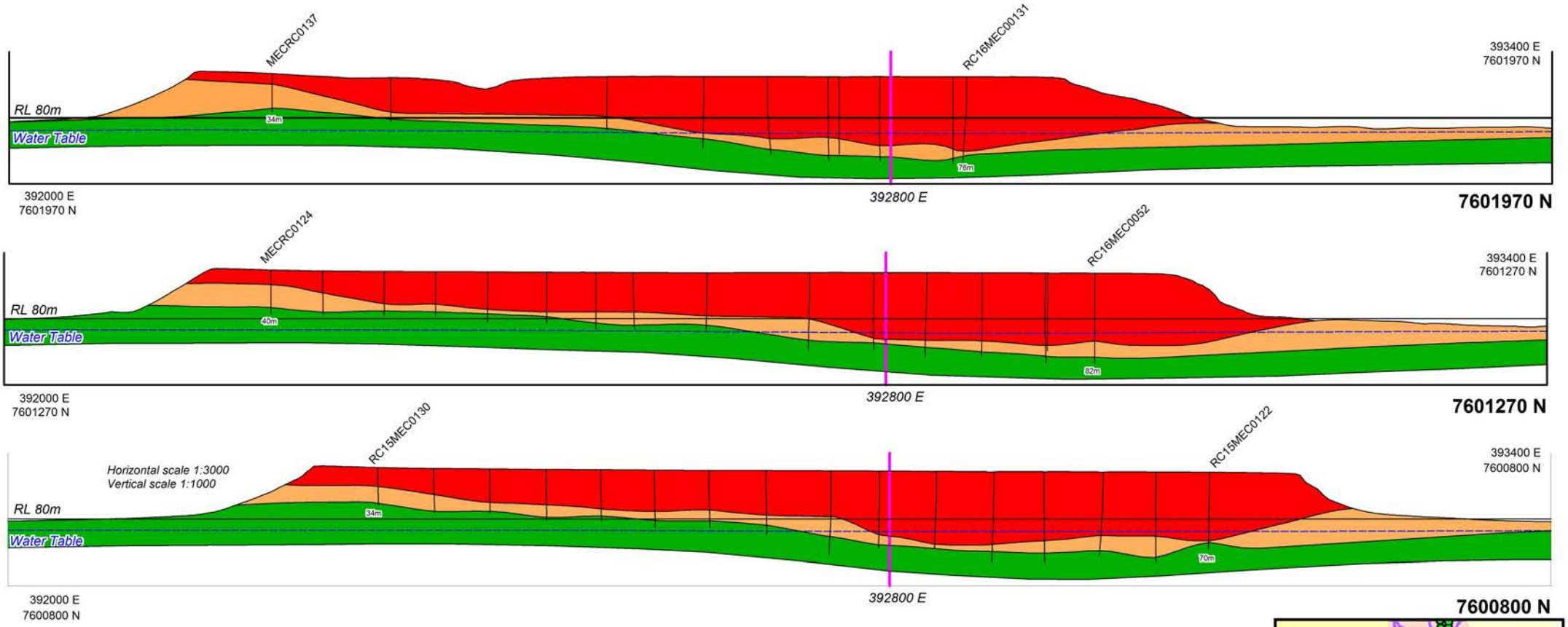
RioTinto

Iron Ore (WA)

Figure 6-6: Typical schematic long-section of Mesa B

Drawn:T.M.
Date: July, 2018

Plan No:PDE0157531v3
Proj: GDA94 Zone 50



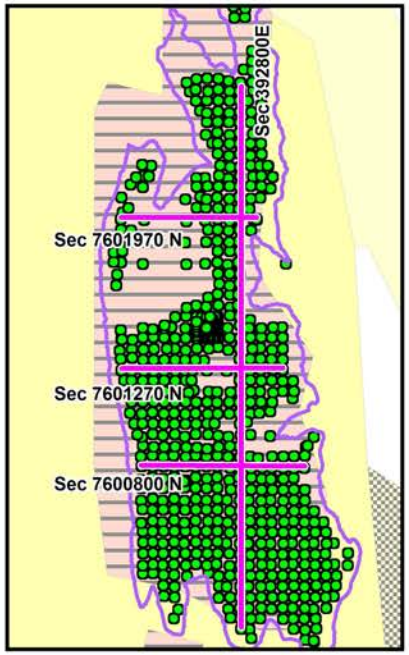
LEGEND

- Robe Pisolite
- Basal Tertiary Pisolite
- Ashburton Formation
- Drill hole

100 0 100m

A4 scale 1:5000
MGA94 Zone 50

- Drill hole
- Section line
- Top of Mesa Escarpment
- Elluvium and Alluvium
- Robe Pisolite
- Colluvium
- Alluvium



RioTinto

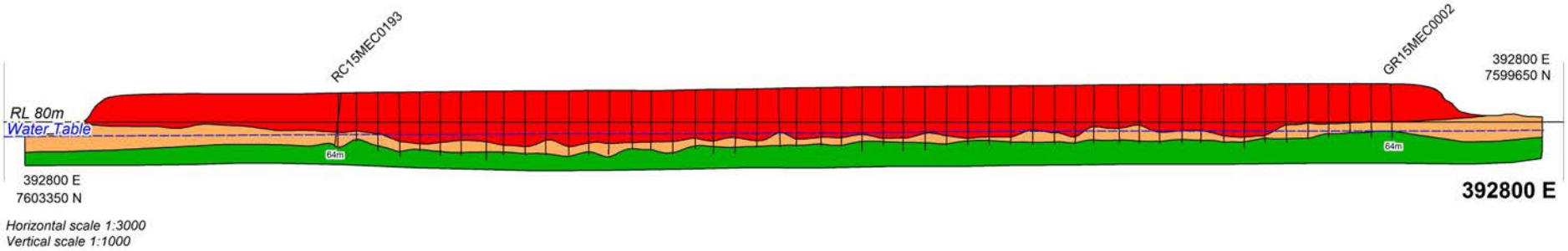
Iron Ore (WA)

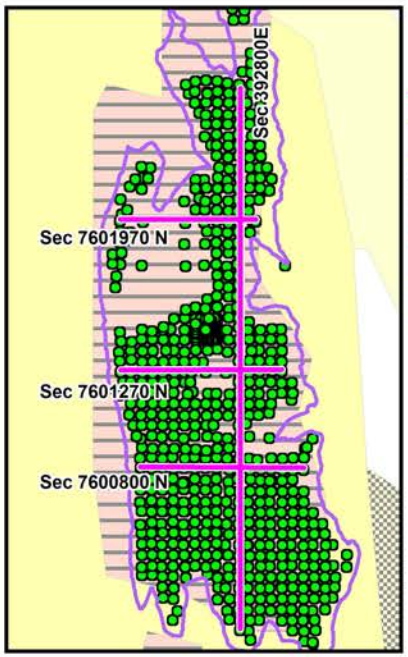
Figure 6-7: Typical schematic cross-sections of Mesa C

Drawn:T.M.
Date: July, 2018

Plan No:PDE0157530v3
Proj:GDA94 Zone50

Geospatial Information and Mapping





- Drill hole
- Section line
- Top of Mesa Escarpment
- Elluvium and Alluvium
- Robe Pisolite
- Colluvium
- Alluvium

100 0 100m

A4 scale 1:7 500
MGA94 Zone 50

LEGEND

- Robe Pisolite
- Basal Tertiary Pisolite
- Ashburton Formation
- Drill hole

RioTinto

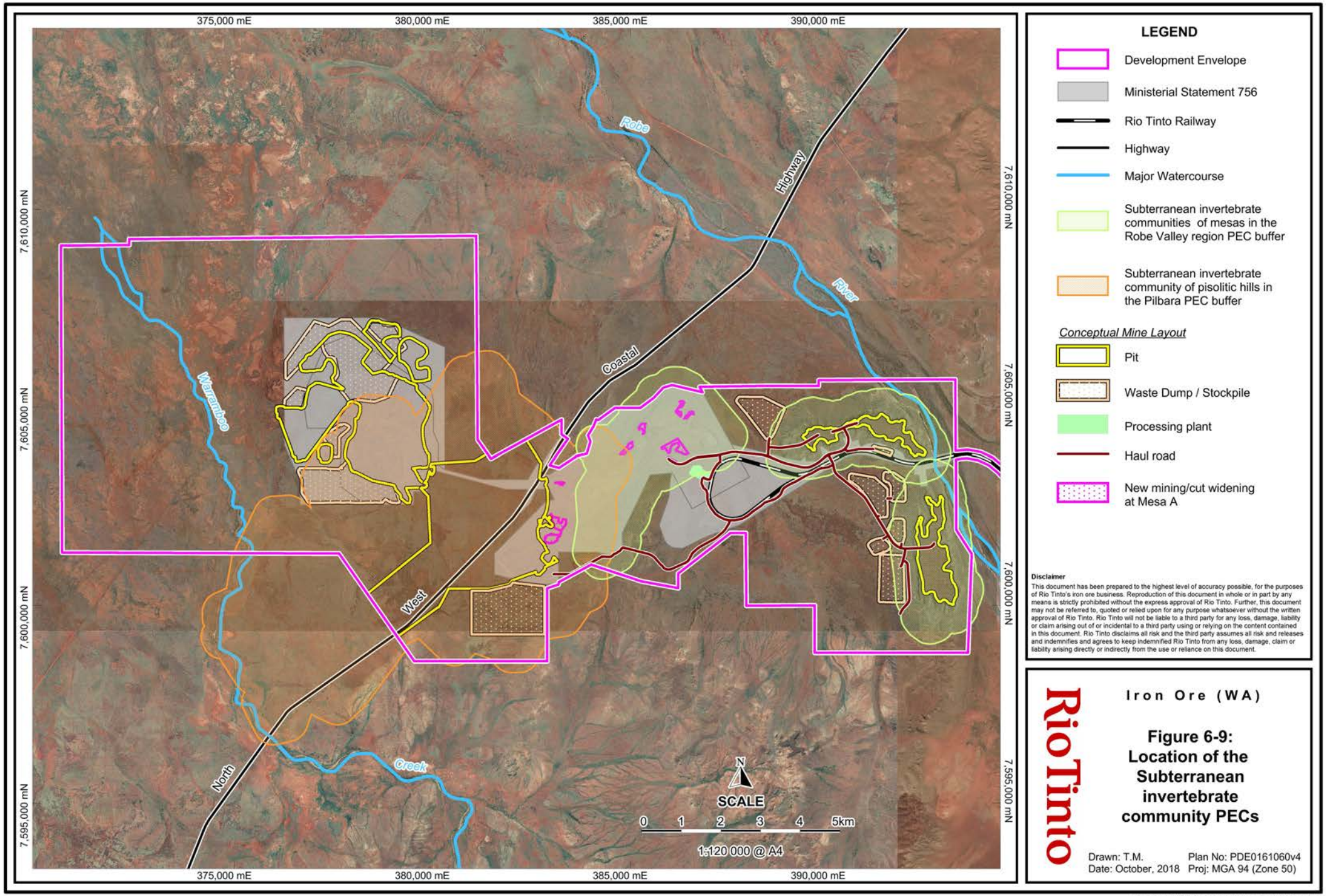
Iron Ore (WA)

Figure 6-8: Typical schematic long-section of Mesa C

Drawn:T.M.
Date: June, 2018

Plan No:PDE0157530v3
Proj:GDA94 Zone50

Geospatial Information and Mapping



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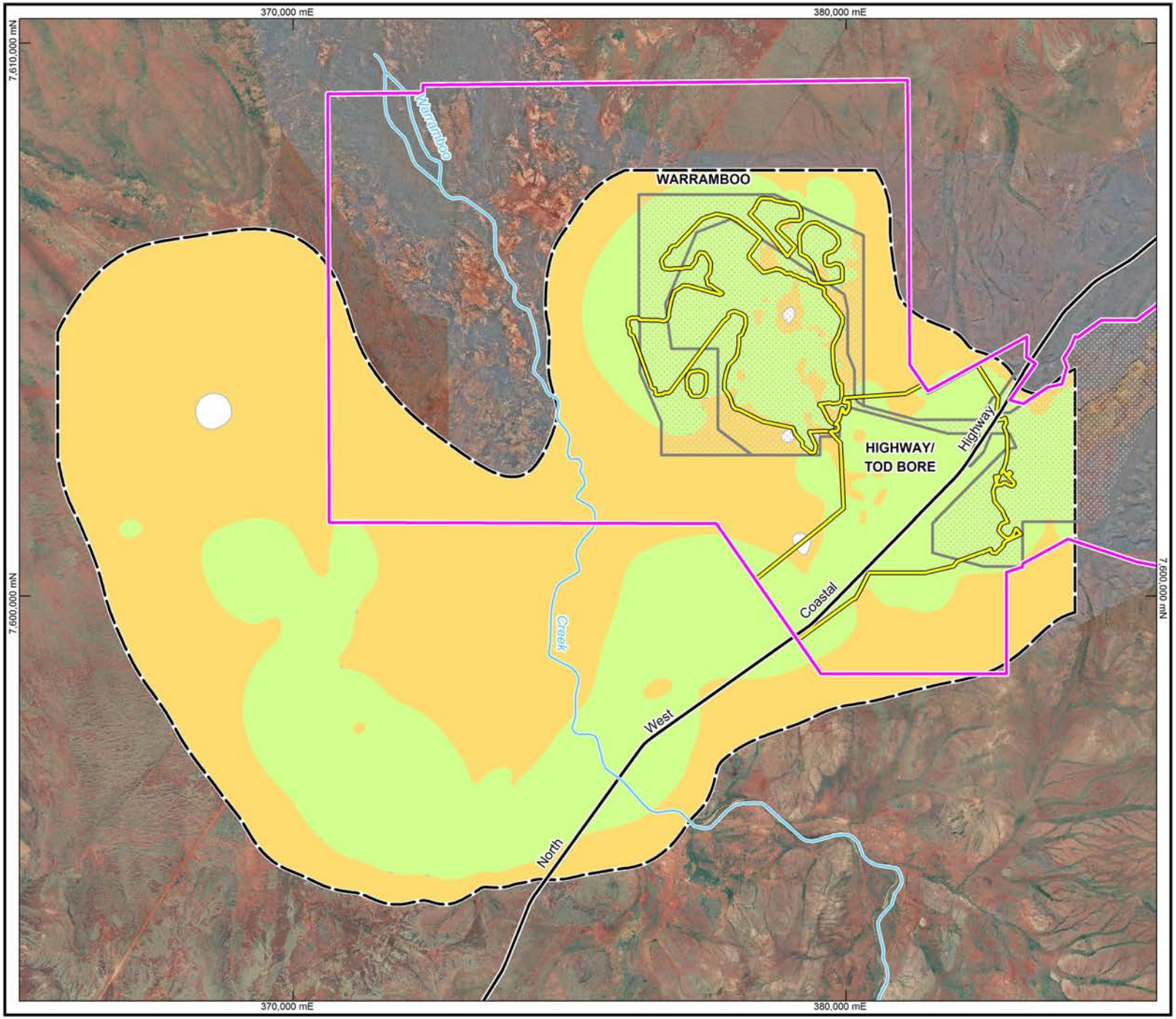
Rio Tinto

Iron Ore (WA)

Figure 6-9: Location of the Subterranean invertebrate community PECs

Drawn: T.M. Plan No: PDE0161060v4
Date: October, 2018 Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Major Watercourse
- Rio Tinto Railway
- Highway

Conceptual mine layout

- Pit
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Propectivity: High
- Habitat Propectivity: Medium
- Habitat Propectivity: Low

N

SCALE

0 1 2 3 4km

1:100 000 @ A4

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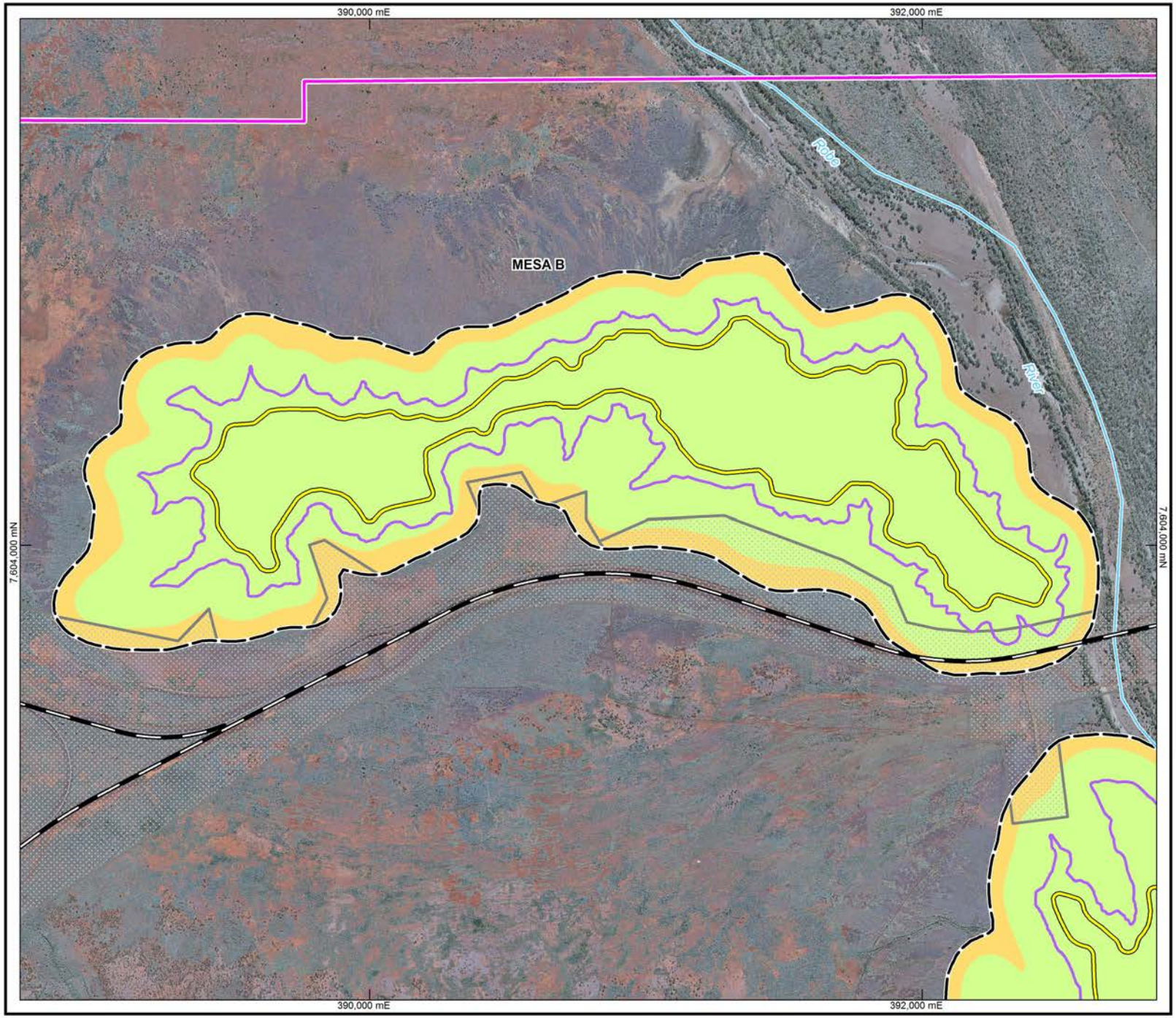
Iron Ore (WA)

Figure 6-10: Modelled pre-mining troglofauna habitat prospectivity Warramboo, Highway/ Tod Bore and surrounds

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0161068v4
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Major Watercourse
- Rio Tinto Railway
- Highway

Conceptual mine layout

- Conceptual Pit
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Propectivity: High
- Habitat Propectivity: Medium
- Top of mesa escarpment

N

SCALE

0 200 400 600 800m

1:20 000 @ A4

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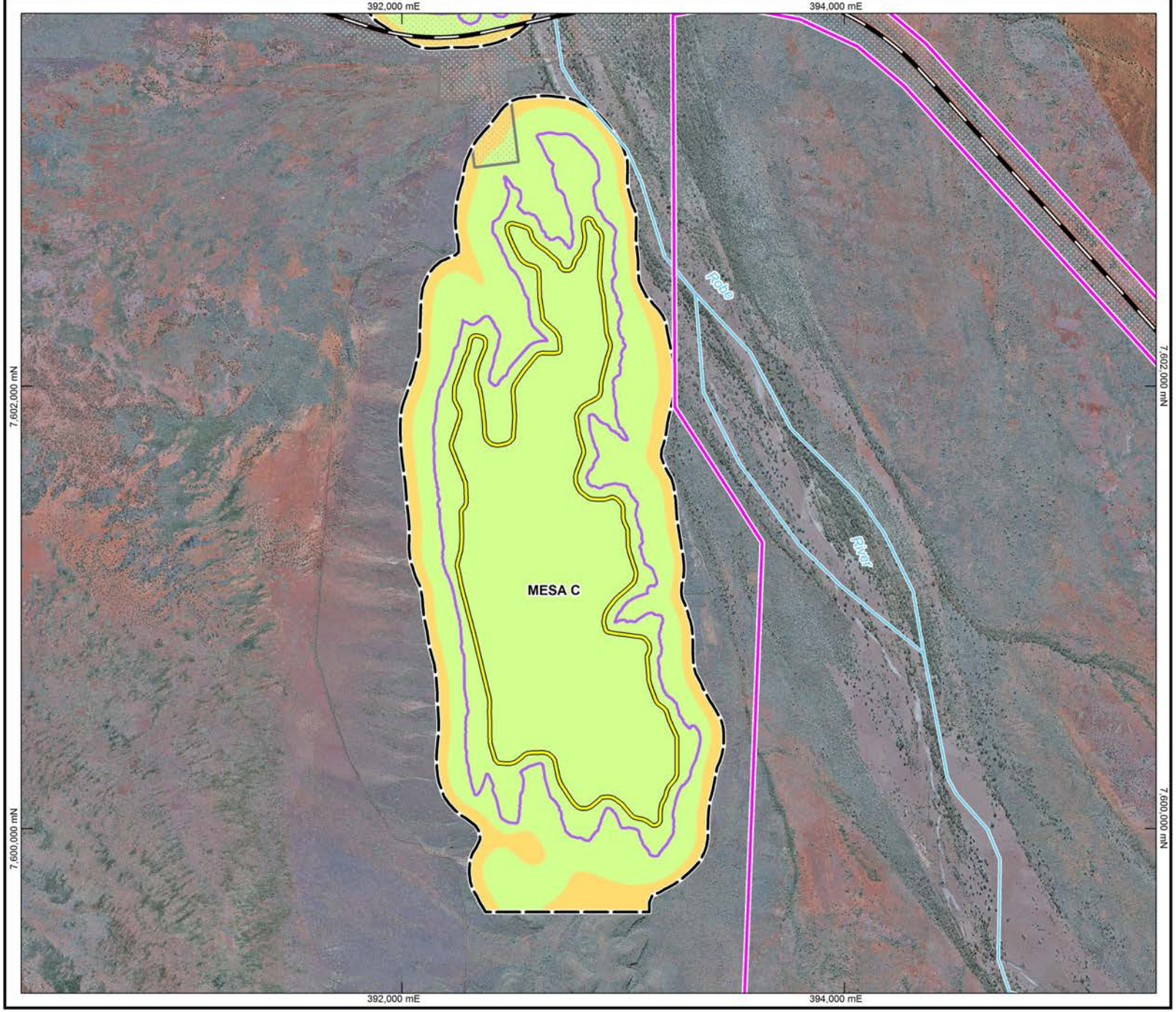
Iron Ore (WA)

Figure 6-11: Modelled troglofauna habitat prospectivity Mesa B

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0154719v6
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Major Watercourse
- Rio Tinto Railway
- Highway

Conceptual mine layout

- Conceptual Pit
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Propectivity: High
- Habitat Propectivity: Medium
- Top of mesa escarpment

N

SCALE

0 0.25 0.5 0.75 1km

1:25 000 @ A4

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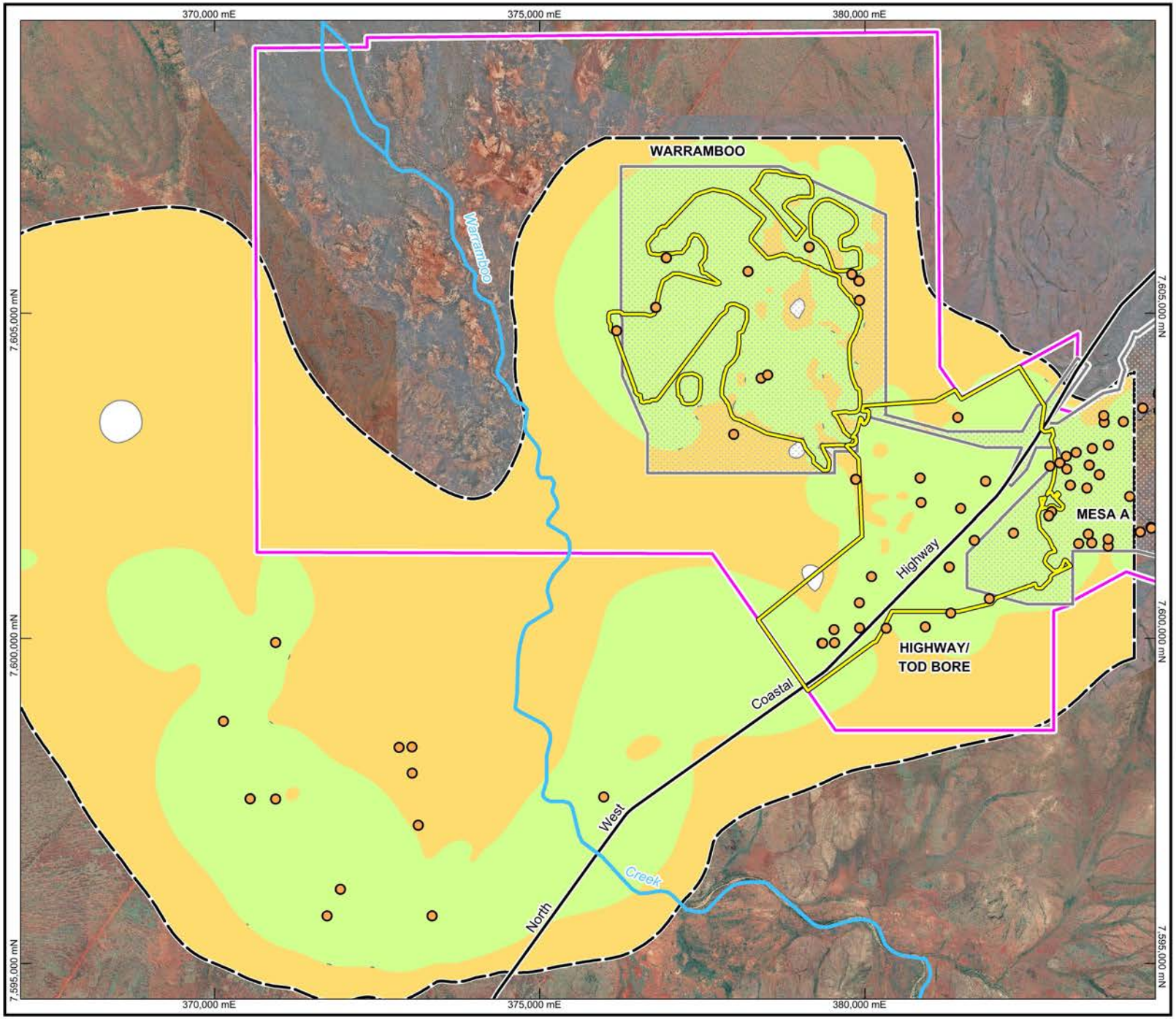
Rio Tinto

Iron Ore (WA)

Figure 6-12: Modelled troglofauna habitat prospectivity Mesa C

Drawn:T.M. Plan No:PDE0161458v5
Date: Nov, 2018 Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Highway
- Major Watercourse

Conceptual mine layout

- Conceptual Pit
- Troglofauna recorded
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Habitat Prospectivity: Low

N

SCALE

0 2 4 6km

1:120 000 @ A4

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Rio Tinto

Iron Ore (WA)

Figure 6-13: Modelled pre-mining troglofauna habitat prospectivity and troglofauna records Warramboo, Highway/ Tod Bore and surrounds

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0154723v8
Proj:MGA94 Zone50

Geospatial Information and Mapping

Mesa B and Mesa C

Figure 6-14 shows troglofauna records overlaid on modelled troglofauna habitat prospectivity in the vicinity of Mesas B and C. The habitat model indicates that the following areas of troglofauna habitat prospectivity occur in the vicinity of Mesas B and C:

- Approximately 618 ha of modelled high prospectivity habitat
- Approximately 809 ha of modelled medium prospectivity habitat[9]
- Approximately 1208 ha of modelled low prospectivity habitat[10].

Molecular evidence for some troglobitic orders indicates that there is unlikely to be continuous gene flow between the mesas of the Robe Valley. However, five species of conservation significance - either listed as Threatened or with potential SRE status occur on both Mesas B and C:

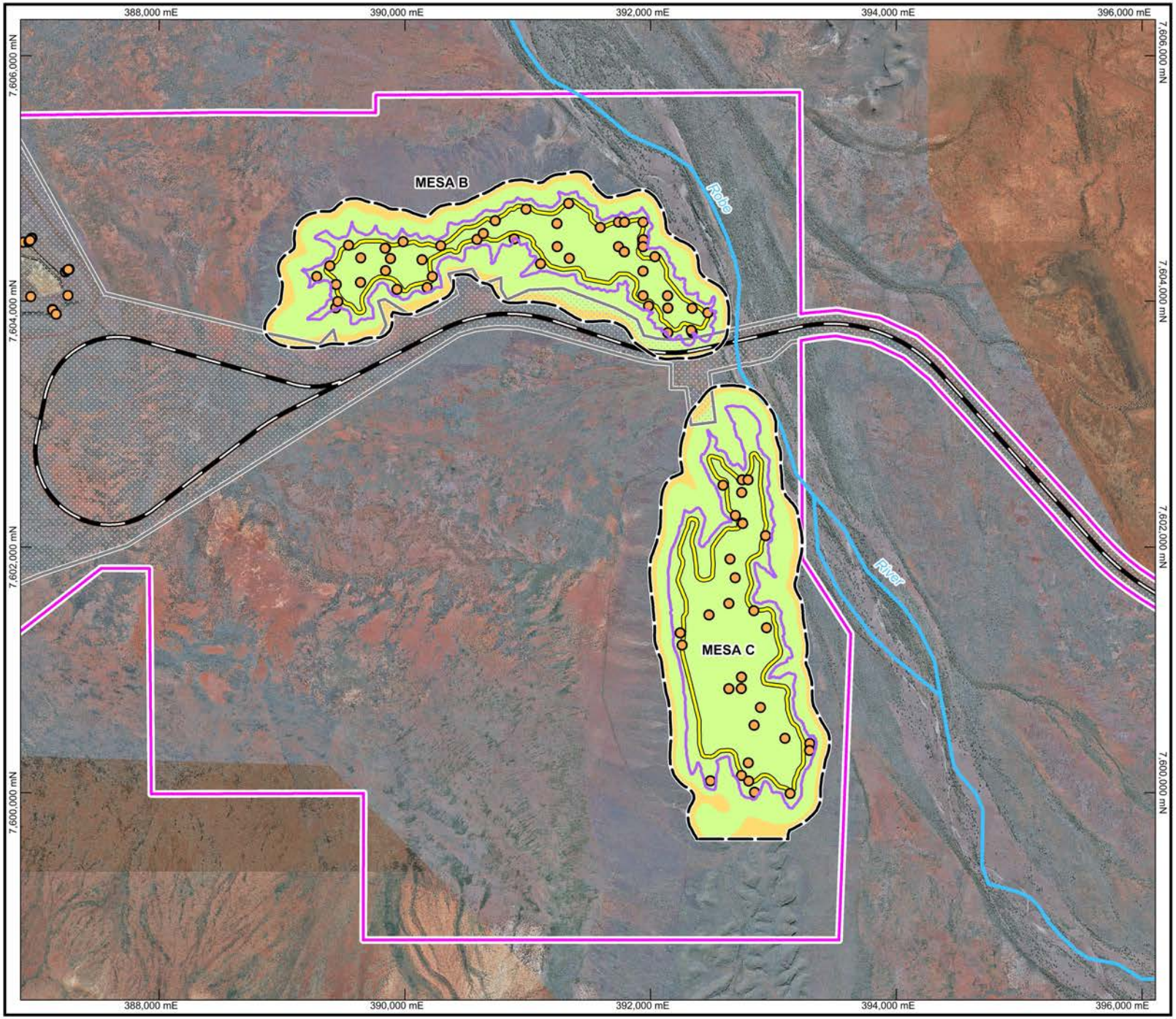
- *Paradraculoides bythius* - listed as Vulnerable under Schedule 3 of the WC Act
- *Hubbardiidae gen. nov*. sp. 'SCH052'
- *Theriidae* sp. 'AT001'
- *Haplodesmidae* sp. 'DIHAP001'
- *Curculionidae* sp. 'CCU004/005'.

The occurrence of these species on both mesas suggests that the habitats in Mesas B and C may have some connection or were, in geological time, recently connected. Habitat analysis at Mesas B and C to date has not been able to determine the level of connectivity between the mesas and the surrounding colluvium and alluvium (medium habitat prospectivity) (Biota 2017b). In previous studies throughout the Pilbara, areas of weathering or hydrated zones have been identified as potentially occurring in connection with superficial geologies such as colluvium and alluvium and provide possible avenues of gene flow (Biota 2017b).

Although a troglofauna sampling program is underway sampling medium prospectivity habitat between Mesas B and C to examine the degree of habitat connectivity for Mesas B and C, there are currently insufficient data to determine the degree of habitat connectivity and utilisation of the habitat. Given there are insufficient data to determine the degree of habitat connectivity between Mesas B and C and given that proposed mining at Mesas B and C will impact solely on high prospectivity habitat, only modelled high prospectivity habitat is considered when assessing potential impacts on troglofauna at Mesas B and C. This conservative approach allows modelling to be done using a three-dimensional estimate of pisolite thickness with outputs as habitat volume (Section 6.4.2.1).

[9] The model domain crops the modelled medium prospectivity habitat; it is likely medium prospectivity habitat continues beyond the current model domain.

[10] The model domain crops the modelled low prospectivity habitat; it is likely low prospectivity habitat continues beyond the current model domain.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Railway
- Major Watercourse

Conceptual mine layout

- Conceptual Pit
- Troglofauna recorded
- Top of mesa escarpment
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium

N

SCALE

0 1 2km

1:45 000 @ A4

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Iron Ore (WA)

Figure 6-14: Modelled troglofauna habitat prospectivity and troglofauna records Mesa B and Mesa C

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0154763v7
Proj:MGA94 Zone50

Geospatial Information and Mapping

Mesa A

Robe Pisolite is the primary habitat for troglofauna at Mesa A. The Mesa A/Warramboo Iron Ore Project approved under MS 756 was designed to retain a total of at least 50% troglofauna habitat behind the Mesa A escarpment and beneath the pit floor as part of the approved activities. The current approved configuration of habitat to be retained is shown in Attachment 2, Figure 3 of MS 756 and reproduced here as Figure 6-15.

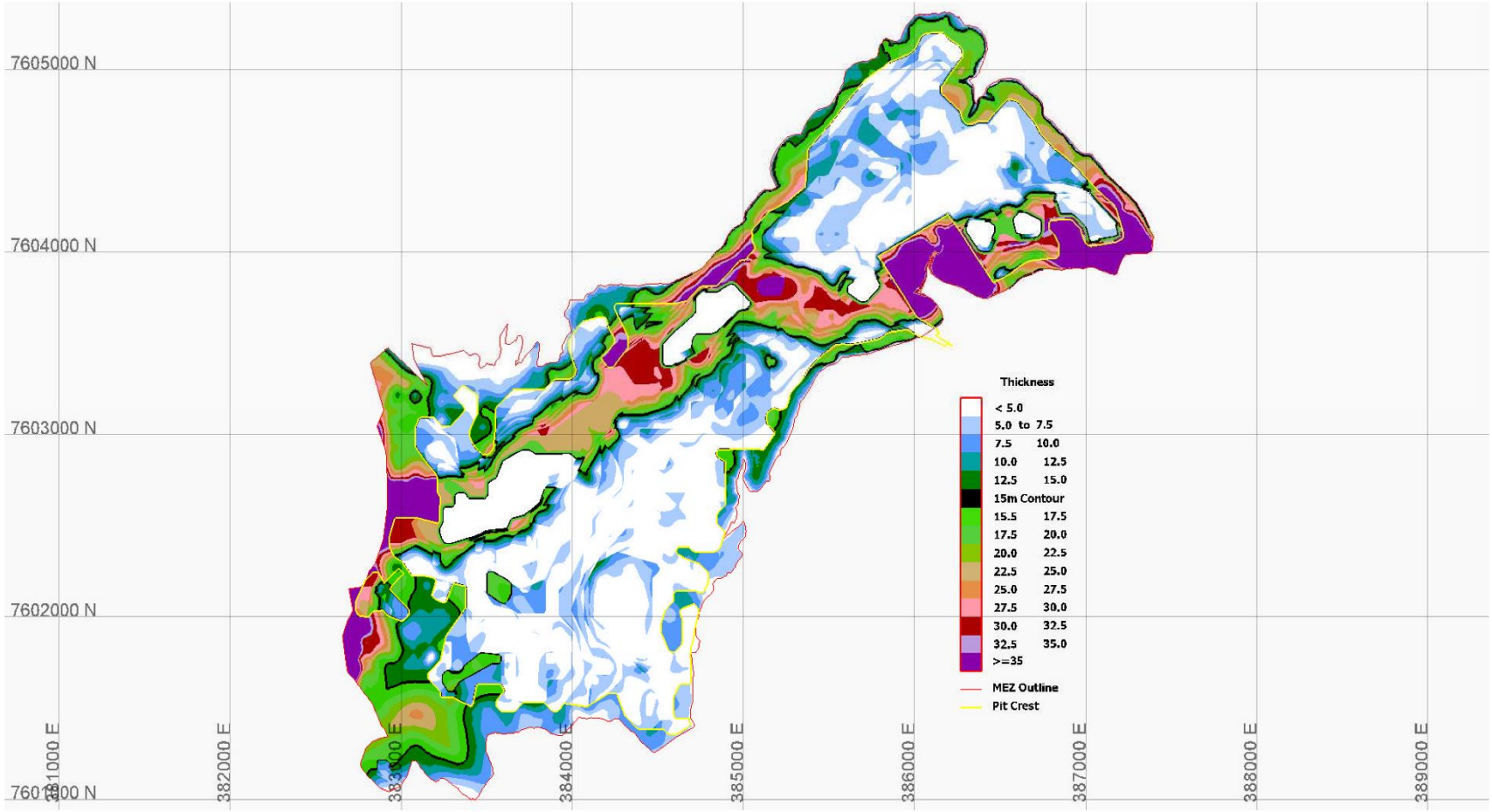


Figure 6-15: Current approved configuration of troglofauna habitat to be retained – Mesa A

6.4.1.4 Records

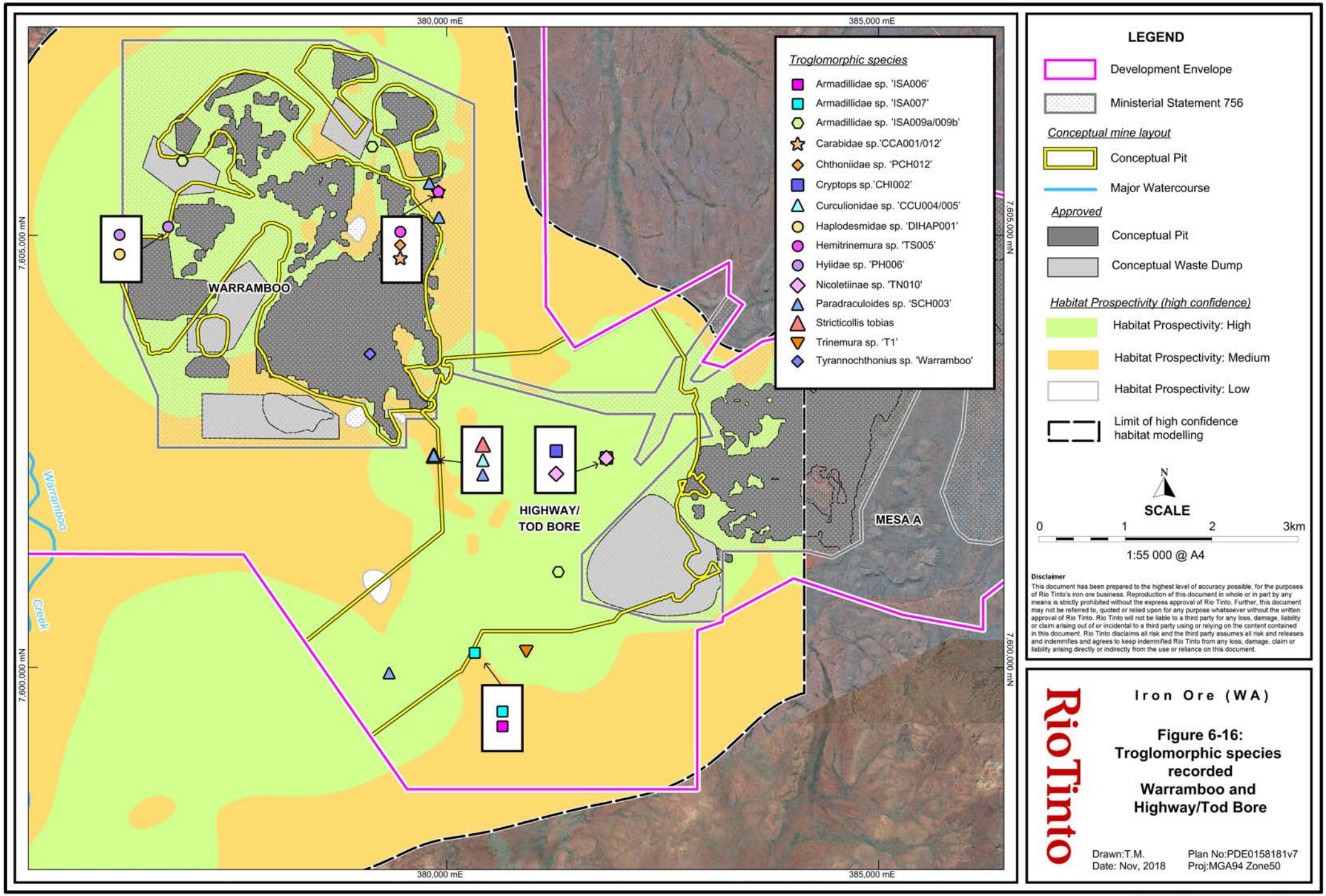
Warramboo, Highway/Tod Bore

A total of 22 troglomorphic species level taxa are known from the Biota (2017a) survey area which includes the Warramboo and Highway/Tod Bore area and part of Mesa A. Of these, 15 species have been recorded in the Warramboo and Highway/Tod Bore area, including 14 potential SREs and one widespread species (Table 6-4 and Figure 6-16).

One widespread species was recorded from the survey area as indicated in Table 6-4. This species is globally widespread and is unlikely to represent a true troglobite or SRE. The potential SRE species are treated as troglobitic and SRE fauna for the purposes of conservative Environmental Impact Assessment.

Table 6-4: Troglomorphic species recorded from Warramboo and Highway/Tod Bore

Order	Species	Conservation significant / SRE	Known locations
Chilopoda	*Cryptops* sp.'CHI002'	Potential SRE	Highway/Tod Bore
Coleoptera	*Carabidae* sp.'CCA001/012'	Potential SRE	Warramboo Also recorded from Mesa B
	Curculionidae sp. 'CCU004/005'	Potential SRE	Highway/Tod Bore Also recorded from Mesas A , Mesa B and Mesa C.
	Stricticollis tobias	Widespread	Highway/Tod Bore Introduced species with a worldwide distribution.
Isopoda	*Armadillidae* sp. 'ISA006'	Potential SRE	Highway/Tod Bore
	Armadillidae sp. 'ISA007'	Potential SRE	Highway/Tod Bore
	Armadillidae sp. 'ISA009a/9b'	Potential SRE	Warramboo and Highway/Tod Bore Also recorded from Mesas A
Polydesmida	*Haplodesmidae* sp. 'DIHAP001'	Potential SRE	Warramboo Also recorded from Mesa B, Mesa C and Hardey River (215 km south-east of Warramboo)
Pseudoscorpiones	*Chthoniidae* sp. 'PCH012'	Potential SRE	Warramboo
	Tyrannochthonius sp. 'warramboo'	Potential SRE	Warramboo
	Hyiidae sp. 'PH006'	Potential SRE	Warramboo
Schizomida	*Paradraculoides* sp. 'SCH003'	Potential SRE	Warramboo and Highway/Tod Bore
Zygentoma	*Hemitrinemura* sp. 'TS005'	Potential SRE	Warramboo
	Nicoletiinae sp. 'TN010'	Potential SRE	Highway/Tod Bore Also recorded from Mesa B
	Trinemura sp. 'T1'	Potential SRE	Highway/Tod Bore



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Iron Ore (WA)

Figure 6-16: Troglomorphic species recorded Warramboo and Highway/Tod Bore

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0158181v7
Proj:MGA94 Zone50

Geospatial Information and Mapping

Mesa B / Mesa C

A total of 49 troglomorphic species are known from Mesas B and C (Table 6-5, Figure 6-17, Figure 6-18 and Figure A7-1 and Figure A7-2 in Appendix 7), including:

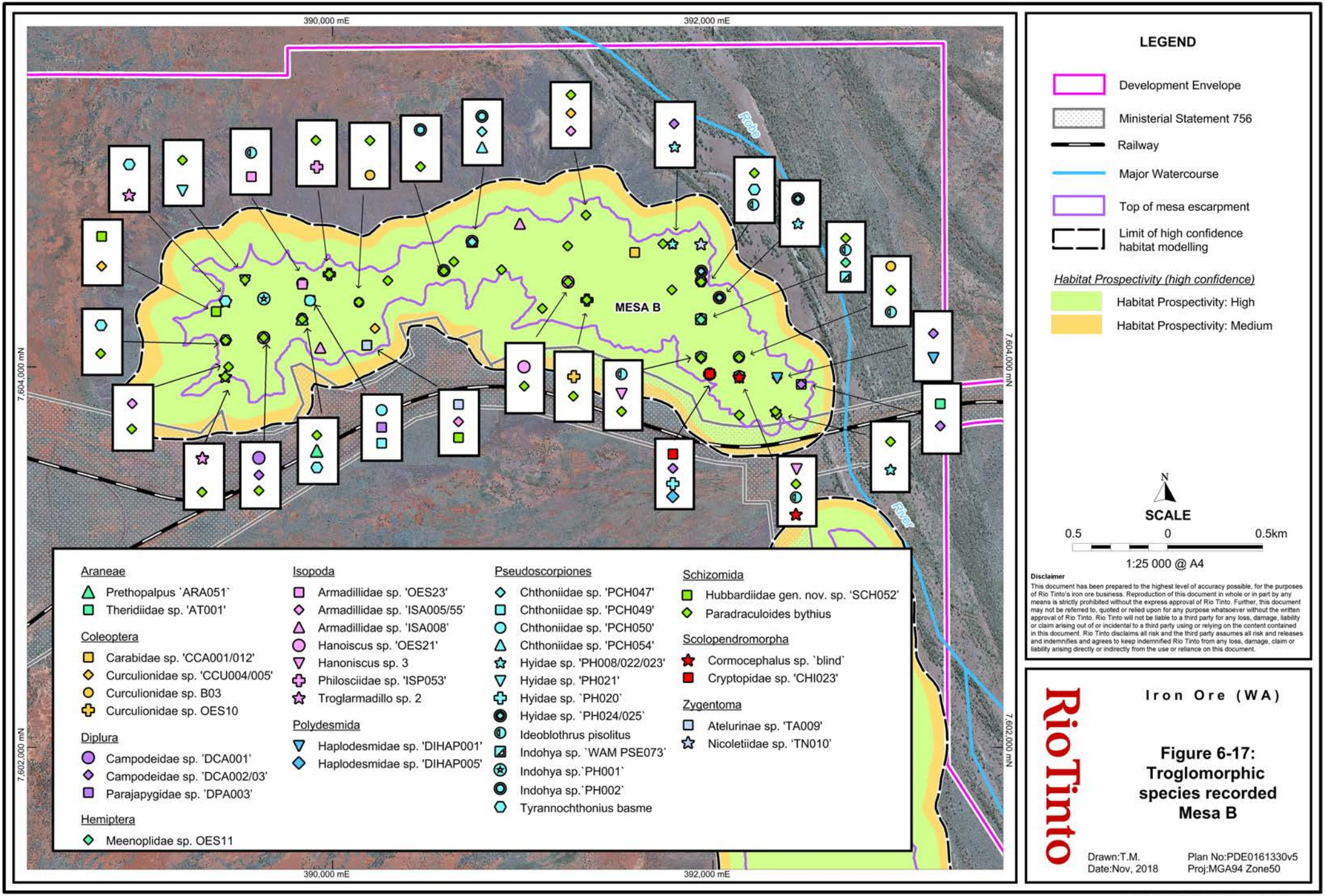
- One conservation significant species: *Paradraculoides bythius* - listed as Vulnerable under Schedule 3 of the WC Act
- One confirmed SRE species: *Ideoblothrus pisolitus*
- 47 potential SRE species.

Table 6-5: Troglomorphic species recorded from Mesas B and C

Order	Species	Conservation significant / SRE	Known locations
Araneae	*Gnaphosidae* sp. 'AG001	Potential SRE	Mesa C
	Prethopalpus sp. 'ARA051'	Potential SRE	Mesa B
	Theriidae sp. 'AT001'	Potential SRE	Mesa B and C
Coleoptera (Beetles)	*Carabidae* sp. 'CCA001/012'	Potential SRE	Mesa B Also recorded from Warramboo
	Curculionidae sp. 'CCU004/005'	Potential SRE	Mesa B and Mesa C Also recorded from Highway/Tod Bore
	Curculionidae sp. 'OES10'	Potential SRE	Mesa B Also recorded from Mesa A and Mesa K.
	Curculionidae sp. B03	Potential SRE	Mesa B
Diplura	*Campodeidae* sp. 'DCA001'	Potential SRE	Mesa B
	Campodeidae sp. 'DCA002/03	Potential SRE	Mesa B
	Parajapygidae sp. 'DPA003'	Potential SRE	Mesa B
	Parajapygidae sp. 'DPA004	Potential SRE	Mesa C
	Parajapygidae sp. 'DPA005'	Potential SRE	Mesa C
	Parajapygidae sp. 'DPA006/07'	Potential SRE	Mesa C
	Parajapygidae sp. 'DPA008'	Potential SRE	Mesa C
Hemiptera	*Meenoplidae* sp. 'OES11'	Potential SRE	Mesa B Also recorded from Mesa A and Mesa K

Order	Species	Conservation significant / SRE	Known locations
Isopoda	*Armadillidae* sp. 'ISA005/55'	Potential SRE	Mesa B
	Armadillidae sp. 'ISA008	Potential SRE	Mesa B
	Armadillidae sp. 'ISA054	Potential SRE	Mesa C
	Armadillidae sp. 'ISA056/57'	Potential SRE	Mesa C Also recorded from Mesa H (approximately 28 km east)
	Armadillidae sp. 'OES23'	Potential SRE	Mesa B
	Hanoniscus sp. '3'	Potential SRE	Mesa B
	Hanoniscus sp. 'OES21'	Potential SRE	Mesa B
	Philosciidae sp. 'ISP053'	Potential SRE	Mesa B
	Troglarmidillo sp. '2'	Potential SRE	Mesa B
Polydesmida (Millipedes)	*Haplodesmidae* sp. 'DIHAP001'	Potential SRE	Mesa B and Mesa C Also recorded from Warramboo and Hardey River (approximately 202 km south-east).
	Haplodesmidae sp. 'DIHAP005'	Potential SRE	Mesa B
	Haplodesmidae sp. 'new genus'	Potential SRE	Mesa C
Pseudoscorpiones	*Chthoniidae* sp. 'PCH047'	Potential SRE	Mesa B
	Chthoniidae sp. 'PCH049'	Potential SRE	Mesa B
	Chthoniidae sp. 'PCH050'	Potential SRE	Mesa B
	Chthoniidae sp. 'PCH054'	Potential SRE	Mesa B
	Chthoniidae sp. 'PCH058'	Potential SRE	Mesa C
	Indohya sp.`PH001`	Potential SRE	Mesa B
	Indohya sp.'PH002'	Potential SRE	Mesa B
	Hyiidae sp. 'PH008/022/023'	Potential SRE	Mesa B
	Hyidae sp. 'PH020'	Potential SRE	Mesa B

Order	Species	Conservation significant / SRE	Known locations
	Hyidae sp. 'PH021'	Potential SRE	Mesa B
	Hyidae sp. `PH024/025`	Potential SRE	Mesa B
	Ideoblothrus pisolitus	Confirmed SRE	Mesa B
	Indohya sp. 'WAM PSE073'	Potential SRE	Mesa B
	Tyrannochthonius basme	Potential SRE	Mesa B Also recorded from Congo Bore, south of Mesa A.
Schizomida	*Hubbardiidae gen. nov*. sp. 'SCH052'	Potential SRE	Mesa B and C
	Paradraculoides bythius	Conservation significant (Schedule 3 - Vulnerable)	Mesa B and C
Scolopendromorpha (Centipedes)	*Cormocephalus* sp. `blind`	Potential SRE	Mesa B
	Cryptopidae sp. 'CHI023'	Potential SRE	Mesa B
	Cryptopidae sp. 'CHI026'	Potential SRE	Mesa C
Zygentoma (Silverfish)	*Ateluriininae* sp. 'TA009'	Potential SRE	Mesa B
	Nicoletiinae sp. 'TN010'	Potential SRE	Mesa B Also recorded from Highway/Tod Bore
	Nicoletiinae sp. 'TN012'	Potential SRE	Mesa C



LEGEND

- Development Envelope
- Ministerial Statement 756
- Railway
- Major Watercourse
- Top of mesa escarpment
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium

N

SCALE

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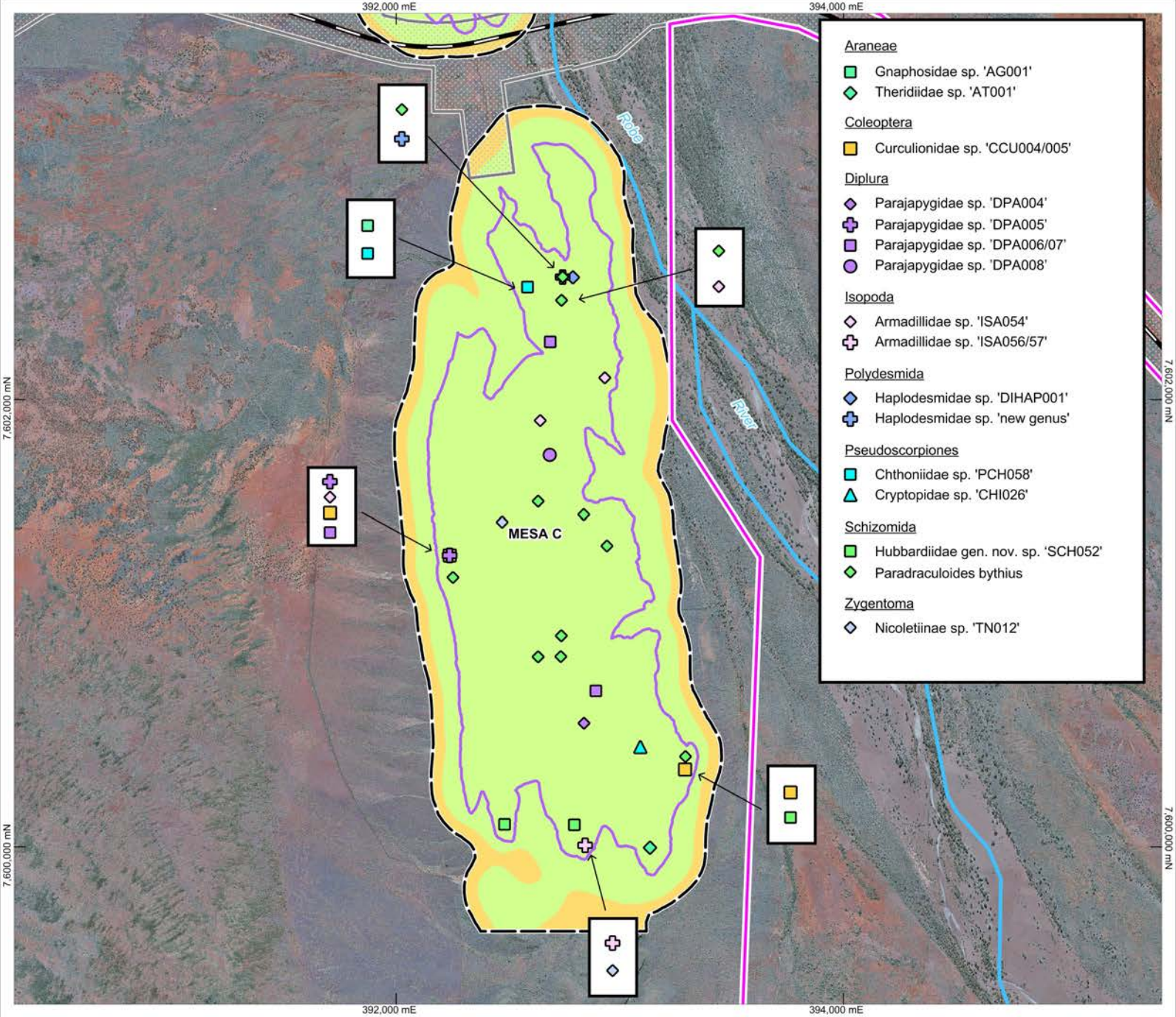
Iron Ore (WA)

Figure 6-17: Troglomorphic species recorded Mesa B

Drawn:T.M.
Date:Nov, 2018

Plan No:PDE0161330v5
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Railway
- Major Watercourse
- Top of mesa escarpment
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium

N

SCALE

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Iron Ore (WA)

Figure 6-18: Troglomorphic species recorded Mesa C

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0161331v4
Proj:MGA94 Zone50

Geospatial Information and Mapping

Mesa A

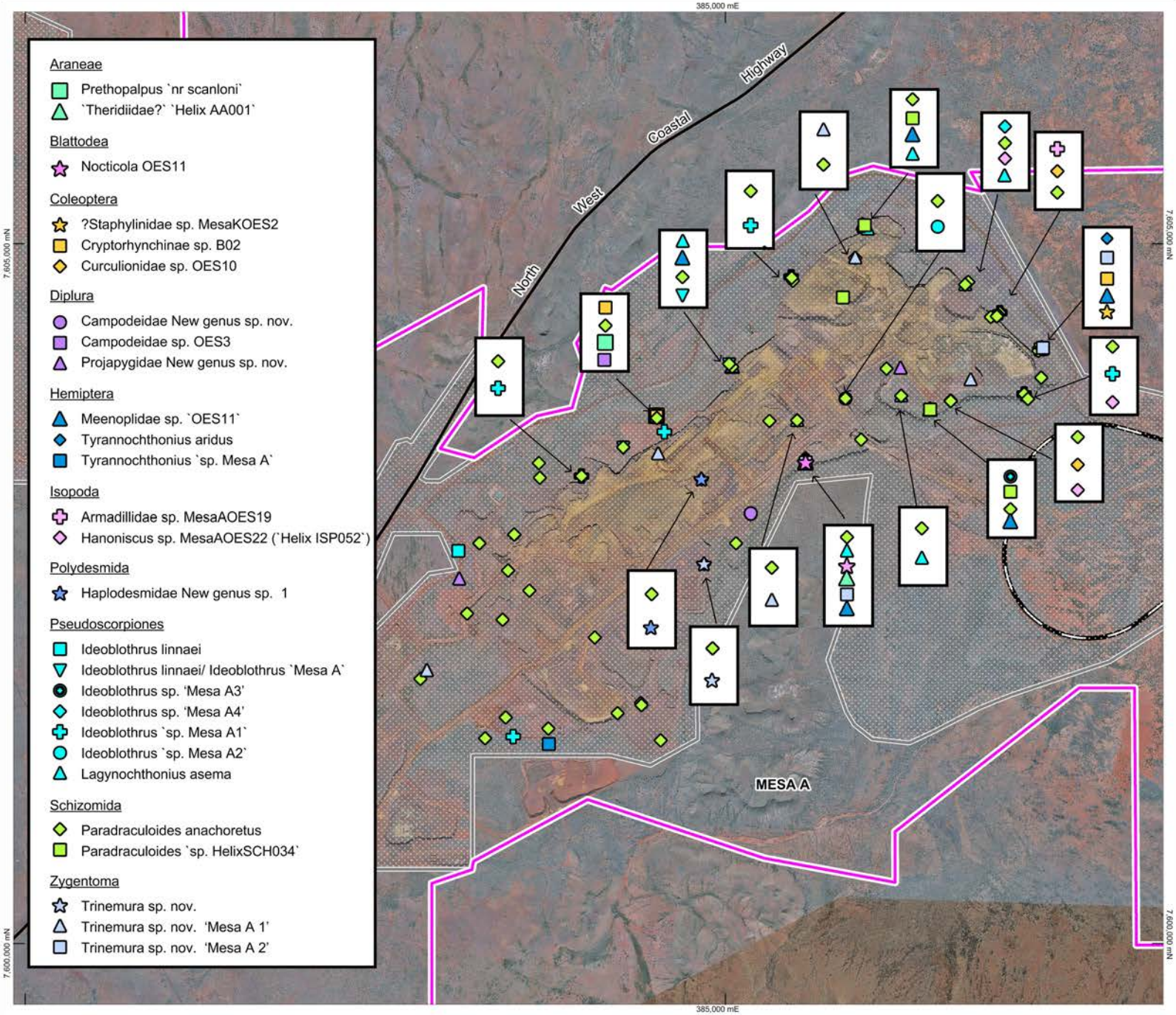
Troglofauna were first recorded at Mesa A in 2003 as by-catch of stygofauna sampling. Multiple phases of targeted troglofauna sampling were conducted at Mesa A during 2005 2006 and 2007 as part of the Environmental Impact Assessment for the Mesa A/Warramboo Iron Ore Project. Biennial troglobitic fauna sampling in the MEZ commenced in October 2010 in accordance with the approved Mesa A Troglofauna Management Plan (Biota 2009a) required by Condition 5 1 of MS 756. A total of 27 troglomorphic species are currently known from Mesa A (Table 6-6, Figure 6-19 and Figure A7-3 in Appendix 7) including:

- Seven confirmed SRE species, including five conservation significant species listed as Threatened species (Vulnerable under Schedule 3 of the WC Act), or as Priority species (Priority 1)
- 20 potential SRE species.

Table 6-6: Troglomorphic species recorded from Mesa A

Order	Species	Conservation Significance / SRE status	Known locations
Araneae	*Prethopalpus* nr *scanloni*	Potential SRE	Mesa A
	`Theridiidae?` `Helix AA001`	Potential SRE	Mesa A
Blattodea	*Nocticola* OES11	Potential SRE	Mesa A and Mesa K
Coleoptera	*Cryptorhynchinae* sp. B02	Potential SRE	Mesa A
	?*Staphylinidae* sp. MesaKOES2	Potential SRE	Mesa A and Mesa K
	Curculionidae sp. OES10	Potential SRE	Mesa A, B and K
Diplura	Campodeidae sp. OES3	Potential SRE	Mesa A
	Projapygidae new genus sp. nov.	Potential SRE	Mesa A
	Campodeidae new genus sp. nov.	Potential SRE	Mesa A
Hemiptera	*Meenoplidae* sp. `OES11`	Potential SRE	Mesa A, B and K
Isopoda	*Hanoniscus* sp. MesaAOES22 (also called `sp. Helix ISP052`)	Potential SRE	Mesa A
	Armadillidae sp. MesaAOES19	Potential SRE	Mesa A
Polydesmida	*Haplodesmidae new genus* sp. 1	Potential SRE	Mesa A
Pseudoscorpiones	*Ideoblothrus linnaei*	Conservation Significant (Priority 1)	Mesa A
	Ideoblothrus sp. 'Mesa A'	Conservation Significant (Priority 1)	Mesa A

Order	Species	Conservation Significance / SRE status	Known locations
	Ideoblothrus sp. 'Mesa A1'	Confirmed SRE	Mesa A
	Ideoblothrus sp. 'Mesa A2'	Confirmed SRE	Mesa A
	Ideoblothrus sp. 'Mesa A3'	Potential SRE	Mesa A
	Ideoblothrus sp. 'Mesa A4'	Potential SRE	Mesa A
	Lagynochthonius asema	Conservation Significant (Priority 1)	Mesa A
	Tyrannochthonius sp. 1 (also called T. `sp. Mesa A`)	Conservation significant (Priority 1)	Mesa A
	Tyrannochthonius aridus	Potential SRE	Mesa A
Schizomida	*Paradraculoides anachoretus*	Conservation Significant (Schedule 3 - Vulnerable)	Mesa A
	Paradraculoides `sp. HelixSCH034`	Potential SRE	Mesa A
Zygentoma	*Trinemura* sp. nov.	Potential SRE	Mesa A
	Trinemura sp. nov. 'Mesa A 1'	Potential SRE	Mesa A
	Trinemura sp. nov. 'Mesa A 2'	Potential SRE	Mesa A



LEGEND

- Development Envelope
- Ministerial Statement 756
- Highway

N

SCALE

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Iron Ore (WA)

Figure 6-19: Troglomorphic species recorded Mesa A

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0161376v4
Proj:MGA94 Zone50

Geospatial Information and Mapping

6.4.2 Analysis of Robe Valley troglofauna habitats and monitoring results

Historical monitoring and management of troglofauna impacts at Mesa A, Mesa K and other projects in the Robe Valley are relevant to the assessment and mitigation of impacts associated with this Proposed Change. The following sections provide a comparison of habitats within the Robe Valley (6.4.2.1) and a summary of monitoring results adjacent to mining at other sites (6.4.2.2).

6.4.2.1 Habitat comparison of Robe Valley mesas

Mesas A, B and C are part of a series of mesas that are remnants of a palaeochannel formed by sedimentary deposition of iron rich material (Robe Pisolite, more generically known as a CID) within the Robe River palaeochannel between ~23 and ~5 million years ago. Subsequent uplift, erosion and surface water flows have removed much of the adjacent erodible basement material, leaving preserved parts of the paleo-river channels as outcropping mesas.

Similar to the other CID mesas of the Robe Valley, and based on the formations being formed as part of the same downstream extension of the Robe River paleo-channel, Mesas A, B and C comprise the same pisolite geology, with similar inter-stratigraphic features consisting of five primary layers:

- The upper hardcap layer: The Hardcap Pisolite (HTP), which is the weathered/laterized surface of the Pisolite, generally around 5 - 10 m in thickness, containing secondary soils, silica and iron. The transition between the Hardcap Pisolite and the underlying Pisolite is gradational
- The upper Pisolite: Pisolite (Tp / TPH) has a pisolitic texture, cemented together by a goethitic matrix, with internal interstices (relatively high porosity). This zone includes infrequent clay or hydrated/denatured pisolite zones/lenses
- The lower Pisolite zone: Underlying the Pisolite is the Mixed/Massive Pisolite (TPM) this zone is characterised by a limonitic, denatured/massive appearance and clay is common throughout. This contact is also transitional / gradational to the underlying basal Pisolite. This zone may have been subjected to a variable palaeo-water table, which has resulted in a significant hydration effect in comparison to the overlying Tertiary Pisolite/Tertiary Pisolite Hard
- The Pisolite Clay (TPC) is characterised by bands of predominantly clay-rich material mixed throughout pisolite
- The basal Pisolite (TPB) forms the base of the CID palaeochannel, comprising massive clay-rich limonitic pisolite with remnant pisolite textures.

The CID is incised through the Yarraloola Conglomerate into sediments interpreted to be part of the older Proterozoic Ashburton Formation and the Boolgeeda Iron Formation of the Hamersley Group, which forms the majority of the basement to the CID.

One of the key characteristics of geological units known to provide habitat for troglofauna relates to the physical features, particularly the presence of fractures, cavities, vugs or interstices sufficient in size to accommodate troglofauna. Throughout the Pilbara, a range of geological formations contain, or are more likely to be pre-disposed to containing the necessary physical characteristics that have been shown to provide habitat for troglofauna. In the Development Envelope, the Robe Pisolite is considered to be the geological unit that provides primary habitat for troglofauna as it contains the necessary vugs and cavities to accommodate troglofauna. The clay pockets and lenses within the Robe Pisolite may also contribute to the suitability of the habitat for troglofauna as the

retention of water in or on top of certain clay types may assist in maintaining high humidity levels in the subterranean environment.

The presence of potential cavities at Mesas B and C was compared to those at Mesa A using available information from drill hole data to assess whether any physical differences in troglofauna habitat between the mesas were apparent. For comparative purposes, an analysis of the relative percentages per metre logged of potential cavities (as indicated by a change in the downhole caliper reading of greater than 17 mm) in each stratigraphic layer in Mesas A, B and C was undertaken (Table 6-7). The amalgamated data for HTP, TPH, TPM and TPC indicate that the frequency of occurrence of cavities at Mesas B and C is similar to that at Mesa A. The relative distribution of cavities between the strands varies between the mesas with more cavities present in the HTP and TPH and fewer cavities present in the TPC at Mesa B compared with Mesa A. A slightly lower percentage of cavities per metre logged was recorded in all strands at Mesa C compared with Mesa A. Overall, however, the caliper data show cavities are likely to be present in all strands of the CID and the overall occurrence of cavities is similar in each of the mesas.

Table 6-7: Summary of the occurrence of potential cavities at Mesas A, B and C

Strand	Mesa A Caliper > 17mm (% of total metres logged)	Mesa B Caliper > 17mm (% of total metres logged)	Mesa C Caliper > 17mm (% of total metres logged)
Amalgamated data for HTP, TPH, TPM, TPC	1.4%	2.6%	0.8%
Hardcap Pisolite (HTP)	0.5%	2.2%	0.2%
Pisolite (TPH)	1.8%	4.4%	0.6%
Mixed/Massive Pisolite (TPM)	1.6%	1.7%	1.1%
Pisolite Clay (TPC)	1.0%	0.1%	0.6%

Mesas of the Robe Valley, including Mesas A, B and C were formed through the same broad depositional processes and therefore comprise the same geological units with similar stratigraphy, although the relative proportion of each inter-stratigraphic layer varies between the mesas. The basement and channel morphology, relative portions of clays, and secondary alteration features can vary between the mesas which can translate to variability in cavity, void and interstitial proportions, however the key propensity of the Pisolite to host voids and cavities suitable to support troglofauna remains similar between the mesas.

At order level troglofauna assemblages across the Robe Valley are similar (Table 6-8) indicating that habitats on each mesa are similar with a similar range of ecological niches.

Table 6-8: Order level representation of troglofauna across the Robe Valley

Troglomorphic Order	Mesa A	Mesa B	Mesa C	Mesa H	Mesa K
Araneae	✓	✓	✓	✓	✓
Blattodea	✓			✓	✓
Coleoptera	✓	✓	✓	✓	✓
Diplura	✓	✓	✓	✓	
Geophilomorpha					✓
Hemiptera	✓	✓			✓
Isopoda	✓	✓	✓	✓	✓
Opiliones			✓		✓
Polydesmida	✓	✓	✓		✓
Pseudoscorpiones	✓	✓	✓	✓	✓
Schizomida	✓	✓	✓	✓	✓
Scolopendromorpha	✓	✓	✓	✓	✓
Zygentoma	✓	✓	✓	✓	✓

As mining operations and associated troglofauna monitoring have been underway at Mesa A since 2010 and similar troglofauna habitat is present at other mesas within the Robe Valley, including Mesas B and C, results from the monitoring conducted at Mesa A (and at Mesa K) have been used to guide the design of the Proposed Change and management actions at Mesas B and C.

6.4.2.2 Results of monitoring at Mesa A and other Robe Valley locations

Troglofauna were first recorded at Mesa A in 2003 as by-catch of stygofauna sampling. Multiple phases of targeted troglofauna sampling were conducted at Mesa A during 2005 and 2006 as part of the Environmental Impact Assessment for the Mesa A/Warramboo Iron Ore Project. Active mining commenced at Mesa A in February 2010 under MS 756. Monitoring conducted in accordance with the approved Mesa A Troglofauna Management Plan (Biota 2009a) required under Condition 5-1 of MS 756 includes:

- Biennial troglofauna sampling in the Mesa A MEZ
- Troglofauna sampling in disturbed habitats
- Subterranean habitat monitoring
- Downhole optical image surveys.

The results of the above monitoring as they pertain to the effectiveness of the Mesa A MEZ in maintaining the biological diversity of the subterranean fauna community are discussed below.

Troglofauna abundance in the Mesa A MEZ

Troglofauna sampling commenced at Mesa A prior to commencement of mining and has continued during mining. Given the inherent sampling limitations in the subterranean environment, an analysis of capture rates was undertaken to normalise the data sets in relation to intensity of sampling. Table 6-10 shows the number of troglofauna specimens collected per 100 holes sampled via trapping[11] (capture rate) at Mesa A pre-mining and from the MEZ at Mesa A during mining. For most taxa capture rate is very low with some taxa only known from one record over a ten year sampling period; the capture rate for these taxa is estimated to be approximately one specimen per 300 traps. In contrast, *Paradraculoides anachoretus* was the most abundant taxa with multiple collections from Mesa A during every sampling round. Capture rate for *Paradraculoides anachoretus* has, therefore, been included in Table 6-9 along with the capture rate for all troglofauna specimens. Table 6-9 shows that the capture rate of between 61.5 to 163.9 specimens per 100 trapped holes for all troglofauna taxa during mining is similar to the capture rate range of between 51.6 to 164.3 specimens per 100 trapped holes pre-mining. The capture rate for *Paradraculoides anachoretus* of between 34.1 to 122 specimens per 100 trapped holes during mining is similar to the capture rate of between 29.0 to 92.9 specimens per 100 trapped holes pre-mining.

The statistical power of troglofauna sampling is limited by the sampling methodology. Within the limitations presented by current troglofauna sampling methodology[12], the capture rates of troglofauna from the MEZ at Mesa A during mining are similar to those recorded across Mesa A prior to commencement of mining. If capture rate is taken as a measure of abundance then the similar range in capture rates before and during mining indicates that troglofauna abundance during mining is similar to the abundance recorded prior to commencement of mining.

[11] Scraping for troglofauna was not routinely applied as a sampling methodology during the pre-mining phase. To allow for comparison between pre-mining and mining phases, capture rates are calculated exclusive of troglofauna captured via scraping.

[12] Limitations include access to the subterranean environment for sampling (only via drill holes); modification of potential habitat through establishment of drill holes; trapping and scraping methodology may not be appropriate for some species depending on species preferences and mobility; sampling bias towards orebodies; difficulty in determining the specific geological strata that specimens originate from.

Table 6-9: Number of troglofauna specimens and individuals of *Paradraculoides anachoretus* recorded at Mesa A per 100 holes sampled via trapping

Order	Pre-mining						During mining			
	Jan 2005	May 2005	Sep 2005	Aug 2006	Feb 2007	May 2007	Oct 2010	Jul 2012	Sep 2014	Sep 2016
Total number of trapped holes	11	14	49	31	31	36	41	36	41	39
Total number of troglofauna specimens recorded per 100 trapped holes	54.5	164.3	81.6	80.6	51.6	75.0	63.4	163.9	92.7	61.5
Total number of *Paradraculoides anachoretus* specimens recorded per 100 trapped holes	54.5	92.9	36.7	38.7	29.0	58.3	51.2	122.2	34.1	51.3

Troglofauna diversity in the Mesa A MEZ

Table 6-10 synthesises the troglobitic fauna sampling results from Mesa A to show the troglobitic and troglomorphic Orders collected from Mesa A between 2003 and 2016, that is before and during active mining. The summary is provided at Order level to allow easier comparison of the results than is possible at the lowest taxonomic level. For completeness, the complete set of records identified to species level is provided in Appendix 7. Sampling prior to mining commencing was conducted across the mesa formation, while sampling during mining operations has been conducted in the MEZ. Despite the inherent limitations in sampling troglofauna, the results confirm the persistence of a troglofauna community at Mesa A of similar general composition to that pre-mining.

Table 6-10: Troglobitic and troglomorphic taxa collected from Mesa A (shown at Order level)

Order	Pre-mining							During Mining				Combined results of orders recorded during mining
	Dec 2003*	Jan 2005	May 2005	Sep 2005	Aug 2006	Feb 2007	May 2007	Oct 2010	Jul 2012	Sep 2014	Sep 2016	
Araneae			✓						✓			✓
Blattodea**								✓	✓	✓		✓
Coleoptera					✓	✓				✓	✓	✓
Diplura	✓		✓	✓			✓			✓		✓
Hemiptera**								✓			✓	✓
Isopoda				✓				✓	✓	✓		✓
Polydesmida	✓						✓	✓				✓
Pseudoscorpiones				✓	✓	✓	✓	✓	✓	✓		✓
Schizomida	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scolopendromorpha				✓	✓							
Zygentoma			✓	✓	✓	✓						

* Sampling in 2003 was for stygofauna using haul nets; no troglofauna traps were set

** Prior to 2010, experts considered that these groups were unlikely to contain troglobitic representatives thus no specimens were recorded during pre-mining surveys. Since 2010 a change in expert opinion has meant that potentially troglobitic Blattodea and Hemipterans are collected and retained for further assessment although there is still uncertainty whether these are truly troglobitic or simply edaphabitic (soil dwelling) species.

During the assessment of the Mesa A/Warramboo Iron Ore Project some troglofauna taxa were identified to be 'at risk' as they had only been recorded in the proposed mining area. The proposed MEZ was revised to include the areas around the records of taxa considered to be 'at risk'. Sampling conducted in the MEZ since that time has resulted in collection of additional specimens of some of the taxa originally considered to be at risk. Specifically, at the time of assessment of the Mesa A/Warramboo Iron Ore Project, *Lagynochthonius asema* was known from two locations (one of which is in-pit), however it is now known from eight locations and *Ideoblothrus* sp. 'Mesa A1' was known from three locations (one of which is in-pit) and is now known from four locations.

Troglofauna presence in disturbed habitats

The Proponent is currently undertaking further investigations into the re-colonisation of in-pit waste dumps/low grade stockpiles and utilisation of the formation beneath the waste dumps/stockpile by subterranean fauna. Troglofauna sampling (most recently Biota 2017c) has been undertaken in disturbed habitats at Mesas A and K to provide an initial assessment of the suitability and use of disturbed habitats post-impact. Sampling in these areas is limited both spatially and temporally by access to active and historical mining areas, number of drill holes and the stability of drill holes drilled into waste dumps. The limited sampling results to date are presented in Table 6-11. Schizomids, isopods, curculionid beetles and hemipterans were recorded from a formerly mined, rehabilitated pit and waste dumps at Mesa K. As Mesa K was historically mined, pre-mining troglofauna sampling records are not available. However, all but two taxa recorded in pits and dumps at Mesa K were also recorded outside of these impact areas. The two remaining taxa (*Curculionidae* `sp. B01` and *Curculionidae* `sp. B04`) have not undergone complete taxonomic comparison with surrounding specimens so it is possible they have also been recorded elsewhere.

At Mesa A, limited sampling in disturbed areas has recorded three schizomid taxa (*Paradraculoides* sp. 'SCH034', *Paradraculoides anachoretus* and *Paradraculoides* sp.) from areas within the mining operation. Three schizomid specimens were collected from two drillholes (MOB03a and MOB03b) which are approximately 10 m apart in the southern part of the Mesa A pit. An additional five schizomid specimens were recorded from a drillhole (RC16MEA004) in the northern part of the Mesa A pit. Genetic analysis of these five specimens from the northern part of the pit determined the presence of two distinct lineages, equating to two species, *Paradraculoides anachoretus* and *Paradraculoides* sp. 'SCH034'. *Paradraculoides anachoretus* has been widely recorded from Mesa A, including during pre-mining baseline sampling. *Paradraculoides* sp. 'SCH034' has also been previously recorded from two sites within the Mesa A MEZ but was not identified as such during pre-mining baseline sampling.

The presence of troglofauna in disturbed in-pit areas demonstrates that potential habitat exists in or under waste dumps and under the pit during mining. However, only limited sampling has been undertaken to date in disturbed habitats; further work is required to evaluate the diversity of troglofauna present in disturbed habitats and utilisation of those habitats by troglofauna. This includes the under-pit habitat at Mesa A; due to the complexities of sampling in an operating pit, sampling to determine whether troglofauna communities persist under the pit as successfully as in the MEZ is currently limited. There is, therefore, currently a greater level of confidence of troglofauna persistence in the retained habitat behind the escarpment at Mesa A (that is, in the MEZ) than beneath the pit floor; this information has been used to guide the design of the MEZs at Mesas B and C.

Table 6-11: Sampling effort (orange squares) in-pit and waste dumps at Mesa K and Mesa A, along with the number and taxa collected

Site	Impact type	Sample year								
		2005	2010	2011	2012	2013	2014	2015a	2015b	2016
Mesa K										
MEKRC1721	Rehabilitated waste dump				2x *Isopoda* sp. 1x *Chthoniidae* sp. 2x *Paradraculoides* sp.					
MEKRC1728	Rehabilitated waste dump							1x *Phaconeura* `sp. OES10`		1x *Paradraculoides kryptus*
MEKRC1478	Rehabilitated pit floor			1x *Hubbardiidae* sp. 1x *Paradraculoides kryptus*	1x *Paradraculoides kryptus*	2x *?Staphylinidae* sp. MesaKOES2	1x *Paradraculoides kryptus*			1x *Phaconeura* `sp. OES10` 1x *Curculionidae* sp. B04 2x *Paradraculoides kryptus*
MEKRC1486	Rehabilitated pit floor				1x *Hemiptera* sp. 1x *Paradraculoides* sp.	1x *Hanoniscus* `sp. MesaK1` 2x *Paradraculoides kryptus*	1x *Curculionidae* sp. OES10 1x *Paradraculoides kryptus*	1x *Paradraculoides kryptus* 1x *Curculionidae* sp. B01		
RC16MEK0001	Waste dump									
RC16MEK0003	Pit floor									
RC16MEK0004	Pit floor									
RC16MEK0005	Pit floor									
Mesa A										
MOB EAST PIT 4 (MOB02a)	Pit floor									
MOB WEST PIT 4 (MOB02b)	Pit floor									
MOB EAST PIT 8 (MOB03a)	Pit floor									1x *Paradraculoides* sp.
MOB WEST PIT 8 (MOB03b)	Pit floor									2x *Paradraculoides* sp.
MOB NORTH PIT 2 (MOB01a)	Pit floor									
MOB SOUTH PIT 2 (MOB01B)	Pit floor									
RC16MEA001	Pit floor									
RC16MEA002	Pit floor									
RC16MEA003	Pit floor									
RC16MEA004	Low grade waste dump[1]								3x *Paradraculoides* sp. 'SCH034' 1x *Paradraculoides anachoretus*	1x *Paradraculoides* sp. 'SCH034'
RC16MEA005	Pit floor									
RC16MEA006	Pit floor									

Site	Impact type	Sample year								
		2005	2010	2011	2012	2013	2014	2015a	2015b	2016
RC16MEA007	Pit floor									
Middle Robe										
M2ERC0076	Pit floor									
M2ERC0103	Pit floor									
M2ERC0095	Pit floor									

[1] This hole was drilled through the low grade waste dump, but also partially into the original pisolite geology below the dump.

Downhole habitat parameters in the Mesa A MEZ

Subterranean temperature and relative humidity data are collected continuously from uncased drill holes in the MEZ at Mesas A and B and in the areas remaining at Mesa K following historical mining to assess the potential effects of mining on the retained troglofauna habitat. The monitoring programs were established specifically to examine potential changes in temperature and humidity in the retained habitat due to exposure of habitat at mine pit faces. The monitoring programs include potential impact sites at Mesa A (and Mesa K) as well as reference sites at Mesa B. Potential impact sites at Mesa A include sites established along several transects that run perpendicular to the pit face, across the MEZ, to the outer part of the mesa escarpment, thus allowing assessment of potential habitat changes with proximity to the pit face.

Monitoring of temperature and humidity in the subterranean environment presents several challenges. Measuring humidity near saturation is difficult, particularly when an accurate down hole temperature measurement is also required. Modifications to the probe installations at Mesas A, B and K have been made over time to improve the accuracy and reliability of the data collected. A significant change to probe installation was made in 2013 to remove interference between the heater on the humidity probe and the temperature sensor. The data collected post 2013 are more accurate than previously collected data; these data have, therefore, been used for data analysis.

Statistical analysis of the temperature and relative humidity data collected post 2013 was undertaken by Astron Environmental Services (Astron 2017b). The aim of the analysis was to test for impacts of mining at Mesa A on down hole temperature and relative humidity. The analysis showed proximity to the Mesa A pit edge did not influence mean down hole temperature or humidity (Astron 2017b). Increased proximity to the pit edge may result in an increase in the variability of the subterranean humidity due to increased connectivity with the surface climate. However, some of the highest variability in humidity was recorded well away (approximately 100 m) from the pit face and increases in variability in some near-pit locations are within the error margins of the humidity sensors (Astron 2017b). Variations in temperature and humidity values at Mesa A were not significantly different from those recorded from a reference (Mesa B) and an historical mining area (Mesa K) (Astron 2017b). It was, therefore, concluded that mining at Mesa A has had little discernible influence on down hole temperature and humidity in the Mesa A MEZ (Astron 2017b).

Optical image surveys have been conducted periodically in drill holes at Mesas A, B and K since 2009 to allow qualitative assessment of the extent and type of fracturing and cavities in the drill holes in retained troglofauna habitat. Comparison of the images between years allows for identification of any variations to the cavities. Ten previously monitored drill holes at Mesa A were surveyed in 2017. Figure 6-20 shows an example of downhole images recorded. The images in Figure 6-20 were recorded in 2016 and 2017 between 5.3m and 10.3m below the top of the casing in drill hole MEARC2740. The images show no visible changes in the shapes or sizes of voids between 2016 and 2017.

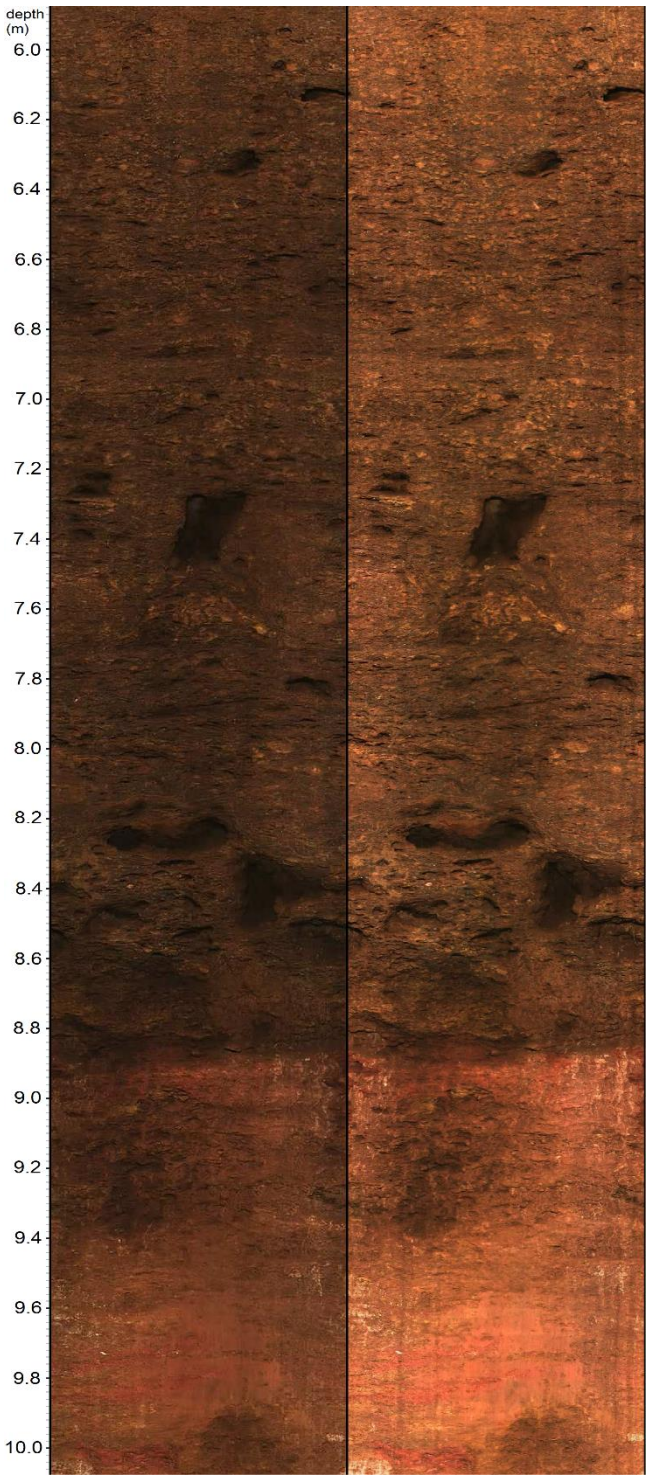


Figure 6-20: Voids that have remained unchanged from 2016 (left) and 2017 (right) in drill hole MEARC2740 at 5.3-10.3m (image supplied by Kinetic Logging Services)

Table 6-12 provides a summary of results from the optical image surveys for the last three years of surveys (Kinetic 2018). Recorded changes were associated with weathering, movement of tree roots and dislodgement of residual dried drilling fluid/mud. Weathering and tree root movement are considered to be a normal variation in the subterranean environment and dislodgement of residual dried drilling fluid/mud is a normal process in drill holes. The images recorded since 2009 show no indications of cavities collapsing (caving in) or generation of anthropogenic fractures of the surrounding rock induced by mining activities.

Table 6-12: Summary of optical image survey results 2015 to 2017 (Kinetic 2018)

Drill hole number	Changes identified		
	2015	2016	2017
MEARC2740	No detectable change	No detectable change	No detectable change
MEARC2927	No detectable change	No detectable change	No detectable change
MEARC4279	No detectable change	Not logged	New root growth 2.7m-4.2m. Reduced root growth 4.2m-6.8m. No changes to cavities and voids
MEARC4286	No detectable change	Not logged	No detectable change
MEARC4288	No detectable change	Not logged	Reduced root growth 2.2m-3.5m. New root growth 4.6m-7m. No changes to cavities and voids.
MEARC4294	No detectable change	Not logged	No detectable change
MEARC4301	No detectable change	No detectable change	Change in weathered zones. Residual mud cake from the drilling fluid has been dislodged at 21.6m revealing a cavity.
MEARC4303	No detectable change	No detectable change	No detectable change
MEARC4318	Dark spot disappeared. No changes to cavities and voids.	No detectable change	No detectable change
MEARC4475	Not logged	Not logged	No detectable change (compared with 2013 and 2014 data)

Summary of Mesa A monitoring results

Troglofauna sampling and habitat monitoring indicate that the Mesa A MEZ is functioning as intended. Within the inherent limitations of troglofauna sampling, the results indicate that a troglofauna community with similar abundance and diversity to the pre-mining community continues to be present at Mesa A. Down hole habitat monitoring shows little discernible influence of mining on subterranean temperature and humidity values with variations in temperature and humidity not significantly different from those at reference sites and proximity to the pit face showing no influence on mean temperature or humidity values. Down hole imagery shows no evidence of degradation of troglofauna habitat through collapse of cavities or generation of new fractures due to mining activities.

6.4.3 Potential impacts

6.4.3.1 Direct impacts

Potential direct impacts of the Proposed Change to troglofauna have been identified as:

- Reduction in troglofauna habitat due to mine pit development
- Loss of individuals and changes to assemblages due to mine pit development.

Reduction in troglofauna habitat due to mine pit development

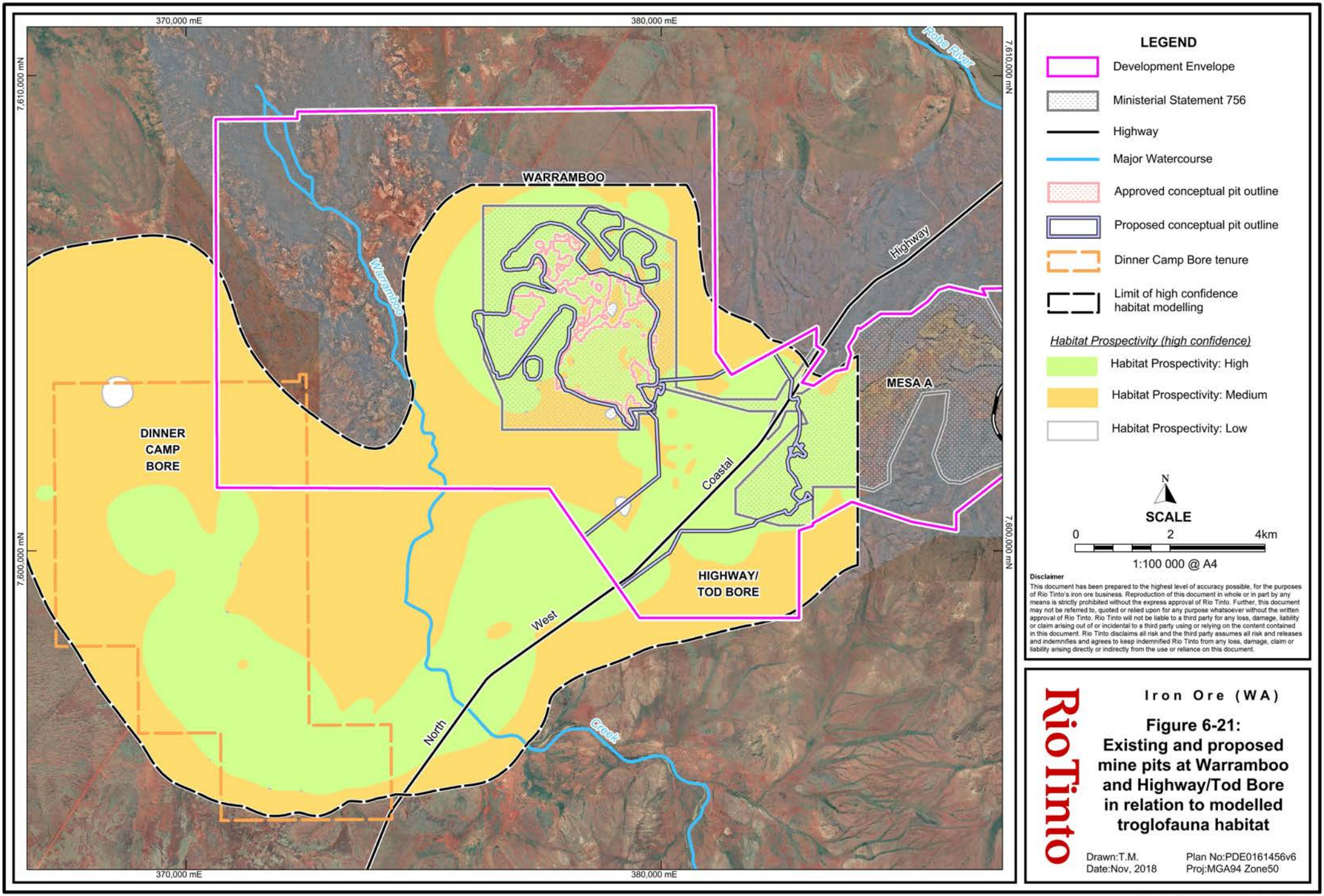
The characteristics of troglofauna habitat and the modelled extent of habitat are described in Section 6.4.1.3.

Warramboo

As discussed in Section 6.4.1.3, high confidence habitat modelling is available in areas with a high density of drill holes. Table 6-13 and Figure 6-21 show the potential troglofauna habitat that will be directly impacted by the proposed mining at Warramboo and Highway/Tod Bore. Assessment of potential impacts of the loss of this troglofauna habitat are provided in Section 6.4.4.1.

Table 6-13: Potential direct impact to troglofauna habitat at Warramboo and Highway/Tod Bore

Habitat prospectivity	Modelled current habitat extent within the limit of high confidence habitat modelling (ha)	Proposed extent of disturbance due to mine pit development			
		Warramboo		Highway/Tod Bore	
		Extent (ha)	% of current modelled extent	Extent (ha)	% of current modelled extent
High	6,136	468	8%	1,072	17%
Medium	9,620	59	1%	88	1%
Low	54	5	10%	5	9%



LEGEND

- Development Envelope
- Ministerial Statement 756
- Highway
- Major Watercourse
- Approved conceptual pit outline
- Proposed conceptual pit outline
- Dinner Camp Bore tenure
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Habitat Prospectivity: Low

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SCALE

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Iron Ore (WA)

Figure 6-21: Existing and proposed mine pits at Warramboo and Highway/Tod Bore in relation to modelled troglofauna habitat

Drawn:T.M.
Date:Nov, 2018

Plan No:PDE0161456v6
Proj:MGA94 Zone50

Geospatial Information and Mapping

Mesas A, B and C

As discussed in Section 6.4.1.3, a conservative approach, considering only the areas of high prospectivity habitat, has been taken to identify and assess potential impacts to troglofauna habitat at Mesas A, B and C. This conservative approach is based upon three-dimensional modelling data and, therefore, allows an output as a percentage of volume. Through the development of mine pits the Proposed Change will directly impact:

- Up to 2% of the volume of pre-mining troglofauna habitat at Mesa A[13]
- Up to 50% of the volume of pre-mining troglofauna habitat at Mesas B
- Up to 50% of the volume of pre-mining troglofauna habitat at Mesa C.

Loss of individuals and changes to troglofauna assemblages due to mine pit development

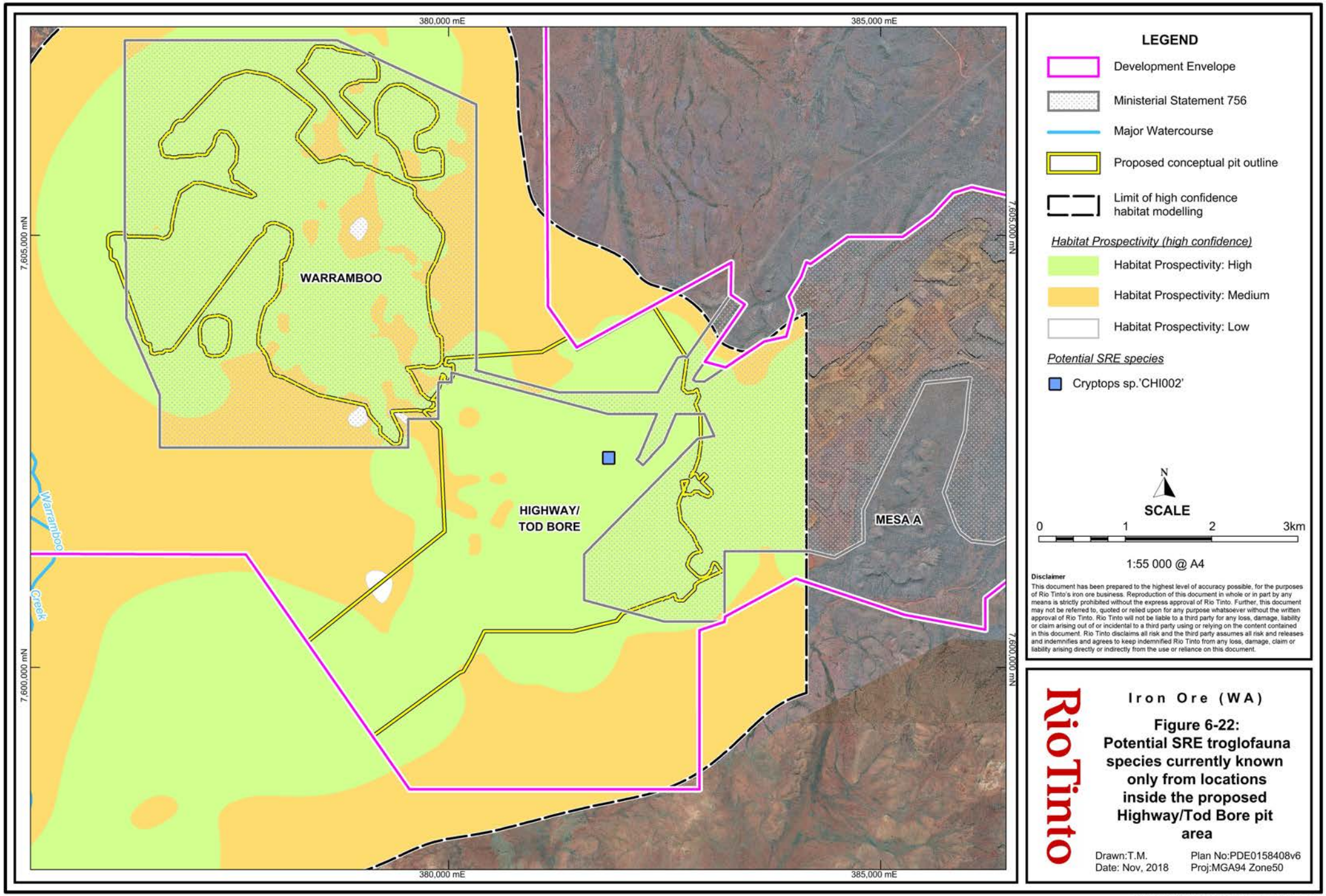
Warramboo

Troglofauna taxa recorded in the survey areas are discussed in Section 6.4.1.4. Nine potential SRE species have been recorded in the Warramboo and Highway/Tod Bore area. One species, *Tyrannochthonius*, sp. 'Warramboo' was recorded in 2005 (Biota 2006c) in an area proposed as a mine pit as part of the Mesa/Warramboo Iron Ore Project. This area was assessed and approved for mining under MS 756. All other troglofauna taxa recorded in proposed impact areas at Warramboo have been recorded elsewhere.

Highway/Tod Bore

One potential SRE species, *Cryptops* sp. 'CHI002', has been recorded only within the proposed Highway/Tod Bore pit area (Figure 6-22).

[13] Only the volume for the Proposed Change is considered here. The cumulative volume for the approved activities and the Proposed Change is considered in Section 6.4.3.3.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Major Watercourse
- Proposed conceptual pit outline
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Habitat Prospectivity: Low

Potential SRE species

- Cryptops sp.'CHI002'

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Iron Ore (WA)

Figure 6-22: Potential SRE troglofauna species currently known only from locations inside the proposed Highway/Tod Bore pit area

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0158408v6
Proj:MGA94 Zone50

Geospatial Information and Mapping

Mesa B and Mesa C

Forty-nine potential or confirmed SRE species have been recorded from Mesas B and C. Ten troglofauna Orders have been recorded from Mesa B of which nine are represented in the proposed MEZ (Table 6-14). Ten troglofauna Orders have also been recorded from Mesa C, of which nine are represented in the proposed MEZ (Table 6-15).

Table 6-14: Troglofauna recorded (Order level) 2005-2016 at Mesa B

Order	Order recorded	
	Mesa B	Mesa B proposed MEZ
Araneae	✓	✓
Coleoptera	✓	✓
Diplura	✓	✓
Hemiptera	✓	-
Isopoda	✓	✓
Polydesmida	✓	✓
Pseudoscorpiones	✓	✓
Schizomida	✓	✓
Zygentoma	✓	✓
Scolopendromorpha	✓	✓

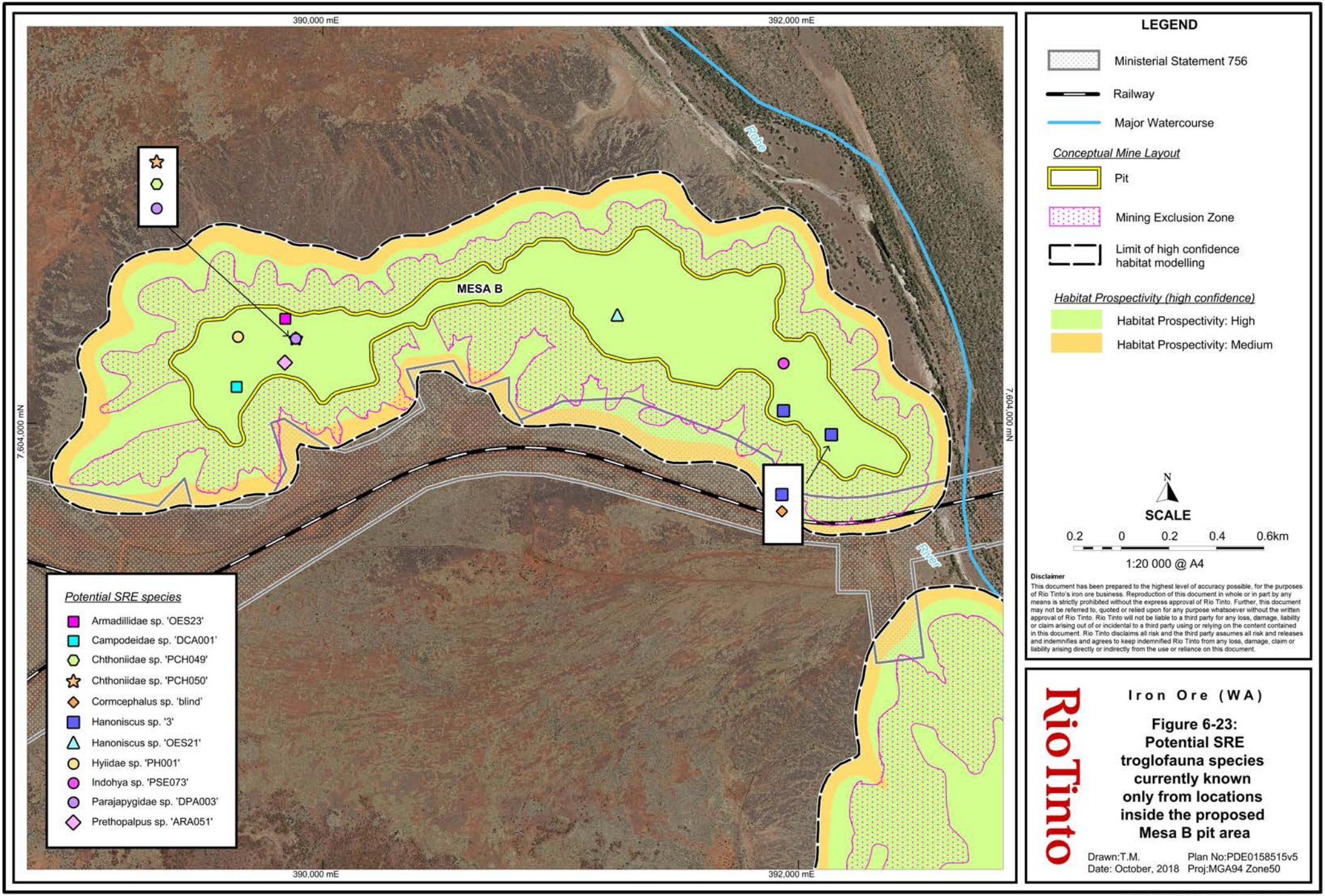
Table 6-15: Troglofauna recorded (Order level) 2005-2016 at Mesa C

Order	Order recorded	
	Mesa C	Mesa C proposed MEZ
Araneae	✓	✓
Coleoptera	✓	✓
Diplura	✓	✓
Isopoda	✓	✓
Opiliones	✓	✓
Polydesmida	✓	✓
Pseudoscorpiones	✓	✓
Schizomida	✓	✓
Zygentoma	✓	✓
Scolopendromorpha	✓	-

From the above Orders, 11 potential SRE troglofauna species are currently known only from the proposed impact area at Mesa B (Table 6-16, Figure 6-23) and three potential SRE troglofauna species are currently known only from the proposed impact area at Mesa C (Table 6-16, Figure 6-24).

