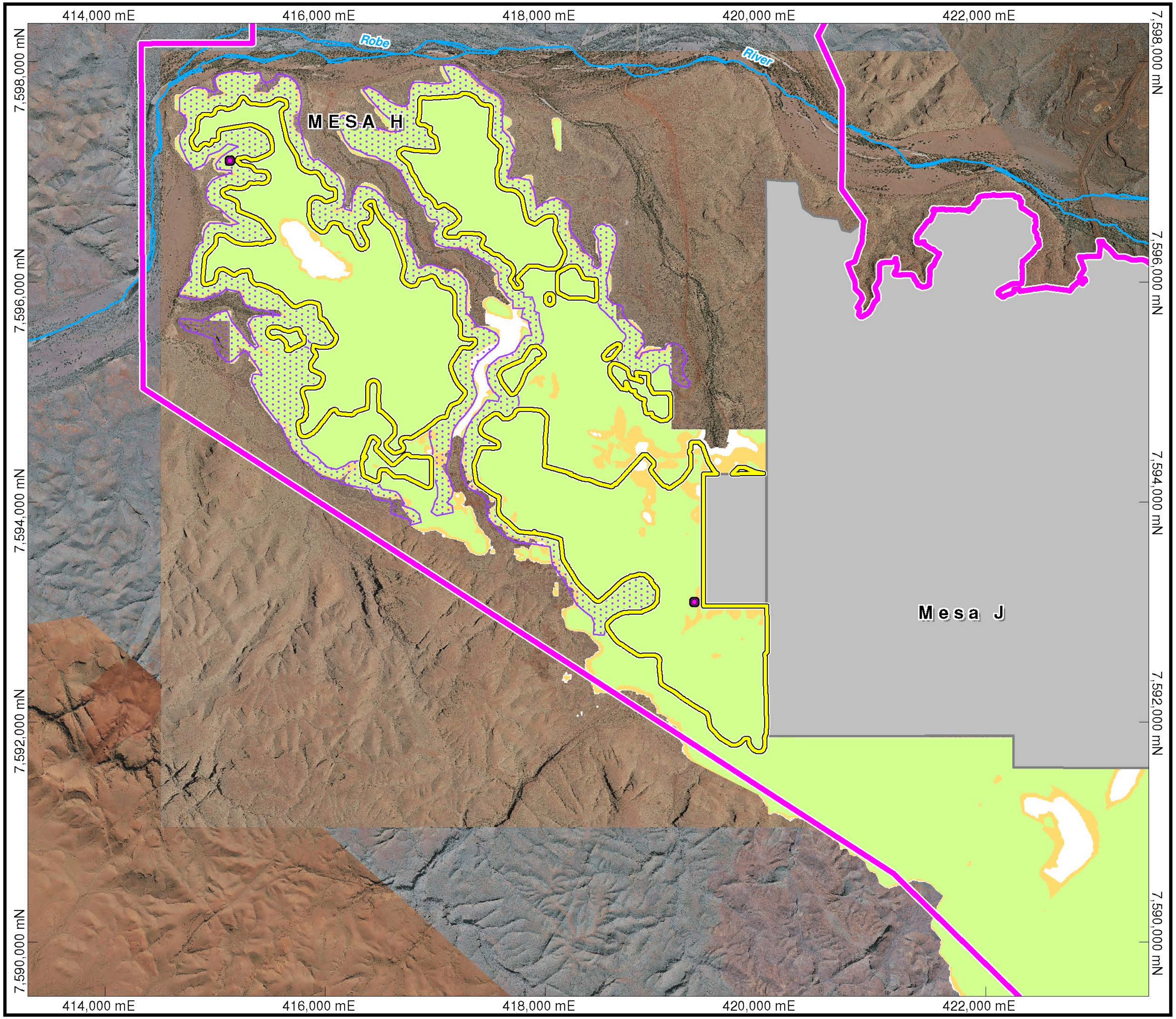


LEGEND

- Development Envelope
- Ministerial Statement 208
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Mining Exclusion Zone

Habitat Prospectivity (high confidence)

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

Blattodea

- ?Nocticola sp. 'West Pilbara Complex'

N

SCALE

0 0.5 1 1.5 2km

1:50 000 @ A4

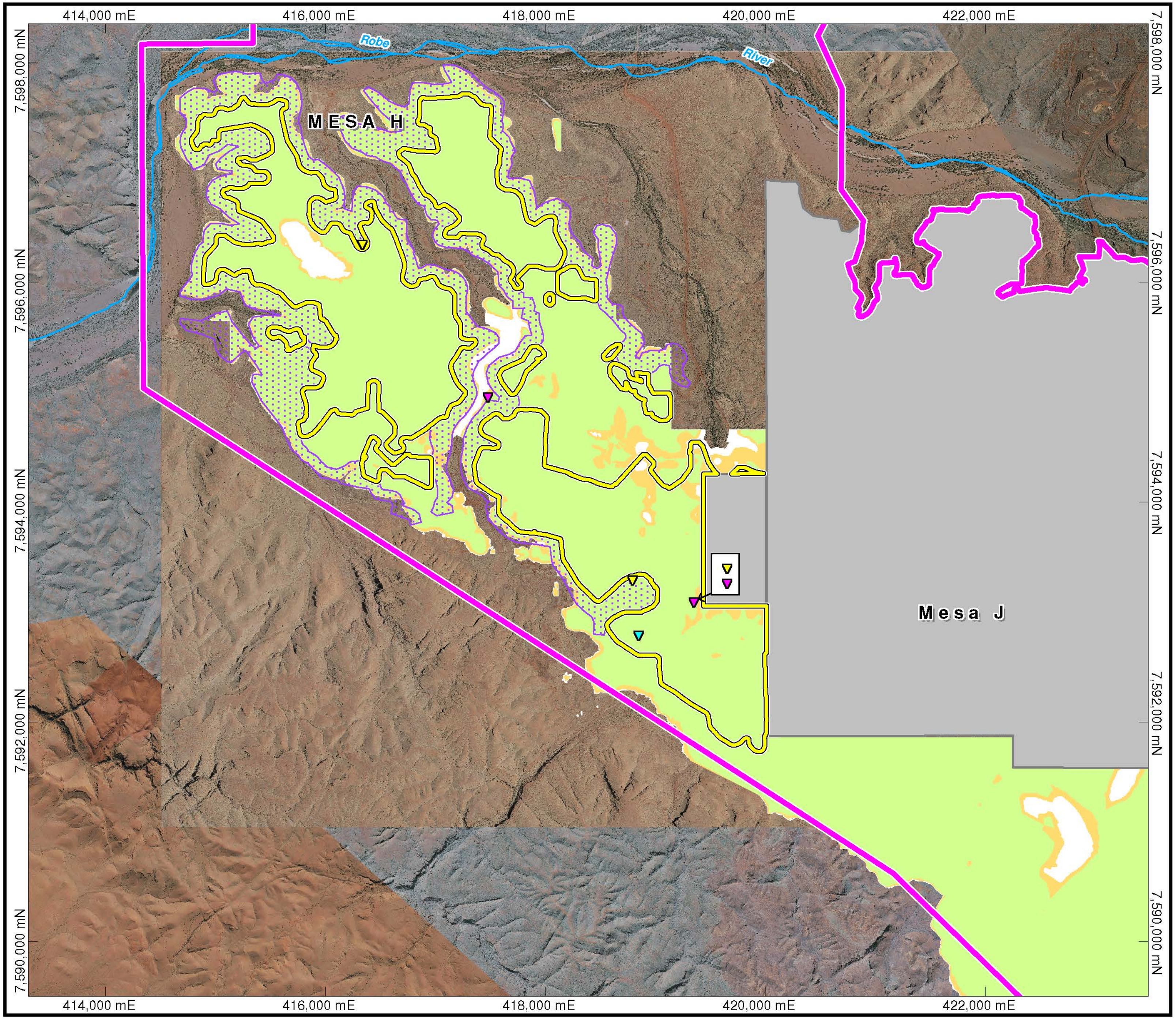
RioTinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 2 - Blattodea

Drawn: GIS
Date: Feb, 2019

Plan No: PDE0160606v6
Proj: MGA94 Zone50

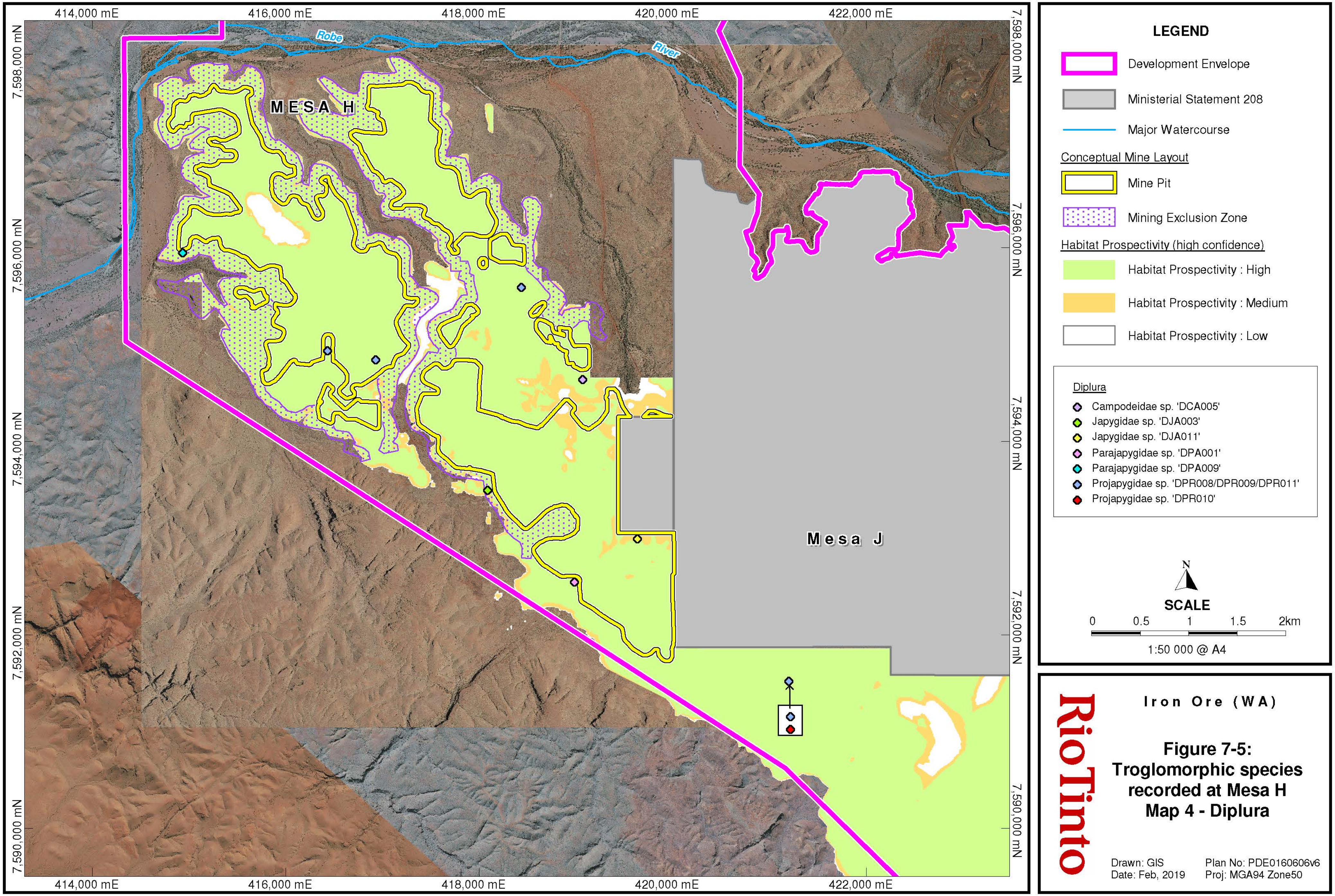


RioTinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 3 - Coleoptera

Drawn: GIS
Date: Feb, 2019
Plan No: PDE0160606v6
Proj: MGA94 Zone50



RioTinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 4 - Diplura

Drawn: GIS
Date: Feb, 2019
Plan No: PDE0160606v6
Proj: MGA94 Zone50

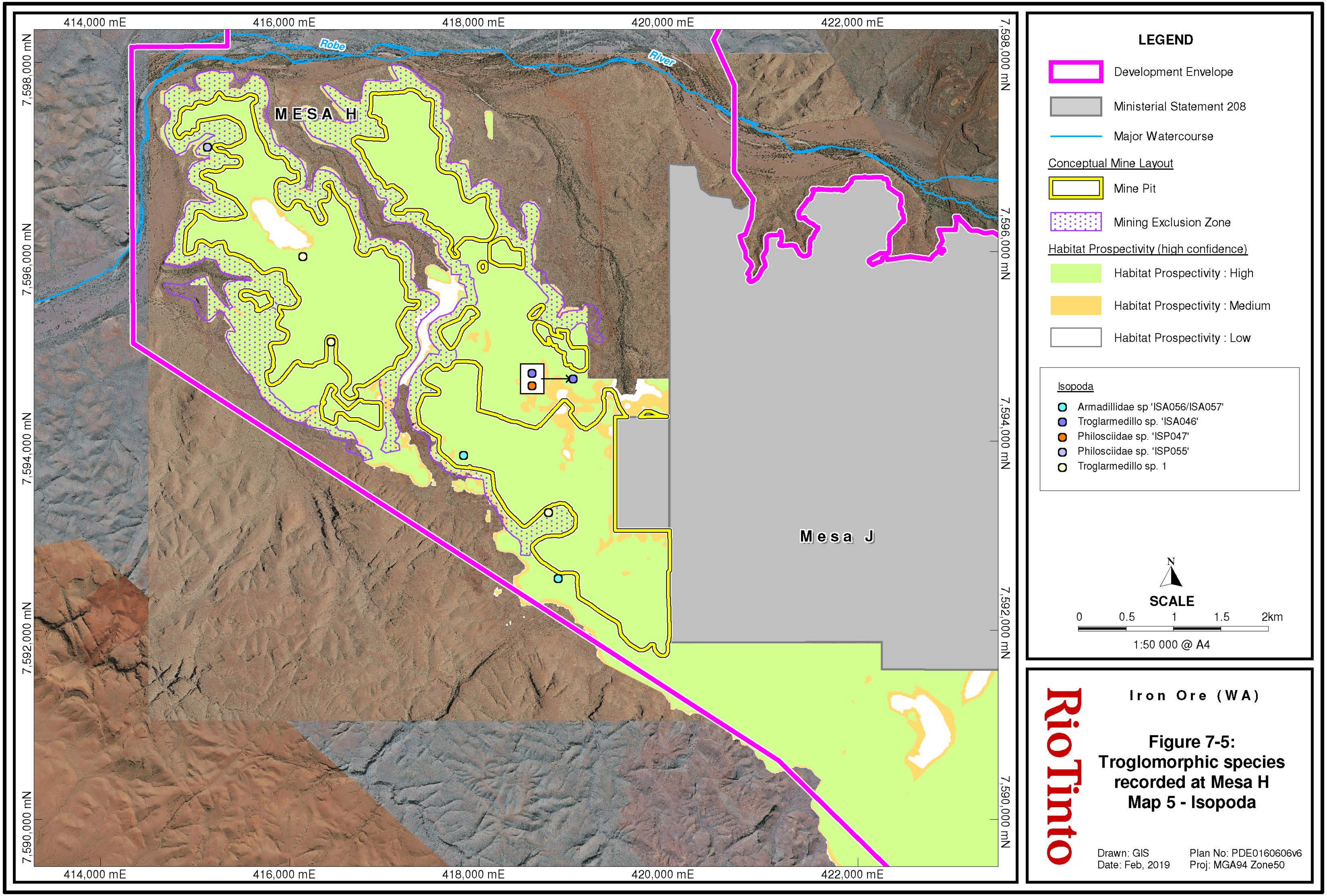
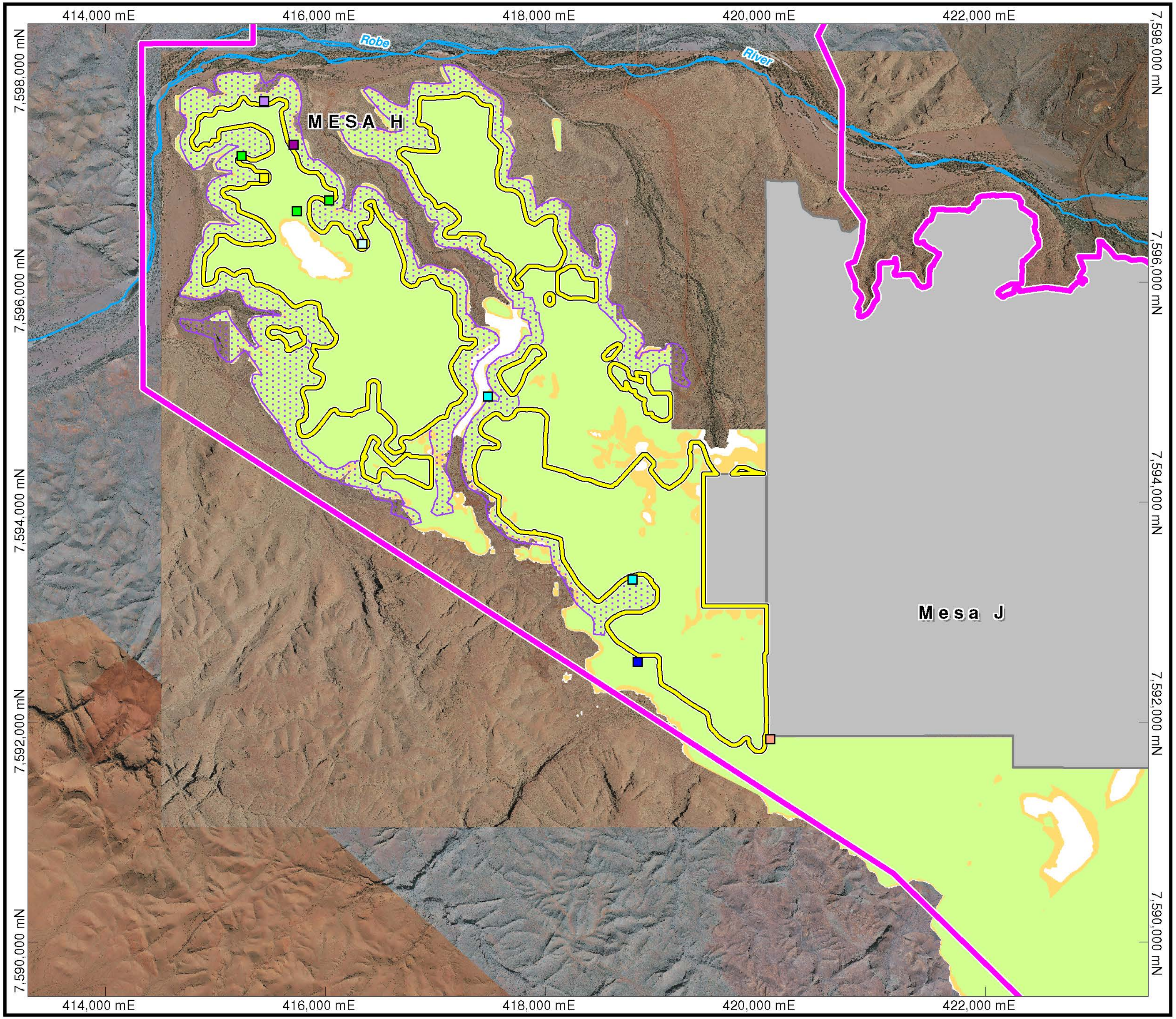


