# Subterranean Fauna Monitoring and Management Plan

## Mulga Downs Iron Ore Mine – Western Australia

Hancock Prospecting Pty Ltd
ABN 69 008 676 417

EPBC Assessment Number: 2022/09255
EPA Assessment Number: 2326

**19 December 2024**

## Revision Register

| REV | DATE | DESCRIPTION | PREPARED BY | REVIEWED BY | AUTHORISED BY |
|---|---|---|---|---|---|
| A1 | June 2024 | SFMMP draft to HanRoy | JBS&G | JBS&G | |
| A2 | November 2024 | Update MP for12 Mtpa Proposal.<br>Update to new template | JBS&G | JBS&G | |
| A3 | December 2024 | Fimal Management Plan | HanRoy and JBS&G | D. Tucker | |

# Abbreviations

| Abbreviation | Definition |
|---|---|
| AER | Annual Environmental Report |
| ANZECC | Australian and New Zealand Environment and Conservation Council |
| ARMCANZ | Agriculture and Resource Management Council of Australia and New Zealand |
| BC Act | *Biodiversity Conservation Act 2016* |
| BIF | Banded Iron Formation |
| CEO | The Director General of the Western Australian Department of Water and Environmental Regulation, or his/her delegate |
| CID | Channel Iron Deposit |
| DBCA | Department of Biodiversity, Conservations and Attractions |
| DMIRS | Department of Mines, Industry Regulation and Safety |
| DWER | The Western Australian Department of Water and Environmental Regulation, or any of its successors responsible for the administration of section 48 of the Environmental Protection Act 1986 |
| EMS | Environmental Management System |
| EP Act | *Environmental Protection Act 1986* |
| EPA | Environmental Protection Authority |
| EPBC Act | *Environment Protection and Biodiversity Conservation Act 1999* |
| ET | Evapotranspiration |
| EWB | Ecohydrological Water Balance |
| Fm | Formation |
| FY | Financial Year |
| GL/a | Gigalitres per annum |
| GWMP | Groundwater Management Plan |
| GWOS | Groundwater Operating Strategy |
| ha | Hectare |
| HPPL | Hancock Prospecting Pty Ltd |
| IBRA | Interim Biogeographic Regionalization of Australia |
| km | Kilometre |
| $km^2$ | Square kilometre |
| LOM | Life of Mine |
| L/s | Litre per second |
| m | Metre |
| MAR | Managed Aquifer Recharge via reinjection |
| mbgl | Metres below ground level |
| Mbr | Member |
| MDIOM | Mulga Downs Iron Ore Mine |
| $m^2$/ha | Square metre per hectare |

| Abbreviation | Definition |
|---|---|
| mg/L | Milligrams per litre |
| ML/d | Megalitre per day |
| mm/yr | Millimetres per year |
| MNES | Matters of National Environmental Significance |
| mRL | metres Reduced Level |
| Mtpa | Million tonnes per annum |
| NATA | National Association of Testing Authorities |
| NDVI | Normalised Difference Vegetation Index |
| NDWI | Normalised Difference Wetness Index |
| OSA | Overburden Storage Area |
| PAW | Plant Available Water |
| PEC | Priority Ecological Community |
| SBA | Stand Basal Area |
| SRE | Short-range Endemism |
| SFMMP | Subterranean Fauna Monitoring and Management Plan |
| T/ET | Transpiration to Evapotranspiration Ratio |
| TDS | Total Dissolved Solids |
| TEC | Threatened Ecological Communities |
| TSF | Tailings Storage Facility |
| TSS | Total Suspended Solids |
| WRD | Waste Rock Dump |
| WMP | Water Management Plan |
| µS/cm | Microsiemens per centimetre |

# Executive Summary

This Subterranean Fauna Management and Monitoring Plan (SFFMP) has been prepared to outline Hancock Prospecting Pty Ltd (HPPL) strategy for managing impacts to the subterranean fauna from implementation of the Mulga Downs Iron Ore Mine (MDIOM, the Proposal).

The Proposal is subject to assessment under the Western Australian *Environmental Protection Act 1986* (EP Act) (Assessment Number 2326) and will also be assessed separately under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (EPBC 2022/09255). The Proposal is not being assessed as an accredited assessment.

In accordance with consultation undertaken with the Environmental Protection Authority (EPA), this SFMMP has been developed in accordance with:

- '*Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans'* (EPA, 2020), as stated in the ESD, and addresses any specific additional work required for assessment of the Proposal under the EP Act; and

The purpose of this SFMMP is to outline HPPL's approach to monitoring and managing subterranean fauna at the MDIOM, in response to potential impacts associated with construction and operation of the Proposal. This document has been prepared to support the assessment of the MDIOM under the EP Act and must be considered in conjunction with the provisions of the Water Management Plan (WMP).

**Table ES 1** presents a summary of this SFMMP, including the key environmental factors and outcomes that must be achieved through the implementation of this SFMMP.

Table ES 1: Subterranean Fauna Monitoring and Management Plan Executive Summary

| | |
|---|---|
| **Proposal name** | Mulga Downs Iron Ore Mine |
| **Proponent name** | Hancock Prospecting Pty Ltd |
| **Short Description / Key Elements** | The Proposal is for the development of the MDIOM, located 210 km south of Port Hedland and 180 km northwest of Newman in the Pilbara Region of Western Australia. The Proposal includes but is not limited to the following:<br>• The development of a series of above and below water table mine pits;<br>• Ore processing facility; (Dry)<br>• Groundwater abstraction for water supply (for the mine and all associated infrastructure) and for the dewatering to facilitate the recovery of ore below water table in the mine pits;<br>• Surplus water management with discharge of excess water via managed aquifer recharge (MAR);<br>• Mineral waste management (waste rock dumps (WRD));<br>• Infrastructure to manage surface water (diversion of creeks and surface water flows);<br>• Linear infrastructure (haul roads, powerlines, pipelines and conveyor corridors);<br>• Mine infrastructure and support facilities (including, but not limited to accommodation camp, energy supply infrastructure, airstrip; wastewater treatment plant; landfill, offices, workshops, laydown areas, etc.); and<br>• Transport of ore via the Great Northern Highway to Port Hedland for export. The Great Northern Highway transport option will enable commencement of the Mulga Downs Iron Ore Mine. Future transport options (e.g. rail) will be subject to a separate referral. |
| **Ministerial Statement** | To be determined<br>*Note: This document has been prepared to support the EPA's assessment of the Proposal*. |

| | |
|---|---|
| **Purpose of the EMP** | To outline HPPL's approach to managing the subterranean fauna (stygofauna and troglofauna) in the proposed MDIOM.<br>To provide management actions in minimising the loss of subterranean fauna habitat and the potential impacts to subterranean fauna as a result of pit excavation. pit dewatering and managed aquifer recharge (MAR) to ensure the EPA objectives for this factor are met. |
| **Key Environmental factor/s and objectives relevant to this SFMMP** | **Subterranean Fauna:** To protect subterranean fauna so biological diversity and ecological integrity are maintained. |
| **Main Potential Impacts and Management Strategies** | Main potential impacts to subterranean fauna are changes to groundwater levels and/or quality resulting in the loss / degradation of habitat and changes in community structure/ mortality. The management strategies proposed to control these potential impacts are the monitoring programs implemented to identify exceedances in trigger or threshold criteria which in turn activate required management actions. |
| **Condition clauses (if applicable)** | Not Applicable. The Proposal has been referred to the EPA for assessment, a Ministerial Statement, and associated conditions are yet to be issued. |
| **Key Components in this SFMMP** | • Minimise potential impacts to subterranean fauna habitat associated with groundwater abstraction and MAR including water levels and groundwater quality.<br>• No adverse impact that could result in contamination of groundwater environments due to mining and associated activities.<br>• Undertake appropriate monitoring and report sufficiently to demonstrate compliance with likely approval requirements and enable appropriate and informed management decisions. |
| **Proposed construction date** | Construction of the Proposal is anticipated to commence at the beginning of FY2027 (subject to approvals) and is forecast to take approximately two years. |
| **EMP required pre-construction?** | Yes ☒ No☐ |

# TABLE OF CONTENTS



## TABLES

## FIGURES

# 1 Context, Scope and Rationale

Hancock Prospecting Pty Ltd (HPPL) is proposing to construct and operate the Mulga Downs Iron Ore Mine (MDIOM, the Proposal), located approximately 210 kilometres (km) south of Port Hedland and 180 km north of Newman in the Pilbara Region of Western Australia (**Figure 1-1**).

## 1.1 Proposal

HPPL is the proponent for the Proposal, which encompasses the construction and operation of an iron ore mine, borefield and associated infrastructure. The Proposal involves the above and below water table mining of iron ore from open-cut pits, with a production rate of up to 12 million tonnes per annum (Mtpa) of ore over an expected life of 18 years. Ore will be transported via the Great Northern Highway to Port Hedland, or via road to a siding along Roy Hill railway infrastructure for export. Future transport options (e.g. rail) will be subject to a separate referral. Key characteristics of the Proposal are summarised in Table 1-1.

Table 1-1: Key Proposal Characteristics

| Key Characteristics | Description |
|---|---|
| Clearing | • Up to 4,339.16 ha of native vegetation (Disturbance/Indicative Footprint) within the 16, 848.5 ha Development Envelope/Proposed Action Area. |
| Landforms | • Waste rock dumps (WRD), ore stockpile, topsoil stockpiles and sub-soil stockpiles. |
| Support Facilities | • Small scale power generation, telecommunications tower, power infrastructure, workshops, hydrocarbon storage, explosive missing and storage facilities, laydown areas and offices.<br>• Accommodation camps. |
| Infrastructure | • Dry ore crushing, screening plant and truck loading<br>• Linear infrastructure including heavy and light vehicle access roads, conveyors, pipelines and power and communications distribution<br>• Diversion drains, levees and culverts for surface water management<br>• Groundwater abstraction (including dewatering) and associated management infrastructure<br>• Surplus water management with discharge of excess water via managed aquifer recharge (MAR) and/or in-pit infiltration |
| Mining | • Open cut<br>• The development of a series of above and below water table mine pits<br>• Above and below water table mining<br>• Transport of ore via the Great Northern Highway to Port Hedland for export. The Great Northern Highway transport option will enable commencement of the Mulga Downs Iron Ore Mine. Future transport options (e.g. rail) will be subject to a separate referral. |

The location of the proposed pits for the Proposal are shown in Figure 1-2. It comprises seven mining domains (from west to east): Murray's Hill, Anticline Hill, Fridge West, Fridge Central, Fridge Hill, Horseshoe West and Horseshoe Hill. Approximately 20 of the pits are proposed to extend (to varying depths) below the groundwater level and will therefore require dewatering. The lowest estimated pit elevation is 388 mRL (i.e. ~12 to 16 m below the groundwater level) (AQ2 2024d).

The preferred approach to dewatering is via ex-pit dewatering bores with in-pit bores only used where additional abstraction is required to achieve required drawdown levels. In-pit sumps may be used towards the end of mining a pit to access the deepest part of the pit (AQ2 2024d).

Where dewatering exceeds water demands, excess water will be disposed of by Managed Aquifer Recharge via (MAR). MAR is proposed on the slopes of the valley (i.e., in, and along strike of, the proposed mining areas). Initially, MAR is proposed via reinjection bores, with the potential for using repurposed dewatering bores and / or in-pit infiltration, once mining of a pit is complete (AQ2 2024d).

### 1.1.1 Proposal Groundwater Elements

The preferred approach to dewatering is via ex-pit dewatering bores with in-pit bores only used where additional abstraction is required to achieve required drawdown levels. In-pit sumps may be used towards the end of mining a pit to access the deepest part of the pit.

Operational elements of the MDIOM as they relate to ground water include:

- Peak estimated mine pit dewatering volume of 12 Gigalitres per annum (GL/a);
- Peak estimated excess water disposal by aquifer reinjection of 11 GL/a; and
- Peak estimated excess water usage for operational requirements of 1,750 kL/day – 2,250 kL/day.

It is intended that construction water will be sourced from the mining area and, as such will either provide advance dewatering and / or increased aquifer capacity for the disposal of excess water, dependent on the source area. Throughout the mining period water demands will be preferentially met by dewatering volumes and, if required, water treatment will ensure that the water quality criteria are met.

At this stage of the Proposal, the proposed Western and Eastern dewatering borefields and reinjection borefields contain groundwater monitoring bores and test production bores and are without the infrastructure for abstraction or reinjection. Dependent on the optimised dewatering and reinjection layout, these existing sites may be incorporated into the final water management and monitoring scheme. Construction of abstraction and reinjection bores are pending this Ministerial approval and will be staged across the Proposal Life of Mine (LOM).

### 1.1.2 Proposal Subterranean Fauna Elements

A diverse subterranean fauna community exists within the Proposal and in the surrounding area with a number of taxa displaying high level of localised endemism. Habitat which supports stygofauna and troglofauna was assessed and defined.

The Proposal elements of the MDIOM which will impact subterranean fauna include:

- Direct loss of habitat from excavation of a series of open cut mine pits, which extend below the water table;
- Loss of habitat from excavation of pits below the water table or changes in groundwater levels (≥ 1 m);
- Loss of habitat from MAR via reinjection and / or pit infiltration of surplus abstracted groundwater into selected aquifers changes in groundwater levels (≥ 2 m); and
- Reduction in quality of habitat due to salinity changes; and
- Reduction in quality of habitat due to change to groundwater quality from mining (i.e. leachate).

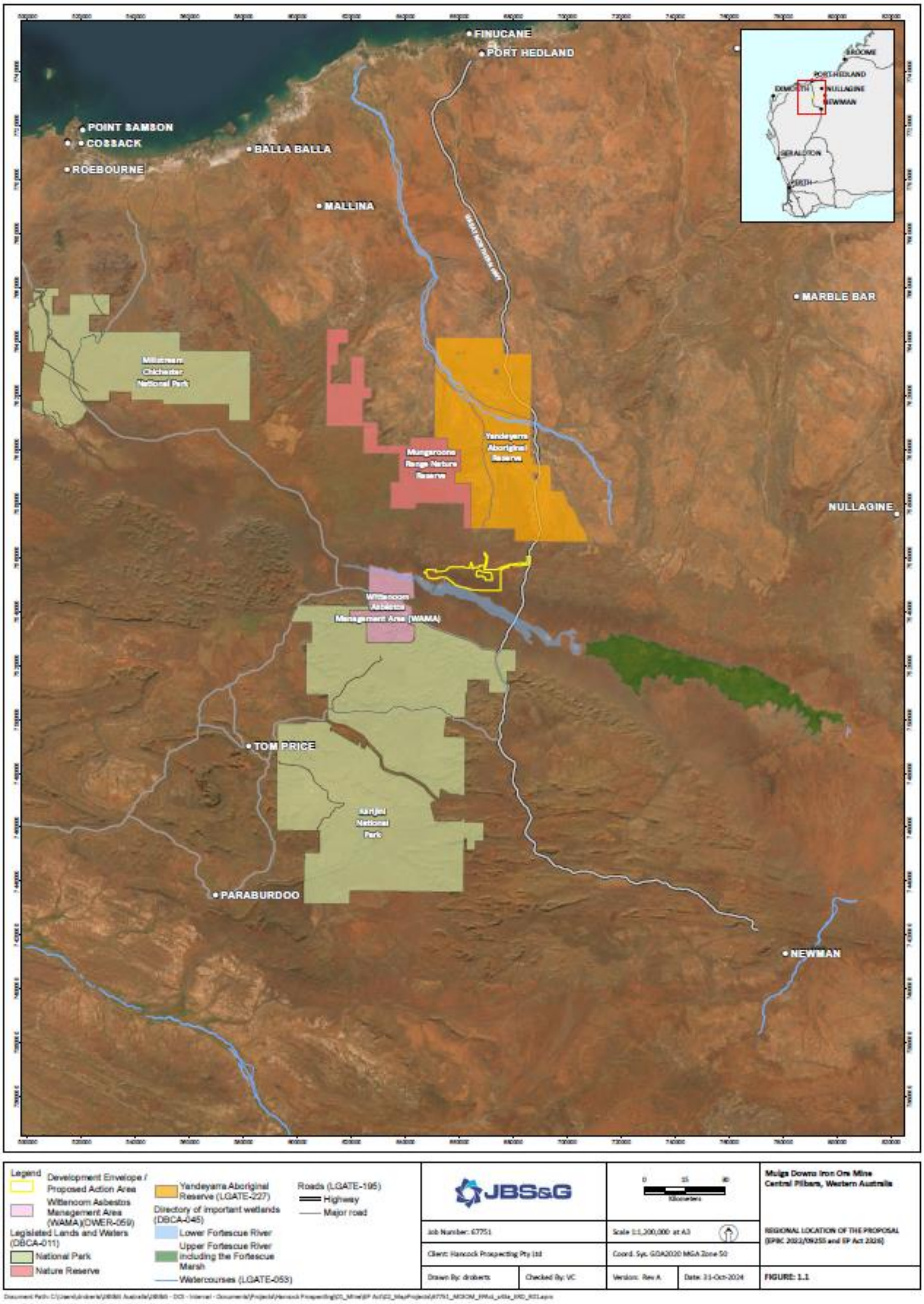



Figure 1-1: Regional location of the Development Envelope (Assessment No 2326)

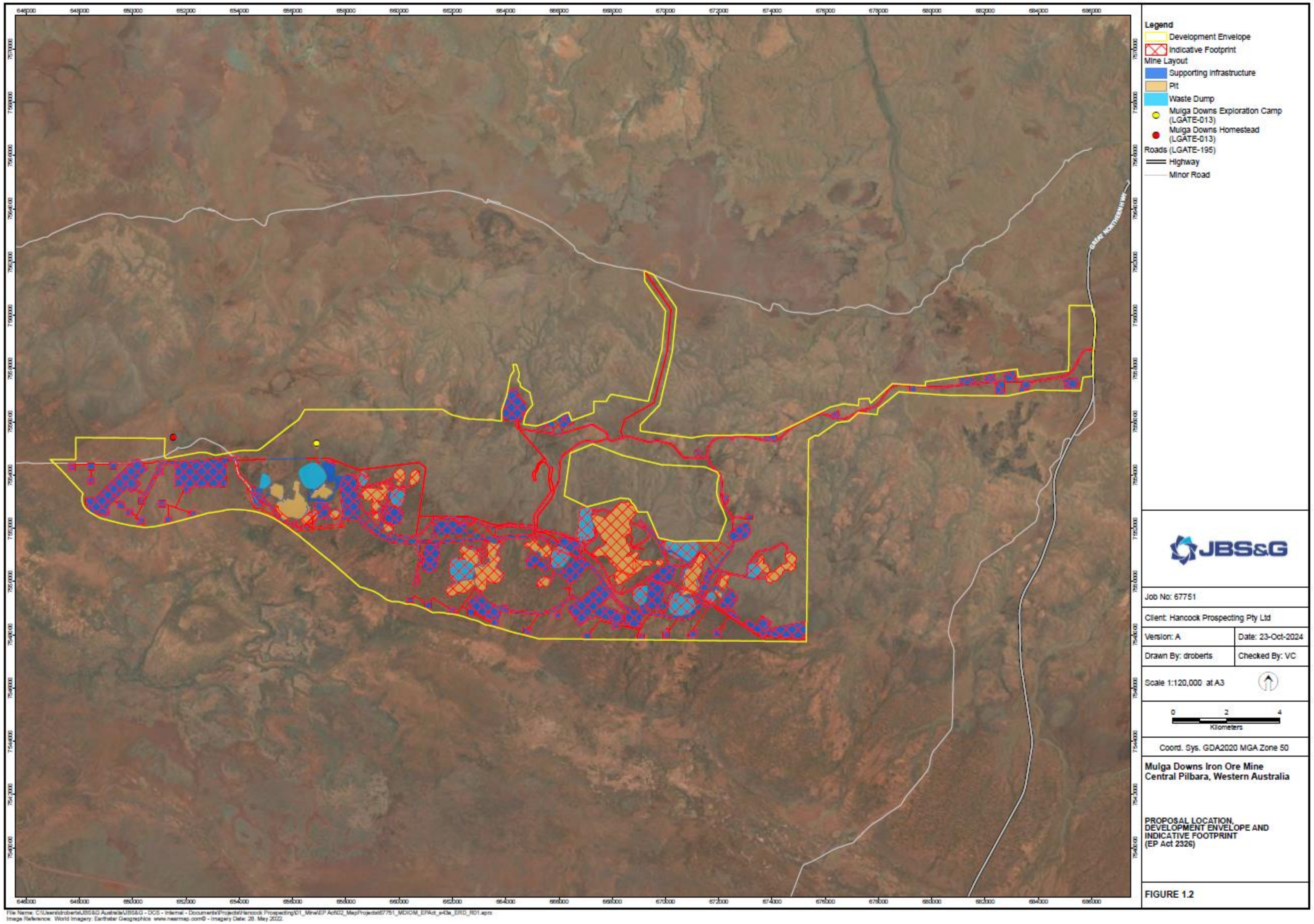



Figure 1-2: State Proposal (Assessment No. 2326)– showing Development Envelope and Indicative Footprint

## 1.2 Key Environmental Factors

This SFMMP has been developed to address potential impacts to EPA's key environmental factors and potential impacts on MNES resulting from alterations to naturally occurring surface water and groundwater environments associated with the development of the Proposal. The key environmental factors and MNES objectives are outlined in **Table 1-2**. **Table 1-3** outlines the Proposal activities and potential impacts to site specific environmental values.