Table 6-16: Potential SRE troglofauna species currently known only from the proposed impact areas at Mesas B and C

Mesa B	Mesa C
Armadillidae sp. 'OES23'	*Cryptopidae* sp. 'CHI026'
Campodeidae sp. ’DCA001	*Parajapygidae* sp. ’DPA004’
Chthoniidae sp. 'PCH049'	*Parajapygidae* sp. ’DPA008’
Chthoniidae sp. 'PCH050'	
Cormcephalus sp. `blind`	
Hanoniscus sp. '3'	
Hanoniscus sp. 'OES21'	
Indohya sp.’PH001’	
Indohya sp. 'PSE073'	
Parajapygidae sp. ’DPA003’	
Prethopalpus sp. 'ARA051'	



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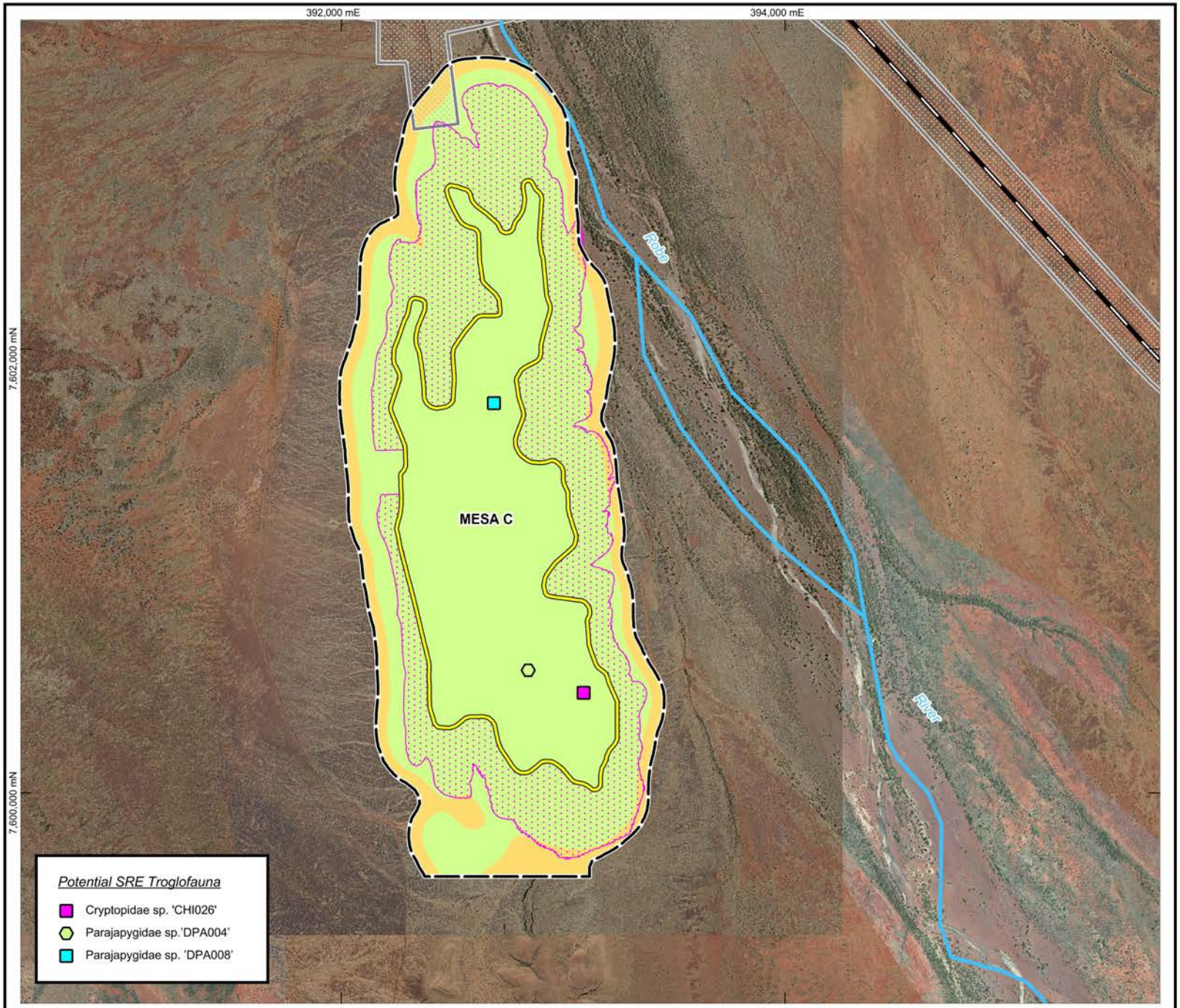
Rio Tinto

Iron Ore (WA)

Figure 6-23: Potential SRE troglofauna species currently known only from locations inside the proposed Mesa B pit area

Drawn:T.M. Plan No:PDE0158515v5
Date: October, 2018 Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Ministerial Statement 756
- Railway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Mining Exclusion Zone
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium

N

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Iron Ore (WA)

Figure 6-24: Potential SRE troglofauna species currently known only from locations inside the proposed Mesa C pit area

Drawn:T.M.
Date: Aug, 2018

Plan No:PDE0158518v5
Proj:MGA94 Zone50

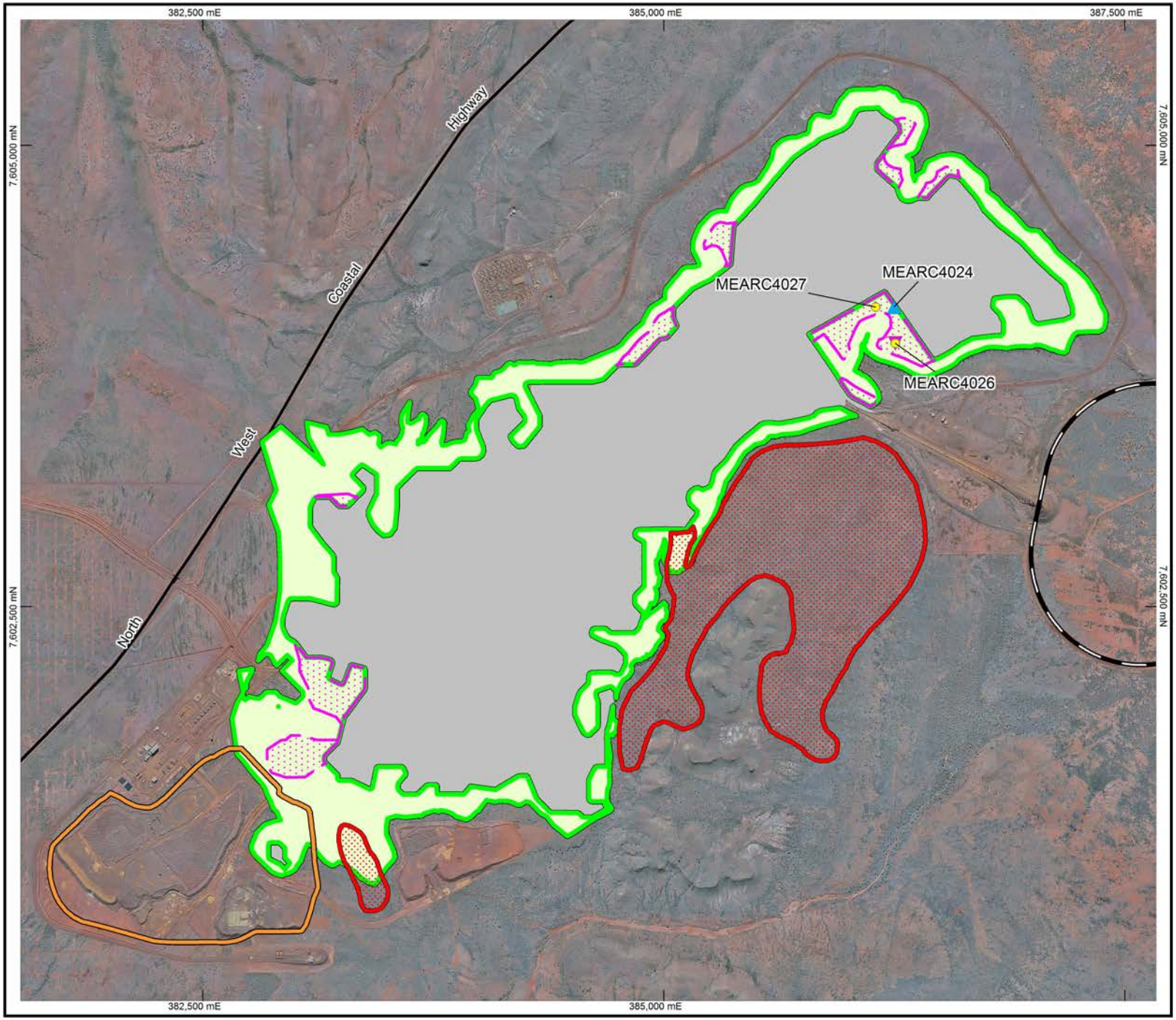
Geospatial Information and Mapping

Mesa A

Three SRE troglofauna taxa have been recorded in the proposed additional mining areas at Mesa A as shown in Figure 6-25. All three taxa have also been recorded in the proposed revised Mesa A MEZ (Table 6-17).

Table 6-17: Troglofauna taxa recorded in the proposed additional mining areas at Mesa A

Drill hole	Order	Family	Taxon	Recorded in proposed revised MEZ?
MEARC4024	Diplura	Projapygidae	*Genus nov*. sp. nov.	Yes
MEARC4026 MEARC4027	Schizomida	Hubbardiidae	*Paradraculoides anachoretus*	Yes
MEARC4026	Pseudoscorpionida	Cthoniidae	*Lagynochthonius asema*	Yes



LEGEND

SRE troglofauna taxa recorded in proposed additional mining areas

- Projapygidae gen nov. sp. nov.
- Lagynochthonius asema
- Paradraculoides anachoretus

- Proposed new mining/cut widening
- Approved MEZ (Pit Shell V_13)
- Mining Exclusion Zone - Sandsheet
- Existing approved waste dump
- Railway
- Highway

N

SCALE

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Iron Ore (WA)

Figure 6-25: Troglofauna taxa recorded in the proposed additional mining areas at Mesa A

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0154330v4
Proj:MGA94 Zone50

Geospatial Information and Mapping

6.4.3.2 Indirect impacts

Potential indirect impacts to troglofauna include temporary loss or degradation of habitat due to mining activities other than mine pit excavation. Mining activities that may result in indirect impacts to troglofauna include:

- Clearing of vegetation and placement of mineral waste potentially leading to a reduction in organic inputs into the subterranean environment. educed organic inputs may diminish the quality of troglofauna habitat
- Seepage from the WFSF will generate a saturated zone above the groundwater table, resulting in a temporary reduction in troglofauna habitat
- Blasting may cause voids and mesocaverns within the remnant mesa formations to collapse, resulting in a reduction in troglofauna habitat
- Exposure of pit faces may cause changes to the temperature and humidity in the subterranean environment, potentially leading to degradation of troglofauna habitat
- Hydrocarbon spills may result in a reduction in the quality of troglofauna habitat.

Considering the high confidence modelling outputs, potential indirect impacts to troglofauna habitat as a result of placement of mineral waste material from the proposed mining at Warramboo and Highway/Tod Bore are shown in Table 6-18. No waste dumps are proposed in high prospectivity habitat (including the proposed MEZs) at Mesas B or C. Therefore, waste dumps for Mesas B and C are not included in Table 6-18.

Table 6-18: Potential indirect impacts to troglofauna habitat in the vicinity of Warramboo from placement of mineral waste

Habitat prospectivity	Modelled current habitat extent within the limit of high confidence habitat modelling (ha)	Proposed extent of disturbance due to waste dumps			
		Warramboo		Highway/Tod Bore	
		Extent (ha)	% of current modelled extent	Extent (ha)	% of current modelled extent
High	6,136	143	2%	81	1%
Medium	9,620	57	1%	160	2%
Low	54	5	9%	0	0%

A significant change in subterranean humidity due to groundwater abstraction is not considered likely. The humidity in the subterranean environment in the Robe Valley is believed to be maintained from a combination of infiltration from rainfall through the porous CID and via fissures and bedding planes; the presence of in-situ moisture content within the CID (including intra clay layers); and the presence of the groundwater table in some areas.

At Mesa A, much of the troglofauna habitat is located at least 20 m above the water table and the retained habitat in the MEZ is not in direct connection with the water table. Numerous troglofauna have been recorded in the MEZ and in areas where troglofauna habitat is located 30 to 40 m above the water table. This indicates that proximity to the water table is not a prerequisite for development and maintenance of suitable troglofauna habitat. As described in section 6.4.2.2, downhole monitoring indicates that mining at

Mesa A has had little discernible influence on down hole temperature and humidity in the Mesa A MEZ (Astron 2017b).

In the western portion of the Development Envelope, only a small volume of troglofauna habitat is in close contact with the water table. Abstraction of groundwater will lower the groundwater table at Warramboo and Mesa C. However, as only a small volume of the troglofauna habitat is currently in close contact with the water table and proximity to the water table has not been demonstrated to be a prerequisite for suitable troglofauna habitat, a significant change in troglofauna habitat due to groundwater abstraction is considered unlikely.

Assessment of the potential indirect impacts to troglofauna and troglofauna habitat is provided in Section 6.4.4.2.

6.4.3.3 Cumulative impacts

The below section presents the incremental impact from the Proposed Change while taking into account previously approved projects. Section 6.4.4.3 discusses the significance of these impacts at each location.

Potential cumulative impacts to troglofauna will occur in the Warramboo and Highway/Tod Bore area as a result of the current and proposed mining operations. Table 6-19 summarises potential cumulative impacts to troglofauna habitat as a result of pit development in the Warramboo and Highway/Tod Bore areas.

Table 6-19: Cumulative impacts to troglofauna habitat as a result of pit development in the Warramboo and Highway/Tod Bore areas

Habitat prospectivity	Modelled pre-mining habitat extent (high confidence) (ha)	Current disturbance (% of pre-mining extent)	Proposed disturbance (% of pre-mining extent)	Total cumulative disturbance (% of pre-mining extent)
High	6,704	8%	23%	31%
Medium	9,675	<1%	2%	2%
Low	54	<1%	19%	19%

The current mine pits at Mesa A have been designed to retain approximately 52% by volume of pre-mining troglofauna habitat[14]. The proposed incremental disturbance will be up to 2% by volume of pre-mining troglofauna habitat, resulting in a proposed cumulative impact up to 50% by volume of pre-mining habitat.

Mesas B and C have not previously been approved for mining and the species present are largely isolated to each mesa thus the Proposed Change does not represent part of a cumulative impact to troglofauna communities at Mesas B and C.

[14] Based on current geological and water table data.

Overall cumulative impacts to the two troglofauna PECs in the area are presented in Table 6-20. The calculation for the remaining extent takes into account other foreseeable proposals in the area (Mesa H) as well as existing approved developments (Mesa A and Warramboo).

Table 6-20: Cumulative impacts to troglofauna PECs as a result of pit development at Warramboo, Highway/Tod Bore and Mesas B and C[15]

PEC	Original assumed pre-mining extent of PEC (ha)	Current extent after other habitat loss* (% of pre-mining extent)	Extent of proposed disturbance (% of pre-mining extent)	Extent after cumulative disturbance (% of pre-mining extent)
Subterranean invertebrate communities of mesas in the Robe Valley region	13,753	87%	2%	85%
Subterranean invertebrate community of pisolitc hills in the Pilbara	9,890	85%	13%	72%

* Other habitat loss includes impacts that have already occurred or are reasonably foreseeable from other proposed developments

Assessment of the significance of the predicted cumulative impacts to troglofauna and troglofauna habitat is provided in Section 6.4.4.3.

6.4.4 Assessment of impacts

6.4.4.1 Direct impacts

Reduction in troglofauna habitat due to mine pit development

Warramboo

Modelling of troglofauna habitat has been undertaken in and around the Warramboo area to assess the potential impact of mine pit development on troglofauna habitat. Additional mine pit development at Warramboo is largely proposed to be BWT within the previously approved pit footprint thus little additional loss of troglofauna habitat at Warramboo due to mine pit development is proposed. It is estimated that the proposed mine pit development at Warramboo will result in the removal of approximately:

- 468 ha of modelled high prospectivity habitat, representing approximately 8% of the current high prospectivity habitat within the limit of high confidence modelling
- 59 ha of modelled medium prospectivity habitat, representing approximately 1% of the current medium prospectivity habitat within the limit of high confidence modelling.

[15] Overlaps in mapped PEC extents within the Development Envelope have been ignored.

Based on the habitat model, both high and medium prospectivity habitat at Warramboo extend into areas to the west and north of the proposed pits, including areas outside the western portion of the Development Envelope (Figure 6-21). Given the relatively small proportion of habitat that will be removed by the proposed additional mining at Warramboo and that modelled high and medium prospectivity habitat extend beyond the approved and proposed mine pit areas, the Proposed Change is unlikely to significantly affect the ecological integrity of the troglofauna habitat in the Warramboo area.

Highway/Tod Bore

Modelling of troglofauna habitat has been undertaken in and around the Highway/Tod Bore area to assess the potential impact of mine pit development on troglofauna habitat. Mine pit design for the Highway/Tod Bore area is preliminary and opportunities to reduce the area required will be explored as mine planning progresses. Based on outputs from the habitat model and the current pit outline, high prospectivity habitat will remain around the Highway/Tod Bore area and medium prospectivity habitat will provide connectivity between Warramboo, Highway/Tod Bore and beyond the western portion of the Development Envelope (Figure 6-21). The proposed mine pit development at Highway/Tod Bore will result in the removal of up to:

- 1,072 ha of modelled high prospectivity habitat, representing approximately 17% of the current high prospectivity habitat within the limit of high confidence modelling
- 88 ha of modelled medium prospectivity habitat, representing approximately 1% of the current medium prospectivity habitat within the limit of high confidence modelling.

Drilling data and CID thickness modelling do not indicate any faults or other structural features in the Highway/Tod Bore area that may indicate a discontinuity in habitat. However, limited sampling from the Dinner Camp Bore area south-west of Highway/Tod Bore on the western extent of the high prospectivity habitat mapping (Figure 6-21) did not record representatives of the strongly troglobitic order, Schizomida, which is represented in the broader Warramboo and Highway/Tod Bore area. The majority of sampling in the Dinner Camp Bore area was completed in a stand-alone survey in 2010; no simultaneous sampling was conducted at Warramboo or Highway/Todd Bore. The lack of schizomid records at Dinner Camp Bore may be due to ecological sampling effects, particularly different sampling methodologies and rainfall during and prior to survey. As a consequence, the results from Dinner Camp Bore may not be directly comparable with those at Highway/Todd Bore and Warramboo (Biota 2017a), or may indicate a discontinuity in troglofauna habitat outside the Development Envelope. Additional troglofauna sampling is underway to further investigate habitat connectivity between the Highway/Tod Bore and Dinner Camp Bore areas; further sampling will continue as per EMP management targets.

Given the extent of modelled high and medium prospectivity habitat that will remain around the Highway/Tod Bore area during and after the proposed mining operation, it is likely that further sampling and investigation will demonstrate that the Proposed Change can be managed to retain the ecological integrity of the troglofauna habitat at Highway/Tod Bore.

Mesa B and Mesa C

The Proposed Change has been designed to retain significant volumes of connected troglofauna habitat at Mesas B and C as delineated by a MEZ. Monitoring results from the existing nearby, and geologically similar, Mesa A mining operation have been used to guide the design of the MEZs at Mesas B and C and assess the likely suitability of those designs.

The statistical power of troglofauna sampling is limited by the sampling methodology. Within the limitations presented by current troglofauna sampling methodology, the abundance and diversity of troglofauna recorded from the MEZ behind the escarpment at Mesa A during mining appear to be similar to those recorded across Mesa A prior to commencement of mining (Section 6.4.2.2). Monitoring of down hole temperature and humidity in the retained troglofauna habitat at Mesa A has shown no influence of proximity to the pit face on mean down hole temperature and humidity and variations in temperature and humidity values at Mesa A were not significantly different from those at Mesa B and Mesa K (Astron 2017b). The Proponent, therefore, considers that the Mesa A MEZ is functioning as intended and is providing habitat to maintain the biological diversity and ecological integrity of the subterranean fauna community.

Comparison of sampling results from the Mesa A MEZ with preliminary sampling results from disturbed habitat in waste dumps and beneath the pit floor at Mesas A and K provides greater certainty of persistence of troglofauna in the retained habitat in the MEZ than beneath the pit floor. Based on the performance of the Mesa A MEZ, MEZs have been included in the mine design for Mesas B and C with a focus on retaining connected habitat behind the mesa escarpments, rather than beneath the pit floors.

Although there is some indication, as discussed in Section 6.4.1.3, that there is, or has been in recent geological time, some habitat connectivity between Mesas B and C, the Proponent has taken a precautionary approach and has assumed that the habitat on Mesas B and C is isolated from the surrounding medium prospectivity habitat. In order to retain suitable habitat, and based on experience at Mesa A, MEZs are proposed on Mesas B and C that consist only of modelled high prospectivity habitat.

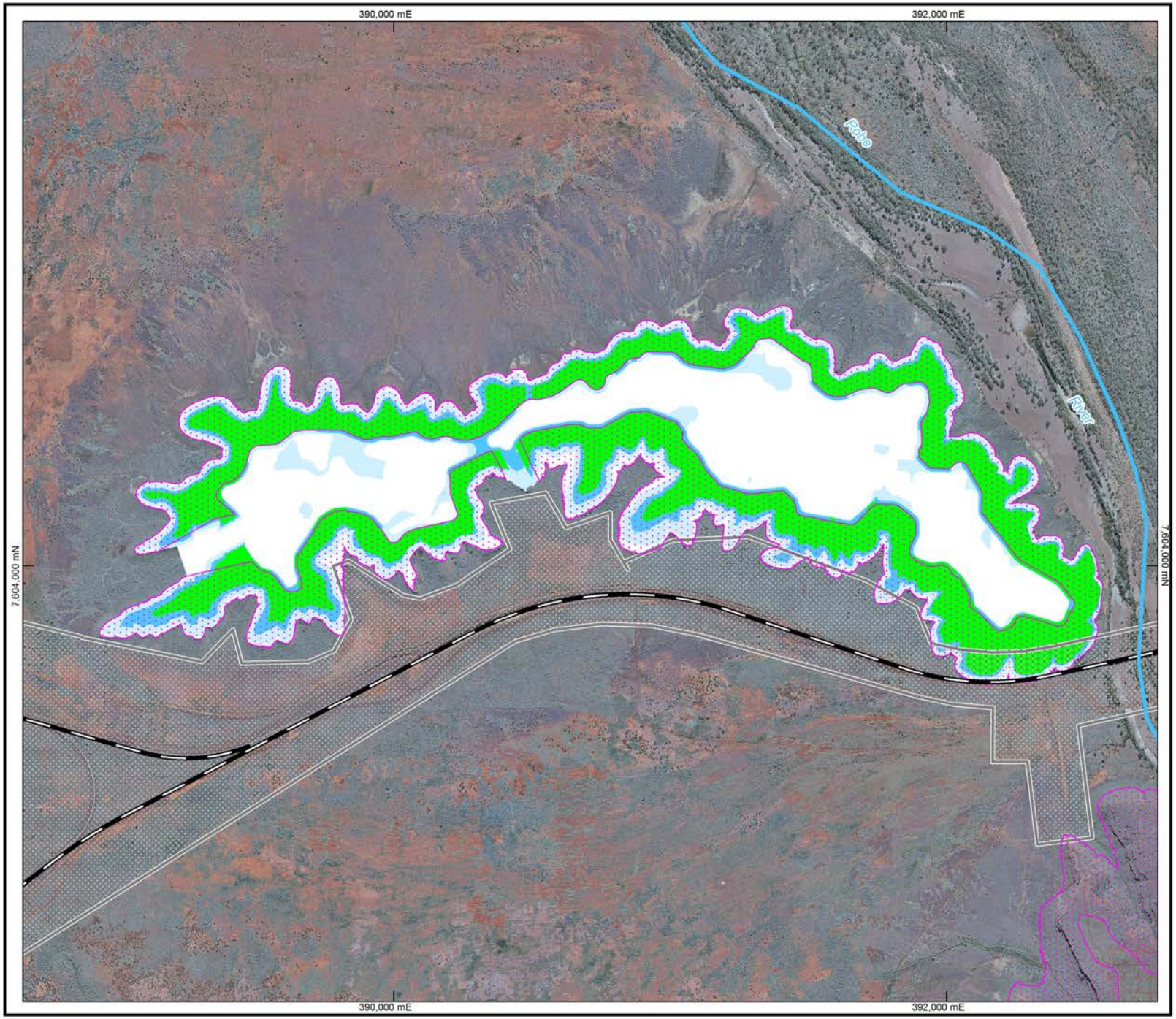
Troglofauna capture rates vary markedly between sampling events. Table 6-21 shows minimum, maximum and overall capture rates at Mesas B and C and in the areas proposed as MEZs at Mesas B and C. The range of capture rates and overall capture rate for each proposed MEZ are similar to the rates for the entire mesa. The similar capture rate for each MEZ compared with the entire respective mesa indicates that the proposed MEZs are representative of the mesa in terms of overall troglofauna utilisation.

Table 6-21: Troglofauna capture rates at Mesas B and C

Location	Capture rate (specimens per 100 holes trapped)		
	Minimum rate	Maximum rate	Overall rate
Mesa B	17	427	155
Mesa B proposed MEZ*	164	200	178
Mesa C*	22	133	72
Mesa C proposed MEZ*	33	147	85

* Surveys with <6 holes excluded from capture rate calculations.

Figure 6-26 and Figure 6-27 show the thickness of material suitable as troglofauna habitat that is proposed for retention at Mesas B and C (backfill of waste material is not shown in these figures). The MEZ has been designed as far as possible to be a continuous block of habitat greater than 15 m thick with retention of at least 50% by volume of the pre-mining habitat at each mesa. The thickness of habitat is less than 15 m in some parts of the MEZ; this occurs where the pre-mining habitat thickness is naturally less than 15 m.



LEGEND

- Ministerial Statement 756
- Railway
- Major Watercourse
- Proposed Mining Exclusion Zone

Thickness of troglofauna habitat to be retained (m)

- <5
- 5 to <10
- 10 to <15
- >= 15

N

SCALE

0 250 500 750m

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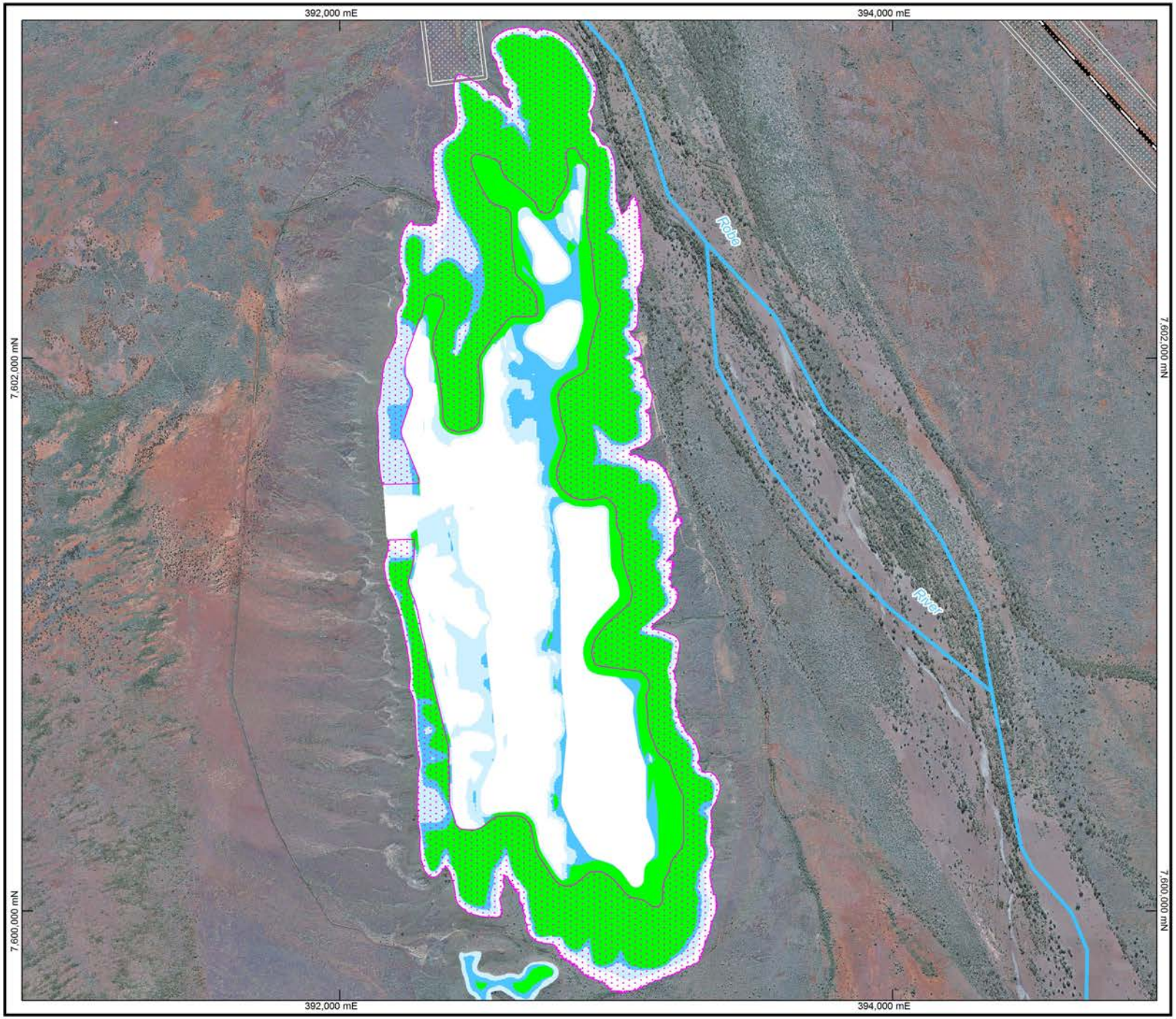
Iron Ore (WA)

Figure 6-26: Troglofauna habitat to be retained at Mesa B

Drawn:T.M.
Date:Nov, 2018

Plan No:PDE0155964v5
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Ministerial Statement 756
- Railway
- Major Watercourse
- Proposed Mining Exclusion Zone

Thickness of troglofauna habitat to be retained (m)

- <5
- 5 to <10
- 10 to <15
- >= 15

N

SCALE

0 250 500 750m

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Iron Ore (WA)

Figure 6-27: Troglofauna habitat to be retained at Mesa C

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0155964v5
Proj:MGA94 Zone50

Geospatial Information and Mapping

Retained habitat will be at least 15 m thick (except in areas where the pre-mining habitat thickness is less than 15 m), with a width of at least 50 m on the mesa plateau. The width of retained habitat at the base of the mesa will be significantly greater than 50m due to the natural slopes of the mesa escarpment and due to the formation of benches during mining (rather than a sheer face from the top to the bottom of the pit). Considering troglofauna typically have dimensions in the order of a few millimetres, the Proponent considers that the dimensions of the proposed habitat to be retained are suitable to retain the ecological integrity of the troglofauna habitat.

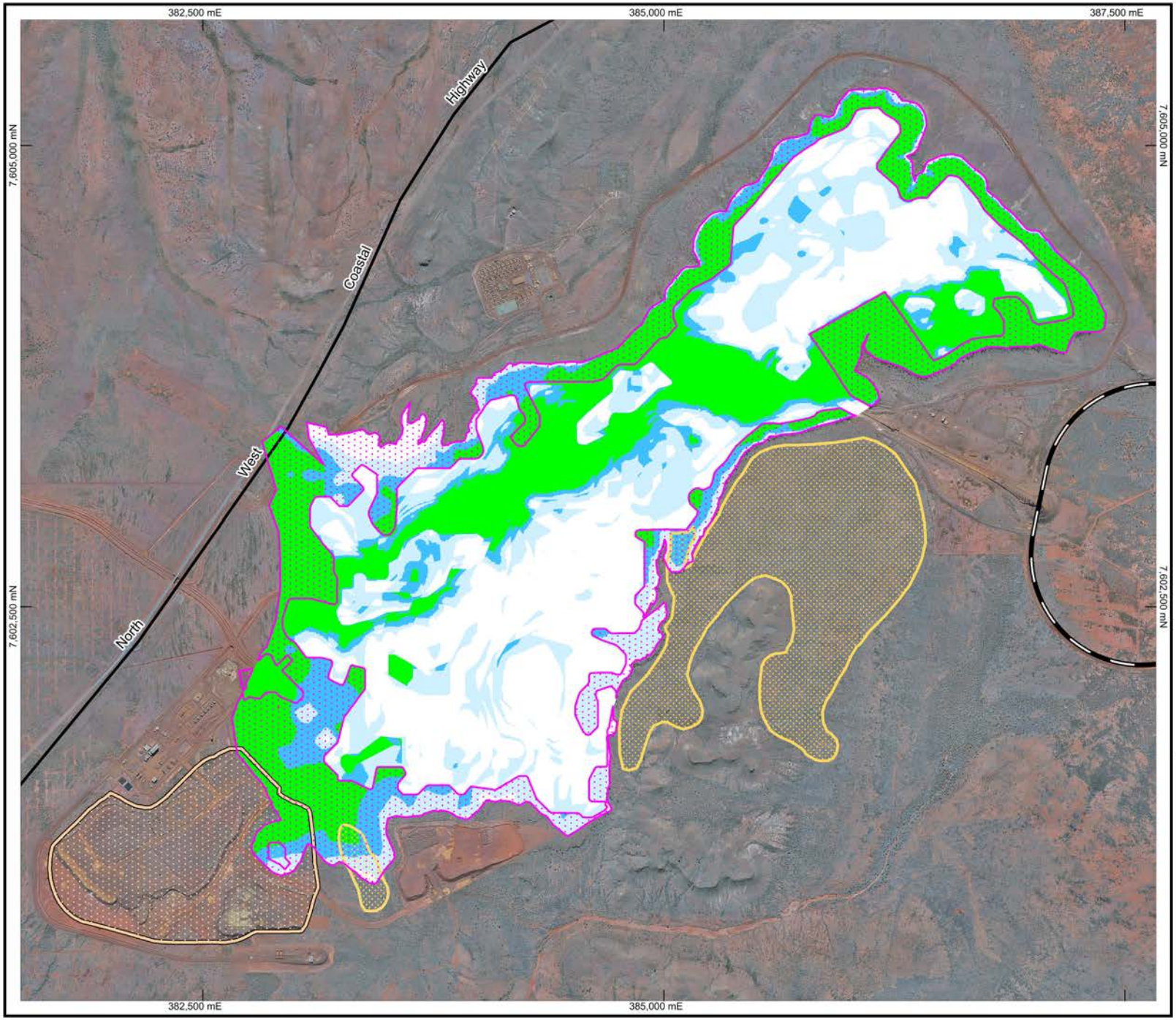
Given that a) the Mesa A MEZ is providing suitable habitat, as evidenced by subterranean temperature and humidity monitoring and troglofauna sampling results; and b) the proposed MEZ designs for Mesas B and C are similar to the Mesa A MEZ and are likely to be representative of the troglofauna habitat throughout both mesas, it is considered that the Proposed Change will retain the ecological integrity of the troglofauna habitat at Mesas B and C.

Mesa A

The Proponent proposes to revise the Mesa A MEZ. The proposed disturbance will be limited to 42 ha which includes preferential mining of higher quality ore (33 ha), widening of the existing escarpment cut (2 ha) and essential associated additional light vehicle access roads and other minor clearing in the Mesa A MEZ (7 ha).

In order to achieve minimal impact to the MEZ, several options were examined for extraction of additional ore from Mesa A. The initial option considered was extraction of all high grade and low grade ore from beneath the currently approved pit floor. This option was not pursued as the Proponent considered it would have resulted in unacceptable impacts to remnant troglofauna habitat beneath the pit floor. Subsequent options considered possible revisions to the MEZ behind the Mesa A escarpment. Options were revised to exclude the catchments for the Sand Sheet PEC and singleton troglofauna (troglofauna known from a single specimen) from the proposed mining area. The proposed option was selected on the basis that it will not impact the catchment for the Sand Sheet PEC, will not impact any singleton troglofauna records and will have the lowest impact on troglofauna habitat of the options considered while optimising the extraction of high grade ore.

The proposed changes to the MEZ at Mesa A are small compared with the existing development at Mesa A. Figure 6-28 and Figure 6-29 show the proposed changes to the thickness of retained habitat. The Proposed Change will continue to retain at least 50% by volume of connected pre-mining habitat at Mesa A, with connected habitat thickness beneath the pit floor of greater than 15 m.



LEGEND

- Approved Mining Exclusion Zone
- existing approved waste dump
- Mining Exclusion Zone - Sandsheet
- Railway
- Highway

Thickness of Troglofauna habitat to be retained (m)

- <5
- 5 to <10
- 10 to <15
- >=15

N

SCALE

0.5 0 0.5 1km

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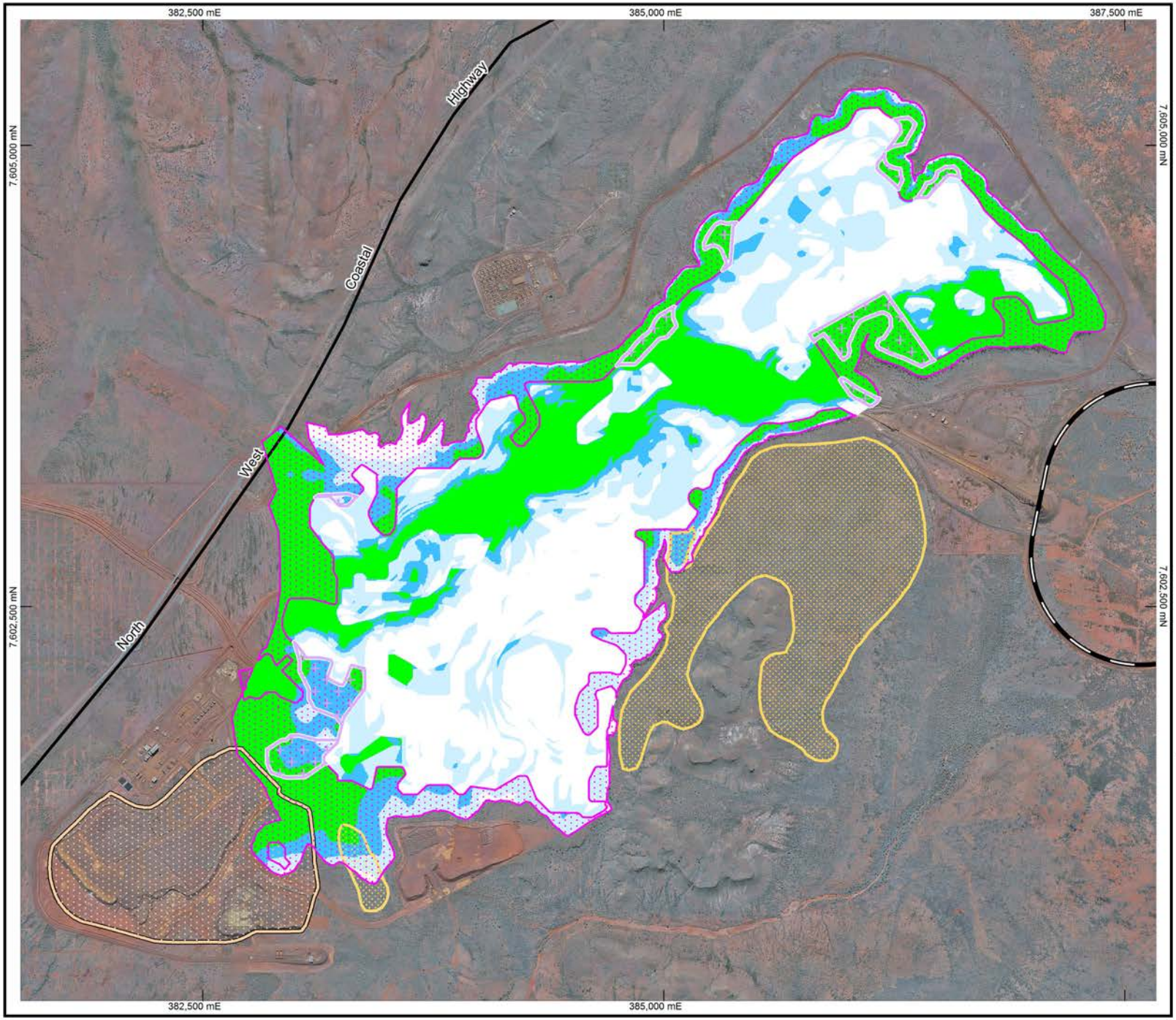
Iron Ore (WA)

Figure 6-28: Troglofauna habitat to be retained at Mesa A - current approved design

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0161460v2
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Approved Mining Exclusion Zone
- Mining Exclusion Zone to be disturbed
- Existing approved waste dump
- Mining Exclusion Zone - Sandsheet
- Railway
- Highway

Thickness of Troglofauna habitat to be retained (m)

- <5
- 5 to <10
- 10 to <15
- >=15

N

SCALE

0.5 0 0.5 1km

1:30 000 @ A4

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Iron Ore (WA)

Figure 6-29: Troglofauna habitat to be retained at Mesa A - proposed design with changes highlighted

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0154324v6
Proj:MGA94 Zone50

Geospatial Information and Mapping

Given that the Mesa A MEZ is providing suitable habitat, as evidenced by subterranean temperature and humidity monitoring and troglofauna sampling results, and that the proposed changes to the Mesa A MEZ are minor, it is considered that the Proposed Change will continue to retain the ecological integrity of the troglofauna habitat at Mesa A.

Loss of individuals and changes to troglofauna assemblages due to mine pit development

Excavation associated with mine pit development will result in the direct loss of individuals and has the potential to change troglofauna assemblages. Proposal design followed an iterative process and considered troglofauna records, available habitat and likely connectivity of habitat. Potential impacts of the Proposed Change on each recorded troglofauna taxon were assessed, regardless of whether the taxon had previously been categorised as confirmed SRE, potential SRE or widespread in biological survey reports (Rio Tinto 2018a).

Warramboo

Additional mine pit development at Warramboo is largely proposed to be BWT within the previously approved pit footprint thus little additional loss of troglofauna habitat at Warramboo due to mine pit development is proposed. As noted in Section 6.4.3.1, other than the record of *Tyrannochthonius*, sp. 'Warramboo' which was assessed and approved for disturbance as part of the Mesa A/Warramboo Iron Ore Project, all troglofauna taxa recorded in proposed impact areas at Warramboo have been recorded elsewhere. It is, therefore, considered that the Proposed Change is unlikely to significantly impact the diversity and ecological integrity of the troglofauna assemblage at Warramboo.

Highway/Tod Bore

One potential SRE species, *Cryptops* sp. 'CHI002', has been recorded only within the proposed Highway/Tod Bore pit area as shown in Figure 6-22. This record is currently a singleton record and represents a potential SRE species. However, this singleton records is unlikely to represent the true distribution of this species and is likely an artefact of sampling effects (Biota 2017a). High and medium prospectivity habitat will continue to be available in the immediate Highway/Tod Bore area within the Development Envelope beyond the proposed impact area. Habitat analysis at Highway/Tod Bore indicates that high, medium and low prospectivity habitat also extends beyond the western portion of the Development Envelope into the wider surrounding region. Drilling data and CID thickness modelling do not indicate any faults or other structural features in the Highway/Tod Bore area that may indicate a discontinuity in habitat. However, limited sampling from the Dinner Camp Bore area south-west of Highway/Tod Bore on the western extent of the high prospectivity habitat mapping outside the western portion of the Development Envelope (Figure 6-21) did not record representatives of the strongly troglobitic order, Schizomida. The lack of schizomid records at Dinner Camp Bore may be due to ecological sampling effects or may indicate a discontinuity in troglofauna habitat outside the Development Envelope (Biota 2017a). Additional troglofauna sampling is underway to further investigate habitat connectivity between the Highway/Tod Bore and Dinner Camp Bore areas.

Given that high and medium prospectivity habitat will continue to be available both within and beyond the western portion of the Development Envelope and that *Cryptops* sp. 'CHI002' is likely to have a wider distribution that extends beyond the proposed impact area, it is likely that further sampling and investigation will demonstrate that the Proposed Change can be managed to retain the ecological integrity of the troglofauna habitat at Highway/Tod Bore.

Mesa B / Mesa C

Although significant, connected troglofauna habitat is to be retained at Mesas B and C, the Proponent has taken a precautionary approach in relation to single location and singleton troglofauna records. The original draft MEZs have been modified several times during mine planning in order to avoid as many single location and singleton troglofauna as practicable. Consistent with Mesa A, revisions of the MEZs aimed to include at least one location in the MEZs for each taxon wherever practicable. This strategy appears to have been effective at Mesa A, with some troglofauna (for example *Lagynochthonius asema* and *Ideoblothrus* sp. 'Mesa A1') originally considered to be at risk but now known from additional locations in the Mesa A MEZ (6.4.2.2). The revisions of the MEZs have resulted in all Orders, except one at Mesa B and one at Mesa C, being represented in the MEZs (Table 6-14, Table 6-15).

Forty-nine conservation significant, confirmed SRE and potential SRE species have been recorded from Mesas B and C of which 27 are known from outside the proposed impact area. Eleven potential SRE troglofauna species at Mesa B are currently known only from locations inside the proposed impact area (Table 6-16) and three potential SRE troglofauna species at Mesa C are currently known only from locations inside the proposed impact area (Table 6-16).

The EPA acknowledges that habitat may be used as a surrogate for inferring distributional boundaries of potentially restricted taxa (EPA 2016g and 2016h). Where a habitat type that supports a species is continuous then the extent of that habitat may be used to infer the likely presence of that species in the same habitat. Figure 6-4 to Figure 6-8 in Section 6.4.1.3 show that Robe Pisolite is present across the entirety of each mesa formation and there are no known geological barriers or faults within Mesas B and C that may restrict troglofauna movement.

The EPA also notes that taxa with greater known distributions may act as surrogates to infer the distributions of poorly sampled species (EPA 2016h). *Paradraculoides bythius*, a conservation significant species listed as Threatened – Vulnerable, has been recorded across the full extent of Mesa B and almost across the full extent of Mesa C (Figure 6-30). Records of the same species from multiple locations indicates that the troglofauna habitat within each mesa is well connected (Figure 6-30).

The occurrence of some taxa from multiple locations within Mesa B and within Mesa C and the absence of known geological barriers and faults from both mesas indicate that the troglofauna habitat within each mesa is well connected. It is, therefore, considered that the troglofauna species currently only recorded from inside the proposed impact area, are likely to have distributions that extend beyond the proposed impact area into the proposed MEZ.

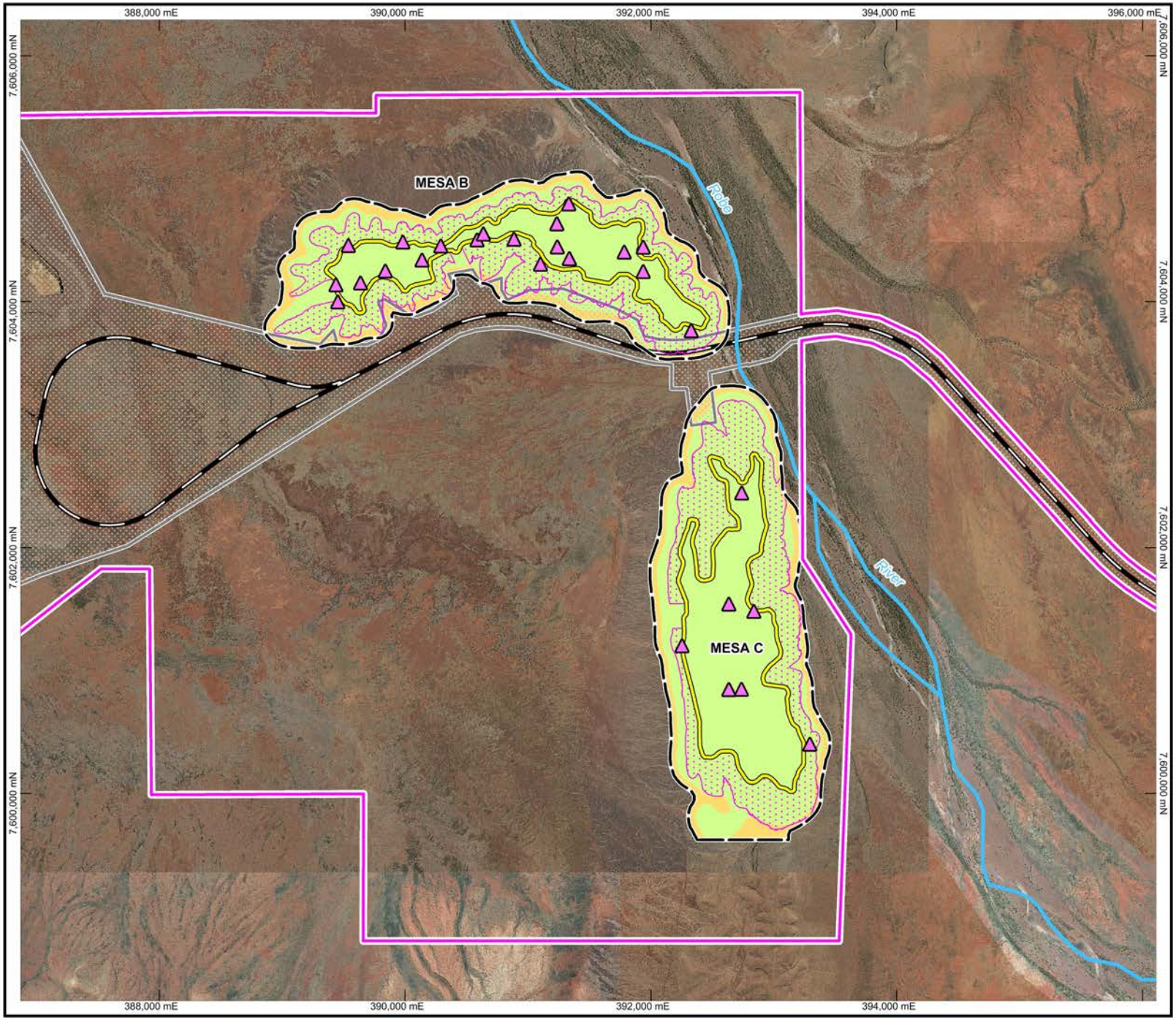
Additional troglofauna sampling will be undertaken with the aim of increasing the recorded occurrences of current single location and singleton troglofauna taxa. Should additional sampling show broader distributions for current single location and singleton taxa around which the MEZs have been designed, the Proponent may seek additional approval to modify the MEZs.

Given the evidence indicating connectivity of the habitat within Mesas B and C, the proposed retention of at least 50% by volume of connected pre-mining habitat at both Mesas B and C and that the MEZs have been designed to incorporate areas with singleton records as far as practicable, it is considered likely that the species recorded only from the proposed impact areas at Mesas B and C have wider distributions that extend beyond the proposed impact area. It is, therefore, considered that the Proposed Change can be managed such that the diversity and ecological integrity of the troglofauna assemblages at Mesas B and C are maintained.

Mesa A

Three SRE troglofauna taxa have been recorded in the proposed additional mining areas at Mesa A as shown in Figure 6-25. All three taxa have been recorded in the proposed revised Mesa A MEZ (Table 6-17).

Given that at least 50% by volume of connected pre-mining habitat will be retained at Mesa A and all documented troglofauna in the proposed additional mining area at Mesa A have been recorded in the revised MEZ, it is considered that the Proposed Change can be managed such that the diversity and ecological integrity of the troglofauna assemblage at Mesa A are maintained.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Railway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Mining Exclusion Zone
- Limit of high confidence habitat modelling

Habitat Prospectivity (high confidence)

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Paradraculoides bythius

N

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Iron Ore (WA)

Figure 6-30: Records of Paradraculoides bythius at Mesas B and C

Drawn:T.M.
Date: Aug, 2018

Plan No:PDE0158519v4
Proj:MGA94 Zone50

Geospatial Information and Mapping

6.4.4.2 Indirect impacts

Mining-related activities such as clearing of vegetation and placement of mineral waste, disposal of waste fines and reverse osmosis plant effluent, blasting exposure of pit faces and hydrocarbon spills may result in temporary loss or degradation of troglofauna habitat.

Clearing of vegetation

Little is known about the origin of energy (i.e. organic carbon), key taxa or connectivity within the food web of subterranean systems. Organic carbon may originate from surface nutrients and once in the subterranean environment may be transferred cyclically through the system from microbial biofilms, to grazers, to predators. Alternatively, energy may be generated in the subterranean system via chemo-autotrophic processes, where bacteria use alternative metabolic pathways to provide energy inputs (Office of the EPA 2012).

If energy in the subterranean system originates from the surface, clearing of vegetation and placement of mineral waste material may lead to a reduction in organic inputs into the subterranean environment, potentially resulting in a reduction in the quality of troglofauna habitat.

The Proposed Change has been designed to minimise clearing through placement of the WFSF in-pit at Warramboo and placement of mineral waste in mined-out pits wherever practicable. The Proposed Change involves clearing of approximately 143 ha and 57 ha at Warramboo of high and medium prospectivity habitat respectively for placement of mineral waste, representing approximately 2% and 1% of the modelled current extent of high and medium habitat prospectivity respectively within the limit of high confidence modelling. The Proposed Change also involves clearing at Highway/Tod Bore of approximately 81 ha and 160 ha of high and medium prospectivity habitat respectively for placement of mineral waste, representing approximately 1% and 2% of the modelled extent of pre-mining high and medium habitat prospectivity respectively. Waste dump design for the Highway/Tod Bore area is preliminary and opportunities to reduce the area required will be explored as mine planning progresses. Disturbed areas will be rehabilitated once they are no longer required by the Proposed Change.

Results from troglofauna sampling in disturbed habitats (Section 6.4.2.2) indicate that troglofauna utilise habitat in or below mineral waste dumps. It is, therefore, likely that troglofauna will utilise habitat in or below the proposed waste dumps at Warramboo and Highway/Tod Bore, although the extent of likely utilisation is not yet known. Studies of troglofauna utilisation of disturbed habitats are ongoing.

Based on outputs from the habitat model and the waste dump outlines, undisturbed high and medium prospectivity habitat will remain around both the Warramboo and Highway/Tod Bore areas, including beyond the western portion of the Development Envelope (Figure 6-21).

Given that disturbance will be minimised outside mining areas, undisturbed habitat will remain around the Warramboo and Highway/Tod Bore areas and rehabilitation will be undertaken, impacts from loss of vegetation are likely to be localised and temporary and are, therefore, unlikely to significantly degrade troglofauna habitat in the Warramboo and Highway/Tod Bore areas.

The Proposed Change has also been designed to limit new clearing in areas designated as MEZs on Mesas A, B and C to infrastructure such as tracks, utilities, telecommunications, monitoring stations and abandonment bunds; such infrastructure is variously required to access troglofauna monitoring sites, meet legal obligations and

because of lack of alternative suitable locations. Proposed mineral waste dumps at Mesas B and C will be located either in-pit or off the mesa in order to minimise clearing in the MEZ. Disturbed areas will be rehabilitated once they are no longer required by the Proposed Change.

Given that disturbance will be minimised outside mining areas and rehabilitation will be undertaken, impacts from loss of vegetation are likely to be localised and temporary and are, therefore, unlikely to significantly degrade troglofauna habitat.

Waste fines storage

In-pit storage of waste fines (from the entire Proposal) and disposal of effluent from the reverse osmosis plant is proposed at Warramboo. Seepage will generate a saturated zone below the WFSF and above the groundwater table thus reducing troglofauna habitat for the duration of seepage. Partial excavation of this habitat has already occurred from the existing mining operation at Warramboo.

Given the temporary nature of the seepage from the WFSF, in-pit storage of waste fines at Warramboo is unlikely to affect the long-term ecological integrity of the troglofauna habitat in the Warramboo area. High and medium suitability troglofauna habitat will continue to be available around the Warramboo area for the duration of seepage (Figure 6-21).

Blasting activities and vibration

Blasting activities and vibration have the potential to degrade troglofauna habitat by causing voids and mesocaverns within the remnant mesa formations to collapse. Optical image surveys conducted periodically in drill holes at Mesas A, B and K since 2009 show no evidence of degradation of troglofauna habitat from collapse of cavities within the remnant mesa formations from as close as 5m to the pit face (Section 6.4.2.2). Significant degradation of troglofauna habitat in proposed MEZs surrounding proposed pit areas is, therefore, considered unlikely.

Exposure of pit faces

Exposure of pit faces to surface climate may cause changes in the temperature and humidity in the subterranean environment and thereby degrade troglofauna habitat.

Subterranean temperature and relative humidity data are collected continuously from uncased drill holes in the MEZ at Mesa A, at Mesa B and in the areas remaining at Mesa K following historical mining. As discussed in Section 6.4.1.2, statistical analysis of down hole temperature and humidity data showed mining at Mesa A has had little discernible influence on the subterranean temperature and humidity in the Mesa A MEZ (Astron 2017b). These results indicate that the proposed exposure of pit faces at Mesas B and C and minor additional exposure at Mesa A is unlikely to significantly degrade troglofauna habitat in the proposed MEZs.

Hydrocarbon spills

The potential exists for the subterranean environment to be degraded by spills of hydrocarbons. Hydrocarbon storage will be situated off the MEZs and will meet relevant Australian Standards. Hydrocarbon storage will be at ground level below the level of the mesa formation thus reducing the risk of contamination within the retained troglofauna habitat. Servicing and re-fuelling of plant and vehicles will not occur within the MEZs,

although re-fuelling of some vehicles will occur in-pit in unsealed areas. Continued implementation of hydrocarbon and spill management procedures will mitigate the risk of hydrocarbon contamination such that hydrocarbon spills are unlikely to significantly degrade troglofauna habitat.

6.4.4.3 Cumulative impacts

Molecular evidence for some troglobitic orders indicates that there is unlikely to be continuous gene flow between the mesas of the Robe Valley. The cumulative impact to troglofauna in mesa environments, therefore, consists of the separate impacts at each mesa.

Up to 50% of the pre-mining habitat volume at Mesas A, B and C will be removed by the proposed mining operation. At Mesa A, this is the total impact, inclusive of the currently approved impact and the proposed additional impact. Given the retention of a significant volume of habitat and that the Mesa A MEZ is functioning as intended (Section 6.4.2.2), it is considered that the proposed changes to the MEZ at Mesa A are small and the ecological integrity of troglofauna habitat in the Mesa A MEZ will be retained.

The current approved mining operation in the Warramboo area will result in removal of approximately 8% of modelled pre-mining high prospectivity habitat and less than 1% of medium prospectivity pre-mining habitat as a result of mine pit development. Proposed pit development at Warramboo and Highway/Tod Bore will result in removal of an additional 23% of the pre-mining extent of high prospectivity habitat and approximately 2% of the extent of medium prospectivity habitat, resulting in a cumulative impact to approximately 31% of the extent of pre-mining high prospectivity habitat and 2% of the extent of pre-mining medium prospectivity habitat within the limit of high confidence modelling (Table 6-19). Given the availability of modelled high and medium prospectivity habitat that occurs outside the proposed Development Envelope, it is considered that the Proposed Change can be managed to retain the ecological integrity of troglofauna habitat around the broader Warramboo and Highway/Tod Bore areas.

Two Priority 1 PECs relevant to troglofauna are present in the western portion of the Development Envelope and across parts of the Robe Valley. The extent of the Subterranean invertebrate communities of mesas in the Robe Valley region PEC after loss from existing mining operations and foreseeable losses is 87% of the pre-mining extent. The Proposed Change will result in an estimated loss of a further 2%, resulting in 85% of the pre-mining extent of the PEC remaining once all cumulative losses have been considered (Table 6-20). The extent of the Subterranean invertebrate community of pisolitic hills in the Pilbara PEC after loss from existing mining operations and foreseeable losses is 85% of the pre-mining extent. The Proposed Change will result in an estimated loss of a further 13%, resulting in 72% of the pre-mining extent of the PEC remaining once all cumulative losses have been considered (Table 6-20). Although a relatively high proportion of the PECs (85% and 72% of pre-mining extent) will remain once all cumulative losses are considered, the Proponent considers that the residual impact associated with the unavoidable clearing of the Priority 1 PECs, is significant and warrants an offset. The proposed offset is discussed in Section 13.

The nearest existing mining operation is the Mesa J Iron Ore mine located approximately 40 km east of the Development Envelope. The nearest proposed mining operations are the API Management West Pilbara Iron Ore Project located approximately 35 km south-east of the Development Envelope and the Mesa H Proposal located approximately 40 km east of the Development Envelope. Troglofauna assemblages in areas near these

existing and proposed operations differ from those in the western portion of the Development Envelope. These operations are, therefore, unlikely to contribute to cumulative impacts on the troglofauna assemblage in the Mesa A Hub Development Envelope.

6.4.5 Closure

The Mesa A Hub Closure Plan (Rio Tinto 2017b) (refer Appendix 3) represents the updated closure plan for the Mesa A, B, C, Warramboo, Highway/Tod Bore operations and supersedes previous closure plans for the approved project. A summary of the approach to closure in the Proposed Change and how it relates to the Subterranean Fauna environmental factor is provided below.

6.4.5.1 Mining Exclusion Zones (MEZ)

A MEZ was established as part of the Mesa A/Warramboo Iron Ore Project to retain troglofauna habitat both during and post-mining operations. Troglofauna sampling and habitat monitoring have shown that the MEZ at Mesa A appears to be providing suitable troglofauna habitat for the continued persistence of a troglofauna assemblage (Bennelongia 2017, Biota 2010b and 2012b, MWH 2014). Similar MEZs are, therefore, proposed for Mesas B and C. The Proposed Change has been designed to limit new clearing in areas designated as MEZs on Mesas A, B and C. Disturbed areas will be rehabilitated once they are no longer required by the Proposed Change, although it is anticipated that minimal rehabilitation works will be required in the MEZs as disturbance will be minimised.

The habitat contained in the MEZs at Mesas A, B and C will be retained throughout the mining operation and upon closure.

6.4.5.2 Retention of troglobitic fauna habitat under the pit floor

At Mesa A, intact troglofauna habitat has been retained under the mine pit in addition to the MEZ. This habitat contains a block of material that is at least 15 m thick and is connected with the MEZ. As current sampling results provide greater certainty of persistence of troglofauna in the retained habitat behind the escarpment at Mesa A than under the pit floor, the design of the MEZs at Mesas B and C has focussed on retention of habitat behind the escarpments. The proportion of pre-mining habitat to be retained behind the mesa escarpments at Mesas B and C is similar to the total proportion of pre-mining habitat retained at Mesa A behind the mesa escarpments and beneath the pit floor.

6.4.5.3 Placement of waste rock

The closure objectives include a final landform that is stable and considers ecological values. To preserve habitat post closure, the integrity of the mesa escarpment needs to be maintained. Several small areas of escarpment at Mesa A are connected by narrow areas of the MEZ which protrude into the pit. Pits will be backfilled against these narrow areas ('fingers' of MEZ) to ensure landform stability and potential connectivity of troglofauna habitat in the long-term (Rio Tinto 2017b). Backfilling of the Mesa B and C pits will be undertaken where mine scheduling allows. No narrow areas ('fingers') of MEZ are currently planned to protrude into the pit at Mesas B and C; should narrow areas of MEZ be required, a similar backfill strategy would be implemented as that at Mesa A.

The Proponent is currently undertaking further investigations into the re-colonisation of in-pit waste dumps/low grade stockpiles by subterranean fauna. Early results from Mesa A

and Mesa K indicate troglofauna utilisation of disturbed habitats (Section 6.4.1.2). However, given only limited sampling has been completed to date in disturbed habitats; further work is required to evaluate the diversity of troglofauna present in disturbed habitats and the utilisation of those habitats by troglofauna.

6.4.6 Mitigation

6.4.6.1 Application of the mitigation hierarchy

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 6-22.

The Mesa A Hub EMP (Appendix 4) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa A Hub. The EMP identifies:

- Mitigation strategies proposed to minimise impacts to significant environmental values
- The environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met
- Trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach
- The management actions that will be implemented in response to monitoring results.

Table 6-22: Mitigation strategies and predicted outcomes for Subterranean Fauna

Potential impacts	Mitigation to address potential impacts	Predicted outcome
EPA objective: *To protect subterranean fauna so that biological diversity and ecological integrity are maintained.*		
Direct impact: reduction in troglofauna habitat due to mine pit development Excavation for the Proposed Change will remove up to: • 468 ha of modelled high prospectivity troglofauna habitat at Warramboo (8% of current modelled high prospectivity habitat) • 59 ha of modelled medium prospectivity habitat at Warramboo (1% of current modelled medium prospectivity habitat) • 1,072 ha of modelled high prospectivity habitat at Highway/Tod Bore (17% of current modelled high prospectivity habitat) • 88 ha of modelled medium prospectivity habitat at Highway/Tod Bore (1% of current modelled medium prospectivity habitat). Excavation will remove up to an additional 2% by volume of pre-mining habitat on Mesa A. Excavation will remove up to 50% by volume of pre-mining habitat on Mesas B and C.	The following key management strategies will be implemented to manage impacts to troglofauna as a result of mine pit development: **Minimise:** The mine plan has been designed to retain at least 50% by volume of connected pre-mining troglofauna habitat at Mesas A, B and C by delineation of a MEZ (and pit floor in the case of Mesa A). The Proponent proposes that mine pit development be subject to a new Ministerial Statement for the Revised Proposal (Appendix 2). The conditions of the new Ministerial Statement shall require the Proponent to implement an EMP (Appendix 4) to ensure suitable troglofauna habitat is retained. The Proponent also proposes to conduct troglofauna sampling in the Warramboo and Highway/Tod Bore area and in the MEZs at Mesas A, B and C to verify persistence of troglofauna. **Rehabilitation:** The Proponent proposes to backfill pits with waste rock material where mine schedules allow and to continue to monitor subterranean temperature and humidity at Mesa A. The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans (2015). The Closure Plan (Appendix 3) includes a closure	*Warramboo* It is estimated that the proposed additional pit development at Warramboo will result in loss of 8% and 1% of high and medium prospectivity habitat respectively in the limit of high confidence modelling. Given the relatively small proportion of habitat that will be removed by the proposed additional mining at Warramboo and that modelled high and medium prospectivity habitat extend beyond the approved and proposed mine pit areas, it is considered the proposed mining at Warramboo can be conducted such that the ecological integrity of troglofauna habitat in the Warramboo area is maintained. *Highway/Tod Bore* It is estimated that the proposed pit development at Highway/Tod Bore will result in loss of 17% and 1% of high and medium prospectivity habitat respectively in the limit of high confidence modelling. Given the extent of modelled high and medium prospectivity habitat that will remain around the Highway/Tod Bore area during and after the proposed mining operation, it is likely that further sampling and investigation will demonstrate that the Proposed Change can be managed to retain the ecological integrity of the troglofauna habitat at Highway/Tod Bore.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	objective to ensure the final landform is stable and considers ecological values. Pit will be backfilled against narrow areas ('fingers') of MEZ where they occur, to ensure landform stability and potential connectivity of troglofauna habitat in the long-term. **Other legislation:** The Proponent will adhere to the requirements of the WC Act.	*Mesas A, B and C* The Proposed Change has been designed to retain at least 50% by volume of connected pre-mining habitat at Mesas A, B and C through delineation of MEZs. Data collected from Mesa A indicate that the MEZ at Mesa A is functioning as intended to provide suitable habitat for persistence of troglofauna adjacent to the active mining operation. It is, therefore, considered that the proposed MEZs at Mesas A, B and C will continue to provide suitable troglofauna habitat and that the Proposed Change will retain the ecological integrity of the troglofauna habitat. The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor.
Direct impact: loss of individuals and changes to troglofauna assemblages due to mine pit development Excavation will result in the loss of individuals and has the potential to result in changes to troglofauna assemblages. The troglofauna habitat contained within the mesa landforms at Mesas A, B and C has conservatively been assessed as being isolated from the surrounding landscape.	The following key management strategies will be implemented to manage impacts to troglofauna as a result of mine pit development: **Avoid:** The mine plans for Mesas A, B and C have been designed to avoid as many single location and singleton troglofauna as practicable and ensure their ongoing avoidance by the retention of a MEZ. Additional sampling will be undertaken with the aim of increasing the recorded occurrences of current single location and singleton troglofauna taxa. **Minimise:** Impacts to troglofauna taxa and assemblages will be minimised through retention of connected habitat that is at least 50% by volume of the pre-mining troglofauna habitat at Mesas A, B and C through designation of MEZs.	*Warramboo* Other than the record of *Tyrannochthonius*, sp. 'Warramboo' which was assessed and approved for disturbance as part of the Mesa A/Warramboo Iron Ore Project, all troglofauna taxa recorded in the proposed impact area at Warramboo have been recorded elsewhere. It is, therefore, considered that the Proposed Change is unlikely to significantly impact the diversity and ecological integrity of the troglofauna assemblage at Warramboo. *Highway/Tod Bore* One potential SRE troglofauna species, *Cryptops* sp. 'CHI002', recorded only in the proposed impact area at Highway/Tod Bore will be impacted by the Proposed Change. This single record is unlikely to represent the

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	The Proponent proposes that mine pit development be subject to a new Ministerial Statement for the Revised Proposal (Appendix 2). The conditions of the new Ministerial Statement shall require the Proponent to implement an EMP (Appendix 4) to ensure suitable troglofauna habitat is retained. **Rehabilitation:** The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans (2015). The Closure Plan (Appendix 3) includes a closure objective to ensure the final landform is stable and considers ecological issues. **Other legislation:** The Proponent will adhere to the requirements of the WC Act.	true distribution of this species and is likely to be an artefact of sampling effects (Biota 2017a). Given that high and medium prospectivity habitat will continue to be available both within and beyond the western portion of the Development Envelope and that *Cryptops* sp. 'CHI002' is likely to have a wider distribution that extends beyond the proposed impact area, it is likely that further sampling and investigation will demonstrate that the Proposed Change can be managed to retain the ecological integrity of troglofauna habitat at Highway/Tod Bore. *Mesa B and C* Fourteen potential SRE troglofauna species are currently known only from the proposed impact areas at Mesas B and C (11 from Mesa B and three from Mesa C). Robe Pisolite is present across the entirety of each mesa formation, no geological barriers or faults are known in Mesas B or C and the confirmed SRE species, *Paradraculoides bythius* (listed as Threatened – Vulnerable), has been recorded across the full extent of Mesa B and almost across the full extent of Mesa C, indicating that the troglofauna habitat on each mesa is well connected and extends beyond the proposed impact area, into the proposed MEZ. Given the evidence for connectivity of habitat beyond the proposed impact area and the retention of at least 50% by volume of the pre-mining habitat at each mesa, it is considered that the taxa currently recorded only from inside the proposed impact area are likely to have distributions that extend beyond the proposed impact area.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
		It is, therefore, considered that the Proposed Change can be managed such that diversity and ecological integrity of the troglofauna assemblages at Mesas B and C are maintained. *Mesa A* All troglofauna taxa recorded from the proposed additional mining area at Mesa A have been recorded elsewhere in the Mesa A MEZ. It is, therefore, considered that the Proposed Change can be managed such that diversity and ecological integrity of the troglofauna assemblage at Mesa A is maintained. The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor.
Indirect impact: temporary reduction in or degradation of habitat due to mining-related activities Mining-related activities such as clearing of vegetation and placement of mineral waste, disposal of waste fines and reverse osmosis plant effluent, blasting, exposure of pit faces and hydrocarbon spills may result in temporary loss or degradation of troglofauna habitat.	The following key management strategies will be implemented to manage impacts to troglofauna from activities that may result in the temporary loss or degradation of habitat. **Avoid:** Warramboo was selected as the preferred location for the WFSF rather than the alternative location of in-pit at Mesa A in order to avoid impacts to the higher value troglofauna habitat retained in the pit floor at Mesa A. Hydrocarbon storage and servicing and re-fuelling of plant and vehicles will not occur within the MEZs at Mesas A, B and C. **Minimise**: Clearing within the MEZs at Mesas A, B and C will be minimised and limited to infrastructure such as tracks, utilities, telecommunications, monitoring stations and abandonment bunds. Mineral waste dumps required	Given that the Proposed Change has been designed to minimise clearing, including placement of mineral waste in mined out pits wherever practicable and that disturbed areas will be rehabilitated once they are no longer required by the Proposed Change, impacts from loss of vegetation and placement of mineral waste material are likely to be localised and temporary and are unlikely to significantly degrade troglofauna habitat. Given the area proposed for the WFSF has been previously mined; that suitable troglofauna habitat exists outside the area; and given the temporary nature of the disturbance that may result from seepage from the WFSF, it is considered that the Proposed Change can be managed such that the continuity and ecological integrity of the troglofauna habitat at Warramboo are maintained.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	as part of the Proposed Change will be located either in-pit or off the mesa in order to minimise clearing in the MEZ. **Rehabilitate**: The Closure Plan (Appendix 3) includes a closure objective to ensure that final landform is stable and considers ecological values and that vegetation is self-sustaining. Progressive rehabilitation will be undertaken which will assist in re-establishing nutrient flows into the subterranean environment. **Offsets:** The Proponent proposes the provision of an environmental offset at the higher offset rate ($1,500 per hectare) for the unavoidable clearing of areas with other environmental values: PECs (the Subterranean invertebrate community of mesas in the Robe Valley region and the Subterranean invertebrate community of pisolitic hills in the Pilbara).	Monitoring results from Mesa A indicate that vibrations from blasting are not resulting in significant changes to subterranean cavities in the Mesa A MEZ (Section 6.4.1.2). Blasting conducted as part of the Proposed Change is, therefore, unlikely to affect the integrity of troglofauna habitat in the MEZs at Mesas A, B and C. Monitoring at Mesa A indicates that mining has had little discernible influence on the subterranean temperature and humidity in the Mesa A MEZ (Section 6.4.1.2). It is, therefore, considered that exposure of pit faces as part of the Proposed Change is unlikely to significantly alter the subterranean temperature and humidity in the MEZs at Mesas A, B and C. Given the proposed hydrocarbon management measures, hydrocarbon spills are unlikely to significantly degrade troglofauna habitat. The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor.

6.4.6.2 Management Plan

The management actions in the current Mesa A Troglofauna Fauna Management Plan have been reviewed and, where appropriate, incorporated into the draft Mesa A Hub EMP (Appendix 4). Subject to approval, the Mesa A Hub EMP will supersede the current Mesa A Troglofauna Management Plan.

Review of the sampling of troglofauna conducted under the current Troglofauna Management Plan indicated that the current sampling is providing valuable data that demonstrate persistence of troglofauna in the MEZ at Mesa A. The Proponent considers the troglofauna sampling program can be improved by:

- Increasing the area sampled to include Mesas B and C, Warramboo, Highway/Tod Bore and Dinner Camp Bore in addition to the currently sampled area at Mesa A
- Utilising both scraping and trapping troglofauna sampling methods at all holes
- Defining the timing of sampling and the minimum number of holes to be sampled
- Identifying all specimens to species level and aligning specimens with existing taxa/specimens where possible.

The proposed improvements to the current troglofauna sampling program are discussed in further detail in the draft Mesa A Hub EMP (Appendix 4).

Review of the measurement of subterranean temperature and humidity conducted under the current Troglofauna Management Plan indicated that the current monitoring is providing valuable data about the subterranean environment. The Proponent, therefore, proposes to continue monitoring of subterranean temperature and humidity at Mesa A. The proposed changes to the pit design at Mesa A will result in decommissioning of one of the troglobitic fauna habitat monitoring stations; 11 monitoring stations will remain accessible. The Proponent proposes to continue monitoring at Mesa B by relocating the three current reference locations to the proposed MEZ at Mesa B thus ensuring continuity of data collection from Mesa B as far as possible. Establishment of an additional three monitoring locations at Mesa F as reference sites is also proposed. The design of the proposed subterranean temperature and humidity monitoring program thus includes monitoring before mining (Mesa B), during mining (Mesa A and subject to approval, Mesa B) and in reference habitat (Mesa F). Given the mesas in the Robe Valley comprise the same pisolite geology with similar inter-stratigraphic features and similar occurrence of cavities, the subterranean temperature and humidity data collected from Mesas A, B and F will provide data to assess potential impacts of mining that is relevant to all mesas in the Robe Valley.

The impact of blasting and mining on the integrity of troglofauna habitat at Mesa A has been examined annually since commencement of mining in 2010 using an optical televiewer probe. Impacts that could be attributed to mining operations have not been detected. As monitoring of potential impacts from blasting and mining have not been detected over a significant period, it is considered that additional monitoring would not provide any further insight into potential impacts, nor could the results be usefully linked to triggers and thresholds. Optical televiewer assessment has, therefore, not been included in the draft Mesa A Hub EMP.

A review characterising troglofauna habitat and the potential for reconstruction of habitat was undertaken in 2013 (Biota and D.C. Blandford & Associates 2013). The review concluded that air-filled cavities and a constantly high relative humidity are the key

troglofauna habitat requirements. Current methods for placing waste rock material in-pit are unlikely to result in a structure with cavities similar in size and connectivity to those in the natural mesa formations. Despite these limitations sampling from drillholes that run through waste dumps and into the formation below has yielded troglofauna, demonstrating that troglofauna continue to use habitat under waste dumps and/or use the waste dumps themselves. Further work is underway to establish whether the habitat beneath the waste dump or the waste dump itself is being utilised. Troglofauna sampling beneath the pit floor and in waste dumps will continue at Mesas A and K but has not been included in the Mesa A Hub EMP as this sampling is dependent on the limited availability of, and access to, drill holes in the active mining area

6.5 Stygofauna

6.5.1 Receiving environment

6.5.1.1 Surveys and studies

Sampling for stygofauna was undertaken in water monitoring sites, stock-wells and production bores within or near the Warramboo borefield (including sites in the Yarraloola area to the north of the Development Envelope) in 2006 (Biota 2006b). The survey was undertaken to address the potential impacts on stygofauna arising from the then proposed Mesa A/Warramboo Iron Ore Project which required a local groundwater source to supply production water for the proposed mining operations.

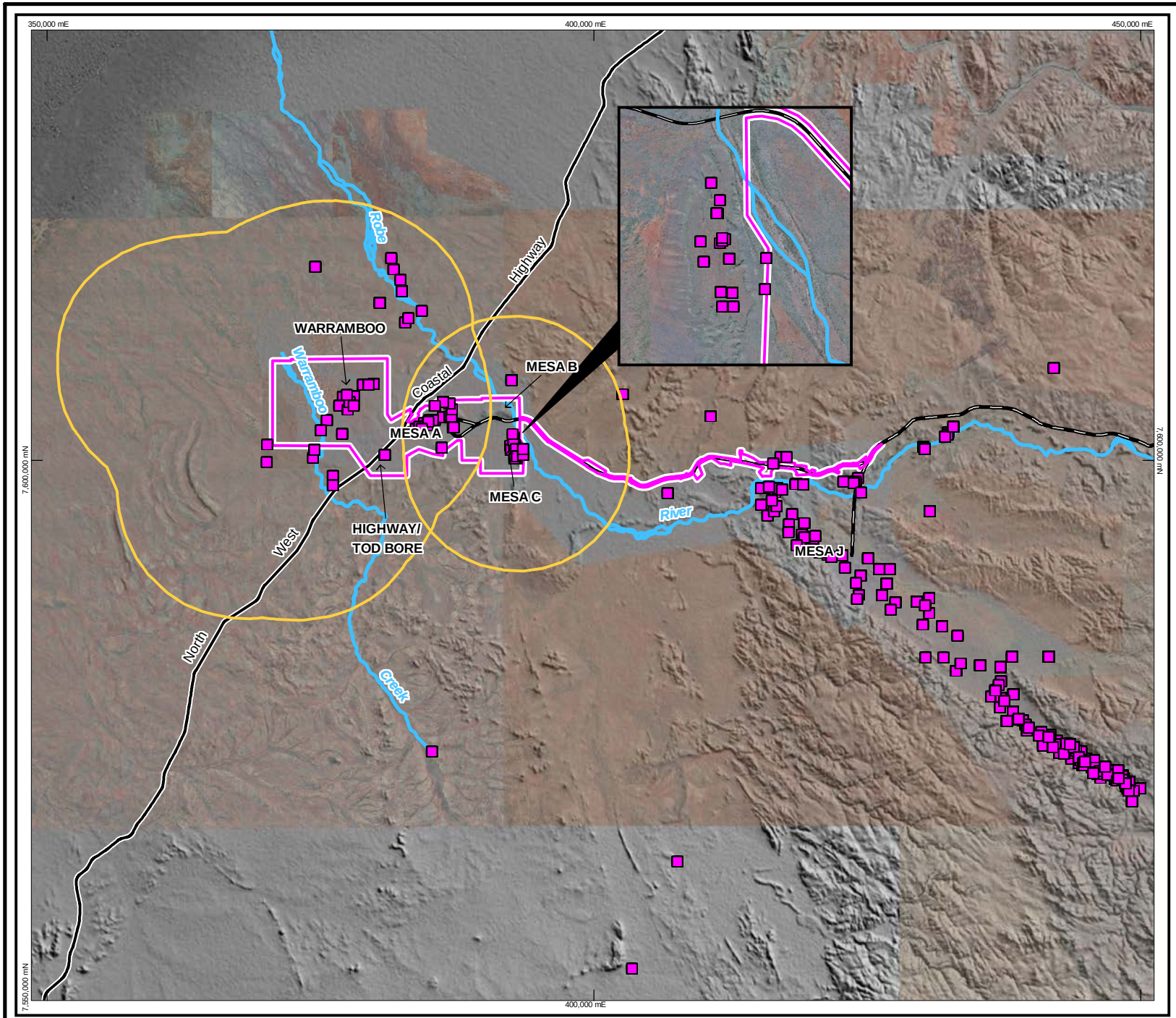
One Level 2 stygofauna study has subsequently been undertaken specifically for the Proposed Change (Biota 2017d) which comprised a detailed desktop assessment along with a three phase survey at Warramboo (between June 2015 and December 2016) and a two-phase survey at Mesa C (between December 2016 and March 2017). Biota (2017d) considered stygofauna recorded within the modelled extent of drawdown at Warramboo and Mesa C as well as within an area extending 10 km around the modelled drawdown extent at Warramboo ('Warramboo buffer area') and Mesa C ('Mesa C buffer area') (refer Figure 6-31) and within the broader Robe Valley.

In addition, three aquatic fauna surveys have been undertaken as part of the Proposed Change investigations: a baseline sampling program for aquatic ecosystems of Warramboo Creek in 2016 and 2018 (WRM 2016, 2018); and a baseline sampling program for aquatic ecosystems of the Robe River/Mungarathoona Creek, adjacent to Mesas B and C (WRM 2017). While these surveys do not target subterranean fauna or stygofauna, stygobites (obligate groundwater dwellers) do occasionally get caught as by-catch. Eight stygofauna species were recorded as by-catch during these surveys (five previously recorded and three new species).

Stygofauna sampling effort across the Robe Valley is shown in Figure 6-31. Stygofauna species recorded are described in Section 6.5.1.3 and the aquatic fauna surveys are described further in Section 7.4.

Table 6-23: Summary of supporting stygofauna surveys

Report	Summary	Survey date
Mesa A/Warramboo and Yarraloola Borefield Development Baseline Stygofauna Assessment Biota (2006b)	A survey for stygofauna within or near the Warramboo borefield. Sites sampled included monitoring sites, stock-wells and production bores in the Warramboo borefield area and in the Yarraloola area to the north of the Development Envelope. The survey was undertaken to address the potential impacts on stygofauna arising from the then proposed Mesa A/Warramboo Iron Ore Project to use local groundwater to supply production water for the proposed mining operations.	October 2005
Mesa A Hub: Warramboo and Mesa C Stygofauna Assessment Biota (2017d)	Biota (2017d) undertook a Level 2 stygofauna survey comprising a desktop assessment along with three phases of sampling in and around the Warramboo area (between June 2015 and December 2016), and two phases in and around the Mesa C area (between December 2016 and March 2017). A total of 25 sites were sampled for stygofauna at Warramboo: seven sites located outside of the modelled drawdown extent and 18 sites located within the modelled drawdown extent. A total of 23 sites were sampled for stygofauna at Mesa C: 10 sites located outside the modelled drawdown extent and 13 sites located within the modelled drawdown extent.	April, June, September and October 2015 December 2016 March 2017



LEGEND

- Development Envelope
- Railway
- Highway
- Major Watercourse
- Stygofauna Sampling
- Warramboo and Mesa C 10km buffer

N

SCALE

5 0 5 10 15km

1:420 000 @ A4

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Iron Ore (WA)

Figure 6-31: Stygofauna sampling effort across the Robe Valley

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0158527v5
Proj:MGA94 Zone50

Geospatial Information and Mapping

6.5.1.2 Habitat

The hydrogeology of the western portion of the Development Envelope is described in Section 8.4.

The likely habitats for stygobitic fauna in the study area were characterised using regional information, site specific geological data and stygofauna survey results. Four key geological units occur BWT at Mesa C and Warramboo including:

- Robe Pisolite
- Alluvium
- Yarraloola Conglomerate (occurs at Warramboo only)
- Ashburton Formation.

The geology of Warramboo can be broadly summarised as unsaturated alluvium over Robe Pisolite which is then underlain by the Yarraloola Conglomerate and the basal Ashburton Formation. The Ashburton Formation is comprised of highly folded shale and siltstone and as such, generally exhibits little to no permeability, acting hydrologically as an aquiclude. The Ashburton Aquiclude intersects the water table to the west, south-east and east of Warramboo generating a no-flow boundary between Warramboo and Mesa A and between Warramboo and the Robe River. Other than the no-flow boundary generated by the Ashburton Aquiclude, stygofauna sampling results and hydrogeological data indicate that there is unlikely to be any significant physical barrier to stygofauna dispersal within the Yarraloola Conglomerate in the vicinity of the western portion of the Development Envelope and surrounds. Based on Geological Survey of WA 1:250,000 and 1:500,000 surface geology mapping, the Yarraloola Conglomerate is inferred to extend almost 200 km southwest towards the coast from the Development Envelope. The alluvium and unconsolidated material associated with the Robe River are inferred to extend the length of the Robe River; northwest from the Development Envelope to the coast and upstream of the Development Envelope to the headwaters of Bungaroo and Middle Robe/Deepdale, spanning approximately 230 km. Together these geological units are likely to provide primary habitat for stygofauna (Biota 2017d).

The Mesa C Aquifer occurs within the Robe Pisolite. Hydrogeological and geochemical data indicate that under steady state conditions or during seasons with inconsequential rainfall events the Mesa C Aquifer is likely to be isolated from throughflow recharge as the aquifer is bounded to the west and south by the Ashburton Aquiclude and to the east and bottom by the low permeability Ashburton Aquitard (Rio Tinto 2017c). Groundwater flow between the Mesa C Aquifer and the Robe River Aquifer via the Ashburton Aquitard is expected to be very low. Some groundwater flow may occur at the northern tip of the deposit where the Mesa C Aquifer intersects the Robe River Alluvial Aquifer, however, given the clayey nature of the basal pisolite, throughflow is expected to be minimal. During periods of high rainfall, an indirect connection between the Robe River Alluvial Aquifer and the Mesa C CID Aquifer may exist as the water table may rise above the Ashburton Aquitard, inducing infiltration into the Mesa C CID Aquifer from the Robe River streamflow. This recharge flow may then become trapped in the Mesa C CID Aquifer once the water level drops below that of the Ashburton Aquitard (Section 8.4.3.2 and Figure 8-3).

The likelihood of the geological units described above representing suitable habitat for stygofauna was categorised into Low, Moderate and High, based on the following characteristics (Biota 2017d; Table 6-24):

A. Presence of interstitial spaces or vugs.
B. Continuity and transmissivity of the local occurrence of submerged geological units.
C. The known occurrence of stygal communities recorded from equivalent rock types during previous Pilbara surveys.
D. Absence of large amounts of fine sediments such as clays, silts and sands within the geological unit description.
E. Substrate permits inflow of surface water and infiltration of nutrients.
F. Substrate is submerged below the water table.

Table 6-24: Stygofauna habitat prospectivity definitions (Biota 2017d)

Prospectivity	Definition
High	Majority (five or six) of characteristics confirmed for the geological unit, including the presence of continuous, transmissive aquifer (A, B). Geology sufficiently porous to allow nutrient infiltration from surface water run-off (E). Stygofauna routinely recorded from same rock type (C) and partially or completely submerged below the water table (F).
Medium	Unit likely partially or completely submerged below the water table (F). Presence of interstitial spaces (A), low numbers of stygofauna have been recorded from this geology previously (C). Small amounts of fine sediments within the unit (D).
Low	Suitable geological unit may occur only above the water table within the study area. Rock type might have interstitial spaces (A) however may have high levels of fine sediments which reduce usability of spaces. Stygofauna not known from previous studies sampling of the same geology (C).

Of the four key geological units, Alluvium and Robe Pisolite were categorised as high prospectivity habitat and considered likely to provide primary habitat for stygofauna where they occur BWT (Table 6-25 and Figure 6-32). Both the Robe Pisolite and alluvium geological units have been previously identified by the EPA as potential stygofauna habitat (Biota 2017d). The Yarraloola Conglomerate is categorised as having medium habitat prospectivity where it occurs BWT (Biota 2017d; Table 6-25 and Figure 6-32).

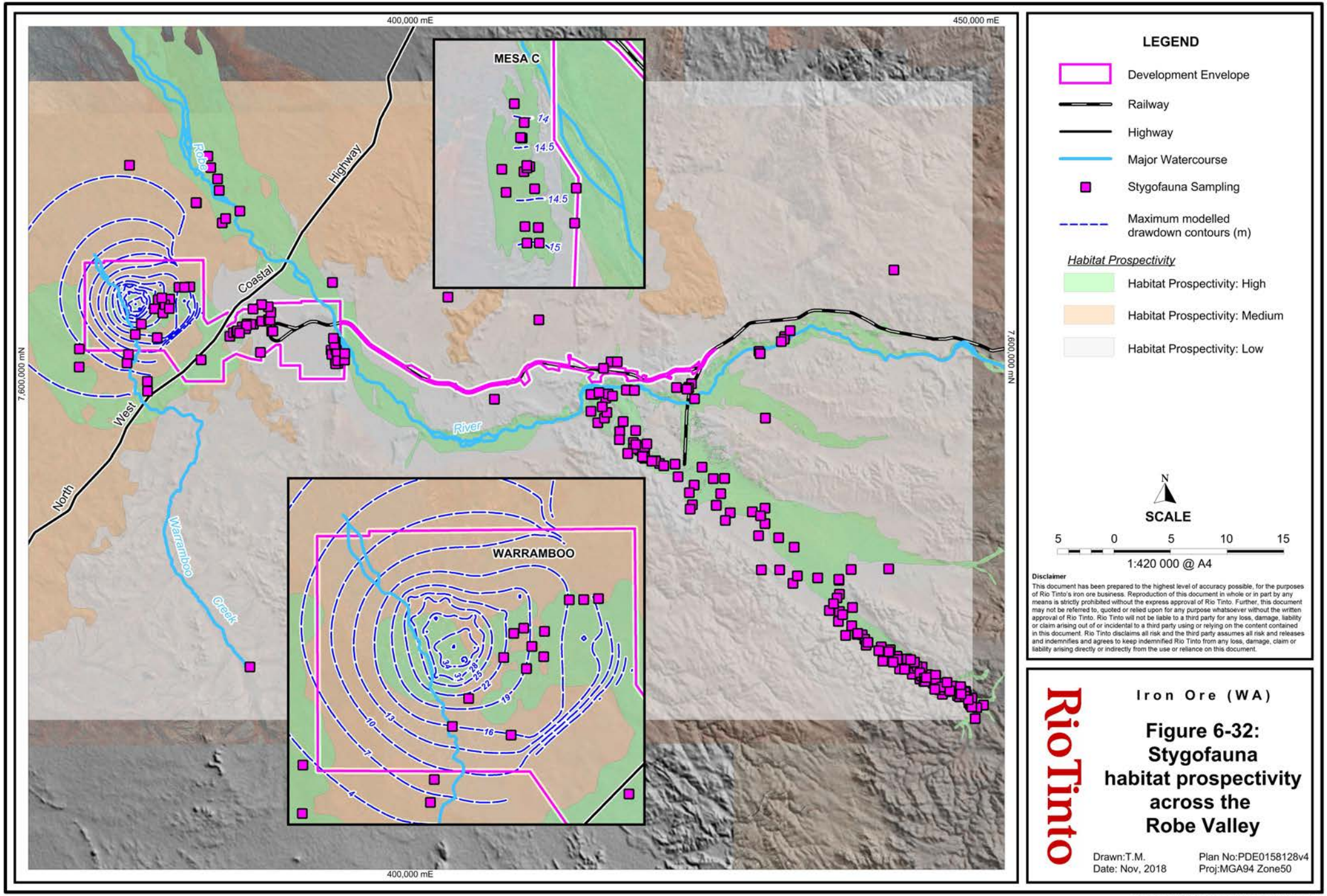
The Ashburton Formation was identified as low prospectivity stygofauna habitat as the general lack of permeability in this unit makes it unsuitable as stygofauna habitat (Biota 2017d; Table 6-25 and Figure 6-32).

Table 6-25: Stygofauna habitat prospectivity of the geological units within the study area

Habitat prospectivity	Geological unit	Description
High	Robe Pisolite	Pisolitic limonite deposits. Occurs along old river channels. Unit predominantly above water table.
	Alluvium	Unconsolidated fluviatile deposits, mostly sand.
Medium	Yarraloola Conglomerate	Polymictic conglomerate, which typically consists of pebbles of chert, BIF and/or quartz in oxidised (limonitic), sandy clays. Predominantly BWT within the study area.
Low	Ashburton Formation	Impermeable basement geological unit predominantly submerged within the study area.

No TECs, PECs or Environmentally Sensitive Areas relating to stygofauna occur in the western portion of the Development Envelope. The Priority 1 PEC, the Stygofauna community of the Bungaroo Aquifer, occurs approximately 30 km south-east of the Development Envelope.

Stygofauna habitat prospectivity across the Robe Valley is shown in Figure 6-32. Habitat prospectivity mapping was verified by overlaying specimen results and null records on the habitat prospectivity mapping.



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Iron Ore (WA)

Figure 6-32: Stygofauna habitat prospectivity across the Robe Valley

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0158128v4
Proj:MGA94 Zone50

Geospatial Information and Mapping

6.5.1.3 Records

A total of 8,824 stygofauna specimens have been recorded in the broader Robe Valley, from an area spanning from the headwaters of the Bungaroo Valley to west of Warramboo between 2002 and 2016. Of these specimens, a total of 128 stygobitic taxa have been identified, including three species of conservation significance (Biota 2017d):

- Two amphipod species: *Nedsia hurlberti* and *Nedsia sculptilis* – both listed as Threatened - Vulnerable under Schedule 3 of the WC Act
- The Blind Cave Eel: *Ophisternon candidum* – listed as Threatened - Vulnerable under the EPBC Act and Vulnerable under Schedule 3 of the WC Act.

In the combined Warramboo and Mesa B buffer areas a total of 85 taxa stygobitic taxa have been identified (Figure 6-33) of which one, *Nedsia hurlberti*, is listed as conservation significant.

A total of 71 stygobitic species have been recorded from the Warramboo buffer area. Of the species recorded only *Nedsia hurlberti* is listed as conservation significant and none are categorised as confirmed SRE species using the WA Museum SRE guidelines (Biota 2017d). The taxa recorded include:

- *Nedsia hurlberti*
- 16 potential SREs
- 54 widespread species.

The 16 potential SRE taxa are listed in Table 6-26. Species (including *Nedsia hurlberti*) were considered widespread where they were recorded in multiple locations throughout the Pilbara or other locations (such as Barrow Island). These species show little geological restriction and are unlikely to represent true stygobites or SREs.

Table 6-26: Potential SRE stygobitic species recorded from the Warramboo buffer area (Biota 2017d, WRM 2017)*

Order	Species	SRE status	Known locations
Amphipoda	*Eriopisidae nov. gen.* sp. 'AMM006'	Potential SRE	Warramboo buffer area
	Nedsia sp. 'AMM002'	Potential SRE	Warramboo buffer area
	Nedsia sp. 'AMM003'	Potential SRE	Warramboo buffer area
	Nedsia sp. 'AMM005'	Potential SRE	Warramboo buffer area
	Nedsia sp. 'AMM027'	Potential SRE	Warramboo buffer area
	Nedsia sp. 'AMM028'	Potential SRE	Warramboo buffer area
	Nedsia sp. 'AMM031'	Potential SRE	Warramboo buffer area and Mesa C buffer area
	Niphargidae sp. 'AMN001'	Potential SRE	Warramboo buffer area
	Niphargidae sp. 'AMN008'	Potential SRE	Warramboo buffer area
Bathynellacea	*Atopobathynella* sp. 'B25'	Potential SRE	Warramboo buffer area

Order	Species	SRE status	Known locations
Podocopida	*Cypretta* sp. '4'	Potential SRE	Warramboo buffer area
	Humphreyscandona imperfecta	Potential SRE	Warramboo buffer area. Also recorded from Fortescue River site approximately 58 km north of Warramboo and from a site 175km south-east of Warramboo
	Humphreyscandona pilbarae	Potential SRE	Warramboo buffer area Also recorded from Fortescue River site approximately 58 km north of Warramboo
	Meridiescandona sp. '2'	Potential SRE	Warramboo buffer area
	Origocandona sp. '2'	Potential SRE	Warramboo buffer area Also recorded from Fortescue River site approximately 58 km north of Warramboo.
Tubificida	*Phreodrilus* sp. 'WA32'	Potential SRE	Warramboo buffer area Also recorded from one Department of Parks and Wildlife Pilbara Stygofauna Survey site approximately 50 km west of Warramboo.

* Widespread species excluded

Of the 71 stygobitic species recorded from the Warramboo buffer area, three were recorded during the aquatic fauna surveys undertaken at Warramboo in 2018 (WRM 2018):

- *Candonopsis tenuis*
- *Vestalenula marmonieri*
- *Parastenocaris jane*.

A total of 34 stygobitic species have been recorded from the Mesa C buffer area. Only *Nedsia hurlberti* is listed as conservation significant and none are categorised as confirmed SRE species using the WA Museum SRE guidelines (Biota 2017d). The taxa recorded include:

- *Nedsia hurlberti*
- 11 potential SREs
- 22 widespread species.

The 11 potential SRE taxa are listed in Table 6-27. The 22 widespread species recorded at Mesa C are unlikely to represent true stygobites or SREs and as such, these species have been excluded from further assessment in this ERD.

Of the 34 stygal taxa, five were recorded during the aquatic fauna surveys undertaken at Mesa B / C (WRM 2017):

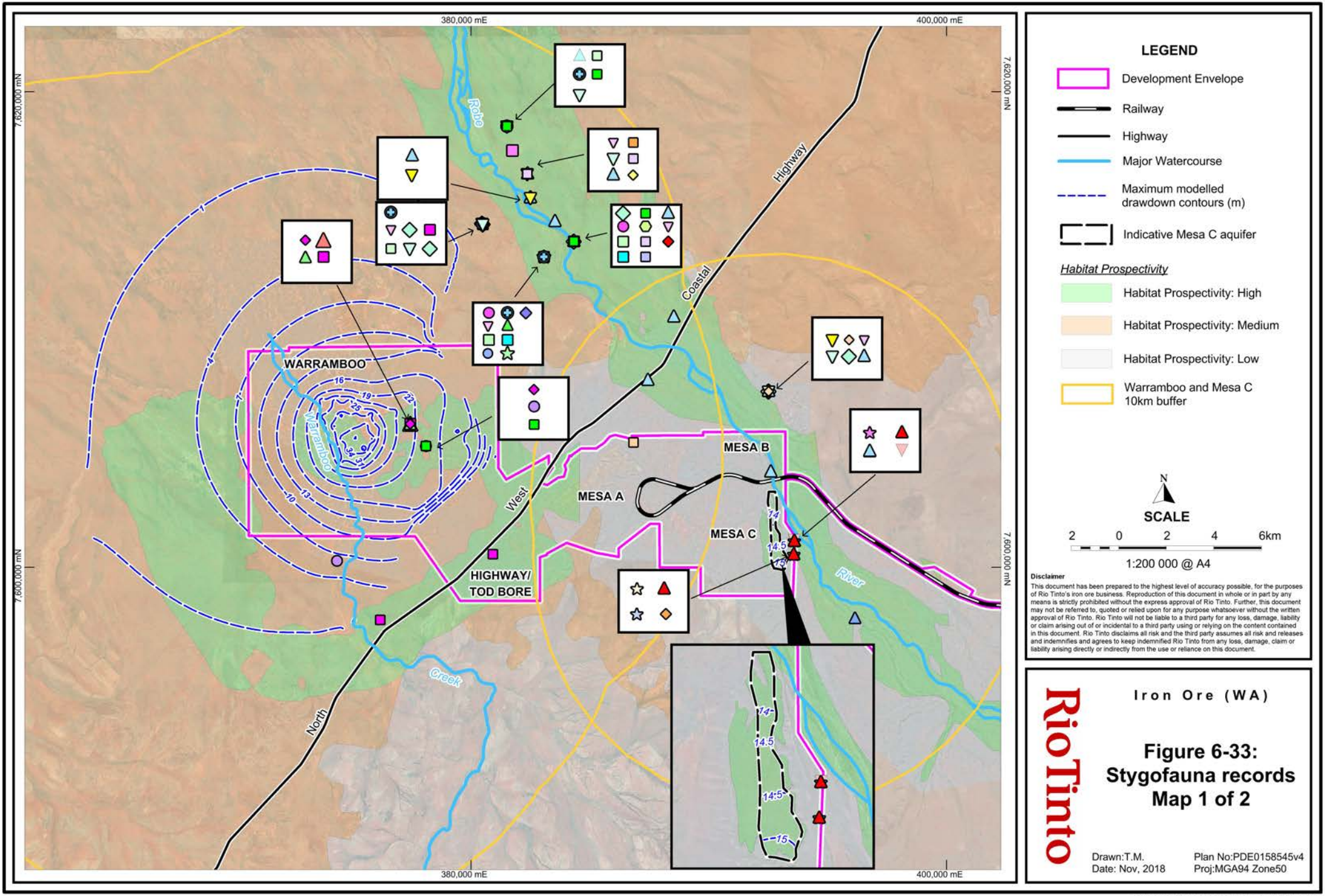
- *Pilbarophreatoicus platyarthricus*
- *Halosbaena tulki*
- *Nedsia* sp. 'AMM001/029/030' (also called *Nedsia* AMP-Eri-001)
- *Candonopsis cf. tenuis*
- *Vestalenula marmonieri*.

Following subsequent molecular work on the *Nedsia* taxa only *Pilbarophreatoicus platyarthricus* remains as a potential SRE taxa (see Western Australian Museum report in Appendix 2 of Biota 2017). *P. platyarthricus* is known from the Robe River catchment and its tributaries, including Mungarathoona Creek. The remaining four taxa are relatively widespread in the Pilbara region.

Table 6-27: Potential SRE stygobitic species recorded from the Mesa C buffer area (Biota 2017d, WRM 2017)*

Order	Species	SRE status	Known locations
Amphipoda	*Nedsia* sp. 'AMM004'	Potential SRE	Mesa C buffer area Also recorded from Mesa H
	Nedsia sp. 'AMM031'	Potential SRE	Mesa C buffer area and Warramboo buffer area
	Niphargidae sp. 'AMN007'	Potential SRE	Mesa C buffer area
	Niphargidae sp. 'AMN008'	Potential SRE	Mesa C buffer area
Cyclopoida	*Dussartcyclops uniarticulatus*	Potential SRE	Mesa C buffer area
Harpacticoida	*Lucionitocrella yalleenensis*	Potential SRE	Mesa C buffer area Described from site approximately 78 km east of Mesa C
	Megastygonitocrella unispinosa	Potential SRE	Mesa C buffer area Also recorded from Robe River site approximately 47 km north of Mesa C
Isopoda	*Pilbarophreatoicus platyarthricus*	Potential SRE	Robe River catchment and its tributaries, including Mungarathoona Creek
Ostracoda	*Areacandona* sp. BOS818	Potential SRE	Mesa C buffer area
Podocopida	*Meridiescandona* sp. '2'	Potential SRE	Mesa C buffer area
	Pilbaracandona sp. 'BOS526'	Potential SRE	Mesa C buffer area

* Widespread species excluded



LEGEND

- Development Envelope
- Railway
- Highway
- Major Watercourse
- Maximum modelled drawdown contours (m)
- Indicative Mesa C aquifer

Habitat Prospectivity

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Habitat Prospectivity: Low
- Warramboo and Mesa C 10km buffer

N

SCALE

2 0 2 4 6km

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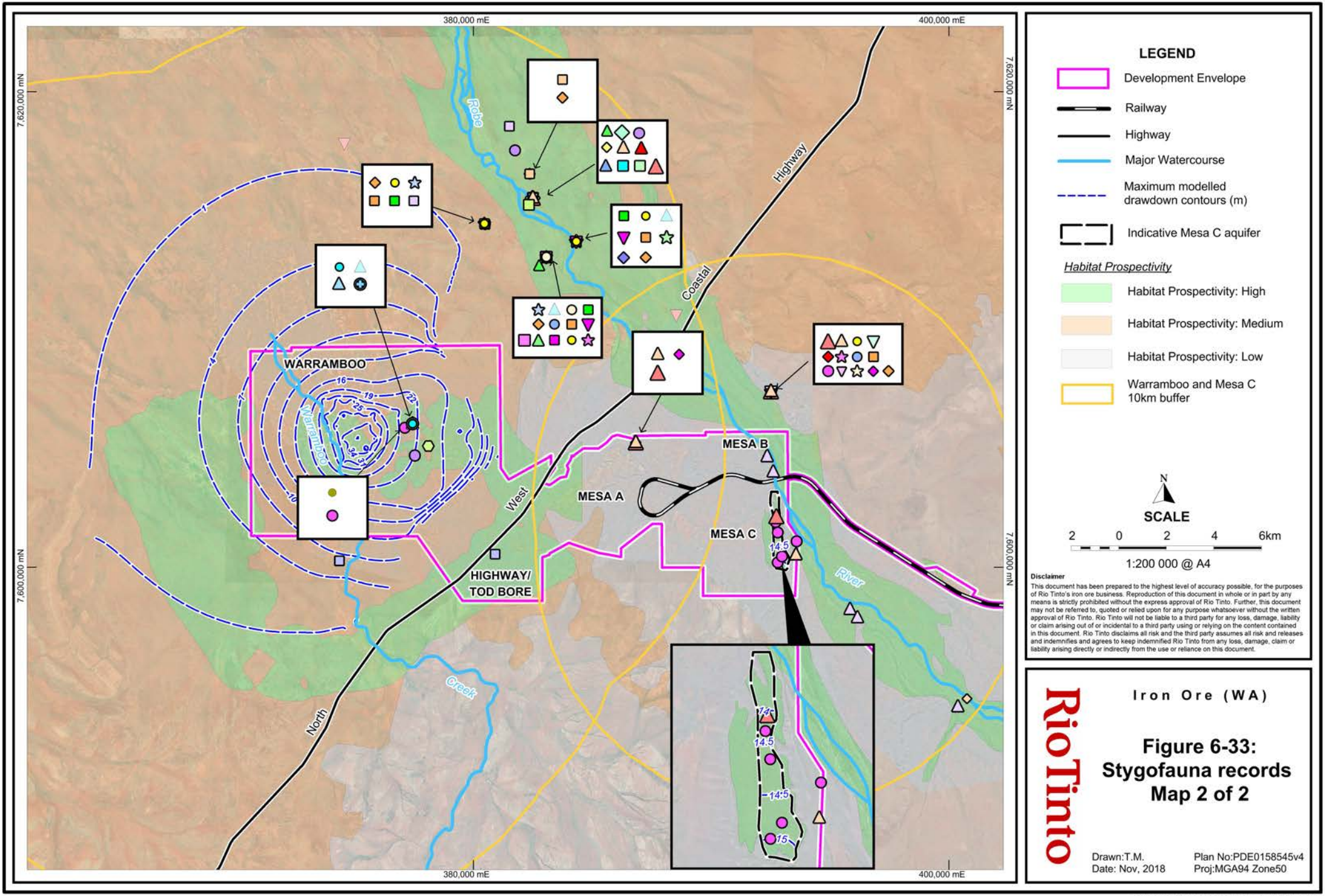
Iron Ore (WA)

Figure 6-33: Stygofauna records Map 1 of 2

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0158545v4
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Railway
- Highway
- Major Watercourse
- Maximum modelled drawdown contours (m)
- Indicative Mesa C aquifer

Habitat Prospectivity

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Habitat Prospectivity: Low
- Warramboo and Mesa C 10km buffer

N

SCALE

2 0 2 4 6km

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Iron Ore (WA)

Figure 6-33: Stygofauna records Map 2 of 2

Drawn:T.M.
Date: Nov, 2018

Plan No:PDE0158545v4
Proj:MGA94 Zone50

Geospatial Information and Mapping

LEGEND

Stygofauna species Map 1

- Aeolosoma sp. 3
- Apocyclops dengizicus (Lepeschkin)
- Areacandona astrepte Karanovic
- Areacandona scanloni Karanovic
- Areacandona sp. 'BOS818'
- Areacandona sp. 4
- Arrenurus sp. nov. 2
- Atopobathynella sp. 'B25'
- Atopobathynella sp. A
- Bathynella sp. 2
- Bogidiellidae sp. 1
- Candonopsis cf. tenuis
- Cypretta seurati Gauthier
- Cypretta sp. 4
- Deminutiocandona aenigma Karanovic
- Dero furcata
- Diacyclops einslei De Laurentiis et al.
- Diacyclops sobeprolatus Karanovic
- Dussartcyclops uniarticulatus
- Elaphoidella humphreysi Karanovic
- Elaphoidella nr humphreysi
- Enchytraeus Pilbara sp. 1
- Enchytraeus Pilbara sp. 2
- Eriopisidae nov. gen. sp. 'AMM006'
- Eriopisidae sp. 'AMM026'
- Gomphodella hirsuta Karanovic
- Guineaxonopsis sp. S1
- Halicyclops (Rochacyclops) roachi De Laurentiis et al.
- Halosbaena tulki
- Haptolana yarraloola
- Humphreyscandona fovea
- Humphreyscandona imperfecta Karanovic
- Humphreyscandona pilbarae Karanovic and Marmonier
- Humphreyscandona woutersi Karanovic and Marmonier
- Kagalana tonde Bruce
- Lucionitocrella yalleenensis
- Megastygonitocrella unispinosa
- Melitidae sp. 1

Stygofauna species Map 2

- Meridiescandona sp. 2
- Metacyclops pilbaricus Karanovic
- Microcyclops varicans
- Namanereis sp. '1'
- Nedsia nr hurlberti
- Nedsia sp. 24
- Nedsia sp. 'AMM001/029/030'
- Nedsia sp. 'AMM002'
- Nedsia sp. 'AMM003'
- Nedsia sp. 'AMM004'
- Nedsia sp. 'AMM005'
- Nedsia sp. 'AMM027'
- Nedsia sp. 'AMM028'
- Nedsia sp. 'AMM031'
- Nematoda sp. 11
- Nematoda sp. 2
- Nematoda sp. 3
- Niphargidae sp. 'AMN001'
- Niphargidae sp. 'AMN008'
- Niphargidae sp. 'AMN007'
- Niphargidae sp. 'AMN008'
- Orbuscyclops westaustraliensis Karanovic
- Oribatida group 1
- Oribatida group 4
- Origocandona sp. 2
- Paracyclops chiltoni
- Paramelitidae sp. 'AMP009'
- Paramelitidae sp. 'AMP023'
- Paramelitidae sp. 2
- Parapseudoleptomesochra tureei Karanovic
- Phreodrilid with dissimilar ventral chaetae
- Phreodrilid with similar ventral chaetae
- Phreodrilus n. sp. WA32
- Pilbaracandona rosa Karanovic
- Pilbaracandona sp. 'BOS526'
- Pilbarophreatoicus platyarthricus
- Pilbarus millsi Bradbury and Williams
- Pristina longiseta
- Pseudectinosoma galassiae Karanovic
- Schizopera roberiverensis
- Schizopera roberiverensis Karanovic
- Stygonitocrella trispinosa Karanovic
- Stygonitocrella unispinosa Karanovic
- Stygoridgewayia trispinosa
- Thermocyclops decipiens
- Tubificidae stygo type 2A
- Vestalenula marmonieri

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Iron Ore (WA)

Stygofauna records Legend Map 1 and Map 2

Drawn:T.M. Plan No:PDE0158545v1
Date:February, 2018 Proj:MGA94 Zone50

6.5.2 Potential impacts

A number of potential impacts are identified in the ESD. The potential direct, indirect and cumulative impacts identified for the Proposed Change on the basis of stygofauna surveys and assessments are described in Sections 6.5.2.1 to 6.5.2.3.