Figure 7-5: Troglomorphic species recorded at Mesa H Map 5 - Isopoda

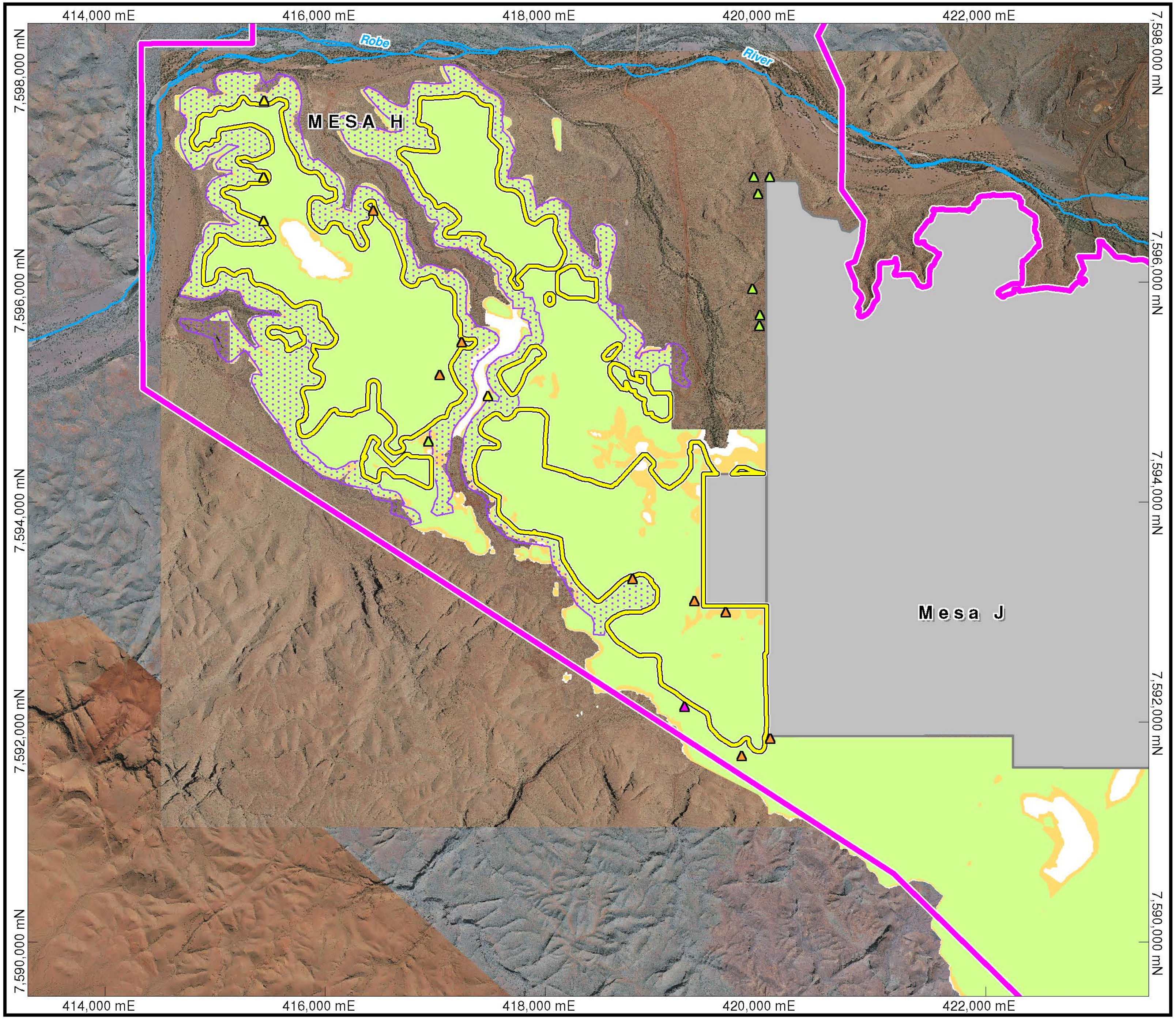


RioTinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 6 - Pseudoscorpiones

Drawn: GIS
Date: Feb, 2019
Plan No: PDE0160606v6
Proj: MGA94 Zone50



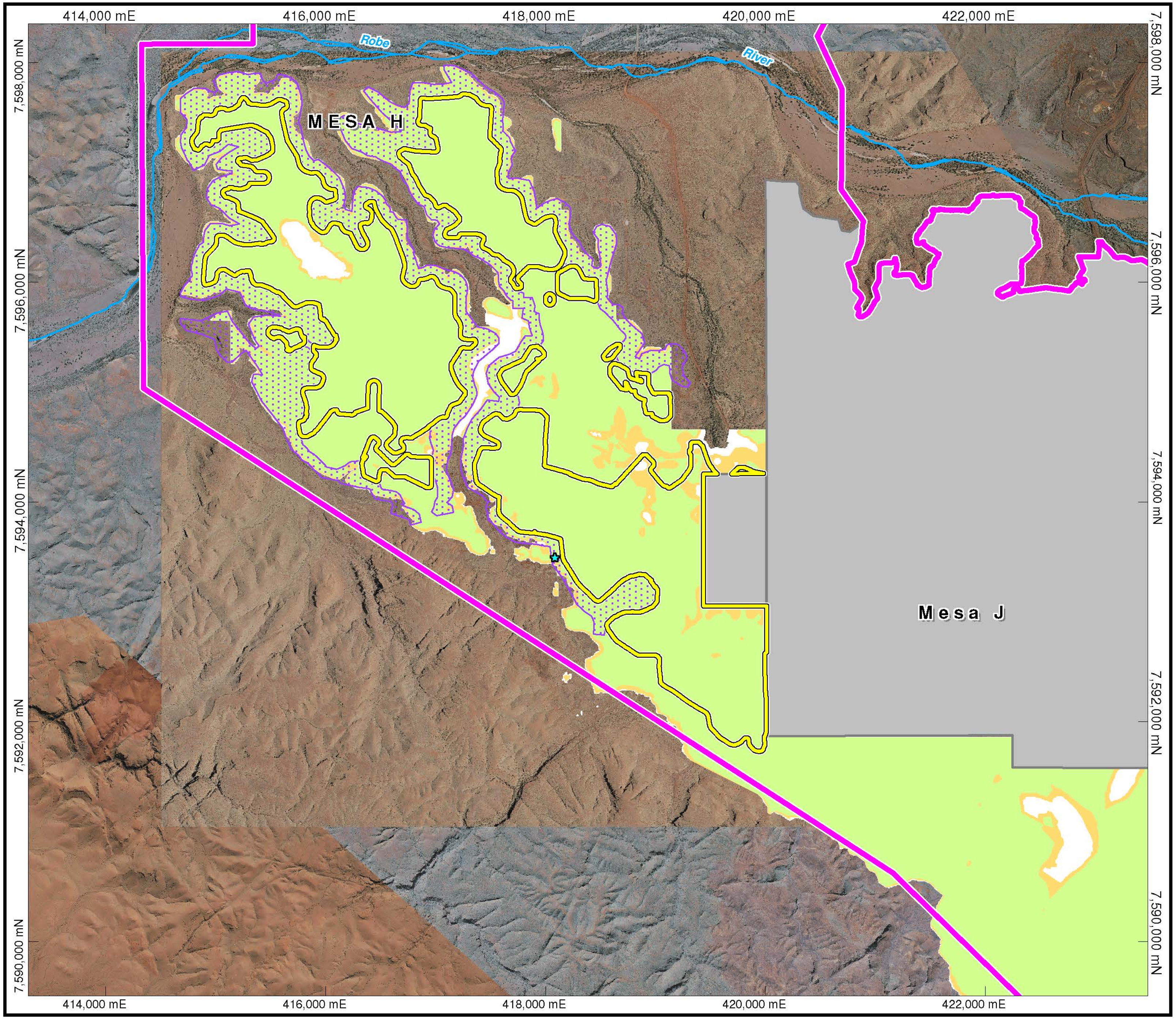
RioTinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 7 - Schizomida

Drawn: GIS
Date: Feb, 2019

Plan No: PDE0160606v6
Proj: MGA94 Zone50



LEGEND

- Development Envelope
- Ministerial Statement 208
- Major Watercourse

Conceptual Mine Layout

- Mine Pit
- Mining Exclusion Zone

Habitat Prospectivity (high confidence)

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

Scolopendromorpha

- Cryptopidae sp. 'SC018'

N

SCALE

0 0.5 1 1.5 2km

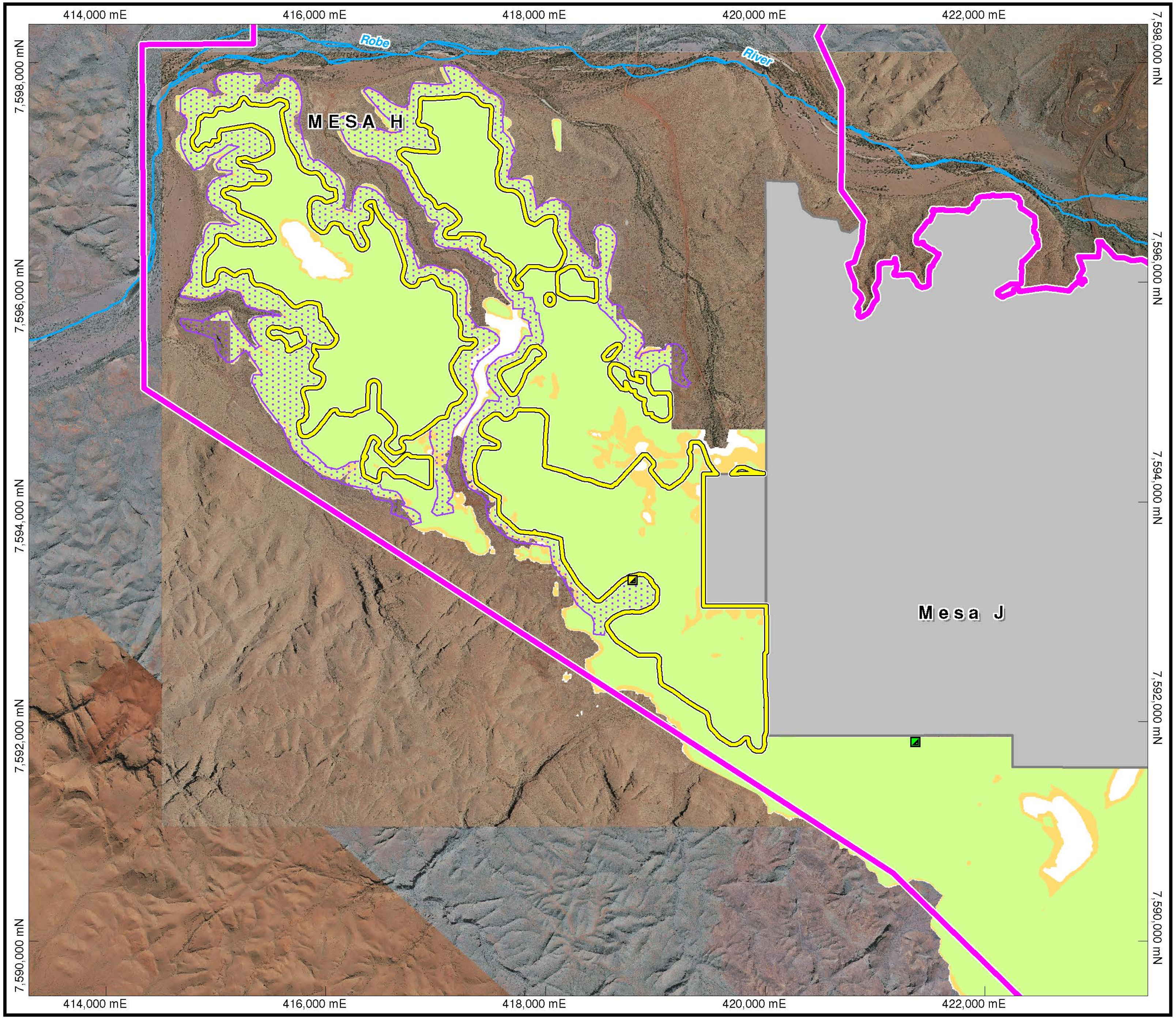
1:50 000 @ A4

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 8 - Scolopendromorpha

Drawn: GIS
Date: Feb, 2019

Plan No: PDE0160606v6
Proj: MGA94 Zone50



LEGEND

Development Envelope

Ministerial Statement 208

Major Watercourse

Conceptual Mine Layout

Mine Pit

Mining Exclusion Zone

Habitat Prospectivity (high confidence)

Habitat Prospectivity : High

Habitat Prospectivity : Medium

Habitat Prospectivity : Low

Zygentoma

Nicoletiidae sp. 'TN019'

Nicoletiidae sp. 'TN020'

N

SCALE

0 0.5 1 1.5 2km

1:50 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-5: Troglomorphic species recorded at Mesa H Map 9 - Zygentoma

Drawn: GIS
Date: Feb, 2019

Plan No: PDE0160606v6
Proj: MGA94 Zone50

7.4.2 Analysis of Robe Valley troglofaunal habitats and monitoring results

Historical monitoring and management of troglofaunal 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 (Section 7.4.2.1) and a summary of monitoring results adjacent to mining at other sites (Section 7.4.2.2).

7.4.2.1 Habitat comparison of Robe Valley mesas

Mesa H is part of a series of mesas that are remnants of a palaeochannel formed by sedimentary deposition of iron rich material, more generically known as a CID (specifically, the Robe Pisolite Formation in the Robe Valley), 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, Mesa H comprises 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 HTP 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 Wittenoom Dolomite and Marra Mamba Iron Formation which forms the majority of the basement to the CID at Mesa H.

One of the key characteristics of the geological units known to provide habitat for troglofauna relate 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 Proposed Change Area, the CID 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 CID 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 Mesa H was assessed and compared to those at the existing Mesa A Operation 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 and H was undertaken (Table 7-5). The data indicate that the frequency of occurrence of cavities logged at Mesa H is greater than that at Mesa A, however the relative distribution of cavities between the strands is similar with a greater portion occurring in the TPH, and fewer in the TPC. The TPB at Mesa H also shows a relatively high portion of cavities in the lower TPB strand.

Table 7-5: Summary of the Occurrence of Potential Cavities at Mesas A and H

Strand	Mesa A Caliper > 17 mm (% of total metres logged)	Mesa H Caliper > 17 mm (% of total metres logged)
Hardcap Pisolite (HTP)	0.5%	1%
Pisolite (TPH)	1.8%	10%
Mixed/Massive Pisolite (TPM)	1.6%	6%
Pisolite Clay (TPC)	1.0%	5%
Basal Pisolite (TPB)	N/A	9%.

Mesas of the Robe Valley, including Mesa H 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 CID to host voids and cavities suitable to support troglofauna remains similar between the mesas.

At an Order level, troglofauna assemblages across the Robe Valley are also similar (Table 7-6) supporting that habitats within each mesa are similar, with a similar range of ecological niches.

Table 7-6: Order level representation of troglofauna across the Robe Valley

Troglomorphic Order	Dinner Camp	Warramboo/ Hwy/Tod Bore	Mesa A	Mesa B	Mesa C	Mesa H	Mesa K
Araneae	Y		Y	Y	Y	Y	Y
Cephalostigmata	Y						
Blattodea		Y	Y			Y	Y
Coleoptera		Y	Y	Y	Y	Y	Y
Diplura	Y	Y	Y	Y	Y	Y	
Geophilomorpha							Y
Hemiptera	Y		Y	Y			Y
Isopoda	Y	Y	Y	Y	Y	Y	Y
Opiliones					Y		Y
Polydesmida		Y	Y	Y	Y		Y
Pseudoscorpiones	Y	Y	Y	Y	Y	Y	Y
Schizomida		Y	Y	Y	Y	Y	Y
Scolopendromorpha		Y	Y	Y	Y	Y	Y
Tetramerocerata	Y						
Zygentoma	Y	Y	Y	Y	Y	Y	Y

Mining and associated troglofauna monitoring have been underway at the Mesa A Operations since 2010 and Mesa K since the 1980s. Given similar troglofauna habitat is present at other mesas within the Robe Valley, including Mesa H, results from the monitoring conducted at Mesa A and at Mesa K[6] have been used to guide the design of the Proposed Change and management actions at Mesa H as described in Section 7.4.2.2.

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

Multiple phases of targeted troglofauna sampling were conducted at Mesa A during 2005 and 2006 as part of the EIA 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 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; and
- downhole optical image surveys.

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[6] The Mesa K operations as approved under MS 776 comprises approval for remnant mining of a historical mining operation previously mined in the 1980s, prior to the first known troglofauna records. For the purposes of statistical analysis and comparison of before and after mining, Mesa A presents the only operation which allows for this type of comparative assessment.

The results of the above monitoring as they relate to the effectiveness of the Mesa A MEZ in maintaining the biological diversity of the subterranean fauna community are assessed in the Mesa A Hub Revised Proposal Environmental Review Document (Rio Tinto 2018f) and summarised below and in Table 7-7.

Troglofauna abundance in the Mesa A MEZ

The statistical power of troglofauna sampling is limited by the sampling methodology. Within the limitations presented by current troglofauna sampling methodology[7], the capture rates of troglofauna from the MEZ at Mesa A during mining were found to be similar to those recorded across Mesa A prior to commencement of mining (Rio Tinto 2018f). 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 abundances recorded prior to commencement of mining.

Troglofauna diversity in the Mesa A MEZ

Sampling at Mesa A prior to the commencement of mining 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 of the analysis confirm the persistence of a troglofauna community at Mesa A of similar general composition to that pre-mining.

In addition, a number of individuals only known from one location and excluded from the mine pit have subsequently been found in multiple other locations.

[7] 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 7-7: Troglobitic and Troglomorphic Taxa Collected from Mesa A (Shown at Order level) (Rio Tinto 2018f)

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	Summary
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.

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 2017; Appendix 10) has been undertaken in disturbed habitats at Mesas A and K to provide a preliminary assessment of the suitability and use of disturbed habitats post-impact. The limited sampling results to date are presented in Table 7-8. Schizomids, isopods, curculionid beetles and hemipterans were recorded from a formerly mined, rehabilitated pit and waste dumps at Mesa K. Pre-mining troglofaunal sampling records are not available for Mesa K as this mine was historically mined. However, all but two taxa recorded in the pits 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, further work is ongoing to evaluate the diversity of troglofauna present in disturbed habitats and utilisation of those habitats by troglofauna.

Due to inherent sampling difficulties, there is currently a greater level of confidence of troglofauna persistence in the retained habitat behind the escarpment MEZ at Mesa A than beneath the pit floor. This information therefore has been used to guide the approach and design of the MEZ at Mesa H.

Table 7-8: 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									

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

[1] This hole was drilled through the low-grade CID waste dump, but also partially into the in-situ CID bedrock geology immediately 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 program was established specifically to examine potential changes in subterranean 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 increasing proximity to the pit face.

Statistical analysis of the temperature and relative humidity data collected was undertaken by Astron Environmental Services (Astron 2017a). The analysis showed proximity to the Mesa A pit edge did not influence mean down hole temperature or humidity (Astron 2017a). 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 2017a). Variations in temperature and humidity values at Mesa A were not significantly different from those recorded from a reference (Mesa B) and an historical (and intermittently active) mining area (Mesa K) (Astron 2017a). 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 2017a).

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 show no visible changes in the shapes or sizes of voids between 2016 and 2017 (Rio Tinto 2018f).

Summary of Mesa A monitoring results

The analysis of the troglofauna sampling and habitat monitoring at Mesa A indicates that the MEZ is functioning as intended with respect to maintaining a viable troglofauna habitat. 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. Downhole habitat monitoring at Mesa A 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.

7.4.3 Potential impacts

7.4.3.1 Direct impacts

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

- reduction in troglofauna habitat due to mine pit development; and
- loss of individuals and changes to assemblages due to mine pit development.

Reduction in troglofauna habitat due to mine pit development

The main direct impact on both troglofauna species and communities key receptors comprises habitat removal that will occur to accommodate the proposed mine pits. This will result in the loss of troglofauna habitat and the mortality of individual animals occurring within it.

The characteristics of troglofauna habitat and the modelled extent of habitat are described in Sections 7.4.1.2 and 7.4.4.1.

As discussed in Section 7.4.4, a conservative approach, considering only the areas of high prospectivity habitat, has been taken to identify and assess potential impacts to troglofauna habitat at Mesa H. This approach is based upon 3D modelling data and, therefore, allows an output as a percentage of volume, and area. Through the development of mine pits, the Proposed Change will not directly impact more than 50% of the volume of pre-mining troglofauna CID habitat at Mesa H (this is conservatively assuming no viable habitat retained below the pit floor or below waste dumps).

From a surface area extent, approximately 85% of the Mesa H Landform habitat will be retained (Table 7-9). However, conservatively, if habitat below the pit floors is excluded as viable habitat, then the troglofauna habitat extent retained via the MEZ and ex-pit is approximately 52% (Table 7-9).

Table 7-9: Potential direct impact to modelled high confidence troglofauna habitat

Habitat prospectivity for troglofauna (AWT habitat)	Current modelled habitat extent (ha)	Post-mining modelled habitat extent (ha)	% habitat by surface area remaining on Mesa H Landform
High	1,537	1,206	78 %
Medium	1,24	2,00	39 %
TOTAL	1,661	1,406	85 %
Excluding below pit habitat	1,661	Pits ~ 790 ha, = 871 ha remaining	~52%

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

The higher order taxonomic composition of the fauna of the Proposed Change Area is considered representative of virtually all components of the best-sampled CID (pisolitic) mesa habitats of the Robe valley (Biota 2019b).

Thirty-three potential or confirmed SRE species have been recorded from the Proposed Change Area representing nine troglofauna Orders. All nine of the troglofauna Orders recorded from the Proposed Change Area are represented in the proposed MEZ Table 7-10. Eight of these Orders are represented within the proposed mine pit footprint.

Table 7-10: Troglofauna recorded (Order level) 2011 - 2017 at Mesa H

Order	Order recorded	
	Mesa H Mine Impact area	Mesa H proposed MEZ
Araneae	✓	✓
Blattodea	✓	✓
Coleoptera	✓	✓
Diplura	✓	✓
Isopoda	✓	✓
Pseudoscorpiones	✓	✓
Schizomida	✓	✓
Scolopendromorpha	-	✓
Zygentoma	✓	✓

From the above Orders, only one potential SRE troglofauna species is currently known only from the proposed mine-pit impact area at Mesa H (Figure 7-6).

Six of the 33 potential SRE troglofauna species recorded in the Proposed Change Area, have also been recorded from outside of the Proposed Change Area and have demonstrated wider distributions. Of the remaining 27 potential SRE species known only from the Proposed Change Area, only four occur within the proposed Mesa H mine pit (i.e. within the direct impact area). Three of these taxa also occur within the MEZ leaving only one singleton species, the Diplura Japygidae sp. 'DJA011' currently only known only from the proposed mine pit impact area (Table 7-11).

Table 7-11: Troglofauna Species Currently Known Only from within the Proposed Change Area and Their Distribution Relative to the Proposed Mine Pits (Species Shaded Grey Currently Only Known From the Mine Pits)

Species	In-pit species (Drillhole Locations)	Sites outside of Mine Pits	
		Inside MEZ (Drillhole Locations)	Other Remnant Habitat (Drillhole Locations)
Pseudoscorpiones			
Hyidae sp. 'PH017/PH027'	-	RC14MEH0252	RC16MEH0264
Hyidae sp. 'PH026'	-	RC16MEH0436	-
Olpiidae sp. 'PO008'	-	RC15MEH0302	-
Beierolpium sp. 'PO014'	-	-	RC16JIM0026
Beierolpium sp. 'PO015'	-	RC16MEH0433	-
Atemnidae sp. 'PA004'	-	RC15MEH0329	-
Chthoniidae sp. 'PC014/PC015'	GR15MEH0015, RC15MEH0315	RC15MEH0335	-
Chthoniidae sp. 'PC055'	-	-	MEHRD0834

Species	In-pit species (Drillhole Locations)	Sites outside of Mine Pits	
		Inside MEZ (Drillhole Locations)	Other Remnant Habitat (Drillhole Locations)
Schizomida			
Paradraculoides sp. 'SCH038'	MEHRC157, RC15MEH0329	RC16MEH0433	RC16MEH0264
Paradraculoides sp. 'SCH039'	-	-	RC15MEJ0019
Scolopendromorpha			
Cryptopidae sp. 'SC018'	-	RC14MEH0388	-
Diplura			
Parajapygidae sp. 'DPA001'	-	-	RC14MEH0308
Parajapygidae sp. 'DPA009'	-	MEHRD0758	-
Projapygidae sp. 'DPR008/DPR009/DPR011'	-	RC15MEH0166	RC15MEH0261, RC15MEH0175, RC16JIM0005
Projapygidae sp. 'DPR010'	-	-	RC16JIM0005
Japygidae sp. 'DJA003'	-	RC14MEH0388	-
Japygidae sp. 'DJA011'	DD13MEH0007	-	-
Campodeidae sp. 'DCA005'	-	-	GR15MEH0032
Isopoda			
Philosciidae sp. 'ISP047'	-	-	RC15MEH0382
Philosciidae sp. 'ISP055'	-	RC15MEH0427	-
Troglarmadillo sp. 1	-	-	MEHDC0865
Troglarmadillo sp. 'ISA046'	-	-	RC15MEH0382
Coleoptera			
Curculionidae sp. 'CCU014'	RC12MEH0221, RC15MEH0302	RC14MEH0252	-
Zygentoma			
Nicoletiinae sp. 'TN019'	-	-	RC16JIM0006
Nicoletiinae sp. 'TN020'	-	RC14MEH0252	-
Araneae			
Prethopalpus sp. 'ARA052'	-	-	RC16JIM0019
Gnaphosidae sp. indet.	-	RC14MEH0270	-

At a troglofauna ecological community level, there are also two key receptors considered for this impact assessment:

- *Subterranean invertebrate communities of mesas in the Robe Valley region* (Priority 1)
- *Subterranean invertebrate community of pisolitic hills in the Pilbara* (Priority 1).