Table 1-2: Key Environmental Factors

| Key Environmental Factor / MNES | Objective |
|---|---|
| **EPA Environmental Factors** | |
| **Subterranean Fauna** | To protect subterranean fauna so biological diversity and ecological integrity are maintained |

Table 1-3: Proposal Activities and Impacts to Environmental Factors and MNES

<table>
<tr><th>Key Environmental Factor / MNES</th><th>Site Specific Value</th><th>Potential Impact</th><th>Potential Impacts of Proposal Activities</th></tr>
<tr><td rowspan="3">Subterranean Fauna</td><td rowspan="2">• Stygofauna species</td><td>Loss of stygofauna habitat</td><td>• Reduction in groundwater levels from abstraction and mine pit dewatering reducing available habitat</td></tr>
<tr><td>Mortality of stygofauna species</td><td>• Changes in the groundwater quality of the aquifer from mine pit dewatering i.e., increasing salinity over time as dewatering drawdown extends beneath the claypans.<br>• Changes in the groundwater quality of the aquifer from reinjection i.e., the introduction of variably brackish groundwater into fresher areas of the aquifer.<br>• Leaching contaminants from WRDs.</td></tr>
<tr><td>• Troglofauna species</td><td>Loss of troglofauna habitat and mortality of troglofauna species</td><td>• Mounding of groundwater from reinjection of excess water.<br>• Loss of habitat from mining.<br>• Groundwater abstraction and mine pit dewatering modifying habitat conditions (reducing humidity).</td></tr>
</table>

## 1.3 Condition Requirements

The Proposal was referred to the EPA under Part IV of the EP Act (Assessment No: 2326) and is currently under assessment. The Commonwealth is currently assessing the Proposal via a Public Environmental Report (PER) under Assessment Number: EPBC 2022/09255. The Proposal is not being assessed as an accredited assessment. It is noted the Murray's Hill Project (Murray's Hill) is included as part of the EPBC Act referral, but it is not part of the EP Act referral, hence the different Disturbance Footprint and Indicative Footprint. Murray's Hill is included for the purpose of this WMP.

This SFMMP will be updated pending State conditions placed on the Proposal, and these conditions will be linked to the Environmental Management Provisions outlined in **Section 2.**

## 1.4 Rationale and Approach

This SFMMP includes both outcome-based and objective-based actions. Outcome-based provisions have been developed where the level of impact is known and quantifiable, with the establishment of trigger and threshold criteria and appropriate exceedance responses. Trigger criteria have been set at a conservative level to ensure response actions are implemented in advance of the environmental objective being compromised.

Outcome-based provisions are performance-based and may be used where the part of the environment is capable of objective measurement and reporting.

This SFMMP proposes objective-based management actions for aspects in which the level of impact is unknown or unable to be quantified. Objective-based management is used where specific trigger or threshold criteria may not be appropriate for the circumstances. This includes where insufficient information is known about the environmental system or where all or part of the environment is not capable of being measured against trigger or threshold criteria. Objective-based management actions have been developed using a risk-based approach to manage and mitigate impacts to the receiving environment.

Survey and study findings, risk assessments, and assessment of assumptions and uncertainties have contributed to the establishment of the SFMMP. Where required, the SFMMP includes details for future surveys and studies in relation to subterranean fauna at the project.

### 1.4.1 Survey and Study Findings

The studies and surveys outlined in **Table 1-4** have been performed to inform assessment of the groundwater, ecohydrology, and subterranean fauna for the Proposal. Full details of the outcomes from all baseline studies is provided in the State ERD. A summary of the key environmental aspects relevant to this SFMMP are provided below.

Table 1-4: Summary and Surveys and Studies

| Report Year | Author | Survey / Study Name | Reference |
|---|---|---|---|
| **Subterranean Fauna** | | | |
| 2024 | Bennelongia | Mulga Downs Subterranean Fauna Survey | BEC, 2024a |
| 2024 | Bennelongia | Stygofauna salinity tolerances | BEC, 2024b |
| 2024 | AQ2 | Mulga Downs Iron Ore Mine –Troglofauna Habitat Assessment | AQ2, 2024a |
| 2024 | AQ2 | Mulga Downs Iron Ore Mine – Stygofauna Habitat Assessment | AQ2, 2024b |
| **Groundwater and Ecohydrology** | | | |
| 2024 | GWC | Mulga Downs Groundwater Modelling | GWC, 2024 |
| 2024 | AQ2 | Mulga Downs Groundwater, Surface Water & Ecohydrological Studies Baseline Assessment | AQ2, 2024c |
| 2024 | AQ2 | Mulga Downs Groundwater, Surface Water and Ecohydrological Impact Assessment | AQ2, 2024d |
| 2024 | CBEC | Mulga Downs Provisional Water Quality Trigger Values | CBEC, 2024 |

#### 1.4.1.1 Subterranean Fauna Habitat Characterisation

The presence of subterranean fauna is strongly linked to the underlying geology and hydrology. Subterranean ecosystems are thought to have reduced habitat diversity compared to terrestrial ecosystems, primarily due to the absence of vegetation, however geology and hydrology drive habitat heterogeneity (Gilbert et al, 1994). Generally, more groundwater transmissive geologies tend to support more substantial assemblages of subterranean fauna, both in terms of abundance and diversity.

A troglofauna and stygofauna habitat assessment model was developed by AQ2 using the Leapfrog Geo (3D) modelling software (Seequent 2022) (AQ2 2024c, d; Appendix 1). A summary of the habitats defined by AQ2 is present in Table 1-5.

Table 1-5 Troglofauna and Stygofauna Habitats

| Habitat Stratigraphy | Lithology / Member | Stratigraphy | Habitat Probability | | Reasoning |
|---|---|---|---|---|---|
| | | | Stygofauna | Troglofauna | |
| **Alluvium** | Alluvium | Recent Alluvium / Colluvium | Unlikely | Unlikely | This unit typically has a clay dominant matrix with low potential for porosity. Where drill data is available it predominantly occurs above the water table |
| **Upper Calcrete** | Upper Calcrete | Tertiary Detritals | **Likely** | **Likely** | This unit typically has a high primary porosity. |
| **Undifferentiated Sediments** | Undifferentiated Sediments | | Possible | Possible | Areas of lower clay content have the potential for high porosity. |
| **CID / Pisolite** | CID / Pisolites | | **Likely** | **Likely** | CID unit is often vuggy, while pisolitic units typically have high primary porosity. |
| **Basal Crete** | Basal Crete (Calcrete / Silcrete) | | Possible | None | Unit always encountered below water table within project area. |
| **Jeerinah** | Jeerinah Shale | Jeerinah Formation | None | None | Unit is dominated by shales with a low primary porosity. |
| **Mineralised Marra Mamba** | Mineralised / Hydrated BIF | Marra Mamba Formation | **Likely** | **Likely** | Units likely to have enhanced secondary porosity due to weathering/mineralisation processes. |
| **Shaley / Unmineralised Marra Mamba** | Undifferentiated | Marra Mamba Formation | Unlikely | Unlikely | Vugs/voids possible down to base of oxidation but unlikely due to shale content and more localised zones enhanced porosity. |
| | Nammuldi Member | | | | |
| | MacLeod Member | | | | |
| | Mt Newman Member | | | | |
| **West Angela Member** | West Angela Member | Wittenoom Formation | Unlikely | Unlikely | Vugs/voids possible down to base of oxidation. |
| - | Paraburdoo Member | | None | None | Units dominated by dolomite and dolomitic shales- low porosity even after weathering. Unit is not impacted by drawdown. |
| - | Bee Gorge Member | | | | |

Figure 1-3 shows the extent of the potential impact from mining and groundwater mounding from MAR (AQ2, 2024b) to troglofaunal habitat and the lines for each habitat cross section. Figure 1-3 shows the extent of the potential impact from mining and groundwater drawdown from pit dewatering (AQ2, 2024b) to stygofauna habitat and the lines for each habitat cross section.

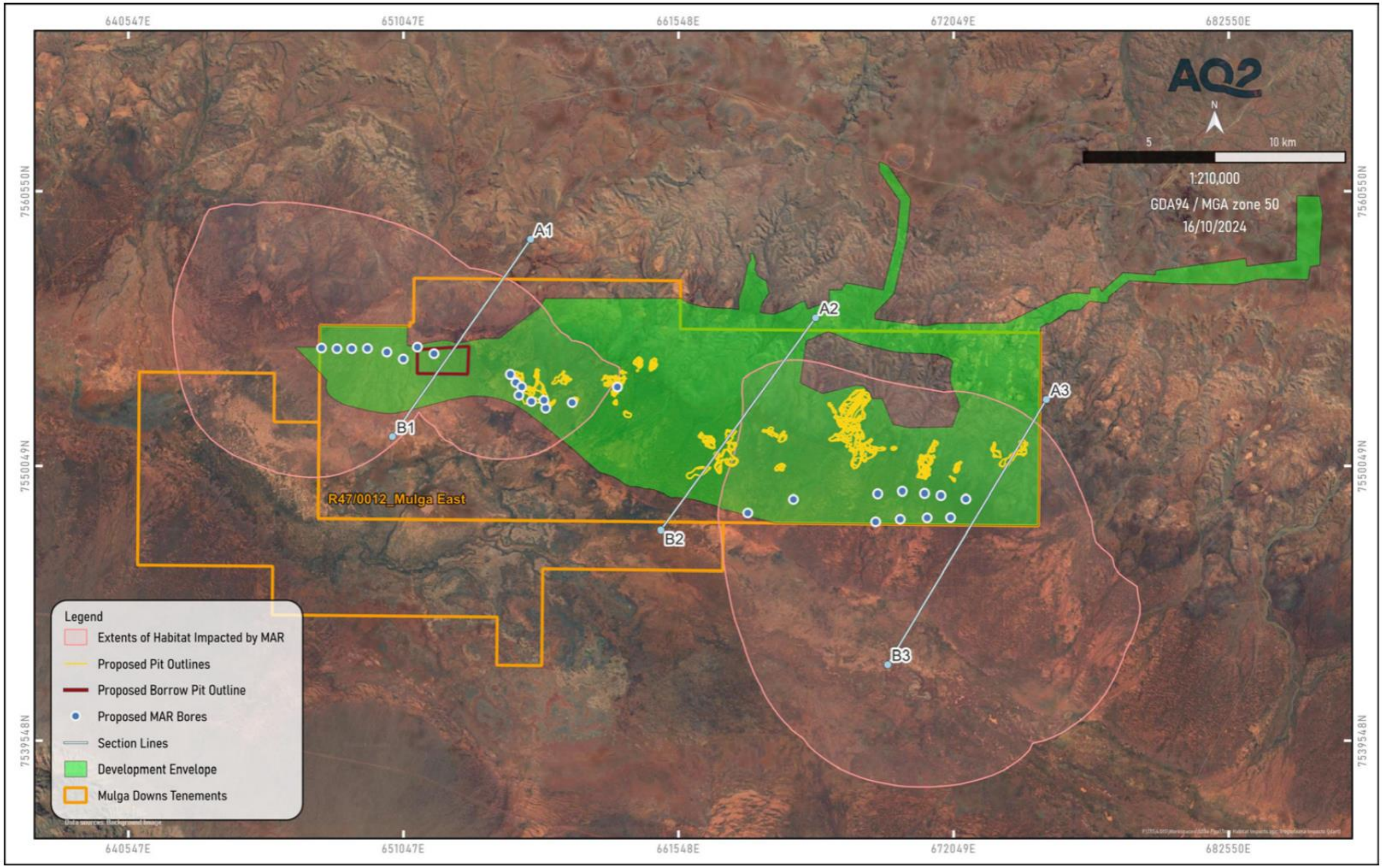
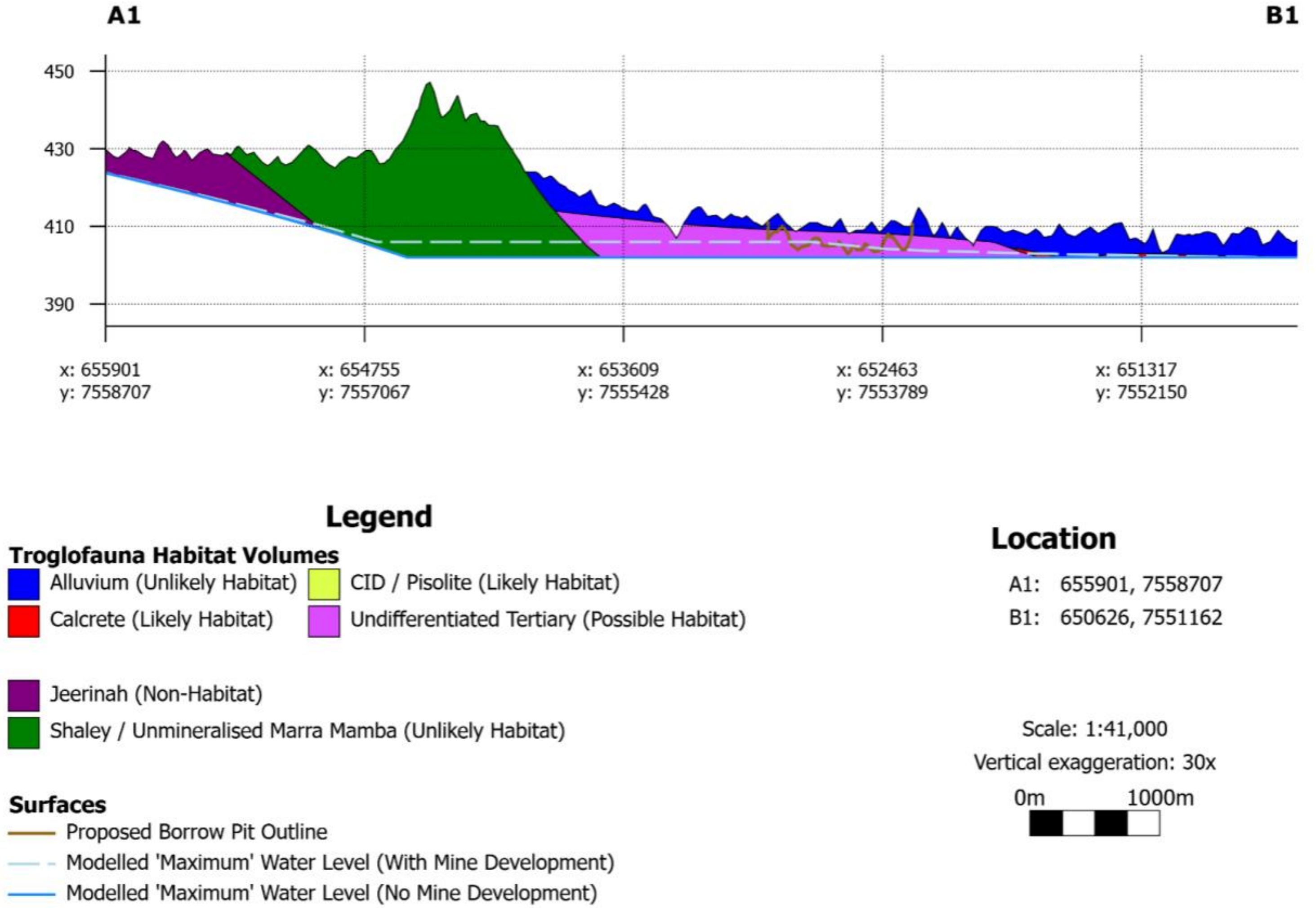
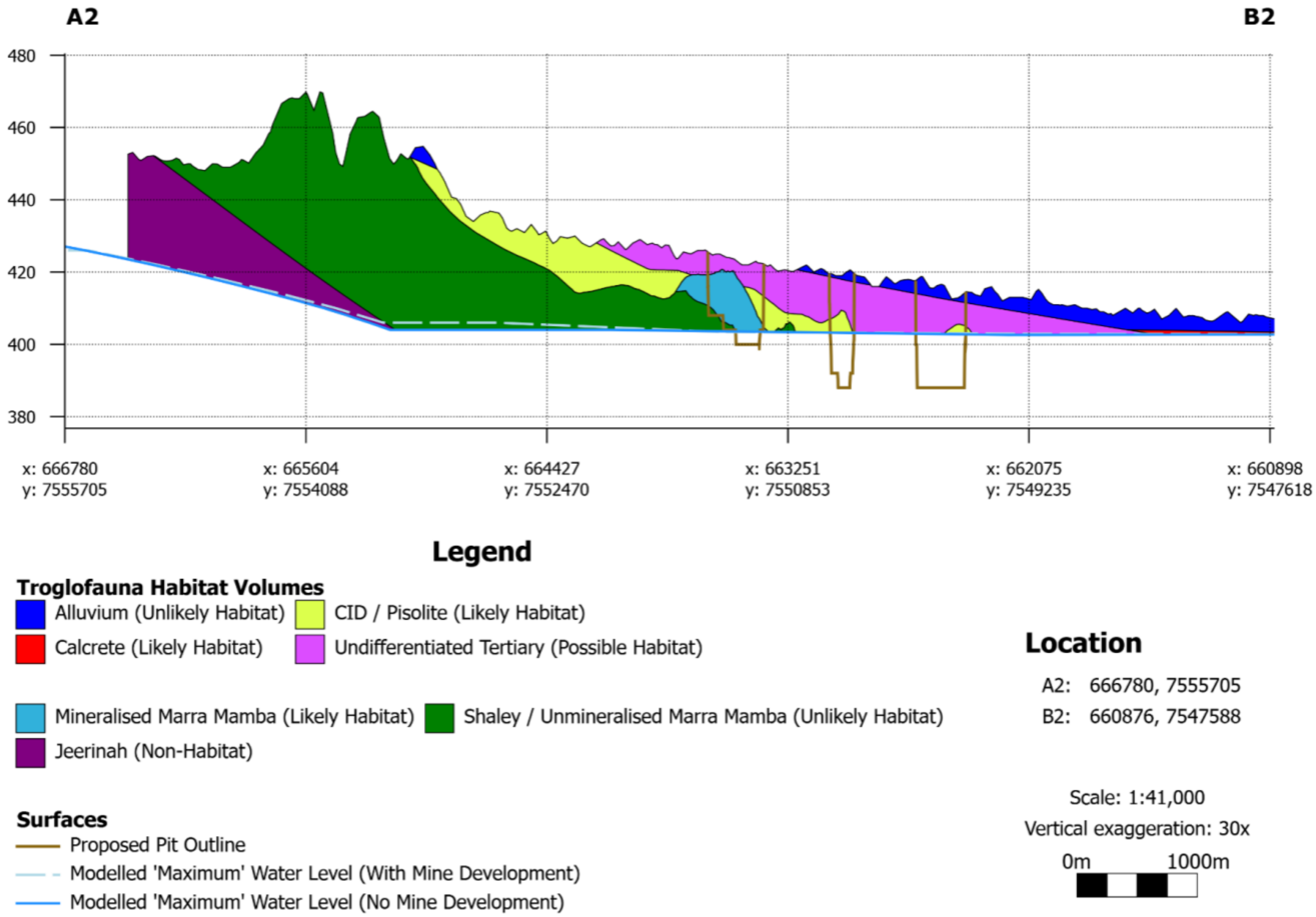
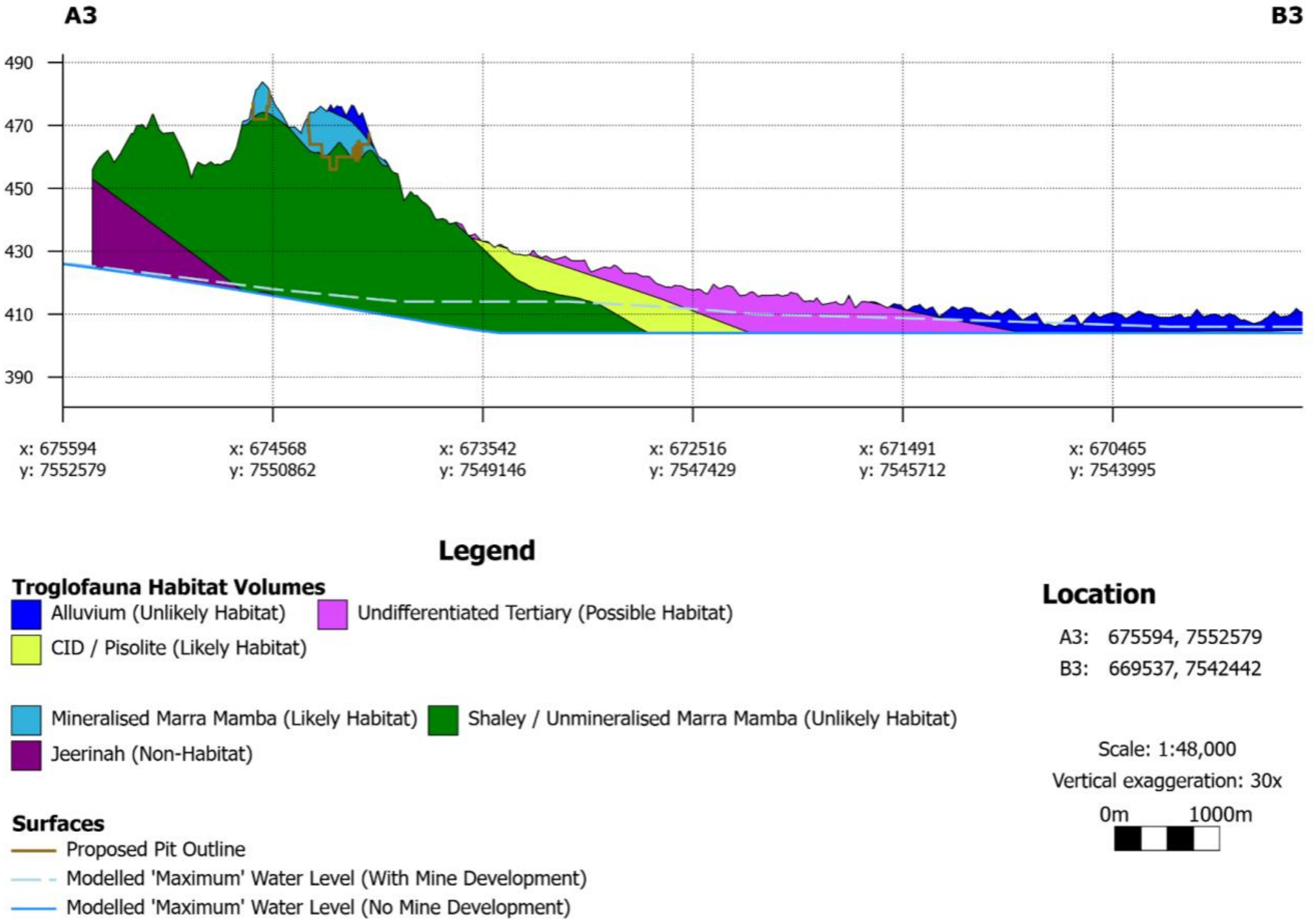



Figure 1-3 Troglofauna Habitat Cross Sections and predicted areal impact from Groundwater Mounding