6.5.2.1 Direct impacts

Potential direct impacts of the Proposed Change have been identified as:

- Reduction in stygofauna habitat due to BWT pit excavation at Warramboo and Mesa C (physical removal of habitat)
- Reduction in stygofauna habitat due to groundwater abstraction resulting in groundwater drawdown at Warramboo and Mesa C
- Loss of individuals and changes to assemblages due to groundwater abstraction and BWT mining at Warramboo and Mesa C.

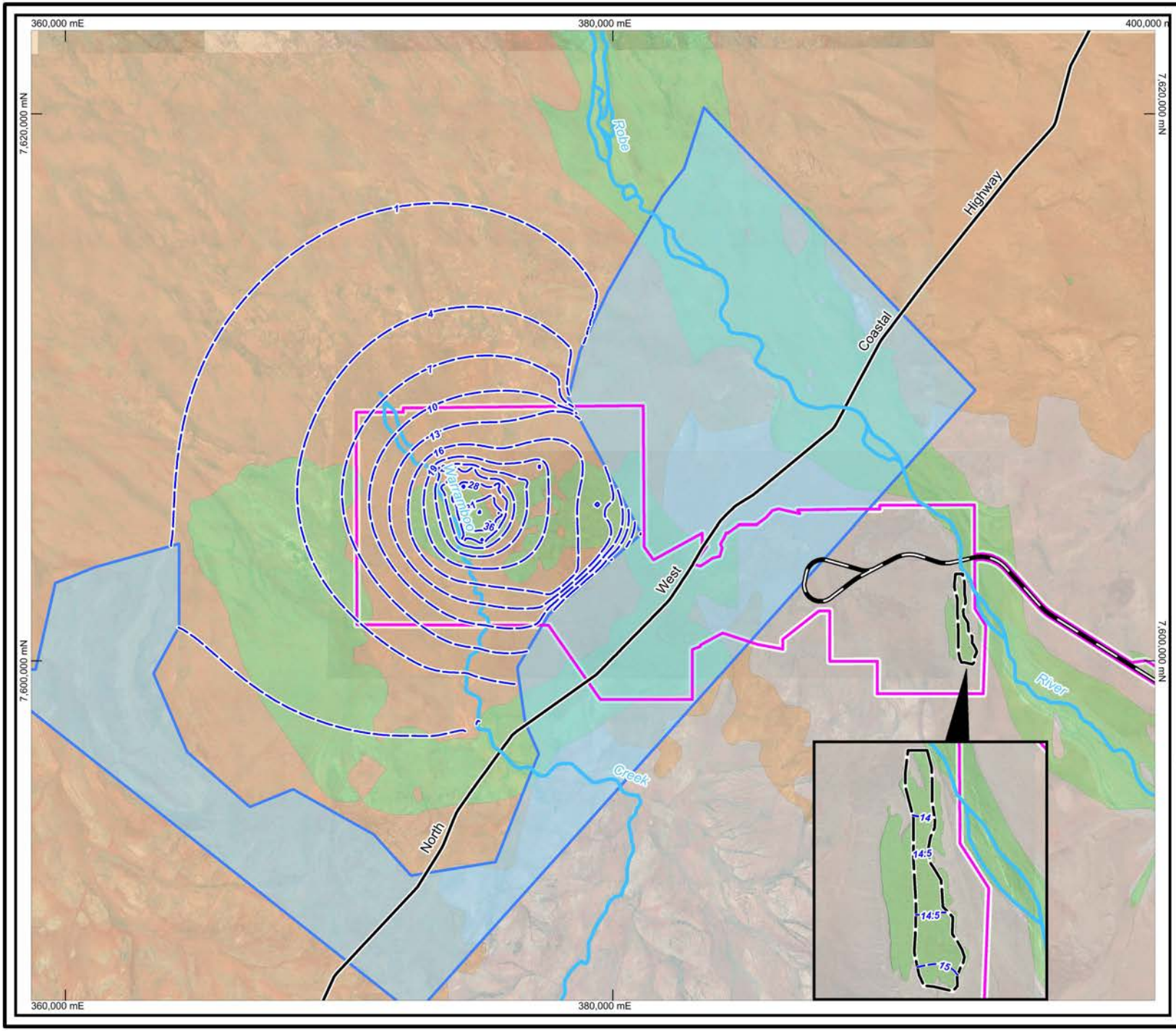
BWT mining and groundwater abstraction are not proposed at Mesas A and B and Highway/Tod Bore, so no direct impacts related to stygofauna are anticipated within these areas.

Figure 6-34 shows the maximum modelled extent of groundwater drawdown at Warramboo and Mesa C in relation to modelled stygofauna habitat prospectivity.

Sixteen potential SRE stygofauna species were recorded from the Warramboo buffer area (Table 6-26) of which four are currently known only from within the modelled extent of drawdown at Warramboo (Figure 6-35):

- *Atopobathynella* sp. ‘B25’
- *Cypretta* sp. ‘4’
- *Nedsia* sp. ‘AMM003’
- *Nedsia* sp. ‘AMM005’.

Two stygofauna species were recorded at Mesa C (*Nedsia* sp. ‘AMM004’ and *Nedsia* sp. ‘AMM031’). Both of these species have also been recorded from the adjacent Robe River Alluvial Aquifer and the level of genetic divergence between the specimens from the two aquifers was established to be low (Biota 2017d).



LEGEND

- Development Envelope
- Railway
- Highway
- Major Watercourse
- Indicative Mesa C aquifer
- Ashburton Formation intersects water table (modelled no-flow boundary)
- Maximum modelled drawdown contours (m)

Habitat Prospectivity

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Habitat Prospectivity: Low

N

SCALE

2 0 2 4 6km

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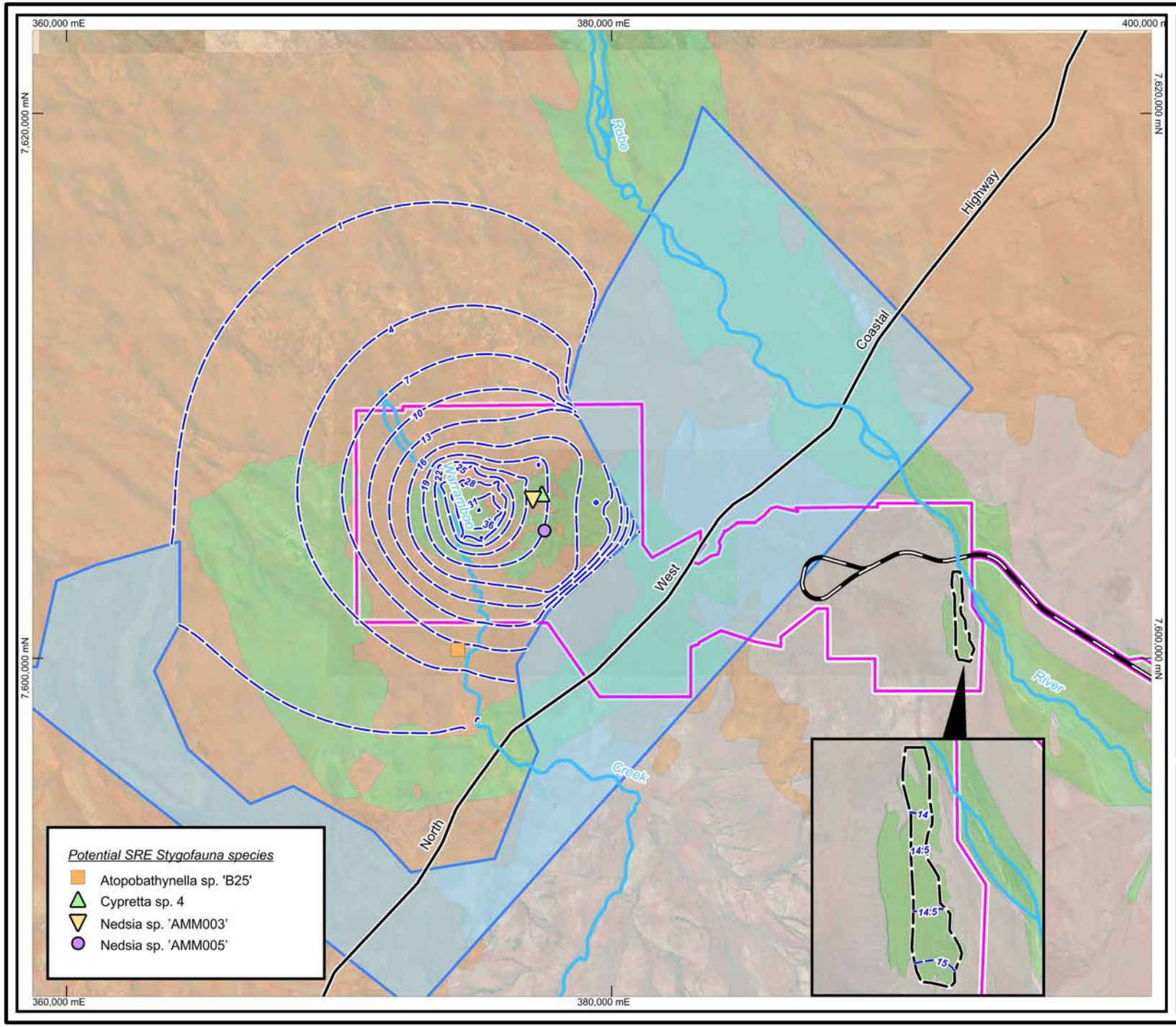
Iron Ore (WA)

Figure 6-34: Maximum modelled extent of groundwater drawdown in relation to stygofauna habitat prospectivity

Drawn:T.M.
Date:Aug, 2018

Plan No:PDE0161677v3
Proj:MGA94 Zone50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Railway
- Highway
- Major Watercourse
- Indicative Mesa C aquifer
- Ashburton Formation intersects water table (modelled no-flow boundary)
- Maximum modelled drawdown contours (m)

Habitat Prospectivity

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Habitat Prospectivity: Low

N

SCALE

2 0 2 4 6km

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Iron Ore (WA)

Figure 6-35: Potential SRE stygofauna species currently known only from locations within the modelled extent of groundwater drawdown at Warramboo

Drawn:T.M.
Date: Aug, 2018

Plan No:PDE0161680v3
Proj:MGA94 Zone50

Geospatial Information and Mapping

6.5.2.2 Indirect impacts

Mining activities other than mine pit excavation and groundwater abstraction which may impact stygofauna through temporary loss or degradation of habitat include:

- Seepage from in-pit disposal of waste fines and reverse osmosis effluent which has the potential to change groundwater chemistry and degrade stygofauna habitat
- Hydrocarbon and wastewater spills which may result in a reduction in the quality of stygofauna habitat.

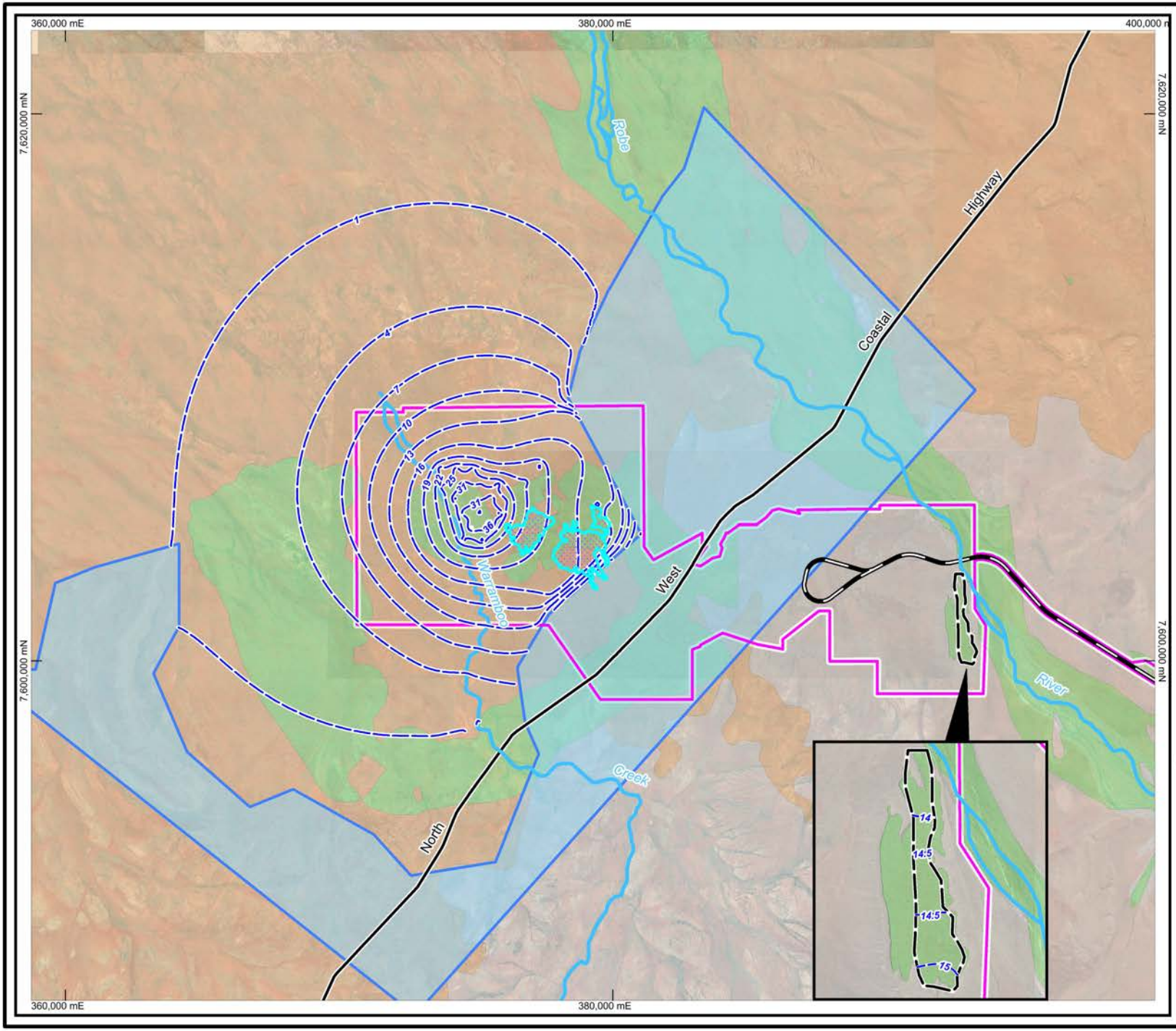
Figure 6-36 shows the location of the proposed WFSF in relation to stygofauna habitat prospectivity and the modelled drawdown contours.

6.5.2.3 Cumulative impacts

Existing and foreseeable groundwater users in the vicinity of the Development Envelope are identified in Section 8.5.3 and include:

- The approved activities
  - Groundwater license allowing up to 3 GL/a to be abstracted from the existing Warramboo borefield
- Yarraloola pastoral station
  - Six pastoral station bores within the modelled extent of drawdown for the Proposed Change
- Department of Main Roads
  - One bore within the modelled extent of drawdown for the Proposed Change
- The Revised Proposal
  - Abstraction of up to 15 GL/a (including the currently licensed 3 GL/a) from the extended Warramboo borefield
  - Abstraction of up to 5 GL/a from the Mesa C CID Aquifer.

The abstraction rates from the pastoral station bores and the Department of Main Roads bore are likely to be negligible compared with the proposed abstraction rate for the Proposed Change. Groundwater abstraction from the pastoral station and Department of Main Roads bores are, therefore, unlikely to significantly impact stygofauna habitat.



LEGEND

- Development Envelope
- Railway
- Highway
- Major Watercourse
- Indicative Mesa C aquifer
- Ashburton Formation intersects water table (modelled no-flow boundary)
- Maximum modelled drawdown contours (m)

Habitat Prospectivity

- Habitat Prospectivity: High
- Habitat Prospectivity: Medium
- Habitat Prospectivity: Low
- Waste Fines Storage Facility

N

SCALE

2 0 2 4 6km

1:200 000 @ A4

Disclaimer

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Iron Ore (WA)

Figure 6-36: Waste fines storage facility in relation to stygofauna habitat prospectivity and modelled extent of groundwater drawdown

Drawn:T.M.
Date: Aug, 2018

Plan No:PDE0161692v3
Proj:MGA94 Zone50

Geospatial Information and Mapping

6.5.3 Assessment of impacts

6.5.3.1 Direct impacts

Reduction in stygofauna habitat due to mine pit development and groundwater abstraction

The habitat characterisation undertaken by Biota (2017d) indicates stygofauna habitat is generally widespread across at least a third of the mapped broader Robe Valley area. The widespread nature of the habitat and the confirmation that at least 63 of the species recorded in the Warramboo and Mesa C buffer areas are considered widespread and occur in the wider Pilbara region, indicate that there is little evidence of significant barriers to dispersal across the mapped high and medium habitat prospectivity areas.

Warramboo

Eighty-nine percent of the Robe Pisolite deposit at Warramboo lies above the pre-mining water table and therefore very little of the deposit is suitable as stygofauna habitat. The Robe Pisolite is incised into the Yarraloola Conglomerate and where the Robe Pisolite intersects the water table, water throughflow is largely unconfined due to the presence of cavities in the Robe Pisolite. The proposed reduction in stygofauna habitat due to BWT mining of the Robe Pisolite at Warramboo is negligible compared with the extent of the connected Yarraloola Conglomerate.

The Yarraloola Conglomerate is considered to represent medium prospectivity habitat in the area (Biota 2017d). The Yarraloola Conglomerate is an extensive regional aquifer that extends to the west of Warramboo. The geology of the Warramboo area and the widespread distributions of most taxa recorded indicate there are unlikely to be any significant barriers to stygofauna dispersal within the proposed impact area or adjacent habitat to the north and west of the modelled extent of drawdown. Based on the inferred extent of the Yarraloola Conglomerate and hydrogeological modelling, it is estimated that the modelled cone of depression would impact less than 2% of the area of the Yarraloola Conglomerate (Rio Tinto 2017c). Extensive stygofauna habitat will, therefore, continue to be available outside the impact area during and after mining operations.

Hydrogeological modelling indicates that water abstraction at Warramboo for mine dewatering and water supply will temporarily reduce the saturated thickness of the aquifer by up to 70% at the centre of the cone of depression, reducing to approximately 2% of the saturated aquifer thickness approximately 12 km from the centre of the cone of depression. Stygofauna habitat (>19 m thick) will, therefore, continue to be available during and after mining operations within the footprint of the proposed groundwater drawdown. Following cessation of groundwater abstraction, recovery of the groundwater table, and hence recovery of stygofauna habitat, is expected to occur. Modelling indicates recovery of the groundwater table to 80% of the pre-mining groundwater level is expected to take approximately 40 years.

Given the small proportion of available habitat that will be impacted by the proposed groundwater drawdown and pit excavation at Warramboo and the lack of potential barriers to dispersal of stygofauna to the north and west of the area, it is considered that the Proposed Change is unlikely to significantly affect the ecological integrity of the stygofauna habitat in the Warramboo area.

Mesa C

Approximately 5% of the Mesa C orebody lies BWT at a depth of approximately 50 m below the surface of the mesa. Very little of the deposit is, therefore, suitable as stygofauna habitat.

As discussed in Section 6.5.1.2, hydrogeological test work indicates that the Mesa C CID Aquifer may be seasonally recharged from Robe River streamflow and the Robe River Alluvial Aquifer during periods of high rainfall. The Robe River Alluvial Aquifer is an extensive aquifer present along the length of the Robe Valley passing in close proximity to Mesa C. This aquifer is considered to represent high prospectivity stygofauna habitat (Biota 2017d). Recharge from the Robe River Alluvial Aquifer is likely to carry stygofauna with it, resulting in stygofauna potentially being deposited in the Mesa C Aquifer or dispersing from the Mesa C Aquifer into the wider groundwater system.

Results of stygofauna sampling from the Mesa C CID Aquifer indicate that recharge of the Mesa C CID Aquifer occurs on a reasonably frequent basis as the two stygofauna species recorded at Mesa C (*Nedsia* sp. 'AMM004' and *Nedsia* sp. 'AMM031') have also been recorded from the Robe River Alluvial Aquifer and the level of genetic divergence between the specimens from the two aquifers was low (Biota 2017d). Together the hydrogeological test work and stygofauna sampling results indicate that the Mesa C CID Aquifer is seasonally connected to the extensive stygofauna habitat present in the adjacent Robe River Alluvial Aquifer.

Given the evidence indicating connection of the Mesa C CID Aquifer with extensive high prospectivity habitat and the small proportion of available stygofauna habitat represented by the Mesa C CID Aquifer, it is considered that the Proposed Change is unlikely to significantly affect the ecological integrity of stygofauna habitat in the Mesa C area.

Loss of individuals and changes to assemblages due to mine pit development and groundwater abstraction

Mine pit excavation and groundwater abstraction will result in the direct loss of individuals. Sixteen potential SRE stygofauna species were recorded from the Warramboo buffer area (Table 6-26) of which five were recorded from within the modelled Warramboo drawdown extent. Of the five species recorded in the Warramboo drawdown extent, four (*Atopobathynella* sp. 'B25', *Cypretta* sp. '4', *Nedsia* sp. 'AMM003', *Nedsia* sp. 'AMM005') have currently been recorded only from within the modelled drawdown extent (Figure 6-35). The single conservation significant species, *N. hurlberti*, recorded in the vicinity of the western portion of the Development Envelope was not recorded within the drawdown extent. Eleven potential SRE species were recorded from the Mesa C buffer area of which two (*Nedsia* sp. 'AMM004' and *Nedsia* sp. 'AMM031') were recorded in the modelled Mesa C drawdown extent. Both of these species have also been recorded outside the modelled drawdown extent.

The EPA acknowledges that habitat may be used as a surrogate for inferring distributional boundaries of potentially restricted taxa (EPA 2016g and 2016h). Where a habitat type that supports a species is continuous then the extent of that habitat may be used to infer the likely presence of that species in the same habitat. The EPA also acknowledges that taxa with greater known distributions may act as surrogates to infer the distributions of poorly sampled species (EPA 2016g and 2016h).

Warramboo

The habitat characterisation undertaken by Biota (2017d) indicates stygofauna habitat is generally widespread across at least a third of the mapped broader Robe Valley area, extending well beyond the modelled impact areas and the Yarraloola Conglomerate is recognised as an extensive regional aquifer (Rio Tinto 2017d). Hydrogeological data indicate that intersection of the Ashburton Formation (known hydrogeologically as the Asburton Aquiclude) with the water table to the south and east of Warramboo generates a no-flow boundary. However, the stygofauna sampling results and geological and hydrogeological data indicate that there is unlikely to be any significant geological or hydrogeological barriers to stygofauna dispersal within the Yarraloola Aquifer to the north and west of the Development Envelope.

Mesa C

The stygofauna sampling results and hydrogeological data indicate that the Mesa C CID Aquifer is hydraulically connected to the extensive stygofauna habitat in the Robe River Alluvial Aquifer on a reasonably frequent basis. This alluvial aquifer is not expected to be impacted by the Proposed Change and therefore represents extensive connected and un-impacted stygofauna habitat. As described above (Section 6.4.3.1), the two stygofauna species recorded at Mesa C (*Nedsia* sp. 'AMM004' and *Nedsia* sp. 'AMM031') have also been recorded from the Robe River Alluvial Aquifer and the level of genetic divergence between the specimens from the two aquifers was confirmed to be low (Biota 2017d) which supports habitat connectivity.

The widespread nature of the habitat and the confirmation that at least 63 of the species recorded are considered widespread and occur in the wider Pilbara region, indicate that little evidence of significant barriers to dispersal across the mapped high and medium habitat prospectivity areas (Biota 2017d). It is therefore considered that the species recorded in the buffer areas at Warramboo and Mesa C, including the four species currently recorded only in the modelled Warramboo drawdown extent, are likely to have wider distributions that extend beyond the proposed impact areas. It is, therefore, considered that the Proposed Change is unlikely to have a significant impact on the diversity and ecological integrity of the stygofauna assemblages in the western portion of the Development Envelope.

6.5.3.2 Indirect impacts

Degradation of habitat due to mining related activities

Waste fines storage

In-pit storage of waste fines (from the entire Proposal) and disposal of effluent from the reverse osmosis plant is proposed at Warramboo. Seepage from in-pit disposal of waste fines and reverse osmosis effluent has the potential to change the local groundwater chemistry and degrade stygofauna habitat.

Based on results of monitoring around the Mesa J waste fines tailings storage facility (refer Section 8.6.3.2) it is anticipated that the proposed WFSF at Warramboo will result in increases in analytes such as salinity, nitrogen, nitrate, NOx and zinc in the immediate vicinity of the WFSF. DHI undertook modelling to assess the potential for changes to water quality as a result of groundwater drawdown extending towards naturally occurring higher salinity areas and seepage from the WFSF, using chloride as a suitable analyte (DHI 2018) (Section 8.6.3.2). The results showed naturally occurring areas of higher

chloride concentration located towards the coast to the west of the Warramboo pits will likely increase the chloride concentrations in some water supply bores over the life of mine, while the higher salinity areas located east of the Warramboo pit will have limited impact on water supply bores. The modelling also indicated groundwater chloride concentrations due to seepage from the WFSF will be contained within the cone of depression resulting from groundwater abstraction and that the majority of the increase in chloride concentration due to the presence of the WFSF will remain beneath the pit area and is not expected to reach water supply bores located approximately 400 m from the pit boundary (DHI 2018). Given chloride is generally a conservative solute, it can be inferred that other changes to groundwater chemistry will also be confined to the cone of depression resulting from groundwater abstraction.

Given that seepage from the WFSF will be confined to the cone of depression from the proposed extension to the Warramboo borefield during operations and that this cone of depression represents a small proportion of available stygofauna habitat (less than 2% of the area of the Yarraloola Conglomerate), it is considered that during operations, the Proposed Change is unlikely to significantly affect the ecological integrity of the stygofauna habitat provided by the Yarraloola Conglomerate.

Placement of waste fines into the WFSF will cease prior to closure. There will then be a limited period of time where seepage occurs from the waste fines until the WFSF dries out through a combination of evaporation and seepage, at which stage rehabilitation of the WFSF will be undertaken. Given the limited period of time required for 'drain-down' of the WFSF at closure and the extensive stygofauna habitat available around the Warramboo area, it is considered that at closure, the Proposed Change is unlikely to significantly affect the ecological integrity of the stygofauna habitat provided by the Yarraloola Conglomerate and the Robe River Alluvial Aquifer.

Hydrocarbon and wastewater spills

The potential exists for groundwater to be degraded by spills of hydrocarbons or wastewater. Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements. Hydrocarbon storage will be inspected on a regular basis to identify any maintenance requirements. Hydrocarbon and spill management procedures are expected to effectively mitigate the risk of contamination.

6.5.3.3 Cumulative impacts

The existing and foreseeable groundwater users in the vicinity of the Development Envelope are identified in Section 6.5.2.3. Groundwater abstraction from the pastoral station and Department of Main Roads bores are unlikely to significantly impact stygofauna habitat as the abstraction rates are likely to be low relative to the size of the aquifer and relative to the groundwater abstraction rates associated with the Proposed Change.

Abstraction of groundwater from the existing Warramboo bore field for water supply to the Mesa A/Warramboo Iron Ore Project is approved under Ministerial Statement 756. The drawdown extent from the current approved groundwater abstraction falls within the modelled drawdown extent for the proposed bore field expansion. The assessment of impacts in Section 6.5.3.1 therefore incorporates the existing and proposed impacts.

No other existing or proposed mining operations that would contribute to cumulative impacts on stygofauna occur in the vicinity of the Development Envelope.

6.5.4 Closure

The Mesa A Hub Closure Plan (Rio Tinto 2017b) represents the updated closure plan for the Mesa A, B, C, Warramboo, Highway/Tod Bore operations and supersedes previous closure plans for the approved project. It is applicable to mine developments and associated infrastructure, excluding rail and road infrastructure, within the Development Envelope.

Following cessation of dewatering at Mesa C, the CID Aquifer groundwater level is unlikely to recover to pre-mining levels under steady state conditions; however, extensive rainfall and possibly increased surface run-off and infiltration into the mesa due to reduced vadose zone are likely to assist water level recovery in the CID Aquifer. The adjacent modelled seasonally connected high prospectivity habitat of the Robe River Alluvial Aquifer is not expected to be impacted by the Proposed Change.

Modelling indicates that the groundwater levels at Warramboo will recover. It is estimated that recovery of the groundwater table to 80% of pre-mining groundwater level will take approximately 40 years, with complete recovery of the groundwater level estimated to take up to 140 years due to anticipated low recharge rates (Rio Tinto 2017c).

A closure task has been identified to assess the potential for seepage from the WFSF into the Yarraloola Aquifer. This will ensure any seepage from the facility is considered in terms of any potential impact to groundwater chemistry and subterranean habitats.

6.5.5 Mitigation

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 6-28.

Table 6-28: Mitigation measures and predicted outcomes for stygofauna

Potential impacts	Mitigation to address potential impacts	Predicted outcome
EPA objective: *To protect subterranean fauna so that biological diversity and ecological integrity are maintained.*		
Direct impacts: Reduction in stygofauna habitat, loss of individuals and changes to assemblages due to mine pit development and groundwater abstraction	The following key management strategies will be implemented to manage impacts to stygofauna as a result of indirect impacts: **Avoid:** Additional water requirements will be sourced from an extension to the existing Warramboo borefield, avoiding the requirement for a new borefield impact area. **Minimise:** Dewatering will be minimised to that required to access the BWT resource. Water from mine dewatering will be used on-site where possible to minimise the requirement for additional groundwater abstraction for operational water supply. The Proponent will abstract groundwater within the licence limits and monitor groundwater levels to ensure impact remains within the predicted range of drawdown. **Rehabilitation:** BWT pits will be backfilled and/or used for storage of waste fines material enabling recovery of groundwater levels and stygofauna habitats following cessation of groundwater abstraction.	Geological/hydrological formation which represent potential stygofauna habitat are extensive in the area, and extend beyond the modelled extent of groundwater impact as a result of the Proposed Change. The Robe Pisolite is incised into the underlying Yarraloola Conglomerate which represents an extensive regional aquifer. The geology of the Warramboo area and widespread distributions of most stygofauna taxa recorded indicate there are unlikely to be any significant barriers to stygofauna dispersal to the west and north of the proposed impact area. Given the estimated saturated aquifer thickness is significantly greater than the maximum modelled drawdown; stygofauna habitat will continue to be available within the proposed borefield extension area and outside the impact area both during and after mining operations. Given the small proportion of available habitat that will be impacted by the proposed groundwater drawdown and pit excavation at Warramboo and the lack of potential barriers to dispersal of stygofauna to the west and north of the area, it is considered that although the Proposed Change will result in the loss of individuals, it is unlikely to significantly affect the ecological integrity of the stygofauna habitat or the diversity and ecological integrity of the stygofauna assemblages in the Warramboo area. Approximately 5% of the Mesa C deposit is BWT at a depth of approximately 50 m below the surface of the mesa. Very little of the deposit is, therefore, suitable as stygofauna habitat. Hydrogeological test work and stygofauna sampling results indicate that the Mesa C CID Aquifer is seasonally connected to the extensive stygofauna habitat present in the adjacent Robe River Alluvial Aquifer. Given the extent and connectivity with other primary habitats, such as the Robe River Alluvial Aquifer which is not expected to be impacted by the

Potential impacts	Mitigation to address potential impacts	Predicted outcome
		Proposed Change, it is considered that although the Proposed Change will result in the loss of individuals, it is unlikely to significantly affect the ecological integrity of stygofauna habitat or the diversity and ecological integrity of the stygofauna assemblages in the Mesa C area. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.
Indirect impacts: Degradation of habitat due to mining-related activities Seepage from in-pit disposal of waste fines and reverse osmosis effluent and hydrocarbon spills have the potential to degrade stygofauna habitat.	The following key management strategies will be implemented to manage potential indirect impacts to stygofauna habitat: **Avoid:** Placing fines in-pit at Warramboo avoids the need to disturb a previously undisturbed area. **Minimise**: Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements. Hydrocarbon storage will be inspected on a regular basis to identify any maintenance requirements. Spill response procedures will be followed to contain and clean-up any hydrocarbon spills. **Rehabilitation:** Any hydrocarbon spills will be contained and Hydrocarbon storage and handling facilities will be decommissioned at closure. **Other legislation:** Compliance with the requirements of the *Contaminated Sites Act 2003* if contamination occurs.	Based on results of monitoring around the Mesa J waste fines tailings storage facility (Section 8.6.3.2) it is anticipated that the proposed WFSF at Warramboo will result in increases in analytes such as salinity, nitrogen, nitrate, NOx and zinc in the immediate vicinity of the WFSF. Modelling (DHI 2018) has shown that during operations the seepage from the WFSF will be confined to the cone of depression from the Warramboo borefield, representing disturbance to a small proportion of available stygofauna habitat (less than 2% of the habitat provided by the Yarraloola Conglomerate). Groundwater abstraction will cease prior to closure. Following cessation of groundwater abstraction, there will be a limited period of time when the tailings storage facility 'drains-down' and seepage from the WFSF will not be re-circulated through the wet processing plant. Given the extensive stygofauna habitat available around the Warramboo area and the limited period of time required for 'drain-down' of the WFSF at closure, it is considered that the Proposed Change is unlikely to significantly affect the ecological integrity of the stygofauna habitat provided by the Yarraloola Conglomerate. No significant impact on stygofauna habitat is expected from hydrocarbon storage or handling. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.

6.6 Peer review

A peer review of the proposed impacts to subterranean fauna and the proposed management approach was undertaken by Biologic (Biologic 2018, Appendix 7).

The review considered the potential impacts to subterranean fauna and the suitability of the proposed management of those impacts. In particular, the review focussed on the potential impacts to troglofauna, the potential impacts to retained troglofauna habitat and the suitability of the proposed habitat retention zones to sustain viable troglofauna habitats and assemblages if the Proposed Change were implemented. In doing so, the review considered troglofauna sampling, species assessment and habitat assessment. The review considered all troglofauna sampling, species assessment, habitat monitoring and habitat assessment undertaken in the Development Envelope. The review was conducted in parallel with preparation of the ERD and the draft Mesa A Hub EMP thus the outcomes from the review have been addressed in these two documents.

Table 6.1 of the peer review report (Appendix 7) provides a summary of key items noted during the peer review. Table 6.1 is reproduced below as Table 6-29 with an additional column noting how the Proponent has addressed the key items.

Table 6-29: Summary of key items identified by the subterranean fauna peer review

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
Troglofauna Impact Assessment Documents				
2.1A	**Moderate**	Small changes to MEZ (33 ha[1]) unlikely to be significant to troglofauna. Unresolved uncertainties surrounding the effectiveness of the MEZ as a strategy for conserving restricted troglofauna species and assemblages.	Preclude any additional changes to the MEZ until uncertainties resolved and greater confidence in the effectiveness of the MEZ.	The Proponent agrees that the Proposed Change to the MEZ at Mesa A is unlikely to be significant to troglofauna. Results and analysis from sampling and monitoring at Mesa A and other areas in the Robe Valley have been included in Section 6.4.2.2. The data collected indicate that the MEZ at Mesa A is functioning as intended to provide suitable habitat for persistence of troglofauna adjacent to the active mining operation.
2.2.1A	**Major**	Geological connectivity between Highway/ Tod Bore and CID habitats to the south-west (Dinner Camp Bore) indicated by detailed habitat modelling, but fauna data suggests high species turnover, possible habitat discontinuities. Although it is likely that some habitat occurs beyond impact areas at Highway / Tod Bore, the current information does not allow accurate assessment of how much habitat will be retained following mining.	Further investigations for species / habitat / assemblage comparisons in the following areas; A) high / mod prospective habitats immediately surrounding Highway / Tod Bore pits, B) high / mod prospective habitats extending to south-west of the pits at Highway/ Tod Bore. If no further investigations possible, assess potential for MEZ around Highway/ Tod Bore pits.	The Proponent agrees with the suggested strategy. Additional troglofauna sampling in the broader Warramboo area is currently underway and ongoing sampling is proposed in the Mesa A Hub draft EMP.

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
2.2.1B	**Major**	Current fauna thresholds for high-mod-low prospectivity habitat are not validated by links to fauna occurrence. Although it is likely that some habitat occurs beyond impact areas at Warramboo/ Highway/ Tod Bore/, the current information does not allow accurate assessment of how much will be retained following mining, or what is the likelihood that species known only inside pits will occur there.	Integrate current fauna occurrence records with three dimensional habitat modelling to: A) validate habitat prospectivity categories B) investigate habitat thickness at known occurrence records of different types of troglofauna C) provide a tool for estimating wider potential extent of habitat surrounding known occurrences of a species or an assemblage D) based on potential extent of habitat surrounding all known occurrences of an assemblage, estimate potential amount of habitat retained after mining.	The Proponent agrees with the suggested strategy. Current fauna occurrence records have been integrated with 3-dimensional habitat modelling as described in 6.4.1.3 and in the habitat modelling methodology contained in Appendix 7. Investigation of habitat thickness for known troglofauna records has been undertaken as described in Section 6.4.1.3. Analysis showed that troglofauna have been recorded in the Warramboo and Highway/Tod Bore area where Pisolite thickness is less than 5 m and in some areas where thickness is less than 2 m. The selection of 5 m Pisolite thickness as the threshold for medium prospectivity habitat is therefore considered conservative and provides one of the inputs to the troglofauna habitat assessment which is a tool for estimating the wider potential extent of habitat. The modelled extent of habitat that will remain after mining is provided in Section 6.4.3.1.
2.2.2A	**Moderate**	Design characteristics of the MEZ: A) 30 m buffer justification B) Justification for protection of a minimum of one known location of P1/2 species C) Issues with compliance monitoring.	A) Clarify justification of MEZ around modelled potential extent of habitat B) Add complexity to better describe current state of knowledge about MEZ effectiveness C) Re-examine compliance monitoring data to add justification of MEZ D) Improve scientific rigour of	The Proponent agrees with the suggested strategy. Additional information regarding troglofauna sampling and habitat monitoring in the Mesa A MEZ has been provided in Section 6.4.2. The data indicate that the Mesa A MEZ is functioning as intended and is providing habitat to maintain the biological diversity and ecological integrity of the subterranean fauna community. The volume of connected habitat retained on each mesa is likely to be a key parameter in determining the ongoing suitability of the retained habitat to support a viable troglofauna population.

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
			future monitoring plans E) Engage with current and future research to help determine troglofauna minimum habitat requirements.	The designs of the MEZs at Mesas A, B and C, therefore, focussed on retention of at least 50% by volume of connected pre-mining habitat. Other considerations during the design of the MEZs included retention of habitat for single location and singleton troglofauna, heritage values and the geotechnical stability of the retained escarpments at closure. A 50 m minimum escarpment width has been included in the MEZ designs to ensure heritage values are retained and geotechnical stability requirements are more than met. An additional minimum 30 m escarpment width has been applied where the MEZ has been modified to include single location and/or singleton troglofauna records, resulting in an escarpment width of 80 m in some locations. Troglofauna sampling and monitoring of habitat parameters at Mesa A indicate that an escarpment width of 50 m as part of a significant volume of connected habitat is providing suitable troglofauna habitat. The MEZ designs aimed as far as practicable to retain at least one location where each troglobitic taxon has been recorded. This is consistent with the approach taken at Mesa A. Taxon originally recorded in only a limited number of locations have now been recorded in other locations in the Mesa A MEZ (Section 6.4.4.1) The Proponent has reviewed the troglofauna sampling and habitat monitoring conducted under the current Troglofauna Management Plan. Proposed improvements to sampling and monitoring to improve scientific rigour are discussed in Section 6.4.6.2 and further detailed in the Mesa A Hub draft EMP (Appendix 4).

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
				The Proponent is actively involved in research projects that aim to improve troglofauna sampling methodologies and knowledge of troglofauna habitat requirements.
2.2.3A	**Moderate**	Logical flaw: “species [omitted] that were only ever recorded from the draft MEZ and thus never at risk of impact”.	Remove or reword statement to avoid contradictions with other assumptions about species occurrence within MEZ. Check numbers of species included in assessment.	The Proponent agrees with the suggested strategy. All recorded troglomorphic taxa have been considered in the Environmental Impact Assessment regardless of whether they were recorded in the original draft MEZs or not (Section 6.4.1.4).
2.2.3B	**Moderate**	Perception issues with wording: Priority 1 (singletons found only inside pit), and Priority 2 (species known from multiple sites inside pit).	Change wording to avoid perceptions of Priority 1 and 2 species being treated differently.	The Proponent agrees with the suggested strategy. The wording referred to in the peer review was used to assist with internal classification of recorded troglomorphic taxa and is not used in the impact assessment or the ERD.
2.3A	**Moderate**	30 m minimum buffer issue as in 2.2.2A	See strategy 2.2.2A.	See response to 2.2.2A.
Baseline Troglofauna Survey Documents				
3.1.1A	**Moderate**	Baseline survey issues: A) sampling gaps between Mesas and in moderate to low prospectivity habitats B) Most samples taken from within impact areas (information available at the time of sampling) C) No overall / cumulative assessment of sampling inside/ outside impact areas or comparing different habitat units.	Assess any potential sampling gaps/ artefacts (flow-on effects to inferences regarding potential habitat extent and species occurrence).	The Proponent agrees with the suggested strategy. The Proponent acknowledges that troglofauna sampling between Mesas B and C would provide information about the connectivity and utilisation of the modelled medium and low prospectivity habitat in this area. A sampling program in this area is currently underway but sampling is limited by availability of drill holes and tenure and heritage constraints. Given the lack of sampling between Mesas B and C, the Proponent has taken a conservative approach and has designed the MEZs assuming there is no habitat connectivity between Mesas B and C (Section 6.4.1.3 and Section 6.4.3.1).

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
				Troglofauna sampling has been conducted in both proposed impact and reference areas. A comparison of troglofauna capture rates for Mesas B and C with capture rates for the proposed respective MEZs is provided in Section 6.4.4.1. The data indicate that the proposed MEZs are representative of the mesa in terms of overall troglofauna utilisation. A comparison of the Order level assemblage present on Mesas B and C with the Order level assemblage present in their proposed respective MEZs is presented in Section 6.4.3.1 and discussed in Section 6.4.4.1. The data indicate that the proposed MEZs contain troglofauna assemblages that are representative at Order level of the assemblage in each mesa with all Orders present on each mesa recorded in the proposed MEZs except one Order at Mesa B and one Order at Mesa C. Sampling between Highway/Tod Bore and Dinner Camp Bore to the south-west is limited and results from the sampling programs may be affected by different sampling methodologies and seasonality. Additional troglofauna sampling is underway to further investigate habitat connectivity between the Highway/Tod Bore and Dinner Camp Bore areas. The Proponent acknowledges that sampling further outside proposed impact areas and in different habitat units would improve knowledge of troglofauna habitat requirements. The Proponent undertakes such sampling where possible but is constrained by availability of drill holes and tenure and heritage constraints.
3.1.2A	**Moderate**	Baseline habitat suitability categories used in baseline reports illogically applied and over simplistic.	Habitat assessment in the baseline studies is superseded by RTIO geological/ geomorphological	The Proponent agrees that the naming conventions applied to habitat categories in the baseline reports were unclear. The Proponent has addressed this issue in the ERD by removing the

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
			habitat modelling. For areas where this modelling does not extend, baseline habitat assessment categories should be treated as preliminary and inconsistent with fauna information.	unclear nomenclature and delineating areas where there is high confidence in the habitat modelling. The prospectivity of habitat was assessed based on the physical characteristics of the formation providing suitable habitat features known to support troglofauna, for example the presence of cavities, vugs, interstitial spaces and hydrated/weathered zones. This assessment requires sufficient geological data, particularly from drill logs, to be available for each area to be assessed. The area to south of Mesa A (called 'Congo Bore') is an area where limited drill logs are available. Surface geological mapping was, therefore, used in conjunction with the limited drill hole data to assess troglofauna habitat prospectivity in this area. Use of surface geological data generated a low habitat prospectivity classification over the Congo Bore area as presented in Biota (2017a). As noted in Section 3.1.2A of the peer review, the records of troglofauna in this area do not support the low prospectivity classification. Further investigation has shown the habitat modelling in the Congo Bore area to be of low confidence (due to limited drill hole data and indications that surface geological mapping is not representative of the sub-surface geology in this area). To more accurately depict the overall reliability of the modelling, the modelling outputs in some areas, including the Congo Bore area, were delineated as 'low confidence' habitat modelling. Evaluation of the modelling input and output data and delineation of low confidence areas in response to peer review item 3.1.2A resulted in the Environmental Impact Assessment presented in the ERD using only high confidence habitat modelling outputs.

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
3.1.2B	**Major**	Baseline habitat assessment assumes high connectivity of Warramboo/ Highway/ Tod Bore and Dinner Camp Bore to the south-west, assumptions that are directly contradicted by fauna sampling information showing high species turnover between these areas.	See strategies 2.2.1A, 2.2.1B, and 3.1.1A.	The baseline habitat assessment indicates that there is habitat connectivity between Highway/Tod Bore and Dinner Camp Bore to the south-west. The assessment is based on drilling data and CID thickness modelling, neither of which indicate any faults or other structural features in the Highway/Tod Bore area that may result in discontinuity in habitat. However, limited sampling from the Dinner Camp Bore area did not record the strongly troglobitic order, Schizomida, which is represented in the broader Warramboo and Highway/Tod Bore area. The lack of records for this order may be due to ecological sampling effects (Biota 2017a) or may indicate a discontinuity in troglofauna habitat outside the Development Envelope. Additional troglofauna sampling is underway to further investigate habitat connectivity between the Highway/Tod Bore and Dinner Camp Bore areas.
3.1.2C	**Moderate**	Baseline habitat assessment in-between high suitability habitats based on less habitat data, untested by sampling (implications for assumptions of habitat discontinuity).	Assessment of habitat connectivity between mesas would benefit from additional sampling/ investigations, pending development of suitable holes. If this is not possible, strategy 2.2.1B may help to highlight potential connectivity for some species.	The Proponent agrees that troglofauna sampling between Mesas B and C would provide information about the connectivity of the modelled medium and low prospectivity habitat in this area. A sampling program in this area is currently underway but sampling is limited by availability of drill holes and tenure and heritage constraints. Given the lack of sampling between Mesas B and C, the Proponent has taken a conservative approach and has designed the MEZs assuming there is no habitat connectivity between Mesas B and C (Section 6.4.1.3 and Section 6.4.3.1).

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
3.1.3A	**Moderate**	Inconsistencies in assessment of species ecological status, SRE status, potential distribution between or within baseline reports.	RTIO has advised all species assessments have been updated for the ERD based on cumulative/overall assessment of species ranges, superseding baseline assessments. All species in Table 3.2 should be considered Potential SRE troglobites.	The Proponent agrees that inconsistencies in the assessment of species are present between various sampling reports. The Proponent has addressed this issue in the ERD by considering the potential impacts on all recorded troglomorphic species regardless of whether they have previously been categorised as widespread or not. All species listed in Table 3.2 of the peer review report are, therefore, considered as potential SREs in the ERD (Section 6.4.1.4).
3.2A	**Moderate**	Baseline species accumulation studies considered unidentified specimens to represent additional species, potentially skewing results.	Reassess species accumulation analyses based on RTIO overall data, using a parsimonious approach to indeterminate or unidentifiable specimens (*i.e.* omit them). Provide more detail regarding data handling in estimates.	Species accumulation studies were undertaken as part of the baseline studies for the Mesa A/Warramboo Iron Ore Project and reported in Biota (2006c) and Biota (2007). The Proponent noted from those studies it was noted that the low capture rates for troglofauna result in the species accumulation curves appearing to reach an asymptote over several sampling periods until a new taxon is recorded with a resultant step change in the accumulation curve. Given the low capture rates inherent in current troglofauna sampling methods, the Proponent does not consider species accumulation curves to be a good measure of sampling adequacy. Species accumulation curves have, therefore, not been included in the ERD.
3.2B	**Moderate**	Baseline species accumulation studies inadequately described data handling methods and settings in Estimates used in the analysis.	See strategy 3.2A.	Estimates was used in baseline studies for the Mesa A/Warramboo Iron Ore Project and reported in Biota (2006c) and Biota (2007). Species accumulation curves have not been included in the ERD (refer to peer review number 3.2A), therefore, the methodology used is Biota (2006c) and Biota (2007) in relation to species accumulation curves is not relevant to the current impact assessment.

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
3.3A	**Moderate**	It is difficult to reconcile results from previous studies with current survey results, due to the high number of reports and changes in nomenclature and subterranean/ SRE statuses.	RTIO has advised all species identifications and subterranean/ SRE statuses have been updated for the ERD based on cumulative/ overall assessment of species data, superseding previous baseline assessments.	The Proponent agrees that it is difficult to reconcile results from previous survey reports with those from current survey reports due to new taxonomic information and changes in nomenclature that become available after reports are completed. The Proponent manages this issue by maintaining a Geographical Information System database that contains all troglomorphic specimen records. This database is updated as taxonomic revisions and other data become available. The Proponent used this database with current information for all specimens to complete the Environmental Impact Assessment for the ERD.
Troglofauna Compliance Monitoring Documents				
4.1.1A	**Major**	Compliance monitoring results unable to indicate whether and to what extent troglofauna assemblages at Mesa A have been affected by mining, due to inadequate species level identifications and comparisons with previous data only at taxonomic order level.	Current and future Troglofauna Management Plan's to require: A) All future compliance monitoring to identify all specimens to species level and undertake full comparisons with baseline sampling and monitoring. B) Consistent framework for nomenclature, reference collections for specimens and genetic sequences.	The Proponent agrees with the suggested strategy. For subterranean fauna groups where suitable expertise to identify specimens to species level exists (e.g. schizomids, pseudoscorpions), identifications have been undertaken consistently to species level during baseline sampling and throughout compliance monitoring for Mesa A. Insufficient expertise was available during the baseline studies to identify specimens from some groups to species level. As expertise and advances in molecular analysis have become available the Proponent has identified new specimens to species level and has attempted to align those with historical specimens. However, many of the original specimens have not been appropriately stored or are too old for successful molecular analysis. The Proponent has reviewed the troglofauna sampling and habitat monitoring conducted under the current Troglofauna Management Plan. Proposed improvements to sampling are

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
				discussed in Section 6.4.6.2 and further detailed in the Mesa A Hub draft EMP (Appendix 4).
4.1.2A	**Moderate**	Previous recommendation to reduce compliance monitoring sampling rates not justified by sufficient evidence.	Current and future Troglofauna Management Plan's to require: C) consistent methods and sampling design, seasonality and trap duration etc. D) consideration in sampling design to development of thresholds/ indicators for detecting change in species/ assemblages.	The Proponent agrees with the suggested strategy. The Proponent has reviewed the troglofauna sampling and habitat monitoring conducted under the current Troglofauna Management Plan. Proposed improvements to sampling are discussed in Section 6.4.6.2 and include consistent methods and sampling design. Management targets for troglofauna are proposed in the Mesa A Hub draft EMP (Appendix 4).
4.2A	**Moderate**	Results of targeted sampling of waste dumps and pit floor limited by numbers of holes and extent of holes through multiple habitat zones.	Further investigations required to establish persistence of troglofauna species/ assemblages beneath pit floor and under waste dumps.	The Proponent agrees further targeted sampling of waste dumps and beneath pit floors is required to establish persistence of troglofauna species and assemblages in these areas. Troglofauna sampling beneath the pit floor and in waste dumps will continue at Mesas A and K but has not been included in the Mesa A Hub draft EMP as this sampling is dependent on the limited availability of and access to drill holes in the active mining area.
4.3A	**Moderate**	Downhole visual monitoring lacked assessment framework which could be used to validate results.	Either develop scientifically valid assessment framework for down hole visual survey, or pursue alternative methods for physical habitat monitoring.	The down hole optical imagery reports (as provided for the peer review) contain limited examples of the imagery that has been recorded. Additional high quality imagery, such as that shown in Section 6.4.2.2 is available for each hole logged but was not provided, or requested, as part of the peer review. The use of optical imagery was intended to provide a visual record of down hole cavities and voids over time that would

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
				allow qualitative assessment of changes in the subterranean environment and assist with visualisation and understanding of the subterranean environment. The types of changes the optical image surveys were to assess were collapse of cavities and generation of new fractures. As discussed in Section 6.4.6.2, very few changes to cavities have been noted since annual collection of optical imagery commenced in 2010. No changes of the magnitude of cavity collapse or generation of new fractures have been recorded, nor have any impacts that could be attributed to mining operations been detected. It is, therefore, considered that additional monitoring would be unlikely to provide any further insight into potential impacts. Further optical imagery surveys have, therefore, not been included in the draft Mesa A Hub Environmental Management Plan.
4.4A	**Moderate**	Ability to compare current MEZ conditions to baseline habitat conditions constrained by lack of suitable baseline data and issues with environmental probes.	Design a statistically valid troglofauna habitat monitoring program, using more suitable probes, for Mesas B, C, and Warramboo, and begin collecting baseline data without delay to capture full range of seasonal variability.	The temperature and humidity monitoring program conducted as part of the Mesa A Troglofauna Management Plan was designed to allow comparison and analysis of: 1. pre-mining data with data collected during mining 2. data collected from the Mesa A MEZ with data collected from reference sites 3. data collected near the pit face in the Mesa A MEZ with data collected further from the pit face. Due to issues experienced with the probe setup, comparison of pre-mining data with data collected during mining (item 1 above) is considered unlikely to yield accurate results. However, analysis for items 2 and 3 above are possible and has been undertaken (Section 6.4.2).

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
				The Proponent agrees that collection of baseline data should commence as early as possible and has, therefore, already commenced collection of baseline temperature and humidity data at Mesa B. Mesas of the Robe Valley, including Mesas A, B and C were formed through the same broad depositional processes and therefore comprise the same geological units with similar stratigraphy (Section 6.4.2). Given the similarity between the mesas it is considered that down hole temperature and humidity data collected at Mesas A, B, F and K will provide data that can be applied to management of troglofauna habitat at other mesas. The Proponent, therefore, does not consider that establishment of separate baseline monitoring at Mesa C is warranted. The objective for collection and analysis of down hole temperature and humidity data is to assess whether an exposed pit face results in changes in the temperature and humidity in the subterranean environment. This was considered to be pertinent to the mesa formation due to the limited lateral extent of the troglofauna habitat. Monitoring results show proximity to the Mesa A pit edge did not influence mean down hole temperature or humidity (Astron 2017b) (Section 6.4.2). Core troglofauna habitat at Warramboo consists of the buried downstream continuation of the Robe Pisolite deposit present at Mesas A, B and C. As such, the troglofauna habitat at Warramboo is less exposed to potential changes in subterranean temperature and humidity. The Proponent, therefore, does not consider that establishment of separate baseline monitoring at Warramboo is warranted.

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
Baseline Stygofauna Survey Documents				
5.1A	**Moderate**	Stygofauna sampling uneven inside/ outside predicted drawdown and across putative habitat types. May have had an effect on sampling artefacts.	Undertake deeper analysis of sampling and fauna results to investigate whether the current data is affected by sampling artefacts or if species/ assemblage occurrence patterns concur with inferred habitat extent and connectivity.	Stygofauna sampling is limited to available water bores in the area. There are limited water bores available for sampling in the northern and western extents of the modelled cone of depression. Hydrogeological test work and modelling indicate that the extensive Yarraloola Aquifer is well connected between the centre of the cone of depression at Warramboo to the north and west of the modelled extent of impact.
5.2A	**Moderate**	Stygofauna habitat characterisation over-simplified and lacking validation by species assemblage comparisons (similar to issue 2.2.1A for troglofauna).	More detailed mapping and assessment of stygofauna habitat extent, suitability and connectivity, integrated with fauna occurrence records may improve the assessment (similar to strategy 2.2.1B for troglofauna).	The Proponent agrees that the preliminary stygofauna habitat characterisation was over-simplified. Biota (2017d) considered stygofauna habitat prospectivity across the Robe Valley area based mainly on geological data. At this coarse modelling level a relatively high number of specimens were recorded from areas that were categorised as 'low prospectivity' (Figure 5.8 of Biota (2017d)). However, the majority of the areas categorised as 'low prospectivity' where specimens were collected, were areas where limited drill logs and hydrogeological data were available (i.e. away from areas where the Proponent has undertaken resource evaluation and hydrogeological drilling). The stygofauna habitat modelling output presented in the ERD is at a finer scale than that presented in Biota (2017d) and is based on much greater drill hole data coverage in the vicinity of the western portion of the Development Envelope than is available for the Robe Valley as a whole. The ERD also includes greater consideration of the hydrogeology of the aquifers (that is, stygofauna habitat), rather than focusing on the geology of the area. Consequently, the habitat modelling output

Peer review number	Classification	Issue	Strategy	ERD section and/or proponent comments
				in the ERD for the western portion of the Development Envelope is of a higher confidence level than the broader scale output for the Robe Valley and the correlation between the habitat prospectivity categorisation and the specimen records is much higher (Figure 6-33 of the ERD).
5.2B	**Moderate**	Habitat connectivity assessment for Mesa C/Robe River Aquifer at odds with occurrence of shared stygofauna species.	Species assessment in the baselines studies is superseded by RTIO overall assessment for ERD. More detailed mapping and assessment of stygofauna habitat extent, suitability and connectivity, integrated with fauna occurrence records may improve the assessment (similar to strategy 2.2.1B for troglofauna).	The Proponent agrees that the preliminary habitat assessment for Mesa C was unclear. The Proponent has addressed this issue in the ERD by removing the unclear nomenclature and considering the hydrogeology of the aquifer, rather than just the geology of the area (Section 6.5.1.2).
5.2C	**Moderate**	Stygofauna habitat suitability categories illogically applied and over simplistic (similar to issue 3.1.2A for troglofauna).	More detailed mapping and assessment of stygofauna habitat extent, suitability and connectivity, integrated with fauna occurrence records may improve the assessment (similar to strategy 2.2.1B for troglofauna).	The Proponent agrees that the naming conventions applied to habitat categories in the baseline reports were unclear. The Proponent has addressed this issue in the ERD by removing the unclear nomenclature and considering the hydrogeology of the aquifer, rather than just the geology of the area (Section 6.5.1.2).

[1] This 33 ha refers to the troglofauna habitat that would be removed by the proposed additional mining.

6.7 Predicted Outcome

The key Subterranean Fauna values identified in the Development Envelopment that are considered relevant to the Proposed Change are:

Significant troglofauna habitat

- The Priority 1 PEC, the Subterranean invertebrate community of mesas in the Robe Valley region, occurs at Mesas B and C
- The Priority 1 PEC, the Subterranean invertebrate community of pisolitic hills in the Pilbara.

Troglofauna taxa

- Conservation significant troglofauna species:
  - *Paradraculoides anachoretus*
  - *Paradraculoides bythius*
  - *Ideoblothrus linnaei*
  - *Ideoblothrus* sp. 'Mesa A'
  - *Lagynochthonius asema*
  - *Tyrannochthonius* sp. 1
- Confirmed SRE troglofauna species:
  - *Ideoblothrus pisolitus*
  - *Ideoblothrus* sp. 'Mesa A1'
  - *Ideoblothrus* sp. 'Mesa A2'
- Potential SRE troglofauna taxa.

Stygofauna taxa

- Conservation significant stygofauna species: *Nedsia hurlberti*
- Potential SRE stygofauna taxa.

The key predicted outcomes for the Subterranean Fauna values outlined above are:

- Disturbance to troglofauna habitat on Mesas A, B and C as a result of the Proposed Change will be limited to 50% by volume of connected pre-mining habitat
- Biological diversity and ecological integrity of the troglofauna communities are expected to be maintained given:
  - the small proportion of additional habitat that will be impacted at Mesa A, retention of a significant volume of connected habitat and the evidence that the Mesa A MEZ is functioning as intended
  - retention of significant volumes of connected habitat at Mesas B and C and the evidence that the Mesa A MEZ is functioning as intended
  - the small proportion of habitat that will be impacted at Warramboo and the extent of habitat outside the proposed impact area
  - given the availability of modelled high and medium habitat around the Highway/Tod Bore area and given the Proponent's commitment to further investigate habitat connectivity between the Highway/Tod Bore and Dinner Camp Bore areas

- Biological diversity and ecological integrity of the stygofauna communities are expected to be maintained given:
    - the small proportion of available stygofauna habitat that will be impacted by the proposed groundwater drawdown and pit excavation at Warramboo
    - stygofauna habitat will continue to be available within the proposed borefield extension area at Warramboo and outside the impact area both during and after mining operations
    - the widespread nature of most taxa and the lack of potential barriers to the west and north of the proposed borefield extension area at Warramboo
    - the small proportion of available stygofauna habitat represented by the Mesa C CID Aquifer and the evidence indicating connection of the Mesa C Aquifer with the adjacent, extensive high prospectivity habitat of the Robe River Alluvial Aquifer which is not expected to be impacted by the Proposed Change.

After the mitigation hierarchy has been applied (Table 6-22 and Table 6-28), including retention of connected habitat through designation of a MEZ, and consideration of extensive, connected stygofauna habitat at Warramboo and Mesa C, the Proponent considers that the residual impact associated with the unavoidable clearing of the Priority 1 PECs, the Subterranean invertebrate community of mesas in the Robe Valley region and the Subterranean invertebrate community of pisolitic hills in the Pilbara is significant and warrants an offset. The proposed offset is discussed in Section 13.

Given the proposed mitigation and offset, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Subterranean Fauna.

7. TERRESTRIAL FAUNA

This section describes the terrestrial fauna that occur within the western portion of the Development Envelope and provides an assessment of the potential impacts of the Proposed Change to terrestrial fauna values, proposed mitigation measures and the predicted outcome for this key environmental factor.

7.1 EPA Objective

The EPA's objective for terrestrial fauna is to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

7.2 Policy and Guidance

The following policy and guidance documents have been considered in the assessment of terrestrial fauna.

7.2.1 EPA policy and guidance

- DMP and EPA Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015)
- Environmental Factor Guideline: Terrestrial Fauna (EPA 2016j)
- Statement of Environmental Principles, Factors and Objectives (EPA 2018a)
- Technical Guidance: Sampling methods for terrestrial vertebrate fauna (the content in this Technical Guidance has not yet been updated from the technical report of the EPA and the then Department of Environment and Conservation issued in September 2010 and titled 'Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment') (EPA 2016k)
- Technical Guidance: Terrestrial Fauna Surveys (the content in this Technical Guidance has not yet been updated from EPA Guidance Statement No. 56 issued in June 2004) (EPA 2016l)
- Technical Guidance: Sampling of short range endemic invertebrate fauna (the content in this Technical Guidance has not yet been updated from EPA Guidance Statement No. 20 issued in May 2009) (EPA 2016m)
- Environmental Factor Guideline: Inland Waters Environmental Quality (EPA 2016c)
- Instructions on how to prepare an Environmental Review Document (EPA 2016i)
- Instruction of how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (EPA 2016e).

7.2.2 Other policy and guidance

- WA Environmental Offsets Policy (Government of Western Australia 2011)
- WA Environmental Offsets Guidelines (Government of Western Australia 2014)
- Survey guidelines for Australia's threatened Bats (Department of the Environment, Water, Heritage and the Arts [DEWHA] 2010)
- Survey guidelines for Australia's threatened mammals (Department of Sustainability, Environment, Water, Population and Communities [DSEWPaC] 2011a)
- Survey guidelines for Australia's threatened reptiles (DSEWPaC 2011b)
- Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC and Agriculture and Resource Management Council of Australia and New Zealand 2000).

7.3 Environmental Scoping Document

Table 7-1 summarises where the requirements of the ESD are addressed in this section.

Table 7-1: Requirements of ESD for terrestrial fauna

Task number	Requirement	Comments
31	Provide a desktop review and analysis of all surveys of the Proposal area undertaken in accordance with EPA Policy and Assessment, Survey guidelines for Australia's threatened mammals. EPBC Act survey guidelines 6.5 (DSEWPaC 2011a), Survey Guidelines for Australia's Threatened Bats. EPBC Act survey guidelines 6.1 (DEWHA 2010) and Survey Guidelines for Australia's threatened reptiles. EPBC Act survey guidelines 6.6 (DSEWPaC 2011b).	Section 7.4
32	The study should include: • Justification of how these surveys are relevant and representative of the Development Envelope and if they were carried out using methods consistent with EPA Policy; and • A comprehensive listing of vertebrate fauna and short range endemic (SRE) invertebrate fauna known or likely to occur in the habitats present, and identification of conservation significant fauna species likely to occur in the area.	Section 7.4
33	Conduct Level 2 terrestrial fauna and SRE invertebrate surveys in areas that are likely to be directly or indirectly impacted as a result of the Proposal. Surveys are to be undertaken in accordance with EPA Policy and, where available, species-specific survey guidelines for relevant species listed under the *Wildlife Conservation Act 1950* and the *Environment Protection and Biodiversity Conservation Act 1999*.	Section 7.4.1
34	Conduct additional targeted surveys for conservation significant fauna that are known to or likely to occupy habitats in the project area if demonstrated to be required based on the results of the desktop study and Level 2 surveys.	Section 7.4.1
35	Specify any MNES being assessed as part of the accredited assessment.	Section 12.3
36	Provide a review of bat populations and habitat in the local and regional area including the existing Mesa A Hub Proposal.	Sections 7.4.3
37	Investigate and provide a description of any potential bat populations and habitat in the Mesa A Hub Revised Proposal area, and potential impacts from the Mesa A Hub Revised Proposal.	Sections 7.4.3

Task number	Requirement	Comments
38	For each relevant conservation significant species, including bat species and SREs, identified as likely to occur within the Proposal area, include:	
	• Baseline information on distribution (including known occurrences), ecology and habitat preferences at both the site and regional levels	Section 7.4
	• Information on the conservation value of each habitat type from a local and regional perspective, including the percentage representation of each habitat type on site in relation to its local and regional context	Section 7.4.3 and 7.5.1
	• Size and importance of the population from a local and regional perspective and potential percentage loss of the conservation significant species locally due to loss of habitat	Sections 7.4, 7.5 and 7.6 A qualitative assessment of the size and importance of fauna populations has been provided where possible and the potential percentage loss of habitat has been estimated. The size and importance of populations regionally has been discussed qualitatively using the available information.
	• Maps illustrating the known recorded locations of conservation significant species and SRE invertebrates in relation to fauna habitat and the proposed disturbance and areas to be impacted	Figure 7-4, Figure 7-5 and Figure 7-6
	For Bats	
	• Provide evidence for the assertion made in the referral that bats can be expected to safely move from one cave to another if a cave is disturbed by construction or operational activities	Section 7.6.4
	• Detail the extent to which clearing will remove foraging/hunting habitat for these species and the likely impacts of this on the local population	Section 7.6.3, 7.6.4 and 7.6.1.1
	• The extent to which attraction to light sources will impact these species and what might be done to mitigate this.	Section 7.6.3 and 7.6.4

Task number	Requirement	Comments
	For Northern Quoll:	
	• The extent to which clearing will remove hunting habitat and impact the species	Section 7.6.2
	• Explanation of how the construction of cuttings will avoid harm to the species.	Section 7.6.2
	For Pilbara Olive Python:	
	• The extent to which changes in surface water availability and quality can be expected to impact this species.	Sections 7.6.5, 8.6.3.4 and Table 12-5.
39	Identify the fauna habitat types within and outside the areas of impact. Consider habitat types that provide important ecological function within the Proposal area (e.g. geological features which may support unique ecosystems).	Section 7.4.3
40	Discuss known existing threats to the species, with reference to relevant impacts from the proposed action (including taking into consideration any relevant guidelines, policies, plans and statutory provisions).	Section 7.5
41	Provide a detailed description of the potential direct, indirect (including downstream) and cumulative impacts to conservation significant and other species within the Proposal area and on a regional scale.	Section 7.6
42	Develop a Fauna Management Plan to apply to the entire Mesa A Hub Revised Proposal. The following should be addressed in the plan: • Monitoring of the health and population sizes of threatened species, in particular the following species (all of which are MNES): • Ghost Bat (*Macroderma gigas* – Vulnerable) • Pilbara Olive Python (*Liasis olivaceus barroni* – Vulnerable) • Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* – Vulnerable) • Northern Quoll (*Dasyurus hallucatus* – Endangered).	Appendix 4 The draft EMP includes monitoring programs for the Ghost Bat and the Northern Quoll as these are the species with the greatest potential to be impacted by the Proposed Change. No significant impacts to high value habitat for the Pilbara Olive Python or the Pilbara Leaf-nosed Bat are anticipated as a result of the Proposed Change. Monitoring is, therefore, not considered warranted for these species.

Task number	Requirement	Comments
	• Management options to be triggered should monitoring show a decline in health or population sizes of threatened species as a result of implementing the proposal	Appendix 4 and Section 7.8
	• Retention of critical habitat where possible, and where not possible justification/explanation is required.	Sections 7.6, 7.8 and 12
43	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to terrestrial fauna	Section 7.6, 7.7, 7.8 and 12
44	The Proponent should demonstrate that the proposed action is not inconsistent with any relevant policy and guidance, relevant recovery plan and threat abatement plan.	Section 7.6, 7.7, 7.8 and 12
45	Prepare a Mine Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015), which addresses the need for progressive rehabilitation of habitat for conservation significant species.	Appendix 3
46	Describe the residual impacts for the Proposal and analyse these impacts to identify and detail any that are significant.	Section 7.6, 7.8 and 12
47	Create an offsets position following application of the mitigation hierarchy.	Section 7.8 and 13
48	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 7.6, 7.7, 7.8 and 12

7.4 Receiving Environment

7.4.1 Terrestrial fauna studies

Terrestrial fauna surveys have been undertaken in the Robe Valley area since 1991, covering an area in excess of 72,400 ha. The combined coverage of these surveys provides a considerable knowledge base of the terrestrial fauna present in the western portion of the Development Envelope. Terrestrial fauna surveys have also been undertaken for the approved activities. Table 7-2 summarises the key terrestrial fauna surveys relevant to the Proposed Change.

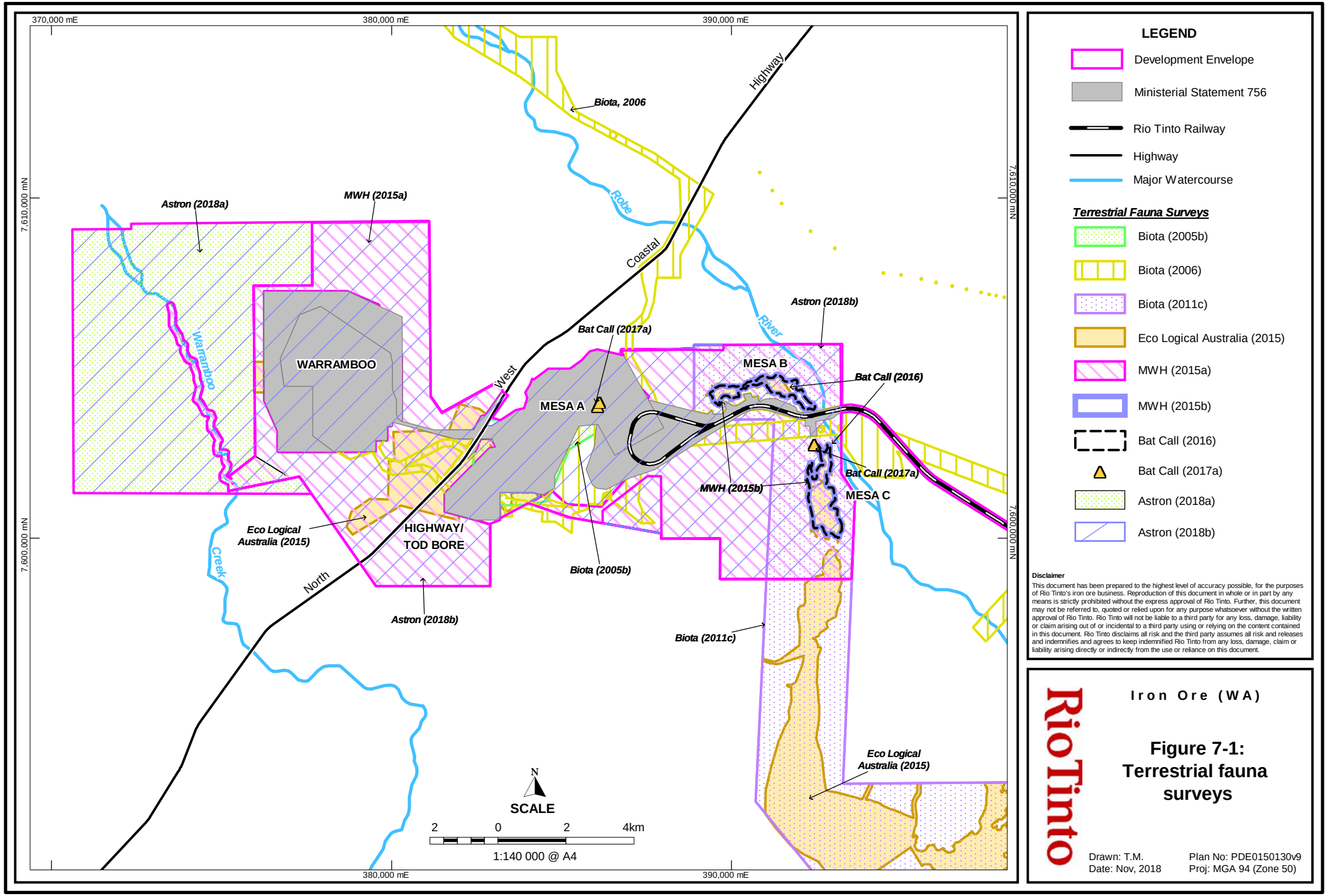
Survey locations within the Development Envelope are shown on Figure 7-1 and Figure 7-2 and the most recent survey reports are provided in Appendix 8. Figure A8-1 is also provided in Appendix 8 showing the fauna sampling locations in relation to fauna habitat.

Table 7-2: Summary of supporting terrestrial fauna studies

Report	Summary	Survey date
Warramboo borefield Level 2 Fauna Assessment May 2017 Astron Environmental Services (Astron) (2018a)	A dual phase Level 2 vertebrate and Short Range Endemic invertebrate fauna assessment of the Warramboo area covering 4,619 ha was conducted in accordance with EPA policy and guidelines and aligned to requirements of Commonwealth guidelines. The survey included a desktop assessment and field survey including identification of habitat types, trapping, avifauna surveys, use of motion sensor cameras, acoustic bat surveys to detect the presence of Ghost Bat and Pilbara Leaf-nosed Bat, active searches, targeted searches and nocturnal spotlighting.	May and September 2017
Mesa A Hub – Targeted Night Parrot Fauna Assessment, September 2017 Astron Environmental Services (2018b)	A targeted Night Parrot fauna survey was undertaken within the western portion of the Development Envelope including a desktop literature review, systematic field survey to verify the results of the desktop study and previous Night Parrot records and to record potential Night Parrot observations or records and assess the potential for the survey area to support a resident population of this species. Astron conducted four fauna habitat assessments within the survey area in habitats prospective for Night Parrot occurrence. The fauna habitat assessments occurred in the best habitat available for this species in the survey area. Fauna habitat assessment is currently the most proficient survey method for describing the habitat for this highly cryptic species and determining likely occurrence of this species.	September 2017
Robe Valley Mesas A and C, Ghost Bat roost cave assessment, April 2017 Bat Call WA (2017a)	A targeted assessment of bat conservation values of three caves at Mesas A and C. The purpose of this survey was to assess the conservation values of three caves potentially associated with Ghost bats at Mesas A and C that had been previously identified by environmental surveys and internal Rio Tinto heritage and fauna assessments. This involved a visual assessment of cave geometry and environments and a search for Ghost Bat presence, including roosting bats and/or middens.	April 2017
Mesa B and C Ghost Bat roost cave assessment Bat Call WA (2016)	An assessment of bat conservation values of caves at Mesa B and Mesa C. The assessment included a visual assessment of cave environments for suitability for Ghost Bat and Pilbara Leaf-nosed Bat, along with searches for the presence of Ghost Bat individuals. The study included the perimeters of both Mesas B and C and the surrounding outwash areas immediately adjacent to the mesas.	July 2016

Report	Summary	Survey date
Level 2 Terrestrial Fauna Surveys: Mesa B-C, Warramboo BWT and Highway to Tod Bore MWH (2015a)	A Level 2 terrestrial fauna survey across the Mesa B, C, Warramboo BWT mine area and Highway to Tod Bore mine areas. The survey was conducted in accordance with EPA policy and guidelines and aligned to the requirements of Commonwealth guidelines. The survey included systematic, targeted and opportunistic sampling of terrestrial vertebrate fauna (mammals, birds, reptiles and amphibians) and potential SRE invertebrate fauna.	May and September 2015
Mesa Façade Assessment – Mesas B and C MWH (2015b)	An assessment to categorise, rank and map the ecological quality of the façades of Mesas B and C. The assessment included a desktop study and field survey to rate the ecological value of, and existing disturbance to, each site and delineate sections of the mesa façades (referred to as escarpments throughout this document) based on these ratings. Both mesas were inspected either via access tracks around the base of the mesas, or from drilling tracks on the mesa plateaus and rated according to quality of habitat for significant flora and fauna.	May 2015
Robe Valley Mesas Fauna Report Biota (2011c)	A single-phase Level 2 survey of a study area encompassing Mesas B, C, D, E, F, H and I to identify and assess fauna assemblages and habitats present in the study area including vertebrate fauna, bats, avifauna and potential SRE species.	October 2010
Fauna Habitats and Fauna Assemblage of the Mesa A Transport Corridor and Warramboo Biota (2006d)	A three stage survey of fauna and fauna habitats in the Mesa A Transport Corridor and Warramboo, including searches for vertebrate fauna, bats, avifauna and invertebrates.	March to August 2005
Fauna Habitats and Fauna Assemblage of Mesa A and G, near Pannawonica Biota (2005b)	A survey of fauna habitats and fauna assemblages within a study area encompassing Mesa A and Mesa G conducted. The survey included searches for vertebrate fauna, bats, avifauna and invertebrates.	May 2004
Mesa A/Warramboo Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016 WRM (2016)	A baseline sampling program for aquatic ecosystems in Warramboo Creek upstream and downstream of the proposed Warramboo BWT development. The program documented current ecological condition, including the presence of any aquatic fauna of conservation and/or regional significance.	May 2016

Report	Summary	Survey date
Mesa B and C Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016 WRM (2017)	A baseline sampling program for aquatic ecosystems of the Robe River undertaken on the Robe River and Mungarathoona Creek in the vicinity of Mesas B and C as well as further upstream and downstream. The program documented current ecological condition of these aquatic ecosystems (encompassing surface water chemistry and aquatic faunal assemblages).	May 2016
Warramboo Project: Baseline Aquatic Ecosystem Survey Wet Season Sampling 2018 WRM (2018)	A baseline sampling program for aquatic ecosystems in Warramboo Creek upstream and downstream of the Warramboo BWT development. The aim of the sampling program was to document current ecological condition, including the presence of any aquatic fauna of conservation and/or regional significance, and provide a benchmark against which any future effects of the Warramboo Mine may be assessed. The wet season sampling in April 2018 constitutes the second sampling event as part of establishing a baseline dataset, with previous sampling undertaken in the wet season of 2016 (WRM 2016).	April 2018



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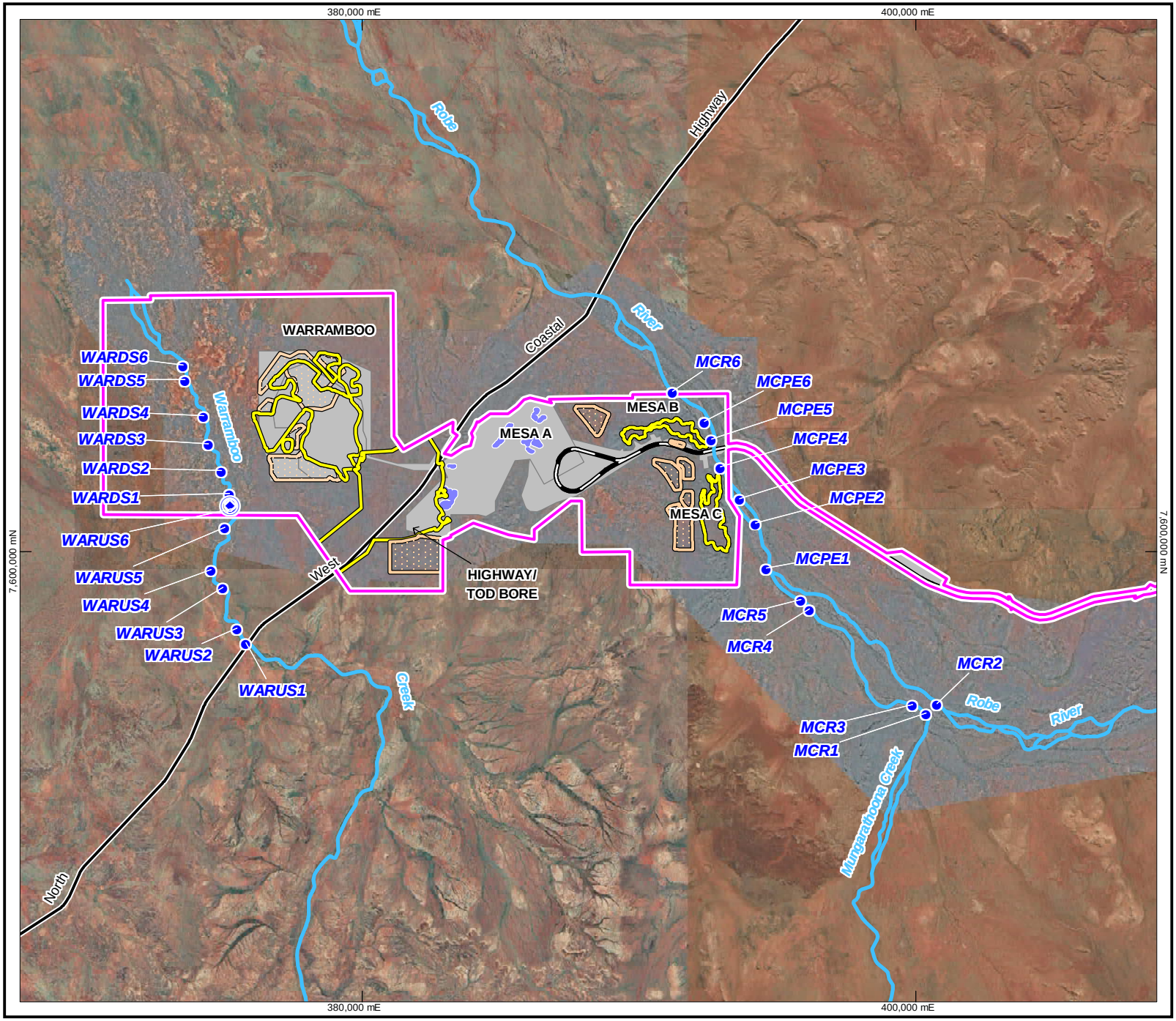
Iron Ore (WA)

Figure 7-1: Terrestrial fauna surveys

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0150130v9
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse
- Aquatic Fauna Sampling Site

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Proposed new mining/cut widening
- Surplus water discharge point

N

SCALE

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Iron Ore (WA)

Figure 7-2: Aquatic fauna sampling sites

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0150128v6
Proj: MGA 94 Zone 50

7.4.2 Regional context

The Pilbara bioregion is a major centre for biodiversity within Western Australia and provides some key habitat types for fauna. This appears to be related to the diversity of geological, altitudinal and climatic elements in the region, as well as being a function of its location (Biota 2011c). The Pilbara is located in a transitional zone between the floras of the Eyrean (central desert) and southern Torresian (tropical) bioclimatic regions, and is also an area of transition for fauna (Kendrick 2001 as cited in Biota 2011c).

One of the key habitat features of the Robe Valley is the mesas which provide habitat for vertebrate species of conservation significance. The mesa escarpments, which are a steep incline between the gentler scree slopes and the mesa plateau, can comprise physical features of caves, fissures, and boulders that provide a range of niches for regionally isolated fauna populations.

7.4.3 Fauna habitats

A total of nine fauna habitats have been mapped in the western portion of the Development Envelope within the three broad landform categories of Rocky Ranges, Plains and Watercourses. Fauna habitats mapped during various surveys of portions of the Development Envelope; MWH (2015a), Astron (2018a) and Biota (2005b) were consolidated to form the list of nine fauna habitat types described in Table 7-3 and shown on Figure 7-3. The habitats were generally assessed as being in Good or Very Good condition (MWH 2015a). Of the nine fauna habitat types mapped in the western portion of the Development Envelope, two are considered to be of elevated conservation significance; Breakaways and Gullies and Major River/Creek habitats and are described further below.[16]

[16] 'Breakaways and Gullies habitat' is used throughout this document rather than 'Mesa Breakaways and Gullies habitat' used in MWH (2015a) as the Breakaways and Gullies habitat is not always associated with a mesa formation.

Table 7-3: Fauna habitats

Habitat	Habitat description and information*	Extent in western portion of the Development Envelope (ha)	Distribution*	Potential to support MNES**	Likelihood to support SREs***
Rocky Ranges					
Mesa Plateau	*Acacia arida* and/or *A. atkinsiana* scattered shrubs over *Triodia wiseana* hummock grassland on stony soils of mesa plateaus.	451	Limited	Limited Provides some foraging and dispersal habitat, for the Northern Quoll, Pilbara Leaf-nosed Bat and Ghost Bat.	Low
Rocky Slopes	*Acacia* shrubland over *Triodia wiseana* open hummock grassland on red shallow loams.	132	Widespread	Limited Provides some foraging and dispersal habitat for the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python but overall is considered to be of limited value to MNES	Low
Breakaways and Gullies	*Eucalyptus leucophloia* scattered trees, over *Acacia*, over *Triodia* sp. hummock grassland on stony soils/red shallow loams of mesa gullies.	129	Limited	High • Denning, shelter and foraging habitat for the Northern Quoll • Temporary nocturnal roosting habitat and foraging habitat for the Pilbara Leaf-nosed Bat • Diurnal, potential maternity and nocturnal roosting and foraging habitat for the Ghost Bat • Breeding, shelter and foraging habitat for the Pilbara Olive Python, particularly the area in close proximity to the semi-permanent and ephemeral pools in the Robe River.	High

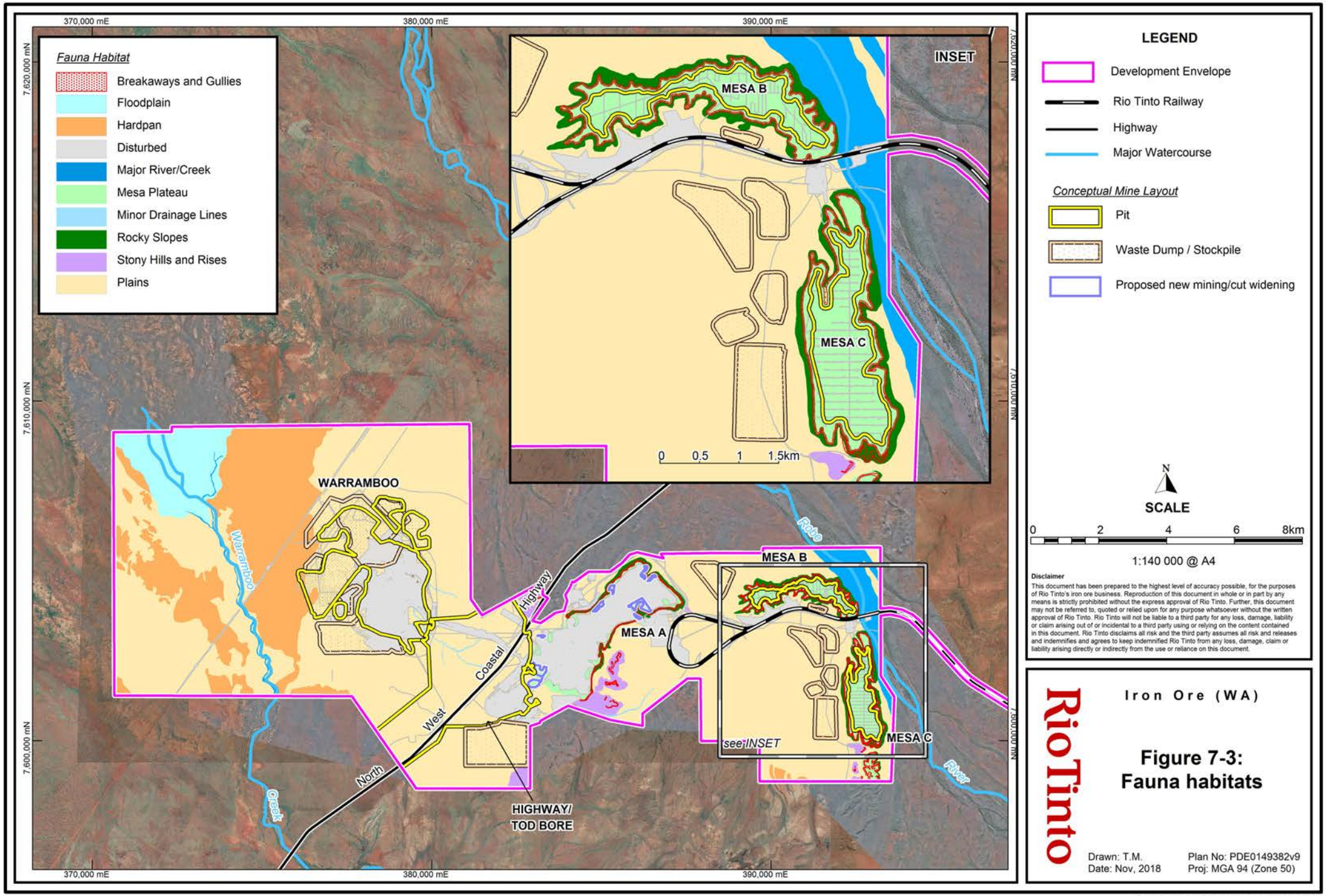
Habitat	Habitat description and information*	Extent in western portion of the Development Envelope (ha)	Distribution*	Potential to support MNES**	Likelihood to support SREs***
Plains					
Plains	Mixed shrubland of *Acacia* over *Triodia* open hummock grassland on red loam/clay soil plains.	9,603	Widespread	Limited Provides limited foraging and dispersal habitat for the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and the Pilbara Olive Python.	Low
Hardpan	Isolated *Corymbia candida* low trees over mixed *Acacia* tall sparse shrubland over *Triodia epactia* hummock to open hummock grassland on heavy non-cracking clays	2,123	Widespread	Limited No features of value to MNES.	Low
Floodplain	Mixed *Eucalyptus* and *Corymbia* spp. low open woodland over mixed *Acacia* tall to mid open shrubland over *Triodia epactia* open to sparse hummock grassland on clay soils	620	Limited	Limited Foraging for Ghost Bat and Pilbara Leaf-nosed Bat.	Medium
Stony Hills and Rises	Mixed *Acacia* tall shrubland over *Triodia* open hummock grassland on stony soils and red shallow loams.	213	Widespread	Limited No features of value to MNES.	Low

Habitat	Habitat description and information*	Extent in western portion of the Development Envelope (ha)	Distribution*	Potential to support MNES**	Likelihood to support SREs***
Watercourses					
Major River/Creek	*Eucalyptus camaldulensis*, *E. victrix* and *Melaleuca argentea* open woodland over mixed *Acacia* shrubland over mixed shrubs and herbs on river bed soils in Riverine habitat.	317	Limited	High • Foraging and dispersal habitat for the Northern Quoll • Foraging and dispersal habitat for the Pilbara Leaf-nosed Bat and Ghost Bat • Shelter, foraging and dispersal habitat for the Pilbara Olive Python (Robe River only) • Foraging and dispersal habitat for the Pilbara Olive Python (Warramboo Creek). Note that Warramboo Creek is not currently considered to be potential shelter habitat for the Pilbara Olive Python due to the lack of permanent water.	Medium
Minor Drainage Lines	*Corymbia hamersleyana* low open woodland over *Acacia* open shrubland over *Triodia* hummock grassland on loamy red earths and river bed soils.	20	Widespread	Medium Potential seasonal foraging habitat for Pilbara Olive Python. Dispersal route for Northern Quoll.	Medium

* Habitats widespread and common within the surrounding region were categorised as widespread; otherwise they were categorised as limited (MWH 2015a).

** The suitability of each habitat to support species of conservation significance or distinct fauna assemblages was categorised as high, medium or limited based on known habitat requirements for fauna of conservation significance in addition to the species that were recorded from each habitat type (MWH 2015a).

*** Likelihood to support potential SRE invertebrates was categorised as low, medium or high based on each habitat's known (or perceived) patterns of distribution, presence of microhabitats, whether the habitat was restricted or widespread in the landscape, and whether the habitat formed isolates or was well connected in the landscape (MWH 2015a).



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Iron Ore (WA)

Figure 7-3: Fauna habitats

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0149382v9
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

7.4.3.1 Breakaways and Gullies habitat

Breakaways and Gullies habitat occurs around the perimeter of the mesas and is described as *Eucalyptus leucophloia* scattered trees, over *Acacia*, over *Triodia* sp. hummock grassland on stony soils/red shallow loams of mesa gullies.

The Breakaways and Gullies habitat in the western portion of the Development Envelope supports species of conservation significance and has a high likelihood of supporting SRE invertebrates (Table 7-3). The Breakaways and Gullies habitat contains caves and deeply incised gullies. These habitat features have a discontinuous and patchy distribution in the landscape and are not commonly found in other habitat types. They provide:

- Denning, shelter and foraging habitat for the Northern Quoll
- Temporary nocturnal roosting habitat and foraging habitat for the Pilbara Leaf-nosed Bat
- Diurnal, potential maternity and nocturnal roosting and foraging habitat for the Ghost Bat
- Breeding, shelter and foraging habitat for the Pilbara Olive Python, particularly the area in close proximity to the semi-permanent and ephemeral pools in the Robe River
- Refugia, sheltered microhabitats and food resources for vertebrate fauna assemblages in general and for invertebrate groups that support SREs.

The Mesa Façade Assessment (MWH 2015b) identified almost half (45%) of the length of the Mesa B escarpment to be of Moderate ecological quality (according to quality of habitat for significant flora and fauna), with the majority (53%) mapped as Good and 2% mapped as Very Good ecological quality. Over half (52%) of the Mesa C escarpment was mapped as Moderate ecological quality, with 39% mapped as Good and 9% as Very Good ecological quality. MWH (2015b) did not rate any areas of the Mesa B or C escarpments as being of Excellent ecological quality.

7.4.3.2 Major River/Creek habitat

The Major River/Creek habitat occurs along Warramboo Creek and the Robe River. The Major River habitat is described as: *Eucalyptus camaldulensis*, *E. victrix* and *Melaleuca argentea* open woodland over mixed Acacia shrubland over mixed shrubs and herbs on river bed soils in Riverine habitat.

The Major River/Creek habitat provides sandy or stony banks which have intermittent areas of dense riparian vegetation which, in turn provide increased shelter and retain water for longer periods than the surrounding plains. This habitat contains microhabitats not common in other habitat types, such as large tree hollows, hollow logs and moist leaf litter that provide a productive ecosystem attracting and supporting a range of predators and prey.

The Major River/Creek habitat of the Robe River in the western portion of the Development Envelope supports riparian vegetation adjacent to the rocky hills and escarpments of Mesas B and C. Within the western portion of the Development Envelope, two semi-permanent pools are present adjacent to Mesa B and C. Permanent pools associated with the Robe River and Mungarathoona Creek (a tributary of the Robe River) are present outside the western portion of the Development Envelope with the closest pools located approximately 4 km to the north and 8 km to the south-east of the Development Envelope. Numerous permanent pools are present further upstream in the

Robe River and a base flow is believed to be continuously present in the upper reaches of the Robe River.

The Robe River and the associated semi-permanent pools near Mesa B and C provide:

- Foraging and dispersal habitat for the Northern Quoll
- Foraging and dispersal habitat for the Pilbara Leaf-nosed Bat and Ghost Bat
- Shelter, foraging and dispersal habitat for the Pilbara Olive Python (Robe River only)
- Habitat for a range of aquatic fauna
- Mesic qualities that have a moderate potential to support SREs.

The Major River/Creek habitat of Warramboo Creek contains riparian vegetation and provides:

- A seasonal source of water to fauna in a largely dry landscape
- Foraging and dispersal habitat for the Northern Quoll
- Foraging and dispersal habitat for the Pilbara Leaf-nosed Bat and Ghost Bat
- Foraging and dispersal habitat for the Pilbara Olive Python
- Habitat for a range of aquatic fauna
- Areas with a moderate potential to support SREs.

The remaining habitats and habitat features recorded within the western portion of the Development Envelope are considered to be well represented in the Robe Valley region and the Pilbara bioregion and are not considered to be of elevated conservation significance.

7.4.4 Terrestrial vertebrate fauna occurrence

MWH (2015a) recorded 176 vertebrate fauna species in the 7,936 ha study area, comprising four amphibians, 60 reptiles, 84 birds and 28 mammals (25 native and three introduced). Systematic sampling was undertaken in the (now amalgamated) Major River/Creek, Plains, Hardpan and Mesa Plateau habitat types. Species richness and abundance were highest in the Major River/Creek habitat, followed by the Plains habitat which is the most extensive habitat in the western portion of the Development Envelope (MWH 2015a); see Figure 7-1.

The vertebrate fauna species of conservation significance recorded, or with the potential to occur, in the western portion of the Development Envelope are described in Table 7-4. Five[17] vertebrate fauna species of conservation significance have been recorded in the western portion of the Development Envelope (Figure 7-4), including species listed under the EPBC Act and/or the WC Act, as well as species listed as Priority species by the DBCA. A desktop assessment (MWH 2015a) identified an additional ten vertebrate fauna species of conservation significance as being likely or very likely to occur within the western portion of the Development Envelope. A further eight species were identified as possibly occurring and six species as being unlikely to occur; these species are described in Table 7-4 but are not considered further in this assessment.

[17] *Merops ornatus* (Rainbow Bee-eater), *Ardea ibis* (Cattle Egret) and *Ardea modesta* (Eastern Great Egret), were removed from the EPBC Act migratory list in Feb 2018, following completion of fauna surveys in the western portion of the Development Envelope. These species are therefore not considered in this assessment.

Table 7-4: Terrestrial (non-aquatic) vertebrate fauna species of conservation significance and their likelihood of occurrence

Species	Conservation status	Likelihood of occurrence*
Confirmed		
Dasyurus hallucatus (Northern Quoll)	Endangered, EPBC Act Schedule 2 (Endangered), WC Act.	Confirmed from trap records, motion cameras and scats.
Rhinonicteris aurantia (Pilbara Leaf-nosed Bat)	Vulnerable, EPBC Act Schedule 3 (Vulnerable), WC Act.	Confirmed from calls.
Macroderma gigas (Ghost Bat)	Vulnerable, EPBC Act Schedule 3 (Vulnerable), WC Act.	Confirmed by direct observation, scats, cave middens and echolocation records.
Liasis olivaceus barroni (Pilbara Olive Python)	Vulnerable, EPBC Act Schedule 3 (Vulnerable), WC Act.	Confirmed from opportunistic record.
Pseudomys chapmani (Western Pebble-mound Mouse)	Priority 4, DBCA.	Confirmed from observation of mostly inactive mounds and one active mound.
Very likely		
Falco peregrinus (Peregrine Falcon)	Schedule 7 (Other specially protected fauna), WC Act.	The Peregrine Falcon is very likely to occur in areas of the western portion of the Development Envelope where suitable nesting habitat (cliffs) occurs associated with Mesas B and C and the Robe River (MWH 2015a). The species has previously been recorded by Biota (2009b) in the vicinity of the Development Envelope. The species is likely to occur in the Development Envelope near Warramboo, but is unlikely to occur in the Highway to Tod Bore area due to lack of suitable habitat (MWH 2015a).

Species	Conservation status	Likelihood of occurrence*
Glareola maldivarum (Oriental Pratincole)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Oriental Pratincole is very likely to occur around semi-permanent pools along the Robe River (MWH 2015a) and has been recorded by Birdlife Australia (2015) and Parks and Wildlife (2015) within 500 m of the Warramboo area. The species is also likely to occur intermittently along drainage lines in the Highway to Tod Bore area of the Development Envelope (MWH 2015a).
Likely		
Falco hypoleucos (Grey Falcon)	Schedule 3 (Vulnerable), WC Act.	The Grey Falcon is likely to occur in the Development Envelope near Mesas B and C due to the presence of suitable habitat along the Robe River and previous records of the species in the vicinity by Biota (2009c). The species may possibly occur in the Development Envelope near Warramboo, but is unlikely to occur in the Highway to Tod Bore area due to lack of suitable habitat (MWH 2015a).
Sminthopsis longicaudata (Long-tailed Dunnart)	Priority 4, DBCA.	The Long-tailed Dunnart is likely to occur in the Development Envelope near Mesas B and C due to the presence of suitable rocky habitat, but is unlikely to occur in the Warramboo or Highway to Tod Bore areas due to lack of suitable rocky habitat (MWH 2015a). The species has previously been recorded within 50 km of the Development Envelope by Biota (2009b).
Notoscincus butleri (Lined Soil-crevice Skink)	Priority 4, Parks and Wildlife.	The Lined Soil-crevice Skink is likely to occur in the Plains habitat in the western portion of the Development Envelope (MWH 2015a). The species was recorded by Biota (2006d) at three sites approximately 40-45 km east of Mesas A, B and C and has been recorded elsewhere within 30 km of the Development Envelope by Biota (2009b, 2011c). It is known from nine additional records within 50 km of the Development Envelope in the DBCA (2018a) database.
Actitis hypoleucos (Common Sandpiper)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Common Sandpiper is likely to occur in suitable habitat along the riverbed, banks and floodplain of the Robe River and Warramboo Creek (MWH 2015a). The species may occur in the Highway to Tod Bore area after periods of flooding, although there is generally no suitable habitat for the species in this area (MWH 2015a). The Common Sandpiper has been recorded within 40 km of the Development Envelope by Birdlife Australia (2015).

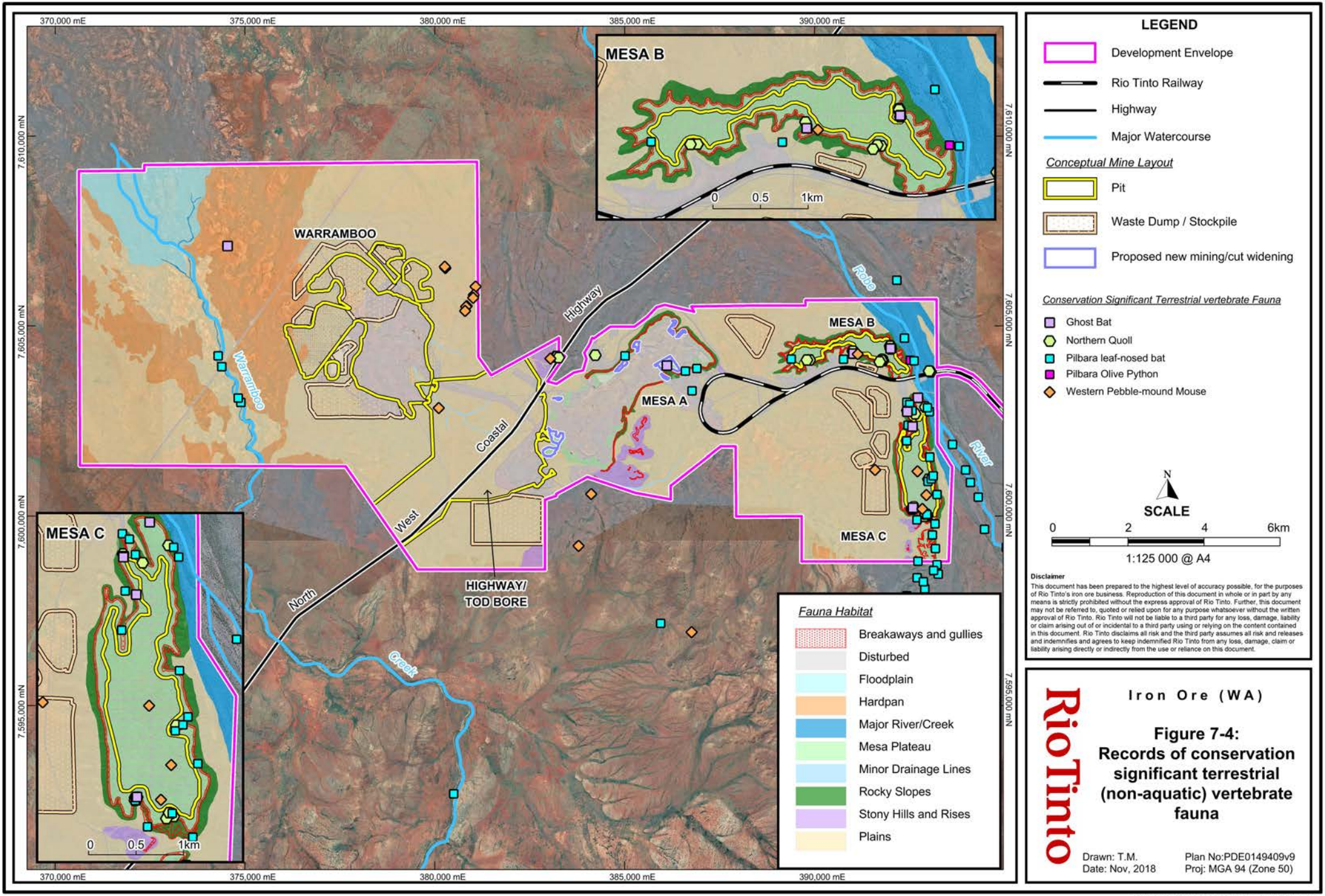
Species	Conservation status	Likelihood of occurrence*
Tringa glareola (Wood Sandpiper)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Wood Sandpiper is likely to occur in suitable habitat along the riverbed, banks and floodplain of the Robe River and Warramboo Creek (MWH 2015a). The species may occur in the Highway to Tod Bore area after periods of flooding, although there is no suitable habitat for the species in this area (MWH 2015a). The Wood Sandpiper has been recorded within 50 km of the Development Envelope by Birdlife Australia (2015).
Tringa nebularia (Common Greenshank)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Common Greenshank is likely to occur in suitable habitat along the riverbed, banks and floodplain of the Robe River and Warramboo Creek. The species may occur in the Highway to Tod Bore area after periods of flooding, although there is no suitable habitat for the species in this area. There are no records of the species within 50 km of the Development Envelope (MWH 2015a).
Numenius minutus (Little Curlew)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Little Curlew is likely to occur in suitable habitat along the riverbed, banks and floodplain of the Robe River and Warramboo Creek, as well as flooded plains (MWH 2015a). The species has been recorded in the region by Biota (2009c).
Pandion cristatus (Eastern Osprey)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Eastern Osprey is likely to occur in the Development Envelope near Mesas B and C as it may disperse upstream along the Robe River from its preferred coastal habitat. Warramboo Creek provides marginal habitat that may possibly be used as a dispersal conduit by the species. The Eastern Osprey is unlikely to occur in the Highway to Tod Bore area of the Development Envelope due to lack of suitable habitat (MWH 2015a).
Possible		
Leggadina lakedownensis (Lakeland Downs Mouse)	Priority 4, Parks and Wildlife.	The Lakeland Downs Mouse may occur in the Hardpan habitat present near Mesas B and C and in the Warramboo area, although its preferred habitat of cracking clays is absent (MWH 2015a). The species is known from seven records within 20 km to the north of the Development Envelope in the DBCA (2018a) database. It is unlikely to occur in the Highway to Tod Bore area due to lack of suitable cracking clay habitat (MWH 2015a).
Elanus scriptus (Letter-winged Kite)	Priority 4, Parks and Wildlife	The Letter-winged Kite may occur over all habitats in the western portion of the Development Envelope due to its irruptive dispersal behaviour; after rainfall, spectacular population explosions of the Letter-winged Kite occur and the species disperses into areas in which it is not normally seen (MWH 2015a).