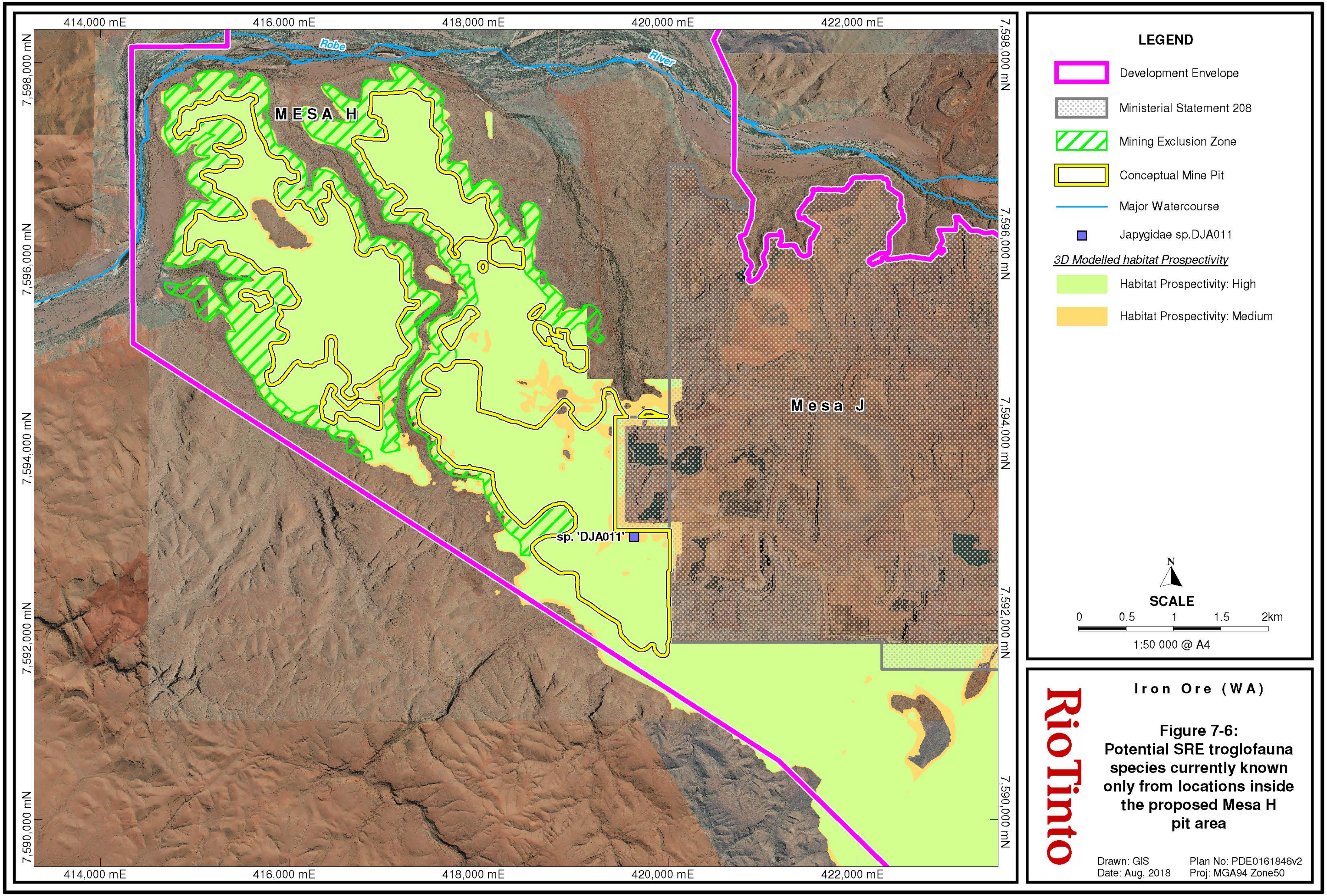

Figure 7-6:
Potential SRE troglofauna species currently known only from locations inside the proposed Mesa H pit area

7.4.3.2 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. 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 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 only high confidence and high prospectivity habitat modelling outputs, potential indirect impacts to troglofauna habitat as a result of placement of mineral waste material from the proposed mining at Mesa H is largely related to where the mineral waste is located on retained habitat within the MEZ. As shown in Table 7-12, less than 6% of the MEZ will be impacted by the placement of mineral waste.

Table 7-12: Potential Indirect Impacts to Troglofauna Habitat at Mesa H and the MEZ From Placement of Mineral Waste

Mesa H Dump	Dump Extent	MEZ		
		Total MEZ Area (ha)	Extent of Waste on MEZ (ha)	% of MEZ
NW Dump	90	447	19.26	4.3%
SW Dump	39		7	1.6%
Total	129		26.26	5.9%

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 insitu moisture content within the CID (including intra clay layers); and the presence of the groundwater table in some areas.

At Mesa H, only a limited volume of troglofauna habitat is in close contact with the water table, and the pre-mining water table does not extend below all areas of Mesa H, in particular, the proposed MEZ. Abstraction of groundwater will lower 7the groundwater table at Mesa H, however, given that only a limited volume of the troglofauna habitat is currently in close contact with the water table, and the proposed MEZ which contains all representative Orders and almost all species (bar one) of troglofauna at Mesa H 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 7.4.4.2.

7.4.3.3 Cumulative impacts

The below section presents the incremental impact from the Proposed Change whilst taking into account previously approved projects. Section 7.4.4.3 discusses the significance of these impacts at each location.

Overall cumulative impacts to the two troglofauna PECs in the Robe Valley are presented in Table 7-13. The calculation for the remaining extent takes into account other foreseeable proposals in the area (the Mesa A Hub Revised Proposal) as well as existing approved developments (Mesa A, Warramboo, Mesa J, Mesa K and historical Middle Robe Mining).

Table 7-13: Cumulative Direct Impacts from the Mesa H Mine Pits on Troglofauna PECs, in Context With Other Habitat Removal

PEC name	Pre-European original extent (ha)	Current extent after other habitat loss (ha)	Extent after Habitat Loss from this Proposed Change (ha)	Incremental impact (ha)
Subterranean invertebrate communities of the mesas in the Robe Valley region.	13,753.9 ha (100%)	11,773.4 ha (85.60%)	11,764.2 ha (85.53%)	9.20 ha (0.07%)
Subterranean invertebrate community of pisolitic hills in the Pilbara.	9,889.7 ha (100%)	952.3 ha (80.41%)	7,164.2 ha (72.44%)	788.1 ha (7.97%)

Assessment of the significance of the predicted cumulative impacts to troglofauna and troglofauna habitat is provided in Section 7.4.4.3.

7.4.4 Assessment of impacts

The assessment of impacts is provided in Sections 7.4.4.1 to 7.4.4.3. To enable an assessment of impacts it is relevant to consider the available information on habitats and troglofaunal records in nearby areas. This information is presented in Section 7.4.2. Comparative data from Mesa J is not available as Mesa J commenced mining in the early 1990s prior to troglofauna being discovered in the Robe Valley.

7.4.4.1 Direct impacts

Reduction in troglofauna habitat due to mine pit development

The Proposed Change will result in the direct loss of up to 50% of the volume of pre mining troglofaunal habitat at Mesa H. The Proposed Change has been designed to retain significant volumes of connected troglofauna habitat, as delineated by a MEZ. Monitoring results from the existing and geologically similar Mesa A and K mining operations have been used to guide the design of the MEZ at Mesa H and assess the likely suitability of the design.

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 indicates there is greater persistence of troglofauna in the retained habitat in the MEZ than beneath the pit floor. Based on the performance of the Mesa A MEZ, a MEZ has been included in the mine design for Mesa H with a focus on retaining connected habitat within the mesa periphery and escarpments, rather than beneath the pit floors.

Although habitat connectivity exists between the Mesa H CID, the Mesa J CID and the Jimmawurrada CID to the south-east the Proponent has taken a precautionary approach and has assumed that the habitat on Mesa H is limited in connectivity to Jimmawurrada, largely due to most of the high prospectively connected CID habitat in the south of Mesa J being already removed due to mining excavation. However, a corridor of connected AWT CID habitat with a width >50 m will remain and will retain a level of connectivity with the Jimmawurrada CID to the south of Mesa J (Figure 7-7). Notwithstanding this connection, the MEZ at Mesa H has been designed to retain sufficient high prospectivity habitat within Mesa H to enable the persistence of troglofaunal assemblages within the mesa.

Troglofauna capture rates vary markedly between sampling events. Table 7-14 provides detail of the overall capture rates at Mesa H and in the areas proposed as a MEZ. The range of capture rates and overall capture rate for the MEZ can be skewed by a single sampling event as seen in Phase 6 sampling. However, combined with connected CID habitat and the representation of all Orders and the majority of taxa within the MEZ (Table 7-11), the information suggests that the MEZ supports a suitable and representative habitat for troglofauna.

Figure 7-8 shows the thickness of CID material suitable as troglofauna habitat that is proposed for retention at Mesa H (backfill of waste material is not included in this figure). The thickness and connectivity of the retained habitat is variable, due to the variable morphology and habitat thickness of the pre-mining habitat, however retention of connected habitat of at least 5 – 15 m depth with a width of at least 50 m around the mesa plateau and a minimum of 50% by volume of the pre-mining habitat is proposed at Mesa H.

Figure 7-9 shows the habitat prospectivity within and around the Development Envelope pre-mining, during operation and following closure. This figure shows the predicted impacts and increase of the habitats during mining as a result of mine pit dewatering, and then the net habitat remaining following closure[8].

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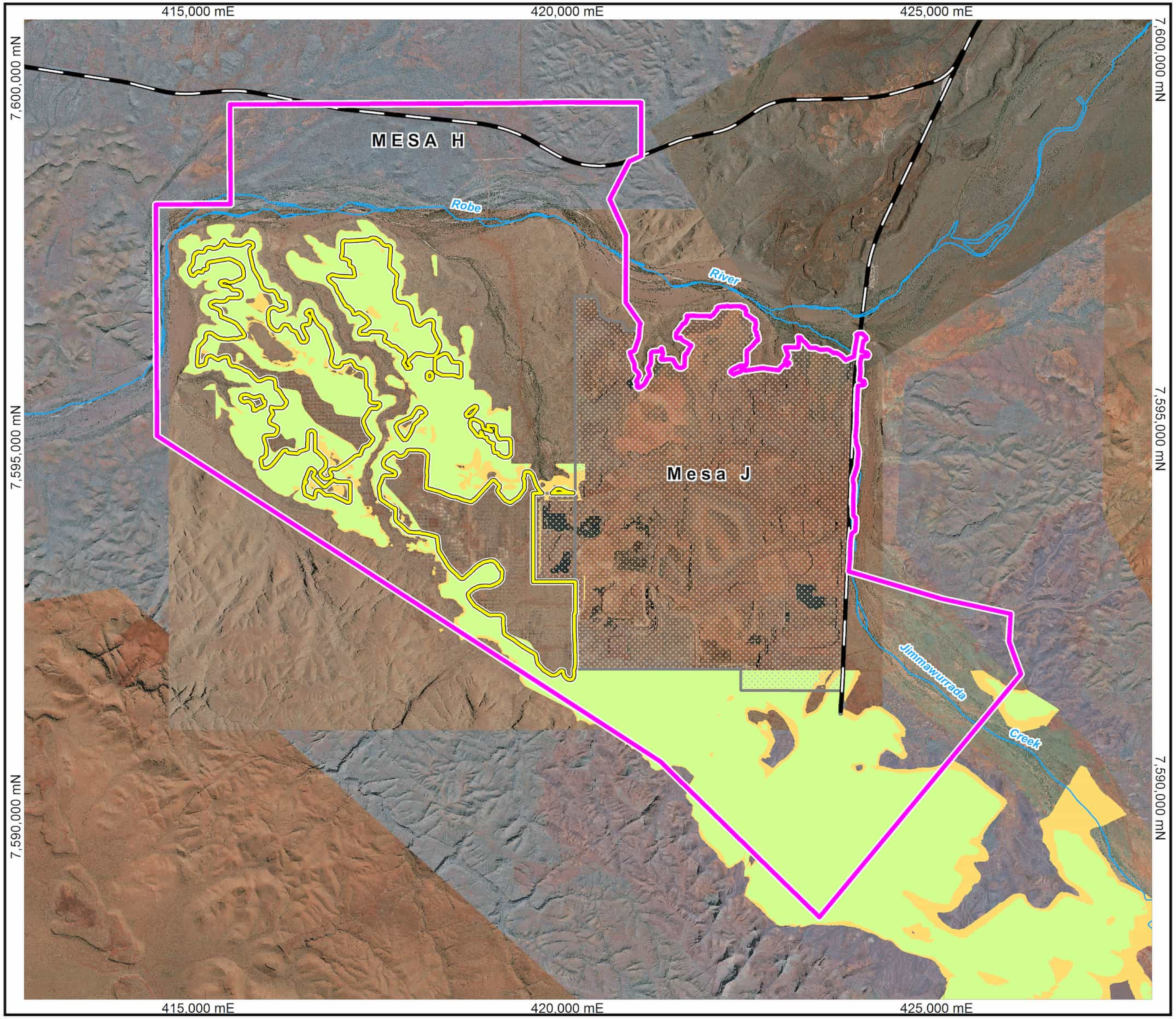
[8] The modelling is conservative and has not included consideration of backfill as additional habitat, however backfill may have the potential to provide additional troglofauna habitat.

Table 7-14: Mesa H Troglofauna Capture Rates

Mesa H	Pre-mining							
Sample collection date	2010 (21st Sep - 10th Nov)	2015 EIA Phase 1 (29th Oct - 12th Dec)	2016 EIA Phase 2 (12th Dec - 21st Jan)	2016 EIA Phase 3 (7th May - 28th Jun)	2016 EIA Phase 4 (14th Sep - 27th Oct)	2016 EIA Phase 5 (27th Oct - 14th Dec)	2017 EIA Phase 6 (14th Dec - 31st Jan)	AVERAGE
Number of trapped holes at Mesa H in MEZ.	6	7	7	16	16	16	4	
Number of trapped holes at Mesa H in pit.	17	39	39	14	27	31	10	
Number of specimens collected in MEZ.	9	5	4	3	3	3	1	
Number of specimens collected in pit.	15	18	16	5	31	5	31	
Number of specimens per 100 trapped holes in MEZ.	150.0	71.4	57.1	18.8	18.8	18.8	25.0	38.9
Number of specimens per 100 trapped holes in pit.	88.2	46.2	41.0	35.7	114.8	16.1	310.0	68.4



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse

Conceptual Mine Layout

- Mine Pit

Habitat Prospectivity (high confidence)

- Habitat Prospectivity : High
- Habitat Prospectivity : Medium

N

SCALE

0 1 2 3km

1:75 000 @ A4

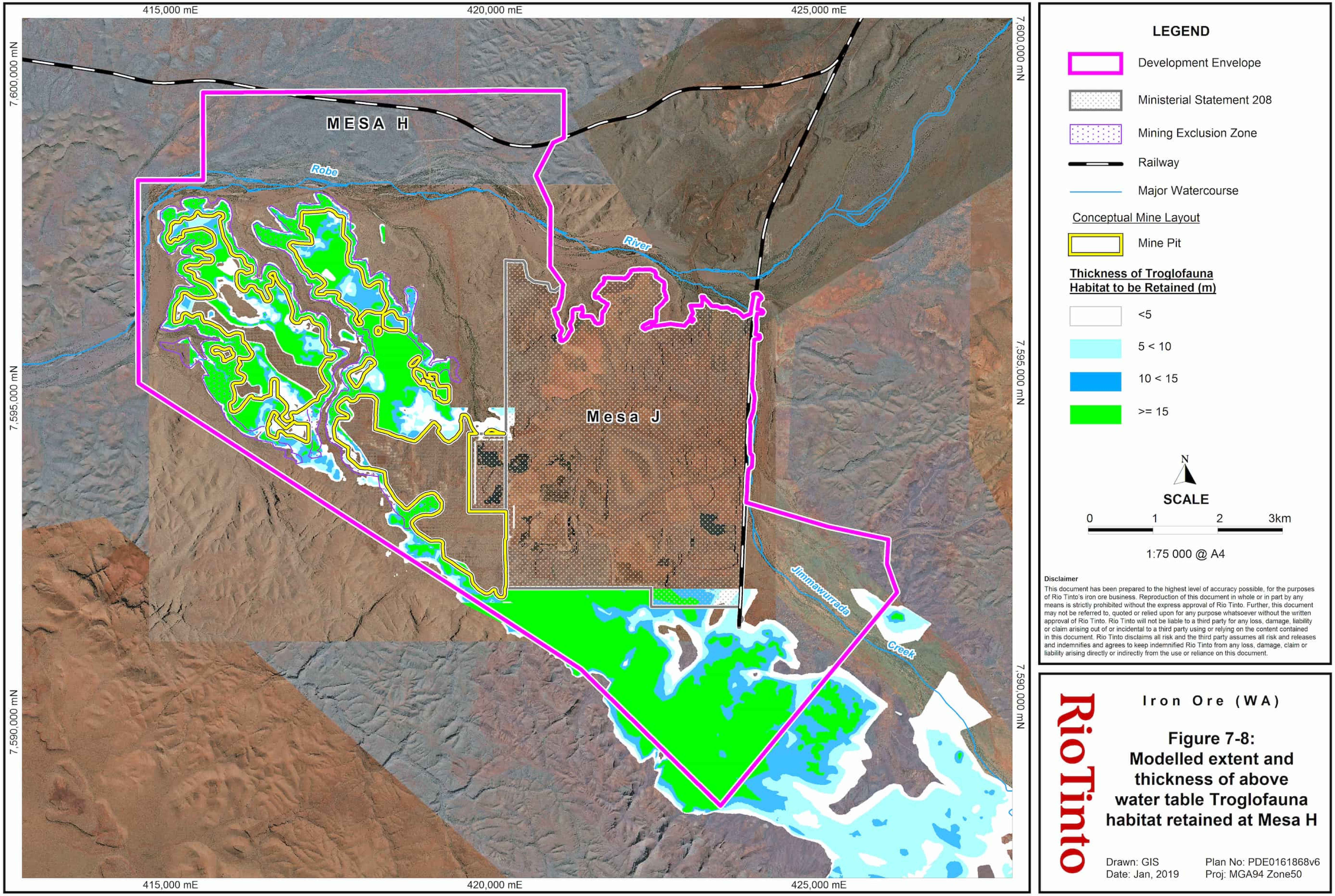
Rio Tinto

Iron Ore (WA)

Figure 7-7: Modelled Troglofauna Habitat to be retained in the Development Envelope

Drawn: GIS
Date: Jan, 2019

Plan No: PDE0161819v3
Proj: MGA94 Zone50



RioTinto

Iron Ore (WA)

Figure 7-8: Modelled extent and thickness of above water table Troglofauna habitat retained at Mesa H

Drawn: GIS
Date: Jan, 2019

Plan No: PDE0161868v6
Proj: MGA94 Zone50

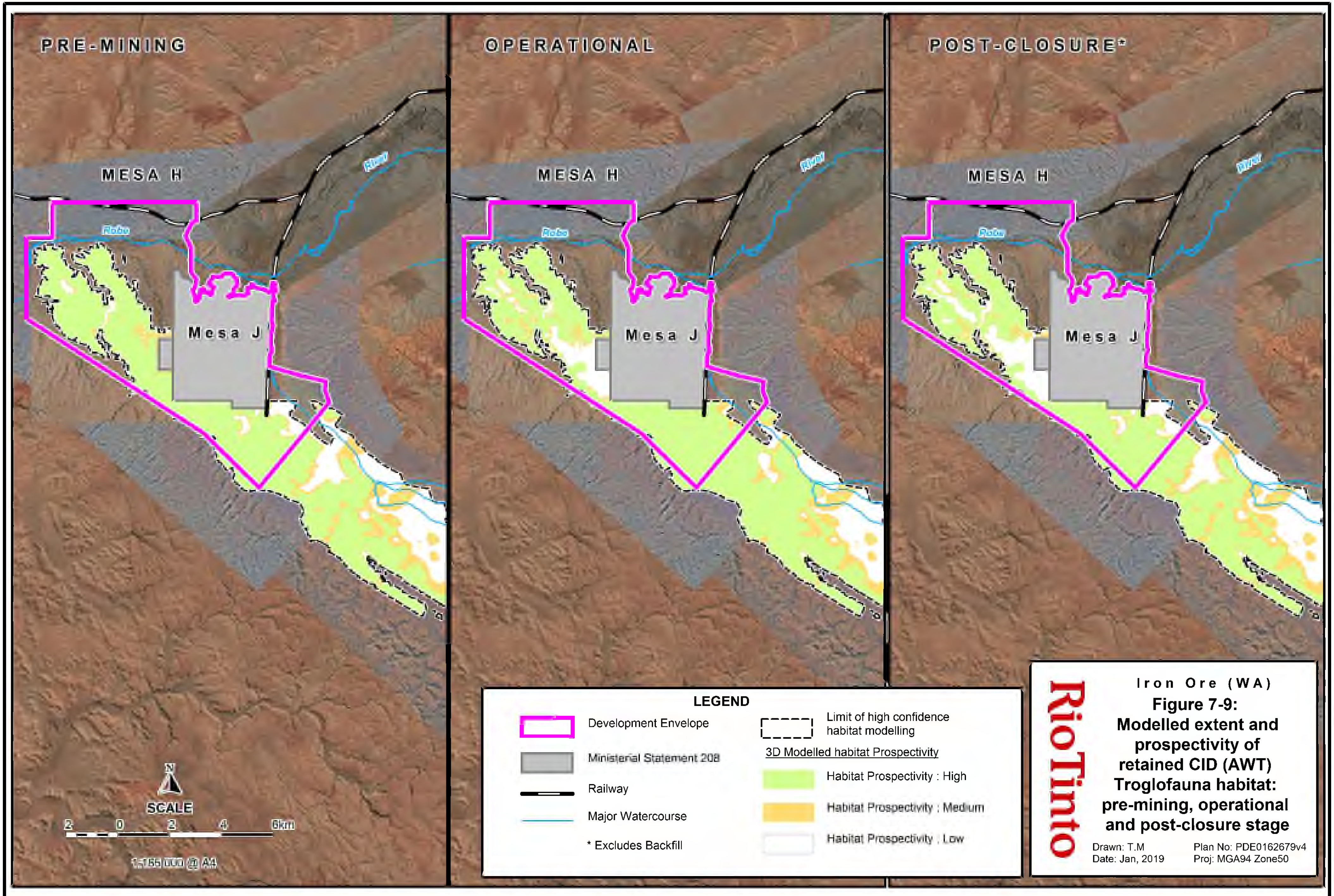


Figure 7-9: Modelled extent and prospectivity of retained CID (AWT) Troglofauna habitat: pre-mining, operational and post-closure stage

Retained habitat will be around 15 m thick 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 50 m due to the natural slopes of the mesa escarpment and due to the construction of benches during mining (rather than a sheer face from the top to the bottom of the pit). Given that the Mesa A MEZ is providing suitable habitat, as evidenced by subterranean temperature and humidity monitoring and troglofauna sampling results; and the proposed MEZ designs for Mesa H is similar to the Mesa A MEZ and is likely to be representative of the troglofauna habitat throughout the mesa, it is considered that the Proposed Change will retain the ecological integrity of the troglofauna habitat at Mesa H.