A1
B1
450
430
410
390
x: 655901
y: 7558707
x: 654755
y: 7557067
x: 653609
y: 7555428
x: 652463
y: 7553789
x: 651317
y: 7552150
Legend
Troglofauna Habitat Volumes
Alluvium (Unlikely Habitat)
CID / Pisolite (Likely Habitat)
Calcrete (Likely Habitat)
Undifferentiated Tertiary (Possible Habitat)
Jeerinah (Non-Habitat)
Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
Surfaces
Proposed Borrow Pit Outline
Modelled 'Maximum' Water Level (With Mine Development)
Modelled 'Maximum' Water Level (No Mine Development)
Location
A1: 655901, 7558707
B1: 650626, 7551162
Scale: 1:41,000
Vertical exaggeration: 30x
0m
1000m



A2
B2
480
460
440
420
400
380
x: 666780
y: 7555705
x: 665604
y: 7554088
x: 664427
y: 7552470
x: 663251
y: 7550853
x: 662075
y: 7549235
x: 660898
y: 7547618
Legend
Troglofauna Habitat Volumes
Alluvium (Unlikely Habitat)
CID / Pisolite (Likely Habitat)
Calcrete (Likely Habitat)
Undifferentiated Tertiary (Possible Habitat)
Mineralised Marra Mamba (Likely Habitat)
Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
Jeerinah (Non-Habitat)
Surfaces
Proposed Pit Outline
Modelled 'Maximum' Water Level (With Mine Development)
Modelled 'Maximum' Water Level (No Mine Development)
Location
A2: 666780, 7555705
B2: 660876, 7547588
Scale: 1:41,000
Vertical exaggeration: 30x
0m
1000m


A3
B3
490
470
450
430
410
390
x: 675594
y: 7552579
x: 674568
y: 7550862
x: 673542
y: 7549146
x: 672516
y: 7547429
x: 671491
y: 7545712
x: 670465
y: 7543995
Legend
Troglofauna Habitat Volumes
Alluvium (Unlikely Habitat)
Undifferentiated Tertiary (Possible Habitat)
CID / Pisolite (Likely Habitat)
Mineralised Marra Mamba (Likely Habitat)
Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
Jeerinah (Non-Habitat)
Surfaces
Proposed Pit Outline
Modelled 'Maximum' Water Level (With Mine Development)
Modelled 'Maximum' Water Level (No Mine Development)
Location
A3: 675594, 7552579
B3: 669537, 7542442
Scale: 1:48,000
Vertical exaggeration: 30x
0m
1000m

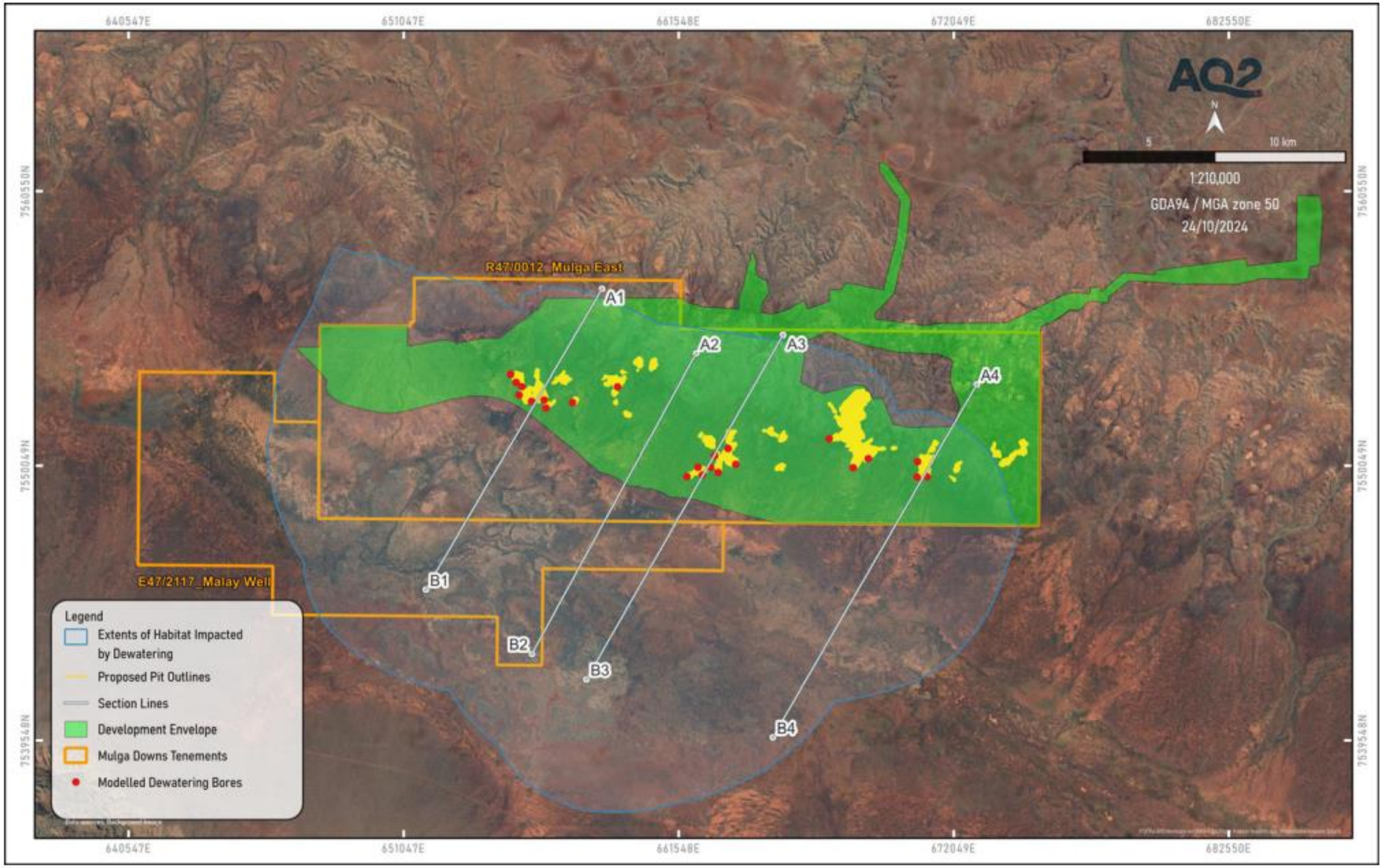
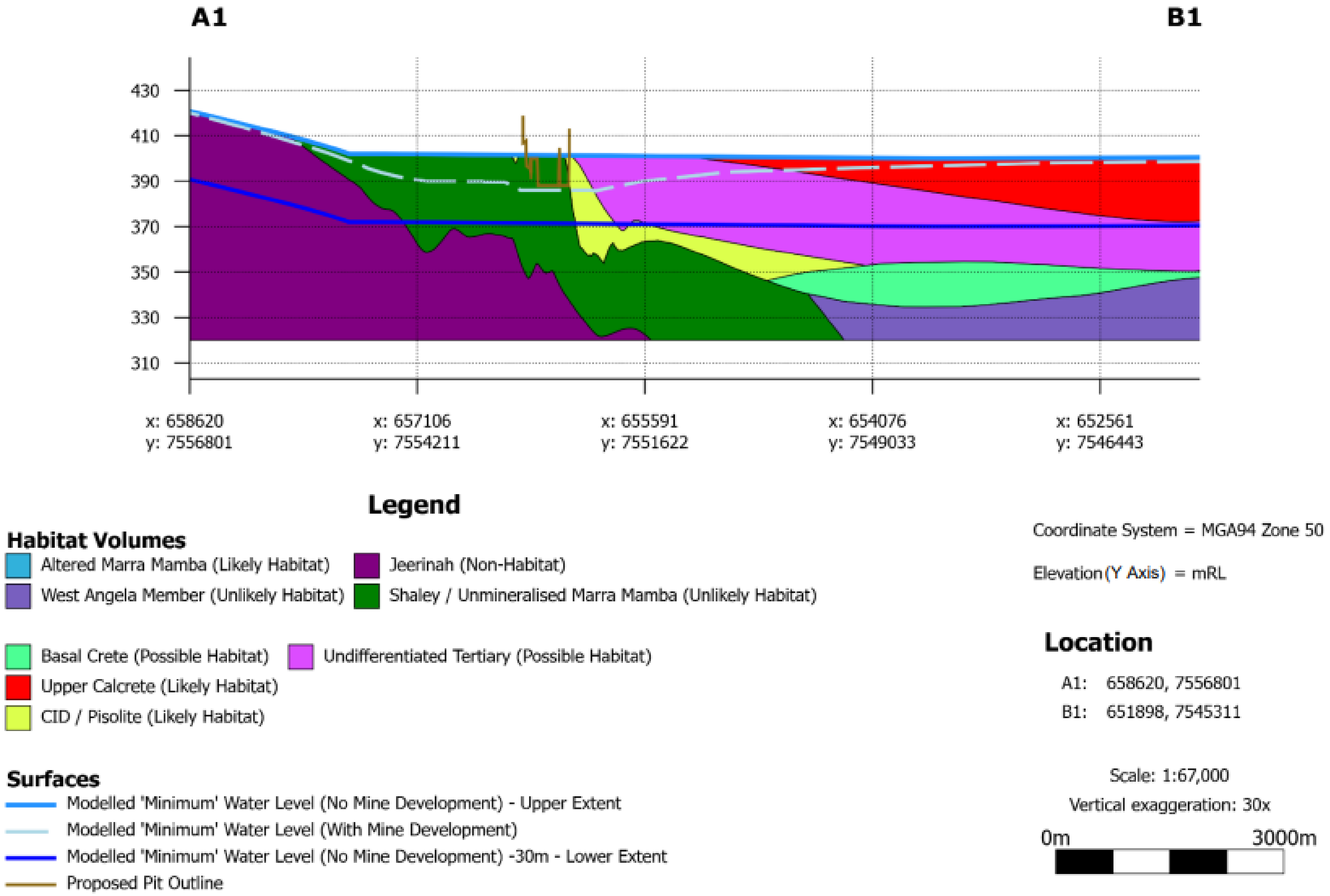
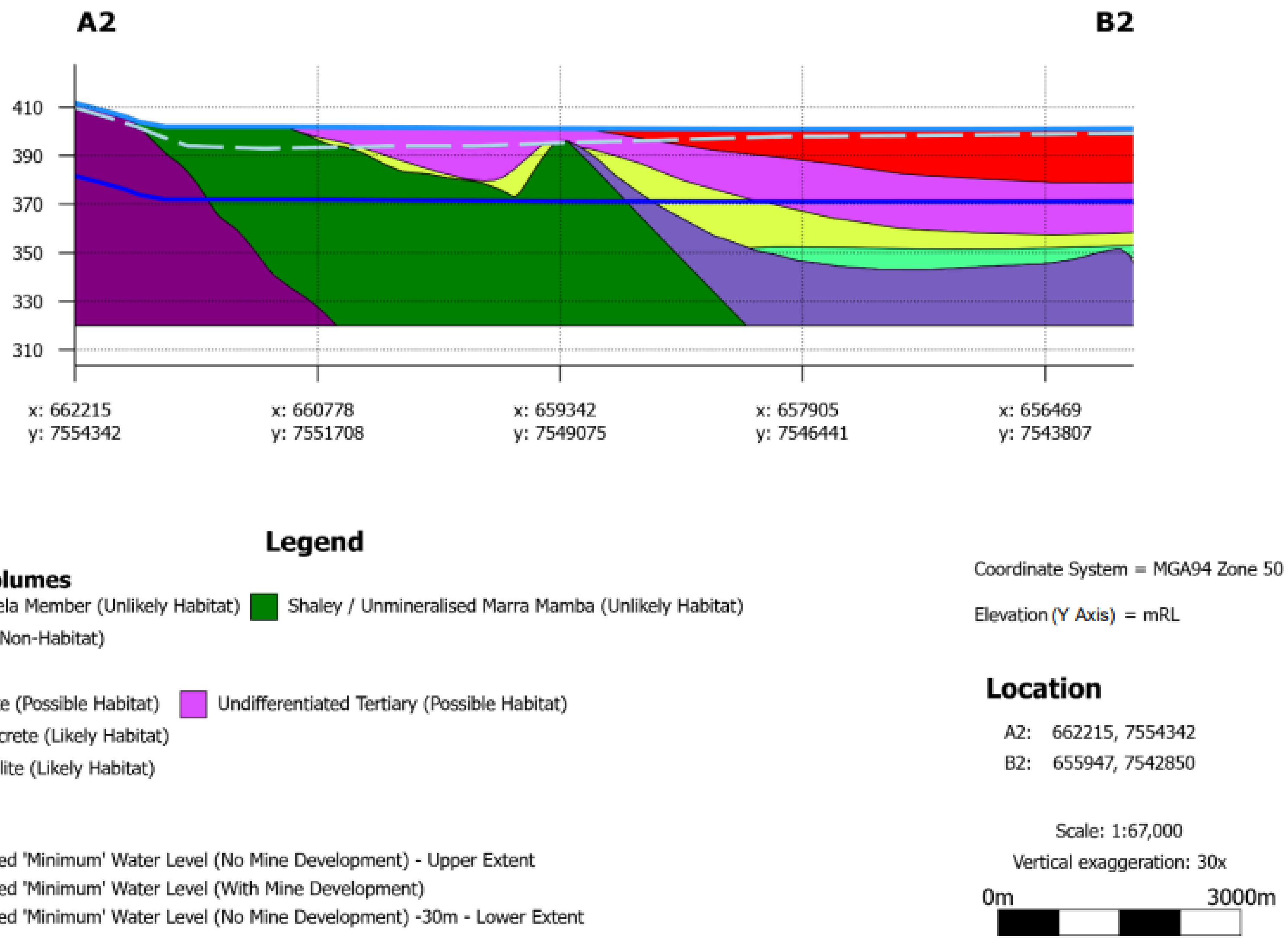
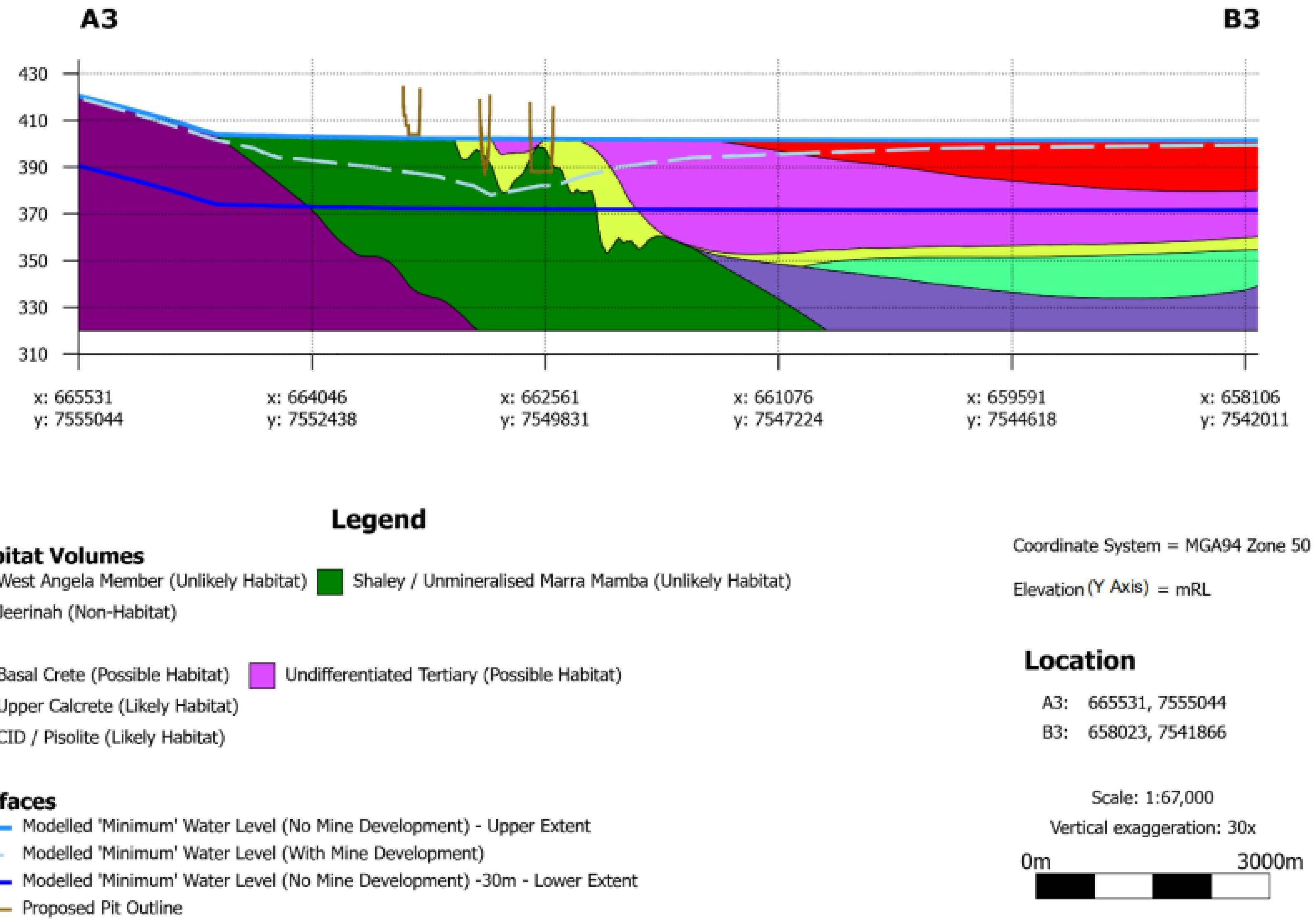
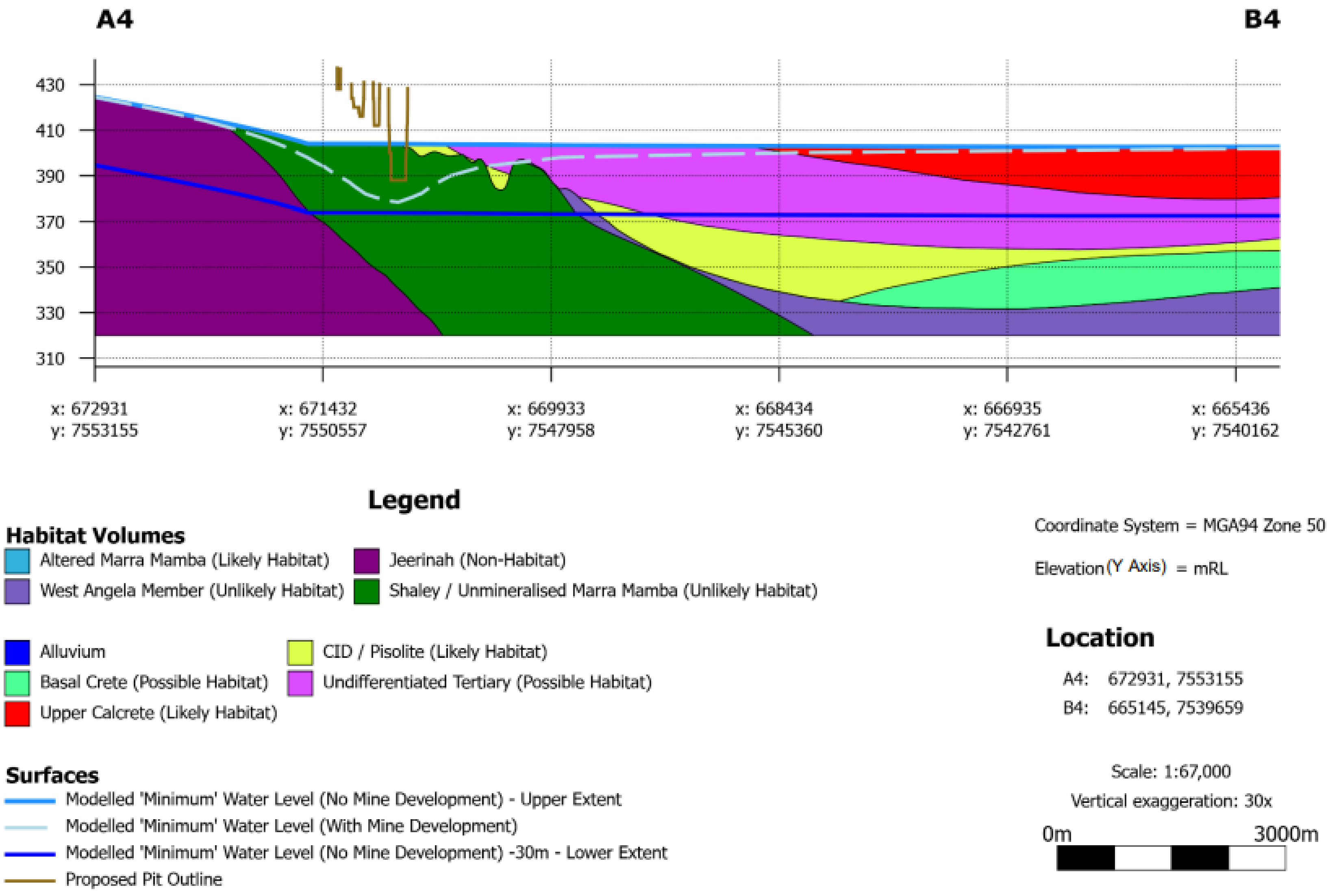



Figure 1-4 Stygofauna Habitat Cross Sections and predicted areal impact from Groundwater Drawdown


A1
B1
430
410
390
370
350
330
310
x: 658620
y: 7556801
x: 657106
y: 7554211
x: 655591
y: 7551622
x: 654076
y: 7549033
x: 652561
y: 7546443
Legend
Habitat Volumes
Altered Marra Mamba (Likely Habitat)
Jeerinah (Non-Habitat)
West Angela Member (Unlikely Habitat)
Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
Basal Crete (Possible Habitat)
Undifferentiated Tertiary (Possible Habitat)
Upper Calcrete (Likely Habitat)
CID / Pisolite (Likely Habitat)
Surfaces
Modelled 'Minimum' Water Level (No Mine Development) - Upper Extent
Modelled 'Minimum' Water Level (With Mine Development)
Modelled 'Minimum' Water Level (No Mine Development) -30m - Lower Extent
Proposed Pit Outline
Coordinate System = MGA94 Zone 50
Elevation (Y Axis) = mRL
Location
A1: 658620, 7556801
B1: 651898, 7545311
Scale: 1:67,000
Vertical exaggeration: 30x
0m
3000m