Species	Conservation status	Likelihood of occurrence*
Haliaeetus leucogaster (White-bellied Sea-eagle)	Migratory, EPBC Act.	The White-bellied Sea-eagle may occur in parts of the Development Envelope near the Robe River and Warramboo Creek. It is a coastal marine species that may disperse upstream along the Robe River during periods of flood. Warramboo Creek provides marginal habitat that may be used as a dispersal conduit by the species. The White-bellied Sea-eagle is unlikely to use the Highway to Tod Bore area of the Development Envelope due to lack of suitable habitat (MWH 2015a).
Apus pacificus (Fork-tailed Swift)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Fork-tailed Swift may overfly the Development Envelope without specifically utilising any particular habitat present. It is a migratory aerial species that is uncommon in the Pilbara (MWH 2015a). Although the species has been recorded near the Development Envelope by Biota (2006d, 2009b).
Hydroprogne caspia (Caspian Tern)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Caspian Tern may occur in habitats along the Robe River and Warramboo Creek, but is unlikely to occur in the Highway to Tod Bore area. There are no known records of the species within 50 km of the Development Envelope (MWH 2015a).
Thalasseus bengalensis (Lesser Crested Tern)	Migratory, EPBC Act.	The Lesser Crested Tern may occur in habitats along the Robe River and Warramboo Creek, but is unlikely to occur in the Highway to Tod Bore area. There are no known records of the species within 50 km of the Development Envelope (MWH 2015a).
Hirundo rustica (Barn Swallow)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Barn Swallow may intermittently utilise habitats along the Robe River and Warramboo Creek during September to April, although the western portion of the Development Envelope does not contain preferred habitat for the species and there are no known regional records of the species (MWH 2015a). The Barn Swallow is unlikely to utilise the Highway to Tod Bore area due to lack of suitable habitat (MWH 2015a).
Charadrius veredus (Oriental Plover)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Oriental Plover may occur intermittently in habitats within the Plains landform category in the western portion of the Development Envelope between August and April, when the species visits northern Australia. There are no known records of the species within 50 km of the Development Envelope (MWH 2015a).

Species	Conservation status	Likelihood of occurrence*
Unlikely		
Notoryctes caurinus (Northern Marsupial Mole)	Endangered, EPBC Act.	The Northern Marsupial Mole is unlikely to occur in the western portion of the Development Envelope as the nearest record is located more than 250 km to the east of the Development Envelope and there are no recent records in the Pilbara (MWH 2015a).
Pezoporus occidentalis (Night Parrot)	Endangered, EPBC Act Schedule 1 (Critically Endangered), WC Act.	The Night Parrot is unlikely to occur in the western portion of the Development Envelope due to the absence of recent records from the locality and a lack of preferred habitat (MWH 2015a; Astron 2018b). The species is known from within 10 km of the Development Envelope from one unpublished 1967 record along the Robe River (Parks and Wildlife 2015). Although rainfall received (based on Pannawonica weather station 005069) in three months preceding the Taregeted Night Parrot survey (Astron 2018b) was 0.3 mm (58.9 mm less than the mean rainfall for the same three months (Bureau of Meteorology 2018 as cited in Astron 2018b)), rainfall that was received in the nine months preceding the survey was 208.7 mm more than the mean rainfall for the same nine months (Bureau of Meteorology 2018 as cited in Astron 2018b). These fluctuations in microclimate rainfall were not considered to limit the survey outcomes (Astron 2018b). The Night Parrot is an adept arid specialist and would be well adapted to long periods of drought (Astron 2018b). A dry period in the area would not, therefore, preclude recording the Night Parrot if it were present.
Macrotis lagotis (Greater Bilby)	Vulnerable, EPBC Act Schedule 3 (Vulnerable), WC Act.	The Greater Bilby is unlikely to occur in the western portion of the Development Envelope as it is located outside the current distribution of the species and the western portion of the Development Envelope does not contain suitable habitat (MWH 2015a). The Greater Bilby has not been recorded in regional studies; the nearest record is located more than 100 km east of the Development Envelope (DBCA 2018a).
Rostratula australis (Australian Painted Snipe)	Vulnerable, EPBC Act Schedule 2 (Endangered), WC Act.	The Australian Painted Snipe is unlikely to occur in the western portion of the Development Envelope due to lack of suitable wetland habitat. There are no known records of the species within 50 km of the Development Envelope and very few records within the Pilbara region (MWH 2015a).

Species	Conservation status	Likelihood of occurrence*
Dasycercus blythi (Brush-tailed Mulgara)	Priority 4, Parks and Wildlife.	The Brush-tailed Mulgara is unlikely to occur in the western portion of the Development Envelope due to lack of suitable sandplains and undisturbed mature spinifex grassland habitat (MWH 2015a). The species is known by one record within 50 km of the Development Envelope (Parks and Wildlife 2015).
Onychoprion anaethetus (Bridled Tern)	Migratory, EPBC Act Schedule 5 (Migratory), WC Act.	The Bridled Tern is unlikely to occur in the western portion of the Development Envelope as there are no regional records of this species which is predominantly a bird of the open sea, rarely venturing inland (MWH 2015a).

*__Confirmed__: the presence of the species in the western portion of the Development Envelope has been recorded unambiguously during the last ten years, i.e. during the MWH (2015a) survey, from other recent surveys and/or from recent records obtained via database searches.
__Very likely__: the western portion of the Development Envelope lies within the known distribution of the species and contains suitable habitat(s), plus the species generally occurs in suitable habitat and has been recorded nearby within the last 20 years.
__Likely__: the western portion of the Development Envelope lies within the known distribution of the species and the species has been recorded nearby within the last 20 years; however, either: the western portion of the Development Envelope contains only a small area of suitable habitat, or habitat is only marginally suitable; or the species is generally rare and patchily distributed in suitable habitat.
__Possible__: there is an outside chance of occurrence, because: the western portion of the Development Envelope is just outside the known distribution of the species, but it does contain suitable and sufficient habitat (the species may be common, rare, or patchily distributed); or the western portion of the Development Envelope lies within the known distribution of the species, but the species is very rare and/or patchily distributed; or the western portion of the Development Envelope lies on the edge of, or within, the known distribution and has suitable habitat, but the species has not been recorded in the area for over 20 years.
__Unlikely__: the western portion of the Development Envelope lies outside the known distribution of the species, the western portion of the Development Envelope does not contain suitable habitat, and the species has not been recorded in the area for over 20 years.



LEGEND

- Development Envelope
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Proposed new mining/cut widening

Conservation Significant Terrestrial vertebrate Fauna

- Ghost Bat
- Northern Quoll
- Pilbara leaf-nosed bat
- Pilbara Olive Python
- Western Pebble-mound Mouse

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SCALE

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Rio Tinto

Iron Ore (WA)

Figure 7-4: Records of conservation significant terrestrial (non-aquatic) vertebrate fauna

Drawn: T.M.
Date: Nov, 2018

Plan No:PDE0149409v9
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

7.4.5 Conservation significant terrestrial fauna (non-aquatic) species profiles and records

7.4.5.1 Northern Quoll (Confirmed)

The Northern Quoll is listed as Endangered under Schedule 2 of the WC Act and as Endangered under the EPBC Act. The Northern Quoll was originally found across northern Australia from the North-West Cape of WA to south-east Queensland; however, its abundance has significantly declined in recent years. This species is now restricted to five regional populations across Queensland, the Northern Territory and Western Australia on both the mainland and offshore islands (DotEE 2017a).

In the Pilbara, the species is considered to favour uplands including rocky gorges, breakaways and hills. Rocky habitats adjoining drainage lines have a heightened level of importance given the close proximity of denning habitat to foraging areas.

MWH (2015a) recorded evidence of the Northern Quoll at 23 sites in the western portion of the Development Envelope, across Mesa Plateau, Rocky Slopes, Stony Hills and Rises, and Major River/Creek habitats. Previous surveys for the existing approved project recorded Northern Quoll on the Mesa B escarpment and in a cave and gorge at Mesa A (Biota 2005b, 2006d) and an additional 92 records are known within 50 km of the Development Envelope, with the nearest approximately 2 km to the south of the Development Envelope (Biota 2011c).

The most important habitats in the western portion of the Development Envelope for the Northern Quoll are considered to be the Breakaways and Gullies and Major River/Creek habitats, which provide high value denning/shelter habitats associated with caves and rocky overhangs and/or enhanced foraging opportunities due to the availability of water (MHW 2015a).

As the Northern Quoll is a MNES, this species is subject to assessment as part of the Environmental Review accredited assessment which is addressed in Section 12.

7.4.5.2 Pilbara Leaf-nosed Bat (Confirmed)

The Pilbara Leaf-nosed Bat is listed as Vulnerable under Schedule 3 of the WC Act and also as Vulnerable under the EPBC Act. The Pilbara Leaf-nosed Bat roosts during the day in caves and mine adits (horizontal tunnels) with stable, warm and humid microclimates. The species is thought to be restricted to such environments because it has a limited ability to maintain its heat and water balance (DotEE 2017b). These underground diurnal and breeding roosts are considered ‘habitat critical to the survival’ of the Pilbara Leaf-nosed Bat (Threatened Species Scientific Committee 2016a).

The Pilbara Leaf-nosed Bat is known to have a typical dry season foraging range up to 20 km from its primary roost caves (Bat Call WA 2016) but may forage at greater distances if suitable water sources are available. The Pilbara Leaf-nosed Bat is most commonly encountered over small pools of water in rocky gullies and gorges, but has been observed foraging in a variety of habitats including *Triodia* hummock grasslands covering low rolling hills and shallow gullies, with scattered *Eucalyptus camaldulensis* along the creeks; over small watercourses amongst granite boulder terrain; over pools and low shrubs in ironstone gorges; and above low shrubs and around pools in gravelly watercourses with *Melaleuca leucodendron* (DotEE 2017b).

Through a series of surveys conducted internally by the Proponent and a survey conducted by MWH (2015a), the Pilbara Leaf-nosed Bat has been recorded via 42 call records at a total of 32 sites in the western portion of the Development Envelope (Figure 7-4).

The timing of the recorded calls, together with the locations of sites, is consistent with the species foraging along the Robe River and adjacent Breakaways and Gullies habitat and along Warramboo Creek (MWH 2015a). Astron (2018a) also recorded acoustic bat records within the Major River/Creek habitat of Warramboo.

Further monitoring for Pilbara Leaf-nosed Bat has been undertaken by Rio Tinto, including deployment of bat detectors at 66 locations in the Robe Valley across Mesas A, B, C, D, E and F for a total of 144 nights. Based on the Pilbara Leaf-nosed Bat's expected patterns of movement from a roost, typical dispersal flight speed of 20 km per hour and the frequency and location of calls, the mesas are considered to form part of a larger home range with the Robe River providing an important foraging source (Rio Tinto 2017e). The individuals recorded in the western portion of the Development Envelope are likely to have originated from an unknown roost located outside the Development Envelope. The individuals are not considered to have originated from either the nearest known roost (30 km upstream along the Robe River from the Development Envelope), or the largest known roost identified by Rapallo Environmental (2012) 60 km to the south of the Development Envelope (MWH 2015a).

As the Pilbara Leaf-nosed Bat is a MNES, this species is subject to assessment as part of the Environmental Review accredited assessment which is addressed in Section 12.

7.4.5.3 Ghost Bat (Confirmed)

The Ghost Bat is listed as Vulnerable under Schedule 3 of the WC Act and also as Vulnerable under the EPBC Act. The Ghost Bat roosts during the day in caves, rock crevices and disused mine shafts and adits. Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23-28^{o}C and humidity above 50%. Individuals require a range of cave sites and move between roosts seasonally or according to weather conditions. Populations are widely dispersed when not breeding and concentrate in relatively few roost sites when breeding.

Ghost Bats forage over a wide range of habitats typically up to 2 km from their diurnal roost site and individuals generally return to the same foraging areas each night. Foraging Ghost Bats use echolocation during flight to detect prey and use passive sit-and-wait hunting techniques using eyesight to scan for prey from roosts up to 3m above the ground, such as rocky overhangs and tree branches (MWH 2015a; TSSC 2016b).

The Ghost Bat has a patchy distribution in the Pilbara. The regional Pilbara Ghost Bat population is estimated at 1,300 to 2,000 individuals (Bat Call WA 2016; Armstrong per. comm. 2015 in TSSC 2016a), the majority of which are known from six historical mine workings; two of which appear to have disappeared (TSSC 2016b). The largest colonies are located in the Chichester subregion and support up to several hundred individuals (Bat Call WA 2016). The smaller colonies of the Hamersley subregion typically support less than ten (TSSC 2016b), but potentially up to around 25 individuals in local groups (Bat Call WA 2016). To persist, these groups need a roost complex including at least one deep cave with characteristics of a maternity roost, multiple caves/shelters and overhangs in close proximity offering nocturnal and refuge opportunities. In addition, these groups need a set of nearby gullies and gorges and productive foraging areas

within a 5 to 10 km radius, which usually includes a good riparian line and protection from human interference (Bat Call WA 2016).

The Ghost Bat is common in the Robe Valley, often occurring in groups of up to 20 individuals (MWH 2015a). Astron completed a fauna survey of the Robe Valley to the east of Mesa J (including assessment of potential Ghost Bat roosts) (Astron 2015) and a contextual Ghost Bat habitat assessment of the Robe Valley from Mesa B to Mesa J (Astron 2017c). Potential diurnal Ghost Bat roosts sites were identified at Mesas B, C, F, G, H and in the Middle Robe region approximately 60 km east of the Development Envelope. The contextual assessment also identified high quality habitat along the Buckland Hills to the south of Mesa H (Astron 2017c). The contextual analysis notes that the Ghost Bat tends to occur in fewer locations but greater numbers in the Chichester subregion when compared to occurrence in the Hamersley subregion where the species is known from more locations, but occurs in smaller numbers.

During the Level 2 survey conducted by MWH (2015a), the Ghost Bat was recorded via three calls from one cave on the north-east flank of Mesa B (MBC-01; Figure 7-5) and was also identified from scats at an open cave on the south flank of Mesa B which is most likely a nocturnal roost (a temporary roost used for night time feeding) (B1; Figure 7-5) (MWH 2015a). Nocturnal roosts were identified at Mesas B and C within the Breakaways and Gullies habitat type.

The targeted Ghost Bat cave assessment conducted by Bat Call WA (2016) confirmed the presence and foraging of Ghost Bat around the perimeters of both Mesa B and Mesa C. A permanent Ghost Bat population of 15 to 20 individuals is estimated to occur in caves on Mesa B. Thirteen caves on Mesa B were assessed as currently in use by Ghost Bats including one potential diurnal/maternal roost and 12 nocturnal roost caves.

Caves forming a potential roost complex at Mesa B, including caves MBC-04, MBC-05 and the shelter MBS-01 were considered the most significant areas on Mesa B for the Ghost Bat (Bat Call WA 2016) (Figure 7-5). MBC-05 is considered a potential maternal roost as it is adequately deep and dark with a high domed chamber at the rear, contains multiple nocturnal roost and daytime refuge opportunities, multiple early evening observation sites and is located within 5 km of productive riparian zones (Bat Call WA 2016). This cave is approximately 21 m deep and is located approximately 105 m from the proposed Mesa B mine pit.

Nine caves on Mesa C were assessed as being currently in use by Ghost Bats, including one potential diurnal roost and eight nocturnal roosts. Cave MCC-02 has two levels of cavities and contained evidence of middens including food scraps. This may be a diurnal roost; however, the cave could not be adequately inspected due to safety concerns related to the height of upper level cavities. This cave is approximately 10 m deep and is located approximately 55 m from the proposed Mesa C mine pit. The number of individuals in this cave could not be determined (Bat Call WA 2016). Ghost Bat roosts from Mesa B and C are shown in Figure 7-5.

Further west, during survey of the Warramboo area Astron (2018a) recorded a single Ghost Bat individual caught in a station fence line.

At Mesa A, two caves have been recorded, one of which was thought to be a potential diurnal roost; however further assessment has indicated that both of the caves at Mesa A are likely nocturnal roost caves (Bat Call WA 2017a; Appendix 8).

As the Ghost Bat is a MNES, this species is subject to assessment as part of the Environmental Review accredited assessment which is addressed in Section 12.

Table 7-5 summarises the morphology of each of the caves recorded at Mesas A, B and C.

Table 7-5: Characteristics of caves and shelters with evidence of Ghost Bat use

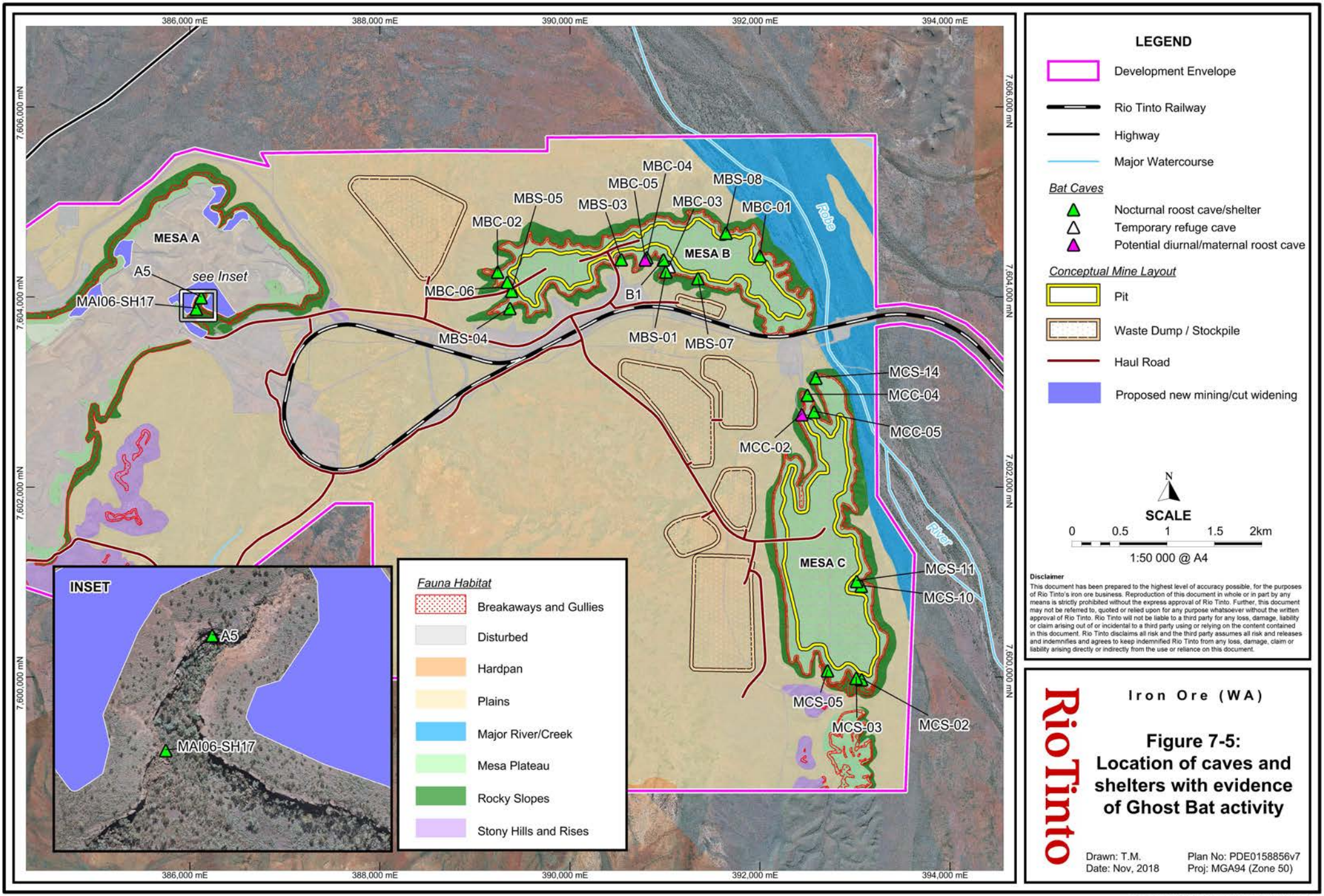
Cave name	Type	Approximate depth[1] (m)	Maximum internal height (m)	Entrance orientation	Internal temperature/ humidity
Mesa A					
A5	nocturnal	10.9	4.5	south-east	ambient
MAI06-SH17	nocturnal	8.4	-	south-east	ambient
Mesa B					
MBC-01	probably nocturnal	11.1	2.8	north-east	ambient
MBC-02	nocturnal	19.3	2	north	ambient
MBC-03	temporary refuge	11.6	1.5	west	ambient
MBC-04	nocturnal	13.3	3	south-east	ambient
MBC-05[2]	diurnal/potential maternal	20.8	-	east	ambient in entrance, unknown in rear chamber
MBC-06	nocturnal	10.7	1.7	south	ambient
MBS-01	nocturnal	10.5	2.5	south-east	ambient
MBS-03	nocturnal	7.2	-	south	ambient
MBS-04	nocturnal	1.5	1.5	south-east	ambient
MBS-05	nocturnal	6.8	1.7	west	ambient
MBS-07	nocturnal	12.2	2.7	south	ambient
MBS-08	nocturnal	11	2	north	ambient
B1	nocturnal	-	-	south	-
Mesa C					
MCC-02	potential diurnal	10	4	north-west	Ambient in lower chamber, warm, humid air from pipes in roof
MCC-04	nocturnal	10	2.5	North-east	ambient
MCC-05	nocturnal	30	2	north	ambient
MCS-02	nocturnal	12.3	1.9	south-west	ambient
MCS-03	nocturnal	8.9	3.3	south	Ambient in front chamber,

Cave name	Type	Approximate depth[1] (m)	Maximum internal height (m)	Entrance orientation	Internal temperature/ humidity
					unknown in rear chamber
MCS-05	nocturnal	9.7	3.1	west	ambient
MCS-10[3]	possible nocturnal	>7.5	-	north-west	Ambient in entrance chamber, unknown in rear chamber
MCS-11	nocturnal	7.5	2	south-east	ambient
MCS-14	possible nocturnal	>8.1	0.2	north	Ambient in entrance chamber, unknown in rear chambers

[1] The lateral extent (cave depth) was measured using a hand-held laser wherever possible

[2] Height of MBC-05 was not measured and depth was estimated only as Ghost Bats were present

[3] Rear chamber of MCS-10 not entered due to presence of a snake



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Rio Tinto

Iron Ore (WA)

Figure 7-5: Location of caves and shelters with evidence of Ghost Bat activity

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0158856v7
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

7.4.5.4 Pilbara Olive Python (Confirmed)

The Pilbara Olive Python is listed as Vulnerable under Schedule 3 of the WC Act and as Vulnerable under the EPBC Act. The Pilbara Olive Python prefers escarpments, deep gorges and waterholes within ranges. It is widespread in the Pilbara region and occurs as scattered populations. This species is known to occur at more than 60 locations across the Pilbara (G. Humphreys, Biota Environmental Sciences, pers. comm. 2012) including populations at Pannawonica, Millstream, Tom Price and the Burrup Peninsula. It also occurs within the Rangelands (Western Australia) Natural Resource Management Region and part of the species' habitat is conserved in Karijini National Park. Individuals occupy distinct home ranges and males can travel distances of up to 4 km during the breeding season (June to August) to locate females (DotEE 2017c).

Individuals spend the cooler winter months hiding in caves and rock crevices away from water sources, and the warmer summer months moving around widely, usually in close proximity to water and rock outcrops. The species uses waterholes to hunt and ambushes prey on animal trails or by striking from a submerged position in water holes (TSSC 2008; MWH 2015a; DotEE 2017c). Individuals occupy distinct home ranges, estimated to range from approximately 87 ha to 449 ha (DotEE 2017c) and males can travel distances of up to 4 km during the breeding season (June to August) to locate females.

The Pilbara Olive Python was recorded at one location in the western portion of the Development Envelope along the Robe River, adjacent to Mesa B (Figure 7-4). Numerous records of the species exist in similar Riverine habitats within 50 km of Mesas B and C (MWH 2015a).

The Major River/Creek habitat in the western portion of the Development Envelope is considered likely to support foraging and shelter habitat and a potential dispersal route for the species. The Breakaways and Gullies habitat present in the western portion of the Development Envelope is likely to provide breeding/shelter habitat, particularly adjacent to the semi-permanent pools near Mesa B in the Robe River.

As the Pilbara Olive Python is a MNES, this species is subject to assessment as part of the Environmental Review accredited assessment which is addressed in Section 12.

7.4.5.5 Western Pebble-mound Mouse (Confirmed)

The Western Pebble-mound Mouse is listed as a Priority 4 species by DBCA. The Western Pebble-mound Mouse is widespread, but patchily distributed in the Pilbara and prefers hilly and/or rocky landscapes with a plentiful supply of small pebbles. The species occurs on skeletal soils containing an abundance of suitably-sized small pebbles and it creates its own microhabitat by constructing a distinctive mound of pebbles around its burrow. Mounds are often located on the spurs and lower slopes of ridges where weathering produces an abundant supply of pebbles of the preferred size. The Western Pebble-mound Mouse is likely to occur over the western portion of the Development Envelope in areas where pebbles conform with the appropriate size to construct mounds, including in Mesa Plateau, Rocky Slopes, Stony Plains and Stony Hills and Rises habitats (MWH 2015a).

Evidence of the Western Pebble-mound Mouse has been recorded in the western portion of the Development Envelope from 11 inactive mounds and one active mound. The active mound was recorded by MWH (2015a) approximately 500 m north-east of the Highway/Tod Bore deposit (Figure 7-4). Four records also occur within 6km to the south

of the western portion of the Development Envelope and seven records also occur within 50 km of the Development Envelope (Parks and Wildlife 2015).

Extensive suitable Plains habitat occurs within the western portion of the Development Envelope. The reasons for scarcity and inactivity of this species in the western portion of the Development Envelope are unknown, but may be related to recent fires; particularly on the plateau of Mesa C and in the Plains habitat (MWH 2015a).

7.4.5.6 Peregrine Falcon (Very Likely)

The Peregrine Falcon is listed under Schedule 7 of the WC Act as other specially protected fauna. This species is widespread across Australia, but requires cliffs, rocky outcrops or large tree hollows for nesting, preferably near water. In the arid zone, breeding is restricted to rocky ranges (MWH 2015a).

The Peregrine Falcon has not been recorded in the western portion of the Development Envelope to date; but is considered very likely to occur given the presence of escarpments along the Robe River and in association with Mesas A, B and C within the Breakaways and Gullies habitat, where ledges and overhangs offer potential nesting locations.

7.4.5.7 Oriental Pratincole (Very Likely)

The Oriental Pratincole is listed under Schedule 5 of the WC Act as a Migratory bird protected under an international agreement and is also listed as Migratory under the EPBC Act. The Oriental Pratincole has not been recorded in the western portion of the Development Envelope to date, but is considered very likely to occur. The species would be expected to occur along the edges of floodplains of larger watercourses such as the Robe River and Warramboo Creek. The Oriental Pratincole is widespread in northern Australia, including along the Pilbara coast. It inhabits open plains, floodplains or short grasslands and often occurs near wetlands or creeks, congregating near the edges of water on bare areas such as clay pans. The species has previously been recorded within 1 km of the Development Envelope (MWH 2015a).

7.4.5.8 Grey Falcon (Likely)

The Grey Falcon is listed as Vulnerable under Schedule 3 of the WC Act. It occurs very sparsely in the interior and north of Australia and prefers timbered lowland plains, especially those dominated by Acacia (AWC 2017) and tree lined watercourses. Plains, Major River/Creek and Minor Drainage Lines habitats may be suitable for this species. The species was not recorded in the recent fauna surveys (MWH 2015a).

7.4.5.9 Long-tailed Dunnart (Likely)

The Long-tailed Dunnart is listed as a Priority 4 species by DBCA. This species occurs on plateaus near breakaways and scree slopes (MWH 2015a) and is likely to utilise the Rocky Slopes, Stony Hills and Rises and Mesa Plateau habitats in the western portion of the Development Envelope.

7.4.5.10 Lined Soil-crevice Skink (Likely)

The Lined Soil-crevice Skink is listed as a Priority 4 species by DBCA. It occurs in spinifex grassland near creeks and river margins and potentially uses the Plains habitat. It has previously been recorded in the Mesa A Transport Corridor (Biota 2006d).

7.4.5.11 Common Sandpiper; Wood Sandpiper; Common Greenshank; Little Curlew (Likely)

These four wader species are listed under Schedule 5 of the WC Act as Migratory birds protected under an international agreement. They are also listed as Migratory under the EPBC Act. They are known to arrive during the summer wet season in the Pilbara and depart during the winter dry season to breed in northern latitudes. Most of these species are coastal but some use inland waters when available (MWH 2015a) and may utilise Major River/Creek or Minor Drainage Line habitat within the western portion of the Development Envelope.

7.4.5.12 Eastern Osprey (Likely)

Eastern Osprey is listed as Migratory under the EPBC Act. It occurs in littoral and coastal habitats and terrestrial wetlands, predominantly in coastal areas but occasionally inland along major rivers. The breeding range extends from Albany in Western Australia up the west coast, across northern Australia and down the east coast to Lake Macquarie in New South Wales. The species is likely to occur in the Major River/Creek habitat.

7.4.6 Short Range Endemic (SRE) invertebrate fauna

SRE species are those that display restricted distributions (less than 10,000 km^2; Harvey 2002) and are therefore generally at greater risk of changes in conservation status and/or local population or taxon extinctions than other, more widely distributed taxa (EPA 2016m). Taxa that exhibit short range endemism are generally characterised by poor dispersal powers, low fecundity levels, confinement to discontinuous habitats and highly seasonal activity patterns, with many species active only during cooler and wetter periods (Harvey 2002). Some better known SRE species have been listed under State or Commonwealth legislation, or as Priority species by the DBCA; however, the majority of SRE species have not been listed under legislation, often due to lack of knowledge.

A total of eight potential SRE species have been recorded in the western portion of the Development Envelope (Table 7-6; Figure 7-6). The MWH (2015a) Level 2 fauna survey recorded 353 invertebrate specimens in the 7,936 ha study area from at least 22 species or morphospecies and the Level 2 fauna survey of Warramboo (Astron 2018a) yielded 48 invertebrates from eight different species. The taxonomic composition of the dual phase SRE survey of the Warramboo borefield area indicates that it may have been completed in unfavourable (dry) conditions. This is considered a minor limitation (Astron 2018a) as the area lacks the more prospective SRE rocky gorge habitat and the area has been impacted by pastoral activities. Additionally the habitat assessment indicates that potential SRE species in the survey area should be widespread due to the wider occurrence of similar habitats within the Roebourne subregion (Astron 2018a). The outcome of the Environmental Impact Assessment is, therefore, unlikely to be affected by this minor limitation.

None of the invertebrate specimens collected during the surveys were identified by expert taxonomists as confirmed SRE species, or species likely to represent SRE species; however, eight species were collected only from habitat with a high or medium potential to support SRE species; that is, the habitat is restricted and/or isolated in the landscape and/or possesses mesic microhabitats (MWH 2015a). These species are therefore considered potential SRE species (Table 7-6), as are those identified by Astron (2018a) as having incomplete taxonomic and geographic distribution data.

The remaining invertebrate species recorded by MWH (2015a) and Astron (2018a) are considered unlikely to represent true SRE species as they were collected from habitats

that were widespread, well connected and lacked microhabitats (MWH 2015a). Four potential SRE species were previously recorded by Biota (2005b, 2006d); however all are considered unlikely to be SRE species given their known broader distributions. These species are not discussed further.

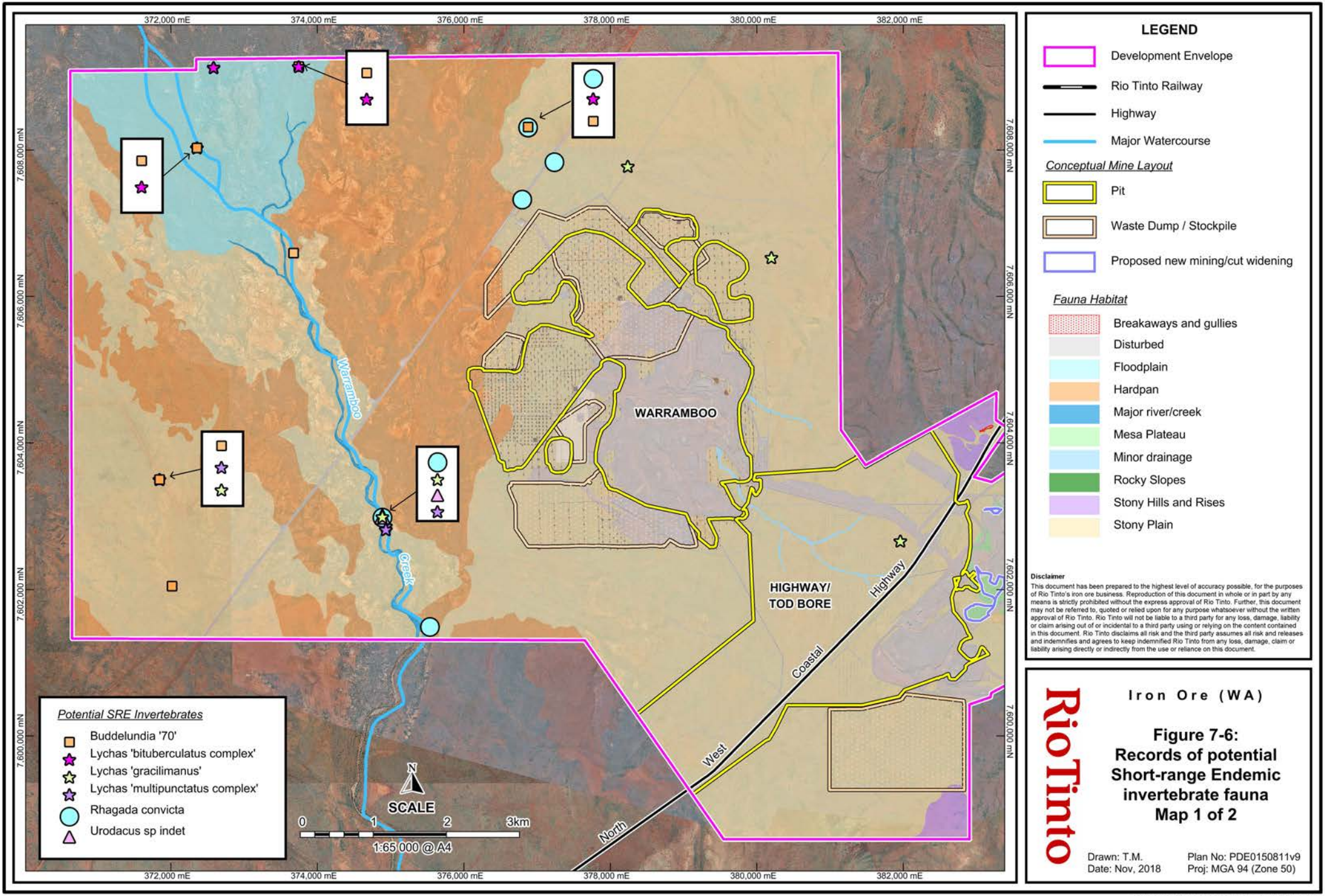
None of the potential SREs collected are listed as Threatened or Priority fauna under the EPBC Act or WC Act.

Table 7-6: Potential SRE invertebrate fauna recorded

Taxon	Location/s	Habitat recorded in	Survey	Species information and status
Selenopid spiders				
?*Karaops* 'indet'	Mesa B-C	Breakaways and Gullies	MWH (2015a)	One specimen was collected from one location within the western portion of the Development Envelope at Mesa B-C (Figure 7-6). The specimen collected was a juvenile and therefore could not be identified to species level; however, the genus *Karaops* contains known SRE species and as such this specimen was identified as a potential SRE (MWH 2015a). In addition, the specimen was recorded from habitat with high potential to support SRE taxa (Breakaways and Gullies). This habitat type is restricted to the Mesa B-C project area. No other specimens of Selenopid spider have been recorded from within a 100 km radius of the Project Area (MWH2015a).
Scorpions				
Lychas 'multipunctatus complex'	Mesa B-C Warramboo	Major River/Creek and Stony Plain	MWH (2015a) and (Astron 2018a)	Seven specimens of the scorpion *Lychas* 'multipunctatus complex' have been recorded from three sites within two habitat types in the western portion of the Development Envelope (Figure 7-6). *L. 'multipunctatus* represents a species complex, meaning that each species most likely represents multiple species based on genetic data. While members of this complex are known from most of the Pilbara, some of the 'species' contained within these complexes appear to be range restricted and as such, these specimens are considered to represent potential SREs (Astron 2018a).
Lychas 'bituberculatus complex'	Mesa B Warramboo	Floodplain and Hardpan, Mesa Plateau	MWH (2015a) and Astron (2018a)	Ten specimens of *Lychas* 'bituberculatus complex' have been recorded from five locations in three habitat types in the western portion of the Development Envelope (Figure 7-6). *Lychas* 'bituberculatus represents a species complex. While members of these complexes are known from most of the Pilbara, some of the 'species' contained within these complexes appear to be range restricted and as such, these specimens are considered to represent potential SREs (Astron 2018a).
Lychas 'gracilimanus'	Mesa B-C Warramboo Highway/Tod Bore	Stony Plain, Major River/Creek and Minor Drainage	MWH (2015a) and Astron (2018a)	A total of 15 specimens of *Lychas* 'gracilimanus' have been recorded from six locations across three habitat types in the western portion of the Development Envelope (Figure 7-6). *Lychas* 'gracilimanus' is an uncommon scorpion in the Pilbara which is represented by two small populations: one associated with the western Pilbara and the other from around Marble Bar in the

Taxon	Location/s	Habitat recorded in	Survey	Species information and status
				Eastern Pilbara. These two populations are currently under investigation using genetic data to verify whether they represent discrete species. If they do represent discrete species, then both may be considered confirmed SREs in the future (Astron 2018a). The species is currently considered to be a potential SRE as it is only represented by few specimens from disparate localities in the Pilbara.
Urodacus sp. indet	Warramboo	Major River/Creek	MWH (2015a)	One specimen was collected from one location at Warramboo in the Major River habitat (Figure 7-6). The genus *Urodacus* is known to have SRE species; however, the juvenile specimen collected by MWH (2015a) could not be identified to species level. Other specimens of *Urodacus* collected in the region include: • The potential SRE *Urodacus* `saipem1`, collected from 12 locations within 2-8 km of the record of *Urodacus* sp. indet. Analysis of aerial imagery suggests that these specimens were collected from Plains habitat • The potential SRE *Urodacus* `waramboo`, collected from two locations 3.4 km east and 5.5 km east of the record of *Urodacus* sp. indet. Molecular analysis would be required to clarify the SRE status of this record.
Slaters				
Philosciidae sp. Indet	Mesa B-C	Major River/Creek	MWH (2015a)	Four specimens of the isopod Philosciidae were collected from two sites and one habitat type (Major River/Creek) within the western portion of the Development Envelope (Figure 7-6). The family Philosciidae is rarely collected in the Pilbara and all individuals in this family are considered potential SRE species. There is a lack of taxonomic resolution within this family and the individuals collected could not be identified to species level (MWH 2015a). It is unknown whether other specimens from the family Philosciidae have been collected in the region as there is not currently a database for slaters.

Taxon	Location/s	Habitat recorded in	Survey	Species information and status
Isopod				
Buddelundia '70'	Warramboo	Floodplain, Hardpan and Stony Plains	Astron (2018a)	Ten specimens of the isopod Buddelundia '70' were recorded in six locations within three different habitat types around the western portion of the Development Envelope (Figure 7-6). Buddelundia '70' is a morphospecies of the common Buddelundia 14 found in the Pilbara. It has previously been recorded on Barrow Island; however, the individuals recorded in this survey are the first mainland records of the species and therefore is considered a potential SRE (Alacran 2017 as cited in Astron 2018a).
Land snails				
Rhagada convicta	Mesa B and Mesa C Warramboo	Stony Plains, Major River/Creek, Minor Drainage, Mesa Plateau and Hardpan	Astron (2018a), MWH (2015a) and Biota (2005b)	A total of 16 specimens of the land snail *Rhagada convicta* have been collected from ten locations and five habitat types within the Development Envelope at Warramboo (Figure 7-6). Based on molecular analysis, *Rhagada convicta* is thought to be a species complex with a number of cryptic species. One of the Lineages is closely related (3.84% average divergence) to specimens collected at Onslow (approximately 85 km west of the Development Envelope) and Cane River (approximately 55 km south of the Development Envelope). However, these specimens were not assigned to a lineage. This genus is known to contain SREs and as such, these specimens are considered to represent Potential SREs.



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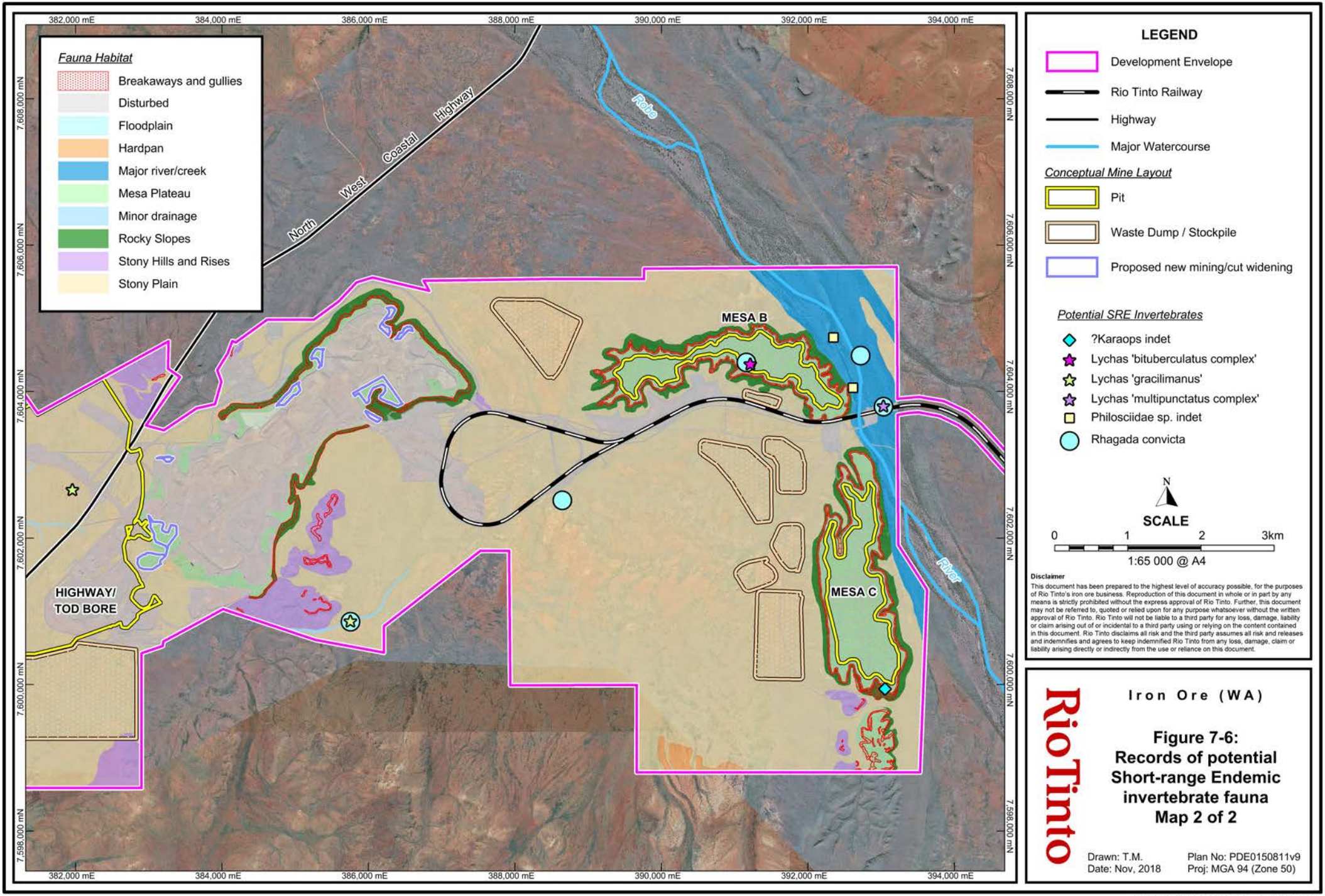
Iron Ore (WA)

Figure 7-6: Records of potential Short-range Endemic invertebrate fauna Map 1 of 2

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0150811v9
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Geospatial Information and Mapping



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Iron Ore (WA)

Figure 7-6: Records of potential Short-range Endemic invertebrate fauna Map 2 of 2

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Geospatial Information and Mapping

7.4.7 Aquatic fauna species profiles and records

7.4.7.1 Micro-invertebrates

Nineteen micro-invertebrate taxa were recorded by WRM (2016) from two locations along Warramboo Creek, upstream of the proposed dewater discharge outlet (WARUS5 and WARUS6; Figure 7-2). The sampling was undertaken from temporary surface water following rainfall. An additional 17 micro-invertebrate taxa were recorded from rehydrated sediment samples from Warramboo Creek. In 2018, 59 micro-invertebrate taxa were recorded from 12 locations along Warramboo Creek, upstream and downstream of the proposed dewater discharge outlet (WARUS1 to WARUS6 and WARDS1 to WARDS6, Figure 7-2).

Forty-seven micro-invertebrate taxa were recorded from the Robe River and Mungarathoona Creek (a major tributary of the Robe River) by WRM (2017). An additional six micro-invertebrate taxa were recorded from rehydrated sediment samples. Some taxa could not be identified to species level.

The majority of micro-invertebrate taxa recorded were common, ubiquitous species with Australasian or cosmopolitan distributions. One species recorded in the Warramboo Creek and Robe River systems (WRM 2016; 2017; 2018), the calanoid copepod *Eodiaptomus lumholtzi*, is listed on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species as Vulnerable; however, this conservation status is considered in need of revision, because the species has been recorded from numerous locations across Australasia since it was first listed in 1996 (WRM 2016).

Two micro-invertebrate species recorded in 2016 by were of scientific interest: the rotifer *Lecane nitida* and the rotifer *Epiphanes spinosa* (WRM 2016). Both species have cosmopolitan distributions and these records represent new records for Western Australia. A potentially new species of cyclopoid copepod was recorded during 2018, in low numbers at the majority of sites along Warramboo Creek. This species has also been recorded elsewhere in the Pilbara (WRM 2018).

7.4.7.2 Hyporheic invertebrates

Hyporheic invertebrates are generally small invertebrates which inhabit the saturated zone beneath the stream or river bed. There are two main categories, including temporary hyporheic invertebrates which occupy the hyporheic zone after flash flooding or heavy rains, while permanent hyporheic invertebrates are specialised in this zone.

Twenty-five hyporheic invertebrate taxa were recorded by WRM (2016) from two sites in Warramboo Creek upstream of the proposed dewater discharge outlet (Figure 7-2). A total of 44 hyporheic invertebrate taxa were recorded in 2018 from 12 locations along Warramboo Creek, upstream and downstream of the proposed dewater discharge outlet (WARUS1 to WARUS6 and WARDS1 to WARDS6, Figure 7-2).

The majority of species recorded in both 2016 and 2018 were not specially adapted to groundwater environments (stygoxene). None of the taxa recorded from Warramboo Creek were considered to be stygobites (obligate groundwater species) or likely SREs (WRM 2016), suggesting limited groundwater-surface water connectivity along Warramboo Creek near the western portion of the Development Envelope (WRM 2016). In 2018, three of the hyporheic invertebrate taxa recorded were considered to be stygobites, however they were only recorded from three sites upstream of the discharge location (WARUS2, WARUS3 and WARUS6). None of the hyporheic invertebrate taxa

recorded along Warramboo Creek have restricted distributions, nor are any listed for conservation significance.

A total of 53 taxa were recorded from the hyporheic zone of pools in the Robe River and Mungarathoona Creek (WRM 2017). The majority of these taxa were classified as stygoxene (51%), 11% were classified as stygobites, 26% were considered occasional hyporheic stygophiles (species that use the hyporheic zone seasonally or during early life history stages), 4% were possible hyporheic taxa and 8% were unable to be classified (WRM 2017). Subsequent molecular work conducted on samples identified the stygal amphipod species as *Nedsia* AMP-Eri-001 of the family Melitidae. This species is widespread and known from Mesa A, Warramboo, to Mesa H and Middle Robe (to the east of Mesa J).

7.4.7.3 Macro-invertebrates

In 2016, 76 macro-invertebrate taxa were recorded from two locations in Warramboo Creek, upstream of the proposed surplus water discharge outlet. In 2018, 94 macro-invertebrate taxa were recorded from 12 locations along Warramboo Creek, upstream and downstream of the proposed dewater discharge outlet (WARUS1 to WARUS6 and WARDS1 to WARDS6, Figure 7-2).

The majority of species are common, with distributions across northern Australia, Australasia and the world and none of the taxa represent species of conservation significance or SREs (WRM 2016).

Anostracans recorded from rehydrated sediment samples from Warramboo Creek in 2016 (collected from WARUS1, WARUS6 and WARDS6; Figure 7-2) were immature and could not be identified to species level but may belong to either the *Branchinella* or *Streptocephalus*. *Branchinella* are known to occur in temporary freshwaters and individual species of *Branchinella* tend to be locally restricted. It is possible that the anostracans from Warramboo Creek belong to one of the eight *Branchinella* species known from ephemeral waterbodies in the Pilbara; however, they may belong to the species *Streptocephalus archeri*, which is known to occur throughout the Pilbara and beyond (WRM 2016).

Of interest in 2018 was the collection from Warramboo Creek of an unknown anostracan (*Branchinella* cf. *proboscida*), and a Pilbara endemic chironomid (?*Pentanuera* sp.) with a disjunct distribution. The specimens of *Branchinella* cf. *proboscida* are yet to be formally identified however may belong to the species *Branchinella proboscida*, which has a wide distribution across the Australian continent, being known from all states and territories except Victoria and Tasmania (WRM 2018). ?*Pentanuera* sp. is currently undescribed and appears to have a highly disjunct distribution in the Pilbara, being known from Weeli Wolli Creek, Marillana Creek, upper Fortescue River, Fortescue River South, Caves Creek (Palm Spring), as well as within the Robe River and DeGrey River catchments (WRM 2018). However, given it has been recorded in several locations in the Pilbara this indicates it is not restricted to the vicinity of the Development Envelope and is unlikely to be significantly impacted so is not considered further in this assessment.

No discharge to the Robe River is proposed, nevertheless for completeness an aquatic fauna survey was completed for the Robe River in the vicinity of Mesas B and C. One hundred and twenty-four macro-invertebrate taxa were recorded in the Robe River system by WRM (2017). One species recorded in the Robe River, the damselfly *Eurysticta coolawanyah*, is listed as Near Threatened on the IUCN Red List of

Threatened Species. This species is restricted to the Pilbara and was recorded from one site in the Robe River main channel approximately 7 km upstream of Mesas B and C.

7.4.7.4 Phytoplankton

As part of baseline sampling, three sites were sampled by WRM (2018) for phytoplankton in each reach; WARUS3, WARUS4 and WARUS6 upstream of the discharge location, and WARDS2, WARDS3 and WARDS4 downstream from the discharge location.

A total of 28 phytoplankton taxa were recorded from the six samples taken. Two species of cyanobacteria known to be 'potential, but unconfirmed toxin producers' were recorded; *Cylindrospermum licheniforme* and *Dolichospermum affine*. However, neither were recorded in sufficient densities deemed to be of concern.

7.4.7.5 Fish

WRM (2017) recorded ten species of fish in the Robe River system, including one conservation significant species, the Priority 4 Fortescue Grunter (*Leipotherapon aheneus*). The Fortescue Grunter was recorded in the Robe River main channel and Mungarathoona Creek and included small individuals, which suggests breeding may occur at these sites (WRM 2017). The Fortescue Grunter is known only from the Fortescue, Robe and Ashburton River systems, but is considered common within this range (WRM 2017).

Five estuarine/marine vagrant fish species were also recorded, none of which are conservation significant.

No fish were recorded from Warramboo Creek. Given the highly ephemeral nature of Warramboo Creek, and the isolation from nearby systems which sustain permanent pools, it is highly unlikely fish are present in Warramboo, unless they are artificially introduced, as has occurred elsewhere in the Pilbara (WRM 2018).

7.5 Potential Impacts

A number of potential impacts are identified in the ESD. The potential direct, indirect and cumulative impacts identified for the Proposed Change on the basis of biological surveys and terrestrial fauna assessments are described in Sections 7.5.1 to 7.5.3.

7.5.1 Direct impacts

The potential direct impacts of the Proposed Change on terrestrial fauna have been identified as:

- Loss or fragmentation of fauna habitat including breeding, foraging and dispersal habitat due to clearing
- Loss of individuals from increased vehicle strikes and collisions with fencing.

Terrestrial fauna habitats mapped in the western portion of the Development Envelope are described in Section 7.4.3. Terrestrial fauna habitats that will potentially be directly impacted by the Proposed Change are presented in Table 7-7. Assessment of potential impacts to these habitats is provided in Section 7.6.1.

Table 7-7: Potential direct impact to terrestrial fauna habitats

Habitat	Extent within western portion of the Development Envelope (ha)[1]	Proposed extent of disturbance (ha)	Proposed extent of disturbance (% in western portion of the Development Envelope)
Mesa Plateau	451	347	77%
Rocky Slopes	132	10	7%
Breakaways and Gullies	129	8	6%
Plains	9,603	2,484	26%
Hardpan	2,123	115	5%
Floodplain	620	< 1	<1%
Stony Hills and Rises	213	20	10%
Major River/Creek	317	3	<1%
Minor Drainage Lines	20	15	75%

[1] All values in this table have been rounded to the nearest hectare or %.

7.5.2 Indirect impacts

Potential indirect impacts of the Proposed Change on terrestrial fauna have been identified as:

- Alteration of fauna habitat due to altered hydrology arising from groundwater abstraction and increased temporal availability of surface water from discharge of surplus water
- Loss or degradation of habitat due to noise and vibration
- Degradation of habitat due to dust and light emissions
- Degradation of habitat due to altered fire regime, introduction or spread of weeds and changes to feral animal populations
- Degradation of aquatic fauna habitat due to changes to water chemistry arising from discharge of surplus water.

Hydrogeological modelling indicates there is limited hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvium. Consequently, drawdown in groundwater levels within the Mesa C CID Aquifer is not expected to result in observable changes to groundwater levels within the adjacent Robe River Alluvial Aquifer. No impacts on fauna are expected along the Robe River. Monitoring of groundwater levels within the Robe River alluvium will be undertaken to ensure that no unforeseen changes are occurring.

With regard to Ghost Bat roost caves, hydrogeological investigations show that the water table at Mesa C lies greater than 50 m below the top of the mesa. The groundwater table is not in direct connection with the Ghost Bat roost caves at Mesa C due to the location of the groundwater in relation to the caves (not directly below), the presence of the low permeability basal pisolite unit and the Ashburton Formation, which acts as an aquiclude (see Figure 8-3). A change in groundwater level due to dewatering is, therefore, not expected to result in changes to the relative humidity in roost caves at Mesa C.

Groundwater drawdown in the CID/Yarraloola Aquifer beneath the defined flow channel of the ephemeral Warramboo Creek and beneath the floodplain downstream of the

defined flow channel has the potential to impact understorey vegetation and hence fauna habitat as shown in Table 7-8.

Table 7-8: Potential indirect impacts on fauna habitat from groundwater drawdown in the CID/Yarraloola Aquifer

Zone[1]	Fauna habitat	Extent of potential indirect impact (ha)	Extent of potential impact (% of mapped habitat in western portion of the Development Envelope) (ha)	Predicted potential impact to fauna habitat
1	Floodplain	150	24%	Current understorey vegetation cover in this area is low and impacted by cattle and weed species. At most, there may be minor changes to the abundance of understorey vegetation that may result in a minor reduction in cover and foraging opportunities for ground dwelling mammals and reptiles.
1	Plains	4	<1%	
1	Hardpan	3	<1%	
1	Major River/Creek	11	4%	
2, 3	Floodplain, Plains, Hardpan, Major River/Creek	-	-	Changes to understorey vegetation are unlikely and therefore impacts to cover and foraging opportunities for ground dwelling mammals and reptiles are also unlikely.

[1] The potential impact zones along Warramboo Creek are described in Section 5.5.2 and shown on Figure 5-10.

Discharge of surplus water into Warramboo Creek will increase water availability and alter the seasonality of surface water in Warramboo Creek up to 8 km downstream of the discharge point for the duration of discharge as summarised in Table 7-9.

Table 7-9: Potential indirect impacts from surplus water discharge

Component	Modelled discharge rate (GL/a)	Modelled Life of Mine (LoM) discharge volume (GL)	Extent of potential impact to fauna habitat	Predicted potential impact to fauna habitat
Discharge to Warramboo Creek	2 to 7	9	Up to 8 km downstream from the discharge point	Temporary, localised changes to fauna habitat

Assessment of impacts to fauna habitat from groundwater drawdown and discharge of surplus water is provided in Section 7.6.1.2. Assessment of all other indirect impacts to fauna is provided in the indirect impacts section relating to each species as appropriate.

7.5.3 Cumulative impacts

Detailed fauna habitat mapping has been completed for the western portion of the Development Envelope. Detailed mapping at the scale undertaken for the western portion of the Development Envelope is not broadly available for the Pilbara region. Identification and assessment of potential cumulative impacts to fauna habitat, therefore, requires broader mapping completed across a greater area.

The nine terrestrial fauna habitat types mapped in the western portion of the Development Envelope have been grouped into five habitat types:

- Breakaways and Gullies
- Hills
- Mesa Plateau
- Plains
- River.

These five habitat types have been mapped for the entire Robe Valley to enable an assessment of the cumulative habitat loss from existing and reasonably foreseeable projects in the region:

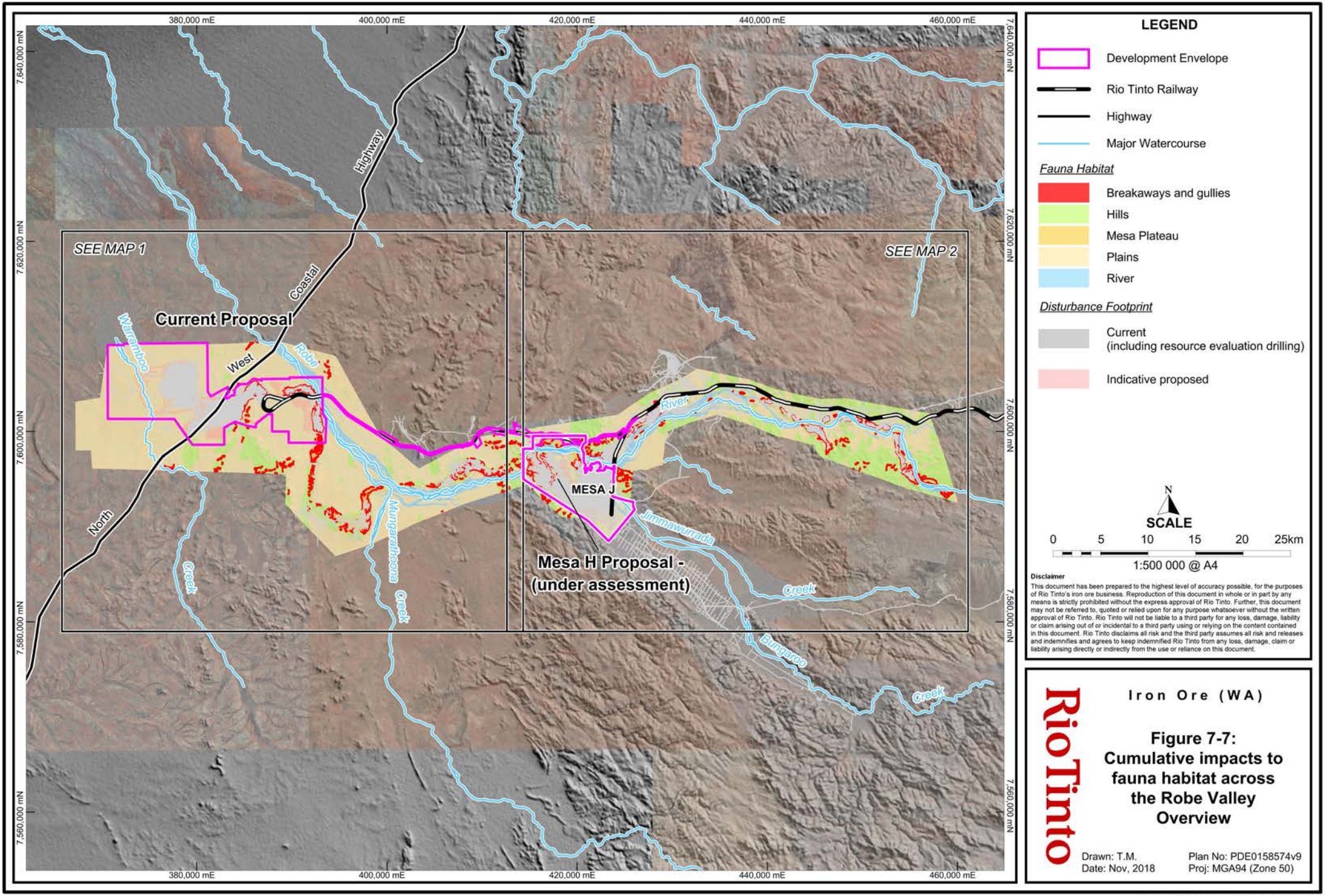
- Existing and historic mining projects: Mining operations (Mesa A/Warramboo, Mesa J, Mesa K, East Deepdale and Middle Robe)
- Existing clearing from other infrastructure: Mesa J and Mesa A Railways, borrow pits, power lines, roads and tracks
- Reasonably foreseeable projects: the Proposed Change and the Mesa H Proposal (currently being assessed). A review of the EPA website has shown no other recently referred proposals in the Robe Valley are currently undergoing assessment.

Table 7-10 shows the pre-European extent of fauna habitat types across the Robe Valley, the proposed disturbance and the total cumulative disturbance taking into account historical, proposed and reasonably foreseeable clearing. Cumulative impacts to fauna habitat are shown on Figure 7-7 and assessed in Section 7.6.1.3.

Table 7-10: Cumulative impacts to fauna habitat types across the Robe Valley

Habitat	Pre-European extent (ha)	Historical clearing (% of pre-European extent)	Mesa A Hub proposed clearing (% of pre-European extent)	Total cumulative clearing[1] (% of pre-European extent)
Breakaway and Gullies	1,010	8%	<1%	10%
Hills	17,680	3%	<1%	4%
Mesa Plateau	7,470	42%	5%	58%
Plains	53,080	4%	5%	10%
River	8,060	1%	<1%	1%

[1] Total cumulative clearing = historical + proposed + reasonably foreseeable



LEGEND

- Development Envelope
- Rio Tinto Railway
- Highway
- Major Watercourse

Fauna Habitat

- Breakaways and gullies
- Hills
- Mesa Plateau
- Plains
- River

Disturbance Footprint

- Current (including resource evaluation drilling)
- Indicative proposed

N

SCALE

0 5 10 15 20 25km

1:500 000 @ A4

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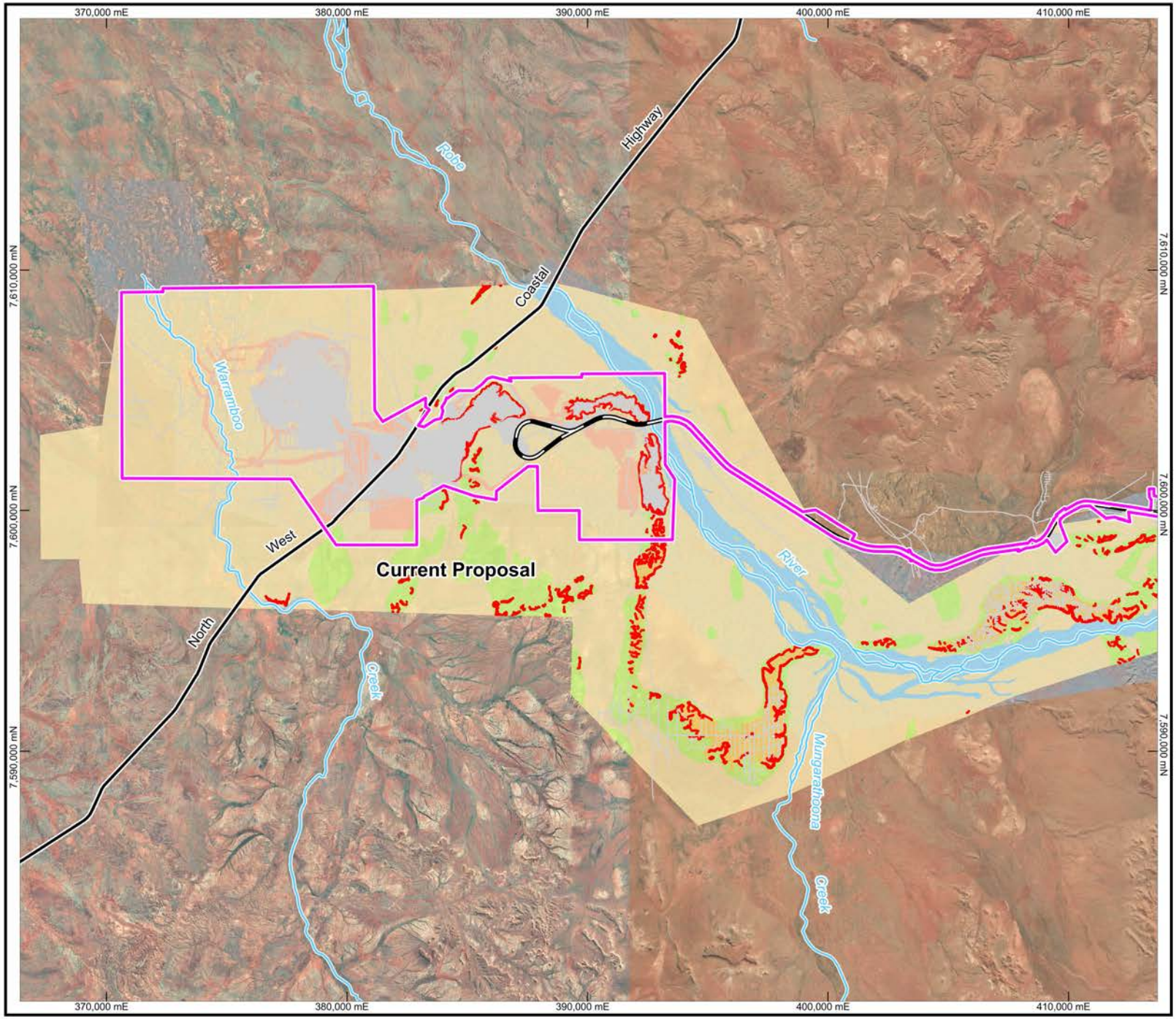
Iron Ore (WA)

Figure 7-7: Cumulative impacts to fauna habitat across the Robe Valley Overview

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Geospatial Information and Mapping



LEGEND

- Development Envelope
- Rio Tinto Railway
- Highway
- Major Watercourse

Fauna Habitat

- Breakaways and gullies
- Hills
- Mesa Plateau
- Plains
- River

Disturbance Footprint

- Current (including resource evaluation drilling)
- Indicative proposed

N

SCALE

0 2.5 5 7.5 10km

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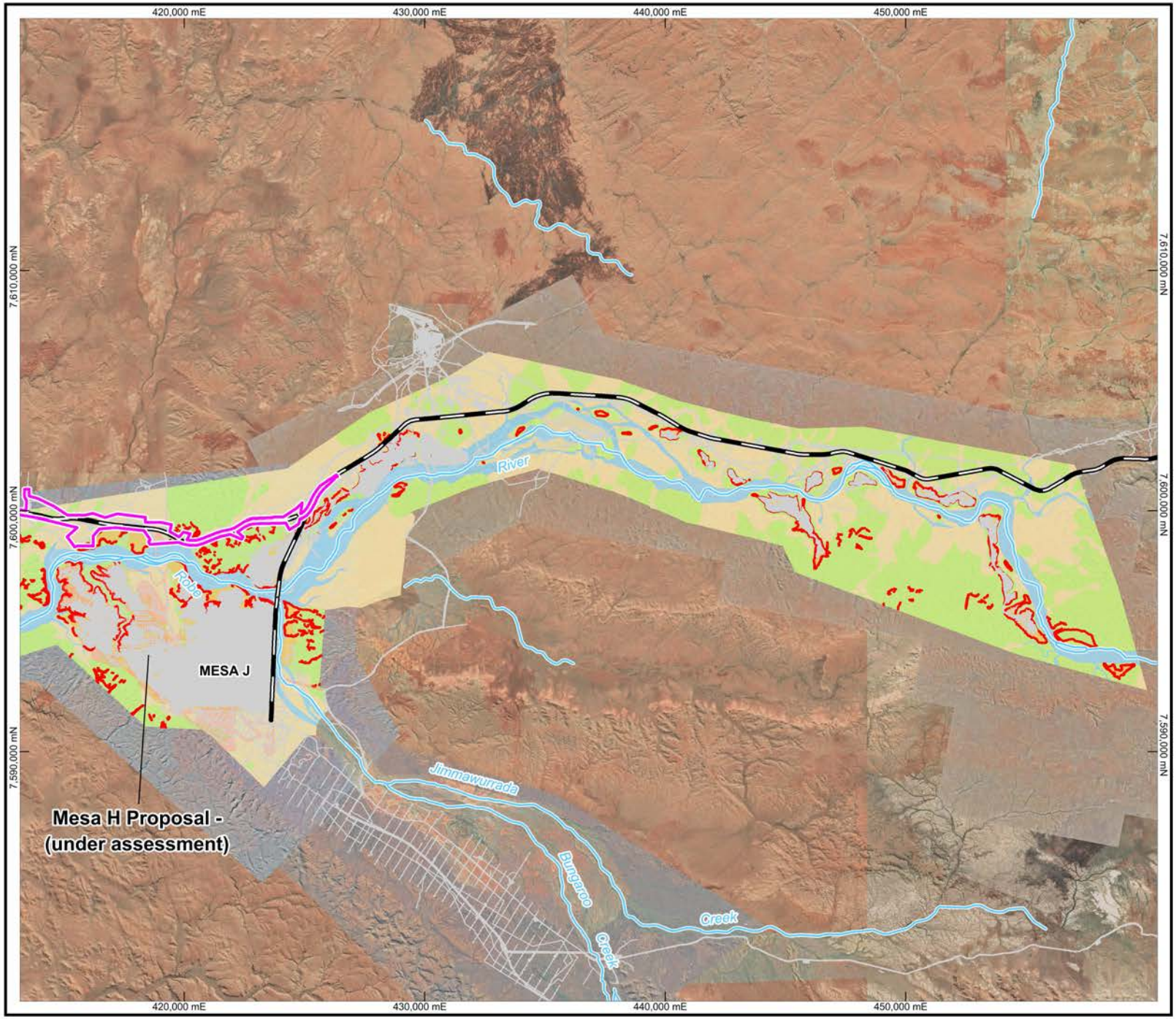
Iron Ore (WA)

Figure 7-7: Cumulative impacts to fauna habitat across the Robe Valley Map 1 of 2

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Geospatial Information and Mapping



LEGEND

- Development Envelope
- Rio Tinto Railway
- Highway
- Major Watercourse

Fauna Habitat

- Breakaways and gullies
- Hills
- Mesa Plateau
- Plains
- River

Disturbance Footprint

- Current (including resource evaluation drilling)
- Indicative proposed

N

SCALE

0 2.5 5 7.5 10km

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Iron Ore (WA)

Figure 7-7: Cumulative impacts to fauna habitat across the Robe Valley Map 2 of 2

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Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

7.6 Assessment of Impacts

Assessment of impacts to each fauna habitat and to each conservation significant species are described below.

7.6.1 Fauna habitat

7.6.1.1 Direct impacts

The Proposed Change will result in clearing of up to 3,000 ha of fauna habitat. None of the recorded fauna habitats are restricted to the western portion of the Development Envelope. The fauna habitats identified in the western portion of the Development Envelope occur throughout the Robe Valley, with five of the nine habitats considered to be widespread and common throughout the surrounding area (MWH 2015a).

The Mesa Plateau and Floodplain habitats are considered to have a limited distribution but also limited value to terrestrial fauna (MWH 2015a).

The most significant habitats are the Breakaways and Gullies habitat and Major River/Creek habitat. During development of the Proposed Change, haul road route options have been considered and preferred options have been selected to meet project requirements while minimising clearing of significant fauna habitats. In particular, widening of the existing Mesa A escarpment cut has been selected in preference to the original project designs that included development of a new escarpment breach at Mesa A and the haul road route to Mesa B has been altered to avoid direct and indirect (dust and noise) disturbance to a diurnal/potential maternal Ghost Bat roost on Mesa B.

Mesa Plateau

The Proposed Change will result in the clearing of up to 77% of the Mesa Plateau habitat mapped in the western portion of the Development Envelope. The Mesa Plateau is the habitat unit that coincides directly with the proposed mine pits, and does not include the mesa escarpments. This habitat type provides limited shelter for conservation significant fauna. Given that no terrestrial conservation significant fauna species are restricted to this habitat and that this habitat has a low likelihood of supporting SREs, the proposed disturbance to this habitat is not considered to represent a significant loss to terrestrial fauna species at a local or regional scale.

Rocky Slopes

The Proposed Change will result in clearing of up to 7% of the Rocky Slopes habitat mapped in the western portion of the Development Envelope. Given that no conservation significant fauna species are restricted to this habitat type and that this habitat has a low likelihood of supporting SREs, the proposed disturbance to this habitat is not considered to represent a significant loss to terrestrial fauna at a local or regional scale.

Breakaways and Gullies

The majority of Breakaways and Gullies habitat will be retained. Clearing of Breakaways and Gullies habitat to support the Proposed Change will be restricted to cuts in the Mesa escarpments. The Proposed Change will result in the loss of up to 200 m of this habitat for each escarpment cut at Mesas B and C. The width of the existing cut at Mesa A will be increased by approximately 100 m to enable widening of the haul road. Together with

the existing cut to the mesa, the cumulative impact to the Mesa A escarpment will be less than 3%.

The Proposed Change will result in the clearing of 8 ha or 6% of the Breakaways and Gullies habitat mapped in the western portion of the Development Envelope.

The Breakaways and Gullies habitat supports high species richness and habitat for conservation significant species including for the Northern Quoll, Pilbara Olive Python, Pilbara Leaf-nosed Bat and Ghost Bat. Breakaways and Gullies habitat also has a high likelihood of supporting SREs. Less than 6% of the Mesa A, B and C escarpments will be impacted by cuts to provide access to the mesas. Cuts have been designed to avoid high value areas in the mesa escarpments as identified in MWH (2015b) which support caves and overhangs, important for roosting and denning by conservation significant fauna.

Given that the majority of this habitat will be retained and that disturbance will avoid the highest value habitat, the proposed disturbance to this habitat is not considered to represent a significant loss at a local or regional scale.

Plains

Plains habitat provides foraging and dispersal habitat for Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and the Pilbara Olive Python and suitable nesting habitat for Western Pebble-mound Mouse; however, these species are not restricted to this habitat type and the habitat is widespread and common in the surrounding region. Clearing for the Proposed Change will impact up to 27% of the mapped extent in the western portion of the Development Envelope. The disturbance is not considered to represent a significant loss of this habitat at a local or regional scale.

Hardpan

Up to 5% of Hardpan habitat mapped in the western portion of the Development Envelope will be cleared as part of the Proposed Change. Hardpan habitat has limited value to conservation significant fauna and has a low likelihood of supporting SREs. On this basis, the loss of approximately 5% of this habitat type is not considered to be a significant loss of this habitat at a local or regional scale.

Floodplain

Floodplain habitat has moderate value to conservation significant fauna and medium likelihood of supporting SREs. The Proposed Change will clear less than 1% of Floodplain habitat. The disturbance is not considered to represent a significant loss of this habitat at a local or regional scale.

Stony Hills and Rises

Up to 10% of Stony Hills and Rises habitat mapped in the western portion of the Development Envelope will be cleared for the Proposed Change. Stony Hills and Rises habitat is widespread and common in the surrounding region, no conservation significant species are restricted to Stony Hills and Rises habitat, and this habitat type is unlikely to support SREs. The direct loss of approximately 10% of this habitat type is not considered to be a significant loss of this habitat at a local or regional scale.

Major River/Creek

Major River habitat has high value to conservation significant fauna and provides foraging and dispersal habitat for Northern Quoll, Pilbara Olive Python, Pilbara Leaf-nosed Bat and Ghost Bat. This habitat type along the Robe River also provides shelter habitat for the Pilbara Olive Python. Major River habitat has a medium likelihood of supporting SREs.

Less than 1% of Major River habitat present within the western portion of the Development Envelope will be impacted by the Proposed Change for the installation and operation of hydrogeological monitoring bores and the surplus water discharge point; this loss is not considered significant.

Minor Drainage Lines

Minor Drainage Lines habitat is widespread in the surrounding region and provides a potential dispersal route for Northern Quoll and seasonal foraging habitat for Pilbara Olive Python. It also has a medium likelihood of supporting SREs. Up to 75% of Minor Drainage Lines habitat mapped in the western portion of the Development Envelope will be cleared by the Proposed Change.

This impact is considered potentially significant locally; however, is not considered to be significant at a regional scale.

7.6.1.2 Indirect impacts

Alteration of surface water and groundwater hydrology

No changes in aquatic fauna habitat are expected from the abstraction of groundwater at Warramboo. Warramboo Creek lacks the alluvial gravel profile of the larger Robe River and is disconnected from underlying groundwater systems. As a result, Warramboo Creek has no permanent or semi-permanent pools. The water sampled by WRM in 2016 and 2018 was water that persists in low-lying areas for a short period following flows after significant rainfall events.

Abstraction of groundwater at Warramboo has the potential to impact phreatophytic species and potentially understorey vegetation along Warramboo Creek. Based on depth to groundwater and the phreatophytic species present, significant changes to understorey vegetation and hence fauna habitat due to abstraction of groundwater are not expected along the majority of the defined flow channel of Warramboo Creek. There is potential for minor changes to the abundance of understorey vegetation in the Floodplain and Plains habitat types downstream of the defined flow channel in Warramboo Creek. Current vegetation cover in this area is low and understorey vegetation has been impacted by cattle and weed species. Neither of the habitat types provide significant microhabitats for terrestrial fauna (Astron 2018a) and both habitat types are widespread in the immediate vicinity as well as the Roebourne subregion and wider Pilbara bioregion (Astron 2018a). Given the widespread nature of both habitat types, the existing disturbance and the minor nature of the proposed changes, the proposed groundwater drawdown in the Yarraloola Aquifer is not expected to have a significant impact on terrestrial fauna habitat.

Discharge of surplus water into Warramboo Creek will increase water availability, alter the seasonality of surface water and may alter surface water chemistry in Warramboo Creek up to 8 km downstream of the discharge point for the duration of discharge. This

may temporarily alter the extent and composition of riparian vegetation which provides fauna habitat. The fauna habitat along the creek may also be temporarily affected by cattle and other introduced fauna being attracted to the available water during periods of discharge. Associated adverse impacts may include overgrazing, trampling of banks and vegetation, erosion, increased turbidity and elevated nutrient levels. This effect will be minimised as discharge will be more frequent following periods of rainfall, where surface water is widely available in the landscape. The habitat provided by Warramboo Creek is not unique in the Robe Valley and although fauna habitat may be altered by a temporary discharge of surplus water, it is considered that habitat values are unlikely to be significantly affected.

7.6.1.3 Cumulative impacts

The Proposed Change will increase cumulative impacts to fauna habitat in the Robe Valley. Approximately 90% of the pre-European extent of the habitat types that are most significant to conservation significant fauna (i.e. Breakaways and Gullies habitat and Major River/Creek habitat) will remain within the Robe Valley following the proposed and reasonably foreseeable impacts (Table 7-10). The habitat type most affected by clearing in the Robe Valley is the Mesa Plateau habitat type which has had disturbance to 42% to date and cumulative impacts from reasonably foreseeable projects are predicted to increase clearing to 58% of pre-European extent. This Mesa Plateau habitat type provides limited shelter for conservation significant fauna.

The retention of the landscape elements with the highest biodiversity value (i.e. the mesa escarpments) and avoidance of disturbance to the Robe River will continue to minimise the cumulative impact of development on the Breakaways and Gullies habitat and the Major River/Creek habitat.

7.6.2 Northern Quoll

7.6.2.1 Northern Quoll Policy and guidance

A National Recovery Plan is in place for Northern Quoll (Hill and Ward 2010) which describes the species' distribution, habitat and population and identifies known threats to the species.

In addition, the EPBC Act referral guidelines of 2016 (Department of the Environment [DoE] 2016) define the requirements for EPBC referral for proposals likely to significantly impact the species, describe the spatial distribution of the species, and define habitat critical to the survival of the species and populations important for the long-term survival of the species.

Populations important for the long-term survival of the Northern Quoll are defined by DoE (2016) as:

- High density[18] quoll populations occurring in refuge-rich habitat critical to the survival of the species, including where Cane Toads are present
- Populations occurring in habitat that is free of Cane Toads and unlikely to support Cane Toads upon arrival i.e. granite habitats in WA, populations surrounded by desert and without permanent water
- Subject to ongoing conservation or research actions i.e. populations being monitored by government agencies or universities or subject to reintroductions or translocation.

The multiple Northern Quoll recordings (cameras/trapped individuals) of multiple individuals across multiple sites in the baseline fauna surveys conducted in the western portion of the Development Envelope indicate that the Northern Quoll population in the western portion of the Development Envelope may be classifiable as a 'population important for the long-term survival' of the species as defined by DoE (2016). A full description of this species' current status and distribution in Australia as well as discussion of records of this species in the Development Envelope and broader Robe Valley is provided in Section 12.3.3.

All habitat that provides shelter for breeding, refuge from fire/or predation and potential poisoning from the Cane Toad, (*Rhinella marina*) is considered to be 'habitat critical to the survival' of the species and usually occurs in the form of (DoE 2016):

- Rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields, major drainage lines or treed creek lines
- Structurally diverse woodland or forest areas containing large diameter trees, termite mounds or hollow logs
- Offshore islands where the Northern Quoll is known to exist.

Rocky habitats are present in the western portion of the Development Envelope and surveys indicate that the Breakaways and Gullies habitat and portions of the Major River/Creek habitat along the Robe River have the potential to provide denning/shelter habitat for the Northern Quoll (MWH 2015a), and therefore are classifiable as 'habitat critical to the survival of the species'.

Habitat defined as critical to the survival of the Northern Quoll (DoE 2016) includes all habitat within the modelled distribution of the Northern Quoll which provides shelter/breeding and/or dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the Northern Quoll. This definition is highly inclusive and could be considered to include all foraging/dispersal habitat in the vicinity of multiple records of Northern Quoll. The local population of Northern Quoll has a strong association with the Breakaways and Gullies habitat and portions of the River habitat (Robe River). Based on the evidence from the location of Northern Quoll records from the Robe Valley and the Development Envelope (Section 12.3.3), the critical habitat locally is considered to comprise the Breakaways and Gullies habitat and portions of the River habitat (Robe River).

[18] A high density Northern Quoll population may be characterised by numerous camera triggers of multiple individuals across multiple cameras and/or traps on a site (DoE 2016).

The River habitat provided by the ephemeral Warramboo Creek is further than 2 km from potential denning habitat and the nearest Northern Quoll record is approximately 7 km from Warramboo Creek. Although the section of Warramboo Creek within the western portion of the Development Envelope may provide foraging and dispersal habitat for the Northern Quoll (Astron 2018a), its habitat value is much less than that of the Robe River, and it is not likely to be used for denning purposes. This habitat is not considered critical to the survival of the species.

The majority of the western portion of the Development Envelope is connected to the shelter habitats of the breakaways and rivers and therefore fits this broad definition of 'habitat critical to the survival of the species'. However, the most important habitats in the western portion of the Development Envelope for the Northern Quoll are considered to be the Breakaways and Gullies habitat and the Major River/Creek habitat, which provide high value denning/shelter habitats associated with caves and rocky overhangs and/or enhanced foraging opportunities due to the availability of water (MHW 2015a).

7.6.2.2 Direct impacts

Loss of fauna habitat

The Proposed Change has been designed to avoid high value denning habitat for Northern Quoll, in particular the major gullies found in the Breakaways and Gullies habitat. Clearing to support the Proposed Change has the potential to result in the loss of up to a 200 m width of this habitat for each escarpment cut at Mesas B and Mesa C and up to a 100 m width for the widening of the existing escarpment cut at Mesa A. In total, a maximum of 8 ha of this habitat type will be cleared as a result of the Proposed Change.

At Mesa B, the cuts will be located on the western and southern sides of the mesa to avoid the most valuable habitat, including the gullies on the northern and southern sides towards the eastern end of the mesa, as identified by MWH (2015b). In particular, the gully on the northern side of Mesa B is adjacent to the Robe River and is, therefore, likely to be important habitat for the Northern Quoll.

At Mesa C, the cut will be located on the western side of the mesa, to avoid the most valuable habitat, including gullies which are considered core habitat for the species and are located on the northern, southern and eastern sides of the mesa.

As the majority of the mesa escarpments which provide denning habitat for the Northern Quoll will be retained by the Proposed Change, and escarpment cuts will avoid high value denning habitat, including gullies, the construction of cuts is unlikely to directly reduce the local availability of denning habitat or disrupt the breeding cycle of the local population.

Habitat defined as critical to the survival of the Northern Quoll (DoE 2016) is discussed in detail in Section 12.3.3 and includes all habitat within the modelled distribution of the Northern Quoll which provides shelter/breeding and/or dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the Northern Quoll. However, given the number of records of Northern Quoll locally and their strong association with Breakaways and Gullies habitat (88% of records are either within Breakaways and Gullies habitat or within 10 m of it), it is proposed that an appropriate definition of critical habitat locally is the Breakaways and Gullies habitat and portions of the River habitat (Robe River). This is consistent with the conclusion of MWH (2015a) that the most important habitats in the western portion of the Development Envelope are considered to be the Breakaways and Gullies and River habitats, which provide high

value denning/shelter habitats associated with caves and rocky overhangs and/or enhanced foraging opportunities due to the availability of water. Other foraging and dispersal habitat within the Development Envelope is considered widespread and low value and not considered critical to the survival of the species.

The Proposed Change will clear foraging and dispersal habitat within the western portion of the Development Envelope; however the majority of disturbance for the Proposed Change will be to the Plains habitat which is widespread and common throughout the Pilbara region and not considered critical to the survival of the Northern Quoll.

The Proposed Change has been designed to limit disturbance to critical habitat locally and will impact less than 6% of Breakaways and Gullies habitat in the western portion of the Development Envelope and less than 1% of Major River/Creek habitat in the western portion of the Development Envelope. This is unlikely to disrupt foraging activities. The proposed habitat loss is not expected to affect the survival of the species locally or regionally.

Northern Quoll have been recorded in historical mining areas in the Robe Valley, particularly where mesa escarpments are largely intact. Astron (2016) recorded the Northern Quoll numerous times during a survey in the East Deepdale and Middle Robe region approximately 60 km east of the Development Envelope. The majority of these records were from the Breakaway habitat type (45 records), with some records from the Riverine (13), Stony Hills and Slopes (two) and Mesa (seven) fauna habitats. The Breakaway habitat was, therefore, considered highly suitable for the Northern Quoll while the Mesa, Riverine and Drainage habitats that act as ecological linkage corridors and may provide refuge and foraging opportunities were considered to be areas of moderate suitability (Astron 2016). Overall the results of the survey indicate Northern Quoll are utilising intact escarpments around previously impacted sites (Astron 2016).

There are 4,153 records of Northern Quoll from the Pilbara (DBCA 2018b). The majority of these are recent records; only 315 records date back further than 2009. The Northern Quoll is known to have a boom and bust population cycle. The study modelled likelihood of occurrence in the Pilbara and identified high likelihood of occurrence on the western edge of the Hamersley Range, the Chichester Range, the granite outcrops of the Abydos Plain and low likelihood of occurrence in the Fortescue River catchment, the alluvial coastal Plain (Roeburne Plain) of the Pilbara and southern areas of the Hamersley Range.

With consideration of the likely occurrence of the species, and availability of suitable habitat outside the Development Envelope, the Proposed Change is considered unlikely to significantly impact the availability of habitat for the species at a regional scale. The Proposed Change will therefore, not reduce the area of occupancy of this species.

Loss of habitat through clearing is unlikely to fragment habitat or the local population. Northern Quolls are known to move over installed linear infrastructure such as roads. The mine pits in the mesa plateaus are unlikely to fragment populations or create barriers to movement, as the mesa plateaus do not provide preferred habitat for the species.

Loss of individuals

Vehicle movements for construction and operation of the mine may result in fauna strike, causing injury or death of individuals. Vehicle movements will take place predominantly during the day and will be generally limited to in-pit operations.

7.6.2.3 Indirect impacts

Noise and vibration

The indirect impact of noise and vibration emissions are considered unlikely to impact Northern Quoll. Viable populations of Northern Quoll have remained at Mesa A despite current mining operations and at Poondano West despite excavation by Main Roads Western Australia over large areas of potential foraging habitat. In addition, the relative lack of change in the population of Northern Quoll across Process Minerals' Poondano project area, demonstrates resilience to noise and vibration emissions arising from the project (Astron 2015).

Lighting

Light emissions are not expected to directly impact potential denning habitat, as lighting will be directed into the active pits to avoid the mesa escarpments and the aspect of potential dens on the mesa escarpments is such that they face away from the mining areas. Light emissions from the Proposed Change are also unlikely to significantly alter nocturnal foraging activities as light emissions are already present in the Mesa A/Warramboo area and lighting will only be installed where required, that is, mainly in-pit and operational areas.

Invasive species

The Cane Toad is considered to be the main invasive species that poses a threat to Northern Quoll. While the Pilbara was once thought likely to provide a refuge for the Northern Quoll from the Cane Toad, recent modelling suggests that Cane Toads will invade the region (Cramer *et al.* 2016). Cane Toads absorb water through their skin from dew or any moist material and need constant access to moisture to survive. Discharge to Warramboo Creek may increase the availability of surface water which may locally increase suitable habitat for Cane Toads for the duration of discharge activities; however, ephemeral pools already occur upstream of the Development Envelope in Warramboo Creek following heavy rains and permanent pools are present in Mungarathoona Creek and the Robe River upstream of the Development Envelope. The Proposed Change will not, therefore, alter the possibility of Cane Toads becoming established in the area.

The Feral Cat (*Felis catus*) is also a known threat to the Northern Quoll. There is little opportunity for the Proposed Change to result in increases to the Feral Cat population. Feral Cat control will continue to be undertaken as needed in areas where the Proponent operates.

The invasion of Gamba Grass (*Andropogon gayanus*) and other introduced grasses are recognised threats to this species as they out-compete native grasses and increase fuel loads, which can contribute to intense, late, dry season fires. These fires can cause direct loss of Northern Quoll or cause predation following fire and may reduce the availability of shelter (DotEE 2017a). Gamba Grass has not been recorded in the western portion of the Development Envelope (Section 5.4) and the Proponent will undertake weed control in areas of retained native vegetation close to disturbance such as roads, tracks and infrastructure.

7.6.2.4 Cumulative impacts

The Proposed Change will add to the approved activities, which were designed to retain the majority of the mesa escarpment, including high value habitat, specifically the northern gorge on the eastern escarpment of Mesa A. The Mesa A operation includes an escarpment cut in the middle of the eastern escarpment to provide access to the mesa. This cut will be widened by approximately 100 m under the Proposed Change resulting in a cumulative impact of less than 3% on the escarpment on Mesa A. The remaining extent of the escarpment of the existing Mesa A operation has been retained in the MEZ and is protected from excavation. The approved Mesa A/Warramboo Iron Ore Project has had limited impact on the Robe River which is also considered important habitat for the species.

In addition, the Mesa H Proposal will retain the majority of the mesa escarpment which supports significant fauna and heritage values including Northern Quoll (Rio Tinto 2017f). Cumulative impacts to fauna habitats present in the Robe Valley are discussed in section 7.6.1.3.

7.6.2.5 Outcome

The Revised Proposal avoids disturbance to the higher value parts (the more incised gullies and rockiest areas) of the Breakaways and Gullies habitat type but may result in disturbance to 6% of lower value sections of the Breakaways and Gullies habitat and less than 1% of the Major River/Creek habitat in the Development Envelope.

Percentage loss of fauna species is difficult to estimate, particularly given that for many fauna species in the Pilbara population size, distribution and dynamics are not well understood. Estimates of loss of species can only be made based on loss of key habitat features. Estimates made on this basis are likely to be worst case estimates as they do not take into account the species distribution, mobility, degree of habitat utilisation and adaptability of fauna species. Using critical habitat loss as a proxy for estimating population loss, the potential loss of the local population of Northern Quoll is estimated at approximately 6% in the vicinity of the Development Envelope and less than 1% in the Robe Valley. This a maximum estimated loss; the actual loss is likely to be less as this species is mobile and suitable denning habitat occurs in adjacent areas.

Given the retention of approximately 94% of the Breakaways and Gullies habitat in the western portion of the Development Envelope, the availability of denning and foraging habitat across the Robe Valley and the persistence of the Northern Quoll near the existing Mesa A/Warramboo Iron Ore Project, the potential loss of denning and foraging habitat as a result of the Proposed Change is considered unlikely to significantly impact the local population and is unlikely to affect the conservation status of this species.

7.6.3 Pilbara Leaf-nosed Bat

7.6.3.1 Pilbara Leaf-nosed Bat policy and guidance

Approved conservation advice for the Pilbara Leaf-nosed Bat (TSSC 2016a) identifies populations and habitat critical to the survival of the species, national conservation objectives and priority conservation actions. There is currently no recovery plan for this species. The key definitions related to habitat critical to the survival of the species, from the conservation advice are as follows:

- Diurnal and breeding roosts are considered 'habitat critical to the survival' of the Pilbara Leaf-nosed Bat (TSSC 2016a)
- The type and quality of potential foraging habitat surrounding known or suspected roost sites can also be critical to the survival of the Pilbara Leaf-nosed Bat (TSSC 2016a). However, given the lack of understanding around which habitats are required to sustain a roosting colony, critical foraging habitat is difficult to define (TSSC 2016a). Instead, foraging habitats used by the Pilbara Leaf-nosed Bat can be categorised as follows (TSSC 2016a):
    - **Priority 1: Gorges with pools** – watercourses through upland areas bounded by sheer rock walls for parts of their length, often containing pools that remain for weeks or months, sites of relatively large biomass production, sometimes containing caves
    - **Priority 2: Gullies** – primary drainage with limited riparian development in upland rocky habitats, sometimes containing small pools that may last for weeks, with less biomass production than Priority 1 gorge habitat
    - **Priority 3: Rocky outcrop** – areas of exposed rock at the top of rocky outcrop and mesa hills that contain caves and overhangs, and boulder piles in the granite terrains
    - **Priority 4: Major watercourses** – riparian vegetation on flat land plus the main gravelly or sandy channel of the river bed, sometimes containing pools that persist for weeks or months, and generally supporting higher productivity of biomass than the surrounding habitats
    - **Priority 5: Open grassland and woodland** – dominated by *Triodia*, on lowland plains, colluvial slopes and hilltops.

7.6.3.2 Direct impacts

Loss of fauna habitat

There are no known Pilbara Leaf-nosed Bat diurnal and/or breeding roosts present in the western portion of the Development Envelope. The timing and location of call records indicate that the bats originate from a diurnal roost outside the Development Envelope. The most significant habitats in the western portion of the Development Envelope for the species are the Major River/Creek habitat (Priority 4) and Breakaways and Gullies habitat (Priority 2 and 3); these areas represent foraging habitat and potential nocturnal refuges. The Proposed Change has been designed to limit disturbance to 6% of the Breakaways and Gullies habitat in the western portion of the Development Envelope and less than 1% of the Major River/Creek habitat in the western portion of the Development Envelope. Although other habitats present in the western portion of the Development Envelope could also be utilised for foraging, these are of lower value (Priority 5).

The loss of foraging habitat will not fragment habitat or a local population, given the species' mobility and the lack of identified roosts in the western portion of the Development Envelope.

Loss of individuals

Pilbara Leaf-nosed Bats are known to be attracted to light and fly low, resulting in the potential for collisions with vehicles. However, vehicle movements at night (when Pilbara Leaf-nosed Bats are foraging) are much less than during the day and are generally limited to in-pit operations. The species may also collide with fences, resulting in injury or death of individuals. The use of barbed wire will be avoided, except where legislated, such that the potential for entanglement as an outcome of the Proposed Change is considered negligible. Where there is a statutory requirement for barbed wire, reflectors will be installed to minimise bat entanglement.

7.6.3.3 Indirect impacts

Noise and vibration

Noise and vibration impacts from mining operations are unlikely to significantly impact the Pilbara Leaf-nosed Bat. The most significant noise and vibration from the proposed mining operation will occur during the day from blasting activities. Given that no Pilbara Leaf-nosed Bat diurnal or breeding roosts have been recorded in the western portion of the Development Envelope and that the species forages at night, noise and vibration from the Proposed Change are unlikely to impact nocturnal foraging behaviour. It is also known that Pilbara Leaf-nosed Bat forage in close proximity to mining operations elsewhere in the Pilbara.

Lighting and dust

This species is known to display a curiosity for light sources (DotEE 2017b). Light emissions may alter nocturnal foraging activities, particularly if light enters potential night roosts or attracts invertebrates, which are a food source for the species. However, as light is already present in the Mesa A/Warramboo area and light emissions will affect only a small proportion of Pilbara Leaf-nosed Bat foraging habitat, light emissions are unlikely to significantly impact this species.

Dust emissions have the potential to impact the quality of foraging habitat but are unlikely to significantly impact night roosts as areas that may contain night roosts are orientated away from dust sources. Based on dust monitoring to date and a study by Matsuki *et al.* (2016), any decline in the quality of Pilbara Leaf-nosed Bat foraging habitat is likely to be limited to the area immediately adjacent to the proposed mining operation.

7.6.3.4 Cumulative impacts

Calls from the Pilbara Leaf-nosed Bat have been recorded within the existing Mesa A/Warramboo Iron Ore Project area during internal Rio Tinto surveys conducted in 2017. The timing of the calls indicates that the recorded individuals originated from a roost remote to Mesa A/Warramboo. It is considered unlikely that the approved activities have had a significant impact on the species.

The species was also recorded in the Mesa H Development Envelope, located to the east of the Development Envelope; however, individuals recorded are considered likely to originate from a known roost approximately 10 km south of the Mesa H Development

Envelope. Cumulative impacts to fauna habitats present in the Robe Valley are discussed in section 7.6.1.3.

7.6.3.5 Outcome

Potential impacts of the Proposed Change on Pilbara Leaf-nosed Bat are limited to loss of potential foraging habitat through clearing, impacts of light, noise, vibration and collision with vehicles/fences.

There are no known Pilbara Leaf-nosed Bat roosts present in the western portion of the Development Envelope and call records indicate that bats originate from a diurnal roost outside the Development Envelope. Given the Proposed Change is unlikely to disturb a diurnal roost, will disturb less than 1% of the Major River/Creek habitat which represents key foraging habitat for this species, and that extensive foraging habitat for this species is present along the Robe River, the loss of habitat as a result of the Proposed Change is estimated to result in a loss of less than 1% of the population of the Pilbara Leaf-nosed Bat in the Robe Valley region.

Given the retention of approximately 94% of the Breakaways and Gullies habitat (which potentially provides nocturnal roosts and foraging habitat), and over 99% of the Major River/Creek habitat, the diverse range of foraging habitat utilised by this species and the presence of extensive foraging habitat along the Robe River, the loss of habitat in the western portion of the Development Envelope is not expected to adversely affect the conservation status of Pilbara Leaf-nosed Bat.

7.6.4 Ghost Bat

7.6.4.1 Ghost Bat policy and guidance

Approved conservation advice for the Ghost Bat (TSSC 2016b) defines the species' distribution, biology and ecology, identifies key threats and assigns threat ratings and identifies conservation and management actions. The advice identifies the consequence rating of habitat loss as severe and disturbance of breeding sites, modification to foraging habitat and collision with fences as moderate.

7.6.4.2 Direct impacts

Loss of habitat

The Breakaways and Gullies habitat provides roost habitat for Ghost Bats. The Proposed Change has been designed to limit disturbance to the Breakaways and Gullies habitat to 6% in the western portion of the Development Envelope. The Proposed Change will only disturb one of the 24 caves/shelters recorded in the western portion of the Development Envelope as being used by Ghost Bats; the nocturnal roost shelter MBS-05 at Mesa B (Figure 7-5).

The Proposed Change has been designed to avoid direct disturbance to:

- the two nocturnal roost caves at Mesa A (Figure 7-8, map 1)
- the one recorded diurnal/potential maternal roost cave at Mesa B (MBC-05) and 11 of the 12 recorded nocturnal roost caves at Mesa B, including MBS-01, MBC-03, MBC-04 and B1 which are considered the most significant nocturnal roosts as they may be part of a diurnal roost complex surrounding cave MBC-05 (Figure 7-8, map 2)
- all nine recorded caves in use by Ghost Bats at Mesa C including one potential diurnal roost (MCC-02) and all eight of the recorded nocturnal roost caves (Figure 7-8, map 3).

The MEZ has been designed to ensure that mine pits are set back from recorded diurnal/maternity roosts by a minimum of 40 m from the lateral extent (recorded back) of the cave and from nocturnal roosts by a minimum of 50 m from the entrance to the cave (except shelter MBS-05 which will be impacted by the haul road to Mesa B).

The Mesa formations of the Robe Valley comprise competent Robe Pisolite (CID) and are highly resistant to erosion relative to the surrounding formations, demonstrated by nature of their current topographic form as outcropping mesa formations in the landscape (as described further in Section 9.4). The understanding of the local geology and geological features in the vicinity of the diurnal / potential maternal caves is supported by both surface geological information (2D) and downhole geological and geophysical data from drill holes (3D), including diamond drill holes which provide in-situ geological cores and structural information. Based on these data, the geology at Mesas B and C within the 40 m buffer behind the diurnal / potential maternal caves comprises competent Robe Pisolite with vugs; intermittent small clay pods; and occasional small <10 cm cavities (largest cavity recorded <45 cm). No structural features that might reduce geotechnical stability have been recorded.

Geotechnical analysis of both the diurnal/potential maternal roost sites and the mesa formations has been completed. The geotechnical analysis of the roost complexes surrounding the diurnal/potential roost sites determined the geotechnical sensitivity for all

of these caves to be 'low' (Rio Tinto 2017h). The geotechnical analysis of the mesa formations was specifically undertaken to understand and support the geotechnical stability requirements to ensure key environmental and heritage values contained within the mesa escarpments, including bat roosts, are maintained. Rio Tinto (2017i) concluded that a minimum of 30 m is required to maintain the geotechnical stability of an open face of Robe Pisolite, hence a 40 m buffer proposed from the lateral extent (back) of the diurnal/potential maternal roost sites to the proposed pits is more than sufficient to meet this geotechnical stability criterion. In addition, the geotechnical stability of pit walls will be monitored as mining progresses as part of operational and safety protocols and the proposed blast management measures.

The Proponent regularly establishes successful vibration control and management projects to protect sensitive sites; vibration control may apply to only a small number of blasts in the mine plan or may apply across a large mining area over a number of years. The Proponent has successfully applied vibration control to blasting near sensitive sites such as culturally sensitive sites, sensitive infrastructure (e.g. high pressure gas pipeline, communications tower) and environmentally sensitive sites (e.g. troglofauna habitat and Ghost Bat roosts) (Rio Tinto 2013). The Proponent's Blast management framework takes a risk-based approach in relation to diurnal/potential maternal roost sites. This approach assumes all diurnal / potential maternal roost sites are sensitive receptors requiring the highest level of blast control. As such, a very conservative blast threshold (peak particle velocity (PPV)) trigger criterion has been set, as detailed in the EMP, to ensure no structural damage to the caves occurs. Typical steps involved in ensuring the trigger PPV criterion is not exceeded at a sensitive site include:

- Calculation of the likelihood that the blast will reach or exceed the set trigger PPV based on a conservative generic set of ground condition parameters
- If the trigger is likely to be reached:
    - Conducting site specific tests to establish site specific ground condition parameters and re-calculation of the vibration levels and/or
    - Revision of the blast design.

The design of the blast can be altered in a number of ways to reduce the PPV. For example distance from the blast to the sensitive site may be increased, drill hole sizes and charge weights may be reduced, blast timing (the layout and delays between firing successive holes) may be modified or high frequency blasting techniques may be used. Based on the Proponent's experience and monitoring from mining operations at other mesa formations throughout the Robe Valley, the Proponent is able to demonstrate the effectiveness of current blast management techniques.

Based on a study of historically mined mesas in the Robe Valley, Bat Call WA (2017b) indicates, 'For current and future mining operations retaining a perimeter of greater than 20 m around the mesa perimeters and providing particular protection to significant diurnal/maternal roost caves will result in no further loss of Ghost Bats in the Robe Valley due to roost destruction'. The proposed buffers of 40 m from the lateral extent of the diurnal/potential maternal roosts and 50 m from the entrance to the nocturnal roosts exceed the recommendation of 20 m and, together with implementation of the proposed blast management techniques, provide particular protection to diurnal/maternal roosts.

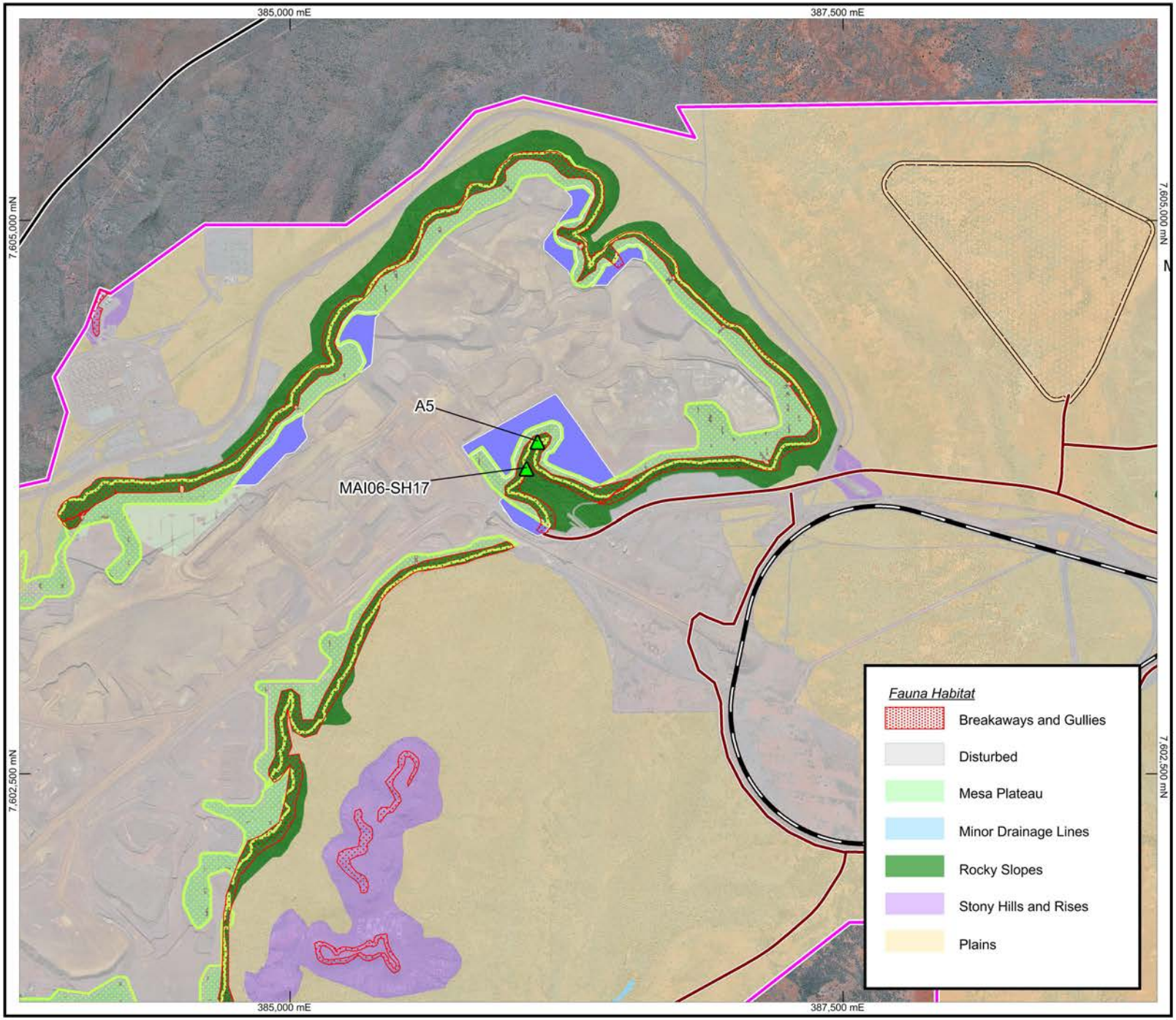
Given the competent nature of the formation surrounding the caves, the operational checks of geotechnical stability and the Proponent's use of, and demonstrated experience in applying, blast management techniques, the Proponent considers the proposed setbacks between the pit boundaries and the diurnal/potential maternal and nocturnal roost sites are appropriate to ensure direct disturbance to the caves is avoided and the integrity of the caves is not compromised by the Revised Proposal.