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. The avoidance of direct impact on most species occurring within the Proposed Change Area (Table 7-11) is due to the Proposed Change design, which 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 or potential SRE, or widespread in biological survey reports.

Although significant, connected troglofauna habitat is proposed to be retained at Mesa H, and the Proponent has taken a precautionary approach in relation to single location and singleton troglofauna records. The original design of the MEZ has been modified several times during the mine planning stages in order to avoid as many single location and singleton troglofaunal records as far as practicable. Consistent with the approach for Mesa A, revisions of the MEZ aimed to include at least one location in the MEZ for each taxon where practicable (Table 7-11). Results from Mesa A, have since shown singletons avoided by the delineation of the MEZ being subsequently found in numerous other locations within the retained MEZ (Rio Tinto 2018f). The current reconfigured mine plan has resulted in all Orders being represented in the MEZ (Table 7-10), and only one species being unable to be avoided (the Diplura: Japygidae sp. DJA011), which is currently known only from the mine impact area. The location of this species record occurs along the boundary between an existing mine pit at Mesa J and one of the proposed mine pits at Mesa H (Figure 7-5, Map 4) i.e. one of the mine pits at Mesa H will form an extension to an existing pit at Mesa J, and is therefore is difficult from a mining and operational perspective to avoid, particularly considering the contiguous interconnected habitat; Order level distribution and high possibility of the record being a sampling artefact. Hence a risk-based approach has been adopted in line with EPA (2016g; 2016h) as described in detail below.

Due to inherent sampling challenges, it is difficult to determine if a singleton species is truly restricted to the mine pit impact areas. In order to address the potential for wider distribution, consideration has been given to the available survey data, distributional records of all troglofauna species known from Mesa H, and the extent and configuration of interconnected troglofauna habitat in the locality.

The above water table CID landforms at Mesa H are considered to form interconnected troglofauna habitat based on the sampling records to date (Biota 2006a, 2016b, 2017, 2019a, 2019b) with over 80% of the recorded species only known to occur at Mesa H (Biota 2019b); and due to the local geology where the troglofauna habitats identified at Mesa H are bounded by major geomorphological features, with Robe River to the north, Jimmawurrada Creek to the east, and the Brockman Iron Formation ranges rising to the southwest (Section 11.1.4.3). Therefore, to assess the risk to the one species only known from within the proposed mine pit impact area, consideration needs to be given to whether such small scale and localised restrictions in species distributions could exist within the extent of troglofauna habitat mapped for Mesa H.

The key lines of evidence to support the conclusion that there is a low risk that the species at Mesa H is truly restricted to the proposed mine pits are summarised below.

Animal abundance

Numerous species recorded at Mesa H are represented by single specimens only, which makes assessing their true distribution difficult and introduces the possibility that their apparent isolation to the record sites is an artefact of ecological sampling effects. This was the case at Mesa A whereby a number of species considered 'at risk' from the mine pit impact area for the Mesa A – Warramboo Proposal have since been found in other locations. For example, *Lagynochthonius asema* was only known from two locations (one of which is in-pit), however is now known from eight locations (Rio Tinto 2018f).

Troglofauna habitats

The combination of surface geology habitat mapping, AWT CID thickness data, and stratigraphic cross-sections (Figure 5-11 to Figure 5-14 in Section 5.4.5), all indicate continuity and connectivity of AWT troglofauna habitats across the extent mapped within the Proposed Change Area. Therefore, it is unlikely that the habitat requirements for one species are unique and restricted.

Assemblage distribution

The EPA notes that taxa with greater known distributions may act as surrogates to infer the distributions of poorly sampled species (EPA 2016b). Other troglofauna species recorded from the same drillhole as the singleton taxa have distributions that extend beyond the direct impact areas. For example, the singleton species only known from within the proposed pit: *Japygidae* sp. 'DJA011' from drillhole DD13MEH0007, co-occurs in this drillhole with *Hubbardiidae* sp. 'SCH015 / SCH016' (Figure 7-5; Map 4 and Map 7); which is not considered a potential SRE and has been recorded both inside and outside the direct impact areas, including in habitat that will remain unmined 1.2 km to the south and other locations outside the Proposed Change Area (Biota 2019a).

At the assemblage level, there are 12 troglofauna species (not limited to potential SRE species) known to occur within the mine pit boundaries and 11 of these have wider distributions within Mesa H, with records from either the MEZ or other troglofauna habitat that will remain unmined. This species distribution pattern indicates connectivity of habitat across the extent of the landform and across the mine pit boundaries, rather than a pattern of very localised species isolation (Biota 2019b). Consistent with this, past surveys at other Robe valley mesas have shown that troglofauna species typically have distributions equivalent to at least the extent of contiguous, AWT CID landforms, once sufficient sampling has been undertaken to demonstrate this (e.g. Biota 2006b, 2007, 2016b).

The EPA acknowledges that species are unlikely to be confined to single recorded locations where there is habitat continuity and as such, endorses the use of habitat as a surrogate for species distributions at a local scale where taxa remain poorly sampled as a result of survey limitations (EPA 2016g, 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. CID with thickness >5 m is considered to represent high prospectivity troglofauna habitat. Figure 7-8 shows a plan view of the pre-mining extent and thickness of the Robe Pisolite at Mesa H in relation to the proposed mine pit outlines. Figure 7-10 shows typical cross-sections of the CID within Mesa H.

The figures show that CID is present across the mesa formation and although the central gully area comprises a reduced habitat, being the basal part of the CID formation overlying

Wittenoom Formation, preliminary troglofauna sampling has recorded the presence of troglofauna in this area, supporting that understanding the habitat is connected across this central gully. There are no other known geological barriers or faults within Mesa H that may restrict troglofauna movement.

In addition, the gradual slope of Mesa H to the southeast towards both Mesa J and Jimmawurrada in combination with the mapped continuation of the CID at Mesa H connecting to AWT CID at Jimmawurrada (Figure 7-7), also supports a broader connected habitat extent via a connected corridor south of Mesa J. This is supported by records of troglofauna in the Jimmawurrada area, albeit with lower catch rates. Hence the approach to ensuring retained troglofauna habitat at Mesa H has been conservative by largely considering Mesa H in isolation.

Figure 7-10a - Typical cross section of Mesa H

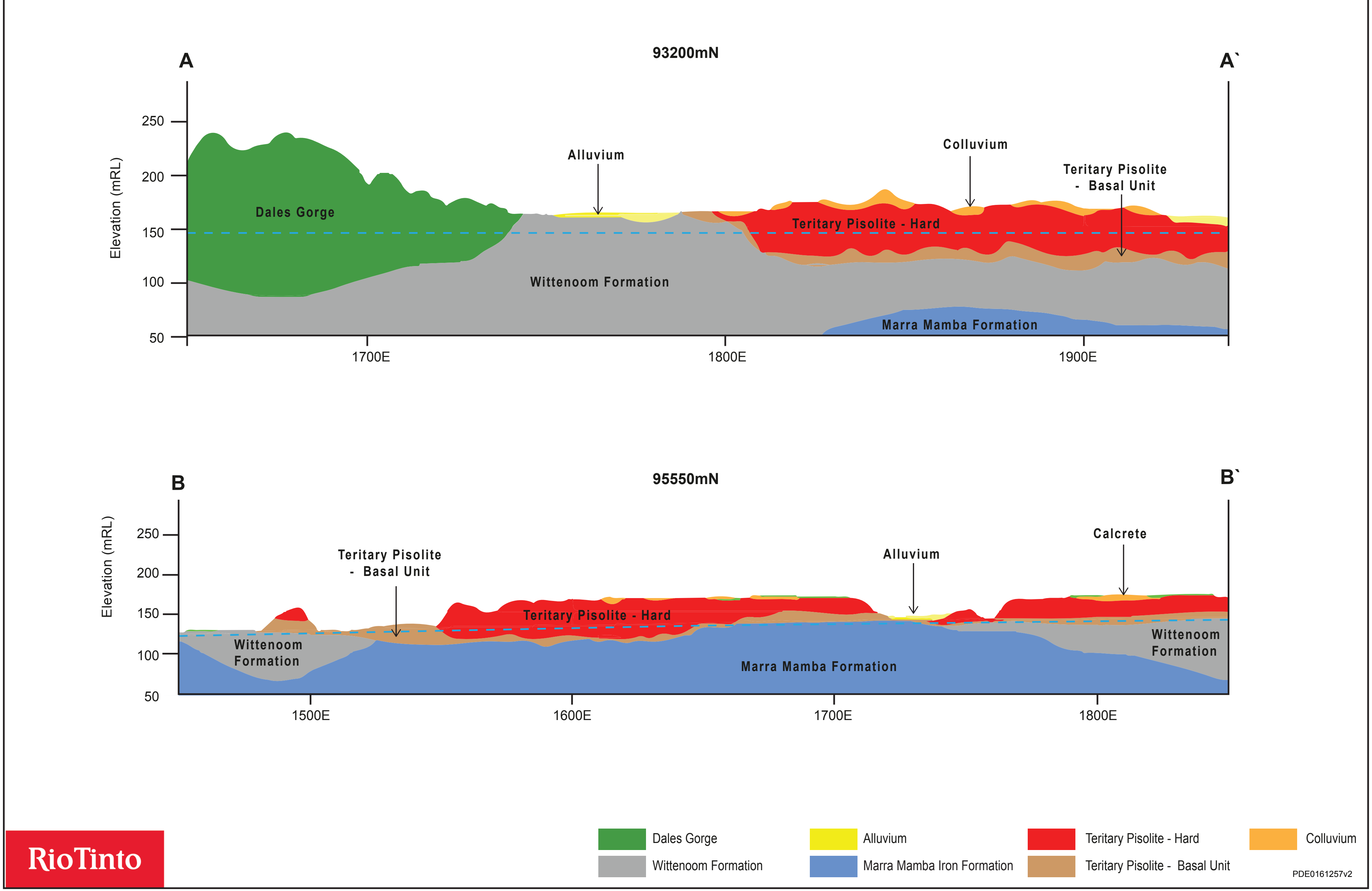
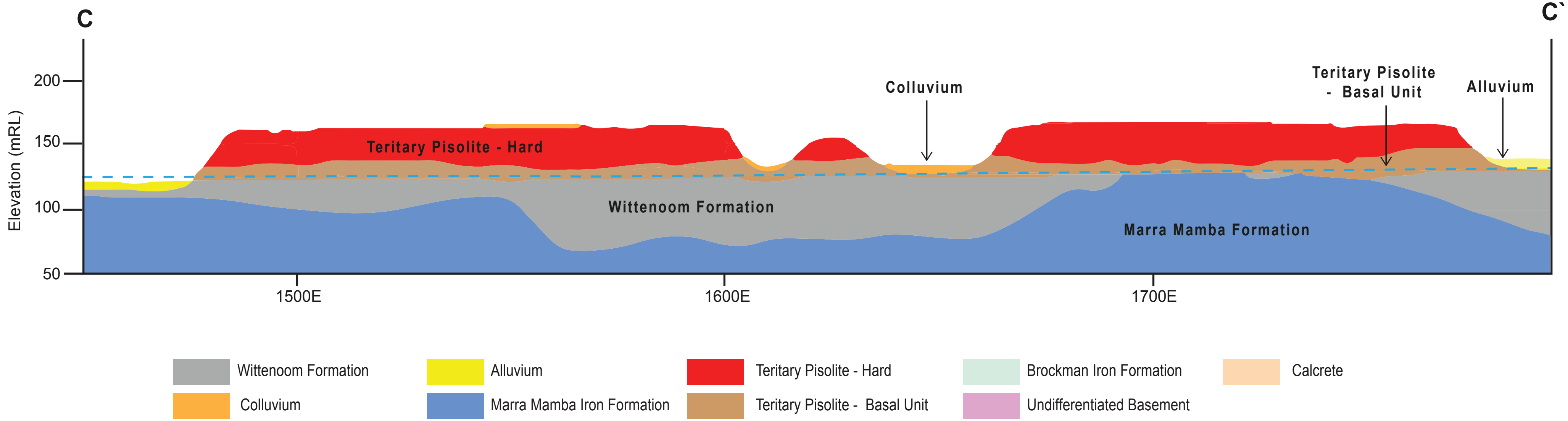
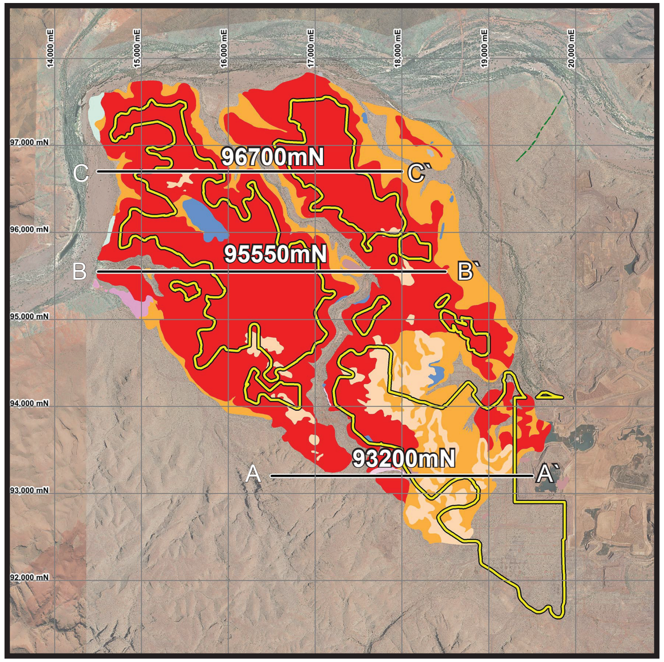


Figure 7-10b - Typical cross section of Mesa H





Location Map
Mesa J Local Grid

RioTinto

PDE0161257v2

The occurrence of some taxa from multiple locations within Mesa H and the absence of known geological barriers and faults indicate the level of connectivity of troglofauna habitat across Mesa H is high. It is, therefore, considered that the singleton troglofauna species currently only recorded from inside the proposed impact area is 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 in the future.

The physical and biological evidence as described above suggests that the one Diplura species known from only the proposed impact area is unlikely to be truly restricted to the small portions of the Mesa H landform from which it has currently been recorded. Data from other co-occurring species, and the broadly continuous nature of AWT CID habitats within Mesa H, suggest that the apparent restriction of this taxon is due to ecological sampling effects and that it occurs more widely within the local habitat extent.

Given these lines of evidence, combined with; the proposed retention of at least 50% by volume of connected pre-mining habitat at Mesa H; that the MEZ has been designed to incorporate areas with singleton records as far as practicable; and that the one singleton species recorded only from the proposed mine-pit impact area (Japygidae sp. DJA011) likely has a wider distribution that extends beyond the proposed mine-pit 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 Mesa H are maintained.

7.4.4.2 Indirect impacts

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

Clearing of vegetation and mineral waste

Little is known about the origin of energy (i.e. organic carbon), key taxa or connectivity within the food web of subterranean systems. 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 and potentially a localised reduction of surface water infiltration into the subterranean environment, which may potentially result in a reduction of the quality of troglofauna habitat.

The Proposed Change has been designed to minimise clearing through placement of the WFSF in-pit at Mesa J and placement of the majority of mineral waste in mined-out pits wherever practicable, in order to minimise clearing in the MEZ. However, as described in Section 11.1, due to the limited availability of space, and constraints on locations due to avoidance of other ecological, heritage and amenity values, the Proposed Change will require placement of two of the mineral waste dumps on the periphery of Mesa H, which is within the area delineated as the MEZ. The placement of the dumps involves clearing of approximately 29.29 ha over high prospectivity habitat, representing approximately 6% of the modelled high prospectivity habitat within the MEZ. Disturbed areas will be rehabilitated once they are no longer required by the Proposed Change.

Results from troglofauna sampling in disturbed habitats (Section 7.4.2) 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, although the extent of likely utilisation is not yet known. Studies of troglofauna utilisation of disturbed habitats are ongoing. As a conservative approach, although intact troglofauna habitat will be retained below the mineral waste dumps, the total volume of retained troglofauna habitat for this assessment has been calculated to ensure that the 50% by volume of high prospectivity habitat is retained, conservatively excluding habitat below the waste dumps.

Excluding the two mineral waste dumps, the Proposed Change has also been designed to limit new clearing in areas designated as MEZs 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 or because of a lack of alternative suitable locations for essential infrastructure.

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

Waste fines generated from Mesa H are proposed to be stored in-pit at existing WFSF's at Mesa J. This approach reduces the risk to Mesa H troglofauna habitat by utilising existing facilities and confining the footprint of seepage mounding above the local groundwater table to Mesa J and therefore is unlikely to affect the long term ecological integrity of the troglofauna habitat in the Mesa H area.

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 5 m to the pit face (Section 7.4.2). Significant degradation of troglofauna habitat in proposed MEZ surrounding the proposed Mesa H pits 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 7.4.2, 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 2017a). Within the limitations presented by current troglofauna sampling methodologies, as described in Section 7.4.2, 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 7.4.1.3). 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. These results indicate that the proposed exposure of pit faces at Mesa H is unlikely to significantly degrade troglofauna habitat in the proposed MEZs.

Hydrocarbon spills

Contamination of soil or groundwater by hydrocarbon spills has the potential to reduce the quality of subterranean fauna habitat. The Proponent has well established strategies for the management of wastes at its Pilbara operations to ensure that risk of contamination of soil or groundwater is minimised. Storage will be in accordance with relevant Australian Standards and will be located at ground level, below the level of the mesa escarpments, situated off the MEZ - thus reducing the risk of contamination within the retained troglofauna habitat. Servicing and re-fuelling of plant and vehicles will not occur within the MEZ, 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.

7.4.4.3 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, is limited to separate impacts at each mesa, however has been broadly contexted in relation to cumulative impacts to the two Priority 1 subterranean fauna PECs.

Up to 50% of the pre-mining habitat volume at Mesa H will be removed or disturbed by the proposed mining operation. The nearest existing mining operation is the Mesa J Iron Ore Development located immediately to the east and adjoining Mesa H. The Mesa J Iron Ore Development commenced mining at Mesa J in the early 1990's prior to discovery of troglofauna in the Robe Valley. Therefore, very limited data is available for troglofauna populations and diversity at Mesa J with which to confidently context with Mesa H. The schizomid species: *Hubbardiidae* sp. 'SCH011' found at Mesa H is, however, also known from the escarpment on the north side of Mesa J adjacent to the Robe River), indicating some connectivity.

The nearest known or proposed (referred) mining operations are the IOH Buckland Hills Project located approximately 35 km south-east of the Development Envelope and the Mesa A Operations and Mesa A Hub Revised Proposal located approximately 40 km west of the Development Envelope. Troglofauna assemblages in areas near these existing and proposed operations differ from those in the Proposed Change Area. These operations are, therefore, unlikely to contribute to cumulative impacts on the troglofauna assemblage in the Proposed Change Area.

7.4.5 Mine closure

The Mesa J Hub Closure Plan (Rio Tinto 2018a) is an integrated closure plan encompassing the existing Mesa J and Mesa K operations, together with the inclusion of the Proposed Change, in order to optimise closure outcomes. The plan is an update to and supersedes previous closure plans for the existing Mesa J and K Operations. The Closure Plan includes the mine developments and associated infrastructure contained within the Development Envelope (Mesa J and H) and within Mesa K's Development Envelope. A summary of the approach to closure of the Revised Proposal and how it relates to the Subterranean Fauna environmental factor is provided below.

7.4.5.1 Mining Exclusion Zones

Similar to the Mesa A / Warramboo Iron Ore Project, a MEZ has been delineated at Mesa H to retain a number of ecological and heritage values including troglofauna habitat both during and post mining operations. The Proposed Change has been designed to limit new clearing in areas designated as the MEZ as far as practicable. Disturbed areas will be rehabilitated once they are no longer required by the Proposed Change, although it is anticipated that limited rehabilitation works will be required in the MEZ (with the exception of the two mineral waste dumps) as disturbance will be minimised.