A2
B2
410
390
370
350
330
310
x: 662215
y: 7554342
x: 660778
y: 7551708
x: 659342
y: 7549075
x: 657905
y: 7546441
x: 656469
y: 7543807
Legend
Habitat Volumes
West Angela Member (Unlikely Habitat)
Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
Jeerinah (Non-Habitat)
Basal Crete (Possible Habitat)
Undifferentiated Tertiary (Possible Habitat)
Upper Calcrete (Likely Habitat)
CID / Pisolite (Likely Habitat)
Surfaces
Modelled 'Minimum' Water Level (No Mine Development) - Upper Extent
Modelled 'Minimum' Water Level (With Mine Development)
Modelled 'Minimum' Water Level (No Mine Development) -30m - Lower Extent
Coordinate System = MGA94 Zone 50
Elevation (Y Axis) = mRL
Location
A2: 662215, 7554342
B2: 655947, 7542850
Scale: 1:67,000
Vertical exaggeration: 30x
0m
3000m


A3
B3
430
410
390
370
350
330
310
x: 665531
y: 7555044
x: 664046
y: 7552438
x: 662561
y: 7549831
x: 661076
y: 7547224
x: 659591
y: 7544618
x: 658106
y: 7542011
Legend
Habitat Volumes
West Angela Member (Unlikely Habitat)
Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
Jeerinah (Non-Habitat)
Basal Crete (Possible Habitat)
Undifferentiated Tertiary (Possible Habitat)
Upper Calcrete (Likely Habitat)
CID / Pisolite (Likely Habitat)
Surfaces
Modelled 'Minimum' Water Level (No Mine Development) - Upper Extent
Modelled 'Minimum' Water Level (With Mine Development)
Modelled 'Minimum' Water Level (No Mine Development) -30m - Lower Extent
Proposed Pit Outline
Coordinate System = MGA94 Zone 50
Elevation (Y Axis) = mRL
Location
A3: 665531, 7555044
B3: 658023, 7541866
Scale: 1:67,000
Vertical exaggeration: 30x
0m
3000m


A4
B4
430
410
390
370
350
330
310
x: 672931
y: 7553155
x: 671432
y: 7550557
x: 669933
y: 7547958
x: 668434
y: 7545360
x: 666935
y: 7542761
x: 665436
y: 7540162
Legend
Habitat Volumes
Altered Marra Mamba (Likely Habitat)
Jeerinah (Non-Habitat)
West Angela Member (Unlikely Habitat)
Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
Alluvium
CID / Pisolite (Likely Habitat)
Basal Crete (Possible Habitat)
Undifferentiated Tertiary (Possible Habitat)
Upper Calcrete (Likely Habitat)
Surfaces
Modelled 'Minimum' Water Level (No Mine Development) - Upper Extent
Modelled 'Minimum' Water Level (With Mine Development)
Modelled 'Minimum' Water Level (No Mine Development) -30m - Lower Extent
Proposed Pit Outline
Coordinate System = MGA94 Zone 50
Elevation (Y Axis) = mRL
Location
A4: 672931, 7553155
B4: 665145, 7539659
Scale: 1:67,000
Vertical exaggeration: 30x
0m
3000m

#### 1.4.1.2 Subterranean Fauna Survey - Troglofauna

In total, 1,743 animals notionally belonging to 86 troglofauna species have been collected from the MDIOM and surrounding area (BEC 2024a). It is possible that as many as 15 species may be represented by more than one name because of taxonomic resolution. Groups represented in the troglofauna surveys include diplurans (13 species), isopods (nine species), beetles (eight species), pauropods (eight species), pseudoscorpions (eight species), silverfish (seven species), true bugs (six species), schizomids (five species), centipedes (four species), palpigrads (four species), cockroaches (four species), spiders (three species), symphylans (three species), millipedes (two species), and flies (one species).

Bennelongia concluded that the number of troglofauna species known only from the areas of impact being the mine pits/areas of excavation and the extent of the groundwater mounding, is somewhere between 30 and 42 (BEC 2024a).

The mining of the ore involves the excavation of material will results in the loss of troglofauna habitat. This has the potential to cause the loss of troglofauna species. The species which have been identified as having limited ranges and considered restricted, are the most at risk. The troglofauna identified from Mulga Downs which occur within the Mineralised Marra Mamba are primarily either singletons or their ranges only extend 500 m outside of the pit. This habitat exists as discontinuous pods.

At present, six of the troglofauna (Table 1-6) are considered to have short ranges and have been recorded from only within the Mineralised Marra Mamba Unit.

Table 1-6 Troglofauna identified as most at risk from implementation of Proposal

| Taxon | Impact Type | Distribution within Likely Habitat | Risk from Proposal |
|---|---|---|---|
| Austrochthonius `BPS257` | Pit and mounding | These taxa were all colleced from within the mine pits and the Minerlaised Marra Habitat. Up to 65% of this habitat will be lost. Abutting these areas, small amounts of habitat remain. While the loss of habitat is considered high, these taxa are presently at risk based on linear ranges from samping effort being concentrated in these areas and the true extent of distribution unknown. | The risk to these taxa at present remains high as they are only located within habtats which are discontinous. Additional sampling may yield more locations. However this habitat appears to be the most suitable for these species given the repeated collections in the same habitat type. |
| Buddelundia sp. B57 | Pit and mounding | | |
| Campodeidae `BDP216` | Pit | | |
| Coleoptera 'BCO207' | Pit and mounding | | |
| Palpigradi sp. MH1 | Pit and mounding | Linear range 0.3 km. Both records of this species has been only within the mine pits. | Palpigradi sp. MH1 is considered at risk from this Proposal as it has only been recorded from Mineralised Marra Mamba within a mine pit |
| Parajapyx `BDP217` | Pit and mounding | This species was recorded in mine pits of the Mineralised Marra Mamba Habitat. Up to 65% of this habitat will be lost. Abutting these areas, small amounts of habitat remain. While the loss of habitat is considered high, these taxa are presently at risk based on linear ranges from samping effort being concentrated in these areas and the true extent of distribution unknown. | Parajapyx `BDP217` is considered at risk from this Proposal as it has only been recorded from Mineralised Marra Mamba within a mine pit |

#### 1.4.1.3 Subterranean Fauna Survey - Stygofauna

In total, 12,045 specimens of at least 150 stygofauna species have been collected from the MDIOM. Up to six species may be duplicate names and two worm species, at least, may comprise multiple species. Invertebrate groups represented at the MDIOM include copepods (45 species), ostracods (31 species), amphipods (23 species), annelid worms (19 species), syncarids (18 species), rotifers (five species), isopods (three species), mites (three species), spelaeogriphacids (one species), flatworms (one species) and nematode worms (treated as a single species but together with flatworms and rotifers not assessed in environmental impact assessments; EPA 2016).

With respect to loss of taxa due to impacts to habitat (loss and changes to groundwater quality) the aquifer found to be likely to support stygofauna is considered extensive and continues along the Fortescue Valley. Many of the taxa identified have a greater distribution outside the Development Envelope. For example, dispersal of stygal ostracods is known to occur within each catchment and not between catchments in the Pilbara. Dispersal has been found to occur along the extent of uninterrupted aquifers (Reeves et al., 2007) and the dispersal of stygofauna within the Development Envelope was evident with a number of taxa from different orders collected from several locations. A number of the singletons were also collected with stygal taxa which were found in several other locations in the Development Envelope and further.

Based on an assessment of the habitat connectivity and the volumes which will be lost from dewatering, the impacts to taxa was found to be low. None of the stygofauna taxa will be at risk from implementation of the proposal.

#### 1.4.1.4 Salinity Tolerance Desktop Assessment

Bennelongia (2024) were engaged to undertake an assessment of the salinity tolerance of stygofauna at the Proposal (Appendix 2). Stygofauna salinity tolerance were considered in relation to the potential impacts of MAR in the Murrays West, Valley Near Murrays Hilla and DB1 Far East borefields illustrated in Figure 1-5 and discussed in the Mulga Downs Groundwater, Surface Water and Ecohydrological Impact Assessment (AQ2, 2024b).

The likely salinity tolerances for eight stygofauna taxa (which display characteristics of local endemism) were calculated by multiplying the mean observed salinity of each species by the median ratio of maximum salinity to mean salinity for the appropriate taxonomic group (e.g. syncarids).

Based on sampling results, three of the potentially restricted species at the MDIOM (all syncarids) are inferred to be true freshwater species with upper salinity tolerances of <500 mg/L (Table 1-7), four species (three syncarids and the water mite) are inferred to have upper salinity tolerances of 500-1500 mg/L, and the single potentially restricted ostracod species has an inferred upper salinity tolerance (3,101 mg/L) just beyond the 'freshwater' range.

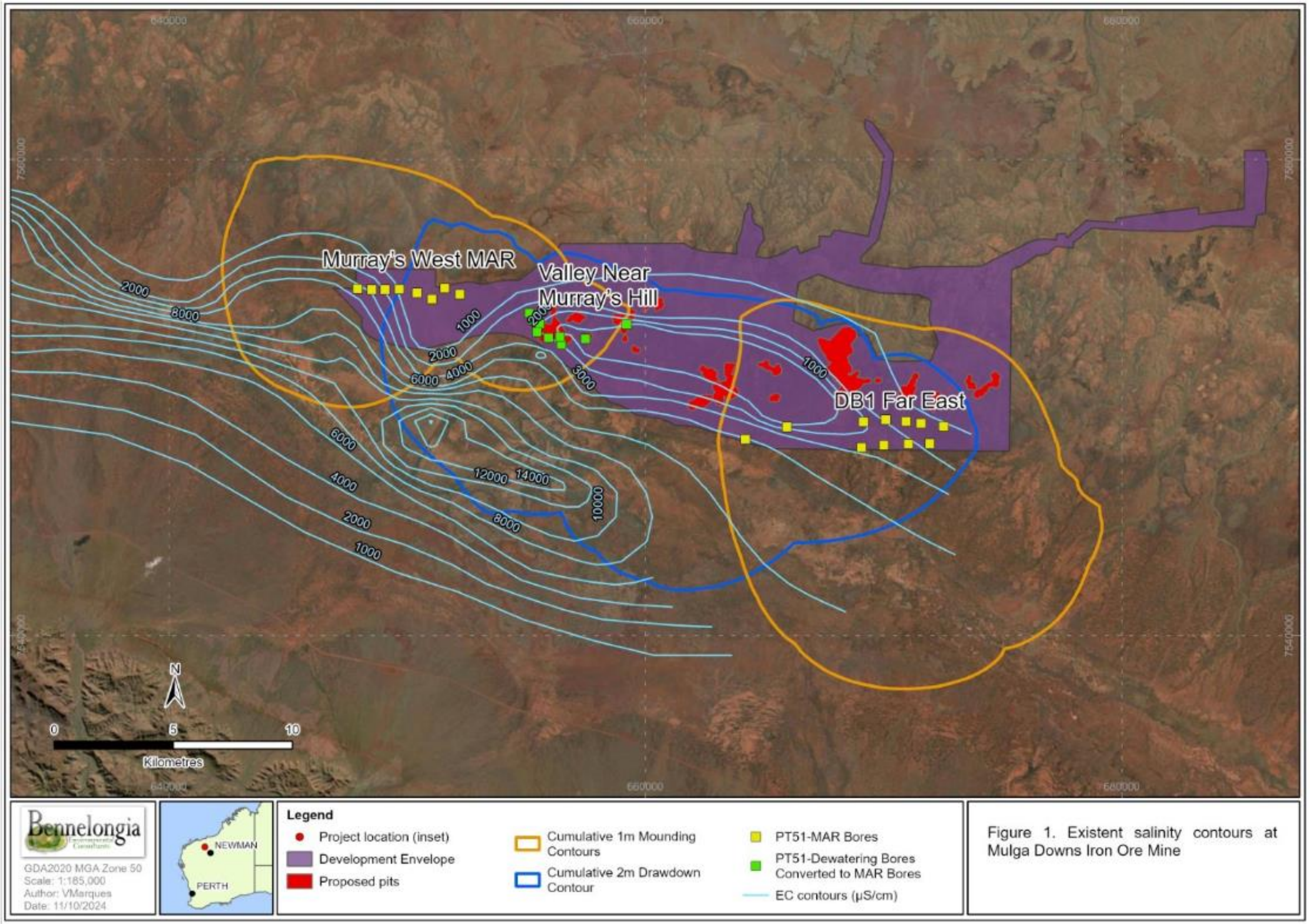



Figure 1-5 Mulga Mine MAR areas, existing salinity contours and groundwater change contours.

Table 1-7 Observed salinity occurrence and inferred salinity tolerance, together with types of impact, for 'restricted' stygofauna species.

| Species | Mean salinity | Maximum salinity | Minimum salinity | *Inferred upper salinity tolerance |
|---|---|---|---|---|
| Oligochaeta | | | | |
| *Achaeta* sp. | - | - | - | - |
| Hydracarina | | | | |
| *Guineaxonopsis* sp. B03 | 406 | 719 | 92 | 731 |
| Ostracoda | | | | |
| *Areacandona* 'BOS1381' | 1723 | 2394 | 1052 | 3101 |
| Syncarida | | | | |
| *Pilbaranell*a 'MH1' | 197 | 257 | 110 | 276 |
| *Pilbaranella* 'MH2' | 1066 | - | - | 1492 |
| *Pilbaranella* sp. B18 | 155 | - | - | 217 |
| *Atopobathynella* sp. B09 | 73 | 92 | 54 | 102 |
| nr *Billibathynella* 'MH2' | 589 | 1049 | 110 | 1049‡ |
| Parabathynellidae 'MH3' | 632 | - | - | 885 |

The weighted average salinity of groundwater abstracted at the MDIOM will periodically reach 3,000 mg/L through the life of the mine. Under one porosity scenario, it will reach 4,200 mg/L during the first half of mine life (AQ2, 2024b).

It is also predicted that most of the MAR area will, on average, experience relatively small salinity increases of approximately 500 mg/L. However, at Murray's West (which supports only one record of *Guineaxonopsis* sp. B03) salinity is expected to increase by 2,550 mg/L. to 3,800 mg/L. The resultant salinity exceeds the inferred upper salinity tolerance of *Guineaxonopsis* sp. B03).

At Valley Near Murray's Hill, salinity is predicted to increase 1,000 mg/L from 3,600 to 4,600 mg/L, although the salinity contours and the salinities at which species were recorded show that current salinity in most of the area, except to the south, is considerably lower than 3,600 mg/L. Even *Areacandona* 'BOS1831', the most salt tolerant of the eight restricted species with an estimated upper tolerance of 3,101 mg/L, is unlikely to tolerate the predicted salinity increase at Valley Near Murray's Hill, although salinity at particular sites may remain lower than suggested by the broad salinity predictions available. The other six species recorded at Valley Near Murray's Hill have inferred salinity tolerances of 217-1,492 mg/L.

At DB1 Far East, salinity is expected to increase by 1,300 mg/L from 1,400 to 2,700 mg/L. The one species collected only from DB1 Far East, *Atopobathynella* sp. B09, has an inferred upper salinity tolerance of 102 mg/L and is highly unlikely to persist at 2,700 mg/L. One of the other species occurring at DB1 Far East (as well as Valley Near Murray's Hill) is also unlikely to persist, with the inferred upper salinity tolerance of *Pilbaranella* 'MH1' being 276 mg/L. The second species, nr *Billibathynella* 'MH2' with an upper salinity tolerance of 1,049 mg/L will probably also not persist, although it is not a robust prediction.

### 1.4.2 Key Assumptions and Uncertainties

Key assumptions and uncertainties adopted for the development of this SFMMP are detailed in **Table 1-8**.

Table 1-8: Key Assumptions and Uncertainties

| | |
|---|---|
| **Key Assumptions** | • This SFMMP has been developed based on information the outcome of studies and completed for the Proposal. As requirements change and knowledge increases over time, this SFMMP may be subject to updates. Consideration and investigation of new technologies and management practices will inform updates to monitoring parameters, monitoring sites, and management measures.<br>• Regular review and update of the monitoring program will be based on changes to mine planning, diversion designs, timings of construction and operations of these diversion structures, operations, hydrological and surface water flood models, and monitoring data. |
| **Key Uncertainties** | • The proposed dewatering and reinjection borefields, and associated monitoring infrastructure, have not yet been constructed due to the preliminary nature of the Proposal. As the Proposal develops and infrastructure is installed and operated (i.e., dewatering and reinjection borefields), this SFMMP will be updated to incorporate new knowledge and understanding.<br>• The SFMMP is pending approval under EP Act, and will be updated upon receipt of approval conditions, as required. |

## 1.5 Management Approach

### 1.5.1 Environmental Management System

HPPL's Environmental Management System (EMS) Framework provides a basis for achieving the key environmental management objectives during the construction and operational phases of the Proposal. The framework is illustrated in Figure 1-6. Implementation of the EMS Framework ensures environmental performance is achieved through environmental management practices consistent with HPPL's Environmental Policy and objectives.


Figure 1-6: Environmental Management System Framework

## 1.6 Rationale for Choice of Indicators and Management Actions

To monitor potential impacts to subterranean fauna from the Proposal, provisions will be applied to key environmental indicators:

- Volume ($m^3$) of disturbance to likely habitat from mining (direct loss of habitat for troglofauna and stygofauna);
- Groundwater level (mbgl) mounding (impact to troglofaunal habitat);
- Groundwater level (mbgl) drawdown (impact to stygofauna habitat);
- Groundwater quality change from mining i.e. leachate (reduction in quality of stygofauna habitat); and
- Groundwater salinity (Total Dissolved Solids, TDS) change from MAR (reduction in quality of stygofauna habitat).

The magnitude of change for outcome-based provisions will be assessed via the use of trigger and threshold criteria. Response actions to trigger and threshold exceedances are to be implemented as soon as reasonably practical to ensure potential impacts to the environment are minimised. Investigation into trigger and threshold exceedances are to commence upon identification of a potential exceedance. The trigger and threshold exceedance response actions are outlined in **Table 1-9**.

The selected triggers and thresholds are based on anticipated Proposal requirements, environmental risk assessments, investigations/studies, and the findings of monitoring assessments. These indicators have been chosen as they provide a basis for detecting and avoiding or otherwise managing potential environmental impacts such that environmental outcomes and objectives can be achieved.

Table 1-9: Trigger and Threshold Exceedance Response

| | Purpose / Objective | Exceedance Response |
|---|---|---|
| **Trigger Levels** | Trigger levels are set at a conservative level to ensure response actions are implemented in advance of environmental objective being compromised. Exceedances of a trigger level, therefore, will not be treated as a non-compliance. There is potential for trigger levels to be exceeded due to natural variability and this must be accounted for in the management response. Exceedance of a trigger criteria will initially be treated as a potential non-compliance against the environmental outcome until the cause of exceedance can be determined. | Investigation:<br>• Source identification (e.g., reinjection, abstraction, natural fluctuations)<br>• Cause and effect analysis (mine-related vs. external factors)<br>• Rate of change assessment<br>• Potential impact evaluation<br>Risk Assessment:<br>• Low risk: Increased monitoring frequency<br>• Moderate or high risk: Contingency management measures implementation<br>Quality Assurance:<br>• Data validation (sampling protocols, collection methods, calibration, documentation)<br>Management Response:<br>• Appropriate measures to reduce exceedances<br>• Ongoing monitoring of effectiveness<br>• Potential for further investigation and management actions |
| **Threshold Criteria** | Threshold criteria represent the limit of acceptable impact on the environment. Exceedance of the threshold criteria will signal the environmental outcome has potential to not be met, implies non-compliance and requires threshold contingency management measures to be implemented. | Tailored Response:<br>• Management measures based on impact location, cause, and severity<br>Remedial Action:<br>• Consultation with the Department of Water and Environmental Regulation (DWER) and specialists for environmental harm<br>• Implementation of remedial actions and monitoring |

### 1.6.1 Disturbance of Habitat from Mining

There will be Direct loss of habitat from excavation of a series of open cut mine pits, which extend below the water table. Volume ($m^3$) of habitat has been inferred in the troglofaunal and stygofauna habitat assessments (AQ2 2024a and AQ2 2024b) and are outlined in Table 1-10 and Table 1-11 respectively.

Table 1-10 Troglofauna habitat predicted volume impacted by mining (AQ2, 2024a)

| Troglofauna Habitat | Habitat Likelihood | Predicted Volume ($m^3$) Impacted (Excavation) |
|---|---|---|
| Upper Calcrete | Likely | 374,740 |
| CID / Pisolite | | 12,275,000 |
| Mineralised Marra Mamba | | 54,082,000 |
| Undifferentiated Tertiary | Possible | 25,833,000 |
| Alluvium | Unlikely | 11,922,000 |
| Shaley / Unaltered Marra Mamba | | 7,895,500 |
| **Total** | | **112,382,240** |

Table 1-11 Stygofauna habitat predicted volume impacted by mining (AQ2, 2024a)

| Stygofauna Habitat | Habitat Likelihood | Predicted Volume Impacted by Mining ($m^3$) |
|---|---|---|
| Upper Calcrete | Likely | 0 |
| CID / Pisolite | | 3,273,500 |
| Mineralised Marra Mamba | | 550,280 |
| Undifferentiated Tertiary /Sediment | Possible | 1,415,200 |
| Basal Crete | | 0 |
| Alluvium | Unlikely | 0 |
| West Angela Member | | 11,438 |
| Shaley / Unaltered Marra Mamba | | 13,937,000 |
| **Total** | | **19,187,418** |

### 1.6.2 Grounding Drawdown and Mounding

Loss of troglofaunal habitat from MAR via reinjection and / or pit infiltration of surplus abstracted groundwater into selected aquifers changes in groundwater levels (≥ 2 m):

*Outcome based provisions for groundwater level and quality are addressed in the WMP (refer Section 3.1).*

Loss of stygofauna habitat from dewatering for excavation of pits below the water table and resulting changes in groundwater levels (≥ 1 m):

*Outcome based provisions for groundwater level and quality are addressed in the WMP (refer Section 3.1).*

### 1.6.3 Reduction in Quality of Habitat Due to Salinity Changes

The Proposal is anticipated to alter baseline groundwater salinity through:

- drawing in of increasingly saline water from beneath the claypans as a result of dewatering; and
- reinjection of variably saline groundwater across the site.

As indicated in Section 1.4.1.4, Stygofauna are susceptible to salinity change associated with the Proposal.