Foraging habitat favoured by the Ghost Bat is diverse, and the species they tend to consume are common and widespread in the Pilbara. Up to 3 ha of foraging habitat comprising Major River/Creek habitat will be impacted by clearing for the Proposed Change. This represents less than 1% of available foraging habitat in the western portion of the Development Envelope. Additional foraging habitat occurs along the Robe River outside the Development Envelope.

Given the mobility of the species and retention of the majority of roost habitat, the construction and installation of infrastructure will not create physical barriers to the movement of the local population. Individual Ghost Bats may be impacted by installation of fencing, causing collisions during flight. The use of barbed wire will be avoided except where the requirement for barbed wire is legislated, such that the potential for entanglement is considered negligible. Where there is a statutory requirement for barbed wire, reflectors will be installed to minimise bat entanglement.

Loss of individuals

Ghost Bats are known to be able to fly low, resulting in potential for collisions with vehicles. However, vehicle movements at night (when Ghost Bats are foraging) are much less than during the day and are generally limited to in-pit operations. Vehicle movements for the Proposed Change are considered unlikely to result in a long-term decrease in the Ghost Bat population.



LEGEND

- Development Envelope
- Proposed Mining Exclusion Zone
- Rio Tinto Railway
- Highway
- Major Watercourse

Bat Caves

- Nocturnal roost cave/shelter

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Haul Road
- Proposed new mining/cut widening

N

SCALE

0 0.5 1 1.5km

1:35 000 @ A4

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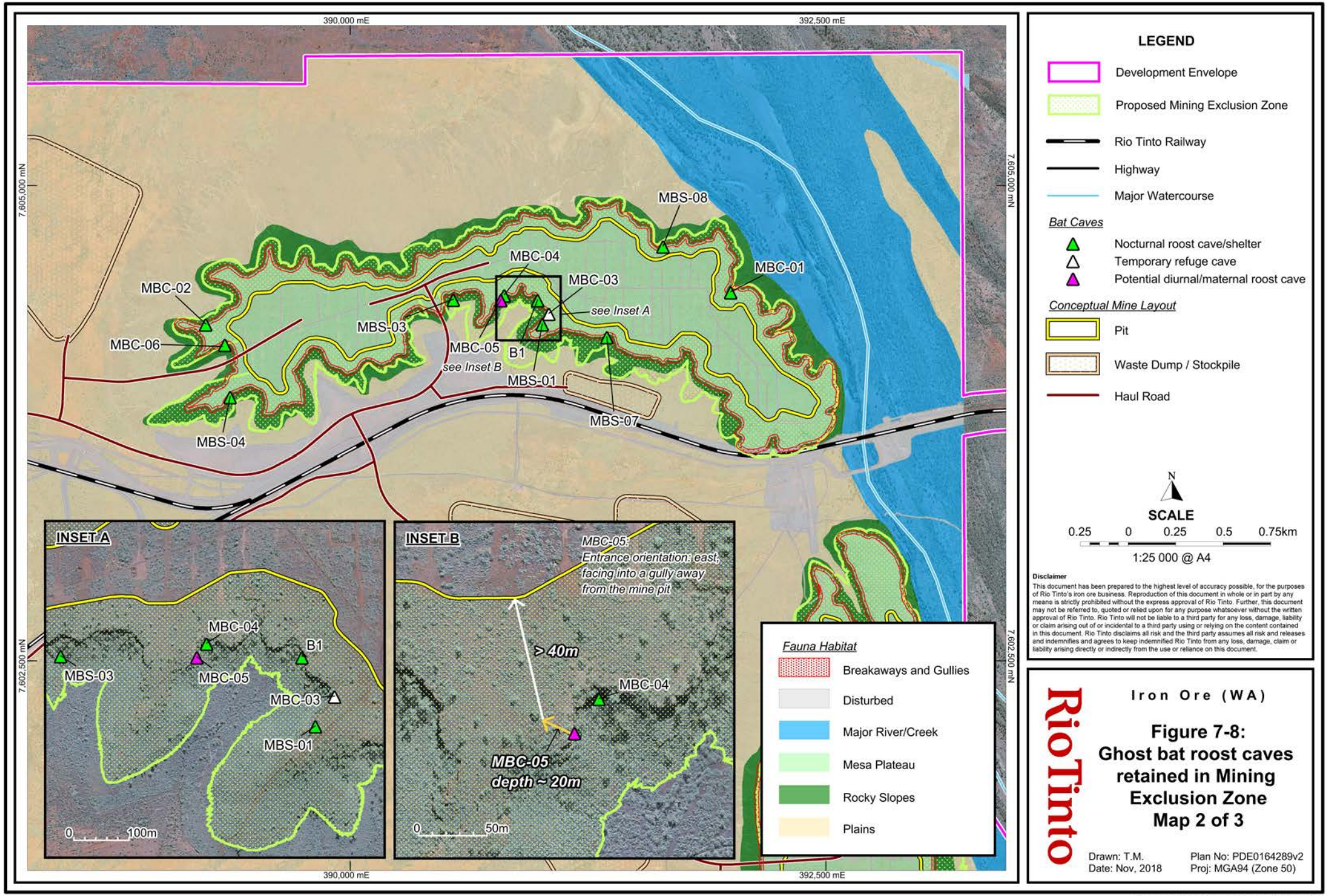
Iron Ore (WA)

Figure 7-8: Ghost bat roost caves retained in Mining Exclusion Zone Map 1 of 3

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164289v1
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Proposed Mining Exclusion Zone
- Rio Tinto Railway
- Highway
- Major Watercourse

Bat Caves

- Nocturnal roost cave/shelter
- Temporary refuge cave
- Potential diurnal/maternal roost cave

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Haul Road

N

SCALE

0.25 0 0.25 0.5 0.75km

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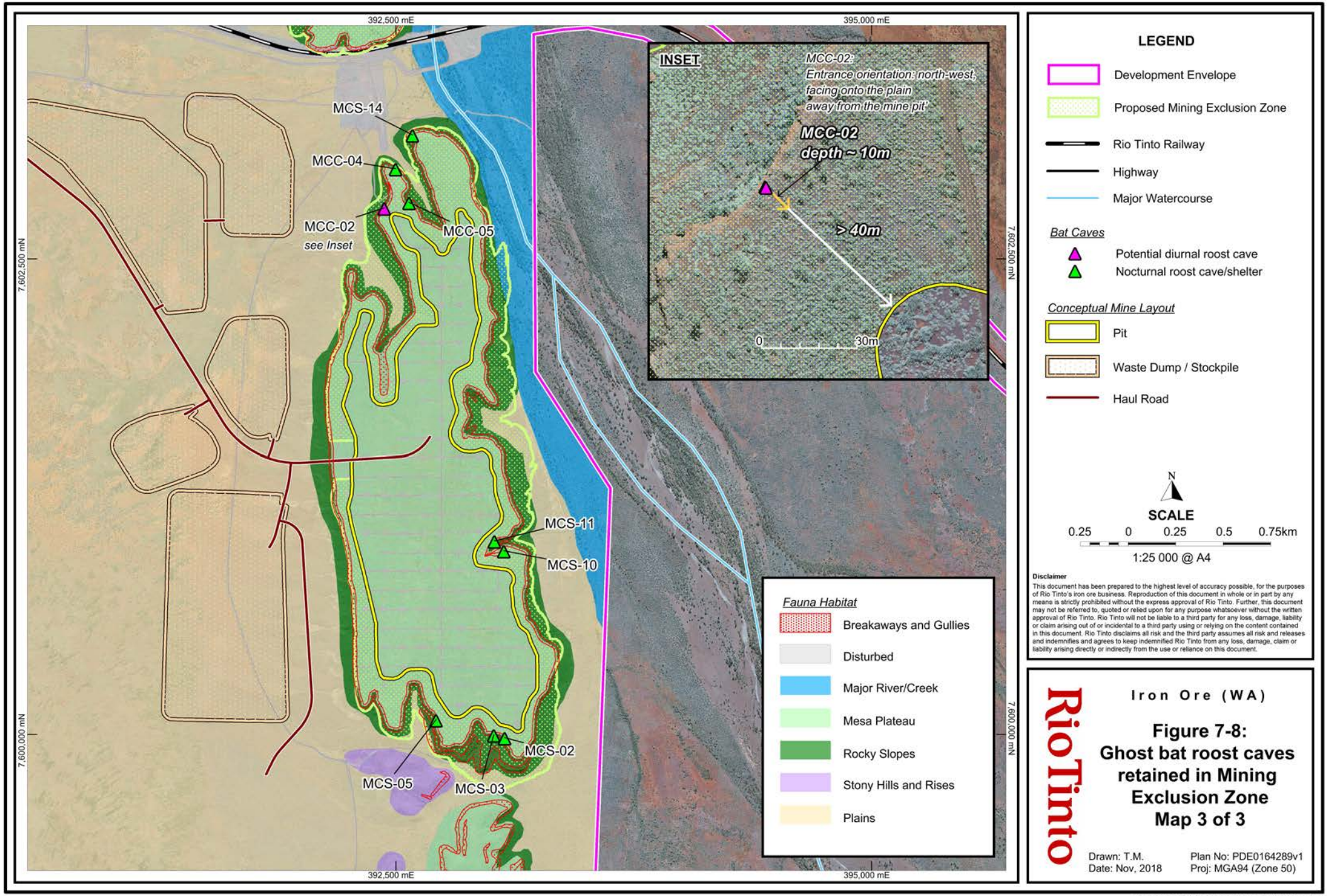
Iron Ore (WA)

Figure 7-8: Ghost bat roost caves retained in Mining Exclusion Zone Map 2 of 3

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164289v2
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Proposed Mining Exclusion Zone
- Rio Tinto Railway
- Highway
- Major Watercourse

Bat Caves

- Potential diurnal roost cave
- Nocturnal roost cave/shelter

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Haul Road

N

SCALE

0.25 0 0.25 0.5 0.75km

1:25 000 @ A4

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Iron Ore (WA)

Figure 7-8: Ghost bat roost caves retained in Mining Exclusion Zone Map 3 of 3

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164289v1
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

7.6.4.3 Indirect impacts

Noise and vibration

Noise and vibration from construction and operation may disturb Ghost Bats and cause individuals to abandon roosts. If these disturbances occur during the breeding season or while pups remain in the roost, the breeding cycle of the local Ghost Bat population may be impacted. However, fauna monitoring at Process Minerals' Poondano project, near Port Hedland, reported the continued presence of a substantial colony of Ghost Bats in a roost approximately 50 m from the mining operation both during and after mining operations (Astron 2015). This suggests that blast management measures, such as implementation of setback distances around caves, and application of vibration thresholds are effective in preventing disturbance to bats and damage to caves (Astron 2015).

Ghost Bat monitoring at West Angelas (Biologic 2015) has been undertaken since 2012. Monitoring in one cave located 70 m from the mine pit has shown evidence of Ghost Bat activity in every year until 2014, with a lack of activity in that year, and a subsequent return of activity recorded in the 2015 survey. Another cave located 90 m from the mine pit showed sporadic use over the monitoring period. The data suggest no significant impact on the size of the local population from mining (Biologic 2015).

Studies on sound and vibration transmissivity through Robe Pisolite as a result of blasting have been undertaken at Mesa A Operations and focussed on vibration propagation through the pit walls (Robe Pisolite). The studies indicated that blast vibrations were attenuated in the CID over a distance of less than 50 m from the blast site, without any specific blast management or trim shots being employed to reduce vibration. As blast management, including trim shots is proposed for mining at Mesas B and C (as described in Section 7.6.4.2 and Section 7.8), the potential for vibration impacts will be further reduced.

The mine design incorporates a 40 m setback distance between the back of each potential diurnal/maternal roost cave and the proposed mine pit and 50 m from the entry to nocturnal roosts (except shelter MBS-05 which will be impacted by the haul road to Mesa B), to protect the integrity of the potential diurnal/maternal roosts and to minimise the impact of noise and vibration on bats. In addition, recorded roosts are orientated away from the mine pit, which is expected to reduce the potential for noise impacts.

Blasting at the existing Mesa A/Warramboo Iron Ore Project occurs on average up to five times per week, with each blast lasting from two to ten seconds. A similar approach is expected to be adopted for the Proposed Change. The sporadic and brief nature of blasting means that blasting related vibrations may, at most, disrupt the local population for very brief periods. Geotechnical assessment of the caves that form the potential diurnal/maternal Ghost Bat roost complexes has also determined that the geotechnical sensitivity of these roosts to structural instability is low (Rio Tinto 2017h).

Ghost Bats are known to move between a number of caves seasonally or as influenced by weather conditions (TSSC 2016b). Studies undertaken by Biologic indicate that groups of Ghost Bats move about within a local area and that multiple groups may use a cave (Biologic 2016). Biologic (2016) note that there generally isn't a continuous presence of Ghost Bats in any one cave and that it is rare to encounter a maternity group despite visiting the most suitable recorded caves in an area across a number of breeding seasons. In 2015 a maternity group was encountered in a small cave in the east Pilbara

that had previously shown little evidence of Ghost Bat occupancy (Biologic 2016). Ghost Bat monitoring at the West Angelas mine site has been undertaken since 2012 (Biologic 2015). Monitoring in one cave located 70 m from the mine pit has shown evidence of Ghost Bat activity in every year until 2014, with a lack of activity in that year, and a subsequent return of activity recorded in the 2015 survey. Another cave located 90 m from the mine pit showed sporadic use over the monitoring period. The field observations thus indicate that Ghost Bats naturally move between a number of caves and that maternity groups may also use different roosts across different seasons. Hormone analysis supports these findings with scats from numerous caves in the same locality containing progesterone levels indicating pregnancy (Biologic 2016).

A study conducted by Bat Call WA (2017b) assessing habitat on all mesas in the Robe Valley from Mesa A to Mesa 2403E, approximately 73 km east of Mesa A (see Figure 9-4 in Section 9.4.4), showed Ghost Bat use of caves in historical mining areas. Thirteen mesas that have been historically mined were assessed. Of these 13 mesas, three have had their escarpments completely removed. No evidence of current Ghost Bat usage on these three mesas was found, although it is possible that occasional foraging visits are made. The percentage of retained perimeter on the remaining ten mesas, varies from 16% on Mesa 2402E to 93% on Mesa 2403D. Six of the ten mesas with retained escarpments had been recently surveyed; all contained evidence of current Ghost Bat usage and a possible diurnal roost was recorded on Mesa 2400E. This result shows that retained mesa escarpments at historically mined sites remain as Ghost Bat habitat and the protected caves and deep shelters on the escarpments continue to offer nocturnal and diurnal roost opportunities for the species (Bat Call WA 2017b).

Given the retention of the two recorded potential diurnal/maternal roosts in the western portion of the Development Envelope, the natural movement of Ghost Bats between roosts, the availability of roosts outside the Development Envelope, the use of caves in historically mine areas and the use of roosts by multiple Ghost Bat groups, it is considered likely that there is opportunity for individuals to move to other caves within the species' range in the event that disturbance causes Ghost Bats to vacate a cave.

Lighting and dust

Light emissions are not expected to directly impact the potential diurnal/maternal roosts, as the orientation of the caves is such that they face away from the proposed mining areas. Light is already present from the Mesa A/Warramboo mining operation. While additional light emissions may alter Ghost Bat nocturnal foraging behaviour by increasing attraction of prey to the area, the light emissions will affect only a small proportion of Ghost Bat foraging habitat and are, therefore, unlikely to significantly impact this species.

Dust management will continue to be implemented in the Development Envelope. Dust emissions are not expected to affect the potential diurnal/maternal roosts due to the protection afforded from the orientation of the caves away from mining areas. In addition, the proposed mesa escarpment cut and associated haul road at Mesa B was moved early in the design process to avoid passing directly in front of the diurnal roost at Mesa B; with the location now approximately 400 m to the West of the diurnal roost. Dust emissions may impact the quality of foraging habitat in the immediate vicinity of the mining operation. Given the small proportion of foraging habitat that may be impacted and the availability of high quality foraging habitat outside the Development Envelope, localised impacts to foraging habitat are unlikely to significantly impact this species.

Invasive species

The Cane Toad is a known threat to the Ghost Bat, if ingested (TSSC 2016b). Cane Toads are not currently established in the Pilbara, and the Proposed Change is considered unlikely to increase the opportunity for Cane Toads to become established.

The Feral Cat is also a threat to the Ghost Bat as they may compete for prey. There is little opportunity for the Proposed Change to cause an increase in the Feral Cat population. Feral Cat control will continue to be undertaken as needed in areas where the Proponent operates.

7.6.4.4 Cumulative impacts

A baseline survey for the Mesa A/Warramboo Iron Ore Project recorded a single Ghost Bat individual leaving cave A5 at Mesa A (Biota 2005b). The cave was noted to be shallow, with no evidence to suggest use as a maternity Ghost Bat roost (Biota 2005b).

Development of the Mesa A/Warramboo Iron Ore Project included delineation of a MEZ which retained the majority of the Mesa A escarpment, including the gully in which cave A5 is located. Roosting and foraging habitat for the Ghost Bat was thereby retained by the Mesa A/Warramboo Iron Ore Project. A section of the Mesa A escarpment approximately 110 m wide was removed to form the escarpment cut to provide access to the top of the mesa. The escarpment cut represents <1% loss of the perimeter of the mesa escarpment (Ghost Bat habitat) at Mesa A. Dust, noise and light emissions from the Mesa A operation also contribute to existing localised impacts to the Ghost Bat.

The Proposed Change will widen the existing escarpment cut at Mesa A by approximately 100 m and will form new cuts at Mesas B and C. The remaining escarpment will continue to be retained in the MEZ such that the Proposed Change will not directly impact potential diurnal/maternal roost sites and will minimise impacts to Ghost Bat habitat. Indirect impacts from the Proposed Change will add to those from the approved activities but will be localised and are not expected to result in a significant impact to the local population.

Ghost Bat has been recorded in the Mesa H Development Envelope (Rio Tinto 2017f) through scats and acoustic recordings. Two potential diurnal roosts have been identified in the Mesa H Development Envelope. The Mesa H Proposal will avoid direct disturbance to the potential diurnal roosts through delineation of a MEZ. Indirect impacts may disturb individuals but are not expected to result in a significant impact to the local population.

Cumulative impacts to fauna habitats present in the Robe Valley is discussed further in Section 7.6.1.3.

7.6.4.5 Outcome

One diurnal/potential maternal Ghost Bat roost is present at Mesa B and one potential diurnal roost is present at Mesa C. The Revised Proposal has been designed to avoid direct disturbance to these roosts. In addition, the Revised Proposal has been designed to avoid direct disturbance to 21 of the 22 recorded nocturnal Ghost Bat roosts at Mesas A, B and C. Given the recorded potential diurnal/maternal roosts will not be directly disturbed and that the loss of key foraging habitat provided by the Major River/Creek habitat will be less than 1% of the available foraging habitat in the Development Envelope, it is estimated that the loss to the local population of this species (using habitat

loss as a proxy for estimating population loss), as a result of the Revised Proposal, will be less than 1%.

Given the setback distances and blast management to be applied to maintain the integrity of the recorded potential diurnal/maternal roost caves, the avoidance of direct impacts to the majority of nocturnal roost caves (all but one avoided), the natural movement of Ghost Bats between roosts, the use of historically mined areas, the diverse foraging habitat of the Ghost Bat and the availability of foraging habitat outside the Development Envelope; the predicted loss of potential foraging habitat through clearing and the loss of one nocturnal roost cave is unlikely to significantly impact the local population and are unlikely to affect the conservation status of the species.

7.6.5 Pilbara Olive Python

7.6.5.1 Pilbara Olive Python policy and guidance

Conservation advice for the Pilbara Olive Python was published in 2008 (TSSC 2008) which describes distribution and habitat, recognised threats and regional and local priority actions. Priority actions relevant to habitat loss, disturbance and modification include:

- Identify populations of high conservation priority
- Ensure road widening, maintenance activities, and gas infrastructure development (or development activities) in areas where the Olive Python (Pilbara subspecies) occurs do not adversely impact on known populations
- Manage any changes to hydrology which may result in changes to the water table levels, increased run-off, sedimentation or pollution
- Investigate further formal conservation arrangements such as the use of covenants, conservation agreements or inclusion in reserve tenure.

7.6.5.2 Direct impacts

Loss of habitat

The Major River/Creek habitat and Breakaways and Gullies habitat in the western portion of the Development Envelope provide the habitat variables required for the Pilbara Olive Python for foraging, shelter and breeding, particularly those locations that contain semi-permanent water (MWH 2015a; DotEE 2017c).

MWH (2015a) notes the following habitats and habitat features of particular significance to the species:

- Caves and major gullies within the Breakaways and Gullies habitat at Mesas B and C which may be used for breeding and shelter purposes
- The Robe River (Major River/Creek habitat) which provides foraging habitat and a potential dispersal route
- The semi-permanent pools along the Robe River adjacent to Mesa B which provide habitat to facilitate the species' typical ambush hunting behaviour.

The Proposed Change has been designed to limit disturbance to 6% of the Breakaways and Gullies habitat in the western portion of the Development Envelope and less than 1% of Major River/Creek habitat in the western portion of the Development Envelope. Retention of the majority of the escarpments and associated gullies of Mesas A, B and C, will ensure available habitat remains for the species.

Installation of infrastructure is unlikely to create physical barriers to the movement of Pilbara Olive Pythons given their ability to move between different habitat types. The mine pits in the mesa plateaus are also unlikely to fragment populations or create barriers to movement, as the mesa plateaus do not provide preferred habitat for the species.

Loss of individuals

Pilbara Olive Pythons are at risk from vehicle strike, as they are slow moving and their first response to the sound and vibration of a vehicle is to freeze (Pearson 2003). Vehicle movements associated with the Proposed Change are unlikely to result in a long-term decrease in the Pilbara Olive Python population. The Pilbara Olive Python is almost entirely nocturnal; vehicle movements at night are much less than during the day and are generally limited to in-pit operations.

7.6.5.3 Indirect impacts

Noise and vibration

Snakes use the inner ear to identify prey and avoid predators by detecting ground vibrations (Christensen *et al*. 2012). Blasting at the existing Mesa A/Warramboo Iron Ore Project occurs on average up to five times per week, with each blast lasting from two to ten seconds. A similar approach is expected to be adopted for the Proposed Change. The sporadic and brief nature of blasting means that blasting related vibrations are unlikely to interfere with the Pilbara Olive Python's ability to detect prey and avoid predators.

Invasive species

The Feral Cat is a threat to the Pilbara Olive Python (TSSC 2008), particularly juvenile Pilbara Olive Pythons. There is little opportunity for the Proposed Change to cause an increase in the Feral Cat population. Feral Cat control will continue to be undertaken as needed in areas where the Proponent operates.

While the Pilbara Olive Python is susceptible to Cane Toad poison, current evidence suggests that adults do not eat Cane Toads (Turvey 2013), although can be poisoned from secondary consumption. Further research is required to more clearly establish the threat the Cane Toad potentially poses to the Pilbara Olive Python. The Cane Toad is not currently established in the Pilbara; the Proposed Change is unlikely to increase the opportunity for the Cane Toad to become established in the area.

7.6.5.4 Cumulative impacts

The Pilbara Olive Python was not recorded in the disturbance footprint of the existing Mesa A/Warramboo Iron Ore Project, but was considered highly likely to occur (Strategen 2006). The potential for individuals to be impacted by habitat loss and for vehicle strike to cause injury or mortality of individuals was noted (Strategen 2006). The Mesa A/Warramboo Iron Ore Project has had only limited impacts to habitat for this species through establishment of the railway Robe River crossing and the Mesa A escarpment access cut.

The Proposed Change will continue to minimise impact to potential denning habitat and will avoid impacts to the Robe River. The Proposed Change will temporarily alter surface water hydrology in Warramboo Creek downstream of the surplus water discharge point

throughout the discharge extent and may thus result in temporary changes to foraging habitat for this species.

The species has also been recorded in the Mesa H Development Envelope. The Mesa H Proposal will retain the majority of the mesa escarpment through delineation of a MEZ. There will be limited direct disturbance to riparian habitat along the Robe River and Jimmawurrada Creek (Rio Tinto 2017f). The Mesa H Proposal will alter hydrology through pit dewatering at Mesa H and discharge of surplus water (Rio Tinto 2017f). These operational elements have the potential to impact foraging habitat for Pilbara Olive Python.

7.6.5.5 Outcome

This species is known to occur at more than 60 locations across the Pilbara (G. Humphreys, Biota Environmental Sciences, pers. comm. 2012) including populations at Pannawonica, Millstream, Tom Price and the Burrup Peninsula. It also occurs within the Rangelands (Western Australia) Natural Resource Management Region and part of the species' habitat is conserved in Karijini National Park.

The Revised Proposal avoids disturbance to the higher value parts of the Breakaways and Gullies habitat type but may result in disturbance to 6% of lower value sections of the Breakaways and Gullies habitat and less than 1% of the Major River/Creek habitat in the Development Envelope. Based on this habitat loss, the potential maximum loss of the local population of Pilbara Olive Python is estimated to be limited to 6% in the vicinity of the Development Envelope and to less than 1% in the Robe Valley. However, percentage loss of populations is difficult to estimate and has been based on habitat loss only for this assessment. The actual loss is likely to be less than this as these species are mobile and suitable denning habitat occurs in adjacent areas.

Given the retention of suitable breeding, shelter and foraging habitat within the western portion of the Development Envelope, the wider availability of habitat in the Robe Valley and the occurrence of populations outside the Development Envelope, the loss of potential breeding, shelter and foraging habitat through construction of escarpment cuts and clearing is not expected to adversely impact the conservation status of the Pilbara Olive Python.

7.6.6 Western Pebble-mound Mouse

There is no conservation advice or recovery plan for this species.

The Proposed Change will directly impact Plains, Mesa Plateau, Rocky Slopes and Stony Hills and Rises habitats which are preferred habitat for the Western Pebble-mound Mouse and which support breeding of the species. The Proposed Change will impact up to 28% of the suitable habitat for this species in the western portion of the Development Envelope. The majority of the impact will be to the Plains habitat type, which occurs extensively throughout the Hamersley subregion. As such, the loss of habitat for the Western Pebble-mound Mouse is not expected to adversely affect habitat availability for this species.

The active mound recorded to the north-east of the Highway/Tod Bore deposit will not be impacted by the Proposed Change. Given the limited records in the western portion of the Development Envelope, it is considered unlikely that vehicle movements will result in collision with individuals of this species.

Surveys elsewhere in the Pilbara have yielded more records for this species including at Yandi Billiards and Pocket South deposits (Biota 2014). The Biota (2014) survey identified 11 mounds, of which six were considered active at the time of survey. A survey for the Marra Mamba West project recorded four Western Pebble-mound Mouse mounds, three of which were active at the time of survey (Biota 2013).

The reason for limited activity in the western portion of the Development Envelope is not known; however, on the basis of the species' common occurrence in suitable habitat outside the Development Envelope in the Hamersley and Chichester subregions of the Pilbara (Biota 2013), the Proposed Change is considered unlikely to adversely affect the local population and is unlikely to affect the conservation status of this species.

Given the very limited potential for impact to this species, the Proposed Change is considered unlikely to contribute to any cumulative impacts to the species.

7.6.7 Migratory shorebirds

Six migratory shorebirds have the potential to occur as migrant non-breeding visitors to the in the western portion of the Development Envelope (although none have been recorded); Common Sandpiper, Wood Sandpiper, Common Greenshank, Oriental Pratincole and Little Curlew and Eastern Osprey. All but the Eastern Osprey are addressed in the DoE's Wildlife Conservation Plan for Migratory Shorebirds (DoE 2015), there is no conservation advice or recovery plan for the Eastern Osprey. All six species are discussed further below.

The Wildlife Conservation Plan for Migratory Shorebirds (DoE 2015) aims to protect important habitats for migratory shorebirds, including wetland habitats and to address information gaps relating to shorebird ecology. The plan defines nationally important habitat for these species as habitat that supports the following:

- 0.1% of the flyway population of a single species of migratory shorebird or
- 2,000 migratory shorebirds or
- 15 migratory shorebird species.

The Proposed Change will directly impact less than 24% of potential habitat present in the western portion of the Development Envelope for the Oriental Pratincole (Major River/Creek, Minor Drainage Lines, Floodplains and Plains habitats). The majority (99%) of this habitat loss is from the extensive Plains habitat type.

The Proposed Change will directly impact up to 5% of potential habitat present in the western portion of the Development Envelope for the other four migratory shorebirds (Major River/Creek and Minor Drainage Lines habitats).

Given that suitable habitat for Common Sandpiper, Wood Sandpiper, Common Greenshank, Oriental Pratincole and Little Curlew occurs seasonally throughout the Robe Valley and that these species generally have wide distributions and are seasonal or itinerant visitors to the area, the loss of habitat is not expected to adversely affect the conservation status of these species.

Individuals of Common Sandpiper, Wood Sandpiper, Common Greenshank, Oriental Pratincole and Little Curlew may be impacted if feral fauna are attracted to operational areas. Feral fauna control will continue to be undertaken as needed in areas where the Proponent operates. On the basis of a lack of records, it is unlikely that the western

portion of the Development Envelope contains nationally important habitat and, the Proposed Change is unlikely to contribute to cumulative effects to these species, or to significantly impact migrating populations of these species.

The Proposed Change will directly impact less than 1% of the available Major River/Creek habitat within the western portion of the Development Envelope, which provides suitable habitat for the Eastern Osprey. On this basis, the Proposed Change is unlikely to significantly impact any itinerant visitors to the local area. In addition, given the Eastern Osprey's wide distribution and breeding range across northern Australia from Albany in Western Australia to Lake Macquarie in New South Wales, and noting a further isolated breeding population on the coast of South Australia, the Proposed Change is unlikely to contribute to cumulative impacts to this species, or to affect either itinerant visitors to the area or the conservation status of the species.

7.6.8 Peregrine Falcon

There is no conservation advice or recovery plan for this species.

The Proposed Change will directly impact up to 6% of Breakaways and Gullies habitat in the western portion of the Development Envelope. No nests have been recorded in the western portion of the Development Envelope.

Given the species' use of a wide range of habitats including woodlands, grasslands, coastal cliffs and at a lower frequency, desert regions and the lack of recorded Peregrine Falcon nests or individuals within the western portion of the Development Envelope in the recent fauna survey (MWH 2015a), the Proposed Change is considered unlikely to significantly impact any itinerant individuals and therefore the conservation status of the species.

7.6.9 Grey Falcon

Up to 26% of potential habitat for the Grey Falcon including Plains and Major River/Creek and Minor Drainage Lines habitat types in the western portion of the Development Envelope, will be directly impacted by the Proposed Change. No Grey Falcon nests have been recorded in the western portion of the Development Envelope in recent studies so the Proposed Change is unlikely to disturb an active nest.

The majority of the impact will occur in Plains habitat (99%) which is not restricted locally or regionally and the Proposed Change has been designed to limit disturbance to less than 1% of the Major River/Creek habitat. On this basis, it is considered unlikely that the Proposed Change will contribute to cumulative impacts or will significantly impact any itinerant individuals or the conservation status of this species.

7.6.10 Long-tailed Dunnart

There is no conservation advice or recovery plan for this species.

This species has the potential to utilise rocky habitat types in the western portion of the Development Envelope including Mesa Plateau, Rocky Slopes and Stony Hills and Rises. Up to 47% of the available habitat within the western portion of the Development Envelope will be directly impacted, the majority of which consists of Mesa Plateau habitat. Given the lack of records from the recent survey (MWH 2015a) and the availability of suitable habitat in the western portion of the Development Envelope and outside the Development Envelope, it is considered unlikely that the Proposed Change will contribute

to cumulative impacts to this species or significantly impact any individuals occurring in the local area, and therefore the conservation status of the species.

7.6.11 Lined Soil-crevice Skink

There is no conservation advice or recovery plan for this species.

Based on previous survey results (Biota 2009b, 2009c), this species is likely to inhabit Plains habitat in the western portion of the Development Envelope. The Proposed Change may directly impact up to 26% of the available Plains habitat within the western portion of the Development Envelope; however, no individuals were recorded during the recent fauna survey (MWH 2015a). Given the lack of records from the recent survey (MWH 2015a) and the availability of suitable habitat in the western portion of the Development Envelope and outside the Development Envelope, it is considered unlikely that the Proposed Change will contribute to cumulative impacts to this species or significantly impact the conservation status of this species.

7.6.12 Potential SREs

Eight potential SRE species were recorded in the western portion of the Development Envelope. The majority of potential SRE species were recorded in Major River/Creek or Hardpan habitat. Less than 1% of the Major River/Creek habitat and less than 5% of the Hardpan habitat type in the western portion of the Development Envelope will be impacted as a result of the Proposed Change.

Although the majority of potential SRE species were recorded in Major River/Creek or Hardpan habitat, the most significant habitat features in the western portion of the Development Envelope in terms of potential SRE taxa are the deeply incised gullies within Mesas B and C, within the Breakaways and Gullies habitat (MWH 2015a). The Breakaways and Gullies habitat has a high potential to support SRE species as it has a limited geographical extent, is isolated in the landscape and contains sheltered microhabitats (MWH 2015a). The Proposed Change has been designed to limit direct impacts to Breakaways and Gullies habitat to 6% within the western portion of the Development Envelope. The one species which was recorded in the Breakaways and Gullies habitat; ?Karaops ‘indet’ is a Selenopid spider which are known to occur in association with rocky terrain where they take shelter in cracks and crevices between rocks. It is therefore unlikely that within the western portion of the Development Envelope this species has a distribution beyond the Breakaways and Gullies habitat type (MWH 2015a). However, it is likely this species would occur in similar rocky habitats in the surrounding landscape (MWH 2015a).

The discharge of surplus water into Warramboo Creek will increase water availability and alter the seasonality of surface water in Warramboo Creek up to 8 km downstream of the discharge point for the duration of discharge. The increased volume and frequency of water presence may temporarily result in greater abundance and diversity of SRE species in the affected section of Warramboo Creek and some SRE species may be affected by changes to the surface water chemistry. However, upon cessation of discharge Warramboo Creek will return to the natural ephemeral flow regime, thus there is unlikely to be any long-term impact to SREs.

Given the minimal impacts predicted to the key habitat types for SRE species in the western portion of the Development Envelope, it is unlikely the Proposed Change will significantly impact the potential SRE species recorded.

7.6.13 Aquatic fauna

The Proposed Change has been designed to limit direct impacts to less than 1% of Major River/Creek habitat present in the western portion of the Development Envelope.

7.6.13.1 Robe River

Hydrogeological modelling indicates there is limited hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvium. Consequently, drawdown in groundwater levels within the Mesa C CID Aquifer is not expected to result in observable changes to groundwater levels within the adjacent Robe River Alluvial Aquifer, surface water levels in the Robe River or surface water levels in the semi-permanent pools near Mesa B. Nor is the Proposed Change expected to alter surface water chemistry in the Robe River.

Surface water run-off generated within operational areas will be intercepted and treated prior to appropriate reuse and/or discharge. It is not expected to alter the surface water chemistry within the Robe River.

7.6.13.2 Warramboo Creek

Groundwater abstraction at Warramboo will result in lowering of the groundwater table. Warramboo Creek lacks the alluvial gravel profile of the larger Robe River and is disconnected from underlying groundwater systems (Section 8.4.3.1). As a result, Warramboo Creek has no permanent or semi-permanent pools. The water sampled by WRM in 2016 and 2018 was water that remains in low-lying areas for a short period following flows. As the pre-mining depth to groundwater along Warramboo Creek through the zone of proposed drawdown is approximately 7-26 m below ground level (with the depth as shallow as 7 m in the coastal plain area in the northern extent of the drawdown zone and the depth up to 26 m in the south of the drawdown extent) and there are no pools present in that section of Warramboo Creek, lowering the groundwater table is unlikely to impact aquatic fauna associated with Warramboo Creek.

Surplus water will be discharged into Warramboo Creek with the wetting front predicted to extend up to 8 km from the discharge point. Discharge of surplus water will increase the seasonal availability of surface water and may alter surface water chemistry in Warramboo Creek during natural no-flow conditions for the duration of discharge activities.

The increase in water availability due to discharge has the potential to impact fauna adapted to ephemeral environments. For example, many aquatic invertebrates possess strategies to avoid desiccation, such as drought-resistant spores, eggs or larval stages, burrowing into moist sediments, or sealing the entrance to protective body parts. As these species are adapted to the drying and refilling cycles, they may be replaced by opportunistic, fugitive and predatory species as water availability increases during discharges. Therefore, a change in hydrology can lead to the loss of fauna which require periods of drying. However, as the discharge will be temporary, on cessation aquatic communities would be expected to return to baseline/background conditions.

The surface and groundwater chemistry of Warramboo Creek is described in Section 8.4.4 and 8.6.3. Surface water samples collected from Warramboo Creek after rainfall events show the water to be fresh with a neutral to mildly alkaline pH. Total nitrogen levels in Warramboo Creek are generally elevated compared with the ANZECC 95% aquatic ecosystem protection level. Aluminium, total chromium, copper, iron, nitrates,

total phosphorus and zinc also show some degree of elevation compared with ANZECC 95% aquatic ecosystem protection levels.

Groundwater chemistry data for samples collected from bores most likely to represent the proposed surplus water discharge were compared with data from surface water samples and ANZECC guidelines. The chemistry of the groundwater proposed for discharge has a neutral to mildly alkaline pH and is considered fresh to brackish. Median concentrations of boron, nitrate, NOx and total nitrogen and also EC in the groundwater are elevated compared with both the surface water in Warramboo Creek and the ANZECC guidelines. Under natural no-flow conditions, potential changes in water chemistry from discharged surplus water may impact aquatic fauna.

Based on the available data, potential risks to aquatic fauna from surplus water discharge are considered to be osmotic shock due to elevated EC, metal toxicity, nitrate toxicity and eutrophication effects due to nitrogen enrichment. Risk will be greatest during natural recessional or no-flow periods when discharge constitutes a greater proportion of flow in the creek, and the diluting effect of rainfall is low. Elevated levels in groundwater do not automatically imply that these are the levels to which creek biota will be exposed. For nitrate, eutrophication and toxicity effects will depend on the biogeochemical capacity of the creek to recycle nitrate through the ecosystem via microbial denitrification in the soil. For dissolved metals, toxicity will be strongly dependent on the form of the metal and the degree to which it is bioavailable. Many metals also readily bind to organic matter and clays and precipitate out of the water column, making them unavailable for direct uptake by plants and fauna and hence of low toxic risk. Levels of dissolved organic matter in most surface waters are often sufficient to remove silver, cadmium, copper and zinc toxicity (ANZECC/ARMCANZ 2000).

No fish were recorded from Warramboo Creek. Three hyporheic invertebrate taxa recorded in Warramboo Creek are considered to be stygobites, however they were only recorded from three sites upstream of the discharge location in 2018 (WARUS2, WARUS3 and WARUS6). None of the hyporheic invertebrate taxa recorded along Warramboo Creek have restricted distributions, nor are any listed for conservation significance.

All invertebrate species recorded from Warramboo Creek are common species, known to occur widely throughout the Pilbara in a range of seasonal and ephemeral waterbodies, except for the potential occurrence of a macro-invertebrate species of *Branchinella* (WRM 2016).

Anostracans recorded from rehydrated sediment samples from Warramboo Creek in 2016 were immature and could not be identified to species level, but may belong to either *Branchinella* or *Streptocephalus*. *Branchinella* are known to occur in temporary freshwaters and individual species tend to be locally restricted. It is possible that the anostracans from Warramboo Creek belong to one of the eight *Branchinella* species known from ephemeral waterbodies in the Pilbara; however, they may belong to the species *Streptocephalus archeri*, which is known to occur throughout the Pilbara and beyond (WRM 2016). An unknown anostracan (*Branchinella* cf. *proboscida*) was also recorded from Warramboo Creek in 2018 (*Branchinella* cf. *proboscida*) and is yet to be formally identified however may belong to the species *Branchinella proboscida*, which has a wide distribution across the Australian continent, being known from all states and territories except Victoria and Tasmania (WRM 2018).

Branchinella species generally only inhabit waters with total dissolved solids (TDS) concentrations less than 2,000 mg/L (Pinceel *et al*. 2013). Although the mean TDS measured in in the proposed surplus discharge from Warramboo is less than 2,000 mg/L, some TDS concentrations may exceed 2,000 mg/L. Therefore, *Branchinella* species present in Warramboo Creek may be impacted in an 8 km section of Warramboo Creek for the duration of discharge.

7.7 Closure

The Mesa A Hub Closure Plan (Rio Tinto 2017b) represents the updated closure plan for the Mesa A, B, C, Warramboo, Highway/Tod Bore operations and supersedes previous closure plans for the approved project. It is applicable to mine developments and associated infrastructure, excluding rail and road infrastructure, within the Development Envelope. A summary of the approach to closure of the Revised Proposal and how it relates to the terrestrial fauna factor is provided below.

Upon closure, the Proponent commits to rehabilitating the area to a safe, stable and self-sustaining native ecosystem that may provide opportunity for suitable fauna habitat. Habitat elements considered as part of the final landform design include:

- Vegetation known to provide food or shelter
- Retaining and replacing woody debris
- Generation and retention of leaf litter using small scale topography (e.g. furrows created from ripping)
- Introducing or leaving rocky features such as oversized waste burden or scree slopes
- Returning soil to allow opportunities for burrowing fauna
- Preserving connectivity with unmined areas and maintaining the quality of these habitats
- Managing feral predators and herbivores across both reference and rehabilitated areas.

In addition, work will be undertaken to determine the best strategy for reducing surplus water discharge, to minimise impact to native fauna which may have adapted to the altered regime.

7.8 Mitigation

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 7-11.

The Mesa A Hub EMP (Appendix 4) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa A Hub. The EMP identifies:

- Mitigation strategies proposed to minimise impacts to significant environmental values
- The environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met
- Trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach
- The management actions that will be implemented in response to monitoring results.

Table 7-11: Mitigation measures and predicted outcomes for terrestrial fauna

Potential impacts	Mitigation to address potential impacts	Predicted outcome
EPA Objective: To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.		
Direct impact: loss of fauna habitat due to clearing Clearing will reduce the available extent of fauna habitat including Breakaways and Gullies and Major River/Creek habitats, which provide high value habitat for conservation listed species recorded in the region.	The following key management strategies will be implemented to manage the potential loss of fauna habitat (including habitats for conservation significant fauna species) as a result of clearing: **Avoid**: Breakaways and Gullies habitat represents habitat of high value to conservation significant fauna. The Proposed Change has been designed to avoid disturbance to Breakaways and Gullies habitat except where escarpment cuts are required to access the mesas. The Proposed Change will avoid direct impacts to all recorded potential diurnal/maternal Ghost Bat roosts. The MEZ has been designed to be wider near the potential diurnal/maternal roosts such that the MEZ will extend at least 40 m from the back of the potential diurnal/maternal roosts to ensure the Proposed Change does not directly impact these roosts. The Proposed Change will avoid direct disturbance to all but one known nocturnal Ghost Bat roost. The nocturnal roosts to be avoided are located inside the MEZ. **Minimise**: The clearing footprint has been minimised through project optimisation to reduce the extent of clearing required. Specifically, in-pit disposal of waste fines and reverse osmosis plant effluent is proposed rather than development of an external tailings storage facility and evaporation pond. Impacts to Breakaways and Gullies and Major River/Creek habitat types will be minimised; up to 6% and less than 1%	The Proposed Change is expected to result in the unavoidable loss of fauna habitat (including habitats for conservation significant fauna species) as a result of clearing. None of the habitats recorded are restricted to the western portion of the Development Envelope; all fauna habitats identified from the western portion of the Development Envelope occur throughout the Robe Valley. The most significant habitat types in the western portion of the Development Envelope are the Breakaways and Gullies habitat and Major River/Creek habitat. Up to 6% of the Breakaways and Gullies habitat type present in the western portion of the Development Envelope and up to 1% of the Major River/Creek habitat type in the western portion of the Development Envelope will be disturbed. The Proposed Change will avoid direct disturbance to all recorded potential diurnal/maternal Ghost Bat roosts. The Proposed Change will avoid all but one of the recorded nocturnal Ghost Bat roosts. Given the proposed avoidance and minimisation of disturbance to the most significant habitats and habitat features, and the widespread distribution and/or low value to terrestrial fauna of the other habitats, the loss of habitat is not expected to adversely affect the conservation status of species (including species of elevated conservation significance). The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	of each respectively will be disturbed within the western portion of the Development Envelope. A five year study of Ghost Bat utilisation of high value habitat in the Robe Valley will be undertaken with the objective to improve knowledge of the Ghost Bat population and utilisation of high value habitat in the Robe Valley in order to assist in maintaining biological diversity and ecological integrity. This will involve bi-annual collection and analysis (genetic and hormone) of scat samples from across the broader Robe Valley and measurement of temperature and humidity in Ghost Bat roost caves (see EMP in Appendix 4). After a period of five years the monitoring frequency and type will be reviewed. The Proponent proposes that clearing be subject to a new Ministerial Statement for the Revised Proposal (Appendix 2). Schedule 1 of the new Ministerial Statement shall authorise clearing of no more than 6,680 ha within the Development Envelope of 16,834ha. **Rehabilitate**: The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA *Guidelines for Preparing Mine Closure Plans* (2015). The Closure Plan (Appendix 3) includes a closure objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use. **Offset**: The Proposed Change is not expected to have a significant residual impact on fauna. Therefore, no specific offset is proposed in relation to fauna. However,	

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	the proposed offset for vegetation and flora loss will benefit fauna in the region. **Other legislation**: The Proponent will also adhere to the requirements of the WC Act.	
Direct impact: loss of individuals from increased vehicle strikes and collisions with fencing	The following management strategies will be implemented to manage the potential loss of individuals: **Avoid:** The use of barbed wire will be avoided except where legislated. Where there is a statutory requirement for barbed wire, reflectors will be installed to minimise the risk of entanglement by bats. **Minimise:** Vehicle movements will take place predominantly during the day and will be generally limited to in-pit operations. The Proponent proposes to undertake annual monitoring of Northern Quoll within the broader Robe Valley. **Rehabilitate:** The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA *Guidelines for Preparing Mine Closure Plans* (2015). The Closure Plan (Appendix 3) includes a closure objective to ensure that final landform is stable and considers ecological issues.	Given barbed wire will not be used except where legislated and that reflectors will be installed where barbed wire is used and given the management measures to be applied, it is considered that the effects on individuals of conservation significant fauna will be minimal. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.
Indirect impact: alteration of fauna habitat due to altered hydrology Lowering of groundwater levels as a result of groundwater abstraction, may impact the quality of foraging habitat for conservation significant terrestrial fauna species.	The following management strategies will be implemented to manage the potential loss of fauna habitat from groundwater abstraction and surplus water discharge:	Potential impacts to phreatophytic species along the majority of the defined flow channel of Warramboo Creek are expected to be limited to changes in canopy cover, with no significant changes to understorey vegetation, and therefore fauna habitat, expected.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
Alteration of surface water chemistry in Warramboo Creek from discharge of surplus water may impact fauna habitat for aquatic fauna, for the duration of discharge activities, during natural no-flow conditions.	**Avoid:** The discharge point will be installed in Major River/Creek habitat, not considered to be of significant value to conservation significant aquatic fauna. **Minimise:** The Proponent will abstract groundwater within the licence limits and monitor groundwater levels to ensure the extent of groundwater drawdown remains within the predicted range of impact. Surplus groundwater will be utilised on-site for mine operations and processing, where practicable. Surplus water will be discharged when supply exceeds demand for the duration of abstraction activities only. **Rehabilitate:** The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP/EPA Guidelines for Preparing Mine Closure Plans (2015). The Closure Plan (Appendix 3) includes a closure objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use.	There is potential for minor changes to the abundance of understorey vegetation in the Floodplain and Plains habitat types downstream of the defined flow channel in Warramboo Creek. Current understorey vegetation cover in this area is low and understorey vegetation has been impacted by cattle and weed species. Neither of the habitat types provide significant microhabitats for terrestrial fauna (Astron 2018a) and both habitat types are widespread in the immediate vicinity as well as the Roebourne subregion and wider Pilbara bioregion (Astron 2018a). Given the widespread nature of both habitat types, the existing disturbance and the minor nature of the proposed changes, the proposed groundwater drawdown in the Yarraloola Aquifer is not expected to have a significant impact on terrestrial fauna habitat. Potential impacts to Major River/Creek habitat in Warramboo Creek from discharge of surplus water are expected to extend approximately 8 km from the point of discharge and will be temporary, lasting for the duration of discharge. During natural flow conditions, the discharge of surplus water is unlikely to impact surface water chemistry. During natural no-flow conditions, discharge of surplus water may change surface water chemistry and potentially impact aquatic fauna in an 8 km section of Warramboo Creek downstream of the discharge point for the duration of discharge. Anostracans recorded from rehydrated sediment samples from Warramboo Creek in 2016 were immature and could not be identified to species level, but may belong to either the *Branchinella* or *Streptocephalus*.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
		An unknown anostracan (*Branchinella* cf. *proboscida*) was also recorded from Warramboo Creek in 2018 (*Branchinella* cf. *proboscida*) and is yet to be formally identified however may belong to the species *Branchinella proboscida*, which has a wide distribution across the Australian continent, being known from all states and territories except Victoria and Tasmania (WRM 2018). Changes in surface water chemistry may result in localised impacts to *Branchinella* species present in an 8 km section of Warramboo Creek for the duration of discharge. Three hyporheic invertebrate taxa recorded in Warramboo Creek are considered to be stygobites, however they were only recorded from three sites upstream of the discharge location in 2018 and none have restricted distributions, nor are any listed for conservation significance. No fish species were recorded from Warramboo Creek and all other invertebrate fauna species recorded from Warramboo Creek occur widely throughout the Pilbara; potential localised impacts to these species as a result of surplus water discharge are unlikely to be significant. As the area will continue to retain fauna habitat values and the potential impacts from surplus water discharge are expected to be temporary, the Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
Indirect impact: loss or degradation of habitat due to noise and vibration The most significant noise and vibration from the proposed mining operation will occur during the day from blasting activities. Noise and vibration emissions may, therefore, disturb roosting Ghost Bat individuals. Vibration may also affect the stability of the mesa escarpments.	The following key management strategies will be implemented to manage the potential impact to fauna from noise and vibration emissions: **Minimise**: The MEZ around Ghost Bat roosts will minimise the potential impact of noise and vibration on roosting Ghost Bats. Blasting at the existing Mesa A/Warramboo Iron Ore Project occurs on average up to five times per week, lasting from two to 10 seconds for each blast. A similar approach will apply to the Proposed Change. In addition, the Proponent will implement a Blast Management Framework to ensure blast vibration levels at the identified diurnal/potential maternal Ghost Bat roosts remain below the trigger level PPV set in the EMP (see EMP in Appendix 4). Measures that may be used to achieve the required blast control are discussed in Section 7.6.4.2. Monitoring of Ghost Bat roosts will include blast vibration monitoring for all blasts within 300 m of the potential diurnal/maternal Ghost Bat roosts, and bi-annual collection and analysis (genetic and hormone) of scat samples from across the broader Robe Valley as part of the five year Ghost Bat study (see EMP in Appendix 4). After a period of five years the monitoring frequency and type will be reviewed.	Noise and vibration emissions are unlikely to reduce the quality of fauna habitat, or cause conservation significant fauna to avoid areas of suitable habitat. The implementation of a vibration threshold will minimise impact. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
Indirect impact: degradation of habitat due to dust and light emissions Light may disrupt nocturnal foraging behaviour of conservation significant fauna and dust emissions may impact fauna habitat quality.	The following key management measures will be implemented to manage the potential disturbance to conservation significant fauna from light emissions and potential impact to fauna habitat from dust: **Avoid:** Lighting will be directed into the active pits to avoid the mesa escarpments. **Minimise:** Lighting will be installed only where required, that is, mainly in-pit and operational areas. Dust emissions will be managed through application of dust suppression methods including water sprays, where applicable.	Given that light emissions are already present in the Mesa A/Warramboo area and that lighting will be directed into the active pits to avoid the mesa escarpments, light emissions from the Proposed Change are expected to result in limited changes, if any, to nocturnal foraging activities in proximity to the operational areas. The potential impact of dust emissions on fauna habitat quality are expected to be limited to retained vegetation in proximity to mining and unsealed roads. Potential impacts are likely to be seasonal (limited to the dry season) and temporary, lasting for the duration of the Proposed Change. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.
Indirect impact: degradation of habitat due to altered fire regime, introduction or spread of weeds and changes to feral animal populations	The Proponent has well established strategies for monitoring and management of the risk of weed ingress, feral animals and increase in fire at its Pilbara operations. The following key management strategies will continue to be implemented to manage these aspects: **Avoid**: The Proponent will implement strict hygiene procedures to prevent introduction of new or additional populations of weed species into the Development Envelope. **Minimise**: The Proponent will undertake annual weed control to minimise weed infestations in the Development Envelope. Feral fauna control will be implemented in the Development Envelope as needed to minimise potential	The Proposed Change is expected to result in a minor increase in the potential for weed infestation; however, this is not expected to significantly alter the condition of vegetation in the western portion of the Development Envelope. Feral animal control measures will continue to be applied as needed, and therefore any increase in feral animals would not be significant. An increase in the occurrence of fire is unlikely given the measures that will be in place, and the procedures to be followed in the event of a fire. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	for loss of conservation significant species to feral predators. Fire prevention measures (and control measures, should a fire break out) will be in place in the Development Envelope, particularly around areas of high risk including all buildings and infrastructure. **Other legislation:** Weed management will be in accordance with the requirements of the *Biosecurity and Agriculture Management Act 2007*.	

7.9 Predicted outcome

The Terrestrial Fauna values identified in the western portion of the Development Envelope that are considered relevant to the Proposed Change, and the key predicted outcomes for those values are outlined below.

Significant fauna habitat

The most significant fauna habitat values are:

- Breakaways and Gullies habitat (129 ha in the western portion of the Development Envelope), including denning and foraging habitat for the Northern Quoll and Pilbara Olive Python, roosting habitat for the Ghost Bat and potential habitat for SREs
- Major River/Creek habitat (317 ha in the western portion of the Development Envelope), including denning/shelter habitat and a dispersal route for Northern Quoll and Pilbara Olive Python and foraging habitat for the Pilbara Leaf-nosed Bat and Ghost Bat.

Conservation significant fauna

- **Confirmed presence** in the western portion of the Development Envelope: Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Pilbara Olive Python, Western Pebble-mound Mouse
- **Very likely to occur** in the western portion of the Development Envelope: Peregrine Falcon, Oriental Pratincole
- **Likely to occur** in the western portion of the Development Envelope: Grey Falcon, Long-tailed Dunnart, Lined Soil-crevice Skink, Common Sandpiper, Wood Sandpiper, Common Greenshank, Little Curlew, Eastern Osprey.

Potential SRE invertebrate fauna

- ?*Karaops* ‘indet’
- *Lychas* 'multipunctatus complex'
- *Lychas* ‘bituberculatus complex’
- *Lychas* ‘gracilimanus’
- *Urodacus* sp. indet.
- *Philosciidae* sp. indet
- Buddelundia ‘70’
- *Rhagada convicta*.

Aquatic fauna

- Potential occurrence of a macro-invertebrate species of *Branchinella.*

The key predicted outcomes for the Terrestrial Fauna values outlined above are:

- Disturbance of the Breakaways and Gullies habitat type as a result of the Proposed Change will be limited to 6% of the extent of this habitat type in the western portion of the Development Envelope
- Disturbance of the Major River/Creek habitat type as a result of the Proposed Change will be limited to 1% of the extent of this habitat type in the western portion of the Development Envelope

- No direct disturbance to confirmed diurnal/maternal Ghost Bat roosts. Loss of one recorded nocturnal Ghost Bat roost at Mesa B
- No significant impacts to local populations of conservation significant species, given the retention of key habitat features and minimal impact to key habitat types
- No adverse effect on the conservation status of species (including species of elevated conservation significance)
- No significant impacts to SRE species or habitat, given the retention of key habitat features and minimal impact to key habitat types
- No significant changes to understorey vegetation (fauna habitat) along the majority of the defined flow channel of Warramboo Creek from groundwater abstraction
- No significant impacts to Major River/Creek habitat in Warramboo Creek from discharge of surplus water (any potential impacts will be temporary and are expected to be limited to approximately 8 km from the point of discharge).

After the mitigation hierarchy has been applied (Table 7-11), including avoidance of direct impacts to key habitat and key habitat features, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Terrestrial Fauna; the proposed loss of habitat is not expected to cause a loss of biological diversity at the local or regional scale and the ecological integrity of the area surrounding the footprint is expected to be maintained. The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on terrestrial fauna and therefore offsets for Terrestrial Fauna values are not proposed.

8. HYDROLOGICAL PROCESSES AND INLAND WATERS ENVIRONMENTAL QUALITY

This section describes the hydrological characteristics of the western portion of the Development Envelope and provides an assessment of the potential impacts of the Proposed Change to hydrological values, proposed mitigation measures and the predicted outcome for these key environmental factors.

8.1 EPA Objective

The EPA objectives for Hydrological Processes and Inland Waters Environmental Quality are:

- To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected
- To maintain the quality of groundwater and surface water so that environmental values are protected.

8.2 Policy and Guidance

The following policy and guidance documents have been considered in the assessment of Hydrological Processes and Inland Waters Environmental Quality:

8.2.1 EPA policy and guidance

- Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015)
- Environmental Factor Guideline – Hydrological Processes (EPA 2016n)
- Environmental Factor Guideline – Inland Waters Environmental Quality (EPA 2016c)
- Inland Waters of the Pilbara Western Australia (Part 1) (EPA 1989a)
- Inland Waters of the Pilbara Western Australia (Part 2) (EPA 1989b)
- Statement of Environmental Principles, Factors and Objectives (EPA 2018a)
- Instructions on how to prepare an Environmental Review Document (EPA 2016i)
- Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (EPA 2016e).

8.2.2 Other policy and guidance

- Government of Western Australia (2011) WA Environmental Offsets Policy
- Government of Western Australia (2014) WA Environmental Offsets Guidelines.
- Australian Water Quality Guidelines for Fresh and Marine Waters. (ANZECC and ARMCANZ 2000)
- State Water Quality Management Strategy Document No.6. Implementation Framework for Western Australia for the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and Water Quality Monitoring and Reporting (Government of Western Australia 2001)
- Pilbara Water in Mining Guideline. Report No 34 (Government of Western Australia 2009)
- Western Australian Water in Mining Guideline. Report No 12 (Government of Western Australia 2013a)

- Statewide Policy No 5 - Environmental Water Provisions Policy for Western Australia (WRC 2000)
- Water Quality Protection Guidelines No. 1 to 11 and Water Quality Protection Note 22 (Government of Western Australia 2000; 2008)
- Strategic policy 2.09: Use of mine dewatering surplus (Government of Western Australia 2013b).

8.3 Environmental Scoping Document

Table 8-1 summarises where the requirements of the ESD are addressed in this section.

Table 8-1: Requirements of the ESD for Hydrological Processes and Inland Waters Environmental Quality

Task number	Requirement of ESD	Comment
49	Characterise the baseline hydrology and hydrogeological regimes and water quality, both in a local and regional context, including but not limited to, water levels, water chemistry, stream flows, flood patterns, and water quantity and quality.	Section 8.4
50	Provide a detailed description of the design and location of the Mesa A Hub Revised Proposal with the potential to impact surface water or groundwater. A Figure should be provided in the PER document with depicts the predicted location of the wetting front.	Sections 8.5 and 8.6 and Figure 8-7
51	Provide an update of the conceptual model of the surface and groundwater systems incorporating the results of monitoring conducted subsequent to the initial approval, including the extent of connectivity between surface and groundwater system.	Sections 8.4 and 8.6
52	Provide a conceptual mine water balance over the life of the Proposal to discuss the capacity to reuse surplus mine dewater.	Sections 8.6.1 and 2.3.9
53	Discuss the potential environmental impacts and benefits of identified surplus water management options (i.e. discharge of excess mine dewater, reuse on site, local water supply, aquifer recharge etc.) and discuss the most appropriate water management strategy for the Proposal.	Sections 8.6.1 and 2.3.9
54	Analyse, discuss and assess surface water and groundwater impacts. The analysis should include but not be limited to: • Changes in groundwater levels and changes to surface water flows associated with the Proposal. • The nature, extent, and duration of impacts. • Cumulative impacts with other projects and referred proposals, for which relevant information is publicly available. • Impacts on the environmental values of significant receptors but not limited to Warramboo Creek catchment.	Section 8.6
55	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to Hydrological Processes and Inland Waters Environmental Quality.	Section 8.8

Task number	Requirement of ESD	Comment
56	Prepare a Mine Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) which addresses the development of completion criteria to maintain of the hydrological regimes and the quality of groundwater and surface water so that environmental values are maintained post closure.	Section 8.7
57	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Sections 8.6 and 8.8

8.4 Receiving Environment

8.4.1 Hydrological and hydrogeological studies

The Proponent has conducted a number of hydrological and hydrogeological studies as part of the Environmental Impact Assessment process for the Proposed Change. Hydrological and hydrogeological studies have also been undertaken as part of the approvals process for the existing Mesa A/Warramboo Iron Ore Project, some of which overlap the western portion of the Development Envelope. Studies completed to date are summarised in Table 8-2 below and the most recent survey reports are attached in Appendix 9.

Table 8-2: Summary of supporting hydrological studies

Report	Summary	Survey date
Warramboo Project: Baseline Aquatic Ecosystem Survey Wet Season Sampling 2018 WRM (2018)	A baseline sampling program for aquatic ecosystems in Warramboo Creek upstream and downstream of the Warramboo BWT development. The aim of the sampling program was to document current ecological condition, including the presence of any aquatic fauna of conservation and/or regional significance, and provide a benchmark against which any future effects of the Warramboo Mine may be assessed. The wet season sampling in April 2018 constitutes the second sampling event as part of establishing a baseline dataset, with previous sampling undertaken in the wet season of 2016 (WRM 2016).	April 2018
Mesa B and C Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016 WRM (2017)	A baseline sampling program for aquatic ecosystems of the Robe River undertaken on the Robe River and Mungarathoona Creek in the vicinity of Mesas B and C as well as further upstream and downstream. The program documented current ecological condition of these aquatic ecosystems (encompassing surface water chemistry and aquatic faunal assemblages).	May 2016
Warramboo H3 Hydrogeological Level Assessment Rio Tinto (2017d)	Hydrogeological assessment summary report, to describe the conceptual hydrogeology of the Warramboo area, analytical model calibration, predictive scenarios and impact assessment. The Warramboo bore completion report and numerical modelling report are provided as appendices to this report.	August 2017
Mesa C H3 Hydrogeological Level Assessment Rio Tinto (2017c)	Hydrogeological assessment summary report, to describe the conceptual hydrogeology of the Mesa C area, numerical model calibration, predictive scenarios and impact assessment.	August 2017
Mesa A Hub 2017 AMD Risk Assessment Update Summary Rio Tinto (2017h)	A review of acid and metalliferous drainage (AMD) risk associated with the Proposed Change.	September 2017
Mesa A/Warramboo Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016 WRM (2016)	A baseline sampling program for aquatic ecosystems in Warramboo Creek upstream and downstream of the proposed Warramboo BWT development. The program documented current ecological condition, including the presence of any aquatic fauna of conservation and/or regional significance.	May 2016

Report	Summary	Survey date
Surplus Water Discharge Extent Assessment - Warramboo below water table Rio Tinto (2015a)	A study to estimate the extent of impact of surplus water discharge along Warramboo Creek. The study involved development of a two-dimensional model of the creek system downstream of the proposed discharge point, estimation of maximum possible extent of discharge under steady state conditions and investigation of multiple discharge rates.	February 2015
2014 Review of Existing Water Quality Data Warramboo/Mesa A Mine Rio Tinto (2015b)	A review of available groundwater and surface water chemistry data for Warramboo/Mesa A.	March 2015

8.4.2 Baseline surface hydrology and regional context

The Mesa A Hub lies within the Onslow Coast hydrology basin, and has mine operations in both the Robe River and Warramboo Creek catchments.

Rainfall in the Onslow Coast area reflects that of the Pilbara generally. Rainfall is highly variable, temporally and spatially, and predominantly occurs over a summer wet season dominated by tropical cyclones, low pressure systems and convective thunderstorms. The Robe Valley and Warramboo Creek catchments can also receive winter (June through August) rainfall from frontal systems that cross the south-west land division and extend to the southern Pilbara, and from rain-bearing northwest cloud bands. As for most parts of the Pilbara, the normal condition for rivers and creeks is dry. Surface water flow typically only occurs following significant or long duration rainfall events.

Mesa B and Mesa C lie adjacent to the main Robe River channel 5-10 km upstream of the North-West Coastal Highway with a contributing catchment area of approximately 7,500 km^2 (Figure 8-1). At the Mesa A Hub operations area the Robe River flows to the north-west as a deep well-defined ephemeral channel with a wide, shallow flood plain. During the dry season water is typically restricted to a series of semi-permanent and permanent pools that are maintained by sub-surface flow within the coarse channel gravels and riparian groundwater. In most cases significant flows occur for only a short duration (few days to week) with a recession flow typically lasting for a few months.

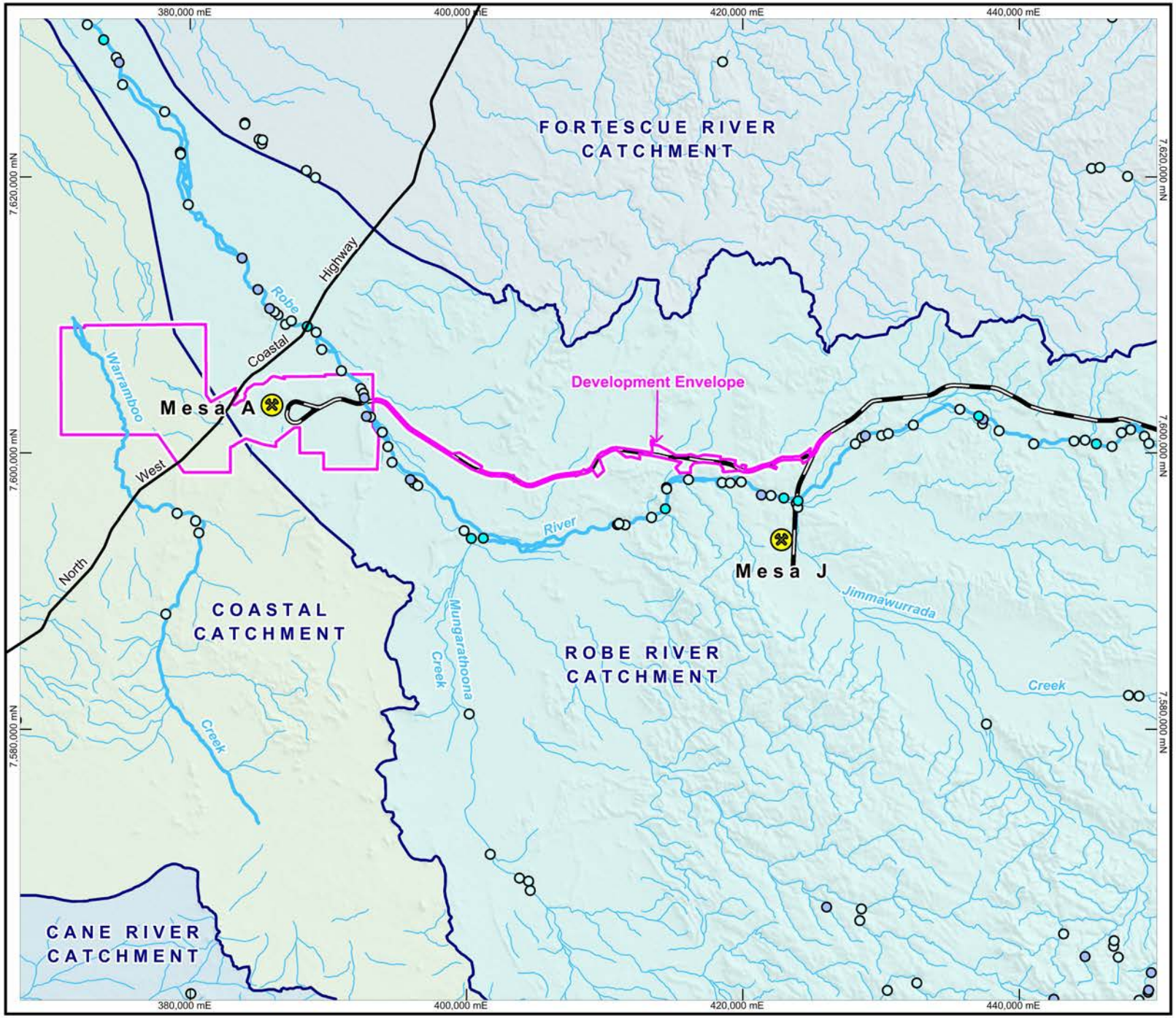
The Warramboo deposit and most of the Highway/Tod Bore deposit lies adjacent to Warramboo Creek in the flat coastal plain scrubland areas west of the North West Coastal Highway (Figure 8-1). Within the operations area (Warramboo Mine and borefield) the Warramboo Creek exists as an incised ephemeral sandy bed creek that flows to the north-west before spreading into multiple shallow poorly defined flow pathways downstream of the mine operations area. It has a contributing area of approximately 670 km^2. Moderate to large flows quickly exceed the channel capacity and spread broadly over the flat landscape to both the north-west and to the west. Warramboo Creek lacks the alluvial gravel profile of the larger Robe River and is disconnected from underlying groundwater systems. As a result, it has no permanent pools; sampling conducted at Warramboo Creek is limited to a few locations where waters remain for a short period following flows.

The Mesa B and Mesa C deposits occur on elevated landforms that are outside critical flood levels and independent of Robe River flooding for most flow events. Access corridors between the deposits cross a poorly drained flat basin area that can cause serviceability issues during significant rainfall events. Existing rail access may be affected during instances of severe flooding of the Robe River. The Warramboo Mine operations sit on slightly elevated slopes at the fringes of the modelled flood extent. Due to the broad flat nature of the coastal plain, modelled flood scenarios indicate shallow low velocity flows and backwater areas at the north-eastern fringes near operations.

Stream flow monitoring of the Robe River has been conducted by the State Government since 1972 at the Yarraloola Stream Gauging station located 6 km downstream of Mesas B and C at the North West Coast Highway. The Robe River at Yarraloola has had annual flows greater than 1 GL/yr in 29 out of 45 years of record. Flow events predominantly occur between February and April but have historically occurred as early as December and as late as September. The median annual flow through the Robe River Catchment at Yarraloola is 18 GL/yr; with 13 years of no-flow and 3 years with <1 GL/yr) reflecting the

typical low net flow situation for drier periods. The median flow is significantly exceeded by wetter flow years having totals of 100-930 GL/yr.

There is no stream flow monitoring station or historical flow data for the Warramboo Creek. The Warramboo Creek (~670 km^2) has a more ephemeral flow regime than either the Robe River (7,500 km^2) or Cane River (~2,300 km^2) to the south. Rio Tinto has undertaken water depth logging within the creek since late 2017 and the data collected to date has shown the creek to be predominantly dry (non-flowing) apart from short duration flows occurring in response to moderate-heavy rainfall in local and upper catchment areas.



LEGEND

- Development Envelope
- Catchment
- Permanent pool
- Semi-Permanent pool
- Ephemeral pool
- Major Watercourse
- Minor Watercourse
- Highway

N

SCALE

5 0 5 10 15km

1:400 000 @ A4

Source: Department of Water, Pilbara Pools

Disclaimer

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Rio Tinto

Iron Ore (WA)

Figure 8-1: Surface hydrology

Drawn: T.M.
Date: November, 2018

Plan No: PDE0149318v5
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

8.4.3 Hydrogeology

8.4.3.1 Warramboo area

The Warramboo area lies on the broad, low-lying coastal plains to the west of the Pilbara Craton. The stratigraphic sequence underlying the Warramboo area from youngest to oldest comprises:

- Quaternary Alluvium: A surficial deposit comprising silts and gravels covering the flat to undulating plains in the Warramboo area
- Tertiary Robe Pisolite: A channel fill deposit within a paleo-channel that has incised into the Cretaceous rocks of the Robe Valley; iron ore mineralisation occurs within this unit
- The Yarraloola Conglomerate: Pebbles of chert, banded iron formation and quartz in oxidised (limonitic) sandy clays
- The Ashburton Formation: Mudstone, siltstone and immature sandstone interbedded with minor amounts of conglomerate, dolomite, mafic volcanic rock and banded iron formation.

The Warramboo deposit is associated with the Robe Pisolite and is approximately 89% above the water table. The Robe Pisolite varies between 8 m and 20 m thick and is underlain locally by up to 70 m of saturated Yarraloola Conglomerate. The pre-mining depth to groundwater along Warramboo Creek, throughout the numerical model domain, is historically 7-26 m below ground level (with the depth as shallow as 7 m in the coastal plain area in the northern extent of the drawdown zone and the depth up to 26 m in the south of the drawdown extent).

Figure 8-2 includes two cross-sections through the Warramboo area indicating hydrostratigraphic units, the mine pit outline and key components of the water balance. Section C-C" shows a northern cross section of the Warramboo pit (from north-west to south-east) where there is no BWT mining proposed. Section E-E" (south-west to north-east) shows the Warramboo pit and the lack of hydraulic connection between the CID and the Robe River Alluvials (Figure 8-2).

The two main hydrostratigraphic units in the Warramboo area comprise the CID Aquifer and the Yarraloola Conglomerate aquifer. The CID overlies the Yarraloola Conglomerate which overlies the basement Ashburton Formation. The details of the hydrostratigraphic units are presented in Table 8-3.

Table 8-3: Hydrostratigraphic units of the Warramboo Area

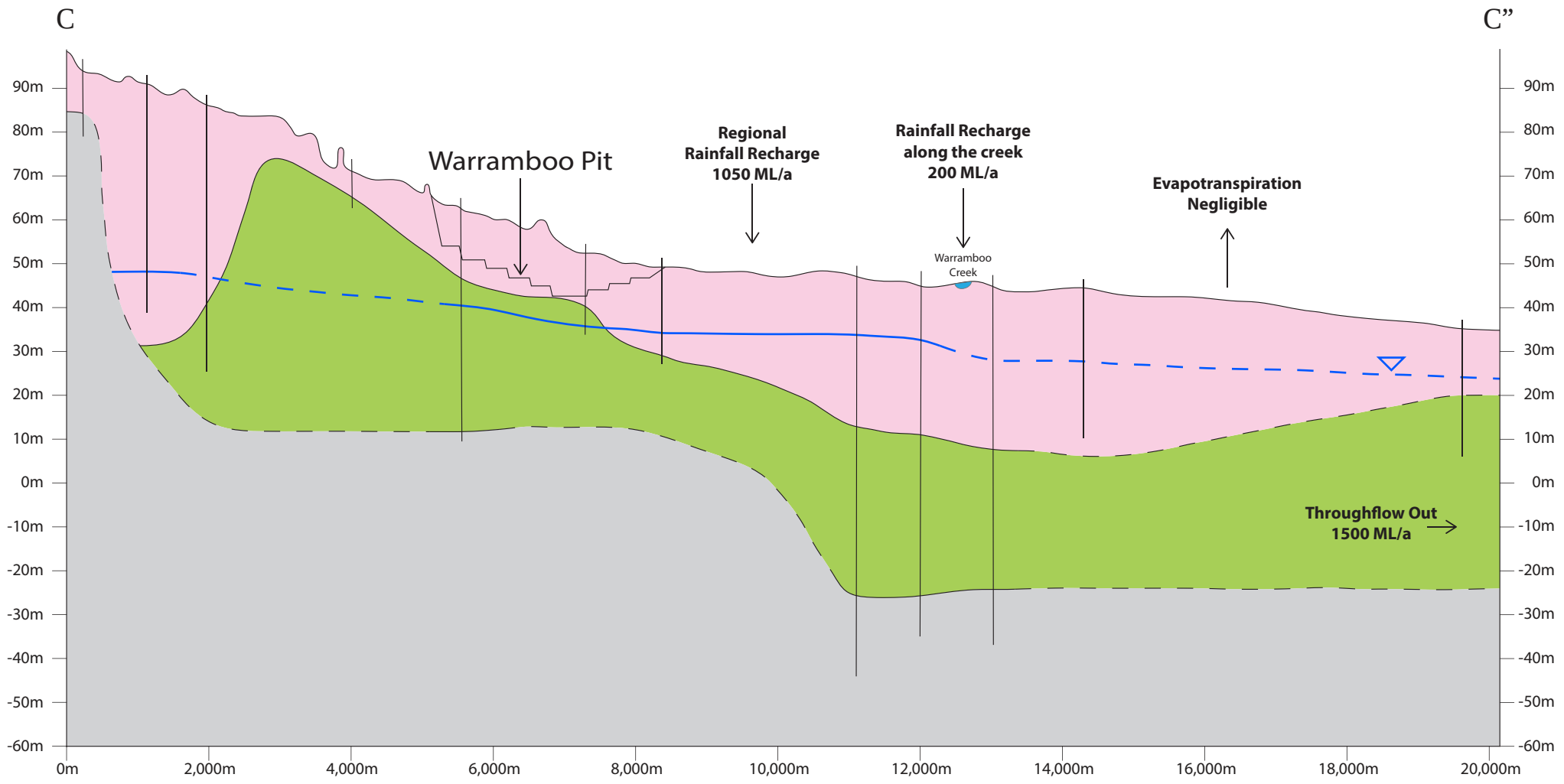
Unit	Aquifer type	Formation name	General lithology	Hydraulic characteristics
Channel Iron Deposit	unconfined, sedimentary, vertical anisotropy, local	Robe Pisolite	clay-rich basal layer, pisolite ore, and hard-capped pisolite	heterogeneous, high and low permeability, horizontally limited
Conglomerate	semi-confined, sedimentary, regional	Yarraloola Conglomerate	pebbles of chert, BIF and quartz in oxidised, sandy clays	heterogeneous, high and medium permeability, clay capped, high storage
Basement	confined, fractured, anisotropic, regional	Ashburton Formation	mudstone, siltstone, and immature sandstone interbedded with minor amounts of conglomerate, dolomite, mafic volcanic rock, and BIF	highly heterogeneous, permeability domains associated with faults and fracturing, permeability decreases with depth

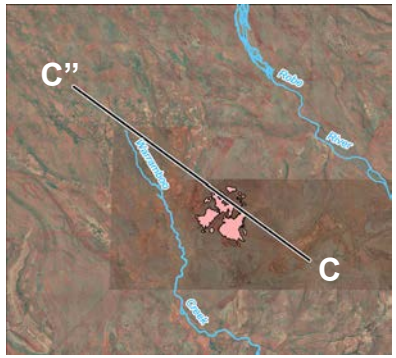
The Yarraloola Conglomerate extends from the Pilbara Craton east of Warramboo towards the coast, approximately 30 km to the north-west. The inferred area of the Yarraloola Conglomerate and other units deposited laterally is approximately 16,000 km^2. In the wider Warramboo area, the saturated aquifer thickness varies between 5 m and 60 m.

The groundwater flow pattern is controlled by topography, hydraulic conductivity, recharge and discharge locations. The regional groundwater flow is to the north / north-west towards the coast, with a hydraulic gradient of 0.0014. The water table is 15-20 m below ground level in the vicinity of the mining area. Recharge in the region is predominantly via direct infiltration from rainfall and indirectly through stream leakage. The pre-mining water balance that was developed for the Warramboo area estimated the regional rainfall recharge to be 1,050 ML/a and rainfall recharge along Warramboo Creek to be 200 ML/a. Natural groundwater discharge occurs in the area mostly by throughflow to the north / north-west towards the coast and parallel to the Robe River located north-east of Warramboo.

Aquifer storage for the Warramboo area was estimated using the aquifer thickness and the specific yield of the aquifer. For the Warramboo area an aquifer thickness of 40-60 m, specific yield of 0.05 and a modelled geometry of the aquifer of 350 km^2 was used, resulting in an estimated groundwater storage volume of approximately 700 GL (Rio Tinto 2017d). However, the specific yield is likely to be conservative with the numerical model transient calibration suggesting values between 0.08 and 0.12.

Hydraulic connectivity is present between the Yarraloola Aquifer and CID Aquifer as observed during test pumping of production bores in the area (Rio Tinto 2017d).





CID Aquifer

Ashburton Aquiclude

Yarraloola Aquifer

(Pre-Mining) Water Level

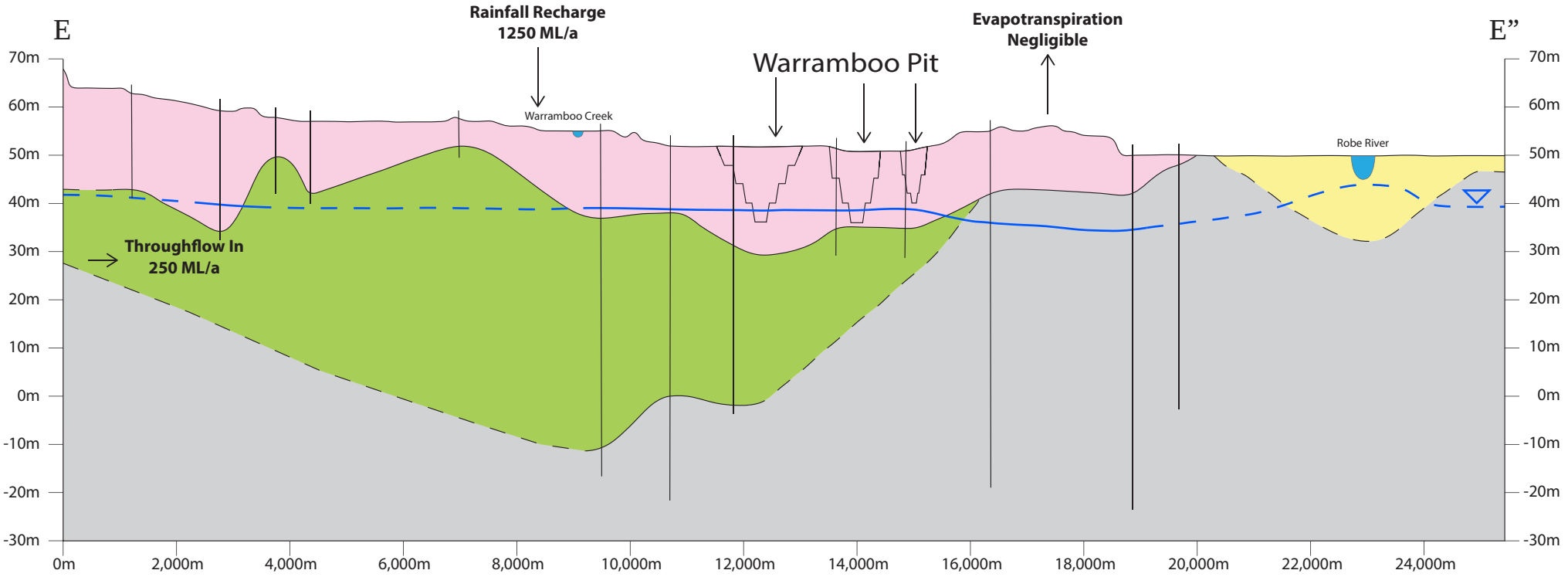
Drill Hole

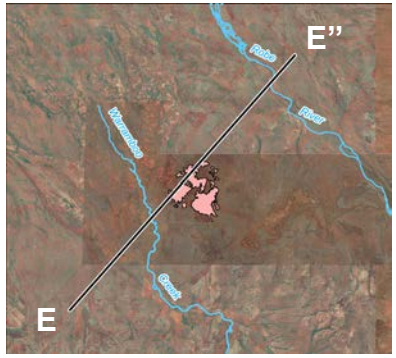
Iron Ore (WA)

Figure 8-2:
Schematic cross-section C-C’ of Warramboo hydrostratigraphic units and mine pit outlines cross-section 1 of 2

Drawn: T.M.
Date: May, 2018

Plan No: PDE0154389v3





Robe River Alluvium Aquifer

CID Aquifer

Yarraloola Aquifer

Ashburton Aquiclude

(Pre-Mining) Water Level

Drill Hole

Iron Ore (WA)

Figure 8-2:
Schematic cross-section E-E’ of Warramboo hydrostratigraphic units and mine pit outlines cross-section 2 of 2

Drawn: T.M.
Date: May, 2018

Plan No: PDE0154389v3

8.4.3.2 Mesa C

Mesa C is one of a chain of mesa CIDs formed by pisolite infill of the Robe River palaeochannel. The pisolite is overlain by Quaternary Alluvium and Colluvium and unconformably underlain by the Ashburton Formation (basement). Table 8-4 summarises the stratigraphic units in the Mesa C area.

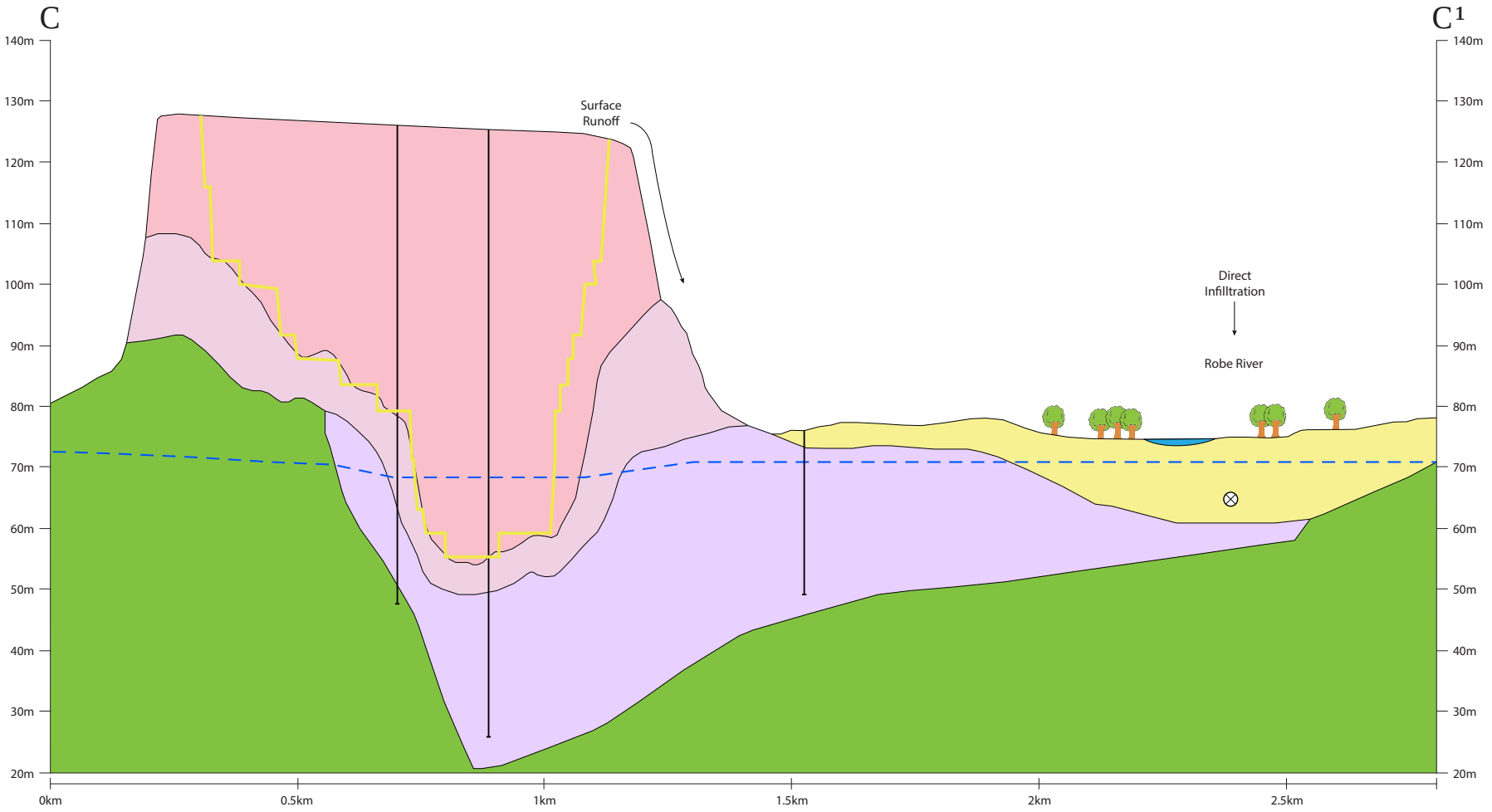
Table 8-4: Stratigraphy of the Mesa C area

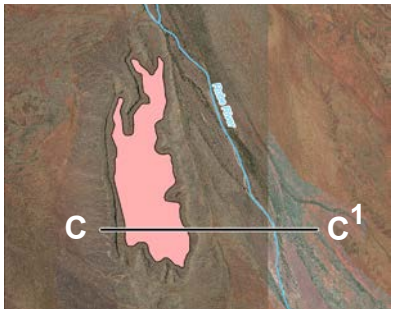
Age	Stratigraphy	Description
Quaternary	Alluvium/Alluvials	Colluvium, alluvial and alluvium sediments of clay, gravels, sands and calcrete
Tertiary	Robe Pisolite	Pisolitic iron stone, silcrete and clay
Proterozoic	Wyloo Group – Ashburton Formation	Mudstone, Sandstone, tuff volcanoclastic and Shale

The hydrogeological setting in the Mesa C area consists of four main hydrostratigraphic units as shown in Figure 8-3. The four units are the Robe Pisolite, hereafter called the 'CID Aquifer', the Robe River Alluvials hereafter called the 'Robe River Aquifer', the Ashburton Aquitard and the Ashburton Aquiclude. A description of the characteristics of each of these units is presented in Table 8-5.

Table 8-5: Hydrostratigraphic units in the Mesa C area

Unit	Aquifer Type	Formation Name	General Lithology	Hydraulic Characteristics
Robe River Aquifer	Unconfined, Alluvial	Robe River Alluvial	Colluvium, alluvial clayey sediments, sands, gravels and calcrete	Highly conductive, 15-20 m saturated thickness
CID Aquifer	Semi-confined, Sedimentary, Regional	Robe Pisolite	Pisolitic stone, silcrete, clay	Heterogeneous, high and medium permeability
Ashburton Aquitard/Ashburton Aquiclude	Confined, Fractured, Anisotropic, Regional	Ashburton Formation	Mudstone, siltstone, and immature sandstone interbedded with minor amounts of conglomerate, dolomite, mafic volcanic rock, and BIF	Highly heterogeneous, permeability domains associated with faults and fracturing, permeability decreases with depth





Robe River Alluvials
Ashburton Formation - aquiclude
Undifferentiated Pisolite (CID aquifer)
Tertiary Pisolite Basal (CID aquifer)
Ashburton Formation - aquitard

Pit Outline
Drill Hole
Current Water Level
Throughflow Direction Alluvial Aquifer

RioTinto

Iron Ore (WA)

Figure 8-3:
Schematic cross-section of Mesa C hydrostratigraphic units and mine pit outline

Drawn: T.M.
Date: May, 2018

Plan No: PDE0154389V3

Groundwater flow in this area is from the south-east to the north-west, parallel to the Robe River. The groundwater level in this area is at an average depth of 64-70 mRL.

The Robe River Aquifer has high storage and high throughflow volumes. It is periodically recharged by direct rainfall and surface water flows in the immediate vicinity and within the upper catchment (Figure 8-3).

The Ashburton Aquiclude is not permeable due to shale and mudstone content and creates a groundwater divide through the basement at Mesa C and features consistently along the west strike of the Mesa C area.

The CID Aquifer has low storage and is spatially limited to the east strike of Mesa C. The clayey nature of the basal pisolite unit of the CID likely acts as a partial barrier to vertical flow. The depth to water at the top of the mesa is greater than 50m, subsequently recharge of the CID Aquifer from direct rainfall is considered negligible.

The CID Aquifer is bounded to the west and south by the Ashburton Aquiclude. Hydrogeological assessment has shown that the CID Aquifer is bounded to the east and bottom by the low permeability Ashburton Aquitard. Groundwater flow between the CID Aquifer and the Robe River Aquifer via the Ashburton Aquitard is expected to be very low given that hydrogeological investigations to date indicate that the CID Aquifer is effectively isolated from the Robe River Aquifer. Some groundwater flow may occur at the northern tip of the deposit where the CID Aquifer intersects the Robe River Aquifer; however, given the clayey nature of the basal tertiary pisolite, throughflow is expected to be minimal (Rio Tinto 2017c).

An indirect connection between the Robe River Aquifer and the CID Aquifer may exist during periods of high rainfall, where leakage to the CID Aquifer is induced as a result of streamflow along the Robe River. This induced infiltration could result in throughflow occurring between the Robe River Aquifer and the CID Aquifer via the Ashburton Aquitard resulting in water being trapped within the CID Aquifer after stream flows have subsided. This indirect connection is at the surface and cannot result in the extension of groundwater drawdown in the CID Aquifer into the Robe River Aquifer.

The estimated groundwater storage volume of the CID Aquifer is approximately 6 GL based on an aquifer area of 2 km^2, aquifer thickness of 20 m and a specific yield of 0.15.

8.4.4 Surface and groundwater chemistry

8.4.4.1 Surface water

Robe River

Water chemistry monitoring has been conducted quarterly between 1992 and 2004 by Rio Tinto at five permanent pools in the Robe River 23-38 km upstream of the Development Envelope and is ongoing (Figure 8-4). The data indicate middle to upper Robe Valley surface waters are fresh (453 - 1,400 µS/cm), with pH values typically in the range 7.0 to 9.0, and relatively low turbidity (<10 Nephelometric Turbidity Unit [NTU]) under baseflow conditions. Background levels of total nitrogen (N-total) and nitrate (N-NO_3) often exceed default ANZECC/ARMCANZ (2000) guidelines (0.15mg/L N-total; 0.03mg/L N-NO_X), with levels of up to 3.45mg/L N-total and 3.1mg/L N-NO_3 recorded at the furthest site upstream of the Development Envelope (WRM 2017).

Surface water samples were collected in May 2016 (following recent rain and flash flooding) at several sites along the Robe River within and outside the Development Envelope as well as in Mungarathoona Creek south-east of the Development Envelope (WRM 2017) (Figure 7-2). Surface waters were recorded as fresh to brackish (1,110-2,150 µS/cm EC), and neutral to mildly alkaline pH (7.16 - 8.45). Salinity (as EC) and concentration of associated ions was relatively high at some sites in Mungarathoona Creek, likely due to evapoconcentration effects following a period of low rainfall. Background concentrations of dissolved metals were generally below ANZECC/ARMCANZ (2000) default 95% protection levels for freshwater species. The exception was dissolved boron, which was elevated at five of the seven sites sampled. Surface waters at most sites were also enriched in nitrate and ammonia, most likely due to current and historic unrestricted cattle access to the creekline (WRM 2017).

Warramboo Creek

Surface water samples were collected from remnant surface water in Warramboo Creek between April 2015 and May 2016, upstream of the proposed discharge location, following rain and flash flooding (Figure 8-4). Surface water chemistry was recorded as fresh (88 - 309 µS/cm EC), with neutral to mildly alkaline pH values (7.6 - 8.2). Salinity (as EC) and concentration of associated ions was relatively low in surface waters, reflecting the influence of rainwater. Background levels of nitrogen (N-total, $N\text{-}NO_3$, $N\text{-}NH_4$), total phosphorus and dissolved chromium, aluminium, copper and zinc, exceed the default 95% protection levels. The elevated aluminium in the surface water samples is likely to be present in colloidal form rather than as dissolved aluminium. The sources of the other elevated concentrations are unknown, but potentially include natural mineralisation from the catchment substrate, contaminants in run-off from North West Coast Highway and/or contaminants in surface water flows or seepage from pastoral and mining lands.

8.4.4.2 Groundwater

Mesa C

Baseline hydro-geochemical information for Mesa C was obtained in 2016 and indicated field parameters were elevated compared with surrounding areas including pH between 6.98 and 7.95 and EC between 2,570 and 5,560 µS/cm (brackish to saline) (Figure 8-5). Major cation and anion concentrations particularly sodium, chloride and sulphate from the CID Aquifer and Ashburton Formation (except valley locations) were also elevated in comparison to surrounding areas (Rio Tinto 2017c). Median groundwater quality results for each individual bore are provided in Table A9-1 and Table A9-2 in Appendix 9.

Geochemical assessment of the CID Aquifer showed high sodium and chloride as well as enriched oxygen isotopes. Elevated chloride levels are indicative of low recharge rates and in conjunction with elevated sodium levels suggest the CID Aquifer is an endpoint for groundwater throughflow (Rio Tinto 2017c). The geochemical signatures suggest that groundwater within the CID Aquifer is aged, supporting the conceptualisation that there is limited hydraulic connectivity between the Robe River Aquifer and the CID Aquifer. The Ashburton Formation has more variation in its geochemical character than the CID Aquifer but also indicates enrichment in chloride and other anions and cations when compared to other areas. The greater variation in geochemistry in the Ashburton Formation can be ascribed to variability in the mineralogy of the formation.

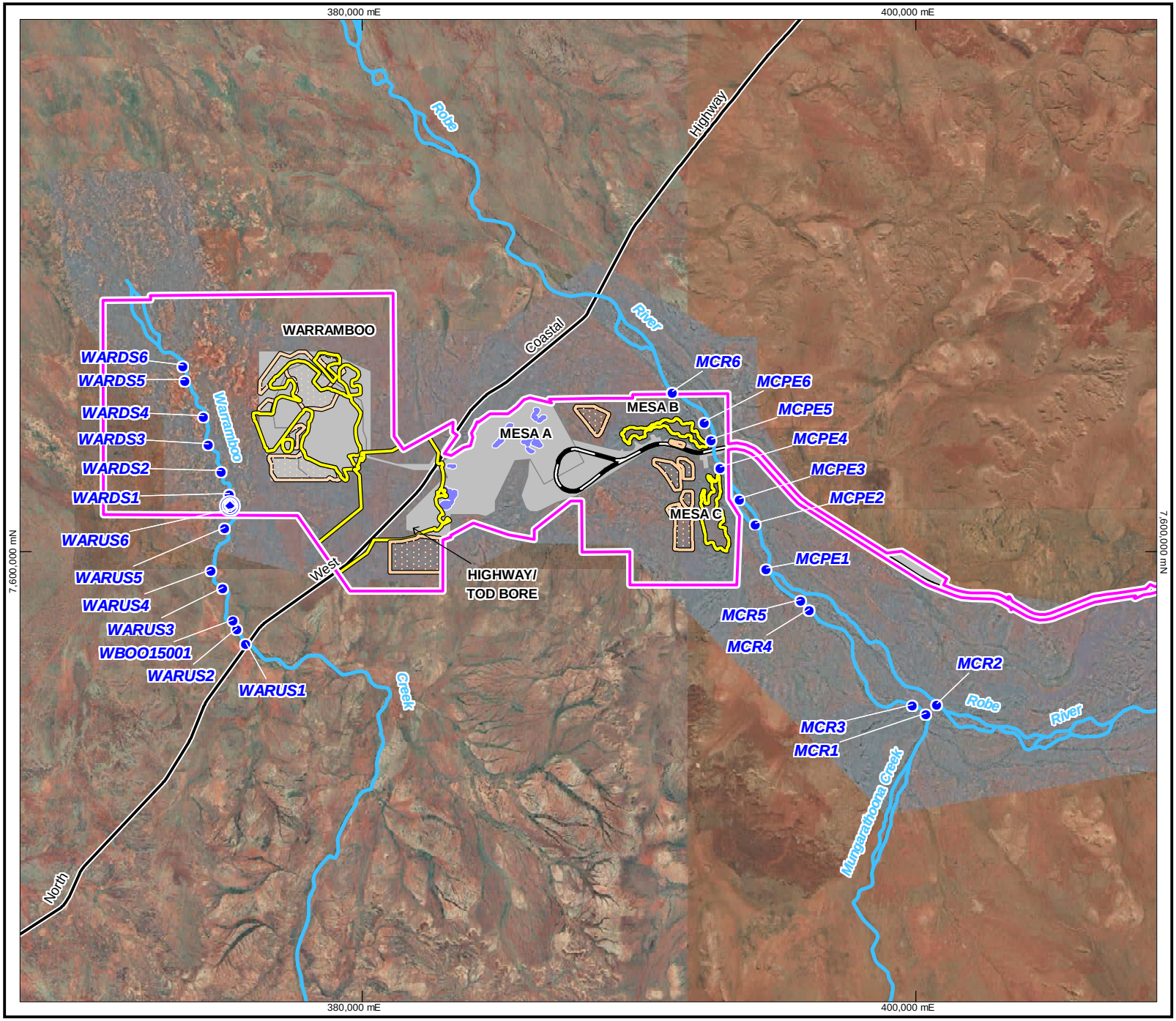
Groundwater test pumping and monitoring demonstrate varying drawdown responses in the CID and Ashburton aquifers. The results indicated that these two aquifers may be connected in some areas and isolated in others (Rio Tinto 2017c). This conclusion is further supported by the hydro-geochemistry results which show very similar groundwater signatures between aquifers in some nested bores and different signatures in other locations.

Warramboo

Baseline hydro-geochemical information for the general Warramboo area was obtained in 2016 (Rio Tinto 2017d) (Figure 8-5). Baseline groundwater chemistry at Warramboo is considered fresh to brackish depending on the relative location, with TDS values ranging from 8 mg/L to 7,000 mg/L Rio Tinto (2017d). Chloride levels range from 48 mg/L to 3,170 mg/L. Both chloride and TDS concentrations appeared to vary spatially with concentrations increasing from south to north. It appears that the TDS concentration in the groundwater is controlled by the associated chloride level.

Nitrate concentrations range from 0.05 mg/L to 130 mg/L. Nitrate levels appeared to be elevated in the shallow bores (36-55 mbgl) with concentrations significantly declining in the deeper bores (74-93 mbgl). Sulphate concentrations were low in all samples, ranging from 8 mg/L to 930 mg/L with the highest concentrations of sulphate typically being found in areas of higher conductivity contrast. Aluminium levels ranged from below the laboratory limit of reporting of 0.005 mg/L at several locations to 0.21 mg/L.

Groundwater chemistry data for samples collected from bores most likely to represent the proposed surplus water discharge are described in Section 8.6.3.4.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse
- Surface Water Sampling Locations

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Proposed new mining/cut widening
- Surplus water discharge point

N

SCALE

4 0 4km

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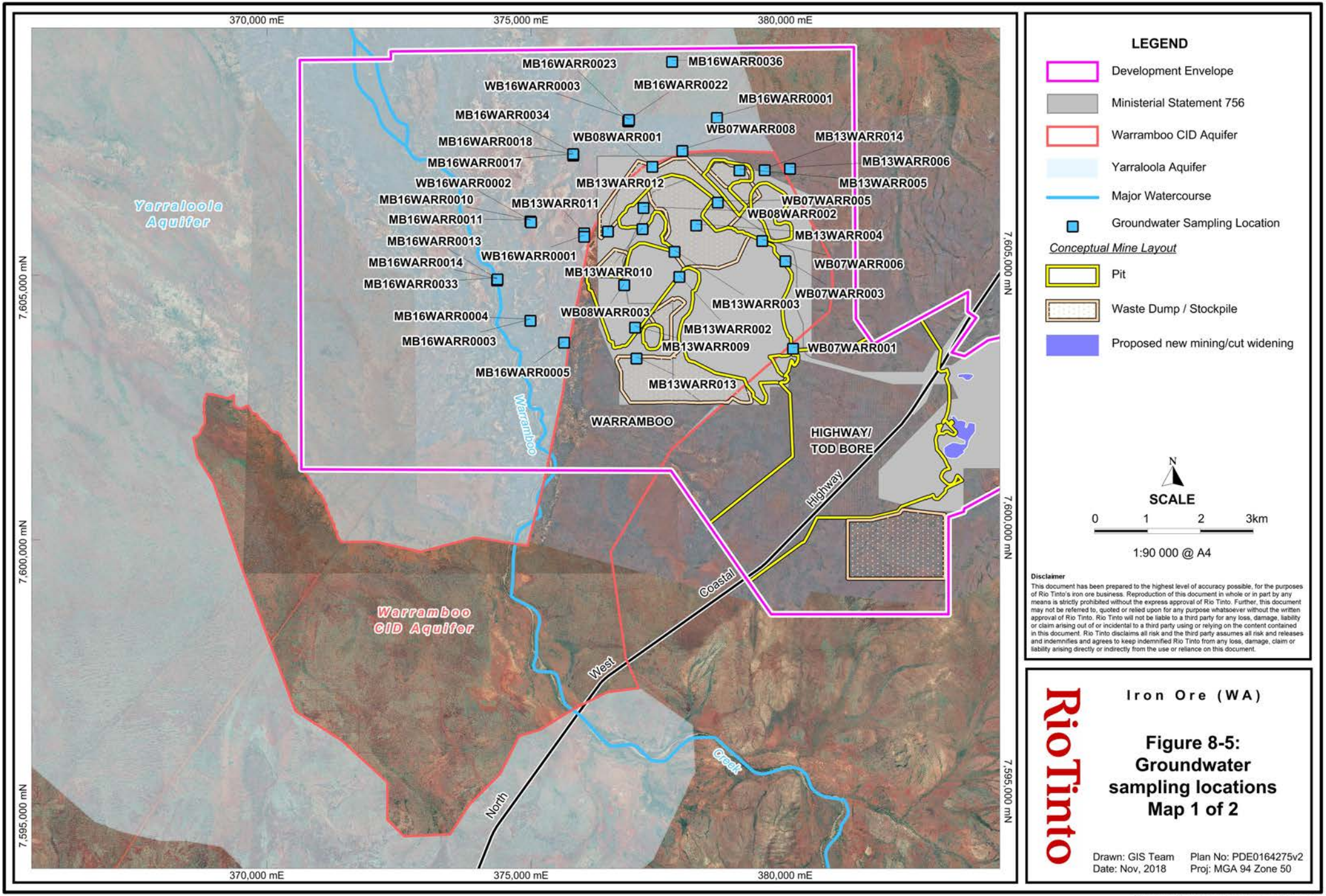
Iron Ore (WA)

Figure 8-4: Surface water sampling locations

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164273v1
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Warramboo CID Aquifer
- Yarraloola Aquifer
- Major Watercourse
- Groundwater Sampling Location

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Proposed new mining/cut widening

N

SCALE

0 1 2 3km

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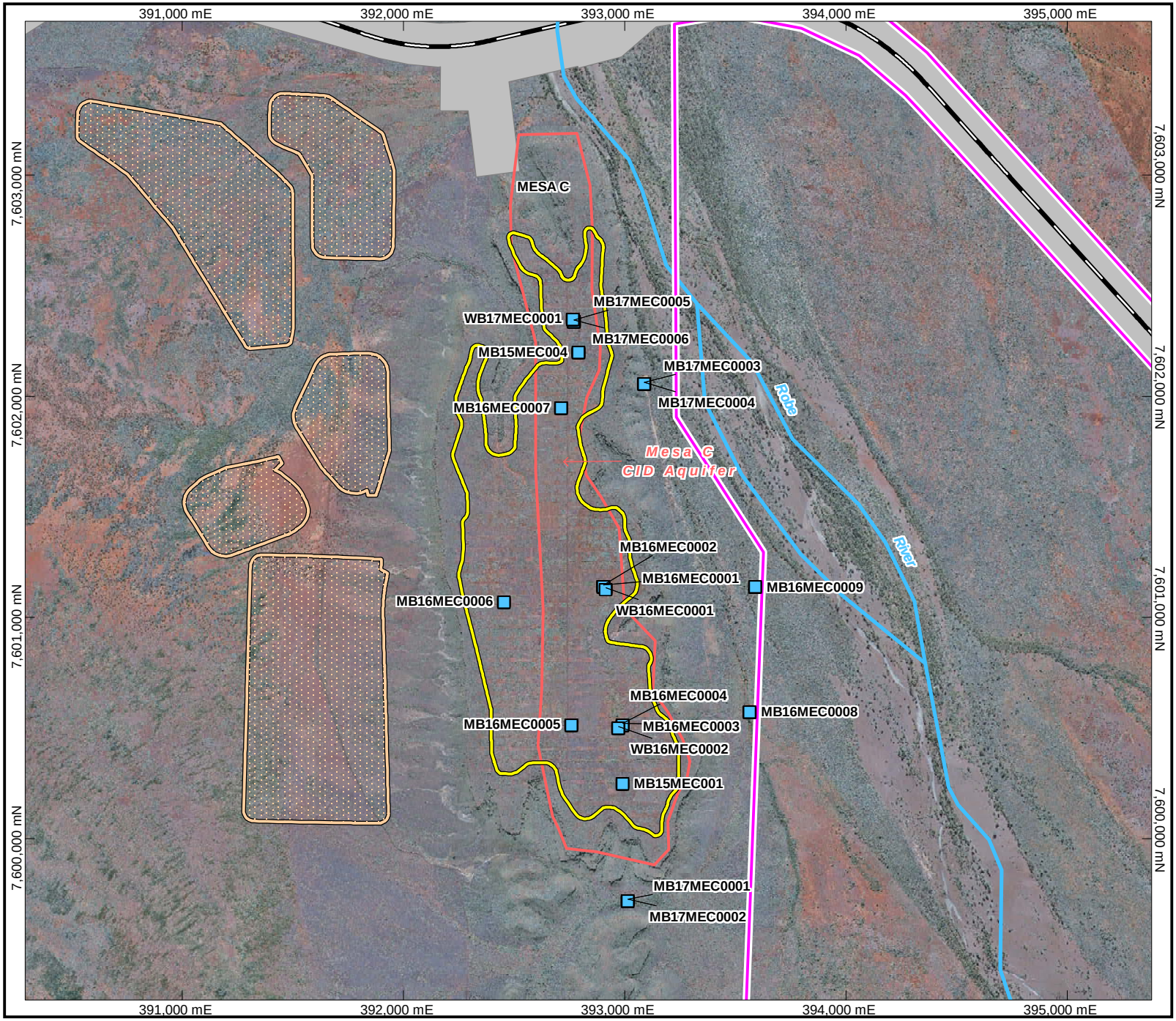
Iron Ore (WA)

Figure 8-5: Groundwater sampling locations Map 1 of 2

Drawn: GIS Team
Date: Nov, 2018

Plan No: PDE0164275v2
Proj: MGA 94 Zone 50

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Mesa C CID Aquifer
- Rio Tinto Railway
- Major Watercourse
- Groundwater Sampling Location

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile

N

SCALE

0 0.25 0.5 0.75 1km

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Iron Ore (WA)

Figure 8-5: Groundwater sampling locations Map 2 of 2

Drawn: GIS Team
Date: Nov, 2018

Plan No: PDE0164275v1
Proj: MGA 94 Zone 50

Geospatial Information and Mapping

8.5 Potential Impacts

A number of potential impacts are identified in the ESD. The key potential direct, indirect and cumulative impacts identified for the Proposed Change on the basis of hydrological surveys and assessments are described in Section 8.5.1 to 8.5.3.