The habitat contained in the MEZ at Mesa H will be retained throughout the mining operation and upon closure. The design of the MEZ at Mesa H has focused on retention of habitat behind the periphery of the Mesa (façade). The proportion of pre-mining habitat to be retained in the MEZ at Mesa H (>50%) is similar to the total proportion of pre-mining habitat retained at the Mesa A Operations.

The predicted post closure habitat prospectivity for troglofauna is shown in Figure 7-9.

7.4.5.2 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. Backfilling will be undertaken where mine scheduling allows. Some narrow areas ('fingers') of MEZ may protrude into the pit as a result of avoiding singleton troglofauna species; these areas will be prioritised for backfill.

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 7.4.2). 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.

7.4.6 Mitigation

7.4.6.1 Application of the mitigation hierarchy

Mitigation strategies to address the potential impacts and predicted outcomes are presented in Table 7-15.

The volume of connected habitat retained on the mesa is likely to be a key parameter in determining the ongoing suitability of the retained habitat to support a viable troglofauna population. The designs of the MEZ at Mesa H, therefore, focuses on retention of at least 50% by volume of connected pre-mining habitat, similar to the current approved Mesa A operation. Other considerations during the design of the MEZ 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 design 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. Troglofauna sampling and monitoring of habitat parameters at the Mesa A Operation 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 7.4.2).

The Mesa J Hub EMP (Appendix 6) 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, fauna and subterranean fauna species associated with the Mesa J 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; and
- the management actions that will be implemented in response to monitoring results.

The EMP for troglofauna focusses on maintaining viable and connected habitat via the MEZ, given the inherent sampling limitations in the subterranean environment. Trigger and threshold criteria, whilst recognising the practical limits to operational precision, have been structured to ensure that significant volumes of troglofauna habitat are not lost from the MEZ over the life of the mine. Volume and extent of habitat excavated is readily measurable and is part of the causal relationship between mining and impacts on troglofauna. This is supplemented by ongoing troglofauna monitoring throughout the life of mine to confirm if any changes in assemblages are apparent as a result of mining, as measured by troglofauna capture rates compared to baseline data.

Table 7-15: Mitigation Strategies and Predicted Outcomes for Troglofauna

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
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 will remove up to 50% by volume of pre-mining habitat at Mesa H.	The following key management strategies will be implemented to manage impacts to troglofauna as a result of mine pit development: **Avoid:** The mine plan has been designed to retain at least 50% by volume of connected pre-mining troglofauna habitat at Mesa H by the delineation of a MEZ **Minimise:** The Proponent proposes that mine pit development be subject to a new MS (Appendix 3). The conditions of the new MS shall require the Proponent to implement an EMP (Appendix 6) to ensure suitable troglofauna habitat is retained. The Proponent proposes to backfill pits with waste rock material where mine schedules allow and to continue to monitor subterranean temperature and humidity at reference sites. The Proponent also proposes to conduct troglofauna sampling in the MEZ to verify persistence of troglofauna. **Rehabilitation:** The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing	Clearing of up to 9.2 ha and 788.1 ha 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*. The Proposed Change will result in the loss of up to 50% by volume of pre-mining troglofaunal habitat at Mesa H.	The Proposed Change has been designed to retain at least 50% by volume of connected viable pre-mining habitat at Mesa H with thickness between 5 – 15 m through delineation of a MEZ. 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 MEZ at Mesa H will also 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 through mitigation measures and provision of an offset.	Yes. The Proponent proposes the provision of an environmental offset at the higher offset rate ($1,500/ha) for the clearing of up to 9.2 ha and 788.1 ha 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*, respectively.

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
	Mine Closure Plans. The Closure Plan (Appendix 7) includes a closure objective to ensure the final landform is stable and considers ecological values. Pits 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 BC Act (WA).			
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 H landform 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 plan for Mesa H has 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 Mesa H through designation of a MEZ. The Proponent proposes that mine pit development be subject to a new MS (Appendix 3). The conditions of the new	The MEZ and mine pit boundaries were specifically designed to avoid troglofauna species records where feasible, which has resulted in all Orders being represented in the MEZ (Table 7-10). Only one (out of 33 recorded) species has been recorded from the mine impact area and not recorded within the MEZ or surrounding areas. This is the singleton species, the *Diplura Japygidae* sp. 'DJA011'. Habitat connectivity indicates that this species is likely to be more widespread, but this is unconfirmed.	AWT CID is present across the entirety of Mesa H, and although habitat thickness is variable and is significantly reduced in the central gully area, sampling supports connectivity with the *Diplura Projapygidae* sp. 'DPR008 / DPR009 / DPR011' occurring across either side of the central Gully, and records of troglofauna within the central gully. No other internal geological barriers or faults are known that would inhibit distribution and habitat 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 mesa, it is considered that the singleton taxa currently recorded only from inside the proposed mine-pit impact area is likely to have distributions that	No. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
	MS shall require the Proponent to implement an EMP (Appendix 6) to ensure suitable troglofauna habitat is retained. **Rehabilitation:** The conditions of the new MS shall require the Proponent to implement a Closure Plan in accordance with the DMP / EPA Guidelines for Preparing Mine Closure Plans. The Closure Plan (Appendix 7) 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 BC Act (WA).		extend beyond the proposed impact area. It is, therefore, considered that the Proposed Change can be managed such that diversity and ecological integrity of the troglofauna assemblages at Mesas H are maintained.	
Indirect Impacts **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, 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**: Mesa J was selected as the preferred location for the WFSF rather than the alternative location of in-pit at Mesa H in order to avoid impacts to the troglofauna habitat at Mesa H. Hydrocarbon storage and servicing and re-fuelling of plant and vehicles will not occur within the MEZ. **Minimise**: Mineral waste dumps required as part of the Proposed Change will be located in-pit or in areas of the MEZ where the escarpments are less well defined, and	The assessment of potential indirect impacts does not indicate that any identified indirect impact would result in the loss of habitat outside of direct impact areas. To account for any uncertainty, the mine planning and design of the MEZ has ensured that 50% by volume of high prospectivity habitat is retained, conservatively excluding habitat below waste dumps in case of indirect impacts. Impacts from loss of vegetation and placement of mineral waste material are likely to be localised and temporary and are unlikely to	Given the area proposed for the WFSF will be located in existing facilities at Mesa J Mesa J, it is considered that the Proposed Change can be managed such that the continuity and ecological integrity of the troglofauna habitat at Mesa H is maintained. Results from troglofauna sampling in disturbed habitats 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, although the extent of likely utilisation is not yet known. Monitoring results from the Mesa A and K Operations indicate that vibrations from blasting are not	No. The Proponent considers that the potential impacts can be managed, and the residual impact is not considered to be significant and therefore does not warrant the application of offsets.

Potential impacts	Mitigation to address potential impacts	Residual impact	Assessment of significance	Offset required?
	troglofauna habitat is generally thinner to minimise clearing in the MEZ. The remainder of clearing within the MEZ will be minimised and limited to infrastructure such as tracks, utilities, telecommunications, monitoring stations and abandonment bunds (if required). **Rehabilitate**: The Closure Plan (Appendix 7) 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 may support re-establishment of nutrient flows into the subterranean environment.	significantly degrade troglofauna habitat.	resulting in significant changes to subterranean cavities in the retained habitat and MEZ (Section 7.4.2). Blasting conducted as part of the Proposed Change is, therefore, unlikely to affect the integrity of troglofauna habitat in the MEZ proposed at Mesa H. Monitoring at the Mesa A Operations indicates that mining has had little discernible influence on the subterranean temperature and humidity in the retained MEZ (Section 7.4.2). 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 MEZ proposed at Mesa H. Given the proposed hydrocarbon management measures, hydrocarbon spills are unlikely to significantly degrade retained troglofauna habitat. The Proponent considers that the Proposed Change can be managed to meet the EPA's objective for this factor.	

7.5 Stygofauna

7.5.1 Receiving environment

7.5.1.1 Surveys and studies

Stygal communities in WA are predominantly Crustacean (e.g. Amphipoda, Isopoda, Decapoda, Syncarida, Ostracoda and Copepoda), however Annelida (e.g. Oligochaeta), Arachnida (e.g. Hydracarina) and Platyhelminthes are also commonly collected. Three species of stygal vertebrates have been recorded from Australia. This includes two species of blind gudgeon (*Milyeringa veritas* and *M. justitia*) as well as the Blind Cave Eel, *Ophisternon candidum* (Humphreys 2001b, Department of the Environment, Water, Heritage and the Arts [DEWHA] 2008a, Foster and Humphreys 2011, Larson *et al*. 2013 in Biota 2019a).

A number of stygofauna surveys relevant to this Proposed Change have been undertaken since 2007 and are summarised in Table 7-16 and depicted in Figure 7-11. Sampling for stygofauna has been undertaken in water monitoring sites and production bores within the Proposed Change Area and in adjacent areas of modelled groundwater drawdown, including the adjacent CWSP in Bungaroo to the south-east. In addition, a desktop review of relevant existing information was undertaken in order to provide context to the assessment of stygofauna at Mesa H as summarised in Section 7.4.1.1.

A total of 53 sites were sampled for stygofauna across the five phases of investigation with the majority of sites (39) sampled on at least two separate phases. Fourteen sites were sampled only once, ten sites were sampled across three phases and one site (WB13MEJ003) was sampled across four of the five phases (Table 7-16). Eighteen of the 53 sites were located outside of the Proposed Change Area, within the predicted groundwater impact area. Stygofauna were sampled using modified plankton haul nets, constructed from 70 μm plankton mesh, with 50 mm and 100 mm apertures attached to a stainless steel catch cylinder. Figure 7-11 shows the stygofauna sampling sites and records in and around the Proposed Change Area.

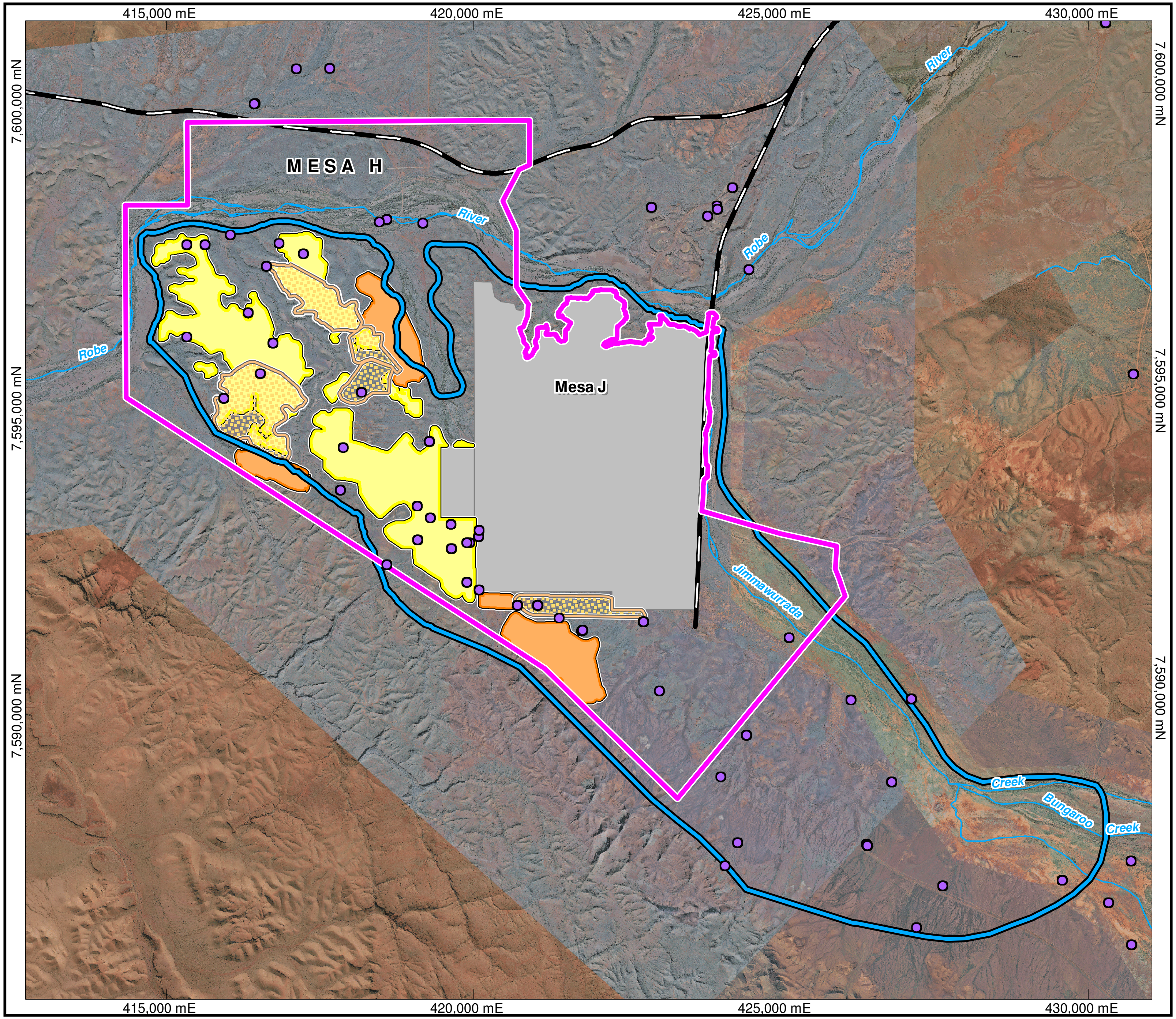
Sixteen of the bores sampled for stygofauna were also sampled for Environmental DNA (eDNA) during the December 2017 Phase 5 stygofauna sampling. The eDNA samples specifically were collected to target the Blind Cave Eel (*Ophisternon candidum*) (Section 7.5.1.3), which is not readily detectable with conventional sampling methods (Biota and Helix 2014 in Biota 2019a). This sampling methodology involves collection of a water sample from bores, to target trace amounts of fauna DNA molecules and fragments of tissues within the water column. The majority of the eDNA sampling sites were located outside of the predicted Proposed Change Area, with five sites located within the predicted impact area.

In addition, aquatic fauna surveys have been undertaken as part of the Proposed Change investigations: a baseline aquatic ecosystem survey for the Robe River and Jimmawurrada Creek in and adjacent to the Proposed Change Area (WRM 2017). Whilst these surveys do not specifically target subterranean fauna, stygofauna or more specifically, stygobites (obligate groundwater dwellers), are occasionally caught as by-catch during these surveys.

Stygofauna species recorded in and around the Proposed Change Area are shown on Figure 7-12 and described in Section 7.5.1.3, and the aquatic fauna surveys are described further in Section 8.4.2.

Table 7-16: Summary of Supporting Stygofauna Surveys

Survey Report	Survey Description / Summary	Survey Date
Mesa H Subterranean Fauna Survey Report 2018. Biota (2019a)	Six phases of troglofauna sampling and five phases of stygofauna sampling were undertaken via ten field mobilisations. This included an eDNA sampling program and qPCR and metabarcoding molecular analysis.	October 2015 and December 2017
Mesa H Subterranean Fauna habitat assessment. Biota (2019b)	Independent assessment of habitat and risk to habitat as a result of implementing the Proposed Change.	N/A
Bungaroo Coastal Waters Project Stygofauna Monitoring 2016. Biota (2016a)	Two phase stygofauna sampling survey of the Bungaroo and Jimmawurrada area. Surveys involved 28 and 25 sites respectively.	April and September 2016
Bungaroo Coastal Waters Project Stygofauna Monitoring 2015. Biota (2016b)	Two phase stygofauna sampling survey of the Bungaroo and Jimmawurrada area. Surveys involved 25 and 26 sites respectively.	May and October 2015
Bungaroo Coastal Water Supply Project Stygofauna Monitoring: 2014. Biota (2014)	Two phase stygofauna sampling survey of the Bungaroo and Jimmawurrada area. Surveys involved 27 and 23 sites respectively.	May and October 2014
Bungaroo Coastal Waters Project Stygofauna Monitoring Baseline Survey. Biota (2013a)	Single phase stygofauna sampling survey of the Bungaroo and Jimmawurrada area. Survey was conducted at 27 sites.	July 2013
Bungaroo Subterranean Fauna Collections Summary; Phases 1-11. Biota (2013b)	Summary of the 11 initial phases of stygofauna and two phases of troglofauna sampling in the Bungaroo and Jimmawurrada area. Includes a consolidated sampling effort and records.	Summary of surveys between 2003 and 2011
Bungaroo Creek Subterranean Fauna Summary Phases I – VII. Biota (2010a)	Summary of the sampling effort, catch data and species identification from the seven phases of stygofauna sampling as well as the initial phase of troglofauna sampling.	Stygo: December 2003 - November 2009 Trog: November-December 2009
Bungaroo Trial Pit Stygofauna Assessment. Biota (2007)	Initial report on three phases of stygofauna sampling in the Bungaroo area.	Sampling between 2003 and 2007



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Stygofauna Sampling Site
- Groundwater Drawdown Extent

Conceptual Mine Layout

- Mine Pit
- Waste Dump
- Topsoil / Subsoil Stockpile

N

SCALE

0 1 2 3 4km

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RioTinto

Iron Ore (WA)

Figure 7-11: Stygofauna sampling in or near the Development Envelope

Drawn: M.Swebbs
Date: Jan, 2019

Plan No: PDE0161246v4
Proj: MGA94 Zone50

7.5.1.2 Habitat

The likely habitats for stygobitic fauna in the study area were characterised using regional information, site-specific geological data and stygofauna survey results. The hydrogeology of the Proposed Change Area is described in detail in Section 5.

Groundwater within and adjacent to the Proposed Change Area occurs predominantly within four key aquifers:

- **Robe River alluvial aquifer**: an extensive and unconfined superficial aquifer consisting of gravelly Quaternary alluvial sediments (shingles, conglomerates and coarse sand), deposited along the Robe River with an approximate 20 m thickness and average width of 400 m.
- **Jimmawurrada Creek alluvial aquifer**: consisting of Quaternary alluvial sediments deposited along Jimmawurrada Creek, incised up to a maximum observed thickness of 40 m in the centre of the alluvial channel (thalweg).
- **CID aquifer**: an unconfined aquifer consisting of CID pisolitic sediments below Mesa H (and connected in the southeast to the Jimmawurrada and Bungaroo CID aquifers) with an average of 20-30 m thickness below the pre-mining water table.
- **Wittenoom aquifer**: a largely confined aquifer underlying the CID aquifer, consisting of weathered dolomite and dolomitic shale (Paraburdoo and Bee Gorge Member) and weathered BIF (Marra Mamba Iron Formation) with a thickness of approximately 25 m.

Pre-mining depth to groundwater within the Mesa H CID aquifer is generally between 25 and 45 m below surface within higher elevation areas, but the water table is considerably shallower in the Robe River and Jimmawurrada Creek alluvial aquifers. Depth to pre-mining groundwater in these alluvial aquifers ranges from approximately 4 – 12 m below surface along Jimmawurrada Creek, and approximately 2 – 5 m below surface along the Robe River. These groundwater levels fluctuate by up to 3 m seasonally, depending on climatic variability and rainfall patterns.

The basal Robe Pisolite (Tpb) is a 5 -10 m thick layer deposited at the base of the CID Aquifer, consisting of a variable clay-rich pisolite. While its hydraulic properties have not yet been defined, the largely impermeable physical characteristics of the unit mean that it is expected to function as a partial barrier to groundwater flow between the CID Aquifer and the underlying Wittenoom Aquifer (Rio Tinto 2019a).

The Robe River and Jimmawurrada alluvial aquifers together with the BWT CID aquifers of Mesas J, H, Jimmawurrada and Bungaroo, are the most likely to provide habitat for stygofauna, based on their physical and hydraulic characteristics. In addition to the extensive data sets that exist from sampling of equivalent aquifers in the locality, the Robe River and Jimmawurrada alluvial aquifers are the primary groundwater system that provides habitat to stygofauna in the wider locality, having yielded many stygofauna records (Biota 2019b). The Mesa H CID aquifer, while deeper and thereby likely to host less fauna is also structurally suitable as stygofauna habitat and has some existing data to confirm that stygofauna utilise the aquifer. The Mesa H CID aquifer is structurally and geologically constrained along its northern and western extents adjacent to the Robe River, and a basement high to the north-east forms an impermeable boundary adjacent to Yeera Bluff (Figure 5-11 to Figure 5-14). The CID is however continuous and connected to the Mesa J, Jimmawurrada and Bungaroo CID aquifers to the south-east, of which the latter two are overlain in places and connected to the Jimmawurrada alluvial aquifer (Figure 7-12). The Jimmawurrada Creek alluvial aquifer is also a tributary into the Robe River alluvial aquifer, which extends over 130 km from the upstream Middle Robe / Deepdale area, all the way to the Pilbara Coast. The Wittenoom Aquifer is considered unlikely to represent significant habitat for stygofauna, given its depth, confined nature, lower transmissivity host rock, and limited connectivity to more superficial systems (Biota 2019b) (Table 7-17, Table 7-18).

The aquifers that provide stygofauna habitat at Mesa H broadly correspond to the regional surface geology map units (1:250,000) and more detailed 1:10,000 local geological mapping by the Proponent, which provide a wider context to the stygofauna habitats of the dewatering extent. The units that represent High or Medium prospectivity stygofauna habitat within the dewatering extent and the wider locality are summarised in Table 7-18 and mapped in Figure 7-12. Habitat mapping was undertaken in 'Leapfrog' modelling software using downhole geological logging data combined with hydrological data including water table levels, which correlated closely with the surficial mapping data.

The mapped habitat extents show a strong spatial correlation with stygofauna record locations, with 129 of the 133 known stygofauna locations falling within units mapped as High prospectivity habitat (97%) (Biota 2019b) (Section 7.5.1.3 and Figure 7-12). The landscape setting of these units also confirms that these habitats occur as low elevation valley fill units. The stygofauna sampling results and hydrogeological data indicate that there is unlikely to be any significant physical barriers to stygofauna dispersal within the CID aquifers and alluvial aquifers in the vicinity of the Proposed Change Area and surrounds. Given the high level of validation from confirmed fauna records and 3D downhole geological modelling using Leapfrog, the regional mapping units combined with these datasets can be used to set wider context to the impacts of the Proposed Change on stygofauna habitat.