*Outcome based provisions for groundwater level and quality are addressed in the WMP (refer Section 3.1).*

### 1.6.4 Reduction in Quality of Habitat Due to Change to Groundwater Quality from Mining

The groundwater chemistry has been investigated based on extensive hydrogeological investigations undertaken for the Proposal. CBEC (2024) performed a statistical analysis which was used to establish suitable water quality trigger values as per the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018; ANZECC & ARMCANZ, 2000b).

*Outcome based provisions for groundwater down gradient of the Mine are addressed in WMP (Draft Condition 4).*

# 2 Subterranean Fauna Monitoring and Management Plan Provisions

## 2.1 Outcome Based Environmental Management Provisions

**Purpose:** Provide draft triggers and thresholds, associated trigger and threshold actions and monitoring associated with groundwater to meet the EPA's objective for subterranean fauna.

**Rationale:** Minimise potential environmental impacts to subterranean fauna habitat associated with mining, groundwater abstraction and MAR;

- No significant impact to subterranean fauna habitat such that the biological diversity and ecological integrity are maintained; and,
- Undertake appropriate monitoring and report sufficiently to demonstrate compliance with likely approval requirements and enable appropriate and informed water management decisions.

Table 2-1: Outcome Based Environmental Management Provisions

**EPA factor/s and objective/s:**

- **Subterranean Fauna:** To protect subterranean fauna so biological diversity and ecological integrity are maintained.

**Outcome:** Minimise impacts to subterranean fauna including minimise extent of groundwater level and quality change.

**Key environmental values:** Stygofauna and Troglofauna taxa and habitat.

**Key impacts and risks:** Changes to groundwater levels, quality, loss of stygofauna and troglofauna habitat.

| Outcome-based | | | | |
|---|---|---|---|---|
| • **Trigger criteria**<br>• **Threshold criteria** | **Response Actions:**<br>• **Trigger level actions**<br>• **Threshold contingency actions** | **Monitoring** | **Timing / Frequency of Monitoring** | **Reporting** |
| **Management of Groundwater Levels and Quality to Impacts on Groundwater Users** | | | | |
| *Outcome based provisions for groundwater level and quality are addressed in the WMP (refer Section 3.1).* | | | | |
| **Management of Release of WRD Contaminants to Impacts on Groundwater Quality** | | | | |
| *Outcome based provisions for groundwater level and quality are addressed in the WMP (refer Section 3.1).* | | | | |
| **Managements of impacts to Subterranean Fauna Habitat from Mining** | | | | |
| **Likely Troglofauna Habitat (m²) trigger and threshold:** (see table below) | **Trigger Level Actions:**<br>• No further mining to be authorised if the mine plan indicates threshold criteria will exceed.<br>• Confirm extent of existing approved mined volume against assessment of volume yet to be mined.<br>• Mining only to proceed once confirmation the mine plan will not exceed the threshold criteria.<br>**Threshold Contingency Actions:**<br>• Immediate cease of mining excavation activities.<br>• Schedule audit on current mined volumes.<br>• Investigation into threshold breach.<br>• Undertake further education and awareness training. | **Indicator:**<br>• Mine Plan Block Model<br>• As mined survey data<br>**Methods:**<br>• Monitoring will be line with HanRoy Environmental Compliance Standard (ECS).<br>• Internal mine plan approval process, to ensure compliance with State approval limits.<br>**Locations:**<br>• Within the Proposal Development Envelope | Prior to commencement of a revised mine plan.<br>In line period reporting requirements. | The exceedance of the threshold criteria constitutes a non-compliance and will be reported in the Annual Compliance Assessment Report.<br>Exceedance of threshold criteria – notify regulatory authorities (DWER) within 7 days of exceedance being identified and provide a written report within 21 days. |

| Fauna Habitat | 90% Trigger Value (m²) | Threshold Stygofauna Habitat (m²) |
|---|---|---|
| Upper Calcrete | 337,266 | 374,740 |
| CID / Pisolite | 11,047,500 | 12,275,000 |
| Mineralised Marra Mamba | 48,673,800 | 54,082,000 |

| **Outcome-based** | | | | |
|---|---|---|---|---|
| • **Trigger criteria**<br>• **Threshold criteria** | **Response Actions:**<br>• **Trigger level actions**<br>• **Threshold contingency actions** | **Monitoring** | **Timing / Frequency of Monitoring** | **Reporting** |
| **Likely Stygofauna habitat (m2) trigger and threshold:** | | | | |

| **Fauna Habitat** | **90% Trigger Value (m²)** | **Threshold Stygofauna Habitat (m²)** |
|---|---|---|
| Upper Calcrete | 0 | 0 |
| CID / Pisolite | 2,946,150 | 3,273,500 |
| Mineralised Marra Mamba | 495,252 | 550,280 |

*Habitat volume will be refined over the life of the project as more detailed resolution of lithologies are mapped through drilling and geological interpretations.*

## 2.2 Monitoring

The purpose of monitoring is to inform, through the environmental criteria, if the environmental objectives are being achieved. In addition, monitoring will inform when trigger level actions or threshold contingency actions are to be implemented or if the objectives are being achieved through the defined management tasks.

Details relating to monitoring for groundwater quality and groundwater level change from Mining and MAR are provided in the WMP.

Monitoring for impacts to subterranean fauna habitat from mining will be through the mine planning process. For each iteration of the mine plan, HPPL will review the mine block model (ore and waste) and pit shell in relation to the subterranean fauna habitat units to assess compliance with the triggers and thresholds for impacts to habitat prior to the commencement of mining in that area.

To confirm compliance with the triggers and thresholds, the volume of actual (mined) vs proposed (mine plan) habitat impact will be periodically validated against the 'as mined' survey data.

HPPL is looking to undertake additional surveys and studies including studies/monitoring to determine the potential for recolonisation of troglofauna following backfilling of mine pits at closure and targeted surveys for troglofaunal identified as at risk during the impact assessment.

### 2.2.1 Troglofauna Backfill Recolonisation at Closure Study

A direct impact to troglofaunal from the Proposal is removal of habitat via excavation for mining. HPPL are proposing to backfill pits to approximately 2m above the pre-mining groundwater level to prevent the formation of pit lakes after closure. For the purpose of EIA, it has been assumed the impact from mining result in a permanent loss of habitat. However, there is the potential for troglofaunal species may recolonise backfill pit areas after closure.

HPPL will undertake a study/monitoring program to determine the potential for recolonisation of backfilled mine pits.

### 2.2.2 Targeted Troglofauna Survey

At present, six troglofauna in Table 1-6 considered to have short ranges have been recorded from only within the Mineralised Marra Mamba Unit. Prior to mining HPPL will undertake additional targeted surveys for troglofauna.

Sample site will be selected based on proximity to restricted species and occurrence within similar habitat types within and outside of proposed mining areas. Areas which should be targeted are shown in Figure 2-1. Species to be targeted are outlined in Table 2-2.

Table 2-2 Troglofauna identified as most at risk from implementation of Proposal

| Taxon | Impact Type | Distribution within Likely Habitat |
|---|---|---|
| Austrochthonius `BPS257` | Pit and mounding | These taxa were all colleced from within the mine pits and the Minerlaised Marra Habitat. Up to 65% of this habitat will be lost. Abutting these areas, small amounts of habitat remain. While the loss of habitat is considered high, these taxa are presently at risk based on linear ranges from samping effort being concentrated in these areas and the true extent of distribution unknown. |
| Buddelundia sp. B57 | Pit and mounding | |
| Campodeidae `BDP216` | Pit | |
| Coleoptera 'BCO207' | Pit and mounding | |
| Palpigradi sp. MH1 | Pit and mounding | Linear range 0.3 km. Both records of this species has been only within the mine pits. |
| Parajapyx `BDP217` | Pit and mounding | This species was recorded in mine pits of the Mineralised Marra Mamba Habitat. Up to 65% of this habitat will be lost. Abutting these areas, small amounts of habitat remain. While the loss of habitat is considered high, these taxa are presently at risk based on linear ranges from samping effort being concentrated in these areas and the true extent of distribution unknown. |

#### 2.2.2.1 Methods

Troglofauna will be collected via scraping and double trapping all sites. Scrape sampling for troglofauna will be conducted by dropping a weighted net down the drill hole and dragging it back to the surface against the drill hole wall. Traps baited with locally sourced and irradiated leaf litter will be left in place for eight weeks prior to their retrieval each sampling round. Two traps will be set in every drill hole to maximise collection of target species.

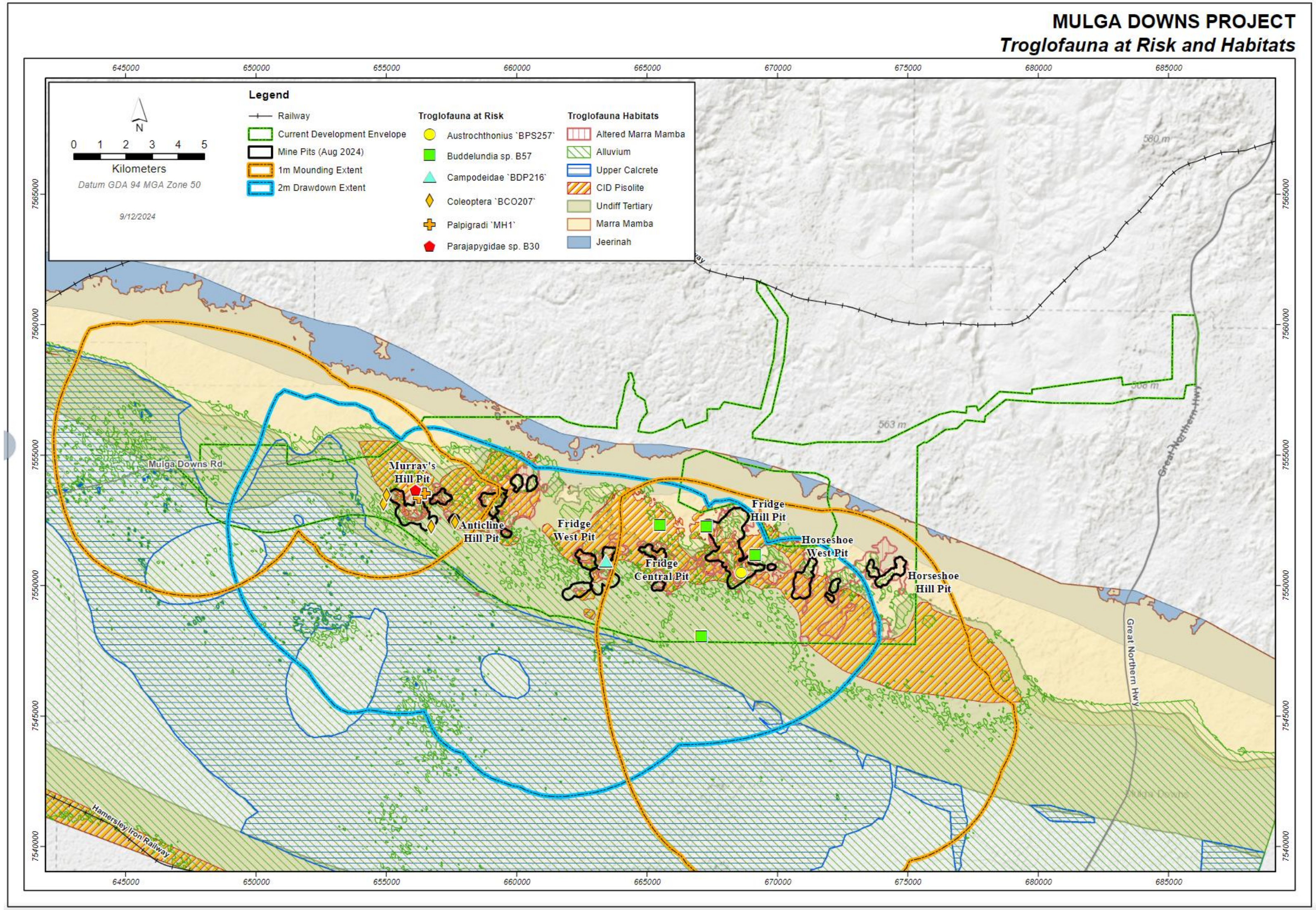



Figure 2-1 Restricted troglofaunal species identified at risk subject to additional targeted surveys

## 2.3 Reporting

**Table 2-3** outlines proposed internal and external reporting actions.

Table 2-3: SFMMP Reporting Actions

| Notification Event / Reporting | Action | Responsibility | Timing |
|---|---|---|---|
| Trigger exceedance (and failure of management target) | Internal incident report and investigation | Environmental Advisor | At time of event or as soon as reasonably practicable. |
| Threshold exceedance | Internal incident report and investigation.<br>External incident report to regulator | Environment Manager | Notify the CEO of DWER within seven (7) days of the exceedance being identified<br>Report on the outcomes of the exceedance investigation within 21 days of event. |
| Management action revision(s) | External notification to regulators (DWER) | Environment Manager | Within 21 days of management action revision(s) |
| Groundwater and Surface Water Monitoring Assessment Report | Includes monitoring conducted, deviations to the WMP, apparent trends or patterns, trigger and threshold exceedances and other observations relevant to the data collated. | Environment Manager | Annually |
| Annual Environmental Report | This report will be submitted to the regulator (DWER) and include an assessment of compliance with any conditions that apply | Environment Manager | Annually – April each year for the reporting period 1 January to 31 December |

## 2.4 Roles and Responsibilities

All employees and contractors are required to comply with the requirements of this Management Plan. An outline of roles and responsibilities for all personnel is provided in **Table 2-4**.

Table 2-4: Roles and Responsibilities for Implementation of this Plan

| Role | Responsibility |
|---|---|
| All personnel | Comply with all legal requirements and the requirements of this plan. |
| Environment Manager | • Maintain the SFMMP, and review the SFMMP as required<br>• Provide advice, including procedures and requirements, to all key parties to ensure compliance with legal requirements, achievement of environmental objectives and improving environmental performance<br>• Provide support to all personnel as required to ensure the SFMMP is implemented. |
| Site Environmental Advisor | • Report on the implementation of the plan.<br>• Provide advice, including procedures and requirements, to all key parties to ensure compliance with legal requirements, achievement of environmental outcomes and objectives |

# 3 Adaptive Management and Review

HPPL will employ adaptive management through the LOM to incorporate knowledge from the implementation of mitigation measures, monitoring, and evaluation of data against trigger and threshold criteria to more effectively meet regulatory conditions and objectives outlined in this SFMMP. The following approach will be followed:

- Monitoring data will be systematically evaluated and compared to baseline data and predictions on an annual basis to verify whether groundwater responses to operational activities are the same or similar to predictions;
- Re-evaluate the risk assessments annually after monitoring is completed;
- Incorporate additional knowledge as it comes to hand to address assumptions and uncertainties to gain increased understanding of vegetation and aquifer response;
- Review the mine planning program, GWOS, and input changes into risk assessments to refine or modify the monitoring program;
- Undertake revision(s) when SFMMP provisions are not as effective as predicted, or trigger levels do not have the outcome anticipated or required;
- Incorporate alternative techniques, technologies, and methodologies to enhance and improve the program;
- Revise the SFMMP periodically to include additional and updated trigger and threshold levels based on developed baseline data;
- Revise the SFMMP periodically to include additional Proposal areas (if required), monitoring locations, parameters and site-specific trigger and threshold levels;
- Develop other monitoring programs as required to respond to additional operational activities; and
- Incorporate and modify the program to include any external changes during the life of the Proposal.

All amendments to this SFMMP must be submitted to and approved by the CEO of DWER. The Management Plans shall also be reviewed, and amendments submitted as and when directed by the CEO in addition to every five years from approval with outcomes of the five-yearly review submitted to the CEO.

# 4 Stakeholder Consultation

HPPL has consulted with key stakeholders in relation to its Proposal. These stakeholders include regulatory groups:

- Department of Water and Environmental Regulation (DWER) (EPA Services; Part V; Water);
- Department of Mining Industry Regulation and Safety (DMIRS) - Environment and Mining Divisions;
- Department of Biodiversity Conservation and Attractions (DBCA);
- Department of Planning, Lands and Heritage (DPLH);
- Department of Jobs, Tourism, Science and Innovation (DJTSI);
- Main Roads Western Australia (MRWA);
- Pilbara Development Commission; and
- Shire of Ashburton.

Key Aboriginal Traditional Owners and communities identified and consulted in regard to the Proposal are as follows:

- Banjima Native Title Aboriginal Corporation RNTBC (BNTAC) is the native title body corporate of the Banjima People Native Title Determination area;
- Youngaleena Community; and
- Wirrilimarra Community.

The following industry stakeholder groups have been identified and consulted:

- Western Australian Chamber of Minerals and Energy;
- Chamber of Commerce and Industry;
- Regional Chambers of Commerce and Industry – Karratha, Port Hedland and Newman;
- Australian Miners and Mineral Associations;
- Association of Mining and Exploration Companies; and
- Fortescue Metals Group.
- The following key community stakeholders have been identified and consultation is ongoing:
- Mulga Downs Station;
- Mt Florance Station;
- Hooley Station; and
- Auski Munjina Roadhouse.

HPPL will continue to engage with stakeholders for the life of the Mine.

# 5 References

Table 5-1: References


| Author, year published | Title |
|---|---|
| ANZECC/ARMCANZ, | National Water Quality Management Strategy |
| AQ2, 2024 | Mulga Downs Iron Ore Mine –Troglofauna Habitat Assessment |
| AQ2, 2024 | Mulga Downs Iron Ore Mine – Stygofauna Habitat Assessment |
| AQ2, 2024 | Mulga Downs Groundwater, Surface Water & Ecohydrological Studies Baseline Assessment |
| AQ2, 2024 | Mulga Downs Groundwater, Surface Water and Ecohydrological Impact Assessment |
| HPPL, 2024 | Mulga Downs Iron Ore Mine Water Management Plan |
| AS/NZS ISO | Risk management – Principles and Guidelines |
| AS/NZS 5667 | Australian and New Zealand water quality standards i.e., Water quality - Sampling Guidance on sampling of rivers and streams (Reconfirmed 2016), and Water quality - Sampling Guidance on sampling of groundwaters (Reconfirmed 2016) |
| Bennelongia, 2024 | Mulga Downs Subterranean Fauna Survey |
| CBEC, 2024 | Mulga Downs Provisional Water Quality Triggers |
| Eberhard et al., 2005 | Stygofauna in the Pilbara region, north-west Western Australia: a review |
| Bennelongia, 2024 | Stygofauna salinity tolerances |
| EPA, 2021 | EPA Guideline: Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans. |
| GWC, 2022 | Mulga Downs Groundwater Modelling |
| Halse et al., 2014 | Pilbara stygofauna: deep groundwater of an arid landscape contains globally significant radiation of biodiversity. |
| Halse, 2018 | What does sampling tell us about the ecology of troglofauna? ARPHA Conference Abstracts 1 |
| Humphreys, 2001 | Groundwater calcrete aquifers in the Australian arid zone: the context of an unfolding plethora of stygal biodiversity |

# Appendix 1 Mulga Downs Iron Ore Mine Subterranean Fauna Habitat Assessment (AQ2, 2024 a and b)

AQ2 Pty Ltd

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# Memo

| | | | |
|---|---|---|---|
| To | Veronica Campagna | Company | JBS&G |
| From | Alex Storey / Emma Bolton | Job No. | 171Y |
| Date | 5/11/2024 | Doc No. | 505b |
| Subject | Mulga Downs Iron Ore Mine – Revised Troglofauna Habitat Assessment | | |

Veronica,

We are pleased to present our revised assessment of the potential impact on troglofauna habitat around the proposed Mulga Downs Iron Ore Mine.

## 1. INTRODUCTION

HanRoy Iron Ore Projects Pty Ltd (HanRoy) on behalf of Hancock Prospecting Pty Ltd (HPPL) is proposing to develop the Mulga Downs Iron Ore Mine (the Project) located in the Pilbara region of Western Australia, approximately 210 km south of Port Hedland. JBS&G are currently assisting HanRoy to prepare an Environmental Review Document (ERD) for the Project.

To support the initial ERD (for a 20 Mtpa Project), AQ2 completed a subterranean fauna habitat assessment in May 2022 (AQ2 ref. 371b) using Leapfrog 3D modelling software to assess the extent, continuity and volume losses of geological units potentially habitable to troglofauna.

HanRoy have recently amended the proposed Project (to a ~12 Mtpa Project), as such, the groundwater management requirements have now been revised. AQ2 have been engaged by JBS&G to assess the impacts of the currently proposed mining activities (i.e., the direct removal of habitat from mining and the reduction in habitat associated with groundwater mounding from managed aquifer recharge (MAR) by re-injection). The proposed open cut pit footprints, referenced as MDE_LOM_20_F_20240805 (MDE_LOM_20), are shown in Figure 1.1, together with the modelled (i.e. nominal) locations for MAR bores.