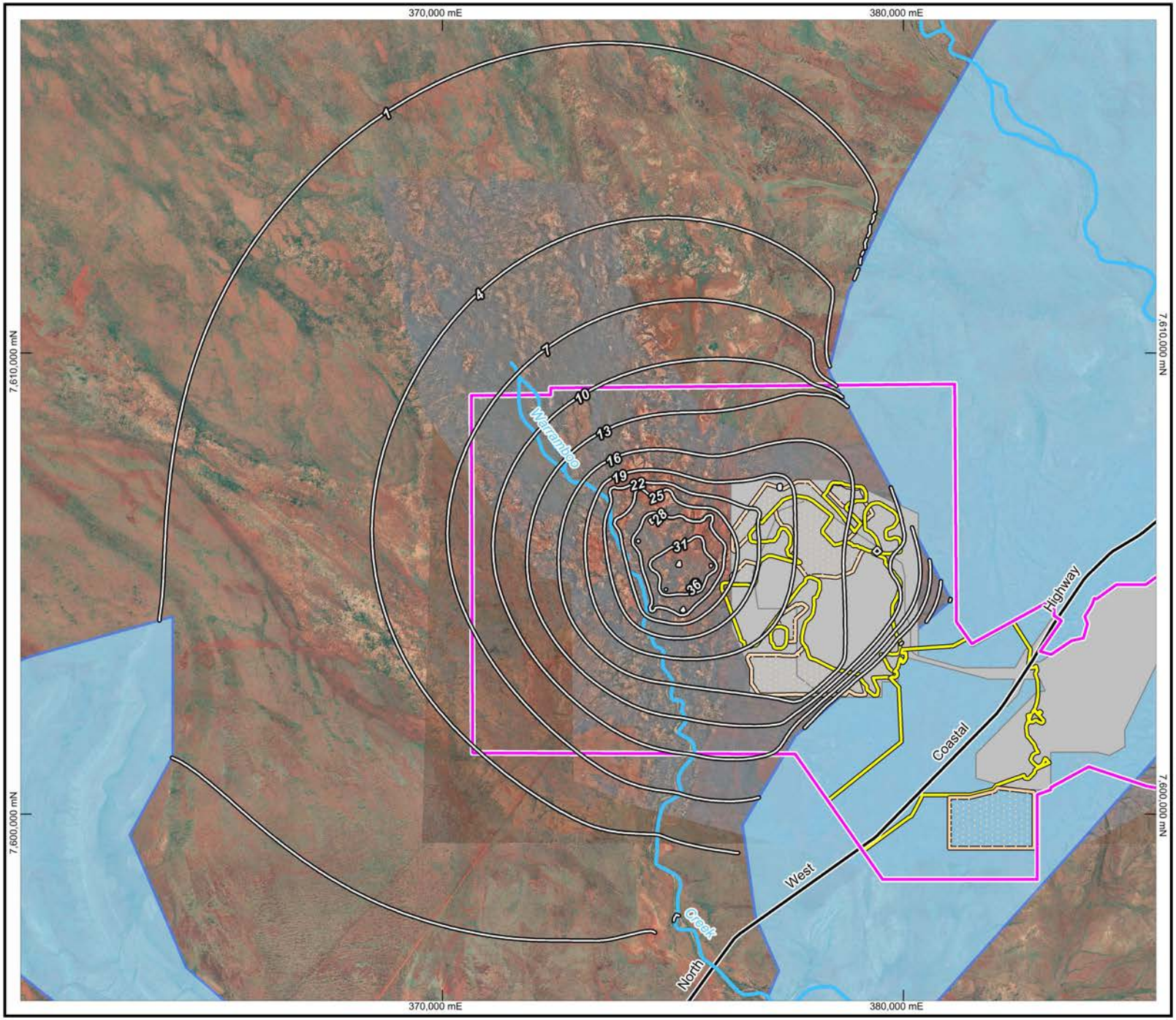
8.5.1 Direct impacts

The potential direct impacts of the Proposed Change on Hydrological Processes and Inland Waters Environmental Quality have been identified as:

- Changes to groundwater levels as a result of groundwater abstraction
- Changes to the hydrological regime of Warramboo Creek as a result of surplus water management.

Figure 8-6 shows the maximum modelled drawdown and extent of drawdown of the Yarraloola Aquifer due to abstraction of water for mine dewatering and water supply. Assessment of potential impacts to groundwater levels as a result of groundwater abstraction is discussed in Section 8.6.2.

Figure 8-7 shows the modelled extent of the proposed discharge flows into Warramboo Creek under natural no-flow conditions. Continuous flow resulting from surplus water discharge is predicted to extend up to 8 km downstream of the discharge point during times of peak discharge (the worst case scenario). Assessment of potential impacts to surface water as a result of surplus water management are discussed in Section 8.6.3.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Ashburton Formation intersects water table (modelled no-flow boundary)
- Drawdown Contour (m)
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile

N

SCALE

2 0 2 4km

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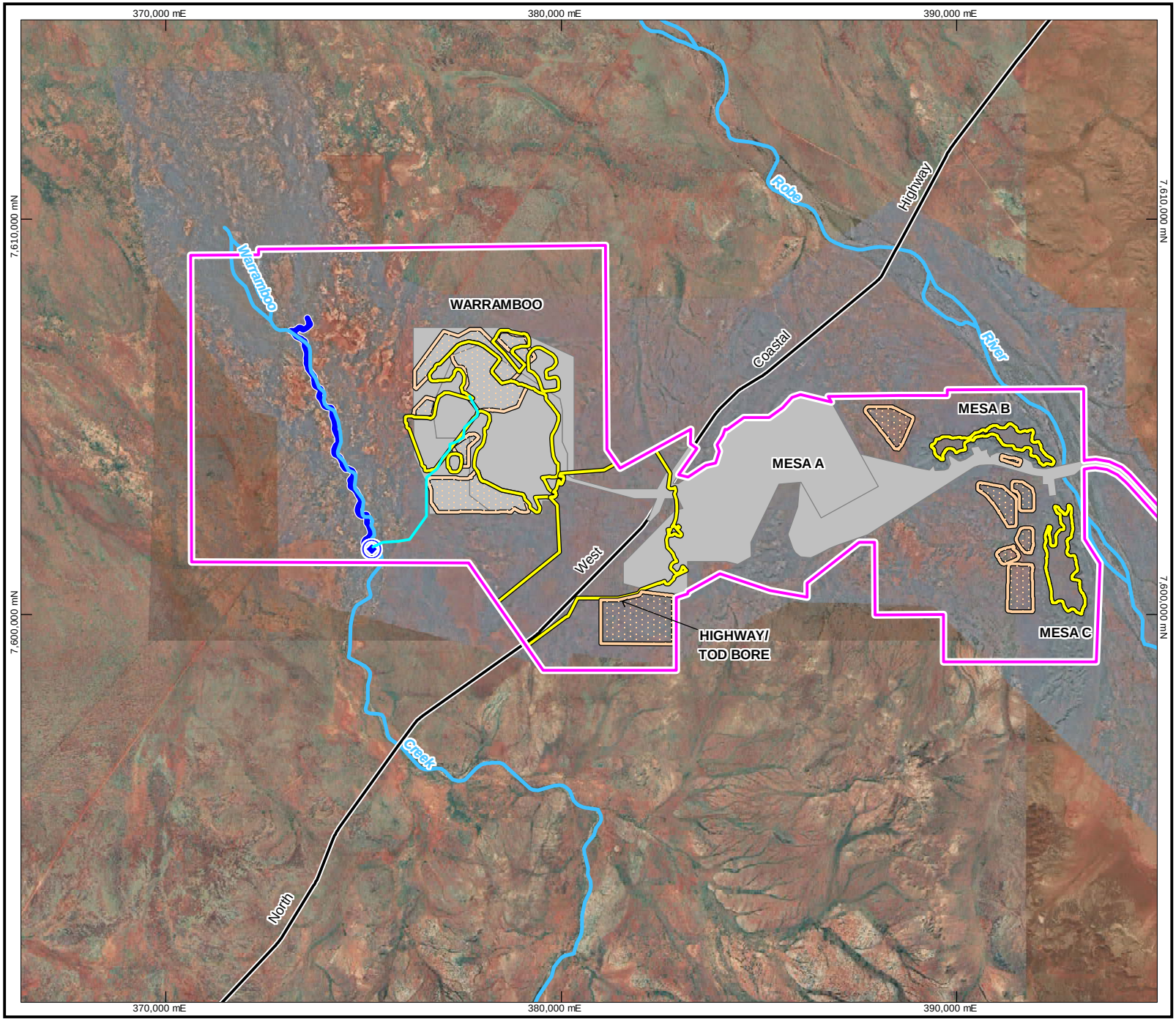
Iron Ore (WA)

Figure 8-6: Maximum modelled drawdown at Warramboo

Drawn: T.M.
Date: June, 2018

Plan No: PDE0153963v7
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Modelled extent of discharge
- Proposed Discharge Point
- Surplus water pipeline

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SCALE

2 0 2 4km

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Rio Tinto

Iron Ore (WA)

Figure 8-7: Modelled extent of discharge into Warramboo Creek

Drawn: T.M.
Date: Aug, 2018

Plan No: PDE0153964v7
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

8.5.2 Indirect impacts

The Proposed Change may indirectly impact surface and groundwater chemistry in Warramboo Creek and the Yarraloola Aquifer as a result of in-pit storage of waste fines, disposal of effluent from the reverse osmosis plant, surface water flows through operational areas and surplus water management.

8.5.3 Cumulative impacts

Existing and foreseeable groundwater users in the vicinity of the Development Envelope are:

- The approved activities
  - Groundwater has been abstracted from the existing Warramboo borefield, since 2010. The current abstraction rate is approximately 1.3 GL/a, with a current groundwater license allowing up to 3 GL/a to be abstracted.
- Yarraloola pastoral station
  - Six pastoral station bores occur in the area potentially affected by the cone of depression associated with the proposed mine dewatering and water supply
- Main Roads WA
  - One bore occurs in the area potentially affected by the cone of depression associated with the proposed mine dewatering and water supply
- The Revised Proposal
  - Future abstraction of groundwater for mine dewatering and water supply from the Yarraloola Aquifer for the Revised Proposal is estimated to be up to 15 GL/a (including the currently licensed 3 GL/a). Future abstraction of groundwater from the Mesa C CID Aquifer is estimated to be up to 5 GL/a.

8.6 Assessment of Impacts

8.6.1 Summary of proposed water management

8.6.1.1 Surplus water management

To maintain ore quality and continuity of supply, dewatering of the Warramboo deposit is required to start at least two years ahead of commissioning the wet processing plant. Once the proposed wet processing plant is commissioned, on-site water demand will increase and the volume of surplus water to be managed will be reduced.

The following surplus water management options were investigated during development of the Proposed Change:

- Use on-site for the Proposed Change
- Transfer to a third party user
- Supply Pannawonica town and industrial area
- Passive recharge via completed mine pits
- Re-injection into Yarraloola or CID Aquifer
- Re-injection into Warramboo Creek alluvial aquifer
- Discharge to Warramboo Creek.

The findings of these investigations are summarised in Table 8-6. The only options that are technically feasible and align with mine scheduling requirements are use on-site for the Proposed Change, passive recharge via completed mine pits and discharge to Warramboo Creek. A combination of these three options is proposed.

Table 8-6: Surplus water disposal options considered

Option	Outcome
Use on-site for the Proposed Change	Feasible. Where possible, surplus water from BWT mining will be used on-site for various activities including processing and dust suppression. The Mesa A water demand is currently being met by the existing Warramboo borefield. An increase in demand is only anticipated once the proposed wet processing plant is commissioned. Commissioning of the proposed wet processing plant is currently scheduled to occur approximately two years after commencement of dewatering to enable BWT mining of the Warramboo deposit.
Transfer to a third party user	Not feasible. No third party users have been identified. The nearest mining operation is at Mesa J (40 km away) which has surplus water discharges after use on-site. The API West Pilbara Iron Ore Project is located approximately 80 km south-east of the Development Envelope. This mine is currently not operating, however when operations commence surplus water will be discharged after use on-site.
Supply Pannawonica town and industrial area	Not feasible. Pannawonica town and industrial area are located approximately 50 km from Warramboo. The water supply requirement of approximately 2ML/day is currently met by a local borefield and is significantly less than the volume to be dewatered from Warramboo. A significant increase in the Pannawonica water supply requirement is unlikely.
Passive recharge via completed mine pits	Feasible. The mine schedule shows that completed mine pits will be available at Warramboo when surplus water management is required. Although this option is feasible it is likely to result in recirculation of water. That is, water that has passively recharged the aquifer is likely to be re-circulated to nearby dewatering bores. This has some adverse cost and efficiency implications.
Re-injection into the CID or Yarraloola Aquifer	Not feasible. Based on previous managed aquifer recharge trials within the Central Pilbara at Marandoo, Karijini National Park, Southern Fortescue, Yandicoogina and Nammuldi, injection as a water management option requires the following criteria to be met: • Permeable aquifer where each injection bore can inject at a rate greater than 1ML/d • Adequate storage available in the aquifer • Depth to water of greater than 40 m to ensure water levels don't rise above acceptable levels, this prevents the establishment of dependent shallow rooted vegetation • Aquifer that is down gradient or disconnected from the mining area to prevent recirculation of water back into the mine • Re-injection area that is outside the mine abstraction borefield's cone of depression to prevent recirculation of water back into the mine • The Yarraloola Aquifer in the vicinity of Warramboo has a depth to water of less than 15 m and therefore lacks sufficient depth to be suitable for re-injection.

Option	Outcome
Re-injection into Warramboo Creek alluvial aquifer	Not feasible. Depth to water is unsuitable (~15m) and there is uncertainty related to aquifer storage and dimensions. It is likely re-injection infrastructure would be damaged by flood events resulting in significant cost and operational delays.
Discharge to Warramboo Creek	Feasible. Discharge may result in continuous surface water expression up to 8 km downstream of the discharge point at its peak and prolonged discharge may alter the water chemistry in Warramboo Creek. This is considered manageable as discharge volumes will decrease once the proposed wet processing plant is commissioned increasing on-site water demands.

8.6.1.2 Water supply

The proposed wet processing plant will increase the site water demand. Options considered for supply of additional water included an extension to the current borefield at Warramboo, a new borefield at Jimmawurrada (located approximately 40 km south-east of Mesa C) or a combination of the two. Extension of the current borefield at Warramboo has been selected as the preferred water supply option as hydrogeological test work showed an extension to the borefield would be able to meet the increased water demand, and the proximity of the borefield to the Mesa A Hub will result in less land disturbance than development of a new borefield at Jimmawurrada. In addition, the Jimmawurrada locality contains some environmental and heritage sensitivities.

8.6.1.3 Conceptual water balance

A conceptual mine water balance has been developed as shown in Table 8-7. The water balance incorporates the wet processing plant demand, operational use, Warramboo dewatering, Mesa C dewatering and management of surplus water. Current hydrogeological modelling shows the rate of groundwater abstraction from Mesa C may be less than 5 GL/a. However, to allow for possible variation in the mining rate, a conservative rate of 5 GL/a has been adopted.

Table 8-7: Conceptual mine water balance model

Component	Rate (GL/a)	Total Volume LoM (GL)
Dewatering and water supply abstraction = 179GL over LoM		
Warramboo – dewatering and water supply	10 to 15	170
Mesa C - dewatering	2 to 5	9
Water use and surplus disposal = 19GL over LoM		
Wet Plant Use	5 to 11	143
Operational Use	2 to 3	32
Discharge to Warramboo Creek	2 to 7	9
Passive recharge via existing mine pits	3 to 7	10

The dewatering, abstraction and surplus water discharge rates vary significantly throughout the LoM. As much of the above water table ore has already been extracted from Warramboo, BWT mining will occur early in the life of the Proposed Change. The rate of groundwater abstraction is, therefore, anticipated to be greater earlier in the life of the Proposed Change. Surface water discharge will only occur in a few years where dewatering volumes or large rainfall event run-off volumes exceed on-site water use.

Surplus water management will include a combination of three options: use on-site, discharge to Warramboo Creek and passive recharge via completed mine pits. These options have been selected to ensure that water is re-used where possible, passive recharge is managed such that recirculation is minimised and surface discharge to Warramboo Creek is managed such that continuous flow from surplus water discharge will extend no more than 8 km downstream of the discharge point under natural no-flow conditions.

Surface water management will be required for direct rainfall and surface run-off management across mine pits during mining operations. This will be required particularly during the wet season when high rainfall events can cause pit flooding requiring management of large volumes of water faster than evaporation and infiltration can occur. Removal of direct rainfall and surface run-off from pits will generally occur via the same sump-pump system as used for mine dewatering; water will either be allowed to infiltrate, will be re-used on-site or will be discharged, following settlement of solids where required.

In summary, the water management approach for the Proposed Change includes:

- Dewatering of the BWT resources at Mesa C and Warramboo (all other resources are above water table)
- Use of dewatering volumes for operational water requirements
- Discharge of surplus water to Warramboo Creek or to existing mine pits at Warramboo where dewatering volumes exceed operational water requirements
- Abstraction from the Warramboo borefield to meet operational water requirements when dewatering is either not occurring or volumes are insufficient
- Management of surface water run-off and abstraction of collected rainfall and run-off water from in-pit sumps.

The water management options considered in the development of the Proposed Change are outlined in Section 8.6.1.

8.6.2 Direct impacts

8.6.2.1 Changes to groundwater levels as a result of groundwater abstraction

The activities associated with the Proposed Change which will reduce groundwater levels are dewatering to facilitate BWT mining at Warramboo and Mesa C, and groundwater abstraction from the proposed Warramboo borefield to supply water for wet processing. Dewatering will result in the reduction of natural groundwater levels at Warramboo extending outwards away from the Warramboo pit. Dewatering at Mesa C will result in the reduction of natural groundwater levels within the Mesa C CID Aquifer.

Warramboo

Extensive drilling, test pumping and hydrogeological investigations at Warramboo have been conducted for wet plant water supply and dewatering of the Warramboo pit. A summary of the water supply investigations undertaken for the proposed water abstraction and dewatering activities at Warramboo is presented in Rio Tinto (2017c).

Approximately 11% of the Warramboo orebody occurs BWT. Mining of this BWT resource will require the groundwater table to be lowered by approximately 28 m at the in-pit centre of the cone of depression. Annual dewatering requirements will vary, with an estimated 27 GL predicted to be dewatered during the LoM and a peak abstraction rate of 15 GL/a (including the current licensed abstraction rate of 3 GL/a).

Wet processing will require up to 11 GL/a which will be supplied by dewatering where available or from groundwater abstraction from the extended Warramboo borefield (Table 8-7).

Modelling of groundwater level drawdown and aquifer yields in the Warramboo area have taken into account the combined effects of dewatering and water supply abstraction requirements (Rio Tinto 2017c). The maximum modelled groundwater drawdown as a result of the combined effects of dewatering and water supply abstraction is 36 m (Figure 8-6).

The thickness of the Yarraloola Aquifer in the wider Warramboo area ranges between 5 m and 70 m, with the proposed water supply borefield planned for installation in the thickest section of the aquifer. Groundwater abstraction from the proposed Warramboo borefield extension will reduce the aquifer saturated thickness by up to 70% at the maximum point of groundwater drawdown.

It is estimated that recovery of the groundwater table at Warramboo to 80% of the pre-mining level will take approximately 40 years, with complete recovery of the groundwater level estimated to take up to 140 years due to the anticipated low recharge rates.

Mesa C

Approximately 10% of the Mesa C orebody occurs BWT. Mining of this BWT resource will require the groundwater table within the CID Aquifer to be lowered by up to 15m. This drawdown will occur within a highly localised area and will be confined to the CID Aquifer within the immediate vicinity of the mesa.

Hydrogeological investigations into the chemistry of the groundwater, geological units and pump test results indicate that the CID Aquifer is effectively isolated from the Robe River Aquifer (refer Section 8.4.3). Rio Tinto (2017c) developed a hydrogeological conceptualisation and analytical model to predict the likely dewatering requirements of the Mesa C deposit. The total abstraction for the LoM dewatering of Mesa C is estimated to be 9 GL. The maximum drawdown in the CID Aquifer is predicted to be up to 15 m. Due to the presence of the Ashburton Aquitard and the clayey nature of the basal tertiary pisolite, drawdown of the CID Aquifer is not expected to result in observable impacts to regional groundwater levels or water levels in the Robe River Aquifer. To improve the understanding of how the system behaves, an alternative scenario where the Robe River, CID and Ashburton Aquitards were assumed to be connected was examined by Rio Tinto (2017c). The sensitivity run indicated that if the Robe River Alluvials and CID Aquifer are

connected then groundwater drawdown could occur in the Robe River Alluvial Aquifer and the total LoM water abstraction would be much greater (up to 21 GL) (Rio Tinto 2017c). This conceptualisation does not match the results of the hydrogeological investigations undertaken to date and was run only to provide a sensitivity analysis for dewatering abstraction volumes. Groundwater monitoring will be undertaken in the Mesa C CID Aquifer and the Robe River alluvial aquifer to ensure that there are no unforeseen changes in groundwater levels.

Following cessation of dewatering, the CID Aquifer groundwater level is unlikely to recover to pre-mining levels under steady state conditions; however, extensive rainfall and possibly increased surface run-off and infiltration into the mesa due to reduced vadose zone are likely to assist water level recovery in the CID Aquifer.

8.6.2.2 Changes to the hydrological regime of Warramboo Creek as a result of surplus water management

Warramboo Creek exhibits high inter-annual variability of streamflow, with long periods of low or no flow. An increase in the presence and availability of surface water within the creek channel is expected during longer periods of continuous discharge; however, discharge is not expected to be continuous over the life of the Proposed Change. Excess water from BWT mining will be used as much as possible on-site for processing and dust suppression. Only surplus water that cannot be used on-site will be discharged into Warramboo Creek.

A total of approximately 9 GL is expected to be discharged to Warramboo Creek during the LoM. Discharge of surplus water won't be required every year due to water being used on-site however when required, the amount to be discharged will be between 2 GL/a and 7 GL/a. Changes to the hydrological regime of Warramboo Creek are likely as a result of surplus water discharge. Modelling of the surface discharge extent in Warramboo Creek has been undertaken for various discharge scenarios. Based on discharge of up to 7 GL/a during periods of no natural flow, it is estimated that continuous flow resulting from surplus water discharge will extend up to 8 km downstream of the discharge point during times of peak discharge.

Indicative flow data for Warramboo Creek was derived from scaling of flow data from the larger Cane River catchment, which drains similar adjacent landscapes to Warramboo Creek. Based on the scaled data, median flow volumes in Warramboo Creek are estimated to be 11.5 GL/a with approximately 85% of flow years expected to drain greater than 4 GL/a. The majority of these flows are expected to occur between January and May. The peak annual rate proposed for discharge to Warramboo Creek is below the flow volumes that occur naturally within the creek during moderate flow events. Discharge flows will remain contained within the low flow channel of Warramboo Creek (Rio Tinto 2015a). Discharge velocities are modelled to be less than 1 m/s and are therefore unlikely to result in channel erosion.

8.6.3 Indirect impacts

8.6.3.1 Changes to surface and groundwater chemistry

In-pit storage of waste fines, in-pit disposal of effluent from the reverse osmosis plant and AMD, could potentially result in contamination of groundwater.

Surplus water discharge may result in contamination of Warramboo Creek. Surface water flows through the western portion of the Development Envelope may become contaminated by sediment or hydrocarbon spills and there is potential for sediment-laden surface water run-off to be produced in the vicinity of the waste dumps.

8.6.3.2 In-pit storage of waste fines and disposal of reverse osmosis plant effluent

In-pit storage of waste fines (from the entire Proposal) and disposal of effluent from the reverse osmosis plant is proposed at Warramboo.

Seepage from the proposed WFSF is expected to recharge the local aquifer immediately below the WFSF, potentially creating a groundwater mound that will be partly negated by the lowering of the water table caused by the water supply borefield. During operations, most of this seepage volume will be captured by the water supply borefield and re-circulated in the wet plant.

The proposed waste fines stream is considered to be chemically benign with its geochemistry similar to the original ore excavated from Warramboo with slight enrichment in some minerals (such as Al_2O_3 and SiO_2). It is proposed the effluent from the reverse osmosis plant be mixed with the waste fines stream to allow for disposal in-pit at Warramboo. It is estimated the resultant chloride concentration in the waste fines stream will be up to approximately 2,440 mg/L; this is within the range of chloride concentrations (48 mg/L-3,170 mg/L) recorded in natural groundwater at Warramboo.

The WFSF proposed for Warramboo will be similar to the current operating WFSF at Mesa J, which includes monitoring of groundwater chemistry in the area surrounding the facilities. Table 8-8 shows the minimum, median and maximum concentrations recorded for relevant analytes from samples collected upgradient and downgradient of the Mesa J WFSF compared with the ANZECC/ARMCANZ (2000) 95% protection levels.

Table 8-8: Groundwater chemistry upgradient (background) and downgradient (potential impact) of the Mesa J waste fines storage facility

Analyte[1]	ANZECC 95% level	Background				Potential impact
		Count	Minimum	Median	Maximum	Median
Aluminium	0.055	500	0.0005	0.004	0.06	<0.01
Antimony	*0.009	408	0.0005	<0.001	0.012	<0.001
Arsenic	0.013	452	0.0005	<0.001	0.05	<0.001
Boron	0.37	416	<0.02	0.11	1.6	0.2
Cadmium	[H]0.0002	270	0.00005	<0.0001	<0.0001	<0.0001
Chromium	0.001	444	<0.0005	<0.001	0.013	<0.001
Chromium VI (Cr VI)	0.001	0				<0.005
Cobalt	*0.014	286	<0.001	<0.001	0.004	<0.001
EC field (µS/cm)	900	1815	34	412	1864	876
Copper	0.0014	312	<0.0001	<0.001	0.015	<0.001
Iron	*0.3	544	0.0025	0.01	2.9	0.020
Lead	[H]0.0034	544	<0.001	<0.001	0.01	<0.001
Manganese	1.9	571	<0.001	0.005	1.3	0.003
Mercury	0.00006	425	<0.00005	<0.00005	<0.00005	<0.0001
Molybdenum	0.034	445	<0.0005	<0.001	0.013	<0.001
Nickel	[H]0.011	413	<0.001	<0.001	0.05	0.001
N ammonia (NH_3-N)	0.9	110	<0.005	<0.01	1.7	<0.005
N nitrate (NO_3-N)	0.03	147	<0.005	1.3	4.4	1.2

Analyte[1]	ANZECC 95% level	Background				Potential impact
		Count	Minimum	Median	Maximum	Median
N NO_X nitrogen (NOx-N)	0.03	141	<0.005	1.3	2.47	0.9
Nitrogen Total	0.3	154	<0.05	1.4	15	1.4
pH field (pH units)	6 - 8	1832	5.5	7.2	11.6	7.6
Phosphate (FRP, P-SR)	0.005	30	<0.005	0.006	0.017	<0.01
Phosphorus Total	0.01	464	<0.01	<0.01	9.3	0.02
Selenium	0.005	397	0.0005	0.001	0.005	<0.01
Tin	*0.003	268	<0.001	<0.001	0.002	<0.001
Vanadium	*0.006	263	<0.001	<0.001	0.018	<0.01
Zinc Total	[H]0.008	133	<0.005	0.005	0.1	0.006

[1] units are mg/L unless otherwise stated

* ANZECC low reliability protection level

[H] Allowance made for hardness (as CaCO3) at time of sampling when comparing against protection level (refer ANZECC/ARMCANZ 2000, Tables 3.4.3 and 3.4.4)

toxicants & stressors >95% protection level

Table 8-8 shows that natural background levels (i.e. upgradient of the Mesa J tailings storage facilities) of some analytes in the groundwater exceed the ANZECC 95% protection levels. This indicates that the ANZECC 95% protection levels do not represent suitable triggers for analytes such as nitrate, phosphate and zinc, in groundwater in the Robe Valley. The most notable changes downgradient of the tailings storage facility that may be attributable to the tailings storage facility are an increase in the median EC, an increase in the median and maximum concentrations of nitrogen, nitrate and NO_x and an increase in the median and maximum concentrations of zinc. There is some evidence to suggest that some of these changes originate from mobilisation of analytes from the underlying formation rather than directly from the WFSF seepage.

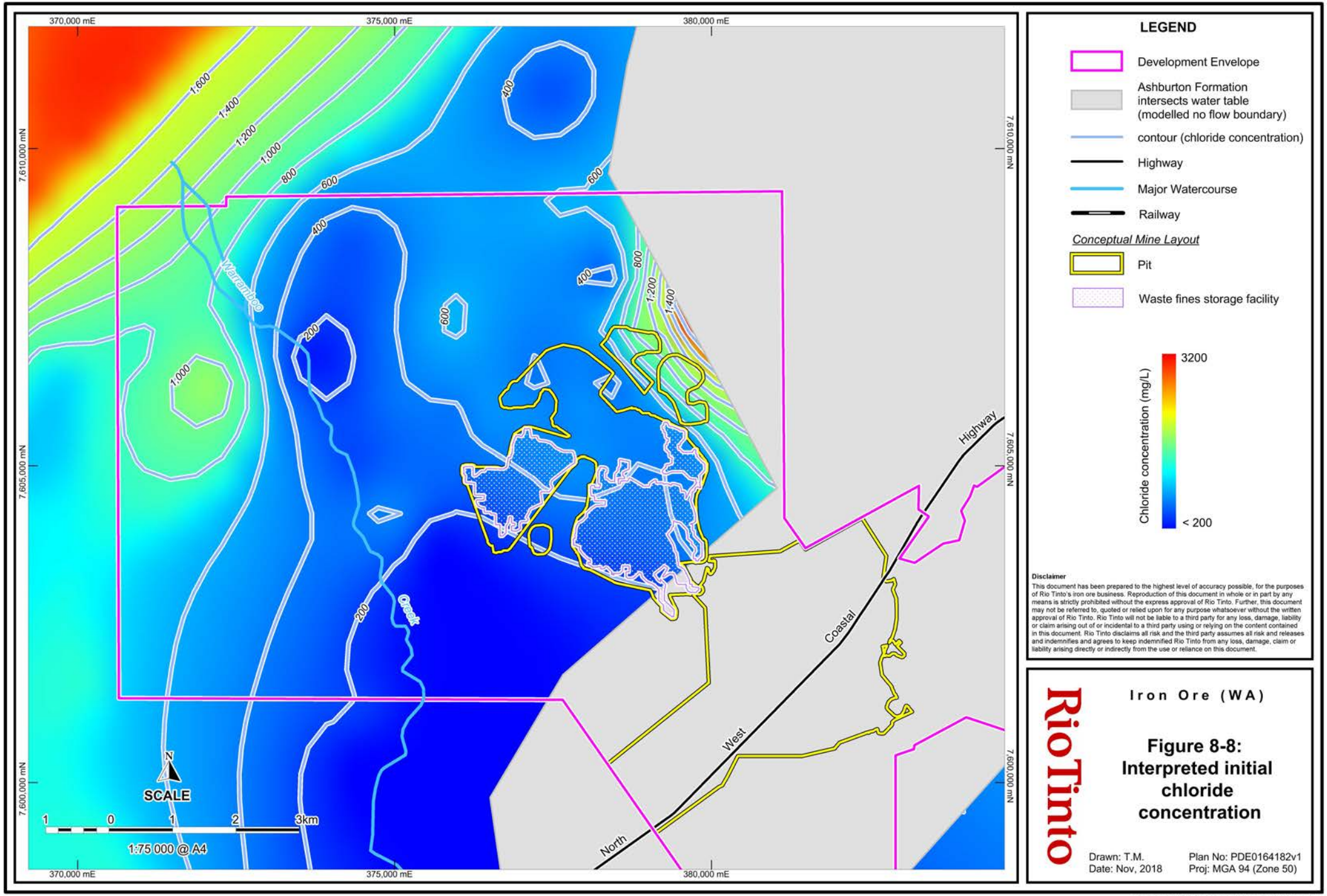
A comparison of standard assay data for ore rock samples associated with the Mesa J and Mesa A areas found similar mean values for elements such as Al, As, Ba, Ca, Cl, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Pb, Si, Sn, Sr, S, Ti, V, Zr and Zn. Furthermore, a comparison of values for elements such as Ag, B, Be, Cd, Hg, Mo, Sb, Se, Th, Tl and U also showed similar results in ore rock samples across the project areas. Therefore, Mesa J waste fines samples may be considered geochemically analogous to potential waste fines from the Development Envelope. However, site specific characterisation of waste fines will be undertaken as operations progress to account for differences in metallurgical properties.

Based on results of monitoring around the Mesa J waste fines tailings storage facilities and that these samples may be considered geochemically analogous to potential waste fines from the Development Envelope, it is anticipated that the proposed WFSF at Warramboo will result in increases in salinity, nitrogen, nitrate, NO_x and some metals in the immediate vicinity of the WFSF. DHI undertook modelling to assess the potential for changes to water quality as a result of groundwater drawdown extending towards naturally occurring higher salinity areas and seepage from the WFSF, using chloride as a suitable analyte (DHI 2018). The results showed naturally occurring areas of higher chloride concentration located towards the coast to the west of the Warramboo pits will likely increase the chloride concentrations in some water supply bores over the life of mine, while the higher salinity areas located east of the Warramboo pit will have limited impact on water supply bores. The modelling also indicated changes to groundwater chloride concentrations due to seepage from the WFSF will be contained within the cone of depression resulting from groundwater abstraction and that the majority of the increase in chloride concentration due to the presence of the WFSF will remain within the area below the pit and is not expected to reach water supply bores located approximately 400 m from the pit boundary (DHI 2018). This is demonstrated in Figure 8-8 to Figure 8-10, where Figure 8-8 shows the initial (baseline) interpreted chloride concentration at Warramboo, Figure 8-9 shows the modelled final chloride concentration in 2086 resulting from both incursion of naturally occurring higher salinity water from the north-west and the north-east and seepage from the WFSF, and Figure 8-10 shows the difference in chloride concentration due only to seepage from the WFSF.

Given chloride is generally a conservative solute, it can be inferred that other changes to groundwater chemistry will also be confined to the cone of depression resulting from groundwater abstraction.

Placement of waste fines into the WFSF will cease prior to closure. There will then be a limited period of time where seepage occurs from the waste fines until the WFSF dries out through a combination of evaporation and seepage, at which stage rehabilitation of the WFSF will be undertaken which will further reduce seepage over time.

Given changes in groundwater chemistry will be confined to the cone of depression during operations, 'drain-down' of the WFSF at closure will likely be dispersed and diluted and given the extent of the Yarraloola Aquifer, it is considered that the Proposed Change is unlikely to significantly impact the environmental values associated with the Yarraloola Aquifer during or after operations.



LEGEND

- Development Envelope
- Ashburton Formation intersects water table (modelled no flow boundary)
- contour (chloride concentration)
- Highway
- Major Watercourse
- Railway

Conceptual Mine Layout

- Pit
- Waste fines storage facility

Chloride concentration (mg/L)
3200
< 200

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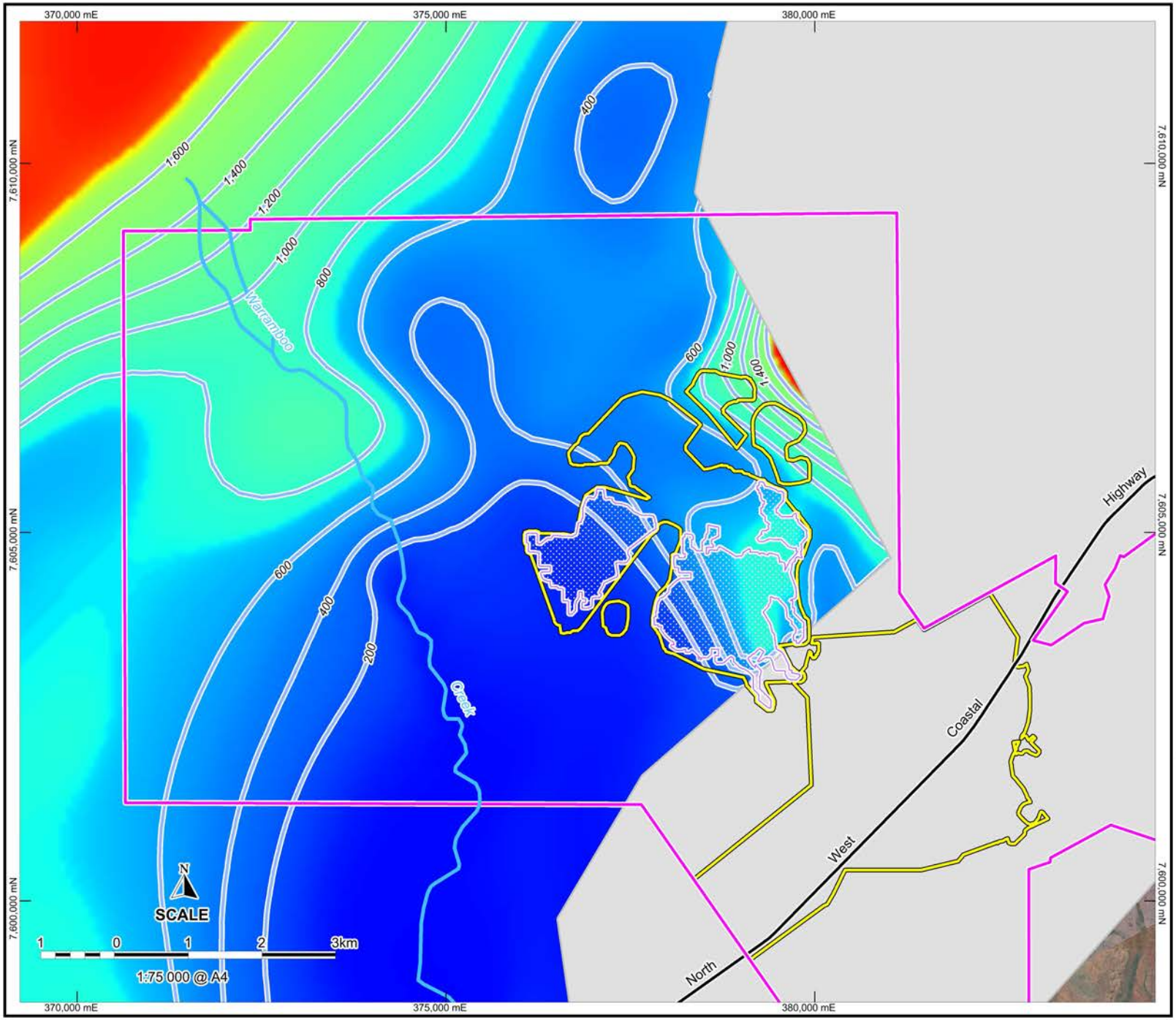
Rio Tinto

Iron Ore (WA)

Figure 8-8: Interpreted initial chloride concentration

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164182v1
Proj: MGA 94 (Zone 50)



LEGEND

- Development Envelope
- Ashburton Formation intersects water table (modelled no flow boundary)
- contour (chloride concentration)
- Highway
- Major Watercourse
- Railway

Conceptual Mine Layout

- Pit
- Waste fines storage facility

Chloride concentration (mg/L): 3200 to < 200

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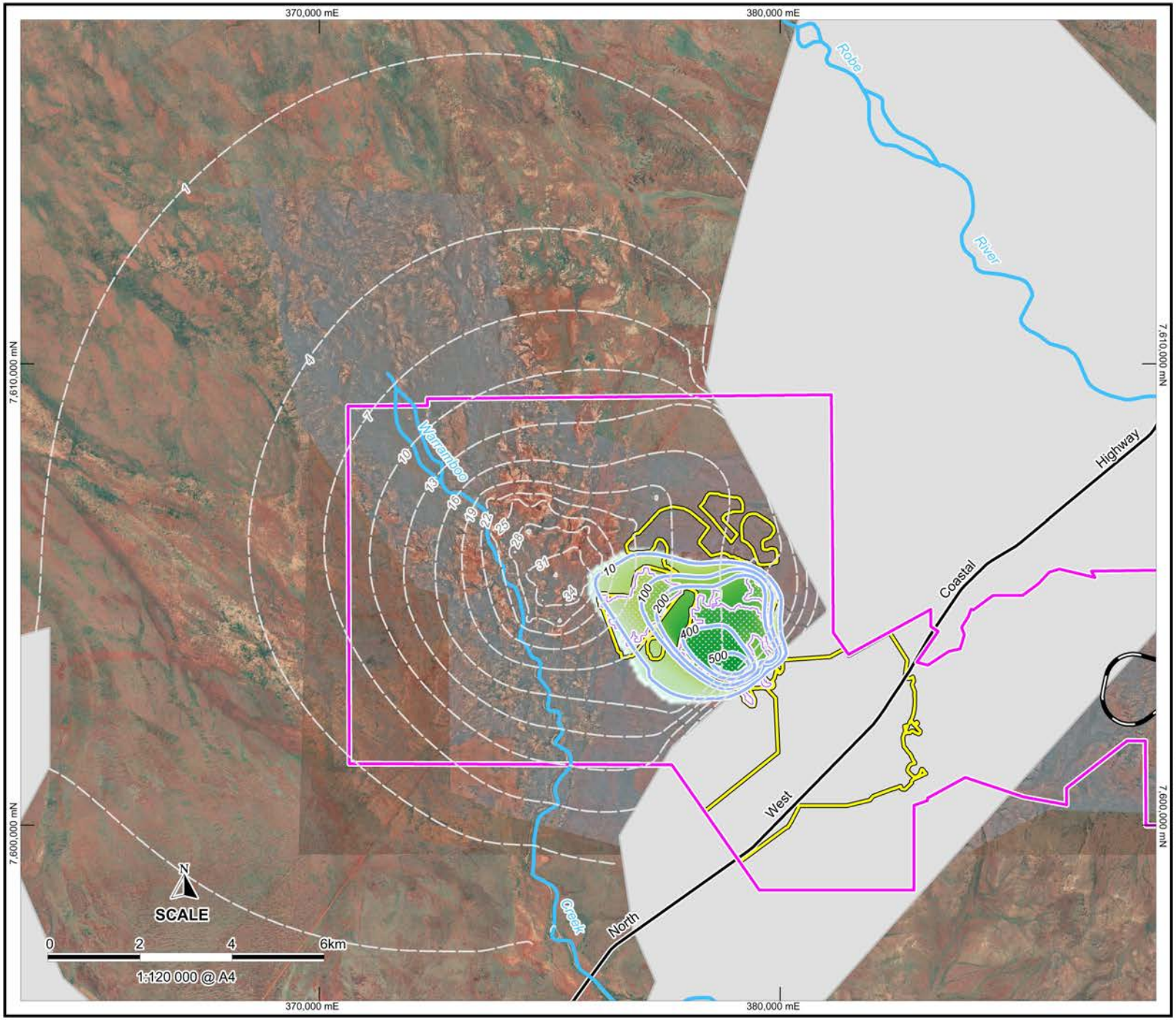
Rio Tinto

Iron Ore (WA)

Figure 8-9: Modelled final chloride concentration in 2086

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164182v1
Proj: MGA 94 (Zone 50)



LEGEND

- Development Envelope
- Ashburton Formation intersects water table (modelled no flow boundary)
- Drawdown Contour (m)
- contour (chloride concentration)
- Highway
- Major Watercourse
- Railway

Conceptual Mine Layout

- Pit
- Waste fines storage facility

536

Difference between modelled initial and final chloride concentration. Positive values indicate an increase in chloride due to the WFSF

5.5

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Rio Tinto

Iron Ore (WA)

Figure 8-10: Difference between modelled initial and final chloride concentration

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164182v1
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

8.6.3.3 Potential contamination of surface and groundwater from potentially acid and metalliferous/neutral mine drainage

Rio Tinto has undertaken an extensive program of geochemical testing over several years to understand the potential for acid and/or metalliferous/neutral drainage to occur as a result of exposing various waste rock types common to mining operations in the Pilbara. The geochemical characterisation process aims to assess sulphur content as an indicator of acid generation potential, and to undertake static (acid base accounting) and, if appropriate, kinetic testing of materials. The most significant geochemical risk posed by mining iron ore deposits in the Pilbara is associated with the sulphide mineral pyrite (FeS_2), which can form sulphuric acid when exposed to oxygen and water.

An assessment was undertaken to review the AMD risk associated with the Proposed Change. The summary memorandum (Rio Tinto 2017h) is provided in Appendix 9 and the key findings are summarised below.

The Mount McRae Shale, most commonly associated with pyrite and AMD in the Pilbara, will not be exposed during mining in the western portion of the Development Envelope. However, pyrite may also occur within black shale of the Nanutarra Formation (KN) which is known to underlie the CID in this area of the Robe Valley. A detailed analysis of the sulphur values of all drill hole samples has resulted in the risk of acid drainage being generated during operations and upon closure being assessed as low.

Based on an assessment of whole rock geochemical data, concentrations of some trace elements (e.g., Fe, As, Co, Cr, Cu, Mn, Pb, Se and Zn) are considered enriched or elevated in some ore and waste drill hole samples. However, based on static leach tests undertaken using distilled water, these elements, in addition to nitrate and other parameters corresponding to water quality assessment criteria, do not appear to be readily leachable in (low-sulphur) rock types likely to be exposed in bulk. As a result, waste rock stockpiles are not considered to present a neutral drainage risk to water chemistry in the surrounding environment.

The likelihood of encountering potentially acid forming materials (PAF) is low; if PAF materials are encountered, existing management strategies within the Iron Ore (WA) Mineral Waste Management Plan and the Iron Ore (WA) Spontaneous Combustion and Acid Rock Drainage (SCARD) Management Plan will be implemented to ensure waste material is adequately geochemically characterised and PAF material that poses an AMD risk is appropriately managed. These management plans have been effectively applied at other Rio Tinto Pilbara mine operations.

Existing PAF management measures to be implemented include:

- Undertake relevant ecological assessment (appropriate for the scale of the SCARD generation and predicted level of pollution/ecological impacts), develop and implement appropriate risk reduction measures and monitoring programmes
- Ensure that routine sampling, visual inspection, and analysis is performed for out-of-pit locations that could potentially be impacted by AMD. This should be consistent with the master monitoring schedule for the site and may include:
    - groundwater monitoring wells surrounding waste dumps and pits (if they can be accessed outside the pit)
    - surface water bodies (including abandoned pit lakes, permanent or seasonal natural water bodies, dewatering discharge to creeks)

- Record sulphidic material environment risks in a site risk register and annually review/verify/validate these risks; verify that the ministerial conditions, legal and other requirements and obligations are met
- An overview of PAF issues must be included in any introductory training provided to new employees and contractors. Further training of those groups involved in the mining of PAF should be commensurate to the level of risk PAF material poses to the operation.

The Proponent has well established management strategies to reduce the potential for sediment-laden surface water run-off to be discharged from site. Practices include design of waste dumps to minimise erosion, use of windrows and on-site drainage and sedimentation structures. The Proponent will continue to implement these strategies.

8.6.3.4 Potential contamination of Warramboo Creek from surplus water discharge

Surface water samples collected from Warramboo Creek after rainfall events show the water to be fresh with a neutral to mildly alkaline pH (Table 8-9). Total nitrogen levels in Warramboo Creek are generally elevated compared with the ANZECC 95% aquatic ecosystem protection level. Aluminium, total chromium, copper, iron, nitrates, total phosphorus and zinc also show some degree of elevation compared with ANZECC 95% aquatic ecosystem protection levels.

Groundwater chemistry data for samples collected from bores most likely to represent the proposed surplus water discharge were compared with data from surface water samples and ANZECC guidelines (Table 8-9). The chemistry of the groundwater proposed for discharge has a neutral to mildly alkaline pH and is considered fresh to brackish. Median concentrations (of the selected bores combined) of boron, nitrate, NO_x and total nitrogen in the groundwater are elevated compared with both the surface water in Warramboo Creek and the ANZECC guidelines. The median groundwater quality values for individual bores are provided in Appendix 9. The analytes which are elevated relative to the ANZECC guidelines vary between the bores. The combined median analyte concentrations from all of the bores are used to indicate groundwater chemistry most likely to represent the proposed surplus water discharge (Table 8-9).

Under natural no-flow conditions, discharged surplus water has the potential to change sediment quality and water chemistry in an 8 km section of Warramboo Creek, potentially causing temporary vegetation stress and impacts to aquatic fauna for the duration of discharge. Potential impacts to vegetation and aquatic fauna are discussed in Sections 1.1 and 7.6 respectively.

Table 8-9: Warramboo surface water and groundwater quality

Analyte[1]	ANZECC 95% aquatic ecosystem protection level	Warramboo Creek surface water quality						Warramboo median groundwater quality
		Warramboo Creek site				WARU S5	WARU S6	
		April 2015	April 2016	June 2016	September 2016	May 2016	May 2016	
Aluminium (at pH>6.5)	0.055	0.019	0.31	0.02	1.12	0.083	0.02	0.005
Antimony	*0.009	<0.001	<0.001	<0.0002	-	-	-	<0.001
Arsenic	0.013	<0.001	<0.001	<0.0002	<0.0005	<0.001	0.001	<0.001
Boron	0.37	0.069	0.08	0.022	<0.1	0.11	0.26	0.63
Cadmium	0.0002	<0.00005	<0.00005	<0.00005	<0.0002	<0.00005	<0.00005	<0.0001
Chromium total	0.001	<0.001	<0.001	<0.0002	0.0011	<0.0005	<0.0005	<0.0005
Cobalt	*0.014	<0.001	<0.001	<0.0001	<0.0002	0.0004	0.0003	0.0005
Copper	0.0014	0.001	0.001	0.0026	-	0.0018	0.003	<0.001
EC lab (µS/cm)	900	88	78	-	-	211	309	2100
Iron	*0.3	0.029	0.26	0.022	0.916	0.093	0.036	0.01
Lead	0.0034	<0.001	<0.001	<0.0001	0.0002	<0.0001	<0.0001	<0.0005
Manganese	1.9	0.004	0.004	0.0054	0.0062	0.14	0.015	0.008
Mercury	0.00006	<0.00005	<0.0001	<0.00004	<0.00004	-	-	<0.0001
Molybdenum	0.034	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001
Nickel	0.011	<0.001	<0.001	<0.0005	0.0013	0.001	0.002	0.0021
N ammonia (NH_3-N)	0.9	0.007	-	0.05	<0.01	0.14	0.02	<0.01

Analyte[1]	ANZECC 95% aquatic ecosystem protection level	Warramboo Creek surface water quality						Warramboo median groundwater quality
		Warramboo Creek site				WARU S5	WARU S6	
		April 2015	April 2016	June 2016	September 2016	May 2016	May 2016	
N nitrate (NO_3-N)	0.03	0.47	<0.01	0.03	<0.01	0.01	<0.01	1.16
N NO_x nitrogen (NO_x-N)	0.03	-	<0.01	0.03	<0.01	0.02	<0.01	1.19
Nitrogen total	0.3	1.2	-	0.4	0.3	1.8	0.79	1.8
pH (pH units)	6 - 8	-	-	-	-	7.6	8.2	7.4
Phosphate (FRP, P-SR)	0.005	0.002	<0.01	<0.01	-	-	-	0.005
Phosphorus total	0.01	0.02	<0.01	0.07	0.01	<0.01	0.014	<0.01
Selenium	0.005	<0.002	<0.01	<0.0002	0.001	<0.001	<0.001	<0.002
Tin	*0.003	<0.001	<0.001	<0.0002	-	-	-	<0.001
Total Dissolved Solids (TDS)	-	63	58	51	47	120	170	1180
Vanadium	*0.006	<0.001	<0.01	-	0.0014	0.0007	0.0007	0.0017
Zinc	0.008	0.014	<0.005	0.003	<0.005	0.005	0.005	0.003

[1] units are mg/L unless otherwise stated

* ANZECC low reliability TV

toxicants & stressors >95% TV

8.6.3.5 Potential contamination of surface water from hydrocarbons

Site drainage will be designed to minimise or eliminate surface run-off into areas where hydrocarbon contamination may occur. Hydrocarbon storage facilities and all associated connections will be within appropriately contained areas. Storm water will be collected from these areas and treated to remove hydrocarbons prior to discharge.

Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements, including DWER's operating licence.

8.6.4 Cumulative impacts

Groundwater users in the vicinity of the Development Envelope are mining operations, and pastoral stations.

Groundwater has been abstracted from the existing Warramboo borefield since 2010. The current abstraction rate is approximately 1.3 GL/a, with a current groundwater license allowing up to 3 GL/a to be abstracted. The rate of groundwater abstraction from the Warramboo borefield for mine dewatering and water supply for the Revised Proposal, is estimated to be up to 15 GL/a (including the currently licensed 3 GL/a).

Six pastoral station bores and one Main Roads WA supply bore occur in the area potentially affected by the cone of depression associated with the extended Warramboo borefield (at maximum pumping rates). These bores will be replaced by the Proponent if their yields are significantly affected.

The Robe Valley has a number of operating and proposed mines; the existing Mesa A/Warramboo Iron Ore Project, the Mesa J operation and the proposed Mesa H operation. The Mesa J operation is located approximately 40 km east of Mesa A at the confluence of the Robe River and Jimmawurrada Creek. The Mesa H Proposal is adjacent to the western side of the Mesa J operation. Groundwater abstraction to enable BWT mining is undertaken at the Mesa J operation and is proposed for a portion of BWT ore (~20%) at Mesa H, subject to approval. Abstracted water is, and will continue to be, used on-site for ore processing and other mining activities with surplus water sporadically discharged to Jimmawurrada Creek and/or tributaries of the Robe River. The Proponent also operates the Coastal Water Supply bore field in the Bungaroo Valley, approximately 10 km south-east of the Mesa J operation.

Given that the Coastal Water Supply borefield is located approximately 45 km from the Development Envelope and the Mesa J operation and the proposed Mesa H operation are approximately 40 km from the Development Envelope, there will be no interaction between the groundwater drawdown at the Coastal Water Supply borefield, Mesa J and Mesa H with the proposed groundwater drawdown at Warramboo. The existing intermittent discharge from the Mesa J operation does not extend downstream to the Development Envelope, nor will the proposed discharge from Mesa H. Therefore, the groundwater and surface water impacts associated with the Proposed Change will not overlap with the impacts of other projects.

8.7 Closure

The Mesa A Hub Closure Plan (Rio Tinto 2017b) is the updated closure plan for the Mesa A, B, C, Warramboo, Highway/Tod Bore operations and supersedes previous closure plans for the approved project. It is applicable to mine developments and associated

infrastructure, excluding rail infrastructure, within the Development Envelope. A summary of the approach to closure of the Revised Proposal and how it relates to the Hydrological Processes and Inland Waters Environmental Quality factors is provided below.

The current closure strategy is for all BWT pits to be backfilled to appropriate levels to prevent the formation of pit lakes.

Following cessation of dewatering at Mesa C, the CID Aquifer groundwater level is unlikely to recover to pre-mining levels under steady state conditions; however, extensive rainfall and possibly increased surface run-off and infiltration into the mesa due to reduced vadose zone are likely to assist water level recovery in the CID Aquifer. It is estimated that recovery of the groundwater table at Warramboo to 80% of the pre-mining level will take approximately 40 years, with complete recovery of the groundwater level estimated to take up to 140 years due to the anticipated low recharge rates.

Water monitoring during closure will focus on confirming groundwater recovery and quality. A specific program of monitoring including timeframes for completion will be developed prior to decommissioning.

A closure task has also been identified to assess the potential for seepage from the WFSF into the aquifer. This will ensure any seepage from the facility is considered in terms of potential impact to groundwater chemistry and subterranean habitats.

Management of surface water will be addressed as part of the overall closure objective to create a safe, stable landform. Minor updates to designs and layouts will occur during the closure planning process; these updates will be incorporated into periodic updates of the Closure Plan.

8.8 Mitigation

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 8-10.

The Mesa A Hub EMP (Appendix 4) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa A Hub. The EMP identifies:

- Mitigation strategies proposed to minimise impacts to significant environmental values
- The environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met
- Trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach
- The management actions that will be implemented in response to monitoring results.

No significant residual impacts are predicted to areas of high environmental value relating to Hydrological Processes and Inland Waters Environmental Quality, therefore no offset is proposed for this factor.

Table 8-10: Mitigation measures and predicted outcomes for Hydrological Processes and Inland Waters Environmental Quality

Potential impacts	Mitigation to address potential impacts	Predicted outcome
EPA Objectives: *To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.* *To maintain the quality of groundwater and surface water so that environmental values are protected.*		
Direct impact: changes to groundwater levels as a result of groundwater abstraction Groundwater abstraction at Mesa C will lower the groundwater table in the Mesa C CID Aquifer by up to 15 m. Groundwater abstraction for dewatering and water supply from the Warramboo borefield will lower the groundwater table by up to 36 m.	The following key management strategies will be implemented to manage impacts to the hydrological regimes of groundwater and surface water: **Minimise:** Hydrogeological modelling has been, and will continue to be, undertaken to facilitate understanding of current and future dewatering and water supply requirements. Abstraction will be minimised to that required to access the BWT resources and meet site water requirements. Monitoring of riparian vegetation and groundwater levels will be undertaken along the Robe River adjacent to the predicted drawdown within the Mesa C CID Aquifer. If changes to groundwater levels and vegetation health are detected, then appropriate mitigation measures will be determined in accordance with the EMP. Groundwater levels in the Warramboo borefield will be monitored to check that drawdown is occurring consistent with modelled predictions. **Rehabilitate**: Mine pits will be backfilled to appropriate levels to prevent the formation of pit lakes. **Other Legislation:** Groundwater abstraction has been, and will continue to be, managed in accordance with the Groundwater Licence issued under the *Rights in Water and Irrigation Act 1914* and associated Groundwater Operating Strategy and any amendments as required.	The Proposed Change will result in unavoidable groundwater drawdown as a result of dewatering BWT resources and supplying water for processing requirements. Dewatering at Mesa C will result in the reduction of pre-mining groundwater levels within the Mesa C CID Aquifer. No observable change to groundwater levels in the Robe River Alluvial Aquifer is anticipated as a result of dewatering at Mesa C. Following cessation of dewatering, the Mesa C CID Aquifer groundwater level is unlikely to recover to pre-mining levels under steady state conditions. Extensive rainfall and possibly increased surface run-off and infiltration into the mesa due to reduced vadose zone are likely to assist water level recovery in the CID Aquifer. Modelling of groundwater abstraction from Warramboo indicates the local saturated thickness of the aquifer will

Potential impacts	Mitigation to address potential impacts	Predicted outcome
		be reduced by up to 70% over the LoM. It is estimated that recovery of the groundwater table at Warramboo to 80% of the pre-mining groundwater level will take approximately 40 years, with complete recovery of the groundwater level estimated to take up to 140 years due to the anticipated low recharge rates. Approximately 13 km of the ephemeral Warramboo Creek is within the estimated cone of depression resulting from water supply from the proposed Warramboo borefield extension. No permanent or semi-permanent pools have been identified in this section of the creek. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.
Direct impact: changes to the hydrological regime of Warramboo Creek as a result of surplus water management Discharge of surplus water has been modelled to generate continuous surface water expression which will extend up to 8 km from the discharge point under natural no-flow conditions.	The following key management strategies will be implemented to manage impacts of discharge of surplus water: **Minimise:** Dewatering water will be utilised on-site in the first instance to supply water for operational purposes. Only surplus water exceeding the operational requirement will be discharged to Warramboo Creek.	The Proposed Change will result in changes to the seasonal occurrence of surface water in Warramboo Creek for the duration of discharge. Discharge will generate continuous surface water expression which will extend up to 8 km from the discharge

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	The Proponent proposes that the discharge of surplus water be subject to a new Ministerial Statement for the Revised Proposal (Appendix 2). The Condition shall require the Proponent to implement an EMP (Appendix 4). Monitoring of the location of the continuous surface water expression under natural no-flow conditions will be included in the EMP. **Other legislation:** Discharge of surplus water will be managed in accordance with the site Operating Licence, issued under Part V of the EP Act, and any amendments as required.	point under natural no-flow conditions. Discharge is not expected to result in erosion for the expected discharge rates. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.
Indirect impact: changes to surface and groundwater chemistry In-pit storage of waste fines and disposal of effluent from the reverse osmosis plant will lead to recharge of the local aquifer below the proposed WFSF and has potential to change groundwater chemistry. Low potential for exposure of PAF and resultant AMD during operations and closure. Surface water flows through operational areas may become contaminated by sediment-laden run-off from waste dumps or hydrocarbon spills. During natural no-flow conditions, discharge of surplus water may change surface water chemistry in Warramboo Creek.	The following key management strategies will be implemented to manage impacts of potential reduced surface and groundwater chemistry: **Avoid:** During operations most of the seepage from in-pit storage of waste fines and disposal of effluent from the reverse osmosis plant will be captured by the water supply borefield and re-circulated in the wet plant. Mine design will avoid exposure of PAF material. **Minimise**: Hydrocarbons will be handled, stored and disposed of in accordance with legal requirements. Hydrocarbon storage facilities and all associated connections will be within appropriately contained areas and storm water will be collected from these areas and treated to remove hydrocarbons prior to discharge. Hydrocarbon storage facilities and bunds will be inspected on a regular basis to identify any leaks or maintenance requirements. The Proponent has well established management strategies for the management of PAF materials, While the likelihood of encountering significant quantities of PAF material is considered	The proposed WFSF may result in changes in groundwater chemistry, with the most likely changes being increases in salinity, nitrogen, nitrate, NOx and some metals in the immediate vicinity of the WFSF. However, modelling (DHI 2018) indicates changes in groundwater chemistry are likely to be confined to the cone of depression generated by groundwater abstraction, with the majority of changes likely to be confined to the area under the mine pits. Alteration of surface water chemistry and sediment quality in Warramboo Creek as a result of discharge may result in a temporary decline in vegetation health and localised impacts to fauna species in an 8 km

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	low; if PAF materials are encountered then existing management strategies within the Rio Tinto Iron Ore (WA) Mineral Waste Management Plan, and the Spontaneous Combustion and ARD (SCARD) Management Plan will be implemented to ensure waste material is adequately geochemically characterised and PAF material that poses an AMD risk is appropriately managed. Water management structures such as windrows around the base of waste dumps and sediment traps will be constructed in key areas to minimise discharge of sediment-laden run-off from the site. The Proponent proposes that the discharge of surplus water be subject to a new Ministerial Statement for the Revised Proposal (Appendix 2). The Condition shall require the Proponent to implement an EMP (Appendix 4). Monitoring of the surface water chemistry in Warramboo Creek will be included in the EMP. **Other legislation:** Compliance with the requirements of the *Contaminated Sites Act 2003* if contamination occurs.	section of Warramboo Creek downstream from the proposed discharge point. Given the likelihood of encountering significant quantities of PAF materials is low and that appropriate management would be implemented if PAF materials were encountered, no significant impacts to surface and groundwater quality from PAF material are expected. Given that hydrocarbon management measures will be implemented, no significant impacts to surface and groundwater quality from hydrocarbons are expected. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.

8.9 Predicted outcome

The key Hydrological Processes and Inland Waters Environmental Quality values identified in the Development Envelope that are considered relevant to the Proposed Change include:

- The Robe River surface flow including the semi-permanent pools to the east of Mesa B
- The Robe River Alluvial Aquifer including groundwater levels and obligate phreatophytic vegetation
- The Yarraloola Aquifer including groundwater levels and groundwater quality
- Warramboo Creek including water quality and riparian vegetation.

The key predicted outcomes for the Hydrological Processes and Inland Waters Environmental Quality values outlined above are:

Groundwater drawdown Mesa C

- Groundwater drawdown from dewatering at Mesa C is not expected to extend beyond the CID Aquifer
- No observable changes are expected to surface water levels or surface water chemistry in the Robe River, groundwater levels in the Robe River Alluvial Aquifer, or surface water levels in the semi-permanent pools near Mesa B.

Groundwater drawdown Warramboo

- Groundwater abstraction for dewatering and water supply from the Warramboo borefield will lower the groundwater table by up to 36 m and recovery of the groundwater table to 80% of pre-mining groundwater level will take approximately 40 years, with complete recovery of the groundwater level estimated to take up to 140 years
- The 13 km section of the defined flow channel of Warramboo Creek within the estimated cone of depression of the Warramboo borefield extension will not be affected given the ephemeral nature of the creek and lack of permanent or semi-permanent pools identified in this section of the creek.

Surplus water discharge

- Surplus water discharge will alter the seasonal occurrence of surface water in Warramboo Creek by increasing water availability up to 8 km downstream of the discharge point. No erosion is expected
- A temporary decline in vegetation health and localised impacts to fauna species may result along the extent of discharge due to alteration of surface water chemistry and sediment quality.

Changes to surface and groundwater chemistry

- No significant impacts to surface and groundwater quality are expected from hydrocarbons or PAF.

After the mitigation hierarchy has been applied (Table 8-10), no significant residual impact to these values is anticipated and therefore no offset is proposed. The Proponent considers that the Proposed Change can be managed to meet the EPA's objectives for Hydrological Processes and Inland Waters Environmental Quality.

9. LANDFORMS

This section describes the landform characteristics of the western portion of the Development Envelope and provides an assessment of the potential impacts of the Proposed Change to landform values, proposed mitigation measures and the predicted outcome for this key environmental factor.

9.1 EPA Objective

The EPA objective for landforms is to maintain the variety and integrity of distinctive physical landforms so that environmental values are protected.

9.2 Policy and Guidance

The following policy and guidance documents have been considered in the assessment of landforms:

9.2.1 EPA policy and guidance

- Environmental Factor Guideline - Inland Waters Environmental Quality (EPA 2016c)
- Environmental Factor Guideline: Landforms (EPA 2018b)
- Statement of Environmental Principles, Factors and Objectives EPA (2018a)
- DMP and EPA Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015)
- Instructions on how to prepare an Environmental Review Document (EPA 2016i)
- Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (EPA 2016e).

9.2.2 Other policy and guidance

- WA Environmental Offsets Policy (Government of Western Australia 2011)
- WA Environmental Offsets Guidelines (Government of Western Australia 2014)
- Visual Landscape Planning in Western Australia a manual for evaluation, assessment, siting and design (WAPC 2007).

9.3 Environmental Scoping Document

Table 9-1 summarises where the requirements of the ESD are addressed in this section.

Table 9-1: Requirements of the ESD for landforms

Task number	Requirement of ESD	Comment
58	Provide a description of the geology and morphology of the landform.	Section 9.4.3
59	Provide an analysis of whether the landform is robust and therefore less sensitive to damage from development activities, or whether it is easily disturbed or degraded.	Sections 9.4.5 and 9.6.1.2
60	Provide an analysis of whether the landform is distinct at a local, regional or national level, or is well represented.	Section 9.6.1
61	Provide a comparison of the character and condition of the landform with others of the same type at a local, regional or national scale.	Section 9.4.4
62	Analyse the spatial extent of the landform to be impacted.	Section 9.5 and 9.6
63	Assess the current integrity of the landform, the degree to which the landform has been disturbed and the degree to which any previous disturbance has fragmented the landform.	Sections 9.4.6 and 9.6.1.2
64	Analyse the environmental values supported by the landform, including how the Proposal will affect the role of the landform in maintaining these values (e.g. surface water or groundwater flows, wind movement, precipitation, temperature, landscape connectivity and soil composition/chemistry).	Sections 9.4.7 and 9.6.2
65	Demonstrate consideration of the cumulative impacts on the landform from historic and reasonably foreseeable future development.	Section 9.6.3
66	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to landforms.	Section 9.8
67	Prepare a Mine Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015) which addresses maintaining the integrity of physical landforms post closure (including geotechnical stability).	Section 9.7; Appendix 3
68	Describe the residual impacts for the Proposal and analyse these impacts to identify and detail any that are significant.	Section 9.8; Table 9-4
69	Create an offsets position following application of the mitigation hierarchy.	Section 9.8
70	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 9.8

9.4 Receiving Environment

9.4.1 Landform studies

Landscape, escarpment and geotechnical assessments have been undertaken in the western portion of the Development Envelope and surrounds. The information provided by these assessments has been used to describe the landforms of the western portion of the Development Envelope and broader Robe Valley to inform the assessment of potential impacts to these landforms from the Proposed Change. Table 9-2 summarises the key assessments relevant to the Proposed Change.

The most recent study reports are provided in Appendix 10.

Table 9-2: Summary of supporting landform studies

Report	Summary	Study date
Warramboo & Mesa B/C Visual Impact Assessment Rio Tinto (2018b)	A Visual Impact Assessment (VIA) examining changes to visual amenity expected to result from the Proposed Change. The VIA included desktop assessment (analysis), field assessment (photograph locations) and visual impact (photo montage analysis). The results show present, operational and closure photo montages to illustrate the indicative visual impact of the proposed operations.	July and August 2016
Robe Valley Deposits Façade Stand-off Distance Memo Rio Tinto (2017i)	A review to determine the appropriate stand-off distance (the distance between the crest of the pit and that of the mesa's natural slope) to be used as a guideline for current and future mining operations on mesas in the Robe Valley. The review included consideration of geotechnical reports relating to mesa façade stability, pit slope performance of as-built slopes and the estimated façade stability during closure.	November 2017
Mesa Façade Assessment – Mesas B and C MWH (2015b)	A mesa escarpment assessment to categorise, map and rank the ecological value of the mesa escarpments at Mesas B and C.	May 2015
Mesa A Geotechnical Assessment, Project No. 5978 Snowden (2007)	A geotechnical assessment examining the stability of mesa escarpments. This assessment was undertaken for Mesa A utilising observations and assessment throughout the Robe Valley. The assessment included a literature review and data analysis of geotechnical characteristics, geological structure and hydrogeology, in addition to a field investigation.	May 2007
Mesa A – Warramboo Robe River Landscape and Geodiversity Assessment Study John Cleary Planning (2005)	An assessment of the potential impacts of the Mesa A/Warramboo Iron Ore Project on landscape and geodiversity values. This assessment was undertaken as part of the Environmental Impact Assessment for the Mesa A/Warramboo Iron Ore Project and provides contextual information for the Development Envelope and the broader Robe Valley.	June 2005

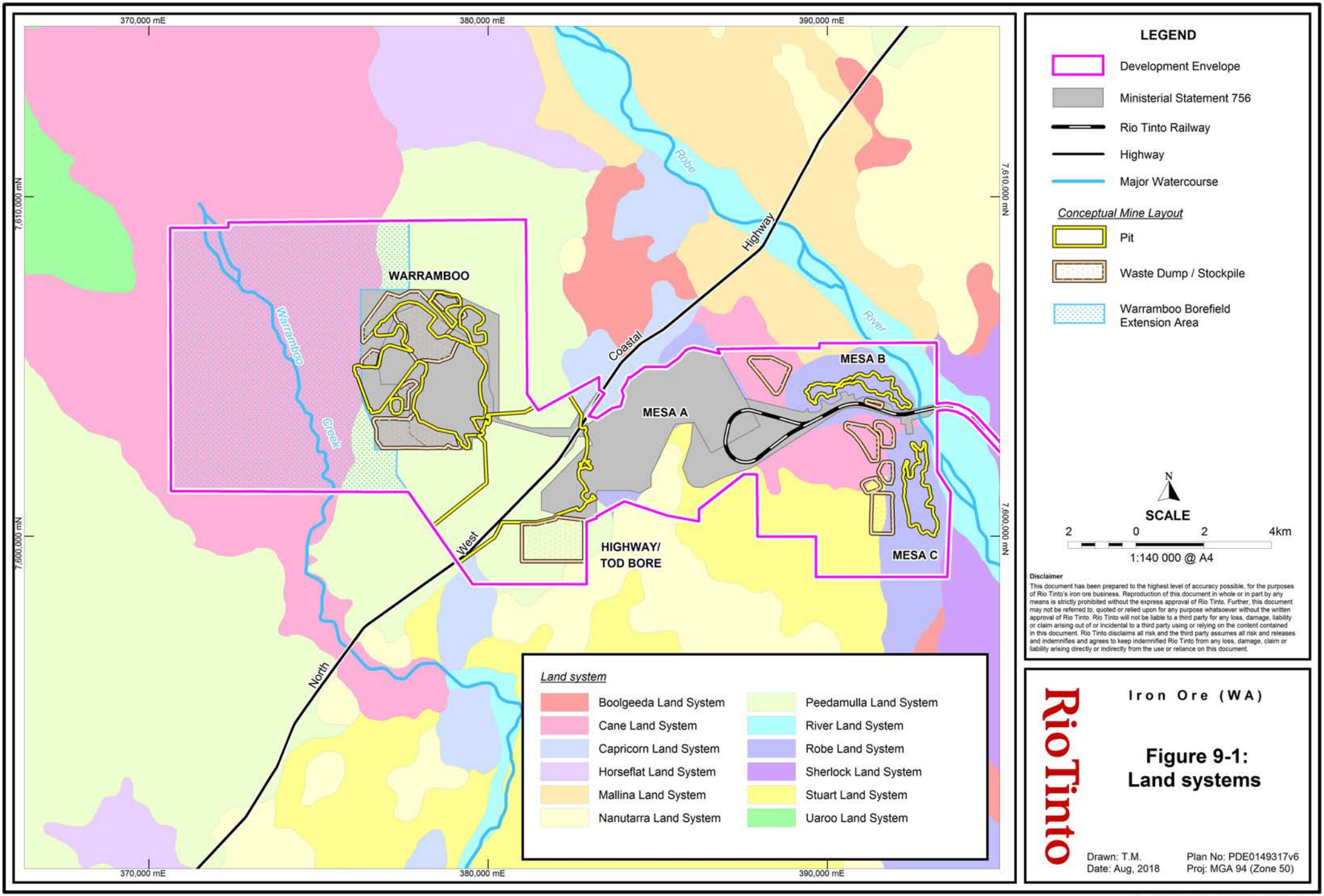
9.4.2 Land systems

The western portion of the Development Envelope intersects the land systems listed in Table 9-3 and shown on Figure 9-1 (van Vreeswyk *et al.* 2004). The mesas within the western portion of the Development Envelope, and more generally in the Robe Valley, are associated with the Robe land system.

Table 9-3: Land Systems

Land System	Geology	Geomorphology	% of western portion of the Development Envelope
Cane	Quaternary alluvium.	Depositional surfaces; flood plains subject to fairly regular flooding and often with windblown scalds and hummocks and/or water erosion, slightly more elevated stony plains and plains with gilgai microrelief, tracts receiving more concentrated throughflow; very widely spaced to sparse patterns of non-tributary, distributing and reticulated channels and larger through going trunk channels.	37
Capricorn	Lower Proterozoic sandstone, greywacke, dolomite and shale.	Erosional surfaces; ranges and hills with steep rocky upper slopes, more gently sloping stony footslopes, restricted stony lower plains and valleys; moderately spaced tributary drainage patterns. Relief up to 180 m.	1
Mallina	Quaternary alluvium and eluvium.	Depositional surfaces; level sandy surfaced plains on alluvium with occasional patches of small claypans, minor clay plains with gilgai microrelief, minor stony plains and occasional isolated low hills; drainage patterns restricted to rare, non-tributary through channels with narrow terraces.	<1
Nanutarra	Cretaceous conglomerate, shale, siltstone and sandstone.	Erosional surfaces; formed by partial dissection of an old plateau of marine sediments - low plateaux, dissected plateaux, mesas, buttes and low hills with rounded crests, short stony footslopes with parallel and radial drainage patterns, narrow dendritic drainage zones and creeklines between dissected plateaux and mesas. Relief up to 40 m.	1
Peedamulla	Quaternary eluvium, alluvium and minor colluvium; minor Cretaceous shale, siltstone, sandstone and conglomerate.	Depositional surfaces; occasional low rises and low hills above extensive, level to gently undulating gravelly plains receiving sheet flow, minor stony clay plains with gilgai microrelief, sparse shallow tributary drainage floors with or without channels. Relief up to 15 m.	36

Land System	Geology	Geomorphology	% of western portion of the Development Envelope
River	Quaternary alluvium.	Flood plains and river terraces subject to fairly regular overbank flooding from major channels and watercourses, sandy banks and poorly defined levees and cobble plains. Banks, levees and slightly higher upper terraces receive less regular flooding than lower terraces and flood plains.	2
Robe	Tertiary pisolitic limonite and laterite (Robe Pisolite).	Erosional surfaces; formed by partial dissection of old Tertiary surfaces, dissected plateaux and long lines of low mesas along present and past river valleys, indented near vertical breakaway faces and steep slopes with limonite outcrop and pisolitic gravelly mantles, restricted gravelly lower slopes and closely to moderately spaced narrow tributary drainage floors. Relief up to 50m.	14
Sherlock	Quaternary alluvium.	Depositional surfaces; level stony alluvial plains with some gilgai development; very rare, mainly non-tributary, through going drainage lines and channels.	<1
Stuart	Lower Proterozoic schist, gneiss, sandstone, shale and minor volcanics. Quaternary colluvium and alluvium.	Mainly erosional surfaces; minor hills, gently undulating stony plains and broad lower plains; moderately spaced tributary drainage tracts in upper parts becoming sparse and much broader downslope, may be channelled or un-channelled. Relief up to 25 m.	8



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile
- Warramboo Borefield Extension Area

N

SCALE

2 0 2 4km

1:140 000 @ A4

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Rio Tinto

Iron Ore (WA)

Figure 9-1: Land systems

Drawn: T.M.
Date: Aug, 2018

Plan No: PDE0149317v6
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

9.4.3 Geology and morphology

The surface geology of the western portion of the Development Envelope is shown in Figure 9-2. The deposits between Mesa C and Warramboo are believed to have formed as part of the Robe River palaeochannel in the late Mesozoic to early Tertiary period. In the vicinity of Mesas A, B and C, the Robe River is thought to have flowed across the broad Yarraloola Conglomerate Formation, with downward erosion into the conglomerate forming the river channel. Later erosion has resulted in a varying cover of alluvium, colluvium and aeolian sands. The more resilient iron rich channel fill remained as elongate topographic highs (mesas) along the current erosional surface. Robe Pisolite generally outcrops as low mesa-form hills within the Robe Valley. The Warramboo and Highway/Tod Bore deposits form part of the buried downstream continuation of the outcropping Robe Pisolite deposit present at Mesas A, B and C.

9.4.4 Character and condition of the mesa landforms

The Development Envelope lies in the west Pilbara region. The landscape in the west Pilbara is dominated by plains interspersed with low-lying hills and mesa formations.

The elevation in the west Pilbara is much lower than that in the eastern and south-eastern Pilbara region, particularly the Hamersley Ranges where the landscape is comprised of rugged and highly dissected landforms, including prominent high points, ridges and cliffs.

The plains in the western portion of the Development Envelope generally lie at approximately 70 m Australian Height Datum (AHD). Elevation gradually increases towards the east where the headwaters of the Robe River originate in the Hamersley Range. The mesa formations, breakaways and hills are prominent in the landscape, with the mesa formations rising in the western portion of the Development Envelope to between 30 m and 50 m above the extensive surrounding plains.

Mesa formations are relatively common in the western Pilbara (Figure 9-3) and are associated with several geology types including pisolite. More than 600 individual occurrences of Robe Pisolite have been mapped across the western Pilbara (including those in the western portion of the Development Envelope). Thirty-four named mesas and numerous unnamed minor mesa formations and breakaways occur in the Robe Valley (including those in the western portion of the Development Envelope) (Figure 9-4).

Mesas B and C feature escarpments, gullies and scree slopes, with elevated flat plateaus. Mesa A is a partial mesa (cuesta) featuring an escarpment, gullies and scree slopes on the north-eastern section of the landform while the south-western section is part of the surrounding landscape and does not have any escarpments or gullies. The Warramboo and Highway/Tod Bore deposits do not exhibit mesa characteristics. The terrain in the vicinity of these deposits is relatively flat and slopes down to the north-north-west.

John Cleary Planning (2005) defined two main types of mesas:

- Discrete mesas
- Partial mesas that have a section that merges with an adjacent landform.

The Robe River mesas are generally discrete mesas. Brief descriptions of the mesas in the western portion of the Development Envelope as defined by John Cleary Planning (2005) are provided below:

Mesa A

- A partial mesa with the landform merging with the plain to the south-west
- A small number of well-separated, distinct, deeply incised gullies
- A variable escarpment, varying from scree with talus to prominent buttresses and walls
- Relatively flat mesa top
- Low to moderate height
- Approximately 770ha in surface area.

Mesa B

- Discrete mesa
- Double-tiered escarpment
- Ridges extending out from the main body of the mesa, alternating with valleys that vary from short bowls to short narrow valleys
- Contiguous flat mesa top
- Approximately 160ha in surface area.

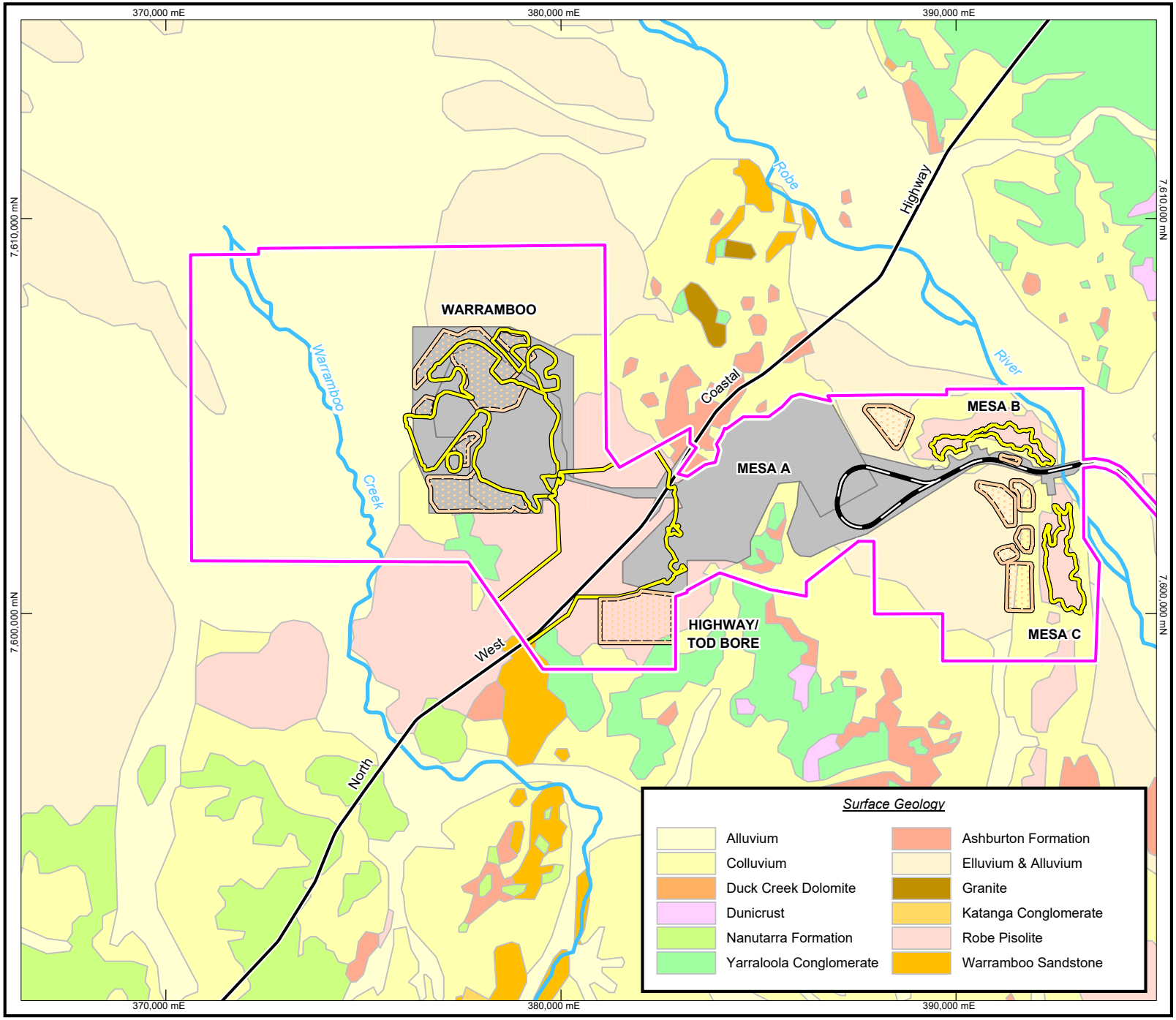
Mesa C

- Discrete mesa
- Long, large valleys that extend well into the body of the mesa
- Various tiers to the escarpment – single, double and triple tiered, the latter especially on the ends of the mesa
- Relatively high with substantial scree footslopes
- Contiguous flat mesa top
- Approximately 218ha in surface area.

The Robe River pisolite mesas have varying characteristics as palaeochannel deposits. John Cleary Planning (2005) identified the distinctive topographic variations amongst Mesas A to N in the Robe Valley and concluded that this is a result of a combination of variations in channel development during their formation in a depositional environment. For example, the well-defined escarpments at Mesa J and Mesa A originated in sharply defined channels, whereas the more undulating landscape of Mesa G is likely to have their origin in a more braided channel environment. The partial mesa formation of Mesa A demonstrates a particular variation in this evolution; however Mesa A is not considered unique as similarly formed mesas have been recorded elsewhere in the western Pilbara (John Cleary Planning 2005). Mesas B and C are not considered to have any particular attributes that set them apart from other mesas in the Robe Valley.

The mesas of the western portion of the Development Envelope are considered to be well represented in the Robe Valley and in the broader western Pilbara region.

Sixteen mesas in the Robe Valley have undergone a degree of mining development and a further seven mesas have undergone a degree of mineral exploration. Most of the mesas that have undergone mining development have at least part of the mesa escarpment remaining, including features that are of ecological importance. It is estimated that on average across the Robe Valley approximately 83% of the mesa escarpments are intact, either on mesas that have not been mined or as retained escarpments (Bat Call WA 2017b).



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile

N

SCALE

0 2 4 6km

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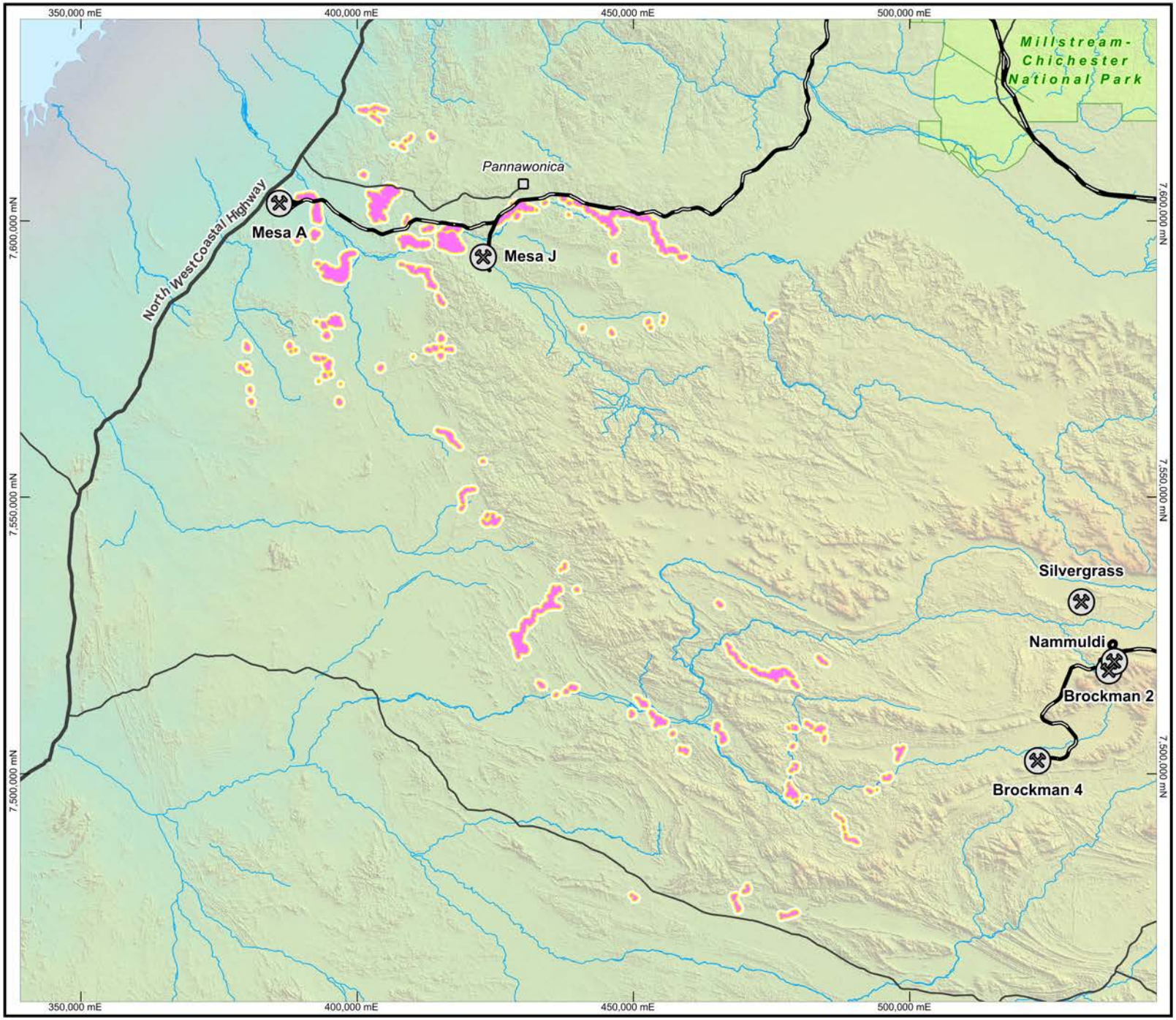
Iron Ore (WA)

Figure 9-2: Surface geology

Drawn: T.M.
Date: Aug, 2018

Plan No: PDE0149316v6
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Town
- Rio Tinto Mine
- Mesa
- National Park
- Rio Tinto Railway
- Highway
- Major Road
- Major River / Creek

N

SCALE

0 10 20 30 40 50km

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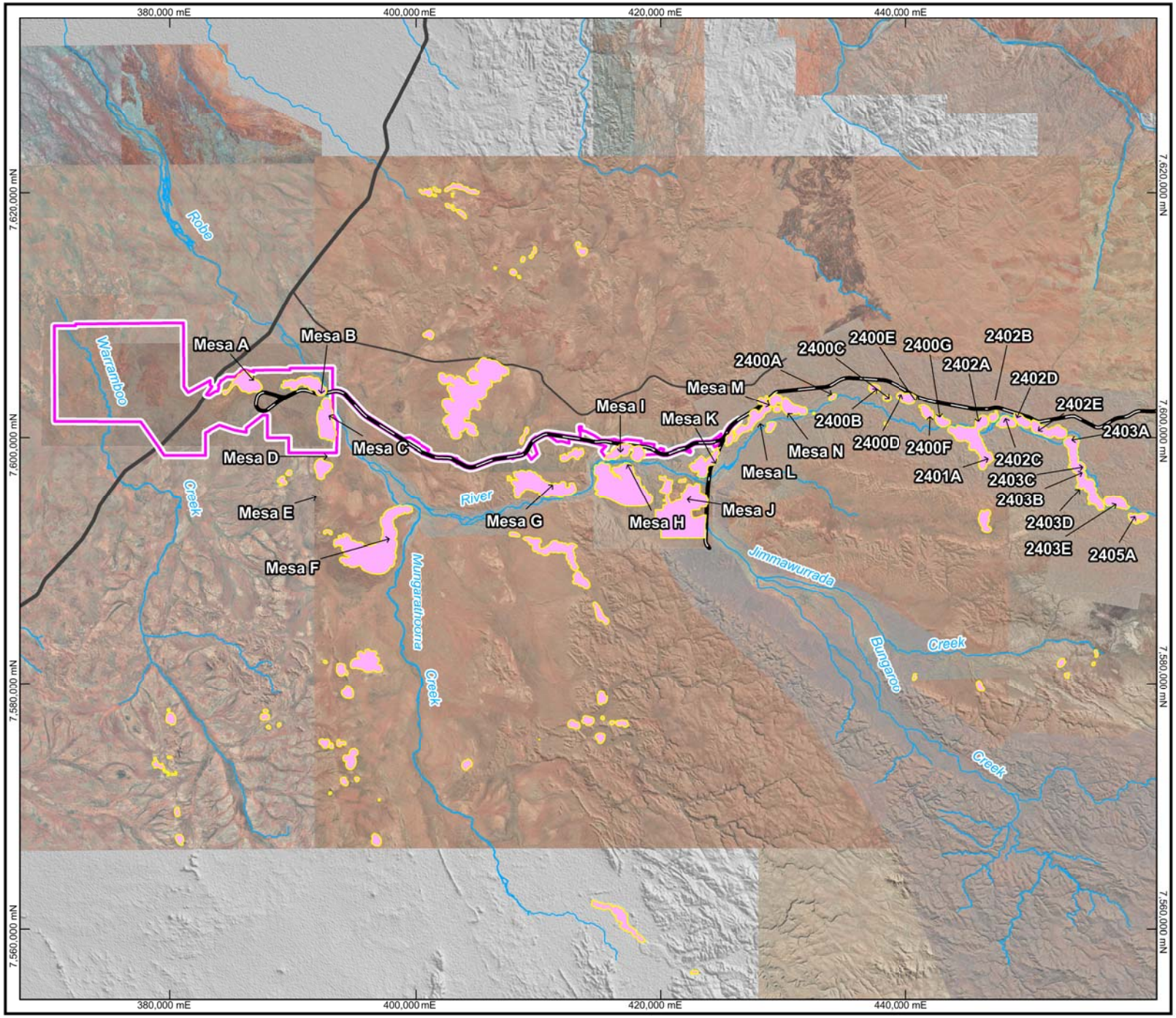
Iron Ore (WA)

Figure 9-3: Mesas in the western Pilbara region

Drawn: T.M.
Date: April, 2018

Plan No:PDE0150930v4
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping



LEGEND

- Development Envelope
- Mesa
- Rio Tinto Railway
- Highway
- Major Road
- Major Creek

N

SCALE

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Iron Ore (WA)

Figure 9-4: Mesas of the Robe Valley

Drawn: T.M.
Date: Aug, 2018

Plan No:PDE0150931v5
Proj: MGA 94 (Zone 50)

Geospatial information and Mapping

9.4.5 Mesa landform robustness

Prior to approval of the existing Mesa A/Warramboo Iron Ore Project, a geotechnical study was undertaken of Mesa A and other mesas in the Robe Valley (Snowden 2007; Appendix 10). The study assessed:

- The stability of mesa escarpments at Mesa A, Mesa J, Mesa K and Mesa M
- The potential effects of mining on natural mesa escarpments.

The literature review conducted by Snowden (2007) found that natural retreat rates of mesa escarpments in analogous geological and environmental conditions to the Pilbara are very low. Following a site visit and further desktop assessment, Snowden (2007) concluded that the mesa escarpments appear to be stable landforms, with little, if any, natural erosion occurring over 15 to 20 years. The mesa escarpments are likely to undergo a very slow process of natural erosion triggered by formation of shallow caves in softer pisolitic or basement material, undercutting the surface hardcap layer which is generally resistant to erosion. There was no evidence of escarpment failures within the last two to three decades at any of the study sites. This, combined with indirect evidence such as the prevalence of mature trees growing on and directly below escarpment faces, suggests the cycle of cave formation leading to roof failure is a very slow process (Snowden 2007).

With regard to sensitivity to damage from development activities, Snowden (2007) found that mining operations adjacent to mesa escarpments have not caused large scale instability of natural slopes. Sections of remnant perimeters at some sites mined up to 25 years ago without blast control showed some blast damage (i.e. flyrock and minor fractures) to the mesa escarpments only where the retained width was reduced to 15 m. However, a natural bluff with a maximum width of 63 m and minimum width of 3 m directly adjacent to a section of mesa mined over 20 years ago showed no damage from blasting and no recent erosion effects. Snowden (2007) noted that there are numerous examples of mesas 50 m in width or less that show no evidence of instability or accelerated erosion. It was concluded that mining activities have no discernible impact on the natural erosion rates of mesa escarpments and the probability of a catastrophic failure of the remnant mesa escarpments in the Robe Valley is extremely low.

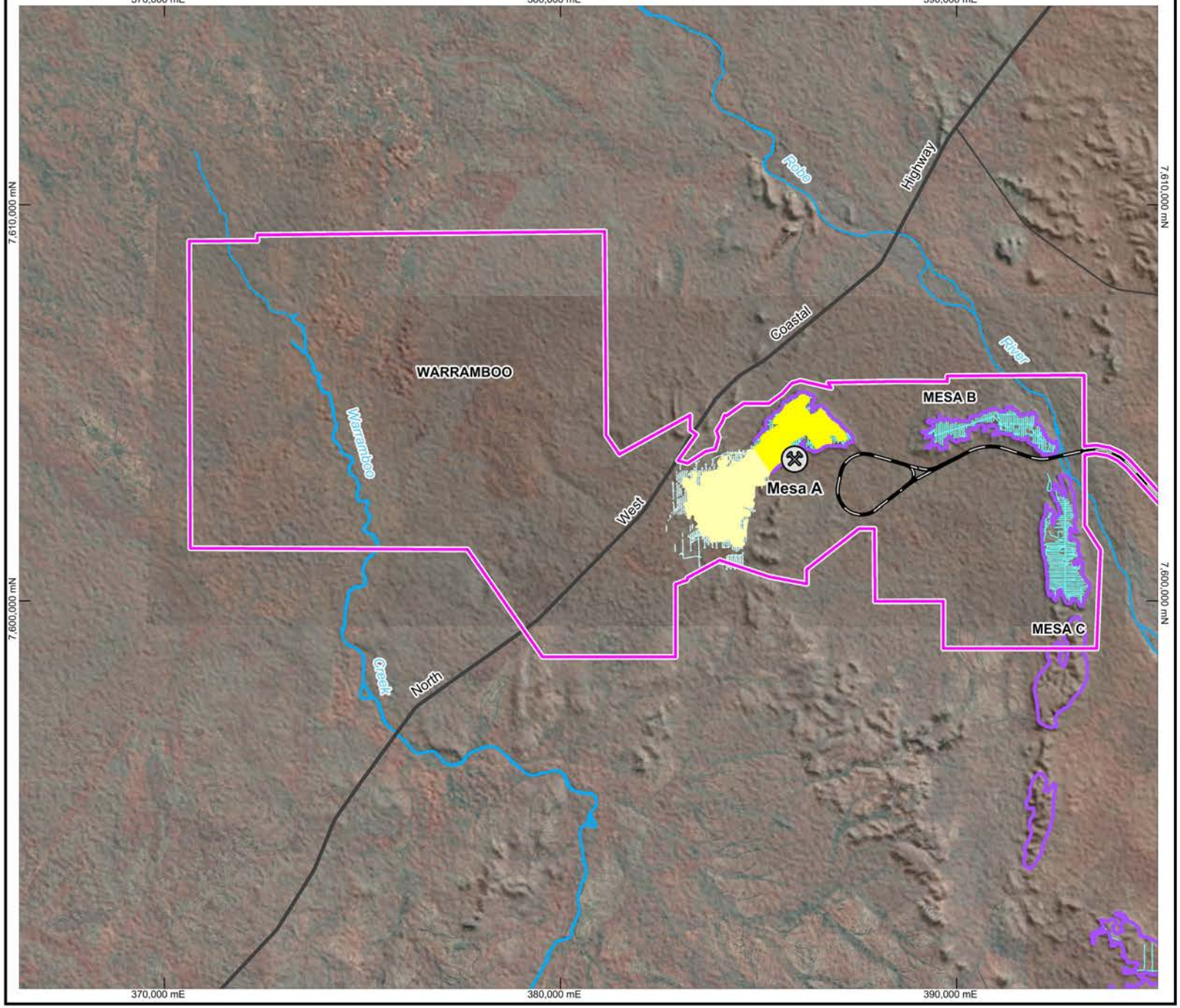
Based on the findings of Snowden (2007), the mesa landforms associated with the Proposed Change are considered to be robust, with low sensitivity to damage from development activities.

9.4.6 Current integrity of the mesa landforms

Existing disturbance to mesas in the western portion of the Development Envelope is shown on Figure 9-5. Mesa A has been disturbed as part of the approved activities. Other than a 110 m wide cut to the escarpment to enable access to the mesa plateau, the mesa escarpment has been retained and remains intact.

A range of management measures in place at Mesa A have resulted in no discernible instability of the retained mesa escarpment. The escarpment varies in width, ranging from 50 m to approximately 200 m at the top surface. Batters within the pit are on a 75 degree slope and extend up to 9 m in height.

Mesas B and C have been subject to exploration drilling involving minor clearing of vegetation; however, these two mesas remain predominantly intact.



LEGEND

- Development Envelope
- Mesa

Disturbance to Mesa

- Mining
- Exploration

Disturbance to Partial-Mesa

- Mining
- Exploration
- Rio Tinto Railway
- Highway
- Major Road
- Major River / Creek

N

SCALE

2 0 2 4 6km

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Iron Ore (WA)

Figure 9-5: Existing disturbance to mesas

Drawn: T.M.
Date: June, 2018

Plan No:PDE0159982v3
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

9.4.7 Ecological values

Key habitat values associated with the mesas occur primarily on the escarpments, with sections of the escarpments of Mesas A, B and C containing features such as caves, rock crevices, overhangs, fissures and boulders that provide a range of habitat for fauna, including conservation significant fauna. There are no specific habitat values associated with landforms provided by the below ground deposits at Warramboo and Highway/Tod Bore. The structural formations of the mesas, and shaded areas of ridgelines, support short range endemic invertebrates by providing mesic qualities and a cooler, more humid microclimate than is present in the surrounding landscape (EPA 2009 as cited in MWH 2015b). The mesa escarpments also provide a fire refuge for a range of flora and fauna species, and associated vegetation communities, within a landscape subject to frequent burns (MWH 2015b).

The caves and deeply incised gullies within the mesa escarpments at Mesas B and C are considered to provide important habitat for Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python, which are listed as threatened under the EPBC Act (see Section 12). The mesa plateaus are considered to be of limited ecological and habitat value to threatened species. The Robe Pisolite within the mesa formations provides troglofauna habitat and, where it intersects the water table, stygofauna habitat. Stygofauna have been recorded at Mesa C and troglofauna have been recorded at Mesas A, B and C, with some of the troglofauna species likely to have limited distributions (see Section 6.3).

An assessment was undertaken in May 2015 (MWH 2015b) to categorise, map and rank the ecological value of the mesa escarpments at Mesas B and C. Categories were defined in terms of various features including importance to species, habitats and vegetation of conservation significance known from the region and level of disturbance. The assessment considered 53% of the Mesa B escarpment as Good and 45% as Moderate, and 39% of the Mesa C escarpment as Good and 52% as Moderate. Areas considered to be Very Good included deeply incised gullies or slopes which provide microclimates and these comprised 2% of the Mesa B escarpment and 9% of the Mesa C escarpment.

9.4.8 Heritage values

Numerous heritage surveys have been undertaken for the approved activities and the Proposed Change. These surveys have identified significant Aboriginal heritage and cultural values on the mesa plateaus and the mesa escarpments in the western portion of the Development Envelope which include artefact scatters, rock shelters, scarred trees and quarries. Sites associated with the mesa landforms that were identified by the Kuruma Marthudunera People as being of particular significance include a rock shelter site with spinifex matting at the rear of the shelter located on the southern escarpment of Mesa B and the ethnographic site Yirrkawiya Gap on the north-west portion of Mesa C. The mesa escarpments are also noted as features of the landscape with cultural significance, including use as navigational landmarks. Further detail on heritage sites occurring in the western portion of the Development Envelope is provided in Section 10.4.

9.4.9 Amenity

The Development Envelope is not located near any major population centres, with the closest town of Pannawonica located approximately 40 km to the east. The region is very sparsely populated, with occasional homesteads, outstations and roadhouses, none of which are located within view of the mesas in the western portion of the Development

Envelope. Primary land uses are mining operations, mineral exploration and pastoral activity. Traditional Owners also use the area near Mesas A, B and C for activities such as camping, fishing and hunting. There are no known tourism activities in the vicinity of the Development Envelope.

The North West Coastal Highway is the main travel route though the region and is a heavy-use, sealed road supporting a mix of local, industrial and tourist traffic. The closest link road extending from the Highway is Pannawonica Road which carries traffic largely related to the mine operations in the area. Pannawonica Road runs east-west and is approximately 2.5 km to the north-east of the Development Envelope. Other roads nearby are generally unformed pastoral access roads, many of which are also used for mining exploration.

Panoramic, long distance views over the surrounding country are generally available throughout the western portion of the Development Envelope and surrounds, due to the open nature of the landforms and sparse vegetation. Views become confined close to, and between, mesa formations, in gullies and near the riparian vegetation. There are clear views of the mesas in the western portion of the Development Envelope from most nearby locations on the North West Coastal Highway, and the mesas are features that contrast with the scenery otherwise experienced by travellers elsewhere on the Highway. In this regard the mesa landforms contribute to the tourism experience in a very small way and may attract interest for some travellers (John Cleary Planning 2005).

9.5 Potential Impacts

A number of potential impacts are identified in the ESD. On the basis of surveys and assessments relating to landforms completed to date, the following are considered the key issues and are addressed in Section 9.6.

9.5.1 Direct impacts

The potential direct impacts of the Proposed Change on the mesa landforms are:

- Loss of variety due to removal or degradation of the mesa landforms
- Loss of the integrity of the mesa landforms due to disturbance.

9.5.2 Indirect impacts

The potential indirect impacts of the Proposed Change on the mesa landforms are:

- Loss or degradation of the ecological values of the mesa landforms
- Loss or degradation of the social values of the mesa landforms through loss of indigenous heritage and amenity values.

9.5.3 Cumulative impacts

Mining has been undertaken historically on 14 mesas in the Robe Valley and is currently underway on two mesas (Mesas A and J) with historic and remnant mining at Mesa K.

9.6 Assessment of Impacts

The Warramboo deposit landform has previously been altered by mining operations, and will be further altered by above and BWT extension of the existing pits, increases in the height of existing waste dumps and generation of additional waste dump areas.

The Highway/ Tod Bore deposit will be altered by producing open depressions where the mine pits will be located and through development of a waste dump. Mining of the Highway/Tod Bore deposit will ultimately require re-alignment of the North West Coastal Highway. It is anticipated that separate approval for the re-alignment of the Highway will be required. Consultation and investigations to determine the most appropriate alignment will be initiated well in advance of commencement of mining of the Highway/Tod Bore deposit. The potential visual impacts of mining the Highway/Tod Bore deposit will be considered once the preferred North West Coastal Highway re-alignment is identified.

The Warramboo and, Highway/Tod Bore deposits are not associated with any significant landform values that may be affected by the Proposed Change. The assessment, therefore, focuses on the exposed mesa landforms of Mesas A, B and C. Where appropriate, these non-mesa deposits are considered, including in the discussion of the approach to closure and potential impacts to visual amenity values from construction of waste dumps.