The likelihood of these geological units described above representing suitable habitat for stygofauna was categorised into Low, Moderate and High, based on the following characteristics (Biota 2019a; Table 7-17):

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 7-17: Stygofauna Habitat Prospectivity Definitions (Biota 2019b)

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 runoff (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 key geological units, Alluvium, colluvium and riverine sheet floodplain (Lacustrine) and CID were categorised as high prospectivity habitat and considered likely to provide primary habitat for stygofauna where they occur BWT (Table 7-18 and Figure 7-12). Both the CID and alluvium geological units have been previously identified by the EPA as potential stygofauna habitat (Biota 2019a). The Wittenoom Formation is categorised as having low habitat prospectivity due to its lack of permeability where it occurs BWT (Biota 2019b; Table 7-18).

Table 7-18: Stygofauna Habitat Prospectivity of the Geological Units within the Study Area

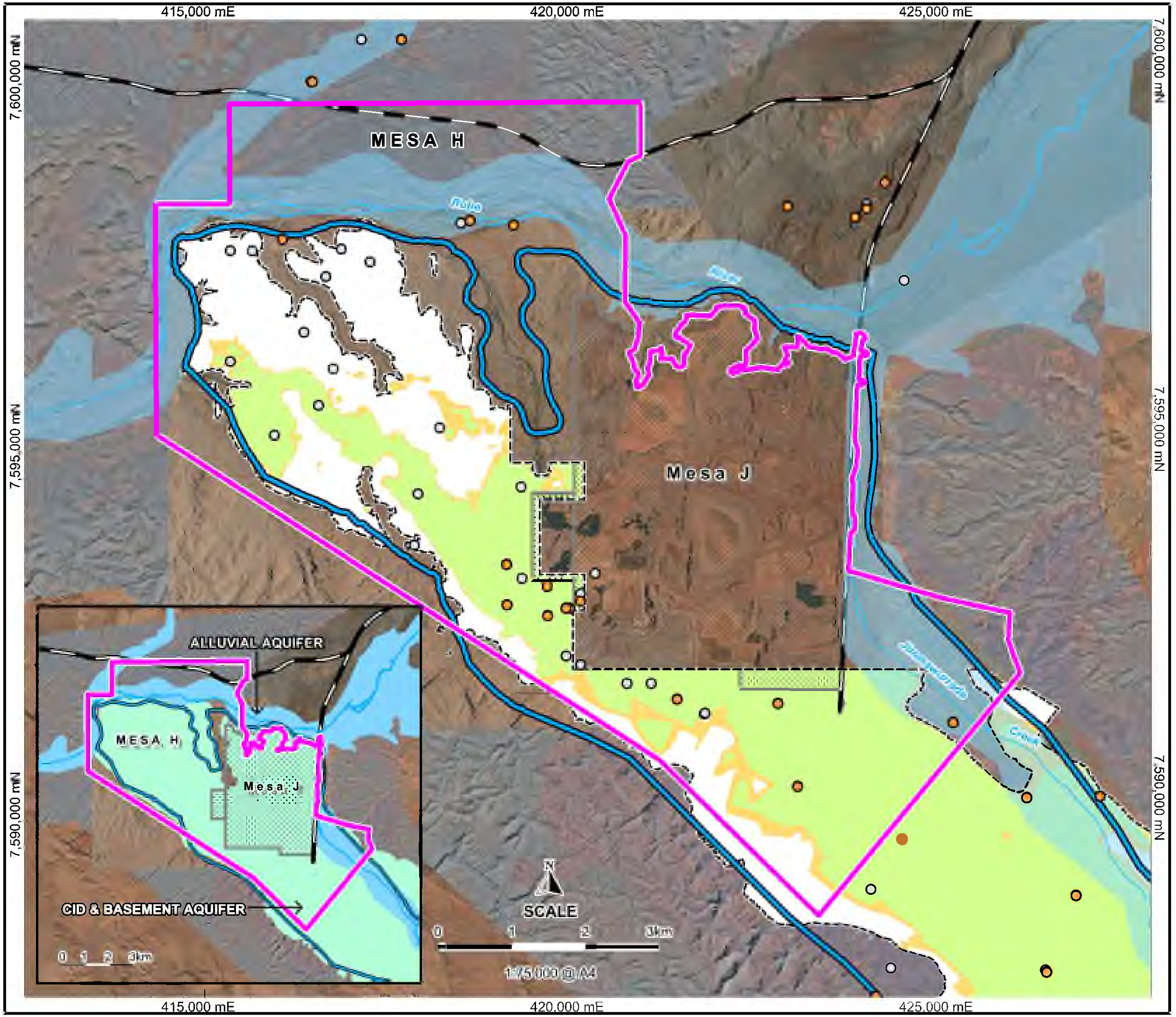
Habitat prospectivity	Geological unit	Description
High	CID (Robe Pisolite)	Pisolitic limonite deposits. Occurs along old river channels. Unit predominantly AWT within Mesa Formations and BWT at Jimmawurrada and Bungaroo Valleys.
	Alluvium[1]	Unconsolidated fluviatile deposits.
	Lacustrine Deposits[1]	Unconsolidated fluviatile and sheet flood deposits in levees and river terraces.
	Colluvium[1]	Partly consolidated valley-fill deposits; Unconsolidated to loosely consolidated slope deposits,
Low	Wittenoom Formation	Confined aquifer underlying the CID aquifer, consisting of weathered dolomite and dolomitic shale and weathered BIF.

[1] Lateral extent defined based on 2D mapping, and 3D depth defined based on available drilling data.

No TECs or Environmentally Sensitive Areas relating to stygofauna occur in the Proposed Change Area or modelled groundwater impact areas, however the Proposed Change Area and modelled groundwater impact area incorporates one PEC in the Southeast of the Proposed Change Area:

- *The Stygofauna community of the Bungaroo Aquifer, Priority 1 PEC.*

Stygofauna habitat prospectivity across the Robe Valley is shown in Figure 7-13 which also shows the location of specimen results and null records relative to the habitat prospectivity mapping.



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Major Watercourse
- Groundwater Drawdown Extent
- Limit of high confidence habitat mapping
- Record of Stygofauna
- Stygofauna Sampling Site

3D Modelled habitat Prospectivity ***(CID)*** *(high confidence)**

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

2D surface geology habitat Prospectivity ***(Alluvials)***

- Habitat Prospectivity: High

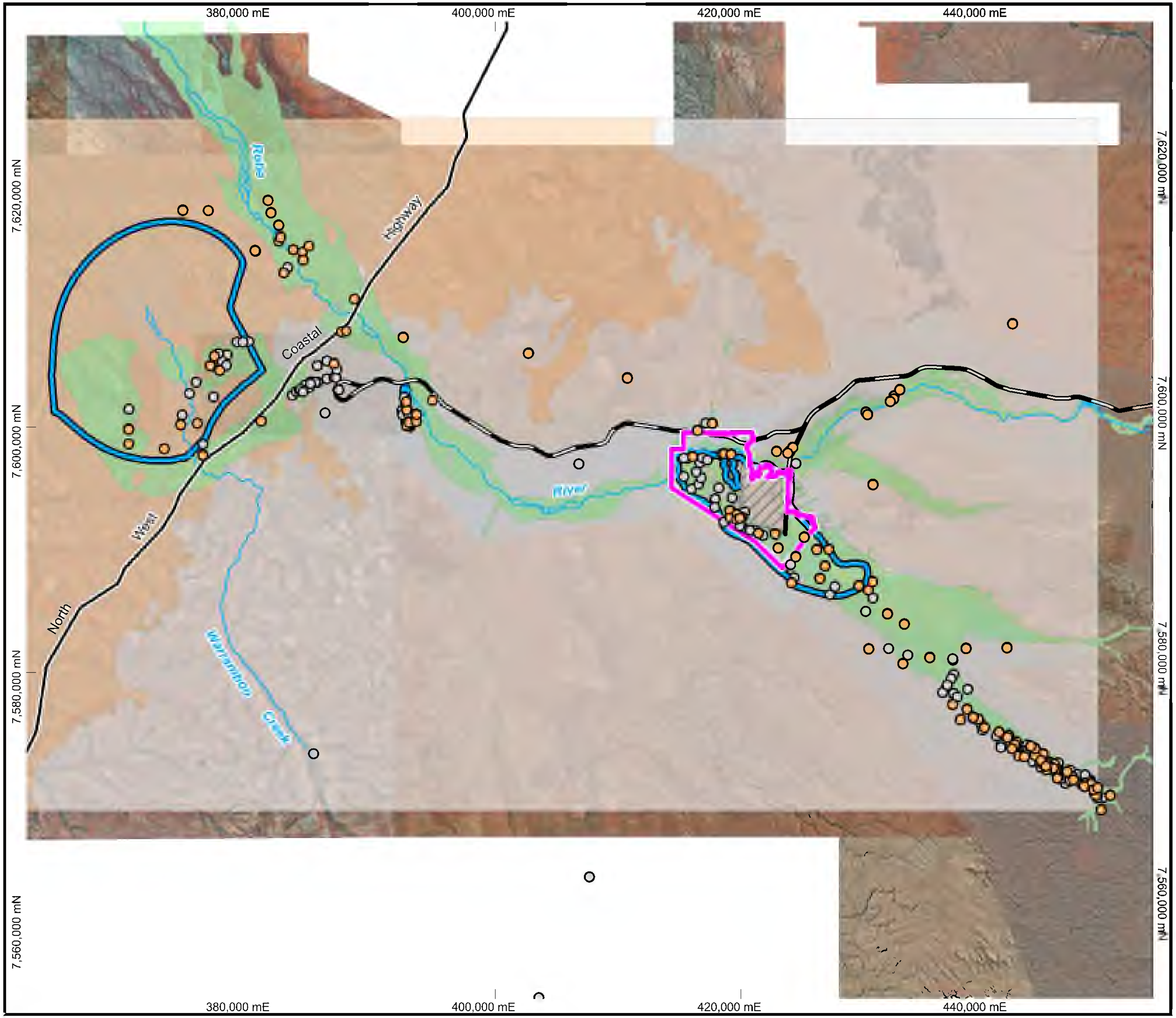
* based on geology and water table levels

RioTinto

Iron Ore (WA)

Figure 7-12: Modelled pre-mining stygofauna habitat Prospectivity and records within or near the Development Envelope

Drawn: GIS
Date: Jan, 2019
Plan No: PDE0161817v4
Proj: MGA94 Zone50



LEGEND

- Development Envelope
- Ministerial Statement 208
- Railway
- Highway
- Major Watercourse
- Stygofauna Record
- Stygofauna Sampling
- Modelled Groundwater Drawdown Extent

Habitat Prospectivity

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

N

SCALE

0 5 10 15 20km

1:450 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-13: Stygofauna sampling, records and modelled stygofauna habitat prospectivity across the Robe Valley

Drawn: T.M.
Date: Jan, 2019
Plan No: PDE0161887v5
Proj: MGA94 Zone50

Geospatial Information and Mapping

7.5.1.3 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 stygobytic taxa have been identified.

A total of 855 stygofauna specimens were recorded over the five-phase stygofauna survey completed for the Proposed Change, comprising at least 326 species-level taxa from in and around the Proposed Change Area, excluding indeterminate specimens (Biota 2019a). The recorded fauna was dominated by the Crustacea, which was represented by seven faunal groups and accounted for 98% of the specimens. Excluding indeterminate records and allowing for species already recorded during the Mesa H survey, an additional 14 species were identified as occurring during the desktop review, bringing the total known fauna to 46 species.

Whilst the BWT mine pits comprise a direct impact, the primary spatial context for the assessment of impacts on stygofauna is the wider groundwater drawdown extent (the lateral extent of the drawdown cone of depression) that will arise from the cumulative groundwater abstraction required to implement the Revised Proposal, including mine pit dewatering and water supply for operational use, and which also takes into consideration the cumulative groundwater drawdown from adjacent projects where they overlap with the drawdown extent of the Proposed Change (refer to Section 5). The predicted extent of groundwater drawdown also encompasses the area that will be directly impacted by the pits themselves. Therefore, all of the stygofauna species and communities that occur within the groundwater drawdown extent i.e. the modelled lateral extent of the groundwater drawdown cone of depression as a result of the Proposed Change are included in this assessment.

Of the known 46 species within the Proposed Change Area, the taxa recorded within the predicted extent of the groundwater impact area includes a total of 31 species, comprising:

- 13 potential SREs (half of which are amphipod taxa);
- Three conservation listed species (Nedsia hurlberti, Nedsia sculptilis and Ophisternon candidum); and
- 15 widespread species.

Conservation Significant Species

Three stygofauna species of conservation significance have been recorded within the Proposed Change Area or within the modelled area of groundwater drawdown from the Proposed Change (Biota 2019b):

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

No additional records of the two conservation significant amphipod species were obtained during the recent surveys however, further sampling targeting this species during the recent surveys (Biota 2019a, WRM 2019 in prep, TrEnD Laboratory 2018) resulted in the detection of Blind Cave Eel DNA at five locations, both along Jimmawurrada Creek and the Robe River, including at two sites within the drawdown extent and three locations outside of the drawdown extent along the Robe River. An additional specimen was also collected during surface water alluvium sampling along the Robe River (WRM 2019 in prep), bringing the number of locations outside of the drawdown extent that physical specimens of the species has been recorded at to five (including Cape Range). The significantly improved distributional data indicate that the species occurs more widely, likely in association with the major alluvial aquifers of the Bungaroo-Jimmawurrada-Robe system.

Blind Cave Eel

The Blind Cave Eel (*Ophisternon candidum*) is a de-pigmented, subterranean fish growing up to 40 cm in length, with a long slender body, no eyes, and a thin rayless membrane around the tip of the tail (DEWHA 2008a) (Section 11.1). The Blind Cave Eel is the world's longest cave fish and one of only three vertebrate animals known from Australia that are restricted to subterranean waters (Humphreys 2001b as cited in Biota 2019a).

The Blind Cave Eel was previously collected from three sites in the Jimmawurrada-Bungaroo Creek system, within the current study area. The first specimen was recorded in 2009 at Bungaroo Creek from borehole BC186, 5.6 km southeast of the Development Envelope (Biota 2010aa), with subsequent specimens from borehole JW023 (1 km southeast of the Development Envelope) (Biota 2016 as cited in Biota 2019a) and from an adjacent borehole JW024 in 2017. Tissue from the Bungaroo specimens has been sequenced at both the CO1 mitochondrial DNA and 16S ribosomal RNA markers, showing that the Bungaroo records are less than 1% divergent from the Cape Range specimens, indicating that they are the same species (Foster and Humphreys 2011 as cited in Biota 2019a).

The species is considered to be associated with the regional alluvial aquifer of the Robe River (Biota and Helix 2014 as cited in Biota 2019a) and the alluvial aquifers of Jimmawurrada and Bungaroo Creeks.

Environmental DNA (eDNA) sampling was undertaken as part of the current study in an attempt to better understand the distribution of the species in the locality.

Environmental DNA Sampling methodology

Environmental DNA sampling of groundwater samples was undertaken on completion of stygofauna haul net sampling during Phase 5 in December 2017. The environmental samples were collected to target the Blind Cave Eel (*Ophisternon candidum*) which is not readily detectable with conventional sampling methods (Biota and Helix 2014 as cited in Biota 2019a).

Environmental DNA sample filters were analysed using two different molecular methods, each of which was undertaken independently by two separate laboratories. The objectives of both methods were to detect residual DNA from the Blind Cave Eel (*Ophisternon candidum*) in the environmental samples.

Helix Molecular Solutions analysed half of the replicate membranes from each sample site using a real-time qPCR method developed previously for the Blind Cave Eel (Biota and Helix 2014 as cited in Biota 2019a). Sequence data from past collections of the Blind Cave Eel from the Jimmawurrada and Bungaroo Creek locality was used to design a species-specific probe using the Integrated DNA Technology design tool PrimerQuest and further edited using Oligo Primer analysis software (Biota 2019a).

The matching halves of the filters from each site were also analysed by TrEnD at Curtin University. The molecular analysis undertaken by Curtin University utilised a Next Generation Sequencing approach to extract and amplify DNA fragments from the membranes and metabarcoding to simultaneously sequence the resultant eDNA (TrEnD 2018; Appendix 10).

The eDNA surveys resulted in the detection of Blind Cave Eel DNA at five locations, both along Jimmawurrada Creek and the Robe River, including at two sites within the drawdown extent and three locations outside of the drawdown extent along the Robe River (including upstream of the Revised Proposal (Figure 7-18). The results from the two eDNA methodologies produced consistent results in terms of both producing positive recordings from the same locations (Biota 2019b).

Summary

All recorded taxa are shown in Figure 7-14 (Maps 1-14) and are listed in Table 7-19. Species 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. As such, the 15 widespread species have been excluded from further assessment in this ERD.

Table 7-19: Stygobitic species recorded from the Proposed Change Area (Biota 2019b, WRM 2018)

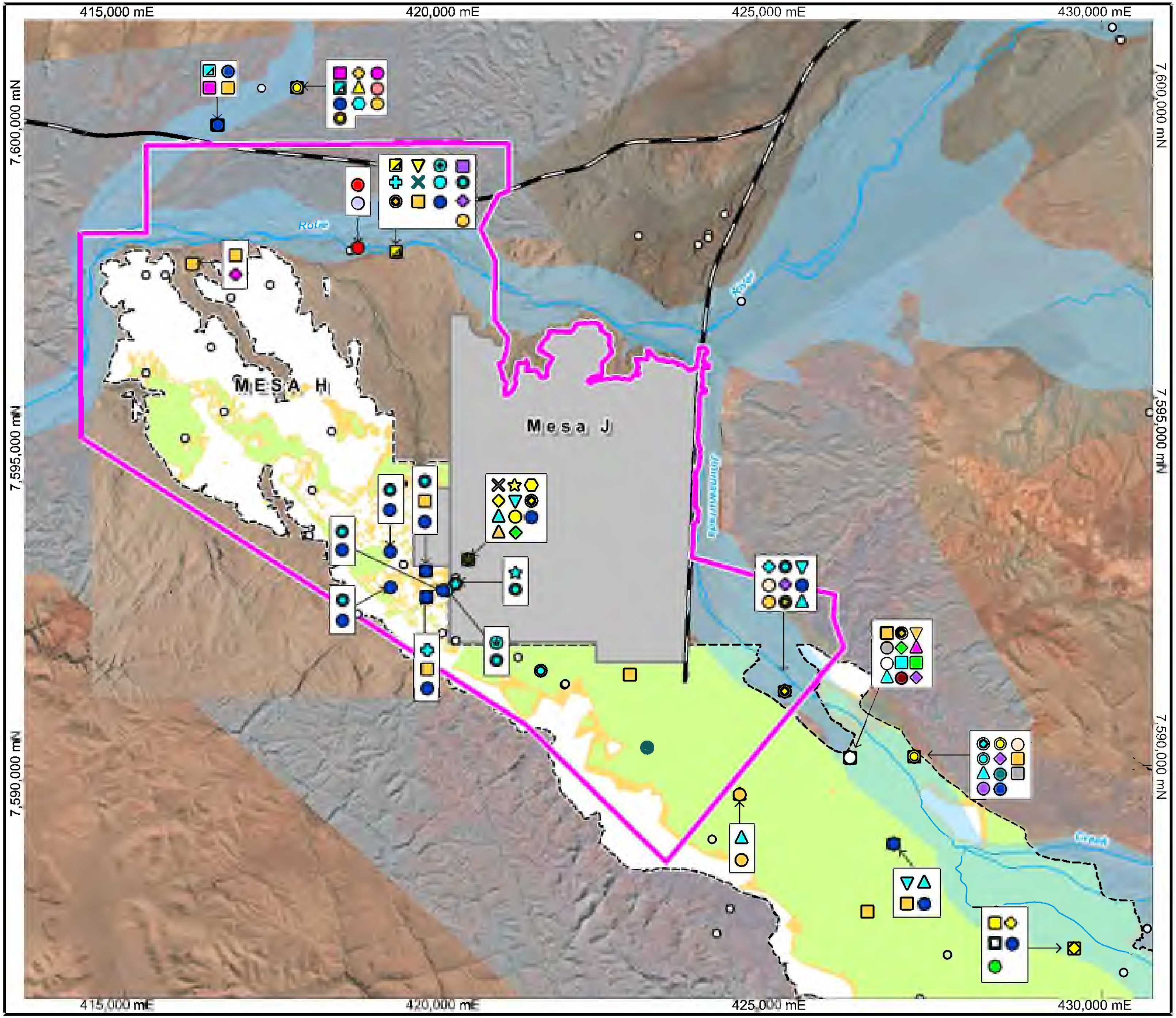
Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
Amphipoda	*Nedsia hurlberti*	Conservation Significant	✓	✓	inside	-	Bungaroo, Robe River near Mesa B, Barrow Island
	Nedsia sp. 'AMM026'	Potential SRE	x	✓	inside	-	Middle Robe
	Nedsia sp. 'AMM001'	Not SRE	✓	✓	inside	RR1	Middle Robe, Warramboo, Budgie Bore, Camp Bore
	Nedsia sp. 'AMM022'	Potential SRE	x	x	outside	-	North of Mesa H (MB17MEH0007)
	Nedsia sp. 'AMM033'	Potential SRE	x	x	outside	-	North of Mesa H (MB17MEH0007, MB17MEH0009, MB17MEH0010)
	Paramelitidae sp. 'AMP003'	Potential SRE	✓	x	inside	-	-
	Paramelitidae sp. 'AMP035'	Potential SRE	✓	x	inside	RR1	-
	Chydaekata sp. 'AMP036'	Potential SRE	✓	x	outside	-	-
	Paramelitidae sp. 'AMP037'	Potential SRE	x	x	inside	-	-
	Paramelitidae sp. 'AMP038'	Potential SRE	✓	**x**	outside	RR1	Middle Robe

Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
	Neoniphargidae sp. 'B02'	Potential SRE	✓	x	inside	-	Middle Robe
	Neoniphargidae sp. 'AMN002'	Potential SRE	✓	x	outside	RR1	-
	Nedsia sculptilis	Conservation Significant	✓	✓	inside	-	Bungaroo, Barrow Island
	Wesniphargus sp. 'AMN004'	Potential SRE	x	x	inside	-	Middle Robe
Harpactacoida	*Megastygonitocrella unispinosa*	Potential SRE	✓	x	Inside	-	Robe River valley
	Parastenocaris sp. 'B28'	Potential SRE	x	x	Inside	-	-
	Abnitocrella halsei	Not SRE	x	x	Outside	-	Widespread
	Elaphoidella humphreysi	Not SRE	x	x	Outside	-	Widespread
Calanoida	*Stygoridgewayia trispinosa*	Not SRE	✓	✓	inside	RR1	Widespread
Cyclopoida	*Diacyclops cocking*	Not SRE	✓	x	Inside	RR1	Widespread
	Diacyclops humphreysi	Not SRE	✓	x	Inside	RR1	Widespread

Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
	Diacyclops sp. 'B03'	Potential SRE	x	x	Outside	-	-
	Halicyclops calm	Not SRE	x	✓	Inside	-	Widespread
	Halicyclops roachi	Not SRE	✓	x	inside	RR1	Widespread
Hypsogastropoda	*Hydrobiidae* sp. 2	Potential SRE	x	x	Inside	-	-
	Hydrobiidae sp. 'B09'	Potential SRE	x	x	Outside	-	North of Mesa H
Isopoda	*Haptolana* sp. 'B01'	Potential SRE	x	x	Inside	-	-
	Haptolana yarraloola	Potential SRE	✓	x	Outside	RR1	Yarraloola, Budgie Bore
	Kagalana tonde	Not SRE	✓	x	inside	RR1	West Pilbara, Hardey River
Podocopida	*Areacandona brookanthana*	Not SRE	x	x	Inside	-	Widespread
	Areacandona lepte	Not SRE	✓	✓	Inside	-	West Pilbara
	Areacandona sp. 'BOS1039'	Potential SRE	x	x	Inside	-	Middle Robe
	Areacandona triangulum	Not SRE	✓	✓	Inside	-	West Pilbara

Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
	Candonidae gen. nov. sp. 'BOS1037'	Potential SRE	x	x	Outside	-	North of Mesa H
	Candonidae sp. 'BOS577'	Potential SRE	x	x	Outside	RR1	-
	Candoninae sp. 'BOS541'	Potential SRE	x	x	Inside	-	-
	Gomphodella sp.	Potential SRE	✓	x	Outside	RR1	-
	Humphreyscandona fovea	Not SRE	✓	✓	Inside	-	Bungaroo, West Pilbara
	Humphreyscandona sp. 2	Not SRE	✓	✓	Inside	-	West Pilbara
	Humphreyscandona waldockae	Not SRE	✓	✓	Inside	-	West Fortescue Valley
	Pierrecandona sp. 'BOS576'	Not SRE	✓	x	Outside	RR1	Warramboo and Bungaroo
	Pilbaracandona rosa	Not SRE	✓	✓	Inside	-	West Pilbara
	Pilbaracandona sp. 'BOS526'	Potential SRE	x	x	Inside	-	Warramboo and Bungaroo
Synbranchiformes	Ophisternon candidum	Conservation Significant	✓	x		RR1,	Control, 25, RRD2, Cape Range, Exmouth

Order	Species	Conservation significant/SRE	Proposed Change Area	Mesa J approved area	GW Drawdown Impact Area	Other known locations (outside impact area but within Proposed Change Area)	Other known locations (outside impact area and outside Proposed Change Area)
Thermosbaenacea	Halosbaena tulki	Not SRE	✓	**x**	Inside	-	West Pilbara, Barrow Island
Oligochaeta	*Enchytraeus* sp. 'AP PSS1'	Not SRE	**x**	**x**	Inside	-	Robe River Valley



LEGEND

- Development Envelope
- Railway
- Major Watercourse
- Ministerial Statement 208
- Limit of high confidence habitat mapping
- Stygofauna Sampling Site

3D Modelled habitat Prospectivity **(CID)** *(high confidence)**

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

2D surface geology habitat Prospectivity

Alluvials

- Habitat Prospectivity: High

* based on geology and water table levels

N

SCALE

0 1 2 3 4km

1:85 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope - overview

Drawn: M.Swebbs
Date: Jan, 2019
Plan No: PDE0159872v5
Proj: MGA94 Zone50

Figure 7-14:
Stygofauna records and Retained habitat in or near the Development Envelope (Legend)

- Stygofauna Legend

Amphipoda

- Chydaekata sp. 'AMP036'
- Nedsia hurlberti
- Nedsia sculptilis
- Nedsia sp. 'AMM001'
- Nedsia sp. 'AMM022'
- Nedsia sp. 'AMM026'
- Nedsia sp. 'AMM033'
- Neoniphargidae sp. 'AMN002'
- Neoniphargidae sp. B02
- Paramelitidae sp. 'AMP003'
- Paramelitidae sp. 'AMP035'
- Paramelitidae sp. 'AMP037'
- Paramelitidae sp. 'AMP038'
- Wesniphargus sp. 'AMN004'

Calanoida

- Stygoridgewayia trispinosa

Cyclopoida

- Diacyclops cockingi
- Diacyclops humphreysi humphreysi
- Diacyclops sp. 'B03'
- Halicyclops calm
- Halicyclops rochai

Harpacticoida

- Abnitocrella halsei
- Elaphoidella humphreysi
- Megastygonitocrella unispinosa
- Parastenocaris sp. B28

Hypsogastropoda

- Hydrobiidae sp. 2
- Hydrobiidae sp. B09

Isopoda

- Haptolana sp. B01
- Haptolana yarraloola
- Kagalana tonde

Oligochaeta

- Enchytraeus sp. 'AP PSS1'

Podocopida

- Areacandona brookanthana
- Areacandona lepte
- Areacandona sp. 'BOS1039'
- Areacandona triangulum
- Candonidae gen. nov. sp. 'BOS1037'
- Candonidae sp. 'BOS577'
- Candoninae sp. BOS541
- Gomphodella sp.
- Humphreyscandona fovea
- Humphreyscandona sp. 2
- Humphreyscandona waldockae
- Pierrecandona sp. 'BOS576'
- Pilbaracandona rosa
- Pilbaracandona sp. 'BOS526'

Synbranchiformes

- Ophisternon candidum (eDNA)
- Ophisternon candidum (specimens)

Thermosbaenacea

- Halosbaena tulki

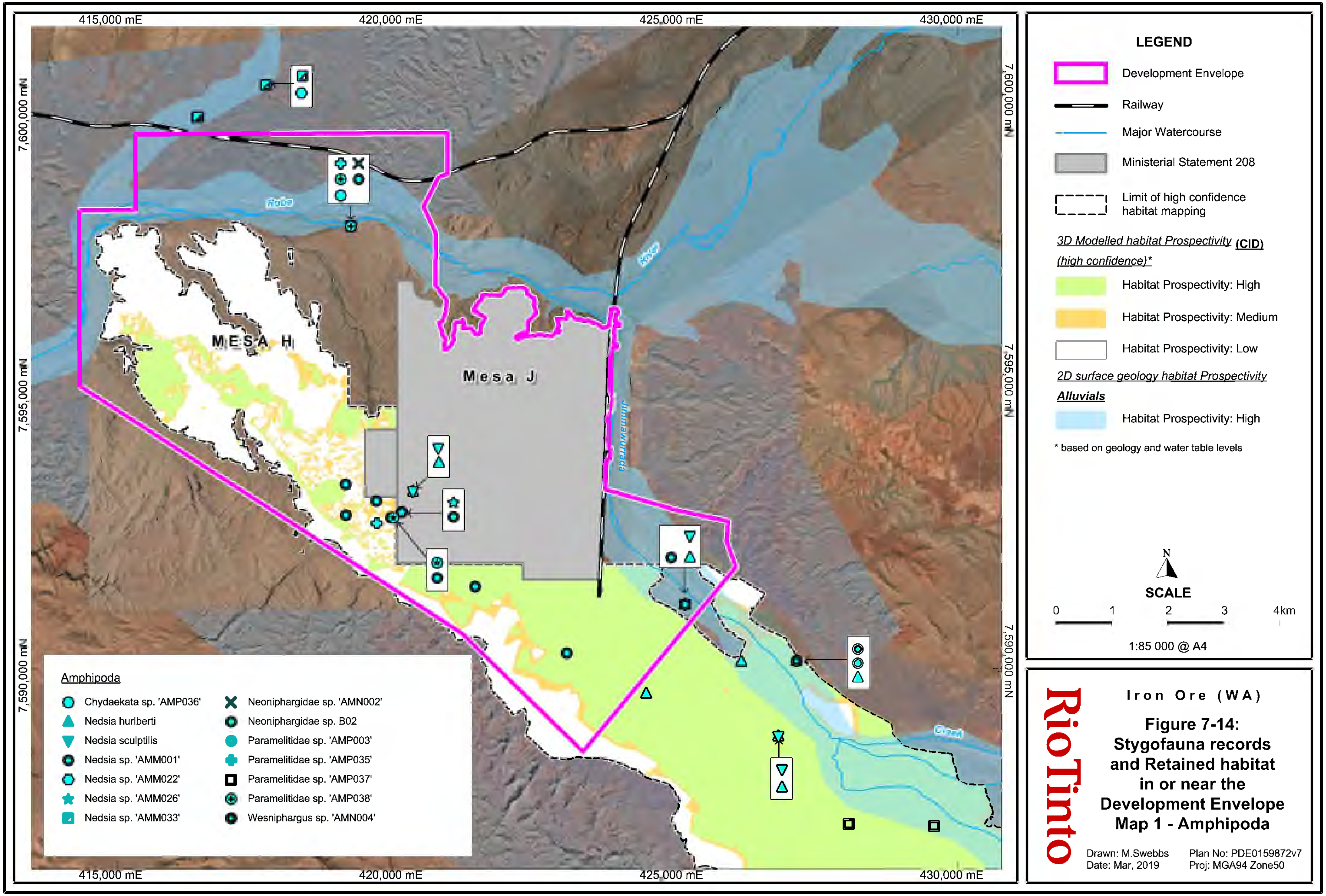
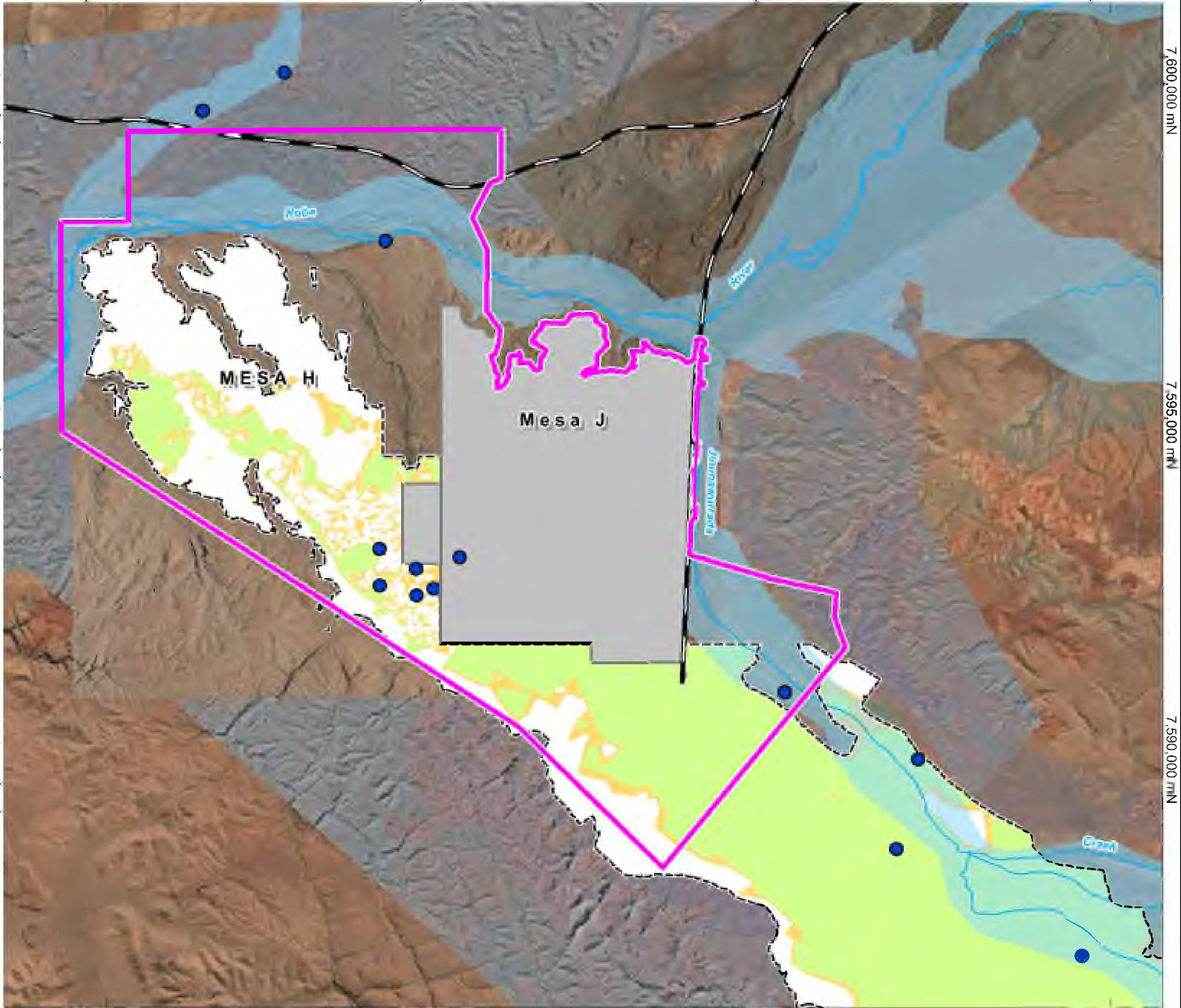


Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 1 - Amphipoda



LEGEND

- Development Envelope
- Railway
- Major Watercourse
- Ministerial Statement 208
- Limit of high confidence habitat mapping

3D Modelled habitat Prospectivity **(CID)**
*(high confidence)**

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

2D surface geology habitat Prospectivity
Alluvials

- Habitat Prospectivity: High

* based on geology and water table levels

Calanoida

- Stygoridgewayia trispinosa

N

SCALE

0 1 2 3 4km

1:85 000 @ A4

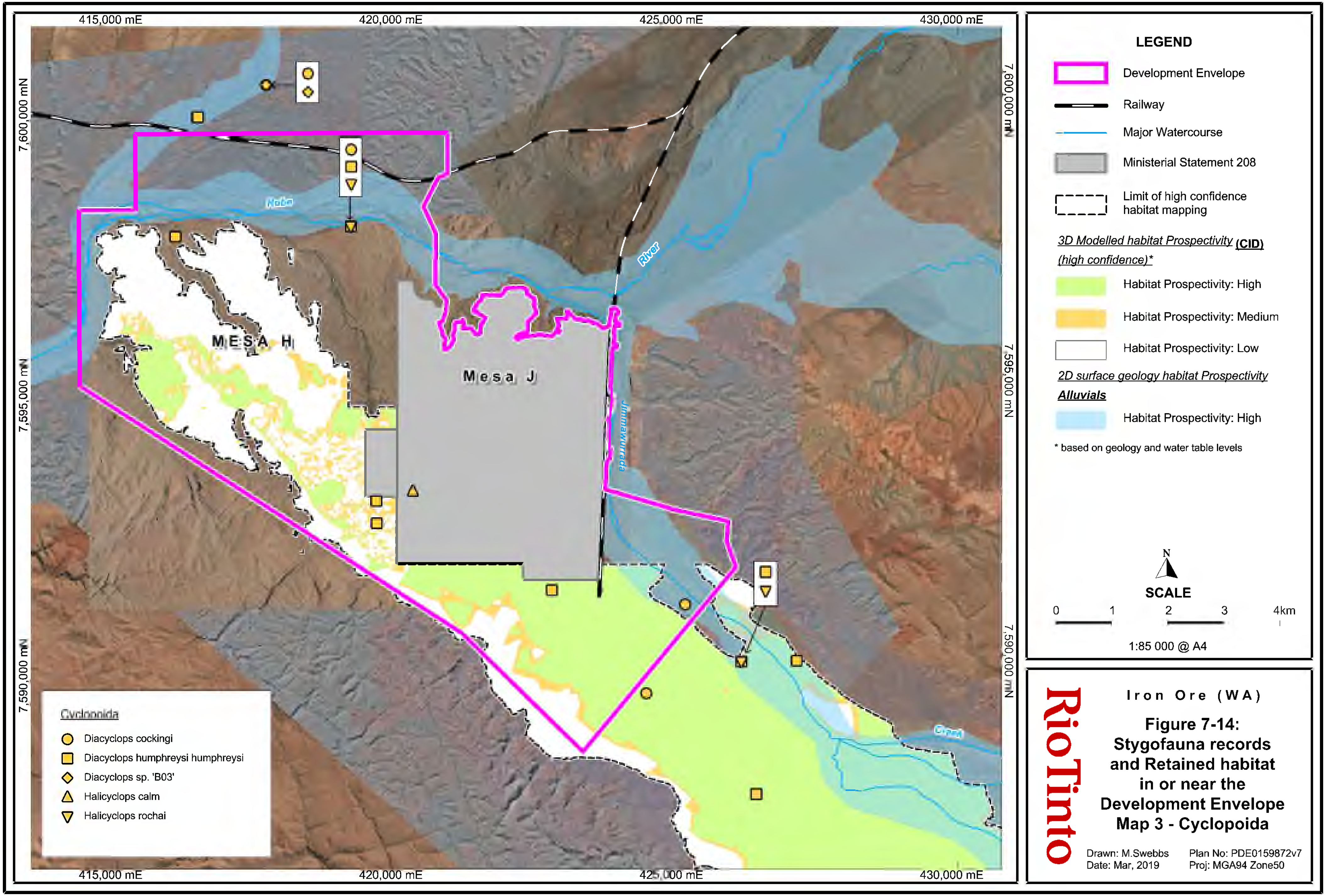
RioTinto

Iron Ore (WA)

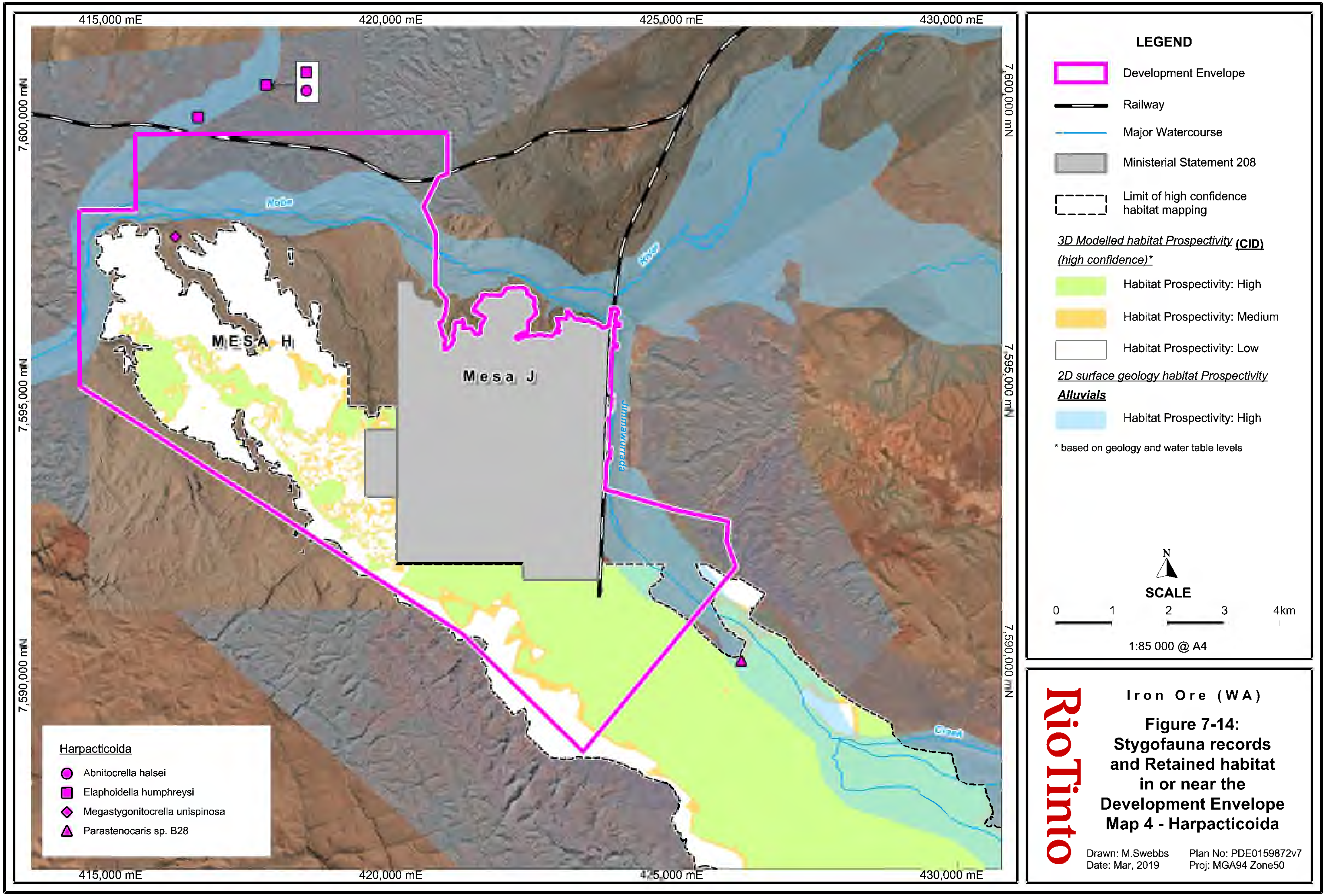
Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 2 - Calanoida