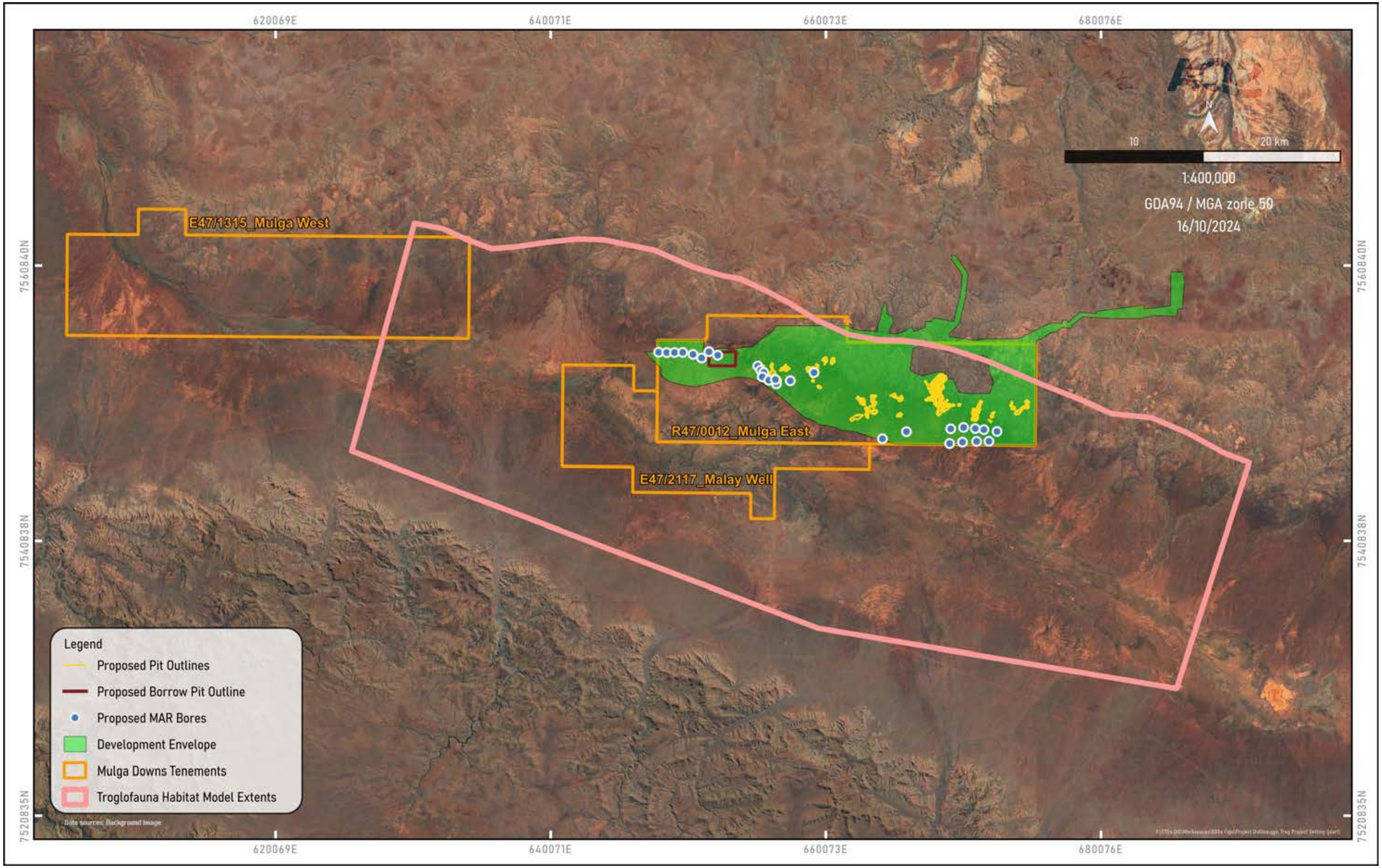



Figure 1.1 Project Outline

# 2. BACKGROUND

## 2.1 Regional Setting

The Project area is located within the Chichester Range, on the northern flanks of the Fortescue Valley. The Chichester Range comprises low-lying hills which rise approximately 30 to 40 m above the level of the river flood plain. The hills are cross-cut by narrow, steep-sided gullies, with colluvium and alluvial fans extending from the hills across the valley floor where drainages flow into the Fortescue Valley.

The bedrock within the Project area consists of south-westward dipping, northwest-southeast striking Banded Iron Formation (BIF), shale, chert and dolomite sequences of the Hamersley and Fortescue Groups (refer Table 2.1). The Jeerinah Formation and Marra Mamba Iron Formation (Marra Mamba Formation) outcrop in the Chichester Range on the northern side of the Fortescue Valley. The Marra Mamba Formation and Wittenoom Formation subcrop beneath the valley floor within Mulga Downs tenements, with the overlying Mt Sylvia and Mt McRae Shale Formations occurring to the south. The Brockman Iron Formation forms the Hamersley Range on the southern side of the Fortescue Valley.

The valley is infilled by Tertiary and Quaternary deposits. The Tertiary deposits are collectively referred as "detritals", they comprise pisolite, clay and calcrete; there is also lateritic hardcap development of Tertiary age and that may be ferricrete (goethite) and calcrete / silcrete on basement rocks. The Quaternary deposits comprise alluvium and colluvium.

The mineralisation within the Project area is primarily associated with the Nammuldi Member of the Marra Mamba Formation (that outcrops along the lower flanks of the Chichester Range), although there is also mineralisation in the overlying Tertiary detrital deposits.

Table 2.1 Regional Stratigraphic Sequence within the Project Area

| Group | Formation | Member | Lithological Description |
|---|---|---|---|
| Recent Alluvium / Colluvium | | | Unconsolidated silt, sand and gravel (clay near pans) |
| Tertiary Detritals (TD) | TD3 | | Red haematitic scree on valley sides. Increasing silt / clay content with distance from slopes / fans<br>Increasing pisolitic content with depth |
| | TD2 | | Silcrete, calcrete (Oakover Formation), Channel Iron Deposit (CID), mottled clay |
| ?* | ?* | Pinjan Chert | Siliceous sediment with alternating laminated chert |
| Hamersley Group | Wittenoom Formation | Bee Gorge Member | Graphitic shale with minor sequences of carbonate, chert, volcaniclastic rock and Banded Iron Formation (BIF) |
| | | Paraburdoo Member | Dolomite with minor amounts of chert and shale |
| | | West Angela Member | Dolomite, dolomitic / manganese-rich shale, BIF and chert |
| | Marra Mamba Iron Formation | Mt Newman Member | BIF with minor shale |
| | | MacLeod Member | Shale, chert and BIF |
| | | Nammuldi Member | BIF, chert and shale |
| Fortescue Group | Jeerinah Formation | Roy Hill Shale Member | Dark grey to black graphitic shale with chert; locally pyritic |
| | | Warrie Member | Grey dolomite with inter-bedded chert (locally ferruginous), shale and mudstone |

*Age of the Pinjan Chert is uncertain

### 2.2 Previous Troglofauna Habitat Assessment

The following troglofauna habitat assessments have been completed to date:

- An initial assessment of potential troglofauna habitat was completed in 2021 (Strategen JBS&G, 2021) by comparing stratigraphy and textural core logging from diamond holes closest to where troglofauna were encountered. Subsequently, the extents of potential troglofauna habitats were assessed by compiling multiple cross sections across the Project area.
- To support the initial ERD, AQ2 completed a subterranean fauna habitat assessment in May 2022, using Leapfrog 3D modelling software. The habitat assessment utilised the existing hydrogeological model and a habitat classification framework developed in conjunction with Bennelongia Environmental Consultants (BEC).

## 3. HABITAT ASSESSMENT & MODEL DEVELOPMENT

### 3.1 Habitat Criteria

For this study, the troglofauna habitat assessment has been developed based on the following criteria:

- Troglofauna inhabit air filled voids and/or vugs within the vadose zone (above water table) of a geological environment.
- The groundwater level represents the lower limits of possible troglofauna habitat.
- The areal and vertical extent of vuggy rock (above the groundwater level) represent further limits on possible troglofauna habitat.
- Burrowing is not a characteristic of troglofauna, meaning any matrix-supported sediments, clay zones or clay filled voids will be unhabitable.

### 3.2 Data Used

The habitat assessment model was developed using Leapfrog Geo 3D modelling software (Seequent, 2022).

A range of data sets were supplied by HPPL, Bennelongia Environmental Consulting (BEC), JBS&G and Groundwater Consulting (GWC), and used in conjunction with data from AQ2's hydrogeological investigations to date (AQ2, 2024) to develop the habitat model. These data included:

- Topographic surface – used to define the topographic setting and upper boundary to the model. NASA's Shuttle Radar Topography Mission (SRTM) data was used for the Leapfrog model to be consistent with the topographic surface used in the numerical groundwater model.
- Drill hole data (including collar/lithology data and core photos) - used to identify potential habitat based on lithology and stratigraphy (i.e. where the geology may naturally include interconnected vugs and pores that could form habitat). It should be noted that no drill hole data is available outside of the HPPL tenements, therefore data outside of these areas have been inferred.
- Troglofauna sampling data - troglofauna survey/sampling results supplied by JBS&G / BEC (Ref: BEC_MULGA_SUBFAUNA_July2024_MGA94.shp), outlining drill/bore holes where troglofauna species were identified.
- "No Development" groundwater level surface supplied by GWC (Ref: PT42-NoDev_Transient Maximum.shp) – used to define the base of the potential troglofauna habitat without the influence of mining. This surface was derived from the numerical groundwater model from the maximum predicted groundwater level at any point over the modelled area, for a 17-year climate sequence to simulate the likely natural climate variability over the Project duration.
- "With Development" groundwater level surface supplied by GWC (Ref: 09-PT51_Predicted_Maximum_Heads_Over_LoM_SP61-246_Jan2027-June2042.shp) – used to define the potential extents of the habitat impacted by groundwater level changes associated with mining. This

surface, also derived from the numerical groundwater model, comprised the predicted maximum groundwater level at any point, over the proposed duration of the Project, taking into account groundwater level changes from dewatering (i.e. drawdown), MAR (i.e. mounding) and natural seasonal variations of groundwater levels. The model prediction was based on the HanRoy mine schedule referenced as MDE_LOM_20, with a 15.5 year life of mine (GWC, 2024).

- Final pit shells (LOM_20_PitDesigns.dxf) - used to define zones of potential habitat loss due to the direct removal of material.
- Proposed borrow pit outline (Borrow_Pits_20240808) – used to define zones of potential habitat loss due to direct removal of material. Note that a 3D shell of the borrow pit was not provided. As such, a volume was determined by assuming a constant 5 m depth from topography (SRTM). It should also be noted that all borrow pits proposed to be excavated outside of the habitat extents were not included in the assessment (i.e. those proposed to be excavated to the north of the Project area).

## 3.3 Lithological Groupings

On the basis of geological logging by HPPL and AQ2 (AQ2, 2024), core photos and troglofauna survey results, lithological units have been grouped based on the potential to support a troglofauna habitat. This grouping is summarised in Table 3.1 with potential habitat categories comprising non-habitat, unlikely habitat, possible habitat and likely habitat. Key points are as follows:

- Likely habitats comprise the Upper Calcrete and Channel Iron Deposits (CID) / Pisolite of the Tertiary sequence and mineralised / hydrated Marra Mamba bedrock, inclusive of the hardcap which can be very vuggy.
- Between the Upper Calcrete and CID / Pisolite is a unit of Undifferentiated Tertiary which is considered a possible habitat in areas where the clay content is lower.
- The shaley, Unmineralised Marra Mamba is considered an unlikely habitat. Although there is the potential for vugs / voids in the oxidised zone, when the results of the troglofauna surveys associated with this unit were assessed, in consultation with BEC (on 21/3/23), it was determined to be an unlikely habitat.
- The Jeerinah Formation is considered a non-habitat as it is dominated by low porosity shale.
- The lowermost Tertiary unit (the Basal Crete) and all other bedrock units with the Project area occur below the groundwater level are therefore considered non-habitats.

## 3.4 Model Boundaries

The extents of the habitat model were identified using the following:

- Laterally, the model domain was defined by the extents of all available lithological / geological data. The extent of the model is shown in Figure 1.1.
- The SRTM topographic surface was used to define the top of the model and potential habitat.
- The base of the potential habitat was defined by the maximum predicted groundwater level over the duration of the Project (i.e. No Development and With Development groundwater level surfaces described above).

### Table 3.1 Lithological Groupings with respect to Potential Troglofauna Habitats

| Habitat Stratigraphy | HPPL Geological Codes | Lithology/Member | Stratigraphy | Habitat Probability | Reasoning |
|---|---|---|---|---|---|
| Alluvium | ALU | Alluvium | Recent Alluvium / Colluvium | Unlikely Habitat | This unit typically has a clay dominant matrix with low potential for porosity. |
| Upper Calcrete | CC | Upper Calcrete | Tertiary Detritals | Likely Habitat | This unit typically has a high primary porosity. |
| Undifferentiated Sediments | ALU | Undifferentiated Sediments | | Possible Habitat | Areas of lower clay content have the potential for high porosity. |
| CID / Pisolite | CIDO, CIDW, DCL, SCR | CID / Pisolites | | Likely Habitat | CID unit is often vuggy, while pisolitic units typically have high primary porosity. |
| - | CC | Basal Crete (Calcrete / Silcrete) | | Non-Habitat | Unit always encountered below water table within project area. |
| Jeerinah | JER, JRS, JRD | Jeerinah Shale | Jeerinah Formation | Non-Habitat | Unit is dominated by shales with a low primary porosity. |
| Mineralised Marra Mamba | HNAM, HNEW, HMNAM, MNAO, TMNAM, TMAC, TMM, TNAM, OMM, HMM, ONEW, HOSAM, OMAC, TNEW, ONAM, OSAM, HMAC | Mineralised / Hydrated BIF | Marra Mamba Formation | Likely Habitat | Units likely to have enhanced secondary porosity due to weathering/mineralisation processes. |
| Shaley / Unmineralised Marra Mamba | SOMM, SMM, MM, DMM | Undifferentiated | Marra Mamba Formation | Unlikely Habitat | Vugs/voids possible down to base of oxidation but unlikely due to shale content and more localised zones enhanced porosity. |
| | MNAM, NAM, SNAM, DNAM, SONAM, FNAM | Nammuldi Member | | | |
| | SMAC, SOMAC, MAC, DMAC | MacLeod Member | | | |
| | SNEW, NEW, SONEW | Mt Newman Member | | | |
| - | - | West Angela Member | Wittenoom Formation | Unlikely Habitat | Vugs/voids possible down to base of oxidation. Unit is encountered below water table around project area. |
| - | - | Paraburdoo Member | | Non-Habitat | Units dominated by dolomite and dolomitic shales- low porosity even after weathering. Unit is encountered below water table around project area. |
| - | - | Bee Gorge Member | | | |

# 4. MODELLING RESULTS

## 4.1 Potential Habitat

Figures 4.1, 4.2 and 4.3 show geological cross-sections of the modelled distribution of potential troglofauna habitat with proposed pit outlines and modelled groundwater level surfaces. The locations of the cross sections are displayed on Figure 4.4.

Troglofauna sampling was undertaken by BEC using scrapes (near surface) and traps set at different depths within selected drillholes. It is understood that troglofauna tend to migrate within the open drill hole, meaning trap depths are not necessarily representative of the habitat location of the sampled troglofauna. Significant troglofauna species have been identified in mineral drillholes both within the extents of the proposed pit footprints and away from the areas of proposed Project development. Salient points from the habitat modelling include:

- The model indicates that the likely troglofauna habitats of Mineralised Marra Mamba and CID / Pisolite extend over much of the Chichester Range, with the CID / Pisolite continuous over the Project area and Mineralised Marra Mamba occurring as discontinuous pods associated with the mineralisation.
- The likely habitat of Upper Calcrete is modelled to exist from the western side of proposed pits, and extend south, covering much of the Fortescue Valley, and west towards the Mulga West tenement. All troglofauna samples collected toward the valley centre were from drillholes within the Upper Calcrete unit. Where the Upper Calcrete occurs below the water table (i.e. within the Fortescue Valley), troglofauna species are less likely to occur.
- The possible troglofauna habitat of Undifferentiated Tertiary extends across the entire Project area along the slopes of the Chichester Range and is continuous in nature.

## 4.2 Habitat Impact Assessment

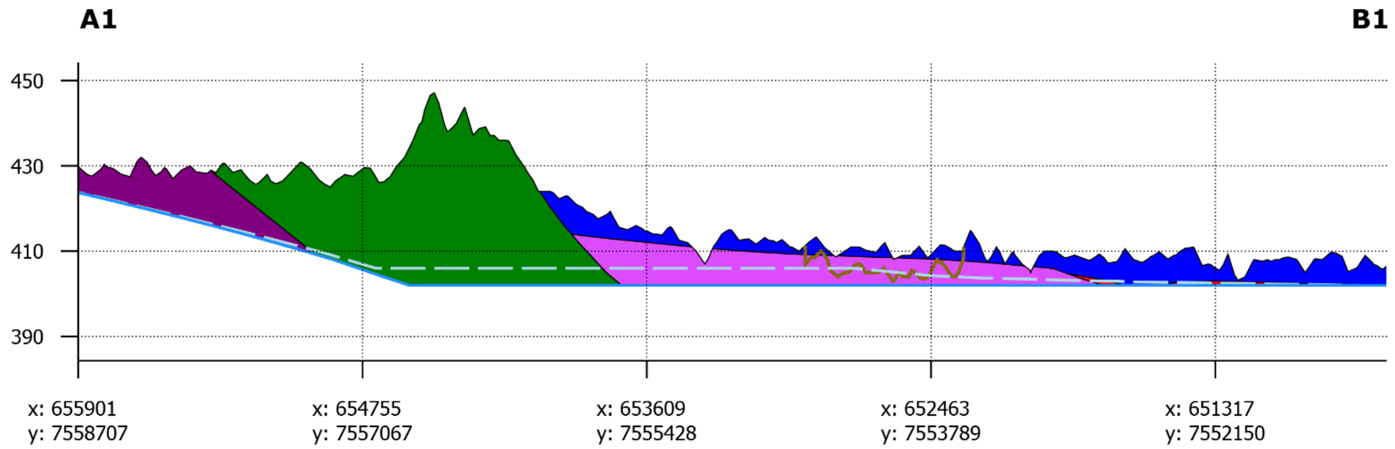
Impacts on potential troglofauna habitat resulting from mining and excavation of the borrow pit (i.e. direct removal of material) and MAR (i.e. loss of habitat due to rising groundwater levels) have been assessed as part of this study. It is understood that dewatering, and the associated changes of humidity/moisture levels in the vadose zone, also has the potential to impact troglofauna environments. However, the potential impacts associated with the lowering of the groundwater level (from dewatering) have not been assessed in this study.

Figure 4.4 shows the areal extent of potential habitat that is predicted to be impacted by mining (i.e. the proposed pit footprints) and MAR whilst Figures 4.1, 4.2 and 4.3 show the predicted impact in cross-section. Historical long-term hydrographs from the Project area (AQ2, 2024) indicate that seasonal responses to rainfall events have the potential to result in groundwater level variations of up to 1 m. As such, the predicted extent of 1 m drawup/mounding throughout the life of the Project has been used as the extent of habitat impact resulting from MAR.

Table 4.1 summarises the predicted loss of troglofauna habitat for each of the rankings of potential (i.e. Likely, Possible and Unlikely) habitat. Of the total volume of potential habitat that is predicted to be impacted (i.e., 854,497,900 m3), 13% is due to the removal of material from within the proposed pit areas and 87% is related to groundwater mounding resulting from MAR. 23% of the total predicted impact volume is within lithological units considered to be likely habitats for troglofauna, 33% for possible habitat units and the remaining 44% for unlikely habitat units.

The percentage of habitat lost for each lithological unit within the predicted area of impact has been calculated and is presented in Table 4.2. It can be seen that 37% of the likely Upper Calcrete habitat, 26% of the likely CID/Pisolite habitat and 70% of the likely Mineralised Marra Mamba within the predicted impact area is anticipated to be lost as a result of mining and MAR.

It should be noted that by using the maximum predicted groundwater level over the entire duration of the Project, it assumes the potential habitat is lost even when groundwater levels recover back to natural (no development levels). In reality, when MAR ceases either in certain areas during the life of mine or across the entire Project area at the completion of mining, groundwater levels will, over time, recover to pre-mining natural conditions, presumably allowing troglofauna habitats to re-establish. As such, the volumes of potential habitat impacted by MAR are not permanently lost and the impacted assessment results should be considered as worst-case.




## Legend

**Troglofauna Habitat Volumes**

- Alluvium (Unlikely Habitat)
- CID / Pisolite (Likely Habitat)
- Calcrete (Likely Habitat)
- Undifferentiated Tertiary (Possible Habitat)
- Jeerinah (Non-Habitat)
- Shaley / Unmineralised Marra Mamba (Unlikely Habitat)

**Surfaces**

- Proposed Borrow Pit Outline
- Modelled 'Maximum' Water Level (With Mine Development)
- Modelled 'Maximum' Water Level (No Mine Development)

## Location

A1: 655901, 7558707

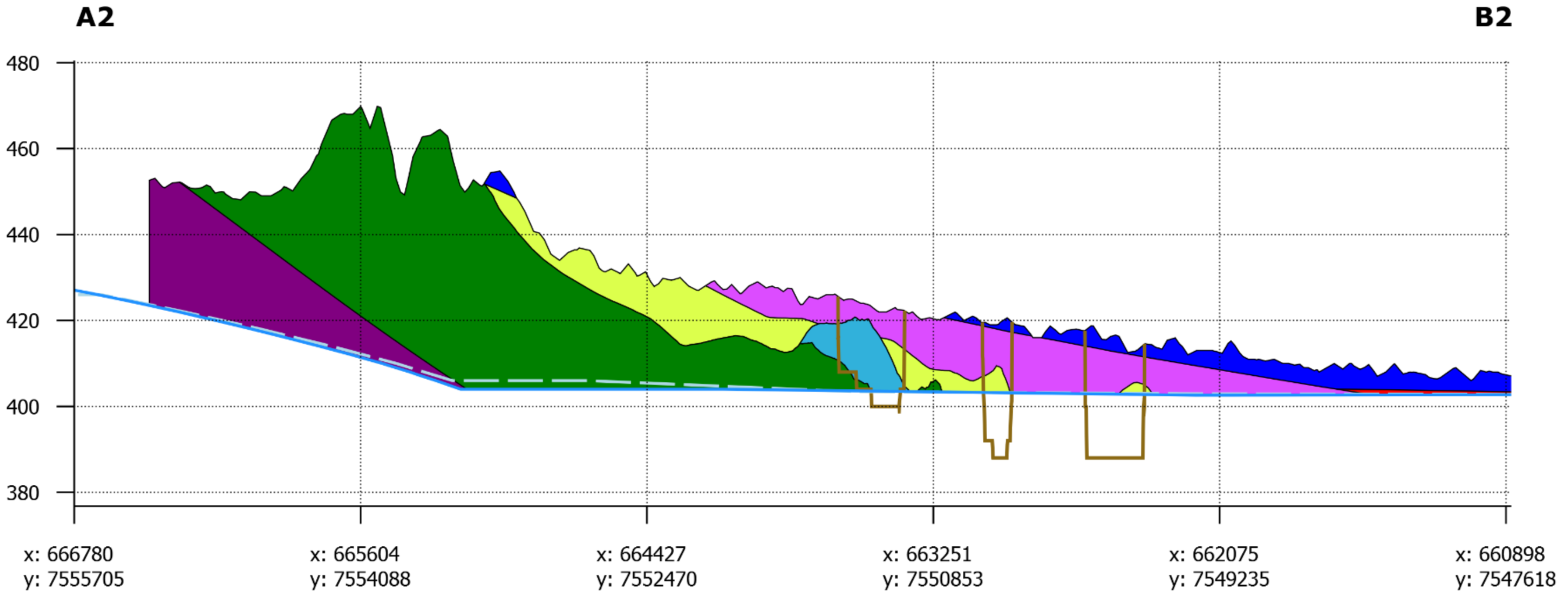
B1: 650626, 7551162

Scale: 1:41,000

Vertical exaggeration: 30x

0m 1000m

Figure 4.1 Cross Section 1




## Legend

**Troglofauna Habitat Volumes**

- Alluvium (Unlikely Habitat)
- CID / Pisolite (Likely Habitat)
- Calcrete (Likely Habitat)
- Undifferentiated Tertiary (Possible Habitat)
- Mineralised Marra Mamba (Likely Habitat)
- Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
- Jeerinah (Non-Habitat)