The Mesa B and Mesa C landforms will be altered by mining activities, including establishment of escarpment cuts to allow access to each mesa and removal of topsoil, overburden and ore from within the mesa formation. The Mesa A landform has previously been altered by mining operations. The Proposed Change will further alter the landform through a minor extension to the existing mine pit, an increase in the height of the existing waste dump and a widening of the existing escarpment cut to allow haul trucks from Mesas B and C to access the primary crusher at Mesa A.

An assessment of how these alterations to the mesa landforms will affect the values of variety, integrity, ecological and social importance is provided in the following sections.

9.6.1 Direct impacts

9.6.1.1 Loss of variety due to removal or degradation of the mesa landforms

As stated in Section 9.4.4, mesa formations are relatively common in the western Pilbara region; it is estimated between 250 and 300 exposed Robe Pisolite mesas occur in the western Pilbara region with 34 named mesas and numerous unnamed minor mesa formations and breakaways occurring in the Robe Valley (including those in the western portion of the Development Envelope). All Robe River pisolite mesas have varying characteristics as palaeochannel deposits; Mesas B and C fall within that variability, are relatively small and are not considered to have any particular attributes which set them apart from other mesas in the Robe Valley. The partial mesa formation of Mesa A demonstrates a particular variation in palaeochannel evolution, but is not considered unique as similarly formed mesas have been recorded elsewhere in the western Pilbara (John Cleary Planning 2005).

The most prominent and unique feature of each mesa is the escarpment. The Proposed Change has been designed to retain the mesa escarpments at Mesas A, B and C, with disturbance limited to widening of the existing escarpment cut at Mesa A and construction of escarpment access cuts at Mesas B and C. Widening and construction of the access cuts will result in disturbance to less than 3% of the perimeter of each mesa escarpment.

The retention of the mesa escarpments will preserve the prominence and scale of the mesa landforms in the landscape.

Given the minimal changes proposed to Mesa A, retention of escarpments at Mesas A, B and C and that similar mesa formations occur throughout the Robe Valley and the wider west Pilbara region, it is considered that the Proposed Change is unlikely to result in a loss of landform variety.

9.6.1.2 Loss of the integrity of the mesa landforms due to disturbance

The integrity of a landform can be considered both in terms of whether the landform is largely intact and whether the landform has structural integrity.

The Mesa A landform has been altered by the existing mining operation which has removed much of the interior part of the landform. The Proposed Change will not significantly change the current remnant Mesa A landform. Consistent with the approach already in place at Mesa A, the Proposed Change has been designed to retain the escarpments of Mesas B and C which represent the most complex and valuable feature of the landform. Although the Proposed Change will affect the integrity of Mesas B and C in that much of the interior part of each landform will be removed, the most valuable and visual part of the landform will be retained with the exception of the areas where minor escarpment access cuts are required. The Proposed Change has been designed to minimise the size of the escarpment cuts such that the proposed cuts represent disturbance to less than 3% of the perimeter of each mesa escarpment.

An assessment of the minimum escarpment width required to ensure the structural integrity of retained mesa escarpments in the Robe Valley was undertaken by Rio Tinto (Rio Tinto 2017i). The study considered geological, blasting, geotechnical and wall monitoring data from current mining operations to conclude that an escarpment width of 30 m is adequate to maintain the long-term stability and integrity of mesa escarpments. This is supported by observations such as that of a remnant bluff with a maximum width of 63 m and minimum width of 3 m directly adjacent to a section of mesa mined over 20 years ago that shows no damage from blasting and no recent erosion effects (Snowden 2007). The existing operations at Mesas A and J, historic and recent remnant mining at Mesa K and other historical mining operations in the Robe Valley demonstrate that mesa escarpments are stable and the structural integrity can be maintained by ensuring retention of an adequate width of escarpment. As the Proposed Change has been designed with escarpment widths that are greater than 30m, the integrity of the remaining landform is not expected to be compromised.

Given the mesa escarpments, which represent the most valuable feature of the mesa landform, will remain largely intact and the structural integrity of the landform will be maintained through retention of an adequate escarpment width, it is considered that the Proposed Change will not significantly impact the integrity of the mesa landforms.

9.6.2 Indirect impacts

9.6.2.1 Loss or degradation of the ecological values of the mesa landforms

The Proposed Change has been designed to retain the mesa escarpments with the exception of the areas required for escarpment cuts to allow access to the mesas. The Proposed Change will minimise the size of the escarpment cuts such that the proposed cuts represent disturbance to less than 3% of the perimeter of each mesa escarpment.

The structural integrity of the retained escarpments will be maintained through retention of an adequate escarpment width (Section 9.6.1.2).

Based on the outcomes of the MWH (2015b) assessment of the ecological value of the mesa escarpments, the locations and designs of the escarpment cuts were selected to avoid disturbance to the sections of the escarpments with the highest ecological value.

Based on the outcomes of Bat Call WA (2016), the locations of the cuts were selected to reduce potential impacts to Ghost Bats. The Proposed Change has been designed to avoid direct disturbance to the one recorded potential diurnal maternal roost cave at Mesa B (MBC-05) and 11 of the 12 recorded nocturnal roost caves at Mesa B, including MBC-03, MBC-04, B1 and MBS-01 which are considered the most significant nocturnal roosts as they may be part of a diurnal roost complex surrounding cave MBC-05. The Proposed Change has been designed to avoid direct disturbance to all nine recorded caves in use by Ghost Bats at Mesa C including one potential diurnal roost (MCC-02) and all of the eight recorded nocturnal roost caves.

The mine design incorporates a 40 m setback distance between the back of each potential diurnal/maternal roost cave and the proposed mine pit and 50 m from the entry to nocturnal roosts (except shelter MBS-05 which will be impacted by the haul road to Mesa B), to minimise the impact of blasting on the structure and quality of roosts.

The Proposed Change has been designed to retain significant volumes of connected troglofauna habitat within the mesa landforms of Mesas A, B and C. Consistent with existing operations at Mesa A, a continuous block of troglofauna habitat greater than 15 m thick (except at the escarpment cuts) with retention of at least 50% of the pre-mining habitat volume on each mesa is proposed.

The run-off provided by each mesa to the surrounding plains during rainfall events is localised with only short runs of surface water onto plains observed. Alterations to surface water run-off from mining of the mesas are not considered to be significant when considered in the context of the size of the Robe River catchment, which is approximately 7,500 km^2.

Given the retention of mesa escarpments with adequate width to maintain structural integrity, avoidance of the escarpment sections with the highest ecological value and retention of at least 50% of the pre-mining troglofauna habitat volume on each mesa, it is considered, that the Proposed Change is unlikely to significantly impact the ecological values of the mesa landforms.

9.6.2.2 Loss or degradation of the social values of the mesa landforms

Aboriginal heritage

The Proposed Change has been designed to retain the mesa escarpments, except where cuts are required for access. The retention of the mesa escarpments will ensure that the mesa landforms will still be present and can still be used as navigational landmarks by the Kuruma Marthudunera People. The proposed escarpment cuts are on the western and southern sides of Mesa B and on the western side of Mesa C thus will not impact the visual amenity of the mesas from the direction of the Robe River.

The location and layout of the mine and associated infrastructure has been designed to minimise impacts to Aboriginal heritage sites. No direct disturbance is proposed to rock

shelters on Mesas B and C, including the rock shelter site on Mesa B with spinifex matting. The MEZs for Mesas B and C include the rock shelters on both mesas, thus protecting the rock shelters from direct disturbance. In consultation with the Kuruma Marthudunera People, the Proponent has decided to submit applications under Section 18 of the AH Act for rock shelters on the escarpments of Mesas B and C where there is any potential for indirect impacts due to vibration or fly rock. This is a conservative approach as the proposed MEZ has been designed to include all recorded rock shelters and to be of a width that is considered geotechnically stable.

Yirrkawiya Gap has recently been delineated in consultation with the Kuruma Marthudunera People. The ethnographic significance of Yirrkawiya Gap is recognised and as such the site boundary has been included in the MEZ at Mesa C. A portion of the area recognised by DPLH as the Yirrkawiya Gap site contains some archaeological sites which may be subject to indirect impact. These archaeological sites will be included in the Section 18 applications for the Mesa C escarpment. Consultation with the Kuruma Marthudunera People has indicated that clearing the archaeological sites will not alter the ethnographic significance of Yirrkawiya Gap. Widening of an existing track through part of the site will also be undertaken under Section 18 during the construction phase but again this will not alter the ethnographic significance of Yirrkawiya Gap.

Given retention of the mesa escarpments, avoidance of direct disturbance to rock shelters, the inclusion of Yirrkawiya Gap in the MEZ and management of sites under the AH Act that may be disturbed, it is considered that the Proposed Change is unlikely to significantly impact the heritage values associated with the mesa landforms.

Amenity

The main physical alteration to the mesa landforms will be the creation of a void in the centre of the mesas where the mine pits will be located. Mining will occur below the mesa surface and behind the retained escarpment face. Retention of the escarpment will minimise the impact to visual amenity as it will conceal the mine pits from view and there will be negligible impact on the horizon silhouette. The main alteration to the landscape in terms of visual amenity will be the construction of mineral waste dumps.

The Warramboo & Mesa B/C VIA (Rio Tinto 2018b; Appendix 10) assessed the visual impact of the Proposed Change for sites with the greatest potential for visual impact and sites of interest (e.g. views from the Robe River). The assessment (Rio Tinto 2018b) showed that the proposed mine pits at Mesas B and C will not be visible behind the retained mesa escarpments. Mineral waste dumps will be partially visible along the portion of North West Coastal Highway within the western portion of the Development Envelope, from Warramboo Creek, along short sections of Pannawonica Road and along the short section (less than 1 km) of the Robe River that aligns with the gap between Mesa B and Mesa C. The proposed waste dumps near Mesas B and C will remain lower than the surrounding mesas; the modelling shows these waste dumps to be visible from the viewing points only as low-lying disturbance in the distance. Most views of the proposed waste dumps will also be obscured by existing vegetation.

The most clearly visible waste dump from the North West Coastal Highway is the existing Mesa A waste dump located approximately 500 m from the highway. This waste dump is currently visible from a section of the North West Coastal Highway to the south of and adjacent to the existing Mesa A/Warramboo Iron Ore Project. It is proposed that this

existing waste dump will increase in height from 10 m to a maximum of 20 m as part of the Proposed Change and thus be more visible.

Waste dumps near Mesas B and C will remain lower than the surrounding mesas. The view of waste dumps from major roads and the Robe River has been minimised as far as possible; however, some will be visible during operation and at closure (see Section 9.7). Visual impacts will be further reduced through construction of the waste dumps to be aesthetically compatible with the surrounding landscape and through rehabilitation of the waste dumps.

Given the limited tourism and sensitive receptors in the area and that the mesa escarpments will be retained, waste dump heights at Mesas B and C will remain lower than the surrounding mesas and waste dumps will be rehabilitated, it is considered that the Proposed Change is unlikely to significantly impact the amenity values associated with the mesa landforms.

9.6.3 Cumulative impacts

The most prominent and unique feature of each mesa is the escarpment. Mining has been undertaken historically on 14 mesas in the Robe Valley and is currently underway on two mesas (Mesas A and J) with historic and remnant mining at Mesa K. In addition to the Proposed Change to undertake mining operations at Mesas B and C, a Proposal to undertake mining at Mesa H has been referred to the EPA under Section 38 of the EP Act. Between Mesa A in the west of the Robe Valley and Mesa 2405A in the east of the Robe Valley, there are an additional 15 named mesas that have not been previously mined and are not currently part of a Proposal for mining.

The initial mining undertaken in the Robe Valley did not prioritise retention of the mesa escarpments. The proportion of escarpment remaining on each of the 14 historically mined mesas varies between 0% and over 90% but is generally less than 50% (Bat Call WA 2017b). The current mining at Mesas A and J and recent remnant mining at Mesa K have retained the prominent mesa escarpments (where they exist), other than disturbance required for infrastructure. The proposed operations at Mesas B, C and H will also include retention of the mesa escarpments, except where escarpment access cuts are required. Considering only the named mesas in the Robe Valley between Mesa A and Mesa 2405A, it is estimated that on average across the Robe Valley approximately 83% of the mesa escarpments are intact, either on mesas that have not been mined or as retained escarpments (Bat Call WA 2017b).

Snowden (2007) concluded that mining activities have no discernible impact on the natural erosion rates of mesa escarpments and the probability of a catastrophic failure of the remnant mesa escarpments in the Robe Valley is extremely low. The existing operations at Mesas A and J and previous operations demonstrate that mesa escarpments are stable and any risk of collapse can be adequately managed.

The retention of mesa escarpments ensures the most prominent and unique feature of each landform is retained. Given the Proposed Change will retain the escarpments at Mesas A, B and C, except for escarpment access cuts, the Proposed Change will not significantly alter the cumulative disturbance to the prominent mesa escarpments in the Robe Valley and their associated ecological, social and amenity values.

9.7 Closure

The Mesa A Hub Closure Plan (Rio Tinto 2017b) is the updated closure plan for the Mesa A, B, C, Warramboo and Highway/Tod Bore operations and supersedes previous closure plans for the approved Mesa A/Warramboo Project. The Mesa A Hub Closure Plan is applicable to mine developments and associated infrastructure, excluding rail and road infrastructure, within the Development Envelope. A summary of the approach to closure and how it relates to the landform factor is provided below.

The proposed final land use assumes that the site will be rehabilitated to create a safe, stable and non-polluting landscape revegetated with native species, to maximise environmental and cultural heritage outcomes and ensure the site does not adversely impact on the current surrounding land use. Due to the nature of the mining activity undertaken, the final landform will include large voids and waste dumps, and will therefore be unlikely to support pastoral activities in the immediate vicinity of the mining areas. The final land use will be determined prior to closure during final planning phases and in consultation with relevant stakeholders.

Mineral waste generated by mining will be placed in external out-of-pit dumps as well as progressively backfilled into pit voids as they become available. The current closure strategy is for all BWT pits to be backfilled to appropriate levels to prevent the formation of pit lakes and above water table pits will be backfilled opportunistically with mineral waste. The majority of the Warramboo Mine pits will be backfilled with waste fines and capped with inert waste rock. Most of the remaining pits at Warramboo will be backfilled with mineral waste.

Waste dumps located on Rio Tinto mine sites are designed and rehabilitated in accordance with internal Landform Design Guidelines, which aim to achieve dumps that are safe, stable, aesthetically compatible with the surrounding landscape, vegetated and non-polluting. The Mesa A and Warramboo areas contain a high proportion of potentially erodible alluvial material, whereas the Mesa B and C areas contain a relatively high proportion of waste which has low erodibility. Erodibility testing and landform modelling of the materials has been completed and the current waste dump designs have incorporated the appropriate design parameters for long-term stability of the proposed waste dumps. Erosion modelling has been conducted on the conservative assumption that slopes are not vegetated; however, vegetation is expected to establish on all slopes, thereby further reducing the erosion potential.

The mesa landforms have landscape, visual, heritage and ecological value. The mesa escarpments are to be retained as part of the MEZ at each mesa and therefore need to be stable in the long-term post closure. Geotechnical assessment of escarpments in the Robe Valley concluded that an escarpment width of 30 m is adequate to maintain the long-term stability and integrity of the mesa escarpments (Rio Tinto 2017i). The Proposed Change has, therefore, been designed such that retained escarpment widths will be at least 30m.

9.8 Mitigation

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 9-4.

The Mesa A Hub EMP (Appendix 4) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa A Hub. The EMP identifies:

- Mitigation strategies proposed to minimise impacts to significant environmental values
- The environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met
- Trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach
- The management actions that will be implemented in response to monitoring results.

No significant residual impacts are predicted to areas of high environmental value relating to landforms therefore no offset is proposed for this factor.

Table 9-4: Mitigation measures and predicted outcomes for landforms

Potential impact	Mitigation to address potential impact	Predicted outcomes
EPA objective: to maintain the variety and integrity of distinctive landforms so that environmental values are protected.		
Direct impact: variety Mining has the potential to result in a loss of landform variety due to removal or degradation of the mesa landforms.	The following key management strategies will be implemented to manage impacts to the 'variety' of the landforms: **Avoid:** The most prominent feature of the mesas; the escarpments, will be retained excluding minor access cuts. **Minimise:** The widths required for the access cuts into the mesa escarpments have been minimised as far as possible.	Mesa B and C are not considered to have any particular attributes which set them apart from the many other mesas occurring in the Robe Valley. The partial mesa formation of Mesa A demonstrates a particular variation in palaeochannel evolution, but is not considered unique as similarly formed mesas occur elsewhere in the western Pilbara. The retention of the escarpments of the mesas will, to a large extent, preserve the prominence and scale of the mesas in the landscape, and therefore the Proposed Change will retain the representation or 'variety' of Robe Pisolite mesas in the Robe Valley. The Warramboo and Highway/Tod Bore deposits are not associated with any elevated landforms and therefore no significant landform values will be affected by the Proposed Change in these areas. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.
Direct impact: integrity Mining has the potential to result in the loss of integrity of the mesa landforms.	The following key management strategies will be implemented to manage impacts to the 'integrity' of the landforms: **Avoid:** The most prominent feature of the mesas; the escarpments, will be retained excluding minor access cuts. Potential loss of integrity of the mesa	Although the Proposed Change will affect the integrity of Mesas B and C in that much of the interior part of each landform will be removed, the most valuable part of the landform will be retained excluding minor access cuts. The Proposed Change has been designed to minimise the size of the escarpment cuts such that the proposed cuts represent disturbance to less than 3%

Potential impact	Mitigation to address potential impact	Predicted outcomes
	escarpments will be avoided by retaining an escarpment width of at least 30 m at the top surface.	of the perimeter of each mesa escarpment, thereby maintaining the integrity of the mesa escarpments. The existing operations at Mesas A and J and historical mining operations in the Robe Valley demonstrate that mesa escarpments are stable and the structural integrity can be maintained by ensuring retention of an adequate width of escarpment. As the Proposed Change has been designed with escarpment widths that are at least 30 m at the top surface, the integrity of the remaining landform is not expected to be compromised. Given the mesa escarpments which represent the most valuable feature of the mesa landform will remain largely intact and the structural integrity of the landform will be maintained through retention of an adequate escarpment width, it is considered that the Proposed Change will not significantly impact the integrity of the mesa landforms. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.
Indirect impact: ecological importance Mining has the potential to result in the loss or degradation of the ecological values of the mesa landforms.	The following key management strategies will be implemented to manage impacts to the 'ecological importance' of the landforms: **Avoid:** Key ecological values associated with the mesas occur primarily on the escarpments of the mesas. The Proposed Change has been designed to retain the mesa escarpments excluding minor access cuts. The	The mesa escarpments and the subterranean habitat within the mesas are of ecological importance. The Proposed Change has been designed to retain the mesa escarpments excluding minor access cuts. The design and locations of the escarpment cuts have been selected to avoid disturbance to the escarpment sections with the highest ecological value. The Proposed Change will minimise the size of the

Potential impact	Mitigation to address potential impact	Predicted outcomes
	locations and designs of the escarpment cuts for both Mesas B and C were selected to avoid disturbance to the sections of the escarpments with the highest ecological value. The Proposed Change has been designed to avoid the Ghost Bat roost complexes associated with the potential diurnal/maternal roosts at Mesas B and C and to avoid all but one recorded nocturnal Ghost Bat roost, and the majority of the nocturnal Ghost Bat roosts on Mesas A, B and C. **Minimise**: The Robe Pisolite within the mesa formations provides troglofauna habitat. The Proposed Change has been designed to retain connected troglofauna habitat of at least 50% of the pre-mining habitat volume on each mesa. The implementation of the Blast Management Framework (including management of potential for flyrock) and retention of escarpments with an adequate width will minimise any potential impacts to the ecological value of the mesa escarpments, including the caves and rock shelters present on the mesa escarpment. **Rehabilitate**: All disturbed surfaces will be rehabilitated including pit floors to maximise the ecological value.	escarpment cuts to less than 3% of the perimeter of each mesa escarpment. A continuous block of troglofauna habitat greater than 15 m thick (except at the escarpment cuts) representing at least 50% of the pre-mining habitat volume on each mesa will be retained. Given the retention of mesa escarpments, avoidance of the escarpment sections with the highest ecological value, retention of at least 50% of the pre-mining troglofauna habitat volume on each mesa and implementation of blast management, it is considered, that the Proposed Change is unlikely to significantly impact the ecological values of the mesa landforms. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.

Potential impact	Mitigation to address potential impact	Predicted outcomes
Indirect impact: social importance Mining has the potential to result in loss or degradation of the social values of the mesa landforms through loss of indigenous heritage and amenity values.	The following key management strategies will be implemented to manage impacts to the 'social importance' of the landforms: **Avoid:** Retention of the mesa escarpments will avoid impact to significant heritage sites located in the escarpments as well as reduce impacts to visual amenity of the landscape. No direct disturbance to rock shelters is proposed, including the rock shelter site on Mesa B with spinifex matting. **Minimise:** The location and layout of the mine and associated infrastructure has been designed to minimise impacts to Aboriginal heritage sites. Where impacts to heritage sites cannot be avoided, applications will be made under Section 18 of the AH Act in consultation with the Kuruma Marthudunera People. Waste dumps near Mesas B and C will remain lower than the surrounding mesas. **Rehabilitate:** Visual impacts will be further minimised through construction of the waste dumps to be aesthetically compatible with the surrounding landscape and through rehabilitation of the waste dumps.	Given the proposed retention of the mesa escarpments, avoidance of direct disturbance to rock shelters, the inclusion of Yirrkawiya Gap in the MEZ, management of sites under the AH Act that may be disturbed and the proposed management of mineral waste, it is considered that the Proposed Change is unlikely to significantly impact the social values associated with the mesa landforms. The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.

9.9 Predicted outcome

The Landforms values identified in the western portion of the Development Envelope that are considered relevant to the Proposed Change are outlined below.

Variety

Mesa landforms are relatively common in the western Pilbara and are prominent in the landscape in the Robe Valley. The most prominent and unique feature of each mesa is the escarpment.

Integrity

Mesas B and C are predominantly intact, with only minor disturbance from exploration activities. The escarpment of Mesa A remains intact excluding the access cut.

Ecological

Sections of the escarpments of Mesas A, B and C contain features such as caves, rock crevices, overhangs, fissures and boulders that provide a range of habitat for fauna, including conservation significant fauna.

Social

The mesa plateaus and the mesa escarpments hold significant Aboriginal heritage and cultural values which include artefact scatters, rock shelters, scarred trees and quarries as well as their use as navigational landmarks. The mesas also have amenity value in that they are visible from most nearby locations on the North West Coastal Highway.

The key predicted outcomes for the Landforms values outlined above are:

- Retention of the majority of the mesa escarpments, preserving the prominence and scale of the mesas in the landscape
- Maintenance of the structural integrity of the landform through retention of an adequate escarpment width
- No direct disturbance to the escarpment sections with the highest ecological value and retention of at least 50% of the pre-mining troglofauna habitat volume on each mesa
- No direct disturbance to significant heritage sites located in the mesa escarpments
- Construction of the waste dumps to remain lower than the surrounding mesas.

After the mitigation hierarchy has been applied (Table 9-4), including avoidance of direct disturbance to the majority of the mesa escarpments, including heritage and ecological values, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Landforms; the proposed loss of small proportions of the mesa escarpments is not expected to significantly impact the variety, integrity, ecological or social values of the landforms at a local or regional scale. The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on the mesa landforms and therefore offsets for Landforms values are not proposed.

10. SOCIAL SURROUNDINGS

This section describes the social surroundings of the western portion of the Development Envelope and provides an assessment of the potential impacts of the Proposed Change to the social values of the western portion of the Development Envelope and surrounds, proposed mitigation measures and the predicted outcome for this key environmental factor.

10.1 EPA Objective

The EPA objective for Social Surroundings is to protect social surroundings from significant harm.

10.2 Policy and Guidance

The following policy and guidance documents have been considered in the assessment of Social Surroundings:

10.2.1 EPA policy and guidance

- DMP and EPA Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015)
- Environmental Factor Guideline: Social Surroundings (EPA 2016o)
- Instructions on how to prepare an Environmental Review Document (EPA 2016i)
- Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans (EPA 2016e).

10.2.2 Other policy and guidance

- Department of Aboriginal Affairs (DAA) and Department of Premier and Cabinet (DPC) Due Diligence Guidelines, Version 3.0 (DAA and DPC 2013).

10.3 Environmental Scoping Document

Table 10-1 summarises where the requirements of the ESD are addressed in this section.

Table 10-1: Requirements of the ESD for Social Surroundings

Task number	Requirement of ESD	Comment
71	Characterise the heritage and cultural values of proposed disturbance areas and any other areas that may be indirectly impacted to identify sites of significance and their relevance within a wider regional context.	Sections 10.4 and 10.6
72	Conduct Aboriginal heritage surveys in conjunction with the native title claim (WC99/012) holders Kuruma Marthudunera People and other local people to identify Aboriginal sites of significance and identify concerns in regard to impacts from proposed mining operations.	Section 10.4.1
73	Provide a description of the heritage values within the Development Envelope and provide a figure(s) of the heritage locations and proposed disturbance.	Section 10.4.3 Figure 10-1 has been provided showing the boundaries of the surveys completed in the vicinity

Task number	Requirement of ESD	Comment
		of the western portion of the Development Envelope. A figure showing heritage locations has not been provided due to cultural heritage sensitivities associated with making site location data publicly available.
74	Assess the impacts of the Proposal on heritage sites and/or cultural associations as a result of implementation of the Proposal, including those arising from changes to the environment which may impact on ethnographic and archaeological heritage significance.	Section 10.6
75	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to social surroundings.	Section 10.8
76	Provide detail on consultation that will be undertaken with Traditional Owners in preparing the Mine Closure Plan, particularly in relation to cessation of discharge of water into Warramboo Creek.	Sections 10.6.2 and 10.7
77	Prepare a Mine Closure Plan consistent with DMP and EPA Guidelines for Preparing Mine Closure Plans (2015), which addresses the need to protect the social surrounds from significant harm post closure.	Section 10.7 and Appendix 3
78	Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 10.8

10.4 Receiving Environment

10.4.1 Social surroundings studies

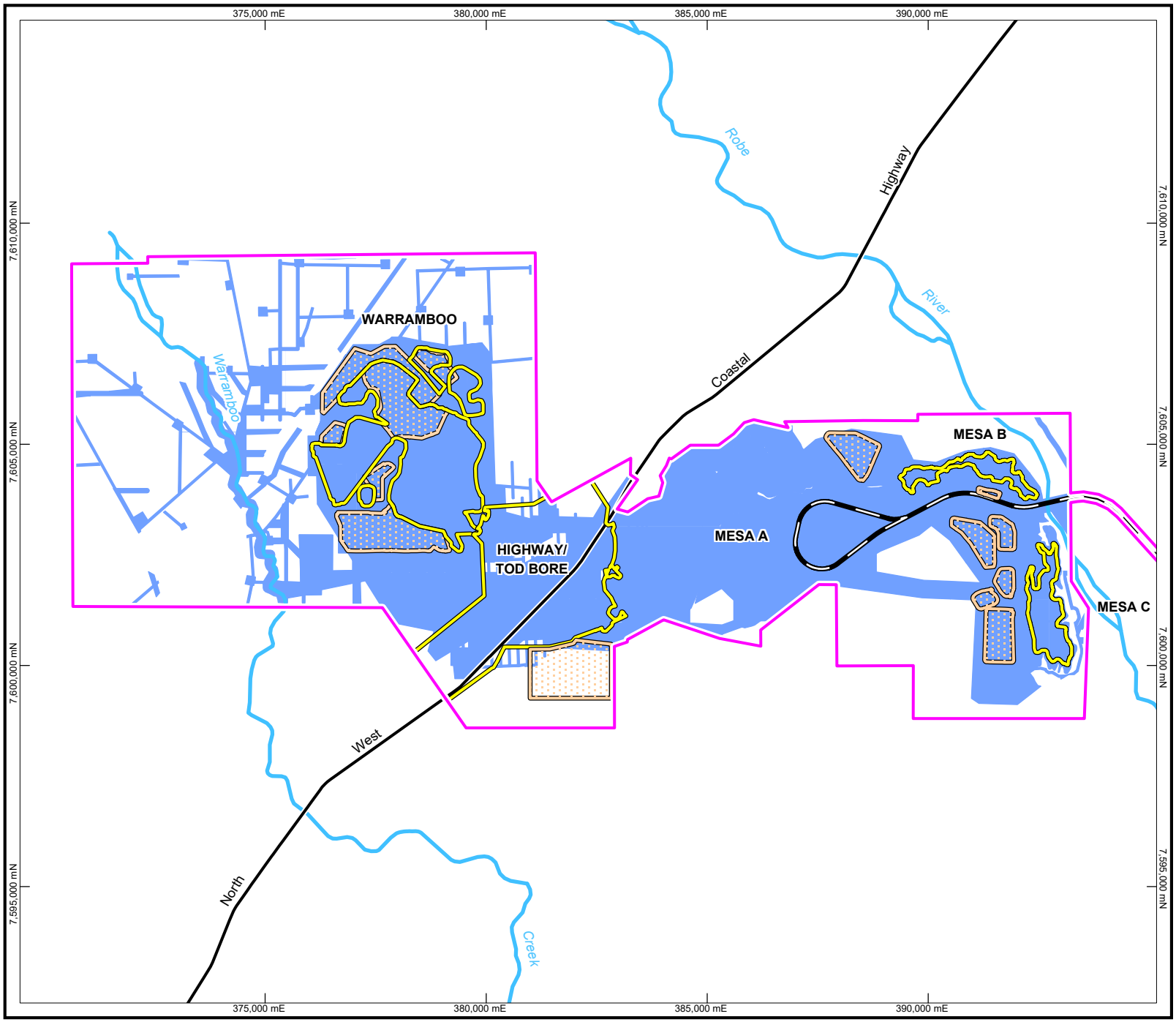
A large number of Aboriginal archaeological and ethnographic surveys have been conducted over the western portion of the Development Envelope in preceding years with the involvement of the Kuruma Marthudunera People. Many of the reports contain information which is of a sensitive nature to the Kuruma Marthudunera People. The Kuruma Marthudenera People have requested that information provided as part of the Environmental Impact Assessment process should be of a general nature only and should not include specific cultural information. Copies of survey reports have, therefore, not been appended to this ERD, rather the scope and location of these studies are summarised in Table 10-2 and Figure 10-1 and a summary report (Rio Tinto 2018c) of the studies conducted is provided in Appendix 11. There are small areas proposed for disturbance in the western portion of the Development Envelope which do not yet have heritage survey coverage; ongoing effort will ensure heritage survey coverage of these areas.

Table 10-2: Summary of social surroundings studies

Report	Summary	Study date
Report of an Ethnographic Survey of Robe's Mesa B & C & Hubert Well Exploration Drilling Program. Ethnosciences (2016)	An ethnographic field survey undertaken in the Mesa B & C and Hubert Well area. Level of recording: Site avoidance level.	November 2015
A Report of the Aboriginal Archaeological Site Bypass Recording Level Survey of Proposed Hydrogeological Bores, Associated Tracks, Pipeline and Discharge Footprint within the Warramboo Area of the Pilbara, Western Australia. GJCRM (2016a)	An archaeological survey undertaken at Mesa C and Warramboo Creek flood plain (including hydrogeological bores). Level of recording: Site bypass.	March 2016
A Report of the Aboriginal Archaeological Site Location and Assessment Recording Level 1 Survey, including Six Previously Recorded Sites, within the Mesa B, Mesa C, Mesa H and Warramboo Areas, Pilbara, Western Australia. GJCRM (2016b)	An archaeological survey undertaken at Mesas B, C, H and Warramboo areas. Level of recording: Site location and Assessment level 1.	April 2016
Ethnographic site assessment heritage survey of heritage places within RTIO's Mesa B and C Project Area, conducted with the Kuruma Marthudunera Traditional Owners. Terra Rosa (in prep)	An ethnographic survey of Mesas B and C. Level of recording: Site assessment.	November 2016

Report	Summary	Study date
Volume 1 of a Report of the Aboriginal Archaeological Site Location and Assessment Recording Level 1 Survey, including Nine Previously Recorded Sites, within Mesa B and C and the Site Bypass Recording Survey within Hubert Well, Pilbara, Western Australia. GJCRM (2015a)	Five archaeological survey trips were undertaken at Mesas B and C and the Hubert Well Drilling area in 2015. The survey focussed on three areas in the Mesa B and C area three drill lines in the Hubert Well Drilling area. Seven previously recorded Aboriginal archaeological sites in the Mesa B and C area were also re-assessed. Level of recording: Site location, assessment level 1 and site bypass.	May, June, July, September and October 2015
Volume 2 of a Report of the Aboriginal Archaeological Site Location and Assessment Recording Level 1 Survey within Mesa B & C and the Site Bypass Recording Survey within Hubert Well, Pilbara, Western Australia. GJCRM (2015b)		
A Report of the Salvage of Thirty-six Indigenous Archaeological Sites within the Mesa A – J Rail Corridor, near Pannawonica, western Pilbara. Archae-Aus (2012)	Survey to salvage 36 Aboriginal heritage sites as part of the original development of Mesa A and Warramboo and associated rail transport corridor.	June 2007 to January 2009
Aboriginal archaeological assessments Conducted for Sterilisation Drilling at Todd Bore and a Troglofauna Sampling Program, Pilbara, Western Australia. VWHC (2012)	Archaeological surveys undertaken at Tod Bore, Congo Bore and Mesa A-F areas. Level of recording: Section 18 & avoidance.	July 2011 and May 2012
Report on Aboriginal Ethnographic Recommendations on Previously Recorded Archaeological Sites on the Mesa A, Warramboo and Rail Transport Corridor Project Areas, Located West of Pannawonica, Western Australia. De Gand Pty Ltd (2006)	An ethnographic survey of Warramboo, Mesa A and rail transport corridor areas. Level of recording: Site Assessment.	November 2006

Report	Summary	Study date
Results of an Ethnographic Heritage Survey of the Mesa A to Mesa J Transport Corridor Robe Valley, West Pilbara Pilbara Native Title Service (2006)	An ethnographic survey conducted about the proposed Mesa A to Mesa J Transport Corridor. Level of recording: Site avoidance.	September 2006
A Report of an Aboriginal Archaeological Survey of Mesa B, Mesa C and Part of Mesa F, near Pannawonica, Western Australia. Gavin Jackson Pty. Ltd. (2004)	Archaeological surveys undertaken at Mesas B, C and F. Level of recording: Site avoidance.	August 2003
Report of an Ethnographic Heritage Survey of Mesas B, C and F. Pilbara Native Title Service (2004)	An ethnographic survey of Mesas B, C and F. Level of recording: Site avoidance.	November 2003
A Re-examination of Department of Indigenous Affairs Sites 8,280 and 18,514: Work Undertaken as Part of the Robe River Mining Warramboo 2004 Evaluation Drilling Program. VWHC (2004)	A re-examination of the previously registered sites DPLH 8280 and 18514, located in the Warramboo area. Level of recording: Site avoidance.	May 2004
An Aboriginal Archaeological Assessment of the Robe River Mining's Mesa A, Warramboo and Todd Bore Exploration Drilling Program. VWHC (2003)	Archaeological surveys undertaken at Mesa A and Warramboo/Tod Bore areas. Level of recording: Site avoidance.	February to June 2003



LEGEND

- Development Envelope
- Heritage Survey Area
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile

N

SCALE

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Rio Tinto

Iron Ore (WA)

Figure 10-1: Heritage surveys

Drawn: T.M.
Date: Aug, 2018

Plan No: PDE0159266v4
Proj: MGA 94 (Zone 50)

Geospatial Information and Mapping

10.4.2 Regional context

The Revised Proposal lies within the Kuruma Marthudunera Native Title Claim (WC99/012). The Proponent has a Participation Agreement and an Indigenous Land Use Agreement with the Kuruma Marthudunera People that include an established consultation framework and ongoing engagement on relevant aspects of the Proponent's operations. These Agreements set obligations for processes such as land access, tenure acquisition, heritage surveys, environmental management, mining benefit payments, and reporting, consultation and communication between the parties. The agreements commit the Proponent and the Kuruma Marthudunera People to work together to manage and maintain the areas in which the Proponent operates.

Studies in the Robe River area by the WA Museum (1979), and Kee and Quartermaine (1986) as reported by VWHC (2003) found consistent evidence of concentrated Aboriginal occupation in the valleys along the Robe River in proximity to permanent pools, frequent yet ephemeral use of mesa tops (with the exception of Mesa A, which may have been used longer term) and preferential use of shelters depending on aspect and accessibility (VWHC 2003, 2012). The largest heritage sites, containing the highest density and greatest diversity of artefacts, occur on alluvial terraces along the Robe River (VWHC 2012). Over half the sites located at Warramboo were aligned along the major ephemeral creek line (VWHC 2012).

10.4.3 Social surroundings values

There are numerous archaeological sites within the western portion of the Development Envelope and vicinity, including artefact scatters, rock shelters, scarred trees and quarries. Ethnographic heritage sites of significance near the Development Envelope include mythological locations, named pools within the Robe River, the Robe River itself, and places of importance due to current use, as well as the mesa profiles.

Consultation between Rio Tinto and the Kuruma Marthudunera People regarding all operations and plans in the Robe Valley is ongoing. Consultation regarding the Proposed Change commenced in 2015 with an outline of the Proposed Change and the surveys planned (Table 3-1). Regular ongoing updates on survey results and discussion of key issues have been provided since 2015.

An intensive consultation session and site visit was held on 15-17 August 2017 to better understand the heritage values of the Robe Valley including the Mesa A Hub Development Envelope. The following heritage values and sites were identified by the Kuruma Marthudunera People as of particular significance:

- Robe River (Gadjiwura), including several pools; Wooroo Pool (also known as Wirunha), Milimitji, Wuntungkarangku (also known as Palarti) and Martangku (also known as Karkuru). The Robe River (DPLH ID 21526) has high significance to the Kuruma Marthudunera People, with the high number of heritage sites in proximity to it reflecting the frequent historical use of the Robe River. For the majority of its course, the Robe River is ephemeral with a wide, shallow flood plain. During the dry season water is often restricted to a series of permanent and semi-permanent pools that are maintained by sub-surface flow. Semi-permanent pools, Wooroo Pool (no DPLH ID) and Milimitji (DPLH ID 6367), are located in the western portion of the Development Envelope at the eastern end of Mesa B. Ephemeral pools, Wuntungkarangku (DPLH ID 6366) and Martangku (DPLH ID 6365), are located to the east of the northern and southern

sections of Mesa C respectively; Wuntungkarangku is located within the western portion of the Development Envelope
- Visual amenity of the mesas. The mesa escarpments are a feature of the visual landscape and have cultural significance, including use as navigational landmarks
- A rockshelter site on Mesa B with spinifex matting. During initial heritage surveys three immediately adjacent rockshelters (all recorded within the one site boundary; field ID MBC15_36) on the southern escarpment of Mesa B were identified as having spinifex matting in the very rear of the shelters. The spinifex matting is a unique feature of the regional archaeology and is of high value in terms of its rarity and representativeness (Westell and Wood 2017)
- Yirrkawiya Gap. The ethnographic site, Yirrkawiya Gap (DPLH ID 6505), is located on the north-western portion of Mesa C, and is a kangaroo dreaming site set up by the Maralga (creation spirits) for training young men in the trapping of kangaroos (Terra Rosa in prep.)
- Warramboo outstation. Warramboo outstation is an historical outstation that has particular significance to the Kuruma Marthudunera People due to past Kuruma Marthudunera People living and working there. The outstation is currently mapped (incorporating an appropriate buffer area around the buildings as agreed between the Proponent and the Kuruma Marthudunera People) as field ID W04-E1
- Warramboo sites. One ethnographic site (field ID W10-ALGYS) and one archaeological feature with ethnographic significance (grinding scoops) (field ID WBOO_SCOOP_EX) within the currently approved Warramboo Mine footprint.

The Urrunha site north-east of Mesa B outside the Development Envelope was also identified by the Kuruma Marthudunera People as significant. Urrunha is a section of the Robe River that was a traditional birthing place for the Kuruma Marthudunera People. It was the birthplace of a past Kuruma Marthudunera elder who was reportedly the last Kuruma Marthudura person to be born 'on country' in the riverbed. The Urrunha site has importance to the Kuruma Marthudunera community as a whole and is of particular importance to the extended family of the past elder. The Urrunha site was identified in the 2015 ethnographic survey and will not be impacted by the Proposed Change.

10.5 Potential Impacts

A number of potential impacts are identified in the ESD. On the basis of surveys and assessments relating to social surroundings completed to date, the following are considered the key issues and are addressed in Section 10.6:

- Disturbance of sites of cultural significance
- Prevention or change to access to a site
- Changes to the physical and biological attributes of the environment (e.g. pools, creeks, mesa breakaways, bush tucker and bush medicine) which would impact on sites of heritage significance
- The proposed intersection of the North West Coastal Highway with a mine pit.

10.6 Assessment of Impacts

The results of the heritage surveys and consultation with the Kuruma Marthudunera People have confirmed that disturbance to sites and environmental values, associated with the mesas and the major creeklines are the key areas of importance associated with the Proposed Change. Any modification of the North West Coastal Highway has been excluded from the Revised Proposal and is therefore not assessed further in this ER.

10.6.1 Direct impacts to sites of heritage significance

The additional disturbance of up to 3,000 ha may impact heritage sites. A number of heritage sites that have not been cleared are located in the western portion of the Development Envelope. The location and layout of the mine and associated infrastructure have been designed to minimise impacts to Aboriginal heritage. The Proponent is committed to avoiding sites wherever possible and will continue to work in close consultation with the Kuruma Marthudunera People.

The most significant heritage values in the western portion of the Development Envelope as identified by the Kuruma Marthudunera People are:

- Robe River, including semi-permanent and ephemeral pools [Wooroo Pool, Milimitji, Wuntungkarangk and Martangku (just outside the Development Envelope)]
- Visual amenity of the mesas
- A rockshelter site (MBC15_36) on Mesa B with spinifex matting
- Yirrkawiya Gap
- Warramboo outstation
- One ethnographic site and one archaeological feature with some ethnographic significance within the currently approved Warramboo Mine footprint.

No infrastructure is proposed that would require clearing or other direct disturbance to the Robe River. Installation of hydrogeological monitoring bores near the Robe River will be required for monitoring purposes.

The mesa escarpments, which include some breakaways, are a feature of the visual landscape and have cultural significance, including use as navigational landmarks. The Proposed Change has been designed to retain the mesa escarpments, except where cuts are required to access the mesas. The retention of the mesa escarpments as part of the MEZ will ensure that the mesa landforms will still be present and can still be used as navigational landmarks by the Kuruma Marthudunera People. The proposed escarpment cuts are on the western and southern sides of Mesa B and on the western side of Mesa C, thus will not impact the visual amenity of the mesas from the Robe River.

No direct disturbance is proposed to rock shelters on Mesas B and C, including the rockshelter site on Mesa B with spinifex matting. The MEZ for Mesas B and C include the rock shelters on both mesas, thus protecting the rock shelters from direct disturbance. In consultation with the Kuruma Marthudunera People, the Proponent has decided to submit applications under Section 18 of the AH Act for rockshelters on the escarpments of Mesas B and C where there is any potential for indirect impacts due to vibration. This is a conservative approach as the proposed MEZ has been designed to include all recorded rockshelters, and blasts will be trimmed as blasting approaches the MEZ to minimise the risk of damage to the escarpment which is a practice applied at a number of other Rio Tinto Pilbara mine operations.

It is anticipated that the Proposed Change will directly impact some artefact scatters on the top of the mesas and on the plains in the western portion of the Development Envelope. Section 18 applications under the AH Act will be submitted for these sites.

A total of approximately 51 sites will be subject to Section 18 applications, consisting of:

- Artefact scatters (21 sites)
- Rockshelters (23 sites)
- Artefact scatter, rockshelter and water source (three sites)
- Artefact scatter and rock shelter (two sites)
- Quarry and rock shelter one site)
- Yirrkawiya Gap (small portion).

Yirrkawiya Gap on the north-west of Mesa C has only recently been delineated in consultation with the Kuruma Marthudunera People. The ethnographic significance of this area is recognised and the site boundary has been included in the proposed MEZ at Mesa C. A portion of the area recognised by DPLH as the Yirrkawiya Gap site contains some archaeological sites which may be subject to indirect impacts. These archaeological sites will be included in the Section 18 applications for the Mesa C escarpment, consistent with the conservative approach taken for the mesa escarpments where there is any potential for indirect impacts to archaeological sites due to vibration. Consultation with the Kuruma Marthudunera People has indicated that clearing the archaeological sites will not alter the ethnographic significance of Yirrkawiya Gap. The Proposed Change includes widening of an existing track through the Yirrkawiya Gap site. A Section 18 application will be required over the portion of the site to be directly impacted by the track widening; however, these works are not expected to affect the ethnographic values of the site.

Ongoing consultation with the Kuruma Marthudunera People has resulted in agreement that the Proponent will retain the Warramboo outstation and enable access to the site for the Kuruma Marthudunera People subject to safety constraints. The Proponent will also retain the ethnographic site and archaeological feature that are within the currently approved Warramboo Mine footprint.

In addition to the sites located at Mesa B, Mesa C and Warramboo, artefact scatters are located in the Highway/Tod Bore area that could be affected by the Proposed Change. Additional surveys and mine planning are required to determine which sites can be avoided as part of the Proposed Change. Section 18 applications will be submitted for those sites where disturbance is required. There are small areas proposed for disturbance in the western portion of the Development Envelope which do not yet have heritage survey coverage; ongoing effort is ongoing will ensure heritage survey coverage of these areas.

10.6.2 Indirect impacts to sites of heritage significance as a result of environmental changes

Safety considerations of an operating minesite will result in the Proposed Change reducing access to some traditional lands that are used for food gathering and hunting. The Proponent will work with the Kuruma Marthudunera People to provide access to traditional lands as far as practicable and to establish procedures to enable safe access.

Groundwater abstraction is required to enable BWT mining at Mesa C. The hydrogeological investigations to date indicate that the Mesa C CID Aquifer is likely to have limited to no hydraulic connectivity with the Robe River Alluvial Aquifer. Dewatering of Mesa C is therefore not expected to have an observable impact on the Robe River, including the semi-permanent pools on the eastern end of Mesa B. Based on current

hydrogeological data, the heritage values associated with the Robe River and Milimitji and Wooroo Pools are unlikely to be impacted by the Proposed Change.

The Proposed Change will result in lowering of the groundwater table as a result of abstraction to enable BWT mining at Warramboo and for water supply from the proposed Warramboo borefield extension. Approximately 13 km of the defined channel of the ephemeral Warramboo Creek is expected to be inside the modelled cone of depression that will result from abstraction of groundwater. Warramboo Creek supports facultative phreatophytic vegetation (i.e. species that utilise groundwater for a portion of their water requirements, but can also satisfy their EWR via stored soil water reserves). Based on depth to groundwater and the phreatophytic species present, potential changes to phreatophytic vegetation along the majority of the defined flow channel are expected to be limited to possible changes in the canopy cover of *Eucalyptus camaldulensis* subsp. *refulgens* and possible increased mortality of phreatophytic species. There is some potential for a reduction in canopy cover, and minor changes to the abundance of understorey vegetation in the floodplain of Warramboo Creek. It is estimated that recovery of the groundwater table at Warramboo to 80% of the pre-mining level will take approximately 40 years, with complete recovery of the groundwater level estimated to take up to 140 years due to the anticipated low recharge rates. While not anticipated to impact any specific heritage sites, these changes may result in a small reduction in the availability of bush tucker (both flora and fauna) and bush medicine along parts of the 13 km section of Warramboo Creek and the associated flood plain.

Surplus water will be discharged to Warramboo Creek. It is estimated that the edge of continuous flow resulting from surplus water discharge will extend up to 8 km downstream of the discharge point under natural no-flow conditions. Availability of surface water may result in unseasonal attraction of native fauna to the creek, including waterbirds, reptiles, amphibians and mammals. This may result in a temporary increase in the availability of fauna for hunting along the 8 km section of Warramboo Creek but is not expected to impact any specific heritage sites. Discharge will not be continuous during the life of the Proposed Change. The altered hydrological regime (i.e. increased water availability during discharge) may result in temporary changes to riparian vegetation along Warramboo Creek. It is anticipated that vegetation adaptation to the altered hydrological regime will include new growth and changes in structure and cover (refer to Section 6.5.4 for further details). Once discharge ceases, the ecosystem is expected to return to one adapted to ephemeral conditions. Ongoing consultation with the Kuruma Marthudunera People will be conducted.

Discharge of surplus water to Warramboo Creek may alter surface water chemistry and sediment quality in Warramboo Creek for the duration of discharge. Alteration of surface water chemistry and sediment quality may result in a temporary decline in vegetation health and possibly localised impacts to fauna habitat. This may result in a temporary reduction in the availability of flora and fauna traditionally targeted for hunting and food gathering in an 8 km section of Warramboo Creek downstream from the proposed discharge point. However, during natural flow conditions that occur during rainfall events, discharged surplus groundwater will be diluted and the system flushed. This will mitigate the potential impacts of altered water chemistry and sediment quality in the 8 km of Warramboo Creek that may be affected by the proposed discharge.

10.7 Closure

Upon mine closure, the Mesa A Hub area will be rehabilitated to create a safe, stable and non-polluting landscape revegetated with native species, to maximise environmental and cultural heritage outcomes and to ensure the site does not adversely impact on the current surrounding land use. Further heritage assessments and consultation will be undertaken with the Kuruma Marthudunera People prior to closure to ascertain potential heritage impacts of closure implementation, and to inform the development of alternative strategies if required. Assessments will also be completed post closure to confirm that implementation has been undertaken in an appropriate manner.

All reasonable and practicable measures to prevent harm to heritage sites will be undertaken, including during works associated with rehabilitation and closure. Where disturbance is unavoidable, artefacts and cultural material will be disturbed and removed under Section 18 consent of the AH Act. Closure works will consider post closure access requirements to heritage sites, and the return of archaeological materials (as appropriate) salvaged during mine construction and/or operations.

The final closure landform has been considered, with visual amenity assessments incorporated in the development of the mine plan to ensure the visual impact is minimised. A strategy to increase backfill has resulted in a reduced number of ex-pit landforms being included in the Proposed Change. Waste dumps near Mesas, B and C will remain lower than the surrounding topography and the view of any waste landforms from the Robe River will be limited (refer to Section 9.6.2.2). Waste dumps located near Warramboo and Highway/Tod Bore will be limited in size due to landform stability considerations. However, these landforms will remain visible at closure due to their location on a flat plain. The Mesa A, B and C escarpments will remain undisturbed except for the cuts required to access the mesas.

10.8 Mitigation

Mitigation actions to address the potential impacts and predicted outcomes are presented in Table 10-3

The Mesa A Hub EMP (Appendix 4) addresses the key environmental factors which were determined by the EPA as being relevant to the appropriate management of dewatering, surface water discharge, conservation significant vegetation communities and fauna species associated with the Mesa A Hub. The EMP identifies:

- Mitigation strategies proposed to minimise impacts to significant environmental values
- The environmental criteria that the Proponent will use to monitor performance of the mitigation strategies to ensure environmental objectives are met
- Trigger criteria, threshold criteria, trigger level actions and threshold contingency actions aligned with the overall management approach
- The management strategies that will be implemented in response to monitoring results.

No significant residual impacts are predicted to areas of high environmental value relating to social surroundings therefore no offset is proposed for this factor.

Table 10-3: Potential impacts, proposed mitigation measures and predicted outcomes for Social Surroundings

Potential impacts	Mitigation to address potential impacts	Predicted outcome
EPA objective: To protect Social Surroundings from significant harm.		
Direct impacts: Ground disturbance has the potential to impact Aboriginal heritage and cultural values. Sites of higher significance include: • Robe River, including semi-permanent and ephemeral pools [Wooroo Pool, Milimitji, Wuntungkarangk and Martangku (just outside the Development Envelope)] • A rockshelter site on Mesa B with spinifex matting • Yirrkawiya Gap • Warramboo outstation • One ethnographic site and one archaeological feature with some ethnographic significance within the currently approved Warramboo Mine footprint • Visual amenity of the mesas.	The Revised Proposal falls within the Kuruma Marthudunera Native Title Claim (WC99/012). The Kuruma Marthudunera People have a Claim Wide Participation Agreement and an Indigenous Land Use Agreement with Rio Tinto. These agreements commit the Proponent and the Kuruma Marthudunera People to work together to manage and maintain areas in which the Proponent operates. The agreements establish clear processes for heritage and include reporting and communication requirements. **Avoid**: The Proposed Change has been designed to avoid direct impacts to sites with high significance, including the Robe River, rock shelter site MBC15_36 on Mesa B with spinifex matting, Warramboo outstation, one ethnographic site and one archaeological site within the approved Warramboo pit footprint. **Minimise:** The Proposed Change has been designed to minimise direct impacts to Yirrkawiya Gap and escarpments on Mesas A, B and C. Where impacts to heritage sites cannot be avoided, applications will be made under Section 18 of the AH Act in consultation with the Kuruma Marthudunera People. Further assessment of sites and salvaging of artefacts is expected to occur. Artefact salvage will ensure the retention of artefact values ex-situ. The Proponent has established an internal system for	The Proposed Change has been designed to avoid impacts to most of the key heritage sites in the western portion of the Development Envelope namely: Robe River and associated pools, rock shelter site MBC15_36, Warramboo outstation, one ethnographic site and one archaeological site within the current approved Warramboo Mine footprint. The Proposed Change has been designed to minimise impacts to Yirrkawiya Gap and the escarpments of Mesas A, B and C. The Proponent is committed to avoiding heritage sites wherever possible. However, some sites are likely to be disturbed by the Proposed Change. The Proponent will seek approval under Section 18 of the AH Act where direct disturbance to sites cannot be avoided or where there is any potential for impacts due to vibration. This is a conservative approach as the proposed MEZ has been designed to include all recorded rock shelters and blasts will be trimmed as blasting approaches the MEZ. Approximately 51 Section 18 applications are anticipated, consisting of: • Artefact scatters (21 sites) • Rockshelters (23 sites) • Artefact scatter, rockshelter and water source (three sites); • Artefact scatter and rock shelter (two sites) • Quarry and rockshelter (one site) • Yirrkawiya Gap (small portion).

Potential impacts	Mitigation to address potential impacts	Predicted outcome
	managing all ground disturbing activities to ensure compliance with heritage commitments and regulatory requirements. The Proponent is committed to consulting with the Kuruma Marthudunera People regarding the Proposed Change through Local Implementation Committee (LIC) meetings and heritage survey processes. The Proponent has developed a Mine Closure Plan consistent with DMP and EPA Guidelines (2015) to ensure social surrounds are rehabilitated post closure (Appendix 3).	Additional surveys and mine planning are required to determine whether heritage sites at the Highway/Tod Bore deposits can be avoided. The Proponent will continue to work in close consultation with the Kuruma Marthudunera People and will avoid sites where possible. Where avoidance is not possible, the Proponent will seek approval under Section 18 of the AH Act. Given the Proposed Change has been designed to avoid impacts to the most significant heritage sites in the western portion of the Development Envelope, disturbance to other sites will be minimised and the Proponent is committed to continuing to consult with the Kuruma Marthudunera People regarding the Proposed Change through LIC meetings and heritage survey processes, the Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.
Indirect impacts: The Proposed Change will alter the access to some traditional lands used for hunting and food gathering and changes to hydrological regimes may alter the availability of bush tucker and bush medicine.	The Proponent will work with the Kuruma Marthudunera People to provide access to traditional lands as far as practicable and to establish procedures to enable safe access.	The Proposed Change will result in a reduction in access to traditional lands due to safety considerations associated with an operating mine site. The Proposed Change may also result in temporary, localised changes to the availability of bush tucker and bush medicine due to abstraction of groundwater and discharge of surplus water. However, the flora and fauna that occur in the area that may be impacted occur more widely in the Robe Valley and the changes are not expected to impact any specific heritage sites. Consultation will continue with the Kuruma Marthudunera People regarding access to traditional lands and changes to the hydrological regime of Warramboo Creek.

Potential impacts	Mitigation to address potential impacts	Predicted outcome
		The Proponent considers that the potential impacts can be managed and the residual impact will not be significant enough to warrant application of offsets.

10.9 Predicted outcome

The Social Surroundings values identified in the western portion of the Development Envelope that are considered relevant to the Proposed Change, and the key predicted outcomes for those values are outlined below.

- The Robe River, including semi-permanent and ephemeral pools [Wooroo Pool, Milimitji, Wuntungkarangk and Martangku (just outside the Development Envelope)]
- Visual amenity of the mesas
- Rockshelter site MBC15_36 on Mesa B with spinifex matting
- Yirrkawiya Gap
- Warramboo outstation
- One ethnographic site and one archaeological feature with some ethnographic significance within the currently approved Warramboo Mine footprint
- A traditional birthing place for the Kuruma Marthudunera People; the Urrunha site in the Robe River north-east of Mesa B outside the Development Envelope.

The key predicted outcomes for the Social Surroundings values outlined above are:

- No direct disturbance to the Robe River and associated semi-permanent and permanent pools
- Retention of the mesa escarpments, except where cuts are required to access the mesas
- No direct disturbance to rockshelter site MBC15_36
- No direct disturbance to other rockshelter sites, but potential indirect disturbance to some rockshelter sites due to vibration for which approval will be sought under Section 18 of the AH Act (approximately 23 Section 18 applications are anticipated)
- No disturbance to Yirrkawiya Gap that would affect the ethnographic significance of the site
- No direct impacts to Warramboo outstation
- Direct disturbance to some artefact scatter sites for which approval under Section 18 of the AH Act will be sought (approximately 28 Section 18 applications are anticipated).
- Reduction in access to some traditional lands due to safety considerations associated with an operating mine site
- Potential for temporary, localised changes to the availability of bush tucker and bush medicine due to abstraction of groundwater and discharge of surplus water.

After the mitigation hierarchy has been applied (Table 10-3), including avoidance of direct impacts to the Robe River, rock shelter site MBC15_36, Warramboo outstation, the identified ethnographic site and archaeological feature within the approved Warramboo pit footprint, the traditional birthing place and the majority of the mesa escarpments, the Proponent considers that the Proposed Change can be managed to meet the EPA's objective for Social Surroundings. The Proponent will continue to consult with the Kuruma Marthudunera People regarding the Proposed Change through LIC meetings and heritage survey processes. The Proponent considers that the Proposed Change is unlikely to have a significant residual impact on Social Surroundings and therefore offsets for this factor are not proposed.

11. OTHER ENVIRONMENTAL FACTORS OR MATTERS

11.1 Air quality

This section describes and assesses the potential impacts of the Proposed Change on air quality, mitigation and the predicted outcome for this other environmental factor. The assessment is provided in Table 11-1 and focusses specifically on greenhouse gas emissions as the potential impacts of dust are considered, where relevant, in Sections 5 to 9.9.

Table 11-1: Assessment of potential impacts to Air Quality

Policy and guidance	Existing emissions	Assessment of potential impacts	Mitigation and predicted outcome
EPA objective: To maintain air quality and minimise emissions so that environmental values are protected			
The relevant policy and guidance for air quality is: • Environmental Factor Guideline: Air Quality (EPA 2016p) • *National Environment Protection Council Act 1994 (Cth) and National Environment Protection Measure for Ambient Air Quality* (Air NEPM) • *National Greenhouse and Energy Reporting Act 2007* (NGER Act).	The approved activities are relatively small contributors of greenhouse gas emissions, contributing the following emissions annually: • 51,565 tonnes of CO_2 equivalent Scope 1 (direct) emissions • 10,251 tonnes of CO_2 equivalent Scope 2 (indirect) emissions.	The following aspects of the Proposed Change may result in the production of greenhouse gas emissions and impacts to air quality: • Diesel combustion by haul trucks • Clearing of native vegetation • Use of explosives during blasting • Power consumption for ore processing. The Proposed Change will bring the total Scope 1 emissions for the Mesa A Hub to approximately 92,759 tonnes of CO_2 equivalent per year. The Proposed Change will bring the total Scope 2 emissions for the Mesa A Hub to approximately 36,753 tonnes CO_2 equivalent per year. These emissions are not considered a significant contribution to Australia's greenhouse gas emissions. The Proposed Change will contribute very low percentages to Australia's greenhouse inventory and the potential impacts are considered insignificant on a national basis. For the 2015-2016 year, corporations required to report under the NGER Act, reported a total of 334 million tonnes of CO_2 equivalent (Scope 1) and 90 million tonnes of CO_2 equivalent (Scope 2) emissions (NGER 2018). On this basis, the Scope 1 emissions for the Proposed Change would represent approximately 0.03% of the national Scope 1 emissions. The Scope 2 emissions for the Proposed Change would represent approximately 0.04% of national Scope 2 emissions.	Rio Tinto manages greenhouse gas emissions from its operations, consistent with all relevant legislation and national and state strategies. Rio Tinto also has well established procedures for reporting greenhouse gas emissions from its Pilbara operations. The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor.

12. MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

12.1 Controlled action provisions

On 8 February 2017, the Minister for the Environment and Energy determined that the proposed additional activities constitute a Controlled Action under Section 75 of the EPBC Act thus requires assessment and a decision about whether approval should be granted under the EPBC Act. The controlling provision is 'Listed threatened species and communities' (Section 18 and 18A of the EPBC Act). The proposed additional activities have the potential to have a significant impact on the MNES listed in Table 12-1.

Table 12-1: MNES that may be impacted

Common name	Species name	Conservation status
Northern Quoll	*Dasyurus hallucatus*	Endangered
Ghost Bat	*Macroderma gigas*	Vulnerable
Pilbara Olive Python	*Liasis olivaceus barroni*	Vulnerable
Pilbara Leaf-nosed Bat	*Rhinonicteris aurantia*	Vulnerable

12.2 Policy and guidance

The relevant policy and guidance for MNES includes:

- Significant Impact Guidelines: 1.1 – Matters of National Environmental Significance (DoE 2013)
- National Recovery Plan for the Northern Quoll *Dasyurus hallucatus* (Hill and Ward 2010)
- EPBC Act referral guidelines for the endangered Northern Quoll *Dasyurus hallucatus* (DoE 2016)
- Wildlife Conservation Plan for Migratory Shorebirds. Commonwealth of Australia, Canberra (DoE 2015)
- Conservation Advice for *Macroderma gigas* (Ghost Bat) (TSSC 2016b)
- Commonwealth Conservation Advice on *Liasis olivaceus barroni* (Pilbara Olive Python) (TSSC 2008)
- Conservation Advice for *Rhinonicteris aurantia* (Pilbara form) (Pilbara Leaf-nosed Bat) (TSSC 2016a).

12.3 Existing environmental values

12.3.1 MNES that may be impacted by the Proposed Change

The four MNES identified in Table 12-1 have been recorded in the western portion of the Development Envelope. A list of surveys conducted to date and a detailed description of survey findings for each of these species is provided in Section 7.4. A summary of those findings is provided below.

12.3.2 Habitat suitability for MNES

Nine broad fauna habitat types were recorded in the western portion of the Development Envelope [consolidated from MWH (2015a) and Astron (2018a)]:

- Mesa Plateau
- Breakaways and Gullies
- Rocky Slopes
- Stony Hills and Rises
- Plains
- Flood Plain
- Hardpan
- Major River/Creek
- Minor Drainage Lines.

The above habitat types have been grouped into five broad habitat types according to their importance to, and use by, the MNES species present in the western portion of the Development Envelope. Utilising this habitat mapping and aerial photography, these habitats were extrapolated and mapped for the remainder of the Robe Valley; an area of approximately 87,300 ha. The MNES habitats are described below and shown on Figure 12-1 for the western portion of the Development Envelope.

12.3.2.1 Breakaways and Gullies

The rocky terrain of the Breakaways and Gullies habitat provides a diverse variety of micro-niches and sheltering opportunities in an otherwise flat landscape. In relation to MNES, the Breakaways and Gullies habitat provides:

- Denning, shelter and foraging habitat for the Northern Quoll
- Temporary nocturnal roosting habitat and foraging habitat for the Pilbara Leaf-nosed Bat
- Diurnal, potential maternity and nocturnal roosting and foraging habitat for the Ghost Bat
- Breeding, shelter and foraging habitat for the Pilbara Olive Python, particularly the area in close proximity to the semi-permanent and ephemeral pools in the Robe River.

The mesa escarpments are part of the Breakaways and Gullies habitat. In their assessment of the Mesa B and C escarpments, MWH (2015b) divided the escarpments into sections and assessed the ecological value of each section on a scale ranging from Moderate to Excellent. The escarpment sections were rated based on the key features of landform, mesic qualities and vegetation, habitat values and the existing level of disturbance. The assessment found 45% of the Mesa B escarpment to be of Moderate ecological quality, 53% as Good and 2% as Very Good. For Mesa C, 52% of the escarpment was assessed to be of Moderate ecological quality, 39% as Good and 9% as Very Good (MWH 2015b). MWH (2015b) did not rate any areas of the Mesa B or C escarpments as being of Excellent ecological quality.

12.3.2.2 River

The River habitat is considered to be of high importance to fauna, providing a range of ecological values to a wide suite of species. In the survey area, the vegetation in this habitat type was complex and provided a range of micro-niches for fauna species to exploit, such as for shelter and foraging. The presence of ephemeral water in this habitat as well as water in two semi-permanent pools in the western portion of the Development

Envelope to the east of Mesa B provide drinking opportunities for a range of species along with attracting prey for predators. In relation to MNES, the River habitat provides:

- Foraging and dispersal habitat for the Northern Quoll
- Foraging and dispersal habitat for the Pilbara Leaf-nosed Bat and Ghost Bat
- Shelter, foraging and dispersal habitat for the Pilbara Olive Python (Robe River only)
- Foraging and dispersal habitat for the Pilbara Olive Python (Warramboo Creek). Note that Warramboo Creek is not considered to be potential shelter habitat for the Pilbara Olive Python due to the lack of permanent water.

12.3.2.3 Mesa Plateau

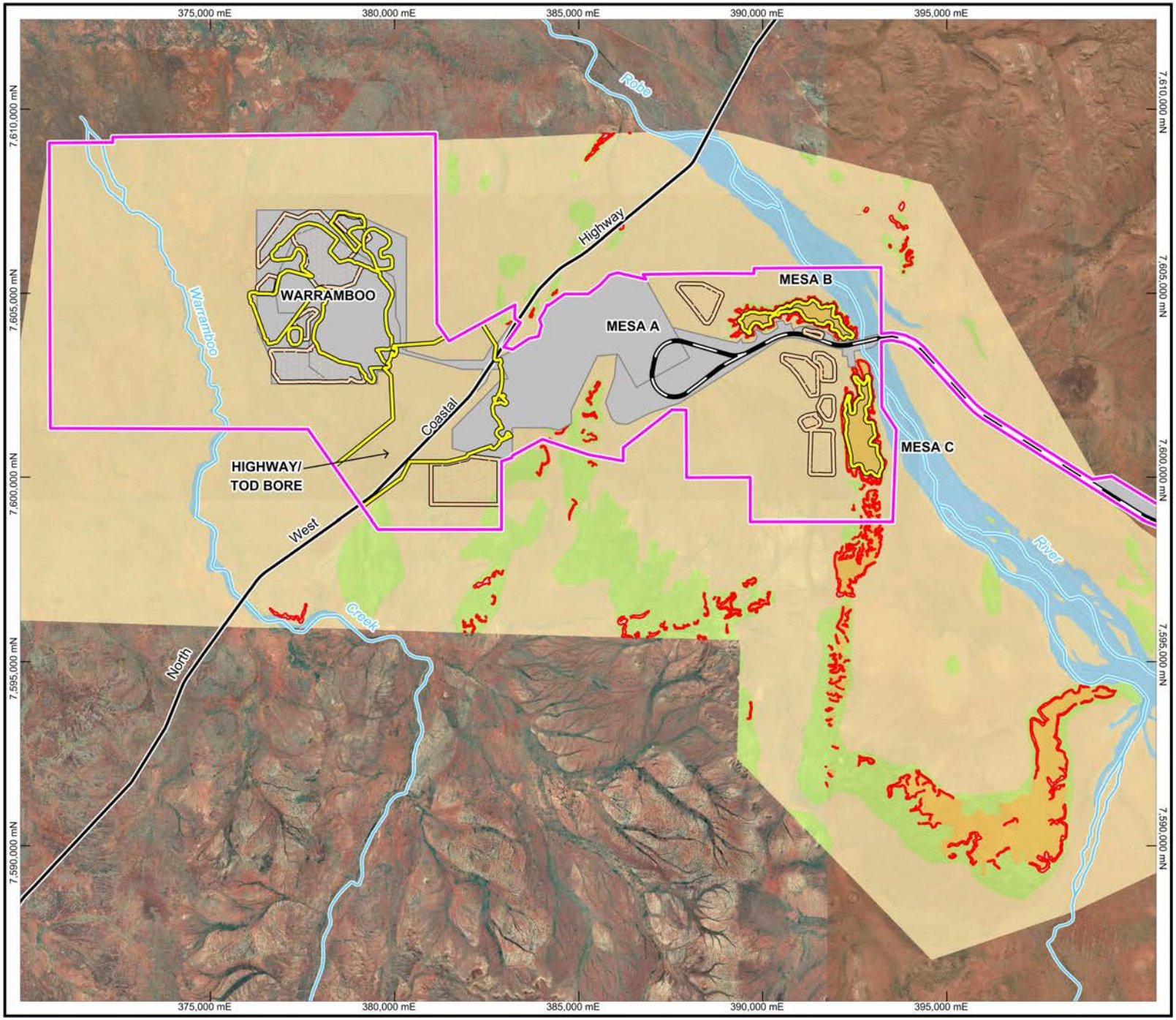
The elevated flat top hills of the Mesa Plateau habitat generally have low vegetation complexity which results in low diversity of microhabitats, such as leaf litter for refuge and shelter. In relation to MNES, the Mesa Plateau habitat provides some foraging and dispersal habitat, for the Northern Quoll, Pilbara Leaf-nosed Bat and Ghost Bat (MWH 2015a).

12.3.2.4 Hills

The Hills habitat type is widespread and common throughout the Pilbara region. This habitat generally has low vegetation complexity and therefore low diversity of microhabitats. In relation to MNES, the Hills habitat provides some foraging and dispersal habitat for the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python but overall is considered to be of limited value to MNES (MWH 2015a).

12.3.2.5 Plains

The Plains habitat type is widespread and common throughout the Pilbara region. In relation to MNES, the Plains habitat provides limited foraging and dispersal habitat for the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and the Pilbara Olive Python.



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile

MNES Fauna Habitat

- Breakaways and gullies
- Hills
- Mesa Plateau
- Plains
- River

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Rio Tinto

Iron Ore (WA)

Figure 12-1: MNES habitat

Drawn:T.M.
Date: Aug, 2018

Plan No: PDE0158573v5
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

12.3.3 Northern Quoll

The Northern Quoll was originally found across northern Australia from the North-West Cape of WA to south-east Queensland; however, its abundance has significantly declined in recent years. The primary cause of the recent decline in this species across northern Australia has been death from predation attempts on the toxic introduced Cane Toad (*Rhinella marina*), resulting in the collapse of some Northern Quoll populations in Queensland and the Northern Territory (Tingley *et al.* 2013 cited in DBCA 2018b). Cane toads have not yet reached the Pilbara, but are projected to naturally colonise the Pilbara mainland (and potentially its offshore islands) between 2026–2064 (Kearney *et al.* 2008 and Tingley *et al.* 2013 cited in DBCA 2018b).

The Northern Quoll is now restricted to five regional populations across Queensland, the Northern Territory and the Kimberley and Pilbara in Western Australia on both the mainland and offshore islands (DotEE 2017a). The Pilbara population of Northern Quoll is separated from the Kimberley population by approximately 500 km of arid Great Sandy Desert and is genetically distinct (DBCA 2018b). Both the mainland Pilbara and Kimberley populations of Northern Quolls retain high levels of genetic diversity and show no evidence of recent or long-term population bottleneck. This indicates that despite habitat fragmentation and population decline, the Pilbara population has not yet suffered a loss in genetic diversity (DBCA 2018b).

Primary areas of Northern Quoll occupation in the Pilbara include the western edge of the Hamersley Ranges, in the granite outcrops of the Abydos Plain, and in the more rugged areas of the Chichester Ranges (Molloy *et al.* 2017). Molloy *et al.* (2017) also identified a high potential for Northern Quoll to occur within the eastern Pilbara where very few records currently exist due to low survey effort.

Northern Quoll are strongly associated with rocky habitats which are used for shelter and denning purposes with surrounding vegetated habitats used for foraging and dispersal (DotEE 2017a). Recent studies have confirmed that Pilbara Northern Quolls are broadly carnivorous but are largely opportunistic in their diet and were recorded to consume vertebrates (mammals, birds, reptiles, frogs), as well as arthropods, molluscs, fruit, and carrion (DBCA 2018b).

Rocky habitats adjoining drainage lines have a heightened level of importance given the close proximity of denning habitat to foraging and dispersal areas. A large area of habitat for this species is protected within the Millstream-Chichester National Park and the Karijini National Park located approximately 110 km north-east and 215 km south-east of the Development Envelope respectively.

There are 4,153 records of Northern Quoll from the Pilbara (DBCA 2018b). The majority of these are recent records; only 315 records date back further than 2009.

Northern Quoll are common in the Robe Valley (Figure 12-2) and have been recorded in historical mining areas in this area, particularly where mesa escarpments are largely intact. Astron (2016) recorded the Northern Quoll numerous times during a survey in the East Deepdale and Middle Robe region approximately 60 km east of the Development Envelope. The majority of these records were from the Breakaway habitat type (45 records), with some records from the Riverine (13), Stony Hills and Slopes (two) and Mesa (seven) fauna habitats. The results indicate the species' reliance upon rocky terrain habitat for shelter and denning. Similarity measures of species assemblages

amongst sites showed the Breakaway fauna habitat type to be statistically different and unique to other fauna habitat types for mammal species including the Northern Quoll. This is likely due to the number of micro-niches that provide shelter and denning opportunities in this habitat type. The Breakaway habitat was, therefore, considered highly suitable for the Northern Quoll while the Mesa, Riverine and Drainage habitats that act as ecological linkage corridors and may provide refuge and foraging opportunities were considered to be areas of moderate suitability (Astron 2016). Overall the results of the survey indicate Northern Quoll are utilising intact escarpments around previously impacted sites and that a resident Northern Quoll population is present in the East Deepdale/Middle Robe region within the Breakaway habitat type (Astron 2016).

MWH (2015a) recorded evidence of the Northern Quoll at 23 sites in the western portion of the Development Envelope (Figure 7-4). All records were in close proximity to rocky substrate associated with Mesa B and Mesa C, and the adjacent Robe River (MWH 2015a). Surveys conducted in 2004 and 2005 for the approved activities recorded Northern Quoll on the Mesa B scarp and in a cave and gorge at Mesa A (Biota 2005b, 2006d). Rio Tinto have a total of 42 records of Northern Quoll from within the Development Envelope (Figure 12-3):

- 25 records from Breakaways and Gullies habitat
- 12 records from the Mesa Plateau or Rocky Slopes habitat units but all of these records were within 10 m of the Breakaways and Gullies habitat units
- Two from Major River habitat
- Two from previously disturbed areas
- One from Plains habitat unit, approximately 50 m from the nearest Breakaways and Gully habitat.

There are an additional 115 null records which are largely from plains, plateau and river habitats with 19 null records from Rocky Slopes. The Northern Quoll records and null records indicate that, consistent with the regional information described above, the local occurrence of Northern Quolls in the Development Envelope is strongly associated with rocky habitat.

An additional 92 records are known within 50 km of the Development Envelope, with the nearest approximately 2 km to the south (Biota 2011c). The multiple Northern Quoll recordings (cameras/trapped individuals) of multiple individuals across multiple sites in the baseline fauna surveys conducted in the western portion of the Development Envelope indicate that the Northern Quoll population in the western portion of the Development Envelope may be classifiable as a ‘population important for the long-term survival’ of the species as defined by DoE (2016). A full summary of policy/guidance relevant to the Northern Quoll is provided in Section 7.6.2.1.

Habitat defined as critical to the survival of the Northern Quoll (DoE 2016) includes all habitat within the modelled distribution of the Northern Quoll which provides shelter/breeding and/or dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the Northern Quoll. This definition is broad and includes the majority of the western portion of the Development Envelope.

All habitat that provides shelter for breeding, refuge from fire/or predation and potential poisoning from the Cane Toad, (*Rhinella marina*) is considered to be 'habitat critical to the survival' of the species and usually occurs in the form of (DoE 2016):

- Rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields, major drainage lines or treed creek lines
- Structurally diverse woodland or forest areas containing large diameter trees, termite mounds or hollow logs
- Offshore islands where the Northern Quoll is known to exist.

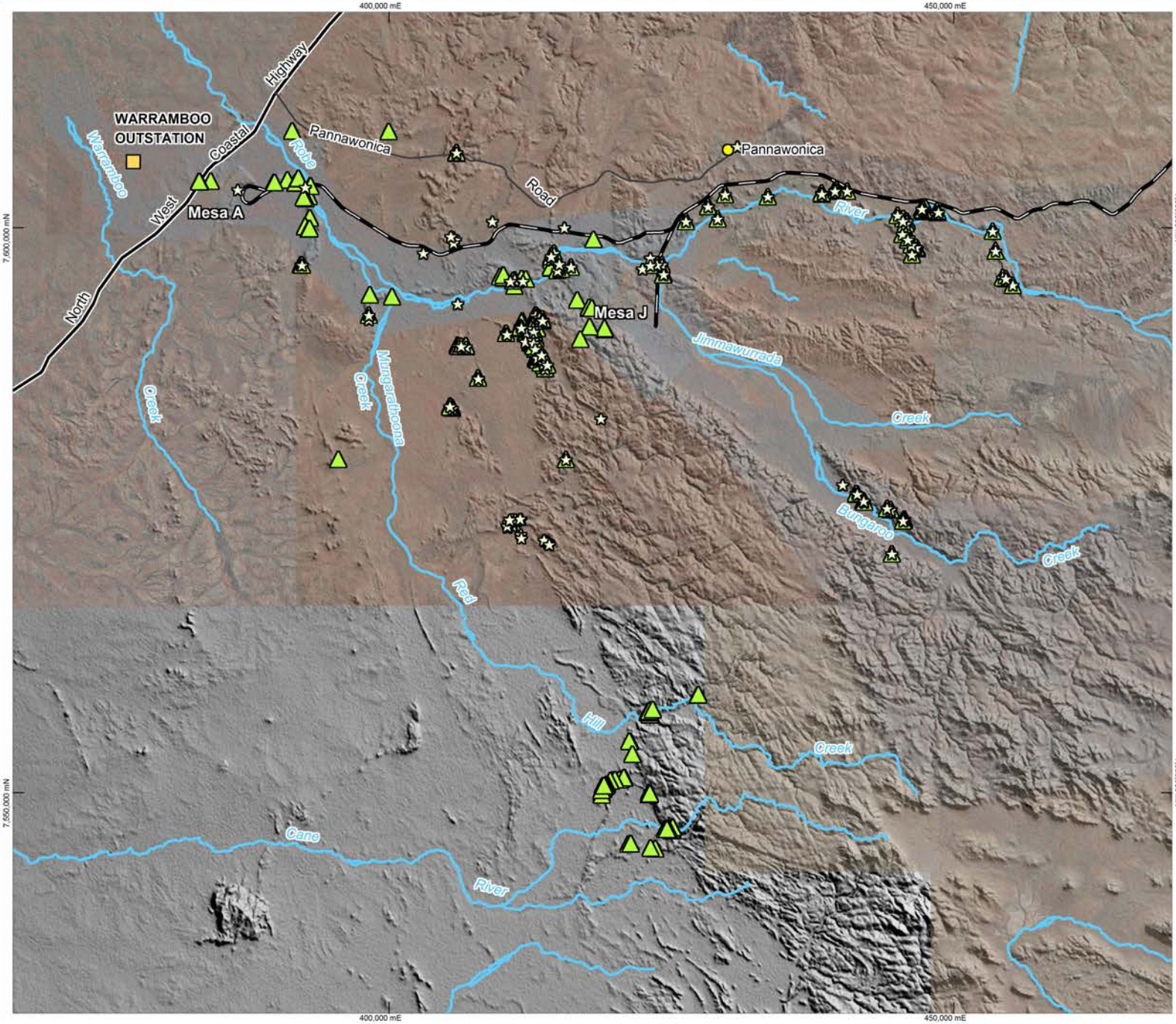
Rocky habitats are present in the western portion of the Development Envelope; surveys indicate that the Breakaways and Gullies habitat and portions of the River habitat (Robe River) have the potential to provide denning/shelter habitat for the Northern Quoll (MWH 2015a), and therefore are classifiable as 'habitat critical to the survival of the species'.

Habitat defined as critical to the survival of the Northern Quoll (DoE 2016) includes all habitat within the modelled distribution of the Northern Quoll which provides shelter/breeding and/or dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the Northern Quoll. This definition is highly inclusive and could be considered to include all foraging/dispersal habitat in the vicinity of multiple records of Northern Quoll. The local population of Northern Quoll has a strong association with the Breakaways and Gullies habitat and portions of the River habitat (Robe River). Based on the evidence from the Robe Valley data (Astron 2016) and locations of records in the Development Envelope, the critical habitat locally is considered to comprise the Breakaways and Gullies habitat and portions of the River habitat (Robe River). This is consistent with the conclusion of MWH (2015a) that the most important habitats in the western portion of the Development Envelope are considered to be the Breakaways and Gullies and River habitats, which provide high value denning/shelter habitats associated with caves and rocky overhangs and/or enhanced foraging opportunities due to the availability of water. Other foraging and dispersal habitat within the Development Envelope is considered widespread and low value and not considered critical to the survival of the species.

The River habitat provided by the ephemeral Warramboo Creek is further than 2 km from potential denning habitat and the nearest Northern Quoll record is approximately 7 km from Warramboo Creek. Although the section of Warramboo Creek within the western portion of the Development Envelope may provide foraging and dispersal habitat for the Northern Quoll (Astron 2018a), its habitat value is much less than that of the Robe River, and it is not likely to be used for denning purposes. This habitat is not considered critical to the survival of the species.

Estimates of the home range of Northern Quoll vary and are likely to be affected by factors such as habitat and seasonality. Home ranges are expected to be smaller in well connected rocky habitats (such as the area near Mesas A, B and C) than in areas where rocky habitats are isolated in the landscape and home ranges of males are expected to be greater in the breeding season than in the non-breeding period. A 2015 study in an area 143 km north-west of Newman in the Pilbara, estimated Northern Quoll home ranges to be 58ha for males and 13.4 ha for females (Henderson 2015). DotEE's Species Profile and Threats Database profile for Northern Quoll describes the estimated home range of the species as greater than 100 ha for males and 35 ha for females based on a radio tracking and live trapping study undertaken in lowland savannah of Kakadu National Park (Oakwood 2002).

Threats to the Northern Quoll include ingestion of the Cane Toad and its lethal toxin, removal, degradation and fragmentation of habitat (including impacts from pastoral activities), inappropriate fire regimes, predation following fire, weeds and feral predators (DoE 2016; DotEE 2017a).



LEGEND

- Rio Tinto Northern Quoll records
- DBCA Northern Quoll records
- Rio Tinto Railway
- Highway
- Major road
- Major Watercourse

Data sourced from: Department of Biodiversity, Conservation and Attractions (2018) Threatened and Priority Fauna. Database Search for Rio Tinto tenements accessed on the 6/11/18. Prepared by the Species and Communities Program for Rio Tinto for the purposeof understanding fauna habitat utilisation and facilitating management outcomes.

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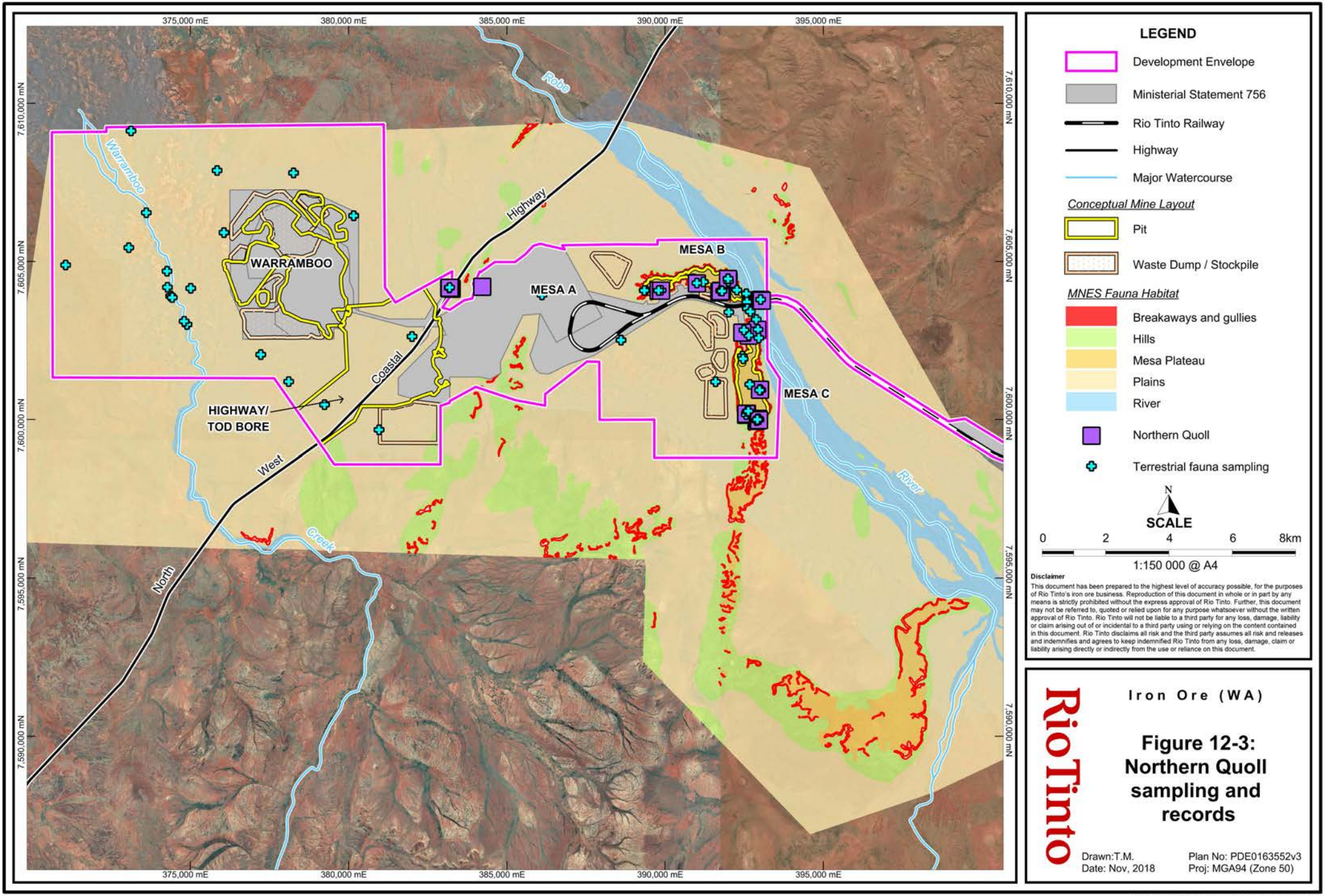
Rio Tinto

Iron Ore (WA)

Figure 12-2: Northern Quoll records in the Robe Valley

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164380v1
Proj: MGA94 (Zone 50)



LEGEND

- Development Envelope
- Ministerial Statement 756
- Rio Tinto Railway
- Highway
- Major Watercourse

Conceptual Mine Layout

- Pit
- Waste Dump / Stockpile

MNES Fauna Habitat

- Breakaways and gullies
- Hills
- Mesa Plateau
- Plains
- River
- Northern Quoll
- Terrestrial fauna sampling

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Iron Ore (WA)

Figure 12-3: Northern Quoll sampling and records

Drawn:T.M.
Date: Nov, 2018

Plan No: PDE0163552v3
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

12.3.4 Pilbara Leaf-nosed Bat

The Pilbara Leaf-nosed Bat population that occurs in the Pilbara and upper Gascoyne is considered to be one interbreeding biological population of genetic divergence which is of national significance (TSSC 2016a). The Pilbara Leaf-nosed Bat has been recorded throughout the Robe Valley (Figure 12-4) and occurs in colonies concentrated around significant roosting sites, often associated with disused mining infrastructure such as abandoned adits (manmade horizontal shafts). Most of the known natural roosting sites coincide with areas of current or future interest for mining development; hence mining activities are an identified threat to Pilbara populations of the species.

The Pilbara Leaf-nosed Bat is restricted to deep roosting caves and mine adits with stable, warm and humid microclimates. The Pilbara Leaf-nosed Bat is known to have a typical dry season foraging range up to 20 km from its primary roost caves (Bat Call WA 2016) but may forage at greater distances if suitable water sources are available. It also appears to range nomadically from roost sites when wet season conditions allow it to use other caves but is likely to return to its primary roosting location in dry periods.

The Pilbara Leaf-nosed Bat is most often observed in flight over waterholes, up to 3 m above the land surface, but sometimes within centimetres of the ground. In the Pilbara, the species has been observed in *Triodia* hummock grasslands covering low rolling hills and shallow gullies; within scattered *Eucalyptus camaldulensis* along the creeks; over small watercourses amongst granite boulder terrain; over pools and low shrubs in ironstone gorges; and above low shrubs and around pools in gravelly watercourses with a *Melaleuca* overstorey (DotEE 2018). As with all cave-roosting bats, the Pilbara Leaf-nosed Bat has separate diurnal and nocturnal habitats including roosting sites and foraging sites. Roosting sites may occur in rocky breakaways, scarps and gorges as these areas have the greatest potential to support relatively warm humid microclimates.

The underground refuges used by the Pilbara Leaf-nosed Bat have been prioritised by TSSC (2016a):

- Permanent diurnal roosts (Priority 1) - considered as critical habitat that is essential for daily survival
- Non-permanent breeding roosts (Priority 2) - considered as critical habitat that is essential for daily and long-term survival
- Transitory diurnal roosts (Priority 3) - considered as critical habitat that is essential for daily and long-term survival
- Nocturnal refuge (Priority 4) - not considered critical habitat, but important for population persistence in a local area.

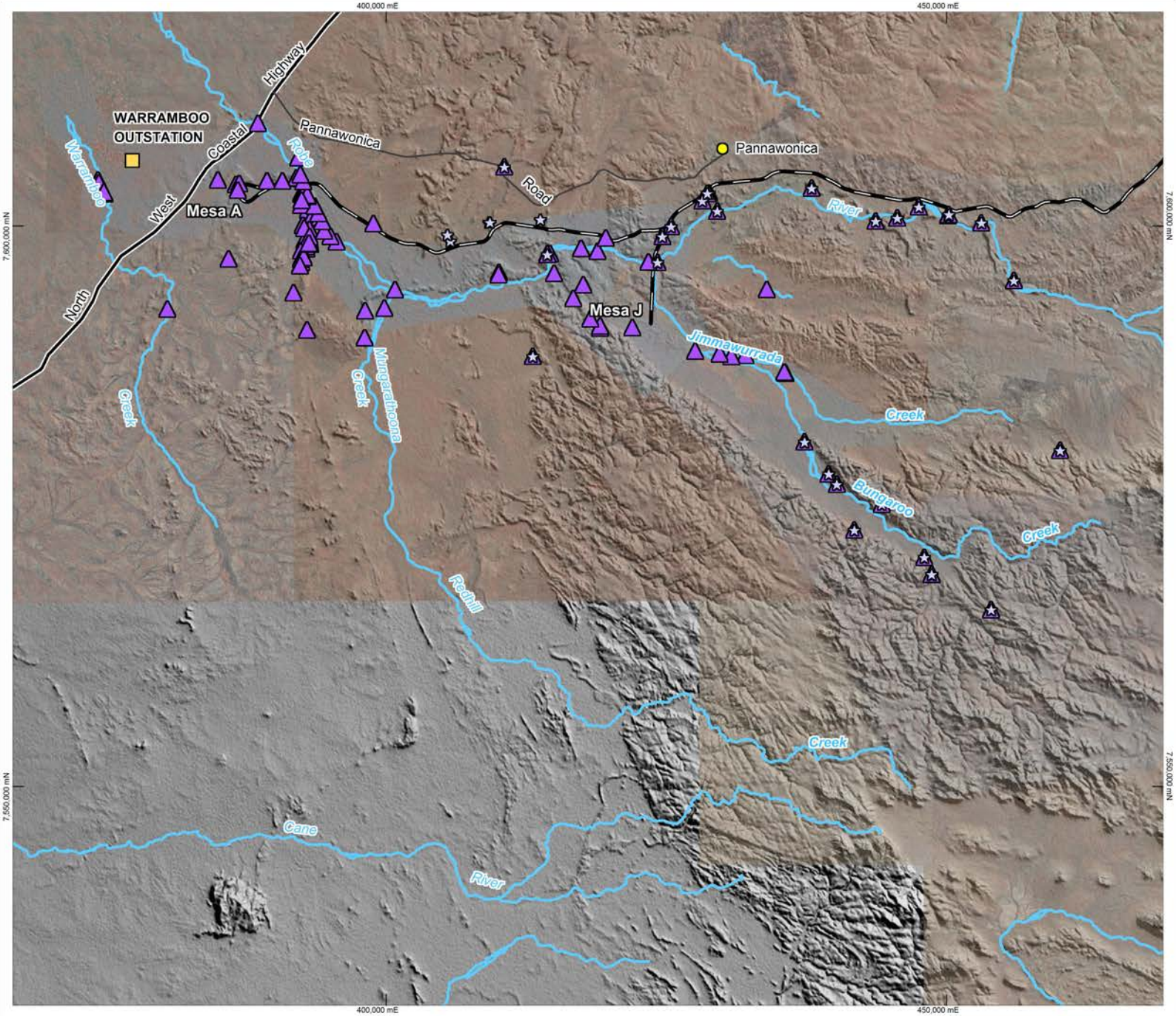
The type and quality of potential foraging habitat surrounding known or suspected roost sites can also be critical to the survival of the Pilbara Leaf-nosed Bat. However, given the lack of understanding around which habitats are required to sustain a roosting colony, critical foraging habitat is difficult to define (TSSC 2016a). Instead, foraging habitats used by the Pilbara Leaf-nosed Bat can be categorised as follows (TSSC 2016a):

- Gorges with pools (Priority 1)
- Gullies (Priority 2)
- Rocky outcrops (Priority 3)
- Major watercourses (Priority 4)
- Open grassland and woodland (Priority 5).

A full summary of policy/guidance relevant to the Pilbara Leaf-nosed Bat is provided in Section 7.6.3.1.

The Pilbara Leaf-nosed Bat has been recorded from 42 call records across 32 locations in the western portion of the Development Envelope (Figure 12-5). The timing and location of call records and the species' expected patterns of movement indicate that the bats originate from a diurnal roost outside the Development Envelope and are consistent with the species foraging along the River habitat of the Robe River and Warramboo Creek, and within Gullies and Breakaway habitat. This species may also utilise temporary nocturnal caves within the western portion of the Development Envelope.

The most significant habitats in the western portion of the Development Envelope for the species are the Breakaways and Gullies habitat and the River habitat; these areas represent foraging habitat and potential nocturnal refuges. The null records on Figure 12-5 show little use of the Plains by Pilbara Leaf-nosed Bat. Overall, the data show the Pilbara Leaf-nosed Bat has a strong association with the Breakaways and Gullies habitat and River habitat. Given the number of records of Pilbara Leaf-nosed Bat locally and their strong association with Breakaways and Gullies and River habitat, it is considered that an appropriate definition of critical habitat locally is the Breakaways and Gullies habitat and River habitat.



LEGEND

- Rio Tinto Pilbara Leaf-nosed Bat records
- DBCA Pilbara Leaf-nosed Bat records
- Rio Tinto Railway
- Highway
- Major road
- Major Watercourse

Data sourced from: Department of Biodiversity, Conservation and Attractions (2018) Threatened and Priority Fauna. Database Search for Rio Tinto tenements accessed on the 6/11/18. Prepared by the Species and Communities Program for Rio Tinto for the purposeof understanding fauna habitat utilisation and facilitating management outcomes.

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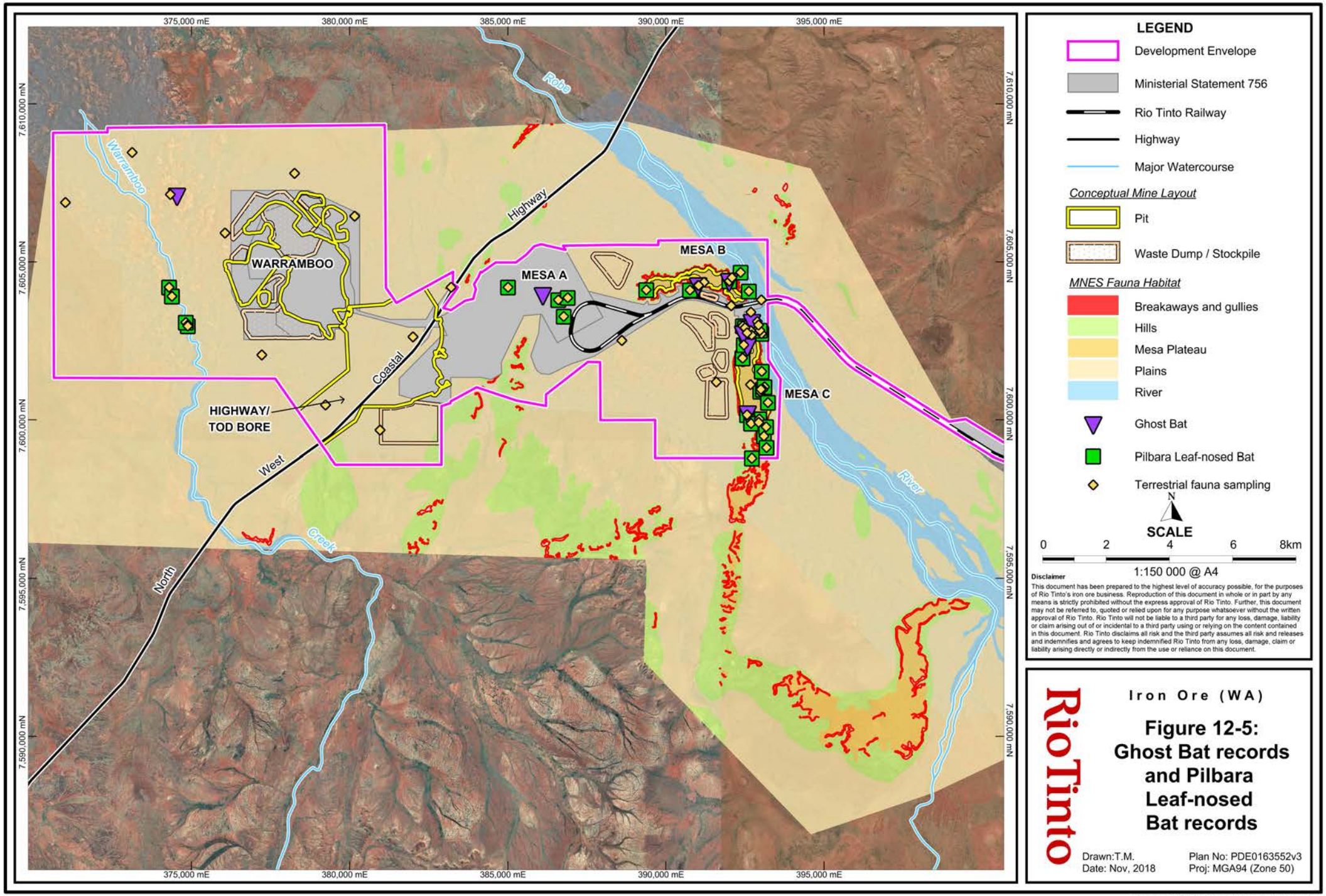
Iron Ore (WA)

Figure 12-4: Pilbara Leaf-nosed Bat records in the Robe Valley

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164383v1
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping



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Rio Tinto

Iron Ore (WA)

Figure 12-5: Ghost Bat records and Pilbara Leaf-nosed Bat records

Drawn:T.M.
Date: Nov, 2018

Plan No: PDE0163552v3
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

12.3.5 Ghost Bat

The Ghost Bat roosts during the day in caves, rock crevices and abandoned mine shafts or abandoned adits. Roost sites used permanently are generally deep natural caves or disused mines with a relatively stable temperature of 23-28^{o}C and humidity above 50%. Individuals require a range of cave sites and move between roosts seasonally or according to weather conditions. Populations are widely dispersed when not breeding and concentrate in relatively few roost sites when breeding (TSSC 2016b).

The Ghost Bat utilises three types of roost regularly:

- Nocturnal roosts (or feeding sites) are used only at night, either habitually or for transitory visits. They are typically shallow, poorly insulated caves and shelters that are well lit during the day (Bat Call WA 2016). The Ghost Bat hunts at night and uses nocturnal caves to consume prey it has captured in the surrounding area
- Diurnal roosts (or day roosts) are caves and mine adits that are deeper and more complex than nocturnal roosts. They typically have one or more large chambers at or beyond the twilight area with additional fissures or chambers at the rear in the fully dark regions. They have a minimum roof height in the chambers of 2 to 3 m providing protection from attack by terrestrial predators. They are often at mid-levels or lower in the strata making them well insulated. The stable temperature and elevated humidity of these caves relative to the ambient conditions create physiologically benign conditions (McKenzie and Bullen 2009)
- Maternity roosts are diurnal roosts that usually include an interior chamber that rises towards the rear trapping warmer, more humid air at the top.

To persist in an area, the Ghost Bat requires a group of caves/shelters that provide diurnal and nocturnal sites and a gully or gorge system that opens onto a plain or riparian line that provides good foraging opportunities. The persistence of the species in the Pilbara is believed to depend on the availability of diurnal roosts that have stable temperature and humidity (TSSC 2016b).

Studies undertaken by Biologic (2016) indicate that groups of Ghost Bats move about within a local area and that multiple groups may use a cave. Biologic (2016) note that there generally isn't a continuous presence of Ghost Bats in any one cave and that it is rare to encounter a maternity group despite visiting the most suitable recorded caves in an area across a number of breeding seasons. Field observations in the vicinity of the proposed Mining Area C Development, approximately 100 km north-west of Newman in the Pilbara region, suggest that maternity groups may use different maternity roosts across different seasons (Biologic 2016). In particular, a maternity group was recorded in 2015 in a small cave that had previously shown little evidence of Ghost Bat occupancy. Hormone analysis showed scats from numerous caves across the area contained progesterone levels consistent with pregnancy thus indicating that the concept of a centralised maternity roost may not be applicable in the Pilbara region. Further information on Ghost Bat activity in the Pilbara and their use of caves in historical mining areas in the Robe Valley is provided in Section 7.6.4.3.

Ghost Bat individuals generally return to the same foraging areas each night. The Ghost Bat can have a relatively small nightly foraging range (up to 2 km from the roost) (Tidemann *et al.* 1985; Pettigrew *et al*. 1986), but has the flight capability to range widely (Bullen and McKenzie 2002), perhaps tens of kilometres in a night. This is evident from

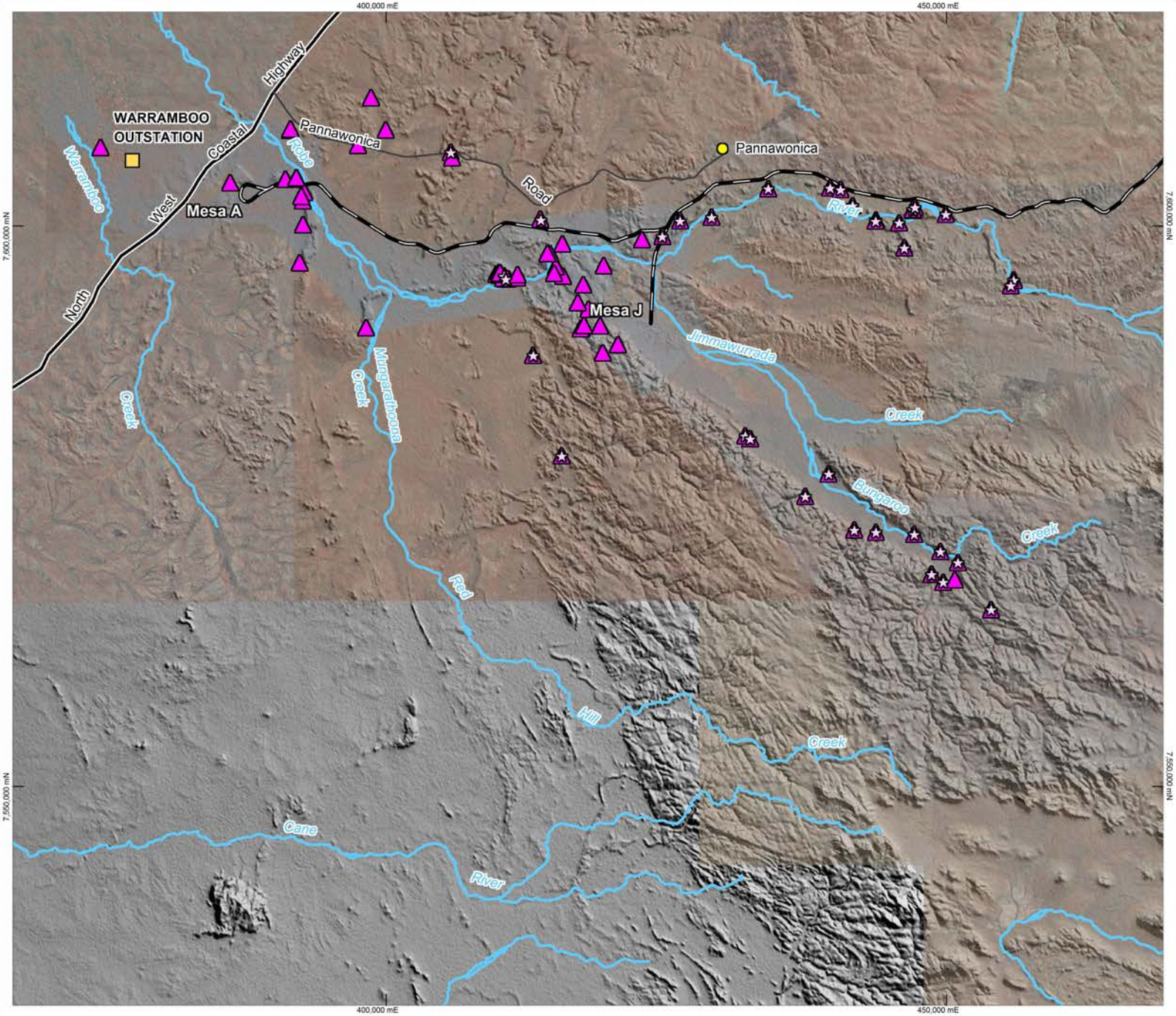
genetic markers, which suggest that males are particularly likely to disperse long distances throughout the landscape (Worthington-Wilmer *et al.* 1994).

Foraging Ghost Bats use echolocation during flight to detect prey and use passive sit-and-wait hunting techniques using eyesight to scan for prey from roosts up to 3 m above the ground, such as rocky overhangs and tree branches (MWH 2015a; TSSC 2016b).

The approved conservation advice for the Ghost Bat (TSSC 2016b) identifies the key threat to the species as the destruction of, or disturbance to, known roosts and nearby areas. A full summary of policy/guidance relevant to the Ghost Bat is provided in Section 7.6.4.1. There are currently no defined criteria for habitat critical for the survival of the species, or identified important populations; however, the population in the Pilbara is genetically distinct from other geographically isolated populations, and contains up to 29% of the current estimated number of Ghost Bat individuals. Current population trends indicate that the WA population is likely to decline by over 30% in the future, with local extinctions predicted in the central and eastern Hamersley Range (TSSC 2016b). The approved conservation advice (TSSC 2016b) for the Ghost Bat identifies the primary conservation actions as:

- Protection of roost sites from mining, human disturbance and collapse
- Replacement of the top strands of barbed wire in fences near roost sites with single-strand wire.

The Ghost Bat has a patchy distribution in the Pilbara with a regional Pilbara population estimated at 1,500 to 2,000 individuals (Bat Call 2017a; Appendix 8). The Ghost Bat is common in the Robe Valley (Figure 12-6), and is often recorded in groups of up to 20 individuals (Bob Bullen pers comm, in MWH 2015a). The most significant habitats in the western portion of the Development Envelope for the species are the Breakaways and Gullies habitat, including the mesa escarpments, and the River habitat (Figure 12-5); these areas represent potential roost habitat and foraging habitat. A total permanent population of 15 to 20 individuals is estimated across caves on Mesa B and Mesa C within the western portion of the Development Envelope (Bat Call WA 2016). Mesa B is considered to contain one diurnal/potential maternal roost and 12 nocturnal roost caves, while Mesa C contains one potential diurnal roost and eight nocturnal roost caves (Bat Call WA 2017a). Two caves have been recorded at Mesa A, one of which was originally thought to be a potential diurnal roost; however, further assessment considering the dimensions of the caves has indicated that both of the caves at Mesa A are likely nocturnal roost caves (Bat Call WA 2017a).



LEGEND

- Rio Tinto Ghost Bat records
- DBCA Ghost Bat records
- Rio Tinto Railway
- Highway
- Major road
- Major Watercourse

Data sourced from: Department of Biodiversity, Conservation and Attractions (2018) Threatened and Priority Fauna. Database Search for Rio Tinto tenements accessed on the 6/11/18. Prepared by the Species and Communities Program for Rio Tinto for the purposeof understanding fauna habitat utilisation and facilitating management outcomes.