Drawn: M.Swebbs
Date: Mar, 2019

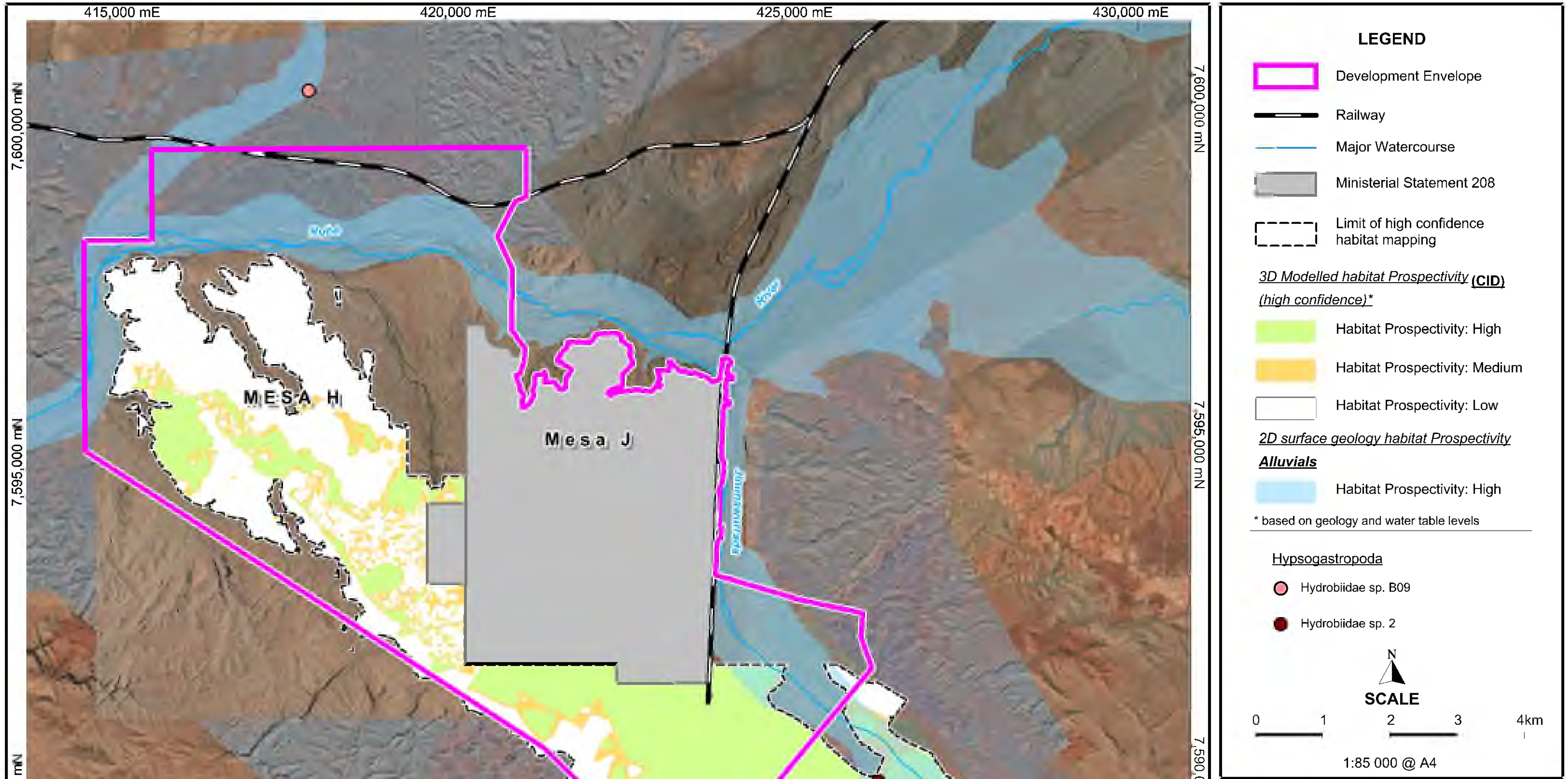
Plan No: PDE0159872v7
Proj: MGA94 Zone50



415,000 mE
420,000 mE
425,000 mE
430,000 mE
7,600,000 mN
7,595,000 mN
7,590,000 mN
MESA H
Mesa J
Robe
River
Jimmawurrada
Creek
Cyclopoida
Diacyclops cockingi
Diacyclops humphreysi humphreysi
Diacyclops sp. 'B03'
Halicyclops calm
Halicyclops rochai
LEGEND
Development Envelope
Railway
Major Watercourse
Ministerial Statement 208
Limit of high confidence habitat mapping
3D Modelled habitat Prospectivity (CID) (high confidence)*
Habitat Prospectivity: High
Habitat Prospectivity: Medium
Habitat Prospectivity: Low
2D surface geology habitat Prospectivity
Alluvials
Habitat Prospectivity: High
* based on geology and water table levels
N
SCALE
0 1 2 3 4km
1:85 000 @ A4
RioTinto
Iron Ore (WA)
Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 3 - Cyclopoida
Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50



415,000 mE
420,000 mE
425,000 mE
430,000 mE
7,600,000 mN
7,595,000 mN
7,590,000 mN
MESA H
Mesa J
Robe
River
Jimmawurrada
Creek
Harpacticoida
Abnitocrella halsei
Elaphoidella humphreysi
Megastygonitocrella unispinosa
Parastenocaris sp. B28
LEGEND
Development Envelope
Railway
Major Watercourse
Ministerial Statement 208
Limit of high confidence habitat mapping
3D Modelled habitat Prospectivity (CID) (high confidence)*
Habitat Prospectivity: High
Habitat Prospectivity: Medium
Habitat Prospectivity: Low
2D surface geology habitat Prospectivity
Alluvials
Habitat Prospectivity: High
* based on geology and water table levels
N
SCALE
0 1 2 3 4km
1:85 000 @ A4
RioTinto
Iron Ore (WA)
Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 4 - Harpacticoida
Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50

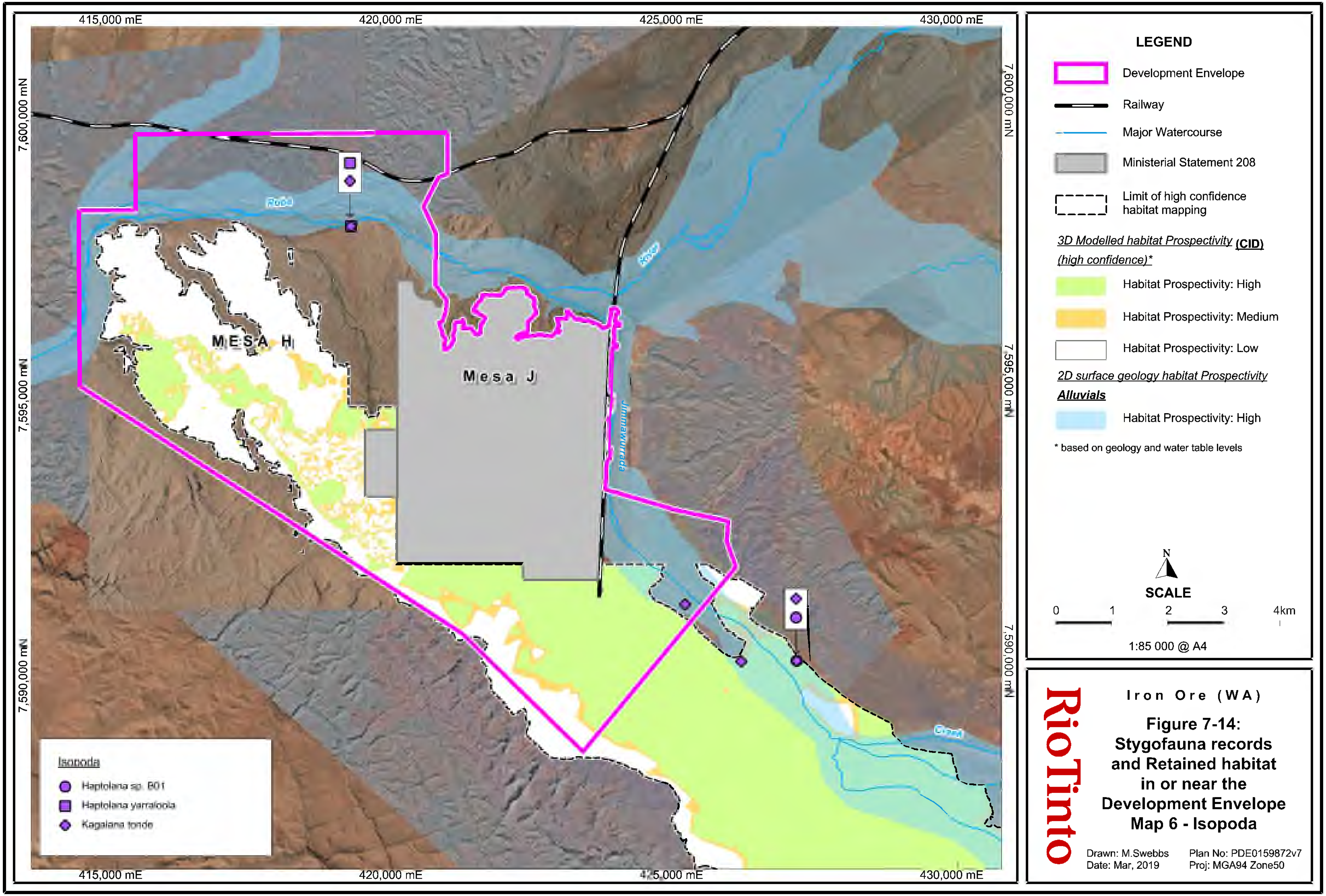


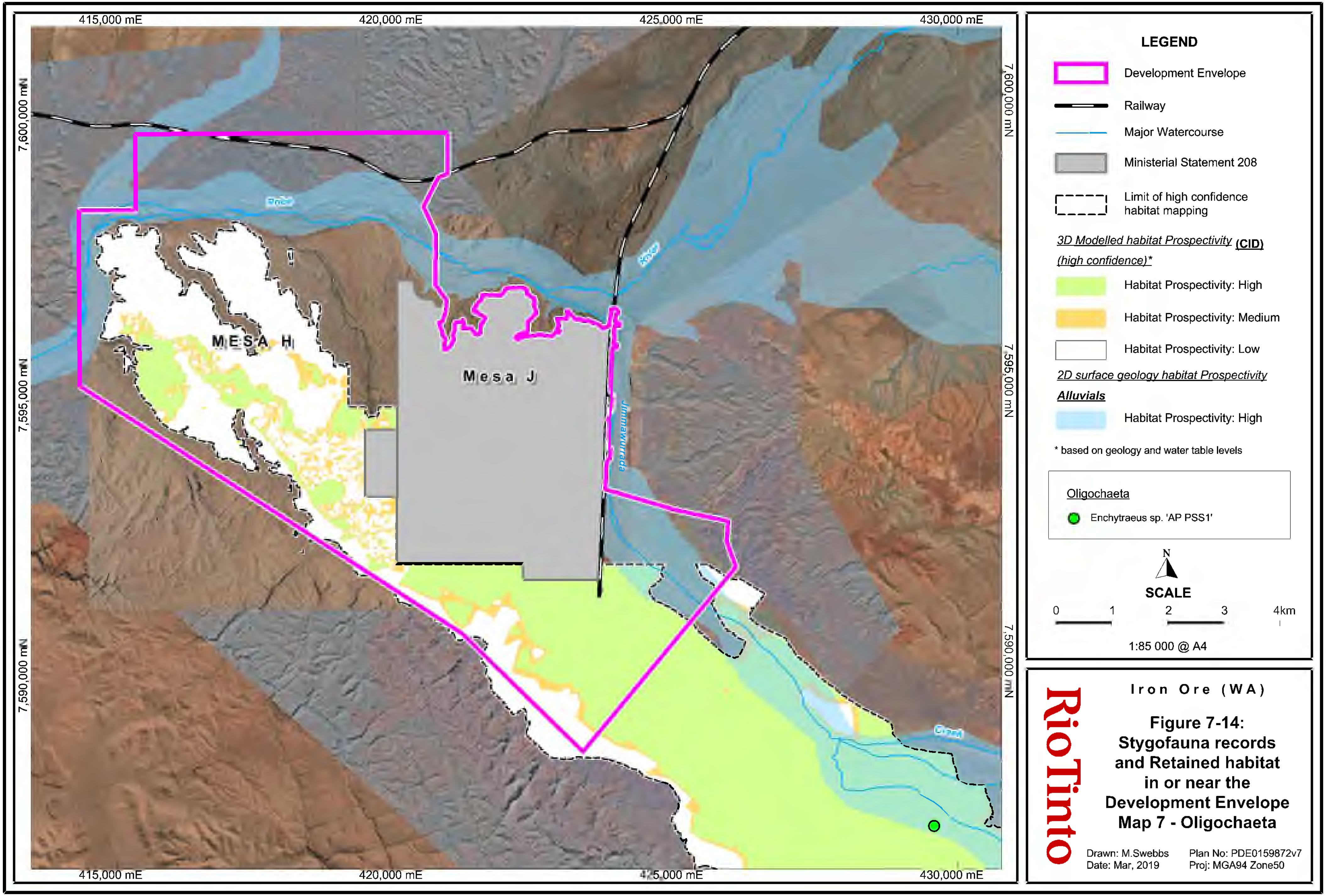
RioTinto

Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 5 - Hypsogastropoda

Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50


415,000 mE
420,000 mE
425,000 mE
430,000 mE
7,600,000 mN
7,595,000 mN
7,590,000 mN
MESA H
Mesa J
Isopoda
Haptolana sp. B01
Haptolana yarraloola
Kagalana tonde
LEGEND
Development Envelope
Railway
Major Watercourse
Ministerial Statement 208
Limit of high confidence habitat mapping
3D Modelled habitat Prospectivity (CID) (high confidence)*
Habitat Prospectivity: High
Habitat Prospectivity: Medium
Habitat Prospectivity: Low
2D surface geology habitat Prospectivity
Alluvials
Habitat Prospectivity: High
* based on geology and water table levels
N
SCALE
0 1 2 3 4km
1:85 000 @ A4
RioTinto
Iron Ore (WA)
Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 6 - Isopoda
Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50



Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 7 - Oligochaeta

Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50

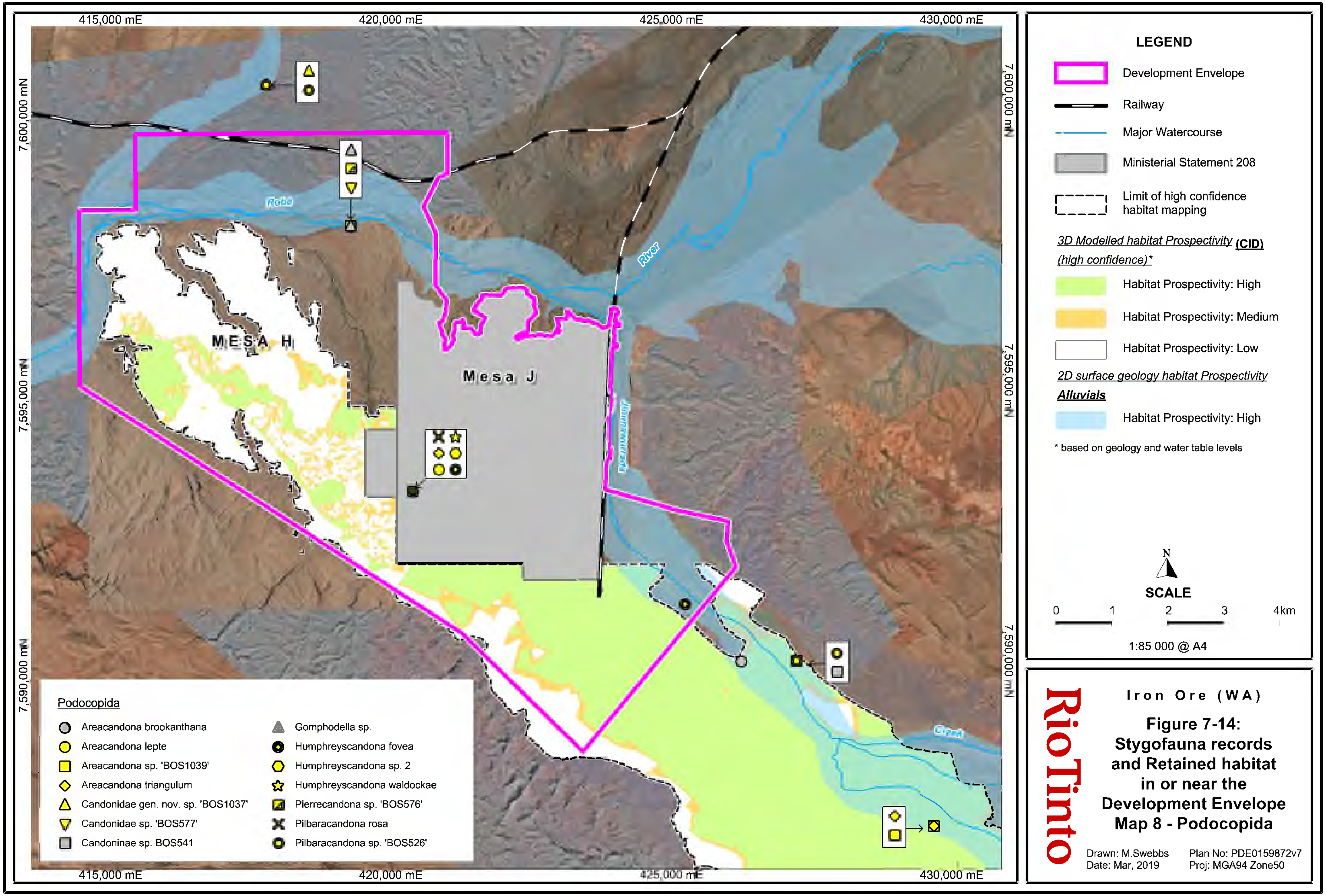
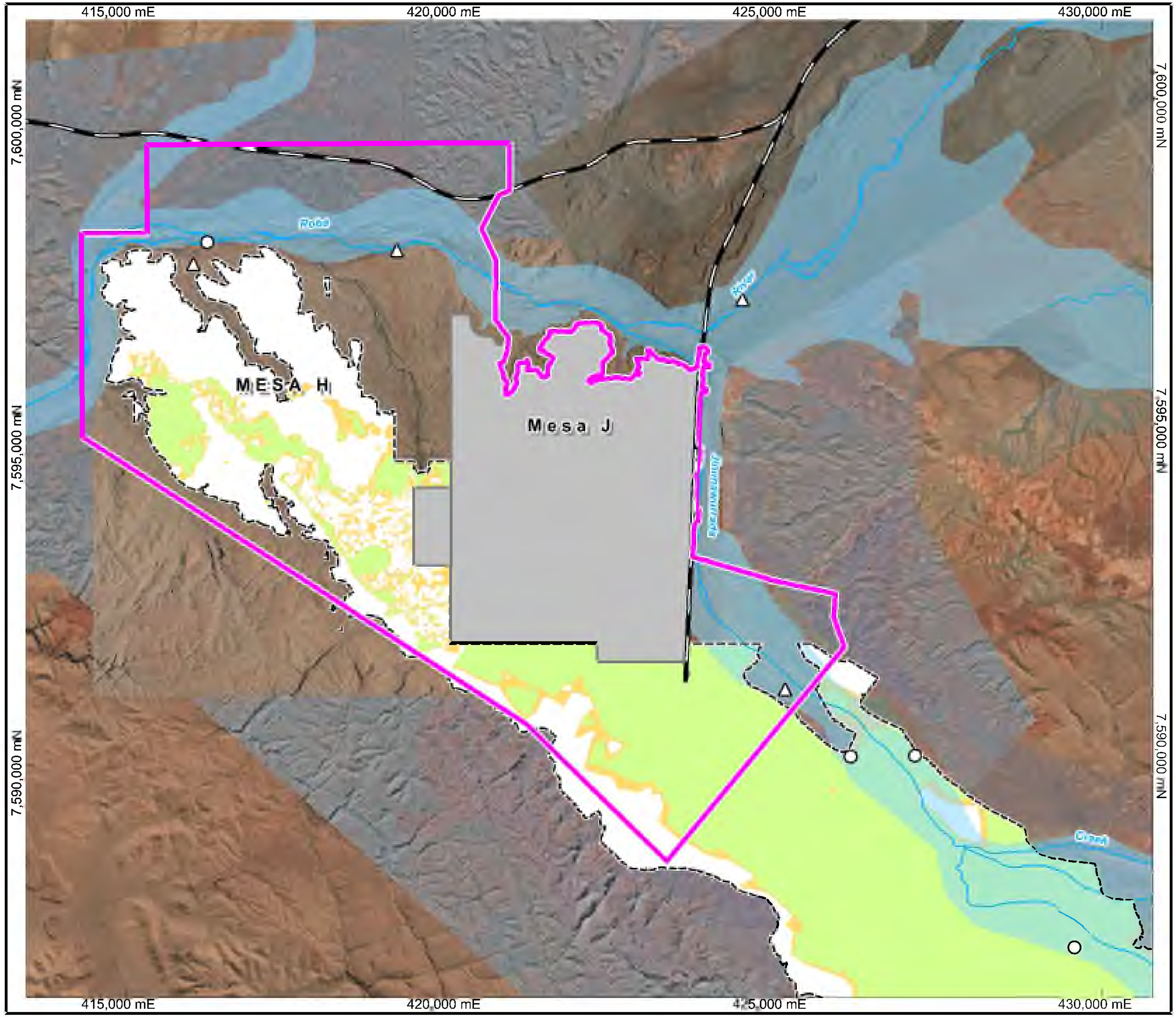


Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 8 - Podocopida



LEGEND

- Development Envelope
- Railway
- Major Watercourse
- Ministerial Statement 208
- Limit of high confidence habitat mapping

3D Modelled habitat Prospectivity **(CID)** *(high confidence)**

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

2D surface geology habitat Prospectivity

Alluvials

- Habitat Prospectivity: High

* based on geology and water table levels

Synbranchiformes

- ○ Ophisternon candidum (specimens)
- △ Ophisternon candidum (eDNA)

N

SCALE

0 1 2 3 4km

1:85 000 @ A4

RioTinto

Iron Ore (WA)

Figure 7-14: Stygofauna records and Retained habitat in or near the Development Envelope Map 9 - Synbranchiformes

Drawn: M.Swebbs
Date: Mar, 2019
Plan No: PDE0159872v7
Proj: MGA94 Zone50