**Surfaces**

- Proposed Pit Outline
- Modelled 'Maximum' Water Level (With Mine Development)
- Modelled 'Maximum' Water Level (No Mine Development)

## Location

A2: 666780, 7555705

B2: 660876, 7547588

Scale: 1:41,000

Vertical exaggeration: 30x

0m 1000m

Figure 4.2 Cross Section 2

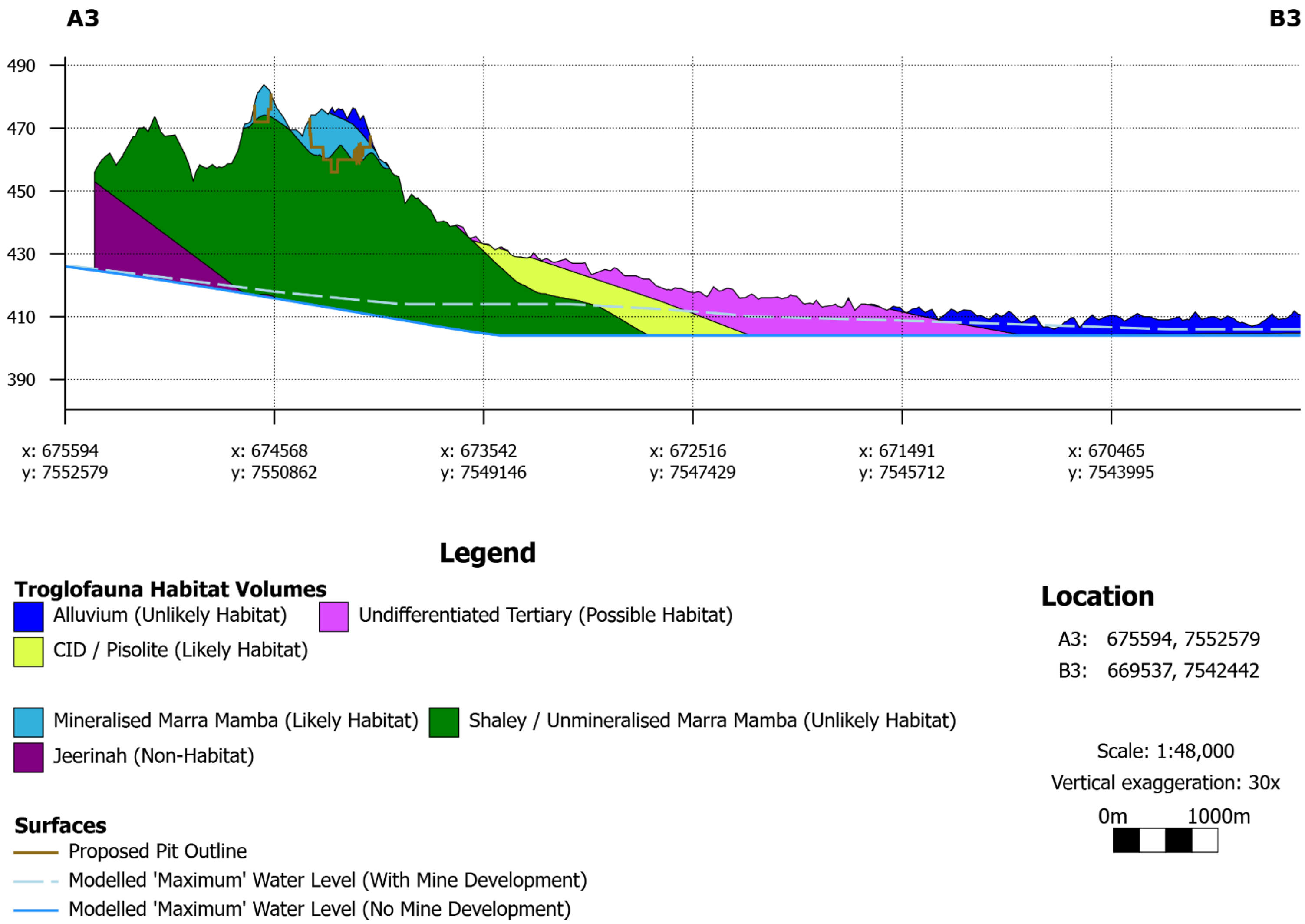



Figure 4.3 Cross Section 3

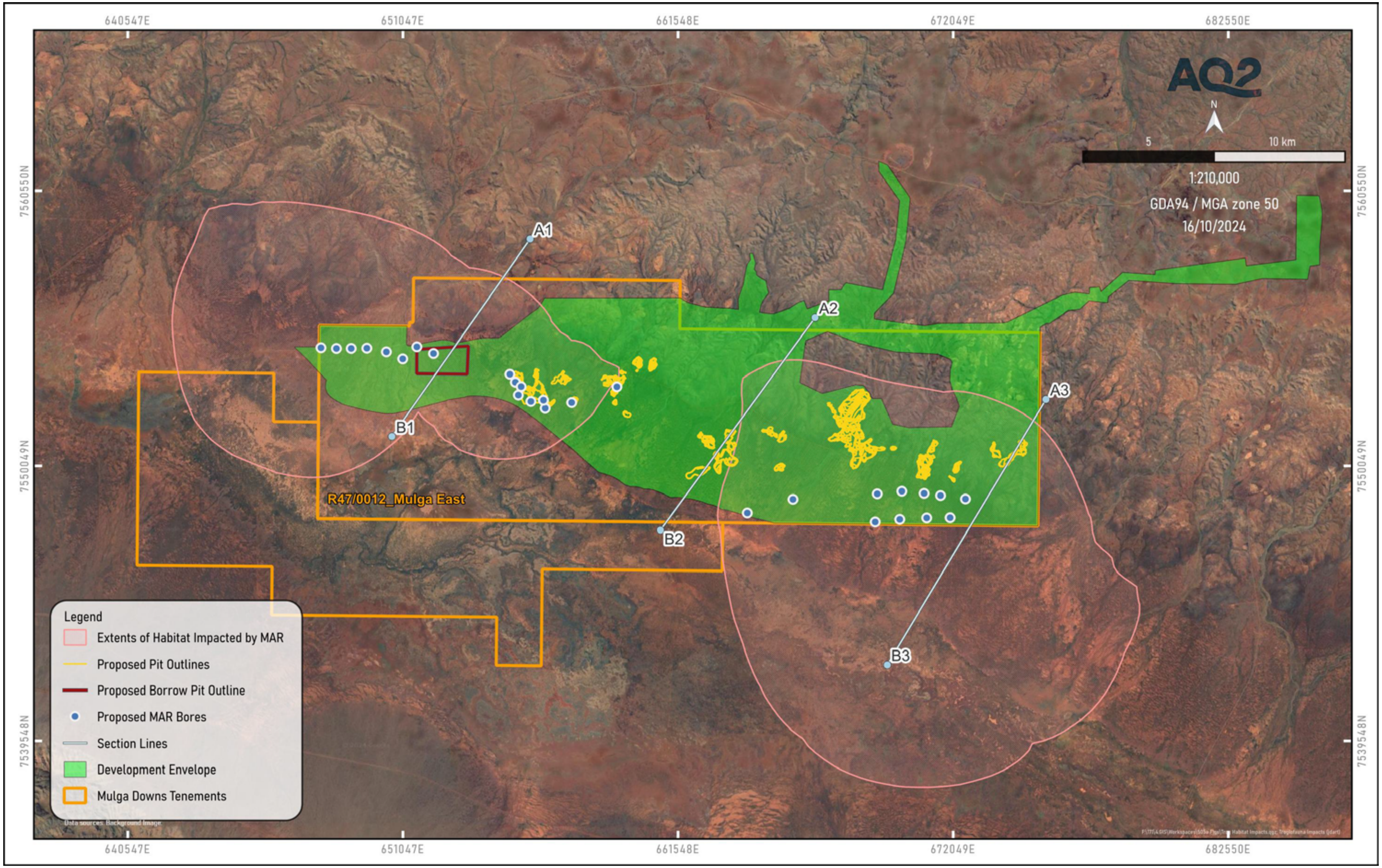



Figure 4.4 Predicted Areal Extent of Impact to Potential Troglofauna Habitat

### Table 4.1 Potential Troglofauna Habitat Loss During Mining

| Troglofauna Habitat | Habitat Likelihood | Predicted Volume Impacted by Mining ($m^3$) (Permanent Loss)[1] | Predicted Volume Impacted by MAR ($m^3$) (Temporary Impact)[2] | Total Predicted Volume Impacted ($m^3$) |
|---|---|---|---|---|
| Upper Calcrete | Likely | 374,740 | 71,185,000 | 195,127,440 |
| CID / Pisolite | | 12,275,000 | 53,598,000 | |
| Mineralised Marra Mamba | | 54,082,000 | 3,612,700 | |
| Undifferentiated Tertiary | Possible | 25,833,000 | 259,740,000 | 285,573,000 |
| Alluvium | Unlikely | 11,922,000 | 90,168,000 | 373,795,500 |
| Shaley / Unmineralised Marra Mamba | | 7,895,500 | 263,810,000 | |
| Total | | 112,382,240 | 742,113,700 | 854,495,940 |

[1] Direct (permanent) removal of material
[2] Non-permanent (temporary) impact resulting from rise in groundwater levels associated with MAR.

### Table 4.2 Predicted Percentage of Habitat Lost within the Area of Impact

| Stygofauna Habitat | Habitat Likelihood | Total Pre-mining Habitat Volume Within the Predicted Area of Impact ($m^3$) | Predicted Volume Impacted by Mining & MAR ($m^3$) | Predicted Percentage of Habitat Lost within the Area of Impact |
|---|---|---|---|---|
| Alluvium | Unlikely | 839,190,000 | 102,090,000 | 12% |
| Upper Calcrete | Likely | 193,130,000 | 71,559,740 | 37% |
| Undifferentiated Tertiary | Possible | 1,036,600,000 | 285,573,000 | 28% |
| CID / Pisolite | Likely | 255,490,000 | 65,873,000 | 26% |
| Mineralised Marra Mamba | Likely | 82,491,000 | 57,694,700 | 70% |
| Shaley / Unmineralised Marra Mamba | Unlikely | 2,178,600,000 | 271,705,500 | 12% |
| Total | | 4,585,501,000 | 854,495,940 | 19% |

## 5. SUMMARY

Based on the troglofauna surveys conducted to date and available geological / lithological logging of drillholes, potential troglofauna habitats are inferred in several lithological units within the Project area. These units are areally extensive and continuous over a wide area.

A Leapfrog model has been developed to assess the potential loss of troglofauna habitat caused by both the removal of material from within the proposed pit footprints and from the predicted mounding of groundwater associated with MAR, noting that the impacts from MAR do not result in a permanent loss of habitat as groundwater levels will, over time, return to pre-mining conditions.

Regards,

*Alex Storey*

Hydrogeologist

*Emma Bolton*

Consulting Hydrogeologist

Author: ATS (5/11/24)
Checked: EJB (5/11/24)
Reviewed: EJB (5/11/24)

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# Memo

| | | | |
|---|---|---|---|
| To | Veronica Campagna | Company | JBS&G |
| From | Alex Storey / Emma Bolton | Job No. | 171Y |
| Date | 18/12/2024 | Doc No. | 508d |
| Subject | Mulga Downs Iron Ore Mine – Stygofauna Habitat Assessment | | |

Veronica,

We are pleased to present our assessment of the potential impact on stygofauna habitat around the proposed Mulga Downs Iron Ore Mine.

## 1. INTRODUCTION

HanRoy Iron Ore Projects Pty Ltd (HanRoy) on behalf of Hancock Prospecting Pty Ltd (HPPL) is proposing to develop the Mulga Downs Iron Ore Mine (the Project) located in the Pilbara region of Western Australia, approximately 210 km south of Port Hedland. JBS&G are currently assisting HanRoy to prepare an Environmental Review Document (ERD) for the ~12 Mtpa Project, with subterranean fauna identified as a key environmental factor to be assessed under Part IV of the *Environmental Protection Act 1986*.

AQ2 have been engaged by JBS&G to complete a subterranean fauna habitat assessment using Leapfrog 3D modelling software to assess:

- The extent and continuity of geological units that are potentially habitable to stygofauna.
- The losses in stygofauna habitat resulting from groundwater level drawdown associated with dewatering.

The proposed open cut pit footprints, referenced as MDE_LOM_20_F_20240805 (MDE_LOM_20), are shown in Figure 1.1, together with the modelled (i.e. nominal) locations for dewatering bores.

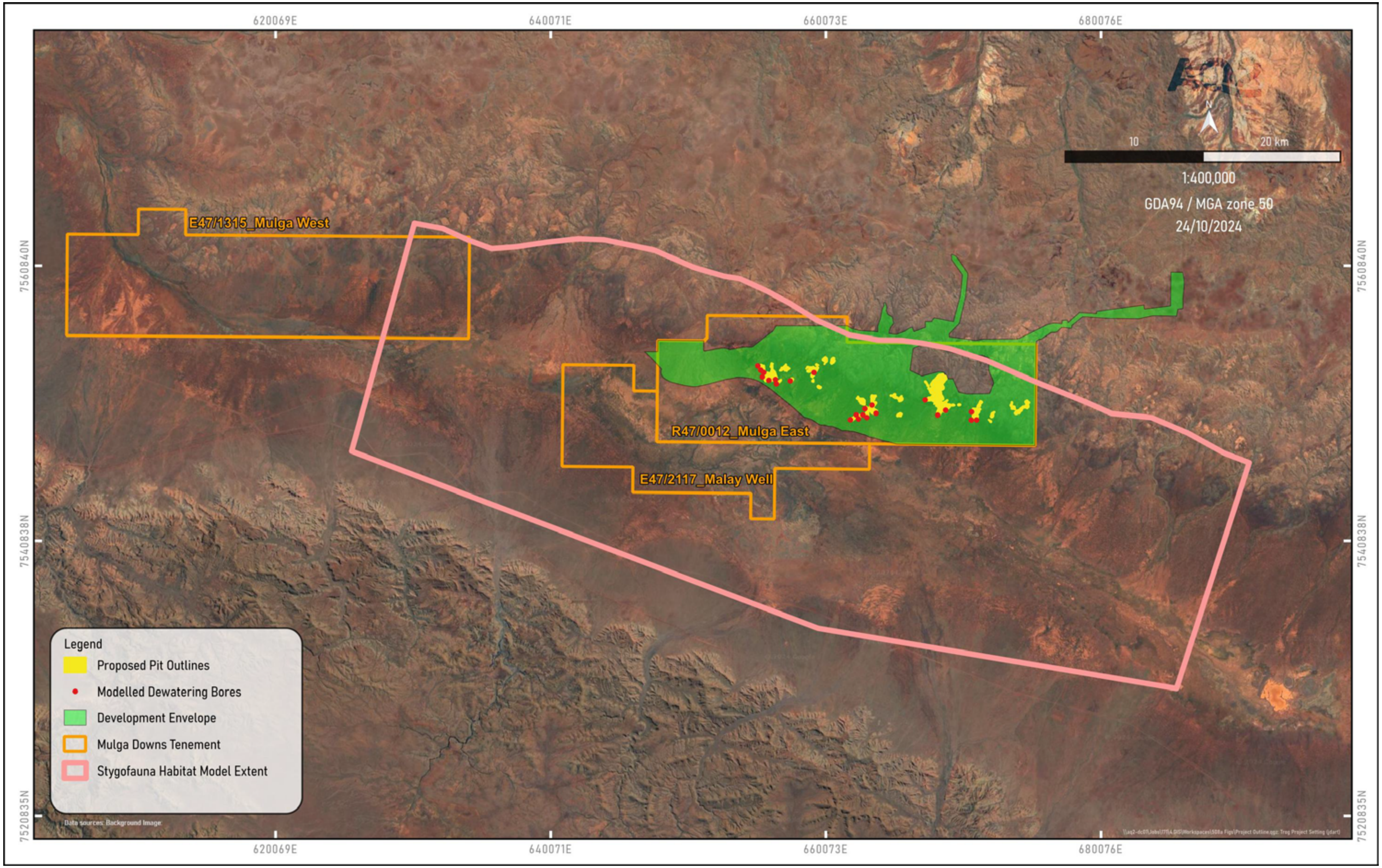



Figure 1.1 Project Outline

# 2. BACKGROUND

## 2.1 Regional Setting

The Project area is located within the Chichester Range, on the northern flanks of the Fortescue Valley. The Chichester Range comprises low-lying hills which rise approximately 30 to 40 m above the level of the river flood plain. The hills are cross-cut by narrow, steep-sided gullies, with colluvium and alluvial fans extending from the hills across the valley floor where drainages flow into the Fortescue Valley.

The bedrock within the Project area consists of south-westward dipping, northwest-southeast striking Banded Iron Formation (BIF), shale, chert and dolomite sequences of the Hamersley and Fortescue Groups (refer Table 2.1). The Jeerinah Formation and Marra Mamba Iron Formation (Marra Mamba Formation) outcrop in the Chichester Range on the northern side of the Fortescue Valley. The Marra Mamba Formation and Wittenoom Formation subcrop beneath the valley floor within Mulga Downs tenements, with the overlying Mt Sylvia and Mt McRae Shale Formations occurring to the south. The Brockman Iron Formation forms the Hamersley Range on the southern side of the Fortescue Valley.

The valley is infilled by Tertiary and Quaternary deposits. The Tertiary deposits are collectively referred as "detritals", they comprise pisolite, clay and calcrete; there is also lateritic hardcap development of Tertiary age and that may be ferricrete (goethite) and calcrete / silcrete on basement rocks. The Quaternary deposits comprise alluvium and colluvium.

The mineralisation within the Project area is primarily associated with the Nammuldi Member of the Marra Mamba Formation (that outcrops along the lower flanks of the Chichester Range), although there is also mineralisation in the overlying Tertiary detrital deposits.

### Table 2.1 Regional Stratigraphic Sequence within the Project Area

| Group | Formation | Member | Lithological Description |
|---|---|---|---|
| Recent Alluvium / Colluvium | | | Unconsolidated silt, sand and gravel (clay near pans) |
| Tertiary Detritals (TD) | TD3 | | Red haematitic scree on valley sides. Increasing silt / clay content with distance from slopes / fans<br>Increasing pisolitic content with depth |
| | TD2 | | Silcrete, calcrete (Oakover Formation), Channel Iron Deposit (CID), mottled clay |
| ?* | ?* | Pinjan Chert | Siliceous sediment with alternating laminated chert |
| Hamersley Group | Wittenoom Formation | Bee Gorge Member | Graphitic shale with minor sequences of carbonate, chert, volcaniclastic rock and Banded Iron Formation (BIF) |
| | | Paraburdoo Member | Dolomite with minor amounts of chert and shale |
| | | West Angela Member | Dolomite, dolomitic / manganese-rich shale, BIF and chert |
| | Marra Mamba Iron Formation | Mt Newman Member | BIF with minor shale |
| | | MacLeod Member | Shale, chert and BIF |
| | | Nammuldi Member | BIF, chert and shale |
| Fortescue Group | Jeerinah Formation | Roy Hill Shale Member | Dark grey to black graphitic shale with chert; locally pyritic |
| | | Warrie Member | Grey dolomite with inter-bedded chert (locally ferruginous), shale and mudstone |

*Age of the Pinjan Chert is uncertain

# 3. HABITAT ASSESSMENT & MODEL DEVELOPMENT

## 3.1 Habitat Criteria

For this study, the stygofauna habitat assessment has been developed based on the following criteria:

- Stygofauna inhabit permeable/porous material within the phreatic zone (below water table) of a geologic environment.
- The water table represents the upper limits of possible stygofauna habitat.
- The permeable/porous material (below water table) represent further limits on possible stygofauna habitats.

## 3.2 Data Used

The habitat assessment model was developed using Leapfrog Geo 3D modelling software (Seequent, 2022).

A range of data sets were supplied by HPPL, Bennelongia Environmental Consulting (BEC), JBS&G and Groundwater Consulting (GWC), and used in conjunction with data from AQ2's hydrogeological investigations to date (AQ2, 2024) to develop the habitat model. These data included:

- Topographic surface – used to define the topographic setting and upper boundary to the model. NASA's Shuttle Radar Topography Mission (SRTM) data was used for the Leapfrog model to be consistent with the topographic surface used in the numerical groundwater model.
- Drill hole data (including collar/lithology data and core photos) - used to identify potential habitat based on lithology and stratigraphy (i.e. where the geology may naturally include interconnected vugs and pores that could form habitat). It should be noted that no drill hole data is available outside of the HPPL tenements, therefore data outside of these areas have been inferred.
- Stygofauna sampling data - stygofauna survey/sampling results supplied by JBS&G / BEC (Ref: SubFauna_2008_2023_240214_stygo.shp), outlining drill/bore holes where stygofauna species were and were not identified.
- "No Development" groundwater level surface supplied by GWC (Ref: PT42-NoDev_Transient Minimum.shp) – used to define the base of the potential stygofauna habitat without the influence of mining. This surface was derived from the numerical groundwater model from the minimum predicted groundwater level at any point over the modelled area, for a 22-year climate sequence to simulate the likely natural climate variability over the Project duration.
- "With Development" groundwater level surface supplied by GWC (Ref: 08-PT51_Predicted_Minimum_Heads_Over_LoM_SP61-246_Jan2027-June2042.shp) – used to define the potential extents of the habitat impacted by groundwater level changes associated with mining. This surface, also derived from the numerical groundwater model, comprised the predicted minimum groundwater level at any point, over the proposed duration of the Project, taking into account groundwater level changes from dewatering (i.e. drawdown), MAR (i.e. mounding) and natural seasonal variations of groundwater levels. The model prediction was based on the HanRoy mine schedule referenced as MDE_LOM_20, with a 15.5 year life of mine (GWC, 2024).