N

SCALE

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1:500 000 @ A4

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Rio Tinto

Iron Ore (WA)

Figure 12-6: Ghost Bat records in the Robe Valley

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164382v1
Proj: MGA94 (Zone 50)

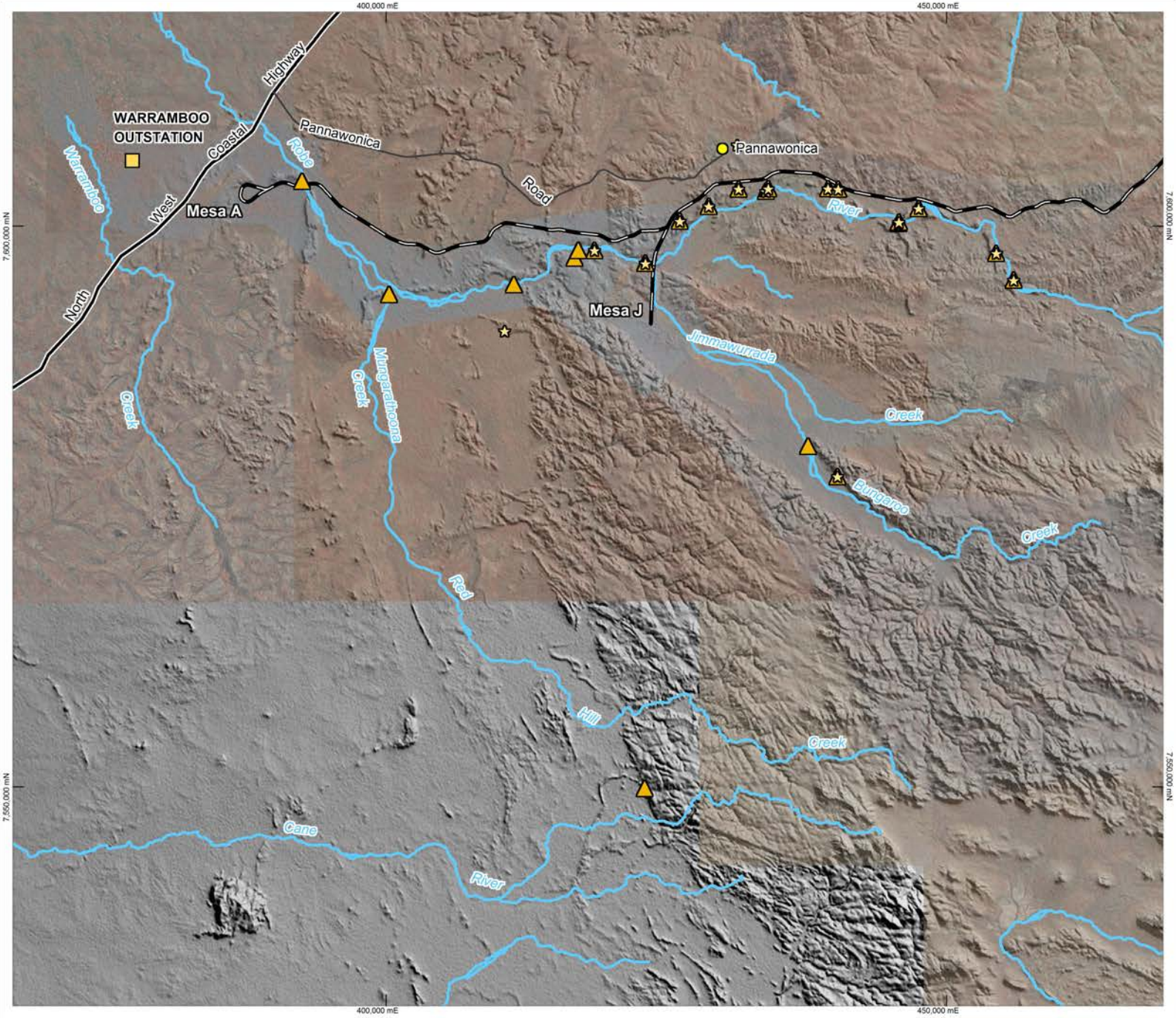
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12.3.6 Pilbara Olive Python

The Pilbara Olive Python is restricted to ranges within the Pilbara region including the Hamersley Range and islands of the Dampier Archipelago. It is widespread in the region and occurs as scattered populations; it is known to occur at more than 60 locations across the Pilbara (G. Humphreys, Biota Environmental Sciences, pers. comm. 2012), 21 of which are currently recognised in the Commonwealth Conservation Advice (TSSC 2008) including populations at Pannawonica, Millstream, Tom Price and the Burrup Peninsula. The species has been recorded throughout the Robe Valley (Figure 12-7). A large area of habitat for this species is protected within the Millstream-Chichester National Park and the Karijini National Park located approximately 110 km north-east and 215 km south-east of the western portion of the Development Envelope respectively.

The Pilbara Olive Python is predominantly found in rocky areas, showing a preference for gorges with streams and permanent pools. Individuals spend the cooler winter months hiding in caves and rock crevices away from water sources, and the warmer summer months moving around widely, usually in close proximity to water and rock outcrops. The species uses waterholes to hunt and ambushes prey on animal trails or by striking from a submerged position in water holes (TSSC 2008; MWH 2015a; DotEE 2017c). Individuals occupy distinct home ranges and males can travel distances of up to 4 km during the breeding season (June to August) to locate females. A summary of policy/guidance relevant to the Pilbara Olive Python is provided in Section 7.6.5.1.

The Pilbara Olive Python was recorded at one location adjacent to the Robe River in the western portion of the Development Envelope (MWH 2015a). Numerous records of the species exist in similar Riverine habitats within 50 km of Mesas B and C (MWH 2015a). The River habitat in the western portion of the Development Envelope is considered likely to support foraging and dispersal of the species. The Breakaways and Gullies habitat present in the western portion of the Development Envelope is likely to provide breeding, shelter and foraging habitat, particularly areas adjacent to the two semi-permanent pools in the Robe River to the east of Mesa B.



LEGEND

- Rio Tinto Pilbara Olive Python records
- DBCA Pilbara Olive Python records
- Rio Tinto Railway
- Highway
- Major road
- Major Watercourse

Data sourced from: Department of Biodiversity, Conservation and Attractions (2018) Threatened and Priority Fauna. Database Search for Rio Tinto tenements accessed on the 6/11/18. Prepared by the Species and Communities Program for Rio Tinto for the purposeof understanding fauna habitat utilisation and facilitating management outcomes.

N

SCALE

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Rio Tinto

Iron Ore (WA)

Figure 12-7: Pilbara Olive Python records in the Robe Valley

Drawn: T.M.
Date: Nov, 2018

Plan No: PDE0164387v1
Proj: MGA94 (Zone 50)

Geospatial Information and Mapping

12.4 Potential impacts on MNES

The following provides a summary of aspects of the Proposed Change which may result in direct and indirect impacts to MNES. Further description of potential impacts is provided in Section 7.6.

12.4.1 Loss of habitat due to clearing

Clearing will remove up to 3,000 ha of fauna habitat, disturbing foraging habitat and potentially breeding habitat for some of the MNES species recorded in the area. The estimates given below (and tabulated in Sections 7.5.1 and 7.5.3) of the potential extent of disturbance in each habitat type represent upper limits for each habitat type.

12.4.1.1 Breakaways and Gullies

The Proposed Change has been designed to limit disturbance to Breakaways and Gullies habitat. Escarpment cuts through Breakaways and Gullies habitat are required to provide access to the mesas. The cuts have been designed to limit clearing in the Breakaways and Gullies habitat to 8 ha, equating to 6% of the Breakaways and Gullies habitat in the western portion of the Development Envelope and less than 1% of the mapped extent of the Breakaways and Gullies habitat in the broader Robe Valley. The escarpment cuts have also been designed to avoid the highest value areas in this habitat type as determined by MWH (2015b).

12.4.1.2 River

The Proposed Change has been designed to limit disturbance to the River habitat to less than 3 ha, representing less than 1% of the mapped River habitat in the western portion of the Development Envelope.

12.4.1.3 Mesa plateau

The Proposed Change will clear up to approximately 77% of the mapped extent of this habitat type in the western portion of the Development Envelope, equating to approximately 5% of the mapped extent of the Mesa Plateau habitat in the broader Robe Valley.

12.4.1.4 Hills

The Proposed Change will clear up to approximately 9% of the mapped extent of this habitat type in the western portion of the Development Envelope, equating to less than 1% of the mapped extent of the Hills habitat in the broader Robe Valley.

12.4.1.5 Plains

The Proposed Change will clear up to approximately 21% of the mapped extent of this habitat type in the western portion of the Development Envelope, equating to approximately 5% of the mapped extent of the Plains habitat in the broader Robe Valley.

12.4.2 Degradation of foraging and dispersal habitat due to groundwater abstraction

Hydrogeological modelling indicates there is limited hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvium. Consequently, drawdown in groundwater levels within the Mesa C CID Aquifer is not expected to result in observable changes to groundwater levels within the adjacent Robe River Alluvial Aquifer. Should there be greater hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvium than current modelling indicates, there is potential for stress to individual

trees and changes to understorey vegetation along the Robe River in the extent of drawdown.

Abstraction of groundwater at Warramboo has the potential to reduce canopy cover of phreatophytic species and potentially reduce the abundance of understorey vegetation along Warramboo Creek. This may in turn impact foraging and dispersal habitat for the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and the Pilbara Olive Python. No permanent or semi-permanent pools have been identified in the section of the ephemeral Warramboo Creek that is within the modelled extent of groundwater drawdown. Based on depth to groundwater and the phreatophytic species present, significant changes to understorey vegetation and hence fauna habitat due to abstraction of groundwater are not expected along the majority of the defined flow channel of Warramboo Creek. There is potential for a minor reduction in the abundance of understorey vegetation in the Plains habitat type downstream of the defined flow channel in Warramboo Creek.

12.4.3 Alteration of foraging and dispersal habitat due to discharge of surplus water

The discharge of surplus water into Warramboo Creek will cause a discharge wetting front which is predicted to extend up to approximately 8 km from the discharge point under natural no-flow conditions. Warramboo Creek is an ephemeral creek, only holding surface water and flowing following heavy rainfall events. Discharge of surplus water will increase the temporal availability and alter the seasonality of surface water. This may lead to an increase in utilisation of the area by fauna for the duration of discharge. Thus, the fauna habitat of Warramboo Creek may be temporarily altered but discharge will not be continuous during the life of the Proposed Change and habitat values are unlikely to be significantly affected.

Groundwater from the Warramboo area naturally exhibits different chemical properties to surface water which occurs ephemerally following rain. Groundwater ranges from fresh to brackish depending on the geographic / geological formation location (Rio Tinto 2017d). Discharge of groundwater into Warramboo Creek may result in changed surface water chemistry in Warramboo Creek, up to 8 km downstream of the discharge point. This may result in temporary stress to vegetation and degradation of foraging and dispersal habitat. Following rainfall events where surface water flow naturally occurs, surplus groundwater will be diluted following discharge into Warramboo Creek.

12.4.4 Loss or degradation of habitat due to noise and vibration

The Northern Quoll, Pilbara Olive Python, Pilbara Leaf-nosed Bat and Ghost Bat utilise caves and shelters on the mesa escarpments for denning and shelter or roosting. Vibrations associated with blasting have the potential to result in loss of, or damage to, the caves and shelters in the mesa escarpment utilised by the MNES species.

Noise and vibration emissions from clearing, construction and blasting have the potential to cause the Northern Quoll and Ghost Bat to temporarily vacate shelters and potential diurnal/maternal roosts for the duration of the impact.

12.4.5 Degradation of habitat due to dust and light emissions

The Proposed Change is located in and near an active mining area and will likely result in increased airborne dust emissions from vegetation clearing, construction activities and mine operation. Dust may impact the health of vegetation which provides foraging habitat for MNES and could potentially impact the quality of Ghost Bat roosts.

Increased night time light emissions in the western portion of the Development Envelope may alter nocturnal foraging behaviour. Light emissions are likely to result in increased availability of prey species (insects) near the western portion of the Development Envelope for the Pilbara Leaf-nosed Bat and Ghost Bat.

12.4.6 Vehicle movements

The Northern Quoll, Pilbara Olive Python, Pilbara Leaf-nosed Bat and Ghost Bat may be affected by vehicle strike, as a result of construction and operation of the mine which may result in injury or mortality of individuals.

12.5 Assessment of impacts

Table 12-2 through to Table 12-5 provide an assessment of potential impacts to MNES against the Significant Impact Criteria for each matter.

Table 12-2: Assessment of the significance of impacts to Northern Quoll

Significant impact criteria	Assessment of impacts to Northern Quoll
Potential to cause a long-term decrease in the size of a population	The National Recovery Plan for the Northern Quoll (Hill and Ward 2010) identifies the Cane Toad as the most significant threat to Northern Quoll. While the Pilbara was once thought likely to a provide refuge for the Northern Quoll from the Cane Toad, recent modelling suggests that Cane Toads will invade the region (Cramer *et al.* 2016). Destruction of habitat from mining is also identified as a threat (Hill and Ward 2010). Habitat defined as critical to the survival of the Northern Quoll (DoE 2016) includes all habitat within the modelled distribution of the Northern Quoll which provides shelter/breeding and/or dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the Northern Quoll. This definition is highly inclusive and could be considered to include all foraging/dispersal habitat in the vicinity of multiple records of Northern Quoll. The local population of Northern Quoll has a strong association with the Breakaways and Gullies habitat and portions of the River habitat (Robe River). Based on the location of Northern Quoll records from the Robe Valley and the Development Envelope, the critical habitat locally is considered to comprise the Breakaways and Gullies habitat and portions of the River habitat (Robe River). *Clearing* Potential impacts to Northern Quoll denning, foraging and dispersal habitats from clearing are unlikely to lead to a long-term decrease in the size of the Northern Quoll population. The Breakaways and Gullies habitat provides denning and foraging opportunities for the Northern Quoll and is considered to represent critical habitat for the species locally. The Proposed Change has been designed to limit clearing in the Breakaways and Gullies habitat to 8 ha, equating to 6% of the Breakaways and Gullies habitat in the western portion of the Development Envelope and less than 1% of the mapped extent of the Breakaways and Gullies habitat in the broader Robe Valley. Escarpment cuts are required to access the mesa. The locations and designs of the escarpment cuts were selected to avoid the sections of the escarpments with the highest ecological value, including the highest value Northern Quoll habitat, based on the outcomes of the MWH (2015b) assessment of the escarpments. The mesa escarpments will be retained through delineation of a MEZ. The River habitat provides foraging and dispersal opportunities for the Northern Quoll and is also considered to be critical habitat at a local level. The Proposed Change has been designed to limit disturbance to the River habitat to less than 1% of the River habitat in the western portion of the Development Envelope, equating to less than 1% of the mapped extent of the River habitat. The Proposed Change will clear foraging and dispersal habitat within the western portion of the Development Envelope; however the majority of disturbance for the Proposed Change will be to the Plains habitat which is widespread and common throughout the Pilbara region and not considered critical to the survival of the Northern Quoll. Cumulatively, the Proposed Change will increase the existing mining footprint within the Robe Valley, resulting in the total cumulative clearing (including historical clearing, the Proposed Change and reasonably foreseeably projects) of Breakaway and Gullies habitat

Significant impact criteria	Assessment of impacts to Northern Quoll
	reaching 10% and cumulative clearing of River habitat reaching 1%. The cumulative impacts on foraging and denning habitat in the Robe Valley is not expected to lead to a long-term decrease in the size of the local or regional Northern Quoll population. *Groundwater abstraction* Potential impacts to Northern Quoll foraging and dispersal habitat from groundwater abstraction are unlikely to lead to a long-term decrease in the size of the Northern Quoll population nor affect its conservation status. No permanent or semi-permanent pools have been identified in the section of the ephemeral Warramboo Creek that is within the modelled extent of groundwater drawdown. Warramboo Creek supports facultative phreatophytic vegetation, that is, species that may opportunistically utilise groundwater to satisfy a proportion of their environmental water requirement. Abstraction of groundwater has the potential to impact phreatophytic species and potentially understorey vegetation along Warramboo Creek. Significant changes to understorey vegetation and hence fauna habitat due to abstraction of groundwater are not expected along the majority of the defined flow channel of Warramboo Creek. There is potential for minor changes to the abundance of understorey vegetation in the Plains habitat type downstream of the defined flow channel in Warramboo Creek. Current vegetation cover in this area is low and understorey vegetation has been impacted by cattle and weed species. The Plains habitat type is widespread and common throughout the Pilbara and provides only limited foraging and dispersal habitat for the Northern Quoll. Given the widespread nature of the Plains habitat type, the limited value of the Plains habitat to the Northern Quoll, the existing disturbance and the minor nature of the proposed changes, the proposed groundwater drawdown in the Yarraloola Aquifer is not expected to have a significant impact on foraging and dispersal habitat for the Northern Quoll, nor are the potential impacts expected to lead to a long-term decrease in the size of the Northern Quoll population. *Discharge of surplus water* Potential impacts to Northern Quoll foraging and dispersal habitat from proposed discharge of surplus water are unlikely to lead to a long-term decrease in the size of the Northern Quoll population. Discharge of surplus water may lead to an increase in utilisation of the area by Northern Quoll for foraging and dispersal for the duration of discharge. Following cessation of discharge, Warramboo Creek will return to the natural ephemeral flow regime, thus there is unlikely to be any long-term impact to Northern Quoll foraging and dispersal behaviour. Discharge of groundwater into Warramboo Creek may temporarily result in changed surface water chemistry and temporal water availability in Warramboo Creek up to 8 km downstream of the discharge point for the duration of discharge. Groundwater to be discharged is expected to vary from fresh to brackish, with the maximum salinity being well within the low risk guidelines for livestock drinking water (ANZECC/ARMCANZ 2000). The change in water chemistry and continual availability of water may result in temporary,

Significant impact criteria	Assessment of impacts to Northern Quoll
	localised vegetation stress and decline in vegetation health in an 8 km section of Warramboo Creek. This area represents a small proportion of foraging and dispersal habitat in the western portion of the Development Envelope and the broader Robe Valley. *Noise and vibration* Noise and vibration from mining operations are unlikely to lead to a long-term decrease in the size of the Northern Quoll population. The mesa escarpments provide denning habitat for the Northern Quoll. Vibrations associated with blasting have the potential to cause instability to caves and shelters within the mesa escarpment. However, given that the MEZ will provide a buffer zone between the mine pit and the mesa escarpment and that Northern Quoll require relatively small rock shelters for denning, it is unlikely that vibrations from mining operations will significantly alter the number or quality of available shelters. The Proponent will implement a Blast Management Framework to limit vibration emissions as described in Section 7.8. Noise from blasting and general mining operations has the potential to disturb Northern Quoll while denning. The buffer zone provided by the MEZ and the aspect of the denning habitat (facing away from the mining area) will reduce potential impacts from noise. Monitoring at Process Minerals Poondano West indicates the ongoing presence of a population of Northern Quoll despite mining activity. Northern Quoll numbers fluctuated over time and were lowest in 2012 during mining, potentially due to temporary displacement of some individuals, however a population remained present. Numbers increased to their highest level in 2014 after mining ceased; however, declined in 2015 across all sites (including control sites). Given that mining activity had ceased and there is no correlation between capture numbers and distance from the impact sites, the declines are considered unlikely to be due to previous mining disturbance (Astron 2015). Northern Quoll also continue to be observed in close proximity to current mining operations at Mesa A and at some other Rio Tinto Pilbara mine operations. *Dust and light* Dust and light emissions are unlikely to lead to a long-term decrease in the size of the Northern Quoll population. There is a general perception that dust deposition on plants causes negative impacts to plants; however, the Pilbara is a naturally dusty environment. A study examining the impacts of dust on plant health in semi-arid environments found no evidence to support that negative impacts result from dust deposition up to 77 g/m^2/month (Matsuki *et al.* 2016). Dust deposition monitoring conducted in 2016 approximately 340 m from the current Mesa A mine pit and approximately 100 m from the Mesa A plant showed a maximum dust deposition rate of 9.4 g/m^2/month. Based on dust monitoring to date and the study by Matsuki *et al*. (2016), any decline in vegetation health, and hence Northern Quoll foraging habitat, due to dust deposition is likely to be limited to the area immediately adjacent to the proposed mining operation. Given that impacts to vegetation from dust emissions will occur in only a small proportion of the available Northern Quoll foraging habitat and that Northern Quoll continue to be observed in close proximity to current mining operations at Mesa A, dust emissions are unlikely to lead to a long-term decrease in the size of the Northern Quoll population.

Significant impact criteria	Assessment of impacts to Northern Quoll
	Lighting in the mining area will be directed into the pit, away from Northern Quoll denning habitat present in the mesa escarpments. Existing light emissions at the Mesa A/Warramboo site do not appear to adversely impact Northern Quoll. It is unlikely the additional light emissions from the Proposed Change will impact Northern Quoll denning or foraging behaviour.
Potential to reduce the area of occupancy of the species	*Clearing* Potential impacts to Northern Quoll denning, foraging and dispersal habitats from clearing are unlikely to reduce the area of occupancy of the Northern Quoll. As described previously, the Proposed Change has been designed to avoid the highest value Northern Quoll habitat and the proposed disturbance will impact only a small proportion of the available denning/shelter habitat (Breakaways and Gullies) and adjacent foraging/dispersal habitat (River habitat). The majority of the western portion of the Development Envelope fits the DoE (2016) definition of Northern Quoll foraging and dispersal habitat with the majority (approximately 85%) of disturbance proposed to occur within the Plains habitat. This habitat type is widespread and common throughout the Pilbara region. *Groundwater abstraction* Potential impacts to Northern Quoll foraging and dispersal habitat from groundwater abstraction are unlikely to reduce the area of occupancy of the Northern Quoll. There are no permanent or semi-permanent pools along the potentially affected section of the ephemeral Warramboo Creek. Vegetation cover around Warramboo Creek is low and the understorey vegetation in the area has been impacted by cattle and weeds. At most, a minor reduction in the abundance of understorey vegetation in the Plains habitat type downstream of the defined flow channel of Warramboo Creek may occur as a result of groundwater abstraction. Given the Plains habitat is widespread and common throughout the Pilbara and provides only limited foraging and dispersal habitat for the Northern Quoll, a minor reduction in the abundance of understorey vegetation is considered unlikely to reduce the area of occupancy of the species. *Discharge of surplus water* Potential impacts to Northern Quoll foraging and dispersal habitat from proposed discharge of surplus water are unlikely to reduce the area of occupancy of the Northern Quoll. A small proportion of the mapped foraging and dispersal habitat will be impacted temporarily, while the higher quality habitat available in the Robe River and upstream in Warramboo Creek will be avoided. Warramboo Creek will return to an ephemeral system following cessation of discharge. *Noise and vibration* Noise and vibration from mining operations are unlikely to reduce the area of occupancy of the Northern Quoll. As described previously, significant impacts to Northern Quoll individuals while denning and to denning habitat are not expected given the ongoing presence of Northern Quoll near active mining operations and the buffer zone provided by the proposed MEZ. *Dust and light*

Significant impact criteria	Assessment of impacts to Northern Quoll
	Dust and light emissions are unlikely to reduce the area of occupancy of the Northern Quoll. Based on dust monitoring to date and the study by Matsuki *et al.* (2016) described previously, any decline in Northern Quoll foraging habitat due to dust deposition is likely to be limited to the area immediately adjacent to the proposed mining operation. Similarly, light emissions may alter Northern Quoll foraging behaviour in some isolated areas of the operation which would represent only a small proportion of the broader Northern Quoll habitat available.
Potential for fragmentation of an existing population into two or more populations	*Clearing* Potential impacts to Northern Quoll denning, foraging and dispersal habitats from clearing are unlikely to fragment an existing Northern Quoll population. The species is highly mobile and only a small proportion of habitat available to the species will be affected by the Proposed Change. An area of mesa plateau immediately adjacent to the denning and shelter habitat provided by the mesa escarpments will be retained around each mesa as part of the MEZ and the Proposed Change has been designed to limit disturbance to the River habitat adjacent to Mesas B and C to less than 1% of the River habitat in the western portion of the Development Envelope. Foraging habitat immediately adjacent to denning habitat will thus be retained. The majority of disturbance for the Proposed Change will be to the Plains habitat which is widespread and common throughout the Pilbara region and provides only limited foraging and dispersal habitat for the Northern Quoll. Installation of linear infrastructure (roads) will intersect Plains habitat. Given that the Northern Quoll is known to move over linear infrastructure such as roads, the proposed linear infrastructure is unlikely to present a barrier to movement of the Northern Quoll. *Groundwater abstraction* Potential impacts to Northern Quoll foraging and dispersal habitat from groundwater abstraction are unlikely to fragment an existing Northern Quoll population. Vegetation cover around Warramboo Creek is low and the understorey vegetation in the area has been impacted by cattle and weeds. At most, a minor reduction in the abundance of understorey vegetation in the Plains habitat type downstream of the defined flow channel of Warramboo Creek may occur as a result of groundwater abstraction. Given the Plains habitat type is widespread and common throughout the Pilbara and provides only limited foraging and dispersal habitat for the Northern Quoll, a minor reduction in the abundance of understorey vegetation is considered unlikely to fragment an existing Northern Quoll population. *Discharge of surplus water* The proposed discharge is unlikely to fragment an existing Northern Quoll population. A small proportion of the mapped foraging and dispersal habitat will be impacted temporarily while impacts to the higher quality habitat available in the Robe River and upstream in Warramboo Creek will be avoided. Warramboo Creek will return to an ephemeral system following cessation of discharge.

Significant impact criteria	Assessment of impacts to Northern Quoll
Potential to adversely affect habitat critical to the survival of a species	*Clearing* Habitat critical to the survival of the Northern Quoll comprises habitat within the modelled distribution of the Northern Quoll which provides shelter/breeding and/or dispersal and foraging habitat associated with or connecting populations important for the long-term survival of the Northern Quoll (DoE 2016). This definition is broad and includes the majority of the western portion of the Development Envelope. The local population of Northern Quoll has a strong association with the Breakaways and Gullies habitat and portions of the River habitat (Robe River). Based on the location of Northern Quoll records from the Robe Valley and the Development Envelope (Section 12.3.3), the critical habitat locally is considered to comprise the Breakaways and Gullies habitat and portions of the River habitat (Robe River). Other foraging and dispersal habitat within the Development Envelope is considered widespread and low value and not considered critical to the survival of the species. The Breakaways and Gullies habitat and the River habitat provide high value denning/shelter habitats associated with caves and rocky overhangs and/or enhanced foraging opportunities due to the availability of water (MHW 2015a). The proposed loss of habitat is not considered significant due to the avoidance of the highest value denning habitat and the extensive availability of foraging habitat both within and outside of the Development Envelope. The Proposed Change has been designed to limit disturbance to critical habitat locally and will impact less than 6% of Breakaways and Gullies habitat in the western portion of the Development Envelope and less than 1% of Major River/Creek habitat in the western portion of the Development Envelope. This is unlikely to disrupt foraging activities. The proposed habitat loss is not expected to affect the survival of the species locally or regionally. The Proposed Change has been designed to limit disturbance to Breakaways and Gullies and River habitats to 8 ha and less than 3 ha respectively, representing less than 1% of the mapped extent of Breakaways and Gullies and River habitats in the broader Robe Valley. The outputs from the MWH (2015b) escarpment assessment were used to ensure the locations of the proposed escarpment cuts avoid disturbance to the highest value Breakaways and Gullies habitat. The Proposed Change will clear foraging and dispersal habitat within the western portion of the Development Envelope; however the majority of disturbance for the Proposed Change will be to the Plains habitat which is widespread and common throughout the Pilbara region and not considered critical to the survival of the Northern Quoll. The proposed habitat loss is not expected to affect the survival of the species locally or regionally. Groundwater abstraction, surplus water discharge and noise, vibration, dust and light emissions are unlikely to significantly adversely affect habitat critical to the survival of the Northern Quoll.
Potential to disrupt the breeding cycle of a population	*Clearing* Given the Proposed Change has been designed to avoid the highest value Northern Quoll habitat and that the disturbance will impact only a small proportion (6%) of the available denning/shelter habitat, it is unlikely the Proposed Change will disrupt the breeding cycle of the Northern Quoll population.

Significant impact criteria	Assessment of impacts to Northern Quoll
	Groundwater abstraction and surplus water discharge Proposed groundwater abstraction and surplus water discharge are unlikely to disrupt the breeding cycle of the Northern Quoll population. Groundwater abstraction and surplus water discharge may temporarily alter the quality of Northern Quoll foraging and dispersal habitat. However, the area that may be impacted represents only a small proportion of available foraging and dispersal habitat in the Robe Valley. *Noise and vibration* Noise and vibration from mining operations are unlikely to disrupt the breeding cycle of the Northern Quoll population. As described previously, significant impacts to Northern Quoll individuals while denning and to denning habitat are not expected given the ongoing presence of Northern Quoll near active mining operations and the buffer zone provided by the proposed MEZ.
Potential to modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely the Proposed Change will lead to decline of the Northern Quoll species. None of the potential impacts are likely to result in a significant impact to the availability or quality of the habitat for this species. The proposed direct impact of habitat loss is not expected to affect the survival of the species locally or regionally. Similarly, the potential indirect impacts from the Proposed Change are unlikely to significantly affect Northern Quoll habitat or individuals to the extent that the species could decline.
Potential for the establishment of invasive species in the endangered species' habitat that are harmful to the endangered species	The Cane Toad is not currently established in the Pilbara and is the invasive species which poses the greatest threat to Northern Quoll. Cane Toads absorb water through their skin from dew or any moist material and need constant access to moisture to survive. Two semi-permanent pools associated with the Robe River are present in the western portion of the Development Envelope adjacent to Mesa B and one ephemeral pool adjacent to the northern part of Mesa C. Permanent pools associated with the Robe River are present outside the Development Envelope with the closest pools located approximately 3.7 km to the north and 8.4 km to the south-east of the Development Envelope. Currently water is continuously available in the middle and upper sections of the Robe River to the east of the Development Envelope and a base flow is believed to be continuously present in the upper reaches of the Robe River. It is, therefore, considered that there is currently sufficient water continuously available in the Robe River to enable establishment of the Cane Toad in the Robe Valley should it spread to the Pilbara. Discharge of surplus water to Warramboo Creek, approximately 13 km south-west of the Robe River will temporarily increase the availability of water for the duration of discharge. However, as permanent water is already available in the Robe River to the east, discharge to Warramboo Creek will not alter the possibility of Cane Toads becoming established in the area. The Feral Cat is also considered to pose a threat to the Northern Quoll. Monitoring of Northern Quoll in the vicinity of the Development Envelope as part of Rio Tinto's Threatened Species Offset Plan demonstrated that Northern Quolls suffer high levels of mortality due to predation by feral cats (Morris *et al.* 2014 cited in Palmer *et al.* 2017). However, it is unlikely the Proposed Change will result in an

Significant impact criteria	Assessment of impacts to Northern Quoll
	increase in the Feral Cat population. Feral Cat control will continue to be undertaken as needed by the Proponent in the areas where the Proponent operates.
Potential for the introduction of disease that may cause the species to decline	The Proposed Change is unlikely to introduce disease that may cause the Northern Quoll to decline.
Potential interference with the recovery of the species	Given the proposed disturbance will impact only a small proportion of the available Northern Quoll habitat and that the Proposed Change has been designed to avoid the highest value denning and foraging habitat, the Proposed Change is unlikely to interfere with the recovery of the Northern Quoll or affect its conservation status.

Table 12-3: Assessment of significance of impacts to Pilbara Leaf-nosed Bat

Significant impact criteria	Assessment of impacts to Pilbara Leaf-nosed Bat
Potential to cause a long-term decrease in the size of a population	The approved conservation advice (TSSC 2016a) for the Pilbara Leaf-nosed Bat defines critical habitat as including permanent and transitory diurnal and breeding roosts, and identifies priority foraging habitat as gorges with pools, gullies, rocky outcrops, major watercourses and grassland and woodland. Nocturnal refuges are not considered critical habitat, but are important for populations' persistence in a local area. *Clearing* No diurnal, breeding or nocturnal roosts for the Pilbara Leaf-nosed Bat have been recorded in the western portion of the Development Envelope and individuals recorded in the western portion of the Development Envelope are considered likely to originate from a roost outside the Development Envelope. Potential impacts to Pilbara Leaf-nosed Bat foraging and dispersal habitat from clearing are unlikely to lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. The Proposed Change will impact only a small proportion of foraging habitat (Figure 12-1). Specifically, the Proposed Change has been designed to limit disturbance to Breakaways and Gullies habitat and River habitat to 8 ha and less than 3 ha respectively, representing less than 1% of the mapped extent of Breakaways and Gullies and River habitats in the broader Robe Valley. Cumulatively, it is not expected that the Proposed Change will lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population locally or regionally. *Groundwater abstraction* Potential impacts to Pilbara Leaf-nosed Bat foraging habitat from groundwater abstraction are unlikely to lead to a long-term decrease in the size of the population. Abstraction of groundwater has the potential to impact phreatophytic species and potentially understorey vegetation along Warramboo Creek. No permanent or semi-permanent pools have been identified in the section of the ephemeral Warramboo Creek that is within the modelled extent of groundwater drawdown. Significant changes to understorey vegetation and hence fauna habitat due to abstraction of groundwater are not expected along the majority of the defined flow channel of Warramboo Creek. There is potential for minor changes to the abundance of understorey vegetation in the Plains habitat type downstream of the defined flow channel in Warramboo Creek. Current vegetation cover in this area is low and understorey vegetation has been impacted by cattle and weed species. The Plains habitat type is widespread and common throughout the Pilbara and provides only limited foraging and dispersal habitat for the Pilbara Leaf-nosed Bat. Given the lack of permanent and semi-permanent pools, the widespread nature of the Plains habitat type, the limited value of the Plains

Significant impact criteria	Assessment of impacts to Pilbara Leaf-nosed Bat
	habitat to the Pilbara Leaf-nosed Bat, the existing disturbance and the minor nature of the proposed changes, the proposed groundwater drawdown in the Yarraloola Aquifer is not expected to lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. *Discharge of surplus water* Potential impacts to Pilbara Leaf-nosed Bat foraging and dispersal habitat from proposed discharge of surplus water are unlikely to lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. Discharge of surplus water may lead to an increase in utilisation of the area by Pilbara Leaf-nosed Bat for foraging and dispersal for the duration of discharge. Following cessation of discharge, Warramboo Creek will return to the natural ephemeral flow regime, thus there is unlikely to be any long-term impact on Pilbara Leaf-nosed Bat foraging and dispersal behaviour. Discharge of groundwater into Warramboo Creek may temporarily result in changed surface water chemistry and temporal water availability in Warramboo Creek up to 8 km downstream of the discharge point for the duration of discharge. Groundwater to be discharged is expected to vary from fresh to brackish, with the maximum salinity being well within the low risk guidelines for livestock drinking water (ANZECC/ARMCANZ 2000). The change in water chemistry and increased availability of water may result in temporary, localised vegetation stress and decline in vegetation health in an 8 km section of Warramboo Creek. This area represents a small proportion of mapped foraging and dispersal habitat in the western portion of the Development Envelope and in the broader Robe Valley. *Noise and vibration* Noise and vibration from mining operations are unlikely to lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. The most significant noise and vibration from the proposed mining operation will occur during the day from blasting activities. Given that no Pilbara Leaf-nosed Bat roosts have been recorded in the western portion of the Development Envelope, and that the species forages at night, noise and vibration from the Proposed Change are unlikely to impact the population. *Dust and light* Based on dust monitoring to date and the study by Matsuki *et al* (2016), any decline in vegetation health, and hence Pilbara Leaf-nosed Bat foraging habitat, due to dust deposition is likely to be limited to the area immediately adjacent to the proposed mining operation. Given that impacts to vegetation from dust emissions will occur in only a small proportion of the available Pilbara Leaf-nosed Bat foraging habitat and that Pilbara Leaf-nosed Bat continue to be observed in close proximity to current mining operations at Mesa A, dust emissions are unlikely to lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. Permanent lighting has been installed at Mesa A/Warramboo in areas such as the camp, administration and workshops. Temporary lighting is installed in individual pits as they are mined and is directed into the pits. As part of the Proposed Change, permanent lighting will continue to be utilised in areas such as the camp, administration and workshops and temporary lighting of individual pits will continue to be utilised as each pit is mined. Lighting of mining areas will continue to be directed into the pits. Light may alter nocturnal foraging behaviour

Significant impact criteria	Assessment of impacts to Pilbara Leaf-nosed Bat
	by attracting prey to the lights; however, given light is already present from the Mesa A/ Warramboo Iron Ore Project and the area impacted will be small compared with the available extent of Pilbara Leaf-nosed Bat foraging habitat, light is unlikely to lead to a long-term decrease in the size of the Pilbara Leaf-nosed Bat population. *Physical presence of infrastructure* Pilbara Leaf-nosed Bats may collide with barbed wire fencing. The Proposed Change will utilise existing infrastructure at Mesa A/Warramboo where possible. Additional key infrastructure for the Proposed Change will be primarily installed in the Plains habitat which provides only limited foraging and dispersal habitat for the Pilbara Leaf-nosed Bat. No major infrastructure will be installed in the Robe River which provides key foraging habitat for the Pilbara Leaf-nosed Bat. Where fencing is required, the Proponent will install non-barbed wire fencing, except where barbed fencing is legislated. Where barbed fencing is required, reflectors will be attached to the fence to reduce the risk of bat entanglement. *Vehicle movements* Vehicle movements for the Proposed Change are unlikely to result in a long-term decrease in the Pilbara Leaf-nosed Bat population. Pilbara Leaf-nosed Bats are known to be attracted to light and fly low, resulting in the potential for collisions with vehicles; however, vehicle movements at night (when Pilbara Leaf-nosed Bats are foraging) are much less than during the day and are generally limited to in-pit operations.
Potential to reduce the area of occupancy of the species	The area of occupancy of the Pilbara Leaf-nosed Bat is limited by the availability of suitable diurnal roosts (TSSC 2016a). No diurnal roosts have been recorded in the western portion of the Development Envelope and individuals recorded are considered likely to originate from a roost remote from the Development Envelope. *Clearing* Potential impacts to Pilbara Leaf-nosed Bat foraging and dispersal habitat from clearing are unlikely to reduce the area of occupancy of the Pilbara Leaf-nosed Bat population. The Proposed Change has been designed to avoid the highest value habitat and the disturbance will only impact a small proportion of the available foraging habitat for the species. *Groundwater abstraction* Potential impacts to Pilbara Leaf-nosed Bat foraging and dispersal habitat from groundwater abstraction are unlikely to reduce the area of occupancy of the species. There are no pools along the potentially impacted section of the ephemeral Warramboo Creek, and the impacts to facultative phreatophytic vegetation supported by Warramboo Creek are predicted to be limited. *Discharge of surplus water*

Significant impact criteria	Assessment of impacts to Pilbara Leaf-nosed Bat
	Potential impacts to Pilbara Leaf-nosed Bat foraging and dispersal habitat from proposed discharge of surplus water are unlikely to reduce the area of occupancy of the Pilbara Leaf-nosed Bat. A small proportion of the mapped foraging and dispersal habitat will be impacted temporarily, while higher quality habitat available in the Robe River and upstream in Warramboo Creek will be avoided. Increased availability of water in Warramboo Creek during the period of discharge has the potential to extend the foraging range of the Pilbara Leaf-nosed Bat. Warramboo Creek will return to an ephemeral system following cessation of discharge. *Noise and vibration* Noise and vibration impacts from mining operations are unlikely to reduce the area of occupancy of the Pilbara Leaf-nosed Bat. The most significant noise and vibration from the proposed mining operation will occur during the day from blasting activities. Given that no Pilbara Leaf-nosed Bat roosts have been recorded in the western portion of the Development Envelope, and that the species forages at night, noise and vibration from the Proposed Change are unlikely to impact nocturnal foraging behaviour. *Dust and light* Dust and light emissions are unlikely to reduce the area of occupancy of the species. No Pilbara Leaf-nosed Bat roosts have been recorded in the western portion of the Development Envelope. Based on dust monitoring to date and the study by Matsuki *et al.* (2016) described previously, any decline in the quality of Pilbara Leaf-nosed Bat foraging habitat is likely to be limited to the area immediately adjacent to the proposed mining operation. Light emissions may alter nocturnal foraging behaviour by attracting prey to the lights. However, given light is already present in the Mesa A/Warramboo area and that light emissions will affect only a small proportion of Pilbara Leaf-nosed Bat foraging habitat, light emissions are unlikely to reduce the area of occupancy of the Pilbara Leaf-nosed Bat.
Potential for fragmentation of an existing population into two or more populations	*Clearing* The proposed disturbance is unlikely to fragment a population given that the Proposed Change will not create physical barriers to movement and no roosts have been recorded in the western portion of the Development Envelope. All other potential impacts associated with the Proposed Change are unlikely to fragment the Pilbara Leaf-nosed Bat population.
Potential to adversely affect habitat critical to the survival of a species	*Clearing* The Proposed Change is unlikely to affect habitat critical to the survival of the Pilbara Leaf-nosed Bat as no diurnal roosts have been recorded in the western portion of the Development Envelope. In addition, the Proposed Change has been designed to limit impacts to priority foraging habitats as defined by the TSSC (2016a). Specifically, the Proposed Change has been designed to impact less than 1% of the mapped Breakaways and Gullies habitat which contain gullies and rocky outcrops (Priority 2 and 3 habitat) and less than 1% of the River habitat of the Robe River and Warramboo Creek (Priority 4 habitat) within the broader Robe Valley. Given the number of records of

Significant impact criteria	Assessment of impacts to Pilbara Leaf-nosed Bat
	Pilbara Leaf-nosed Bat locally and their strong association with Breakaways and Gullies and River habitat, it is considered that an appropriate definition of critical habitat locally is the Breakaways and Gullies habitat and River habitat. Although the Revised Proposal will have a limited impact on critical habitat this will not necessarily result in a significant impact on the Pilbara Leaf-nosed Bat. All other potential impacts associated with the Proposed Change are unlikely to significantly adversely affect habitat critical to the survival of the species.
Potential to disrupt the breeding cycle of a population	*Clearing* No Pilbara Leaf-nosed Bat diurnal or maternity roosts have been recorded in the western portion of the Development Envelope. The Proposed Change will therefore not impact the breeding cycle of an important population. All other potential impacts associated with the Proposed Change are unlikely to disrupt the breeding cycle of the Pilbara Leaf-nosed Bat population.
Potential to modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely the Proposed Change will lead to decline of the Pilbara Leaf-nosed Bat. No diurnal roosts will be affected and only a small proportion of foraging habitat will be impacted. None of the potential direct or indirect impacts are likely to result in a significant impact to the availability or quality of the foraging habitat for this species. The proposed disturbance to habitat is therefore not expected to affect the survival of the species locally or regionally, or affect its conservation status.
Potential for the establishment of invasive species in the endangered species' habitat that are harmful to an endangered species	The TSSC (2016a) notes that the Pilbara Leaf-nosed Bat has been exposed to the degradation and modification of natural habitats caused by introduced species such as invasive weeds, domestic herbivores and other larger feral ungulates since the arrival of Europeans and that invasive species are unlikely to have a significant effect overall. The Proposed Change will not introduce invasive species that are harmful to the Pilbara Leaf-nosed Bat.
Potential for the introduction of disease that may cause the species to decline	There are no known diseases threatening the Pilbara Leaf-nosed Bat (TSSC 2016a). The Proposed Change is unlikely to introduce disease that may cause the species to decline.
Potential interference with the recovery of the species	The primary objective for preventing the decline of the Pilbara Leaf-nosed Bat is to protect known and suspected diurnal roost sites and to avoid activities within close proximity to these roosts that could cause roost abandonment and fatalities of individuals (TSSC 2016a). Given that the Proposed Change will not impact any known or suspected Pilbara Leaf-nosed Bat roosts and that proposed disturbance will impact only a small proportion of available foraging habitat, the Proposed Change is unlikely to interfere with the recovery of the Pilbara Leaf-nosed Bat.

Table 12-4: Assessment of significance of impacts to Ghost Bat

Significant impact criteria	Assessment of impacts to Ghost Bat
Potential to cause a long-term decrease in the size of a population	The approved conservation advice for Ghost Bat identifies the key threat to the species as the destruction of, or disturbance to known roosts and nearby areas. There are currently no defined criteria for habitat critical for the survival of the species, or identified important populations. The most significant habitats in the western portion of the Development Envelope for the species are the Breakaways and Gullies habitat, including the mesa escarpments, and the River habitat; these areas represent potential roosting and foraging habitat. *Clearing* It is unlikely the proposed clearing will lead to a long-term decrease in the size of the Ghost Bat population. The Proposed Change has been designed to avoid the highest value Ghost Bat habitat, including the roost complex associated with the diurnal/potential maternal roost at Mesa B and the roost complex associated with the potential diurnal roost at Mesa C by establishing a MEZ around these roosts. The Proposed Change will limit disturbance of the mesa escarpments to less than 3% of the perimeter of each mesa escarpment. This equates to less than 1% of the mapped undisturbed Breakaways and Gullies habitat in the broader Robe Valley which may provide roost habitat for Ghost Bats. The Proposed Change will avoid direct disturbance to all but one recorded nocturnal Ghost Bat roost, specifically, the Proposed Change will avoid direct disturbance to the two recorded nocturnal roosts at Mesa A, nine of the ten recorded nocturnal roosts at Mesa B and all eight recorded nocturnal/possible nocturnal roosts at Mesa C. In addition, the Proposed Change has been designed to limit clearing of River habitat (foraging habitat) to less than 3 ha, representing less than 1% of the mapped foraging habitat in the broader Robe Valley. The proposed avoidance of roost complexes associated with the recorded potential diurnal/ maternal roost sites and all but one of the recorded nocturnal roost sites is consistent with the approved conservation advice (TSSC 2016b). Cumulatively, the Proposed Change will increase the existing mining footprint in the Robe Valley resulting in the total cumulative clearing (including historical clearing, the Proposed Change and reasonably foreseeably projects) of Breakaway and Gullies habitat reaching 10% and cumulative clearing of River habitat reaching 1%. The cumulative impacts on foraging and roosting habitat in the Robe Valley is not expected to lead to a long-term decrease in the size of the local or regional Ghost Bat population. Further afield, BHP Billiton (BHP) proposes to impact 17 known Ghost Bat caves at the proposed Area C Southern Flank Proposal (approximately 325 km south-east of the Revised Proposal) including five high value caves. The Area C Southern Flank Proposal also includes the loss of 9,307 ha of foraging habitat. The Area C Southern Flank Proposal is predicted to result in a reduction in that local population and will increase the cumulative impacts to the species in the Pilbara region. *Noise, vibration and other disturbance*

Significant impact criteria	Assessment of impacts to Ghost Bat
	Noise and vibration from mining operations are unlikely to lead to a long-term decrease in the size of the Ghost Bat population. Noise from blasting and general mining operations has the potential to disturb Ghost Bats while roosting. However, there is evidence to demonstrate that Ghost Bats will continue to use a roost despite nearby mining activities. For example, monitoring conducted at the Minerals Resources Poondano Iron Ore Project approximately 20 km south-east of Port Hedland recorded Ghost Bats in a roost approximately 50 m from the mining operation both during and after mining operations (Astron 2015). The proposed mine design incorporates a 40 m setback distance between the back of each potential diurnal/maternal roost cave and the proposed mine pit and 50 m from the entry to nocturnal roosts (except shelter MBS-05 which will be impacted by the haul road to Mesa B), to protect the integrity of the roosts and to minimise the impact of noise and vibration on bats. The MEZs at Mesas B and C will provide a buffer zone between the mine pit and the mesa escarpment. The buffer zone provided by the MEZ and the aspect of the roost habitat (facing away from the mining area) will reduce potential impacts to Ghost Bats from noise. Vibration associated with blasting has the potential to result in loss of, or damage to, the caves and shelters in the mesa escarpment. Geotechnical assessment of the caves that form the potential diurnal/maternal Ghost Bat roost complexes determined that the geotechnical sensitivity of these roosts to structural instability is low (Rio Tinto 2017g). In addition, the MEZ will provide a buffer zone of at least 40 m between the mine pit and the diurnal/potential maternal roost caves and a Blast Management Framework to control PPV will be implemented to ensure the structural integrity of potential diurnal/maternal Ghost Bat roost caves is not compromised. The Blast Management Framework will be implemented to ensure blast vibration levels at the identified diurnal/potential maternal Ghost Bat roosts remain below the trigger level PPV set in the EMP (see EMP in Appendix 4). Measures that may be used to achieve the required blast control are discussed in Section 7.6.4.2. Additional information regarding the characteristics of the rock between the proposed disturbance and the diurnal/maternal roost caves, the geotechnical stability of the rock and the Proponent's Blast management control is also provided in Section 7.6.4.2. The Proponent requires personnel to comply with strict guidelines regarding cave entry for safety reasons as well as protection of heritage and environmental values. The Proponent will continue to apply these guidelines. Disturbance to Ghost Bats resulting from human visitation to caves is, therefore, unlikely to result in any changes to the Ghost Bat population in the western portion of the Development Envelope. Given the low geotechnical sensitivity to roost structural instability, the ongoing presence of Ghost Bats at the Poondano site and the proposed blast and human visitation management measures, noise and vibration from the Proposed Change are unlikely to lead to a long-term decrease in the size of the Ghost Bat population. *Physical presence of infrastructure*

Significant impact criteria	Assessment of impacts to Ghost Bat
	Fencing and other infrastructure are unlikely to lead to a long-term decrease in the size of the Ghost Bat population. Ghost Bats have the potential to become entangled in barbed wire fencing as the Ghost Bat does not distinguish the fencing quickly enough when flying just above the ground surface at night. The Proponent will, therefore, install non-barbed wire fencing, except where barbed wire is legislated. Where barbed wire fencing is required, reflectors will be attached to the fence to deter Ghost Bats. *Vehicle movements* Vehicle movements for the Proposed Change are unlikely to result in a long-term decrease in the Ghost Bat population. Ghost Bats are known to be able to fly low, resulting in potential for collisions with vehicles. However, vehicle movements at night (when Ghost Bats are foraging) are much less than during the day and are generally limited to in-pit operations.
Potential to reduce the area of occupancy of the species	*Clearing* Potential impacts to Ghost Bat roosting, foraging and dispersal habitats from clearing are unlikely to reduce the area of occupancy of the Ghost Bat. As described previously, the Proposed Change will retain the most important habitat for Ghost Bat including the recorded diurnal/potential maternal roost at Mesa B, the potential diurnal roost at Mesa C and the majority of nocturnal roosts on Mesas A, B and C. Therefore, the species is likely to continue to occupy habitat within the western portion of the Development Envelope. *Noise and vibration* Noise and vibration emissions are unlikely to reduce the area of occupancy of the Ghost Bat. Noise from blasting and general mining operations has the potential to disturb Ghost Bats while roosting. As discussed previously, there is evidence of continued Ghost Bat presence at the Poondano mine site during and after mining operations (Astron 2015). The MEZ will provide a minimum buffer zone of 40 m between the mine pit and the diurnal/maternal GB roost caves. The buffer zone provided by the MEZ and the aspect of the roost habitat (facing away from the mining area) will reduce potential impacts to Ghost Bats from noise. Historical mining areas in the Robe Valley show evidence of Ghost Bat presence following mining. The initial mining undertaken in the Robe Valley did not prioritise retention of the mesa escarpments. The proportion of escarpment remaining on each of the 14 historically mined mesas varies between 0% and over 90% but is generally less than 50% (Bat Call WA 2017b). Nine of the ten mesas with partial escarpment retention were assessed for Ghost Bat activity. Evidence of Ghost Bat usage was found on six of these mesas demonstrating that retained escarpments continue to offer roosting opportunities for the Ghost Bat (Bat Call WA 2017b). Evidence of current Ghost Bat presence on historically mined mesas in the Robe Valley indicates that Ghost Bats either continued to use the roosts during mining operations or returned to the area after completion of mining.

Significant impact criteria	Assessment of impacts to Ghost Bat
	Ghost Bat roosts are present throughout the Robe Valley. A contextual field survey (Astron 2017c) recorded the following roosts/potential roosts in the Robe Valley (excluding those in the western portion of the Development Envelope): • Two maternal/potential maternal roosts (one confirmed, one potential), including a maternity roost at Mesa F approximately 10 km to the south-south-east of Mesa C • Nine diurnal/potential diurnal roosts (eight confirmed, one potential) • 26 confirmed nocturnal roosts (total only from this study; other nocturnal roosts have been and continue to be recorded in the Robe Valley). As previously discussed, field observations of Ghost Bats and hormone analysis in the east Pilbara suggest that maternity groups may use different maternity roosts across different seasons and the concept of a centralised maternity roost may not be applicable in the Pilbara region (Biologic 2016). Vibrations associated with blasting have the potential to result in loss of, or damage to, the caves and shelters in the mesa escarpment. Loss or damage to roosts has the potential to reduce the area of occupancy of the Ghost Bat. As previously discussed, geotechnical assessment of the caves that form the potential diurnal/maternal Ghost Bat roost complexes determined that the geotechnical sensitivity of these roosts to structural instability is low (Rio Tinto 2017g). In addition, the Proponent will implement a Blast Management Framework in the vicinity of potential diurnal/maternal Ghost Bat roost caves to limit vibration emissions as described in Sections 7.8 and 7.6.4.2. Given impacts from noise and vibration will be reduced by blast management and the minimum buffer distance of 40 m from the pits to the back of the potential diurnal/maternal GB roost caves; evidence that Ghost Bats either continue to be present during mining operations or return to roosts after mining; availability of other roosts in the Robe Valley and evidence that Ghost Bats may use different maternity roosts across seasons, it is considered that the Proposed Change is unlikely to result in a long-term reduction in the area of occupancy of the Ghost Bat. *Dust and light* Dust emissions are unlikely to reduce the area of occupancy of Ghost Bat. While dust has the potential to impact the quality of Ghost Bat habitat, natural protection is afforded to Ghost Bat roosts at Mesas B and C from the orientation of roosts away from mine operations. In addition, the proposed mesa escarpment cut and associated haul road at Mesa B were moved early in the design process to avoid passing directly in front of the diurnal roost at Mesa B; with the proposed location now approximately 290m to the west of the diurnal roost.

Significant impact criteria	Assessment of impacts to Ghost Bat
	Light emissions are unlikely to reduce the area of occupancy of the Ghost Bat. Temporary lighting will be installed in the active mining areas and will face into the mining area, not onto the mesa escarpment. Light is already present from the Mesa A/Warramboo mining operation and while additional light emissions may alter Ghost Bat nocturnal foraging behaviour by increasing attraction of prey to the area, this is unlikely to have an adverse effect on the Ghost Bat.
Potential for fragmentation of an existing population into two or more populations	*Clearing* Potential impacts to the one Ghost Bat nocturnal roost and Ghost Bat foraging and dispersal habitat are unlikely to fragment the existing Ghost Bat population. As described, the Proposed Change has been designed to avoid direct disturbance to Ghost Bat roosts; the roost complexes associated with the diurnal/potential maternal roost at Mesa B and the potential diurnal roost at Mesa C will be retained. The Proposed Change has also been designed to limit clearing of Ghost Bat foraging habitat to less than 3 ha of River habitat, representing less than 1% of the mapped foraging habitat in the broader Robe Valley. Clearing for the Proposed Change and any other potential impacts of the Proposed Change will not create physical barriers to Ghost Bat movement and therefore will not fragment the population.
Potential to adversely affect habitat critical to the survival of a species	*Clearing* It is unlikely the Proposed Change will adversely affect habitat critical to the survival of the species, to the extent that the species would decline at the local or regional scale. There is currently no definition of “habitat critical to the survival of the species” for the Ghost Bat. The approved conservation advice for Ghost Bat (TSSC 2016b) identifies protection of roost sites as the highest priority conservation management action. In addition, bat ecologist Robert Bullen suggests that Ghost Bats require a roost complex, including at least one deep cave with characteristics of a maternity roost, multiple caves/shelters and overhangs in close proximity offering nocturnal and refuge opportunities, a productive set of gullies and gorges locally, a productive foraging area within 5 to 10 km radius and a good quality riparian line (Bat Call WA 2016). This range of habitats and values will continue to be present in and near the western portion of the Development Envelope. As previously discussed, the Ghost Bat and suitable Ghost Bat habitat, including maternity roosts and diurnal roosts, has been recorded throughout the Robe Valley. Evidence of recent Ghost Bat utilisation has been recorded at 20 of the 34 named mesas in the Robe Valley. In addition there are five other sites within 10 km of the Robe River where Ghost Bat activity has been recently recorded (Bat Call WA 2016). Given that the Proposed Change will retain the roost complexes associated with the potential maternal/diurnal roosts and the wider availability of roosting habitat in the Robe Valley, the Proposed Change is unlikely to adversely affect habitat critical to the survival of the species to the extent that the species would decline.

Significant impact criteria	Assessment of impacts to Ghost Bat
	All other potential impacts associated with the Proposed Change are unlikely to affect habitat critical to the survival of the species.
Potential to disrupt the breeding cycle of a population	*Clearing* Given the Proposed Change has been designed to avoid the one recorded diurnal/potential maternal roost at Mesa B and the potential diurnal roost at Mesa C, it is unlikely clearing associated with the Proposed Change will disrupt the breeding cycle of the Ghost Bat population. *Noise and vibration* Noise from blasting and general mining operations has the potential to disturb Ghost Bats while roosting and potentially disrupt the breeding cycle of the Ghost Bats roosting in the western portion of the Development Envelope. As discussed previously, there is evidence of continued Ghost Bat presence at the Poondano mine site during and after mining operations (Astron 2015). There is also evidence to suggest that maternity groups may use different maternity roosts across different seasons (Biologic 2016). As there are other roosts present in the vicinity of the Development Envelope (including the maternity roost at Mesa F, approximately 13 km from Mesa B), it may be possible for Ghost Bats to utilise an alternative roost. The potential to disturb roosting Ghost Bats will be reduced by the minimum 40 m buffer zone between the mine pit and the mesa escarpment that will be created by the delineation of the MEZ and by the aspect of the roost habitat (facing away from the mining area). Vibrations associated with blasting have the potential to disrupt the breeding cycle of Ghost Bats roosting in the western portion of the Development Envelope through loss of or damage to the caves and shelters in the mesa escarpments. As previously discussed, geotechnical assessment of the caves that form the potential diurnal/maternal Ghost Bat roost complexes determined that the geotechnical sensitivity of these roosts to structural instability is low (Rio Tinto 2017g). In addition, the Proponent will implement a Blast Management Framework to limit vibration emissions as described in Sections 7.8 and 7.6.4.2. All other potential impacts are unlikely to disrupt the breeding cycle of the species.
Potential to modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely the direct or indirect impacts associated with the Proposed Change will lead to decline of the Ghost Bat. The proposed habitat loss is not expected to affect the survival of the species locally or regionally. The most significant habitat features for this species will be avoided via the protection afforded by the pit re-design and delineation of a MEZ, and protected through appropriate mitigation measures such as specific blasting measures as outlined above. Therefore, none of the potential impacts are likely to result in a significant impact to the availability or quality of the habitat for this species.

Significant impact criteria	Assessment of impacts to Ghost Bat
Potential for the establishment of invasive species in the endangered species' habitat that are harmful to an endangered species	The Cane Toad is a known threat to the Ghost Bat as Ghost Bats may prey on Cane Toads and have been shown to be susceptible to Cane Toad toxin. The Cane Toad is not currently established in the Pilbara. Cane Toads absorb water through their skin from dew or any moist material and need constant access to moisture to survive. Two semi-permanent pools associated with the Robe River are present in the western portion of the Development Envelope adjacent to Mesa B and one ephemeral pool adjacent to the northern part of Mesa C. Permanent pools associated with the Robe River are present outside the Development Envelope with the closest pools located approximately 3.7 km to the north and 8.4 km to the south-east of the Development Envelope. Numerous permanent pools are present further upstream in the Robe River and a base flow is believed to be continuously present in the upper reaches of the Robe River. It is, therefore, considered that there is currently sufficient water continuously available in the Robe River to enable establishment of the Cane Toad in the Robe Valley should it spread to the Pilbara. Discharge of surplus water to Warramboo Creek, approximately 13 km south-west of the Robe River will temporarily increase the availability of water for the duration of discharge. However, as permanent water is already available in the Robe River, discharge to Warramboo Creek will not alter the possibility of Cane Toads becoming established in the area. Following cessation of discharge, Warramboo Creek will return to the natural ephemeral flow regime. Competition for prey with feral cats may also be a threat to the Ghost Bat. The Proponent will continue to implement feral fauna control as needed in areas where it operates.
Potential for the introduction of disease that may cause the species to decline	The Proposed Change is unlikely to introduce disease that may cause the species to decline.
Potential interference with the recovery of the species	Given the Proposed Change has been designed to avoid the highest value roost habitat, limit disturbance to only a small proportion of mapped foraging habitat and that the Proposed Change includes implementation of a MEZ and Blast Management Framework, the Proposed Change is unlikely to interfere with the recovery of the Ghost Bat.

Table 12-5: Assessment of significance of impacts to Pilbara Olive Python

Significant impact criteria	Assessment of impacts to Pilbara Olive Python
Potential to cause a long-term decrease in the size of a population	There are currently no defined criteria for habitat critical for the survival of the Pilbara Olive Python, or identified important populations. The approved conservation advice for the Pilbara Olive Python describes preferred habitat for the Pilbara Olive Python as including deep gorges and water holes (TSSC 2008). The most significant habitat in the western portion of the Development Envelope for the species is the Breakaways and Gullies habitat, particularly areas in close proximity to the semi-permanent pools near Mesa B in the Robe River. This species is known to occur at more than 60 locations across the Pilbara (G. Humphreys, Biota Environmental Sciences, pers. comm. 2012). The conservation advice (TSSC 2008) notes that estimating population size for the Pilbara Olive Python is difficult due to the cryptic nature of the species, lack of reliable trapping methods or census techniques and the narrow range of reliable surveys. *Clearing* Potential impacts to Pilbara Olive Python shelter/breeding, foraging and dispersal habitats from clearing are unlikely to lead to a long-term decrease in the size of the Pilbara Olive Python population. The Proposed Change has been designed to avoid the highest value shelter/breeding habitat contained in the mesa escarpments. Specifically, the Proposed Change will impact 6% of the potential shelter/breeding habitat (Breakaways and Gullies habitat) and less than 1% of the potential foraging habitat (River habitat) within the western portion of the Development Envelope. A MEZ will be established around the mesa escarpment to protect fauna and habitat values supported by the mesa escarpment. The Proposed Change will utilise existing infrastructure at Mesa A/Warramboo where possible. Additional key infrastructure for the Proposed Change will be primarily installed in the Plains habitat which provides only limited foraging and dispersal habitat for the Pilbara Olive Python. No major infrastructure will be installed in the Robe River which provides key foraging habitat for the Pilbara Olive Python. Waste fines, effluent from the reverse osmosis plant and some waste rock will be disposed of in-pit reducing clearing. Cumulatively, the Proposed Change will add to the footprint of the existing Mesa J Operations together with the Mesa H Proposal, and will result in the direct loss of up to 2ha of foraging habitat comprising River habitat, and limited loss of potential denning habitat. On this basis, it is expected that the Proposed Change will not contribute significant additional impacts to the Pilbara Olive Python which may cause a long-term decrease in the size of the population. *Groundwater abstraction* Groundwater abstraction is unlikely to lead to a long-term decrease in the size of the Pilbara Olive Python population. Abstraction of groundwater has the potential to impact phreatophytic species and potentially understorey vegetation along Warramboo Creek. No permanent or semi-permanent pools have been identified in the section of the ephemeral Warramboo Creek that is within the modelled extent of groundwater drawdown. Significant changes to understorey vegetation and hence fauna habitat due to abstraction of groundwater are not expected along the majority of the defined flow channel of Warramboo Creek. There is potential for minor changes

Significant impact criteria	Assessment of impacts to Pilbara Olive Python
	to the abundance of understorey vegetation in the Plains habitat type downstream of the defined flow channel in Warramboo Creek. Current vegetation cover in this area is low and understorey vegetation has been impacted by cattle and weed species. The Plains habitat type is widespread and common throughout the Pilbara and provides only limited foraging and dispersal habitat for the Pilbara Olive Python. Given the lack of semi-permanent and permanent pools, the widespread nature of the Plains habitat type, the limited value of the Plains habitat to the Pilbara Olive Python, the existing disturbance and the minor nature of the proposed changes, the proposed groundwater drawdown in the Yarraloola Aquifer is not expected to lead to a long-term decrease in the size of the Pilbara Olive Python population. *Discharge of surplus water* The proposed discharge of surplus water is unlikely to lead to a long-term decrease in the size of the Pilbara Olive Python population. The proposed discharge of surplus water into Warramboo Creek will alter the seasonal availability of surface water which may temporarily result in an increase in the utilisation of the area by the Pilbara Olive Python for hunting. Following cessation of discharge, Warramboo Creek will return to the natural ephemeral flow regime, thus there is unlikely to be a long-term impact to Pilbara Olive Python habitat. *Vehicle movements* Pilbara Olive Pythons are at risk to road strike, as they are slow moving and their first response to the sound and vibration of a vehicle is to freeze (Pearson 2003). Vehicle movements for the Proposed Change are unlikely to result in a long-term decrease in the Pilbara Olive Python population. The Pilbara Olive Python is almost entirely nocturnal; vehicle movements at night are much less than during the day and are generally limited to in-pit operations.
Potential to reduce the area of occupancy of the species	*Clearing* It is unlikely the proposed disturbance will reduce the area of occupancy of the Pilbara Olive Python. The Proposed Change will retain the majority of the Breakaways and Gullies habitat which provides suitable denning habitat for the species and will have limited impact on foraging habitat. *Noise and vibration* It is unlikely that noise and vibration emissions will reduce the area of occupancy of the Pilbara Olive Python. While the species relies on-ground vibrations to detect prey and avoid predators, noise and vibration emission from blasting will be intermittent, lasting for two to ten seconds at a time. The brief and sporadic nature of blasts is unlikely to significantly affect the Pilbara Olive Python's foraging ability or reduce the area of occupancy. *Groundwater abstraction*

Significant impact criteria	Assessment of impacts to Pilbara Olive Python
	Given the lack of semi-permanent and permanent pools in the section of the ephemeral Warramboo Creek that is within the modelled extent of groundwater drawdown, the widespread nature of the Plains habitat type, the existing disturbance and the minor nature of the proposed changes, the proposed groundwater drawdown in the Yarraloola Aquifer is not expected to reduce the area of occupancy of the Pilbara Olive Python population. *Discharge of surplus water* The proposed discharge of surplus water is unlikely to reduce the area of occupancy of the Pilbara Olive Python population. The increased availability of surface water in Warramboo Creek during periods of discharge may temporarily result in an increase in the utilisation of the area by the Pilbara Olive Python for hunting. However, following cessation of discharge, Warramboo Creek will return to the natural ephemeral flow regime, thus there is unlikely to be a long-term impact to Pilbara Olive Python habitat.
Potential for fragmentation of an existing population into two or more populations	*Clearing* It is unlikely the limited clearing of potential shelter/breeding and foraging habitat will fragment an existing population of the species. The Proposed Change has been designed to limit clearing to 6% of the potential shelter/breeding habitat (Breakaways and Gullies habitat) and less than 1% of the potential foraging habitat (River habitat) within the western portion of the Development Envelope. The installation of mine infrastructure is unlikely to create physical barriers to movement. All other potential impacts associated with the Proposed Change are unlikely to fragment the Pilbara Olive Python population.
Potential to adversely affect habitat critical to the survival of a species	There are currently no defined criteria for habitat critical for the survival of the Pilbara Olive Python. The approved conservation advice for the Pilbara Olive Python describes preferred habitat for the Pilbara Olive Python as including deep gorges and water holes. *Clearing* While the Proposed Change will disturb some habitat that may be classified as preferred habitat for the Pilbara Olive Python, the majority of shelter/breeding habitat and foraging habitat in the western portion of the Development Envelope will be avoided. A MEZ will be established around the mesa escarpment to protect fauna and habitat values supported by the mesa escarpment. Key infrastructure for the Proposed Change will be primarily installed in the Plains habitat which provides only limited foraging and dispersal habitat for the Pilbara Olive Python. No major infrastructure will be installed in the Robe River which provides key foraging habitat for the Pilbara Olive Python. The limited proportion of habitat that will be impacted is not expected to affect the survival of the species locally or regionally. All other potential impacts associated with the Proposed Change are unlikely to adversely affect habitat critical to survival of the species.

Significant impact criteria	Assessment of impacts to Pilbara Olive Python
Potential to disrupt the breeding cycle of a population	*Clearing* Given the Proposed Change has been designed to avoid the highest value Pilbara Olive Python habitat in the mesa escarpments and that disturbance will impact only a small proportion of the available shelter/breeding habitat, it is unlikely the Proposed Change will disrupt the breeding cycle of a Pilbara Olive Python population. All other potential impacts associated with the Proposed Change are unlikely to disrupt the breeding cycle of the species.
Potential to modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is unlikely the Proposed Change will lead to decline of the Pilbara Olive Python. None of the potential direct or indirect impacts are likely to result in a significant impact to the availability or quality of the habitat for this species. The limited proportion of habitat that will be impacted is not expected to affect the survival of the species locally or regionally and no other threatening processes for this species are expected to be exacerbated by the Proposed Change (e.g. feral predation and fire events).
Potential for the establishment of invasive species in the endangered species' habitat that are harmful to an endangered species	The Feral Cat is a threat to the species, due to direct predation (particularly of juveniles), as well as predation of prey items such as the Northern Quoll (TSSC 2008). The Proponent will continue to implement feral fauna control as needed in areas where it operates. While the Pilbara Olive Python is susceptible from Cane Toad poison, current evidence suggests that adults do not eat Cane Toads (Turvey 2013), although can be poisoned from secondary consumption. Further research is required into the threat the Cane Toad poses to the Pilbara Olive Python. The Cane Toad is not currently established in the Pilbara. As previously discussed, Cane Toads require constant access to moisture to survive. There is currently water continuously available in the middle and upper sections of the Robe River to the east of the Development Envelope and in river pools adjacent to the North West Coastal Highway. As water is already continuously available in the Robe Valley, the Proposed Change is unlikely to increase the opportunity for the Cane Toad to become established in the area.
Potential for the introduction of disease that may cause the species to decline	The Proposed Change is unlikely to introduce disease that may cause the species to decline.
Potential interference with the recovery of the species	Given the proposed disturbance will impact only a small proportion of the available Pilbara Olive Python habitat, and the Proposed Change has been designed to avoid the highest value denning habitat, the Proposed Change is unlikely to interfere with the recovery of the Pilbara Olive Python.

12.6 Predicted outcomes

Mitigation strategies to address potential impacts to relevant MNES species are presented in Section 12.5. Given the mitigation strategies presented, the outcomes for the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat and Pilbara Olive Python are that the Proposed Change is **unlikely to**:

- Lead to a long-term decrease in the size of a population
- Reduce the area of occupancy of the species
- Fragment an existing population into two or more populations
- Modify, destroy, remove isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat
- Introduce disease that may cause the species to decline
- Interfere with the recovery of the species.

The most important habitats in the western portion of the Development Envelope for the Northern Quoll are considered to be the Breakaways and Gullies and River habitats, which provide high value denning/shelter habitats associated with caves and rocky overhangs and/or enhanced foraging opportunities due to the availability of water (MHW 2015a). While the Proposed Change will disturb habitat classifiable as habitat critical to the survival of the Northern Quoll (DoE 2016), the proposed loss of critical habitat locally is not considered significant due to the avoidance of the highest value denning habitat and the extensive availability of foraging habitat both within and outside the Development Envelope.

The Proposed Change has been designed to limit disturbance to high value Breakaways and Gullies habitat and River habitat to less than 11 ha, representing less than 1% of the mapped Breakaways and Gullies and River habitats in the broader Robe Valley. The Proposed Change will clear foraging and dispersal habitat within the western portion of the Development Envelope; however the majority of disturbance for the Proposed Change will be to the Plains habitat which is widespread and common throughout the Pilbara region. The proposed disturbance to this habitat is, therefore considered unlikely to have a significant impact on the Northern Quoll population or the survival of the local population or species.

The proposed disturbance will not affect critical Pilbara Leaf-nosed Bat roost habitat. The Proposed Change will have only limited impact to priority foraging habitat as major infrastructure will be primarily located in the Plains habitat which provides only limited foraging for the Pilbara Leaf-nosed Bat. There is currently no definition of critical habitat for the Ghost Bat. The Proposed Change has been specifically designed to protect the recorded diurnal/potential maternal roost complex at Mesa B and the potential diurnal roost complex at Mesa C by relocating the proposed escarpment cut and haul road at Mesa B, re-designing the mine pit and establishing a MEZ. In addition, the Proposed Change has been designed to limit clearing of priority foraging habitat. The impact to one nocturnal Ghost Bat roost and foraging habitat is considered unlikely to affect the survival of the local population or species.

The approved conservation advice for the Pilbara Olive Python does not define habitat critical to the survival of the species. The Proposed Change has been designed to limit

impact to habitats which may be classified as preferred habitat, namely the Breakaway and Gullies habitat and the River habitat by re-designing the mine pit, establishing a MEZ and locating key infrastructure in the Plains habitat which provides only limited foraging and dispersal for the Pilbara Olive Python. The proposed disturbance is therefore considered unlikely to have a significant impact on the Pilbara Olive Python population or the survival of the local population or species.

Noise associated with mining activities has the potential to disturb Ghost Bats while roosting. In the case of the potential maternity roost on Mesa B this may lead to a disruption to the breeding cycle of the population in that roost. The potential to disturb roosting Ghost Bats will be reduced through delineation of a MEZ and implementation of a Blast Management Framework to limit noise and vibration emissions. The Blast Management Framework will be implemented to ensure blast vibration levels at the identified diurnal/potential maternal Ghost Bat roosts remain below the trigger level PPV set in the EMP (see EMP in Appendix 4). Measures that may be used to achieve the required blast control are discussed in Section 7.6.4.2.

Monitoring at Poondano (Astron 2015) has shown continued presence of a Ghost Bat population during and after mining activity. There is also evidence to suggest that maternity groups may use different maternity roosts across different seasons (Biologic 2016). As there are other roosts present in the vicinity of the Development Envelope (including the maternity roost at Mesa F, approximately 13 km from Mesa B), Ghost Bats may utilise an alternative roost.

For the Northern Quoll and Pilbara Olive Python, the Proposed Change is unlikely to disrupt the breeding cycle of a population given the retention of the majority of suitable breeding habitat. No Pilbara Leaf-nosed Bat roosts have been recorded in the western portion of the Development Envelope, and on this basis, the limited impact on foraging habitat only is unlikely to disrupt the breeding cycle for the Pilbara Leaf-nosed Bat.

As described in this section, while small portions of habitat that may be classified as critical, priority or preferred habitat for some of the MNES relevant to the Proposed Change will be impacted, these impacts are not of a scale or level of significance where a decline in any of these species is likely to occur as a result. The proposed mitigation strategies discussed in Table 12-2 to Table 12-5 will reduce the predicted impacts to MNES and ensure the highest value habitat for each species is protected as far as practicable from direct and indirect impacts. The Proposed Change is therefore not inconsistent with any relevant policy, guidance, Recovery Plan or Threat Abatement Plan for the Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat or Pilbara Olive Python.

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13. OFFSETS

13.1 Background

The WA Environmental Offsets Policy (Government of Western Australia 2011) and WA Environmental Offsets Guideline (Government of Western Australia 2014) provide guidance to proponents on the approach needed to determine offset requirements for proposals. The Environmental Offsets Guideline (2014) states that:

"In general, significant residual impacts include those that affect rare and endangered plants and animals (such as DRF and threatened species that are protected by statute), areas within the formal conservation reserve system, important environmental systems and species that are protected under international agreements (such as Ramsar listed wetlands) and areas that are already defined as being critically impacted in a cumulative context. Impacts may also be significant if, for example, they could cause plants or animals to become rare or endangered, or they affect vegetation which provides important ecological functions".

The rate, scale and nature of current and future development, combined with the impacts of other land uses and threatening processes, have raised the EPA's concerns about cumulative environmental impacts in the Pilbara region (EPA 2017a). In particular, the EPA is concerned about the clearing of native vegetation combined with pastoralism, feral animals, weeds and climate change in the Pilbara, and the lack of reliable information on the extent and condition of native vegetation at a regional scale (EPA 2017a). The Pilbara is mostly Crown land and, as such, traditional land acquisition offsets are not possible in the region. In addition, tenure constraints including pastoral leases and mineral tenements make it difficult to implement on-ground conservation actions to deliver long-term protection of biodiversity (EPA 2014).

Subsequently the EPA has determined that a proactive approach to compensating for the clearing of native vegetation in the Pilbara is required and has established a strategic regional conservation initiative for the consolidation and management of offset funds for the Pilbara; the Pilbara Environmental Offsets Fund (the Fund). The Fund is currently being established by the WA Government in response to recommendations from the EPA for a strategic, coordinated approach to the application of environmental offsets to achieve broad-scale biodiversity conservation outcomes.

The Fund pools environmental offsets for resource and infrastructure projects approved under the EP Act which are conditioned in accordance with the WA Environmental Offsets Policy (Government of Western Australia 2011) and associated guidelines (Government of Western Australia 2014). Offsets contributed to the Fund will be used to implement conservation projects that counterbalance any significant residual impacts of those developments at a landscape level in the Pilbara.

The EPA notes that in establishing and implementing the Fund, the WA Government has committed to ensuring that the offsets implemented via the Fund will:

- Be relevant and proportionate to the values being impacted (Principle 3)
- Use sound knowledge and ensure the offset counterbalances the significant residual impact and delivers long-term environmental benefits (Principle 4)
- Be adaptive and be evaluated to ensure that it achieves the outcomes required (Principle 5) (EPA 2017b).

The EPA has been of the view that proposed offsets for similar projects to the Proposed Change with similar significant residual impacts (e.g. BHP's recent Mining Area C – Southern Flank Project) requiring a contribution to the Fund, will counterbalance those significant residual impacts (EPA 2017b). Projects funded will address the priorities outlined in the Pilbara Conservation Strategy (Government of Western Australia 2017) including Karijini National Park restoration, management of Fortescue Marsh and also management of fire, feral animals and weeds in the Pilbara region. The projects implemented through the Fund will be approved by the Minister for Environment and project development will address matters including partnerships, scheduling, procurement, funding arrangements, performance measures and reporting requirements, which will be prepared in consultation with stakeholders (Government of Western Australia 2017).

Contributions to the Fund to offset the clearing of native vegetation considered in Good to Excellent condition has been used as the standard offset approach by the EPA and proponents in the Pilbara since 2012. Where there are other environmental values with elevated significance, a higher offset is applied to account for this greater value.

Environmental aspects of the Proposed Change were assessed for potential significant residual impacts. The results of the assessment are presented in the following section.

13.2 Significant residual impacts

The evaluation of potential impacts of the Proposed Change on the preliminary key environmental factors is detailed in Sections 5 to 13. This evaluation resulted in identification of environmental factors that may result in a significant residual impact.

The Offsets Template as per the WA Environmental Offsets Guidelines (Government of Western Australia 2014) has been used to further examine the significant residual impacts of the Proposed Change. Potential impacts that may result in a significant residual impact are included in the Offsets Template (Table 13-1 and Table 13-2). The Offsets Template has been split into two parts to allow clear demonstration of the assessment; Table 13-1 presents a summary of the evaluation of significant residual impacts for each of the preliminary key environmental factors and Table 13-2 presents the proposed offsets.

Following application of the mitigation hierarchy, the following significant residual impacts have been identified for the Proposed Change:

- Direct clearing of up to 3,000 ha of native vegetation in Good to Excellent condition, including the following areas with other environmental values:
    - Direct clearing of up to 8 ha of riparian vegetation
    - Direct clearing of up to 1,700 ha of the Priority 1 PECs, the Subterranean invertebrate community of pisolitic hills and the Subterranean invertebrate community of mesas in the Robe Valley region.

Consideration of the Residual Impact Significance Model in the WA Environmental Offsets Guidelines (Government of Western Australia 2014) indicates that the above significant residual impacts may require offsets.

The Proponent proposes environmental offsets in the form of financial contributions to the Fund of:

- $750 per hectare for the unavoidable clearing of native vegetation in Good to Excellent condition
- $1,500 per hectare for the unavoidable clearing of areas with other environmental values (riparian vegetation and PECs).

Where values overlap and have two different offset rates the offset will be provided at the higher of the two rates. The Proponent notes that rates will be adjusted to take Consumer Price Index (CPI) into account and, subject to approval, final rates will be specified in the Ministerial Statement for the Revised Proposal.

In determining offsets, the Proponent has taken into consideration the six principles of the WA Environmental Offsets Policy which underpin the Western Australia Government's assessment and decision making processes in relation to the use of environmental offsets, as outlined below.

1. **Environmental offsets will only be considered after avoidance and mitigation options have been pursued.** As outlined in Section 2.2 avoidance and minimisation of impact has been included as part of the Proposed Change planning process. The Proponent considered various options in the development of the Proposed Change and has avoided environmental impacts in the process. Water supply, waste fines disposal and haul road options will minimise the total area of vegetation clearing required. Where clearing of vegetation is required, the Proposed Change has been designed to avoid clearing of vegetation or habitat with higher conservation significance. The selection of an in-pit waste fines disposal method in Warramboo also avoids impacts to the below pit floor troglofauna habitat that has been specifically retained at Mesa A. One of the key avoidance strategies is the retention of the majority of the mesa escarpment areas; an approach already in place at Mesa A, which avoids several significant environmental values including those associated with conservation significant fauna and cultural heritage. The application of the mitigation hierarchy for the Proposed Change (Section 14.2) has ensured that all practical avoidance and mitigation measures have been considered, and pursued where appropriate. Offsets have only been considered for those significant impacts that are not able to be avoided or minimised.

2. **Environmental offsets are not appropriate for all projects**. The identified significant residual impacts are considered appropriate to be offset as they are not considered to be either minor (too minor to require an offset) or likely to be considered environmentally unacceptable regardless of offsets.
3. **Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted.** The Proponent considers the proposed offsets are cost-effective, relevant and proportionate to counterbalance the significant residual impacts to the identified environmental values of the Proposed Change. The offsets for vegetation are considered appropriate in that the significant residual impacts identified are not related to one specific Threatened species or community, rather they relate to the cumulative loss of vegetation due to clearing in the Pilbara and therefore the contribution to the Fund will allow implementation of offset projects that will benefit Pilbara vegetation and flora values more broadly. The contribution to the Fund for the subterranean fauna PECs is considered appropriate given that subterranean fauna ecosystems are not currently well understood. Contribution to the Fund will enable management or research to be undertaken that will benefit subterranean fauna values more broadly. Actions initiated through the Fund would be in addition to the Proponent's current contribution to Western Australian subterranean fauna research initiatives.
4. **Environmental offsets will be based on sound environmental information and knowledge.** The Pilbara is predominantly Crown land so traditional land acquisition offsets are not possible and on-ground conservation actions are difficult for a single proponent to implement due to tenure constraints including pastoral leases and mineral tenements. Contribution to the Fund is not a traditional offset where, for example a single conservation project would need to consider sound environmental information and knowledge about a particular species or community. However, the conservation and research projects to be implemented at a broad-scale through the Fund are intended to address the cumulative impacts of mining in the Pilbara as identified by the EPA and provide a more detailed understanding of conservation values in the Pilbara region in order to improve decision making regarding conservation and management.
5. **Environmental offsets will be applied within a framework of adaptive management.** The Proponent understands an adaptive management framework should be applied in relation to environmental offsets to take account of the potential risks. One of the key risks associated with the Fund as an environmental offset being applied for the majority of projects in the Pilbara is managing the time lag between establishing offsets and generating the anticipated benefits. This challenge and the adaptive management framework around conservation outcomes are being addressed in the development of the Fund mechanisms including partnerships, scheduling, procurement, funding arrangements, performance measures and reporting requirements in consultation with stakeholders. The Proponent has experience in on-ground implementation and adaptive management of offsets and, therefore, is able to contribute knowledge to this process.

6. **Environmental offsets will be focussed on longer term strategic outcomes.** The EPA recognises that the establishment of the Fund is consistent with this principle in that strategic approaches, such as the use of the Fund, will provide a coordination mechanism to implement offsets across a range of land tenures (Government of Western Australia 2014). The Fund provides a strategic, coordinated approach to the application of environmental offsets to achieve broad-scale biodiversity conservation outcomes for the Pilbara region. Rio Tinto recognises the commitment of the EPA to this strategic approach and is contributing via being a participant in the working group for establishment of the Fund.

Table 13-1: WA Environmental Offsets Template Part 1- Identification of residual impacts and requirement for offsets

Existing Environment/Impact	Mitigation			Significant Residual Impact? (Yes/No)
	Avoid and Minimise	Rehabilitation	Likely Rehab Success	
Flora and Vegetation Direct clearing of vegetation in Good to Excellent condition Direct clearing of riparian vegetation	The Proposed Change has been designed to avoid any direct disturbance to the Sand Sheet PEC. Disturbance to Priority Flora and riparian vegetation will be avoided as far as practicable and clearing will only occur in approved areas. The clearing footprint has been minimised through general project design and through selection of in-pit disposal of waste fines and reverse osmosis plant effluent rather than development of an external tailings storage facility and evaporation pond.	Disturbed areas will be rehabilitated progressively as mining activities are completed. The conditions of the new Ministerial Statement for the Revised Proposal shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans (2015). The Closure Plan (Appendix 3) includes a closure objective to ensure that vegetation on rehabilitated land is self-sustaining and compatible with the final land use.	Can the environmental values be rehabilitated/Evidence? To date, approximately 222ha of rehabilitation has been completed at the Mesa A and Warramboo operations collectively and has generally established well, with a range of native perennial species present and established. Operator experience in undertaking rehabilitation? Rio Tinto conducts rehabilitation activities progressively at all its operations in the Pilbara. All rehabilitation is undertaken in accordance with the Rio Tinto Iron Ore Rehabilitation Handbook, which is reviewed and updated periodically to reflect changes in industry standards, reflect new knowledge obtained through research and development, and to adopt learnings from ongoing rehabilitation projects. The Handbook addresses: • Soil resource management • Rehabilitation techniques • Local provenance species seeding practices • Records and data management • Ongoing monitoring. What is the type of vegetation being rehabilitated? A total of 76 vegetation units have been mapped in the western portion of the Development Envelope. As a general overview the Proposed Change is located within the Fortescue District of the Eremaeum botanical province which is characterised by tree (*Eucalyptus* spp. and *Corymbia* spp.) and shrub (*Acacia* spp., *Hakea* spp., *Grevillea* spp. and *Senna* spp.) steppe communities and *Triodia* spp. hummock grasslands (Beard 1990). Time lag? Due to the long timeframes between commencement of mining and closure of a mining operation, vegetation clearing is treated as long-term and therefore warrants an offset even though rehabilitation will be undertaken. Credibility of the rehabilitation proposed (evidence of demonstrated success) As above, given the substantial modification of landform associated with mining and the long timeframes, the impact assessment is conservative and provides for an offset in addition to committing to rehabilitation.	Yes, the direct clearing of native vegetation in Good to Excellent Condition and direct clearing of riparian vegetation is considered significant. Extent 1,300 ha[1] Quality Good to Excellent Conservation Significance 1,300 ha of Good to Excellent condition native vegetation, including 8 ha of riparian vegetation Land Tenure n/a Time Scale n/a - no temporary clearing Consideration of the Residual Impacts Significance Model indicates that the residual impact is significant because it involves clearing of vegetation in Good to Excellent condition in the Pilbara and clearing of riparian vegetation of high local significance.
Subterranean Fauna Direct clearing of the subterranean fauna PECs	The Proposed Change has been designed to minimise disturbance to the subterranean fauna PECs as far as practicable. The mine plan has also been designed to retain at least 50% by volume of connected pre-mining troglofauna habitat at Mesas A, B and C by delineation of a MEZ (and pit floor in the case of Mesa A). Impacts to the higher value troglofauna habitat retained in the pit floor at Mesa A will be avoided	n/a	n/a	Yes, the direct clearing of the P1 subterranean fauna PECs Extent 1,700 ha Quality Partially disturbed by mineral exploration activities but overall quality is Excellent. Conservation Significance Habitat supports SRE and conservation listed troglofauna species. Land Tenure n/a

Existing Environment/Impact	Mitigation			Significant Residual Impact? (Yes/No)
	Avoid and Minimise	Rehabilitation	Likely Rehab Success	
	through locating the WFSF at Warramboo instead of in-pit at Mesa A. The mine plans for Mesas A, B and C have also been designed to avoid as many single location and singleton troglofauna as practicable and ensure their ongoing avoidance by the retention of the MEZ.			Time Scale n/a - no temporary disturbance

[1] For the purpose of environmental offsets, this is the portion of the 3,000 ha to be offset for impacts to native vegetation in Good to Excellent condition. The remaining 1,700 ha forms the area of subterranean fauna PECs to be impacted and offset for that factor.

Table 13-2: WA Environmental Offsets Template Part 2 – Proposed offset

Significant residual impact	Offset calculation methodology				
	Type	Risk	Likely offset success	Time lag	Offset quantification
Direct clearing of 3,000 ha of Good to Excellent condition vegetation in the Pilbara, including direct clearing of 8 ha of riparian vegetation and 1,700 ha of the P1 subterranean fauna PECs.	Financial contribution to the Pilbara Environmental Offsets Fund	Low - offsets contributed to the Fund will be used to implement conservation projects that counterbalance the significant residual impacts	n/a. The projects implemented through the Fund will be approved by the Minister for Environment and project development will address matters including performance measures and reporting requirements.	n/a	The Proponent proposes the provision of: • An environmental offset ($750 per hectare) for the unavoidable clearing of native vegetation in Good to Excellent condition • An environmental offset at the higher offset rate ($1,500 per hectare) for unavoidable clearing in areas of riparian vegetation • Where values overlap and have two different offset rates the offset will be provided at the higher of the two rates.

13.3 Clearing approved under MS 756

The existing MS 756 approves 3,680ha of clearing for Mesa A. An up front offset of $2 million was provided under the commitments of approval of MS 756 which resulted in the establishment of a molecular systems unit at the WA Museum and funding for a research senior scientist, together supporting a taxonomic revision of *Tephrosia* in northern Western Australia. Therefore, the Proponent considers any past or future clearing undertaken as part of that approved project is exempt from the requirement for a new offset under any new Ministerial Statement for the Revised Proposal. The Proponent proposes that any new Condition relating to offsets should reflect that the clearing of 3,680 ha (as approved under MS 756) is exempt from the requirements of an offset.

14. HOLISTIC IMPACT ASSESSMENT

Sections 5 to 12 provide detailed assessment of the potential environmental impacts and proposed environmental management strategies for each of the environmental factors. This section provides an integrated, holistic assessment of the impacts of the Proposed Change on the whole environment by considering the interactions and connections between the preliminary key environmental factors. Only significant environmental values that may be impacted by the Proposed Change are considered in this section.

The preliminary key environmental factors identified as relevant to the Proposed Change are: Flora and Vegetation; Subterranean Fauna; Terrestrial Fauna; Hydrological Processes and Inland Waters Environmental Quality; Landforms and Social Surroundings. In addition, Closure and Offsets are considered relevant to the Proposed Change and are considered in relation to each factor.

14.1 Proposal activities

The following Proposal activities involve interactions between preliminary key environmental factors and have the potential to impact significant environmental values.

14.1.1 Land disturbance

The Proposed Change will require clearing and disturbance of up to 3,000 ha of native vegetation and fauna habitat in the Development Envelope of 16,834 ha. Land disturbance has the potential to impact on vegetation, fauna habitats, social surroundings and landforms.

The key focus for the Proposed Change design was to avoid the **high value** aspects of the following identified values:

- **Sand Sheet PEC:** The Proposed Change has been designed to avoid disturbance to the Sand Sheet PEC and minimise disturbance to vegetation units of high local conservation significance
- **Riparian vegetation**: The vast majority of riparian vegetation will be avoided. Some minor clearing of riparian vegetation will be required to facilitate installation of the surplus water discharge point on Warramboo Creek
- **Conservation Significant Fauna (MNES):** The Proposed Change has been designed to minimise disturbance to denning and roosting habitat for conservation significant terrestrial fauna species, particularly bat species and the Northern Quoll. MEZs have been developed to avoid and protect potential diurnal/ maternal Ghost Bat roosts from direct disturbance. The Proposed Change has been designed to limit disturbance to high value fauna habitats (Breakaways and Gullies habitat and River habitat), with less than 11 ha proposed to be cleared, representing less than 1% of the mapped Breakaways and Gullies and River habitats in the broader Robe Valley
- **Troglofauna**: The mine plan has been designed to retain at least 50% by volume of connected pre-mining troglofauna habitat at Mesas A, B and C by delineation of a MEZ (and retention of sub-pit floor habitat in the case of Mesa A). The mine plans for Mesas A, B and C have also been designed to avoid as many single location and singleton troglofauna as practicable and ensure their ongoing avoidance through retention of the MEZ

- **Significant Heritage sites:** The Proposed Change has been designed to avoid disturbance to most key heritage sites as identified by the Kuruma Marthudunera People. The Proposed Change has also been designed to minimise direct disturbance to the mesa escarpments, including the rock shelters, through establishment of a MEZ
- **Landform and Social Surroundings:** The Proposed Change has been designed to minimise disturbance to the mesa escarpments and major drainage lines to protect the landform and amenity values of these landscape features.

14.1.2 Abstraction of groundwater

The Proposed Change will require abstraction of up to 5 GL/a of groundwater from the Mesa C CID Aquifer, resulting in the groundwater table being lowered by up to 15 m within the localised area of the CID Aquifer. Following cessation of dewatering, the Mesa C CID Aquifer groundwater level is unlikely to recover to pre-mining levels under steady state conditions. Extensive rainfall and possibly increased surface run-off and infiltration into the mesa due to a reduced vadose zone are, however, likely to assist water level recovery in the CID Aquifer. Based on current hydrogeological modelling, no observable impacts to groundwater levels in the adjacent Robe River Alluvial Aquifer and associated Groundwater Dependent Vegetation are anticipated. However, should there be greater hydraulic connectivity between the Mesa C CID Aquifer and the Robe River alluvium than current modelling and hydrogeological investigations indicate, there is potential for stress to individual trees along the Robe River in the extent of drawdown.

The Revised Proposal will require abstraction of up to 15 GL/a groundwater (including the current licensed abstraction rate of 3 GL/a) from the extended Warramboo bore field. Abstraction of groundwater will alter the hydrological regime and has the potential to impact phreatophytic vegetation and stygofauna within the extent of drawdown.

Water abstraction from the Warramboo bore field is predicted to result in drawdown of the groundwater table of up to 36 m. Following cessation of groundwater abstraction, it is estimated that recovery of the groundwater table at Warramboo to 80% of the pre-mining level will take approximately 40 years, with complete recovery of the groundwater level estimated to take up to 140 years due to the anticipated low recharge rates.

The key focus for the Proposed Change is to maintain the following key environmental values as far as possible:

- **Stygofauna:** Drawdown of the groundwater table will reduce stygofauna habitat in the Mesa C CID Aquifer. However, investigations indicate that the Mesa C Aquifer is seasonally connected to the extensive, adjacent stygofauna habitat present in the Robe River Alluvial Aquifer. Loss of the small proportion of available stygofauna habitat represented by the Mesa C CID Aquifer is, therefore, considered unlikely to significantly affect the ecological integrity of stygofauna habitat in the Mesa C area. Drawdown of the groundwater table will reduce stygofauna habitat in the Yarraloola Aquifer. However, the Yarraloola Aquifer is an extensive regional aquifer with the volume of habitat to be impacted estimated to represent less than 2% of the available aquifer
- **Riparian vegetation:** Groundwater drawdown will affect availability of groundwater to facultative phreatophytic vegetation along the 13 km section of the defined flow channel of Warramboo Creek and into the flood plain downstream of the defined channel. In the majority of the defined flow channel,

drawdown of the groundwater table may result in a reduction in canopy cover and increased mortality of phreatophytic species but structural and compositional changes are considered unlikely. In the floodplain beyond the defined flow channel groundwater drawdown may result in a reduction in canopy cover and increased mortality of phreatophytic species, with some potential for structural and compositional changes to vegetation. The vegetation types in the floodplain are not locally restricted and, based on assessment of aerial photography, are considered to extend beyond the Development Envelope. The proposed impact of groundwater drawdown on the vegetation types of Warramboo Creek is, therefore, not expected to be significant. As discussed in Section 8.6.2, drawdown of the CID Aquifer is not expected to result in observable changes to groundwater levels within the adjacent Robe River Alluvial Aquifer.

14.1.3 Discharge of surplus water

The Proposed Change will utilise dewatering water on-site as far as possible. It is proposed that surplus water from dewatering and large rainfall events be discharged to Warramboo Creek. Discharge of surplus water will alter the hydrological regime of an 8 km section of Warramboo Creek from an ephemeral system to one which has continuous flow during times of discharge and may temporarily alter the surface water chemistry. The change in hydrological regime may result in short-term changes to riparian vegetation and fauna utilisation along the affected section of Warramboo Creek. Following cessation of discharge, riparian vegetation and fauna utilisation of this section of Warramboo Creek is expected to return to that adapted to an ephemeral system.

The key focus for the Proposed Change is to minimise impacts to the following identified values:

- **Riparian vegetation:** Changes to water chemistry may result in temporary vegetation stress and decline in vegetation health along an 8 km section of Warramboo Creek. However, discharge will not be continuous during the life of the Proposed Change and natural flow conditions, which occur during rainfall events, will flush the system and mitigate the potential impacts of short-term increases in salinity on vegetation. Surplus water discharge is, therefore, not expected to have any long-term adverse effects on the riparian vegetation of Warramboo Creek. Vegetation that becomes established as a result of discharge may be affected by a loss of readily available water following cessation of discharge. However, given the volumes and duration of discharge, it is anticipated that the riparian vegetation will revert to that adapted to an ephemeral system
- **MNES habitat:** Any potential increased use of Warramboo Creek by MNES during periods of discharge is expected to be temporary until the vegetation and water availability reverts to that of an ephemeral system. Potential short-term decline in vegetation health along an 8 km section of Warramboo Creek may temporarily affect MNES foraging and dispersal habitat. However, given the temporary nature of the proposed discharge and that this area represents a small proportion of foraging and dispersal habitat in the Development Envelope and the broader Robe Valley for MNES, significant impacts to MNES species from surplus water discharge are considered unlikely.

14.2 Application of the mitigation hierarchy

The Proponent has applied the mitigation hierarchy in the *Western Australian Environmental Offsets Guidelines* (Government of Western Australia 2014) for all proposed activities, including those listed above.

14.2.1 Avoidance

Avoidance is the preferred strategy for managing potentially significant impacts to the environment. The Proposed Change has been designed to avoid potentially significant impacts to the environment; specifically avoidance of *direct* disturbance to:

- Robe River (riparian vegetation, terrestrial fauna, aquatic fauna and heritage values)
- Potential diurnal/ maternal Ghost Bat roosts (terrestrial fauna values)
- As many single location and singleton troglofauna as practicable
- Retained troglofauna habitat beneath the pit floor at Mesa A
- Sand Sheet PEC (vegetation values)
- Rock shelter site MBC15_36 on Mesa B containing spinifex matting (heritage values)
- Warramboo Outstation (heritage values)
- Ethnographic site and archaeological feature within the Warramboo pit footprint (heritage values).

14.2.2 Minimisation

After avoidance strategies were considered, mitigation measures to minimise the remaining significant impacts were investigated to reduce these to an acceptable level. The Proposed Change has been designed to minimise the remaining potentially significant impacts to the environment; specifically minimisation of disturbance to:

- Mesa escarpments (terrestrial fauna, heritage and landscape values)
- Yirrkawiya Gap (heritage values)
- Troglofauna habitat (subterranean fauna values)
- High local significance vegetation and conservation listed flora (flora and vegetation values).

The Proponent also proposes that the Revised Proposal be subject to a new Ministerial Statement that includes the requirement to implement a condition EMP (Appendix 4) to demonstrate that the following environmental outcomes for key environmental factors are met:

- No irreversible impact to the health of riparian vegetation of the Robe River and Warramboo Creek as a result of groundwater abstraction for the Proposed Change
- No irreversible impact to the health of riparian vegetation of Warramboo Creek as a result of surplus water discharge from the Proposed Change
- No direct disturbance to the Sand Sheet Vegetation (Robe Valley) PEC, due to the Proposed Change, that results in an irreversible impact

- No irreversible impact, as a result of the Proposed Change, to retained escarpments of Mesa A, B and C which are high value habitat for the Ghost Bat
- No irreversible impact, as a result of the Proposed Change, to retained escarpments of Mesa A, B and C which are high value habitat for the Northern Quoll
- No irreversible impact as a result of the Proposed Change to the troglofauna habitat retained within the Mesa A, B or C MEZs.

14.2.3 Rehabilitate

Following consideration of avoidance and minimisation measures, rehabilitation measures were considered to further reduce residual impacts. The proposed conditions of the new Ministerial Statement (Appendix 2) shall require the Proponent to manage the implementation of the Revised Proposal to '*ensure that the Revised Proposal is rehabilitated and decommissioned in an ecologically sustainable manner*'. The conditions of the Ministerial Statement shall also require the Proponent to implement a Closure Plan (Appendix 3) in accordance with the DMP / EPA *Guidelines for Preparing Mine Closure Plans* (2015).

The rehabilitation is anticipated to ensure that the Revised Proposal will not compromise land use options in the area.

14.2.4 Offset

If, after the previous steps of the mitigation hierarchy have been considered, significant residual impacts to the environment are expected, then offsets are proposed. The Proponent proposes the provision of an environmental offset ($750 per hectare) for the unavoidable clearing of native vegetation in Good to Excellent condition, and an environmental offset at the higher offset rate ($1,500 per hectare) for the unavoidable clearing of two PECs and riparian vegetation (Section 13).

14.3 Conclusion

The key environmental values in the western Pilbara have been identified as the river systems, gorges and rocky hills/breakaways. These landscape features provide significant shelter and foraging opportunities for fauna (in particular MNES fauna), include aquatic and cave habitats and have high heritage and amenity values. The iron ore resource is associated with the mesas and it has been identified that the breakaways and cave systems of the mesa escarpments are the most significant features of the mesas both environmentally and socially. Therefore, the protection of these escarpments (through limiting clearing in this area and the creation of a MEZ), while allowing mining of the internal mesa plateau, has been the overarching approach to mine planning for the Proposed Change. This approach is expected to protect the MNES habitat values, heritage and amenity values associated with the escarpments.

The Proposed Change avoids almost all direct disturbance of riparian vegetation associated with the Robe River and Warramboo Creek and drawdown of the Mesa C CID aquifer is not expected to result in observable changes to groundwater levels within the Robe River Alluvial Aquifer. Potential indirect impacts from dewatering and surface water discharge into Warramboo Creek may occur. The effects of groundwater abstraction and dewatering have been modelled extensively and ongoing monitoring of key environmental values will be undertaken to ensure that no unforeseen impacts occur. The requirement for surplus water discharge has been minimised as far as possible and will be managed such that surface discharge extends no further than 8 km downstream of the discharge

point under natural no-flow conditions. No irreversible impact on riparian vegetation is anticipated as a result of dewatering or surplus water discharge. The proposed mitigation strategies (outlined in Section 8.8) will ensure that the environmental objectives for Hydrological Processes and Inland Waters Environmental Quality are met and that the significant river and creek systems in the vicinity of the Development Envelope are protected.

The nature of mining a resource or abstracting groundwater from a particular geological strata means there is an inherent risk that any short range endemic species of subterranean fauna may be at risk from habitat loss. Therefore, the definition of habitat and habitat connectivity for subterranean fauna as well as survey coverage has been a key consideration in this environmental assessment. The troglofauna and stygofauna habitat present within each deposit is well connected and extends beyond the proposed impact areas. Monitoring evidence also indicates that the Mesa A MEZ is functioning as intended, in protecting the ecological integrity of troglofauna habitat and assemblages. The proposed mitigation strategies, including the continuation of the MEZ approach, will ensure the proposed mining at each deposit can be conducted such that the ecological integrity of troglofauna and stygofauna habitat, as well as the diversity and ecological integrity of the troglofauna and stygofauna assemblages present are unlikely to be impacted significantly.

The Proponent considers that the Proposed Change is in accordance with the EP Act Environmental Principles (Section 4.1). The proposed rehabilitation is designed to ensure that the Proposed Change will not compromise land use options in the area and therefore is consistent with the environmental principle of intergenerational equity. The Proposed Change can be managed effectively through avoidance, management and mitigation measures to ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

Based on the proposed avoidance of significant areas, proposed mitigation strategies and the continued implementation of existing management strategies (including offsets for the three identified potentially significant residual impacts), the Proponent considers that the EPA objectives can be met for all environmental factors and the Proposed Change is environmentally acceptable and can be adequately managed through the draft Ministerial Statement conditions for the Revised Proposal provided in Appendix 2.

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16. APPENDICES

All appendices are contained on the attached CD.

Appendix 1: ESD

Appendix 2: Draft Ministerial Statement

Appendix 3: Mesa A Hub Closure Plan

Appendix 4: Mesa A Hub EMP

Appendix 5: Key Flora and Vegetation Survey Reports

- Flora and vegetation assessment Proposed Warramboo Borefield Area (Stantec 2018)
- Assessment of Groundwater Dependent Vegetation distribution on the Robe River – Targeted Riparian Vegetation Survey – Stage 1 (Rio Tinto 2017a)
- Level 2 Flora and vegetation survey: Mesa B-C, Warramboo BWT, Highway to Tod Bore and Mesa A extension (MWH 2016)
- Mesa A Annual Sand Sheet Vegetation Monitoring (Astron 2017a).

Appendix 6: Significant Vegetation Units

Appendix 7: Key Subterranean Fauna Survey Reports

- Mesa A Hub: Mesas B and C Troglobitic Fauna Assessment (Biota 2017b)
- Mesa A Hub: Warramboo Troglobitic Fauna Assessment (Biota 2017a)
- Mesas A and K Targeted Troglofauna Survey (Biota 2017c)
- Mesa A Hub: Warramboo and Mesa C Stygofauna Assessment (Biota 2017d).
- Complete set of Troglofauna records identified to species level
- Detailed description of the troglofauna habitat modelling methodology
- Mesa A Hub Subterranean Fauna Peer Review (Biologic 2018)
- Troglofauna Habitat Data Analysis (Astron 2017b).
- Revised troglofauna habitat removal impact assessment process for Mesa A Hub Proposal (Rio Tinto 2018a)
- Figures A7-1 to A7-3: showing the troglomorphic species recorded at Mesas A, B and C, mapped by order

Appendix 8: Key Terrestrial Fauna Survey Reports

- Warramboo Borefield Level 2 Fauna Assessment (Astron 2018a)
- Mesa A Hub – Targeted Night Parrot Fauna Assessment (Astron 2018b)
- Mesa B and C Ghost Bat roost cave assessment (Bat Call WA 2016)
- Level 2 Terrestrial Fauna Surveys: Mesa B-C, Warramboo BWT and Highway to Tod Bore (MWH 2015a)
- Mesa Façade Assessment – Mesas B and C (MWH 2015b)
- Robe Valley Mesas A and C, Ghost Bat roost cave assessment, April 2017 (Bat Call WA 2017a).
- Mesa B and C Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016 (WRM 2017)
- Mesa A/Warramboo Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016 (WRM 2016)
- Warramboo Project: Baseline Aquatic Ecosystem Survey Wet Season Sampling 2018 (WRM 2018)

- Geotechnical assessments – Potential diurnal Ghost Bat roost complexes at Robe Valley (Rio Tinto 2017g)
- Figure A8-1 showing the fauna sampling locations in relation to fauna habitat
- Recent Examples of Blast Vibration Control in Pilbara Iron Ore Mines (Rio Tinto 2013)

Appendix 9: Key Hydrological and Hydrogeological Studies

- Warramboo H3 Hydrogeological Level Assessment (Rio Tinto 2017d)
- Mesa C H3 Hydrogeological Level Assessment (Rio Tinto 2017c)
- Mesa A Hub AMD Risk Assessment Update Summary (Rio Tinto 2017h)
- Surplus Water Discharge Extent Assessment - Warramboo below water table (Rio Tinto 2015a)
- 2014 Review of Existing Water Quality Data Warramboo/Mesa A Mine (Rio Tinto 2015b).
- Warramboo TSF Seepage Study (DHI 2018)
- Table A9-1 and Table A9-2: Groundwater data for monitoring bores at Warramboo and Mesa C

Appendix 10: Key Landforms Studies

- Warramboo & Mesa B/C Visual Impact Assessment (Rio Tinto 2018b)
- Robe Valley Deposits Façade Stand-off Distance Memo (Rio Tinto 2017i)
- Mesa Façade Assessment – Mesas B and C (MWH 2015b)
- Rio Tinto: Mesa A Geotechnical Assessment (Snowden 2007).

Appendix 11: Summary Report of Heritage Works Supporting the Rio Tinto Iron Ore Mesa A Hub (Rio Tinto 2018c)