## 3.3 Lithological Groupings

On the basis of geological logging by HPPL and AQ2 (AQ2, 2024), core photos and stygofauna survey results, lithological units have been grouped based on the potential to support a stygofauna habitat. This grouping is summarised in Table 3.1 with potential habitat categories comprising non-habitat, unlikely habitat, possible habitat and likely habitat. It should be noted that the classifications of habitat potential presented below differ slightly to those identified by BEC (2024); as they are based only on lithological characterisation, with no consideration of the depth of the unit below the water table, as this may be variable across the Project area. For example, on the valley slopes, the CID/Pisolite occurs at shallower depths below the water table than in the valley areas. Key points regarding the assessment of the lithological units as potential stygofauna habitats are as follows:

- Likely habitats comprise the Upper Calcrete and Channel Iron Deposits (CID) / Pisolite units of the Tertiary sequence and mineralised / hydrated Marra Mamba bedrock, inclusive of the hardcap which can be very vuggy.
- Between the Upper Calcrete and CID / Pisolite is a unit of Undifferentiated Tertiary which is considered a possible habitat in areas where the clay content is lower.
- The lowermost Tertiary unit (the Basal Crete) is also considered a possible habitat. It is variable in both composition and nature but can be brecciated, weathered and / or vuggy.
- The shaley, Unmineralised Marra Mamba is considered an unlikely habitat. Although there is the potential for vugs / voids in the oxidised zone, the same habitat potential as has been adopted for the previous troglofauna habitat assessment, in consultation with BEC (on 21/3/23), has been assigned to this unit. Given the shaley nature of the West Angela Formation, but the potential for mineralisation or vugs / voids in the oxidised zones this unit has also been identified as an unlikely habitat.
- The Jeerinah Formation is considered a non-habitat as it is dominated by low porosity shale.
- Other bedrocks units are not impacted by the predicted drawdown.

## 3.4 Model Boundaries

The extents of the habitat model were identified using the following:

- Laterally, the model domain was defined by the extents of numerical groundwater model, with lithological / geological data inferred outside of the HPPL tenement boundaries. The extent of the model is shown in Figure 1.1.
- The top of the potential habitat was defined by the minimum predicted groundwater level, over the LOM duration, with No Development.
- An RL of 320 m defines the base of the model. As the sampling methods for stygofauna does not allow for the determination of the specific depth of the stygofauna occurrence (refer Section 4.1), the base of the potential habitat has not been defined.

Table 3.1 Lithological Groupings with respect to Potential Stygofauna Habitats

| Habitat Stratigraphy | HPPL Geological Codes | Lithology/Member | Stratigraphy | Habitat Probability | Reasoning |
|---|---|---|---|---|---|
| Alluvium | ALU | Alluvium | Recent Alluvium / Colluvium | Unlikely Habitat | This unit typically has a clay dominant matrix with low potential for porosity. Where drill data is available it predominantly occurs above the water table |
| Upper Calcrete | CC | Upper Calcrete | Tertiary Detritals | Likely Habitat | This unit typically has a high primary porosity. |
| Undifferentiated Sediments | ALU | Undifferentiated Sediments | | Possible Habitat | Areas of lower clay content have the potential for high porosity. |
| CID / Pisolite | CIDO, CIDW, DCL, SCR | CID / Pisolites | | Likely Habitat | CID unit is often vuggy, while pisolitic units typically have high primary porosity. |
| Basal Crete | CC | Basal Crete (Calcrete / Silcrete) | | Possible | Unit always encountered below water table within project area. |
| Jeerinah | JER, JRS, JRD | Jeerinah Shale | Jeerinah Formation | Non-Habitat | Unit is dominated by shales with a low primary porosity. |
| Mineralised Marra Mamba | HNAM, HNEW, HMNAM, MNAO, TMNAM, TMAC, TMM, TNAM, OMM, HMM, ONEW, HOSAM, OMAC, TNEW, ONAM, OSAM, HMAC | Mineralised / Hydrated BIF | Marra Mamba Formation | Likely Habitat | Units likely to have enhanced secondary porosity due to weathering/mineralisation processes. |
| Shaley / Unmineralised Marra Mamba | SOMM, SMM, MM, DMM | Undifferentiated | Marra Mamba Formation | Unlikely Habitat | Vugs/voids possible down to base of oxidation but unlikely due to shale content and more localised zones enhanced porosity. |
| | MNAM, NAM, SNAM, DNAM, SONAM, FNAM | Nammuldi Member | | | |
| | SMAC, SOMAC, MAC, DMAC | MacLeod Member | | | |
| | SNEW, NEW, SONEW | Mt Newman Member | | | |
| West Angela Member | - | West Angela Member | Wittenoom Formation | Unlikely Habitat | Vugs/voids possible down to base of oxidation. |
| - | - | Paraburdoo Member | | Non-Habitat | Units dominated by dolomite and dolomitic shales- low porosity even after weathering. Unit is not impacted by drawdown. |
| - | - | Bee Gorge Member | | | |

# 4. MODELLING RESULTS

## 4.1 Potential Habitat

Figures 4.1 to 4.4 show geological cross-sections of the modelled distribution of potential stygofauna habitat with proposed pit outlines and modelled groundwater level surfaces. The locations of the cross sections are displayed on Figure 4.5.

Stygofauna sampling was undertaken by BEC by means of net hauls (BEC, 2024). The method involves a phreatic net being hauled from the base of the sampled drillholes / bores, with collection throughout the entire water column. As such, the depth that the stygofauna occupied at the time of collection is unknown. Unless a bore is screened over a certain interval, assumptions regarding the depth of the collected stygofauna are made based on subterranean ecology. Below a certain depth (~30 to 40 m below the water table), low carbon and nutrient inputs are expected to severely limit the occurrence of subterranean fauna (Halse et al., 2014). The geological cross-sections (Figures 4.1 to 4.4) therefore show a depth of 30 m below the predicted minimum No Development groundwater level to indicate the "preferential conditions" above this level.

Stygofauna species have been identified in drillholes / bores both within the extents of the proposed pit footprints and away from the areas of proposed Project development. Salient points from the habitat modelling include:

- The likely stygofauna habitat of Upper Calcrete is continuous unit that occurs to the south of the proposed mining area and extends both across the Fortescue Valley and along the strike of the valley.
- The model indicates that the likely stygofauna habitats of Mineralised Marra Mamba and CID / Pisolite extend over much of the Chichester Range, with the CID / Pisolite continuous over the Project area and Mineralised Marra Mamba occurring as discontinuous pods associated with the mineralisation.
- The possible stygofauna habitat of Undifferentiated Tertiary is both continuous and extensive, covering both the lower slopes of the Chichester Range and extending across the Fortescue Valley.
- The possible stygofauna habitat of Basal Crete is continuous across the Fortescue Valley area, although generally occurs at depths in excess of 30 m below the water table.

As documented in AQ2's Baseline Assessment Report (AQ2, 2024), hydraulic connection between the different lithological / hydrostratigraphic units is evident both laterally (from the groundwater level contours) and vertically (from the cluster bore data and limited clay / low permeability horizons). Vertical gradients (and reduced hydraulic connection) are only evident at a few cluster and paired bore locations where saprolitic clays or thin intervals of more clayey Tertiary materials are present. On an area wide scale, it is likely the valley aquifers are in vertical hydraulic connection, with local areas of separation caused by low permeability intermediating units (such as the saprolitic clay).

## 4.2 Habitat Impact Assessment

Impacts on potential stygofauna habitat resulting from mining (i.e. loss of habitat due to direct removal of material) and dewatering (i.e. loss of habitat due to lowering groundwater levels) have been assessed as part of this study. Although, the disposal of excess dewatering discharge via managed aquifer recharge (MAR), by reinjection, may provide additional stygofauna habitat, this has not been assessed in the study. The only influence of MAR included in the study, is its limiting effect on the predicted drawdown.

Figure 4.5 shows the areal extent of potential habitat that is predicted to be impacted by mining activities (proposed pit outlines) and dewatering. Historical long-term hydrographs from the Project area (AQ2, 2024) indicate that seasonal responses to rainfall events have the potential to result in groundwater level variations of up to 1 m. As such, the predicted extent of the 1 m drawdown contour, throughout the life of the Project, has been used to define the extent of habitat impact.

The predicted loss of stygofauna habitat for each of the rankings of potential (i.e. Likely, Possible and Unlikely) habitat is presented in Table 4.1. Of the total volume of potential habitat that is predicted to be impacted (i.e., 1,686,509,590 m3), 30% of the total predicted impact volume is within the lithological unit considered to be a likely habitat for stygofauna, 26% for possible habitat units and the remaining 44% for unlikely habitat units.

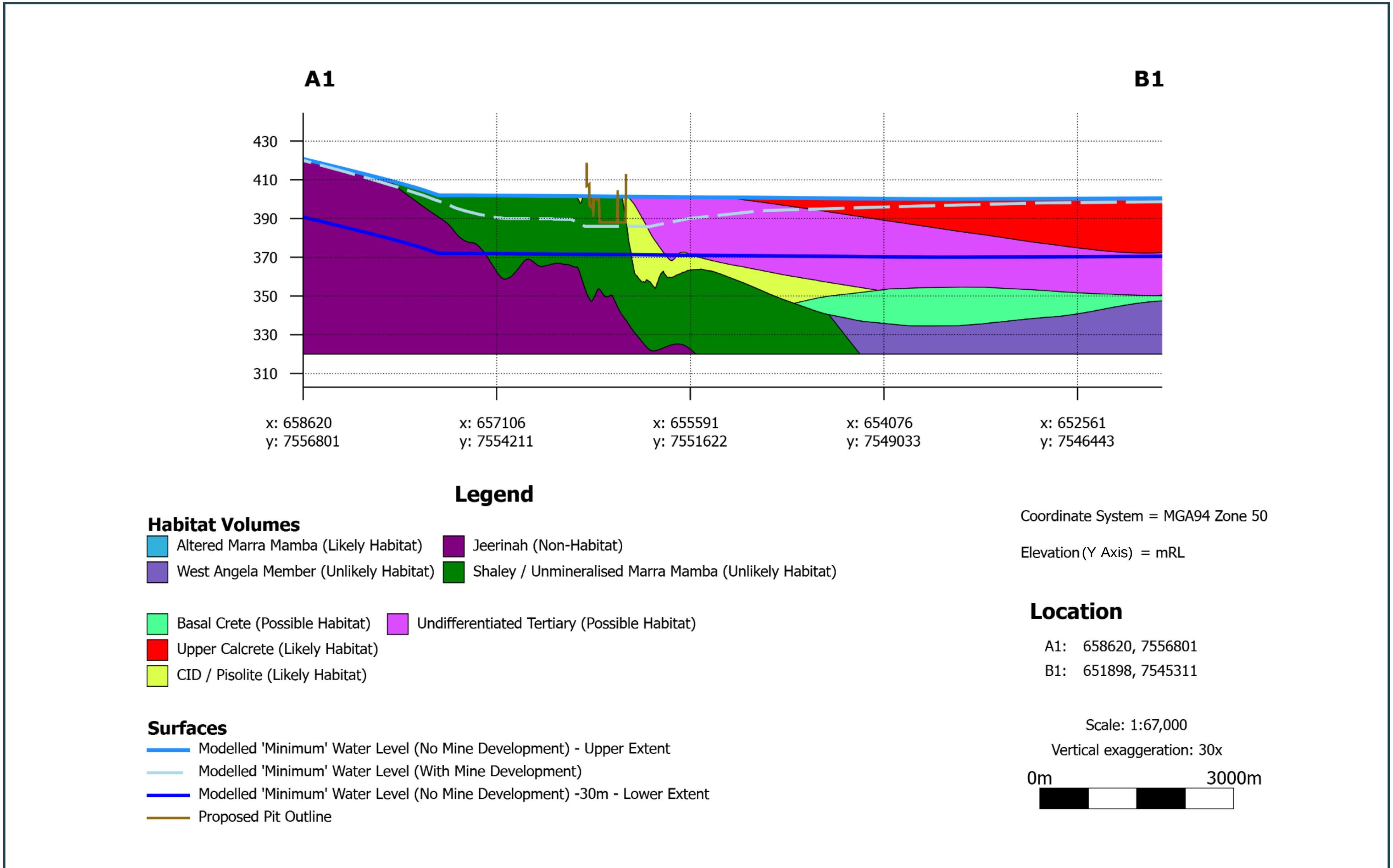
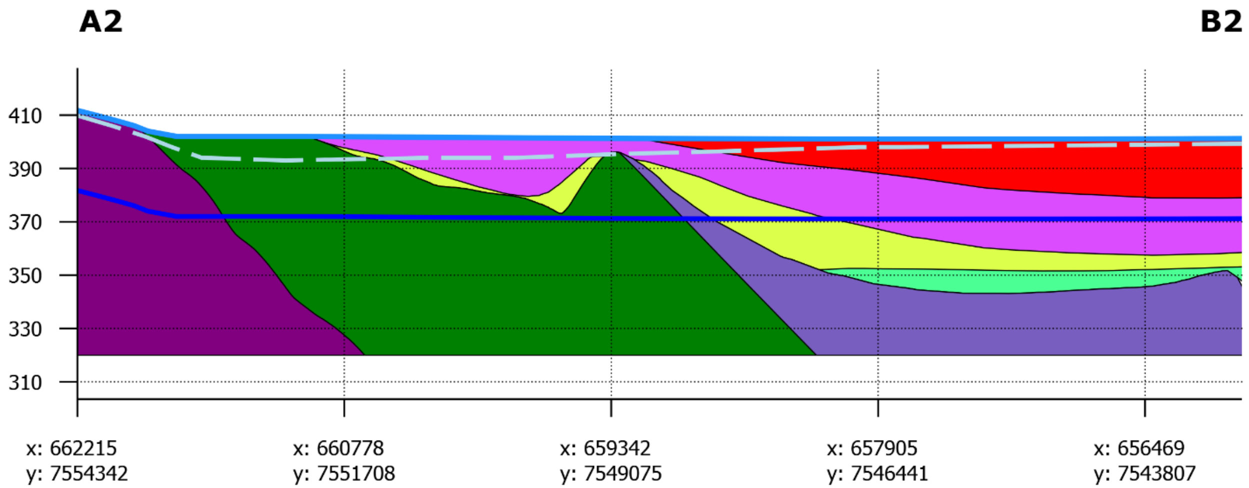



Figure 4.1 Cross Section 1




## Legend

**Habitat Volumes**

- West Angela Member (Unlikely Habitat)
- Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
- Jeerinah (Non-Habitat)
- Basal Crete (Possible Habitat)
- Undifferentiated Tertiary (Possible Habitat)
- Upper Calcrete (Likely Habitat)
- CID / Pisolite (Likely Habitat)

**Surfaces**

- Modelled 'Minimum' Water Level (No Mine Development) - Upper Extent
- Modelled 'Minimum' Water Level (With Mine Development)
- Modelled 'Minimum' Water Level (No Mine Development) -30m - Lower Extent

Coordinate System = MGA94 Zone 50

Elevation (Y Axis) = mRL

**Location**

A2: 662215, 7554342

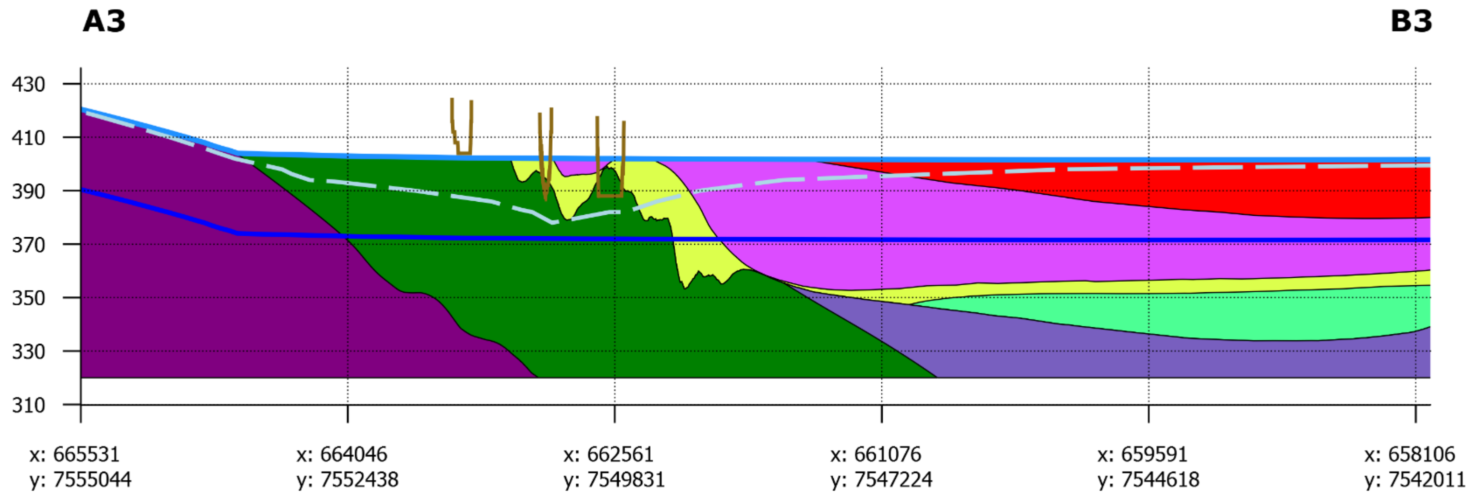
B2: 655947, 7542850

Scale: 1:67,000

Vertical exaggeration: 30x

0m 3000m

Figure 4.2 Cross Section 2




## Legend

**Habitat Volumes**

- West Angela Member (Unlikely Habitat)
- Shaley / Unmineralised Marra Mamba (Unlikely Habitat)
- Jeerinah (Non-Habitat)
- Basal Crete (Possible Habitat)
- Undifferentiated Tertiary (Possible Habitat)
- Upper Calcrete (Likely Habitat)
- CID / Pisolite (Likely Habitat)

**Surfaces**

- Modelled 'Minimum' Water Level (No Mine Development) - Upper Extent
- Modelled 'Minimum' Water Level (With Mine Development)
- Modelled 'Minimum' Water Level (No Mine Development) -30m - Lower Extent
- Proposed Pit Outline

Coordinate System = MGA94 Zone 50

Elevation (Y Axis) = mRL

## Location

A3: 665531, 7555044

B3: 658023, 7541866

Scale: 1:67,000

Vertical exaggeration: 30x

0m 3000m

Figure 4.3 Cross Section 3

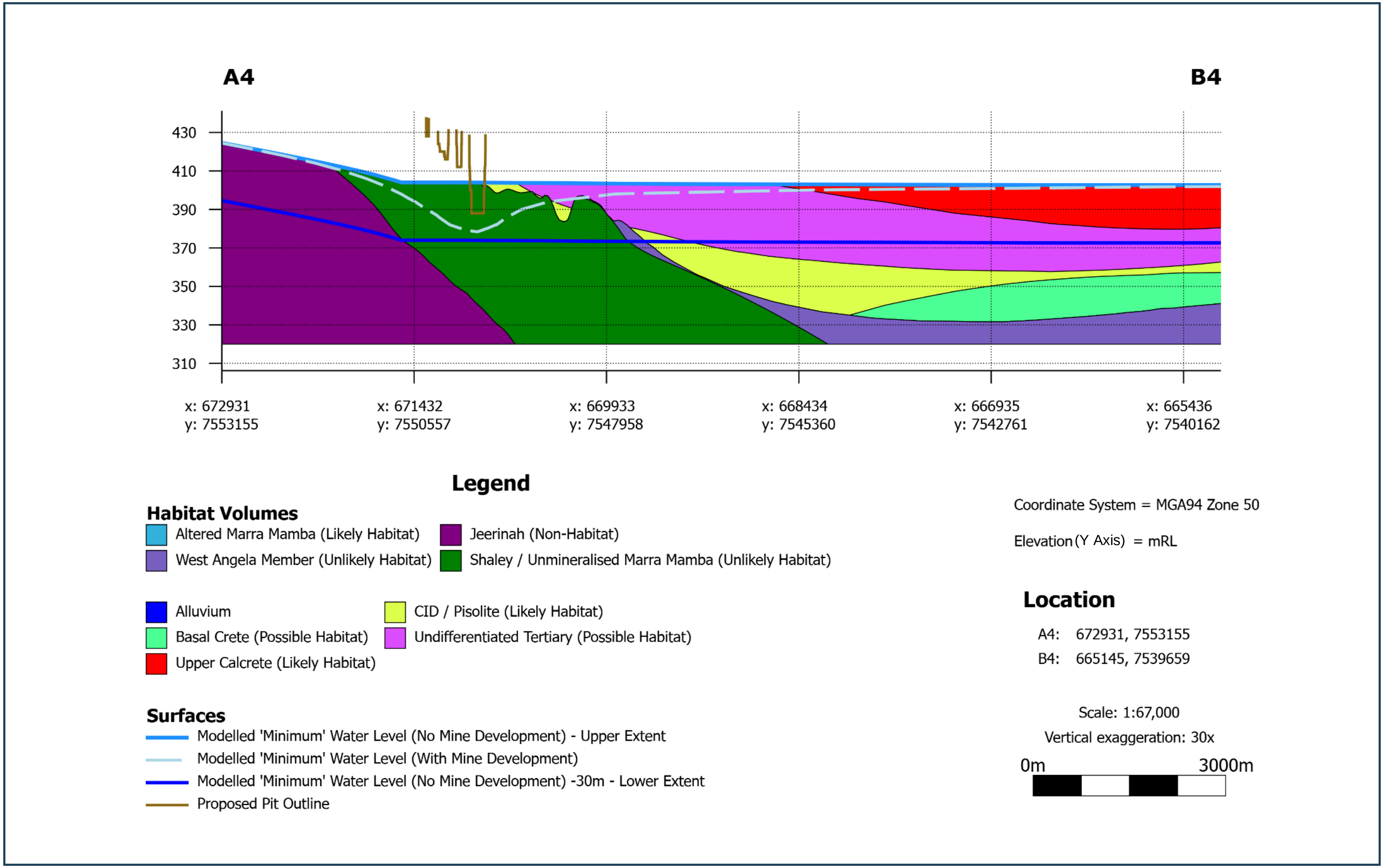



Figure 4.4 Cross Section 4

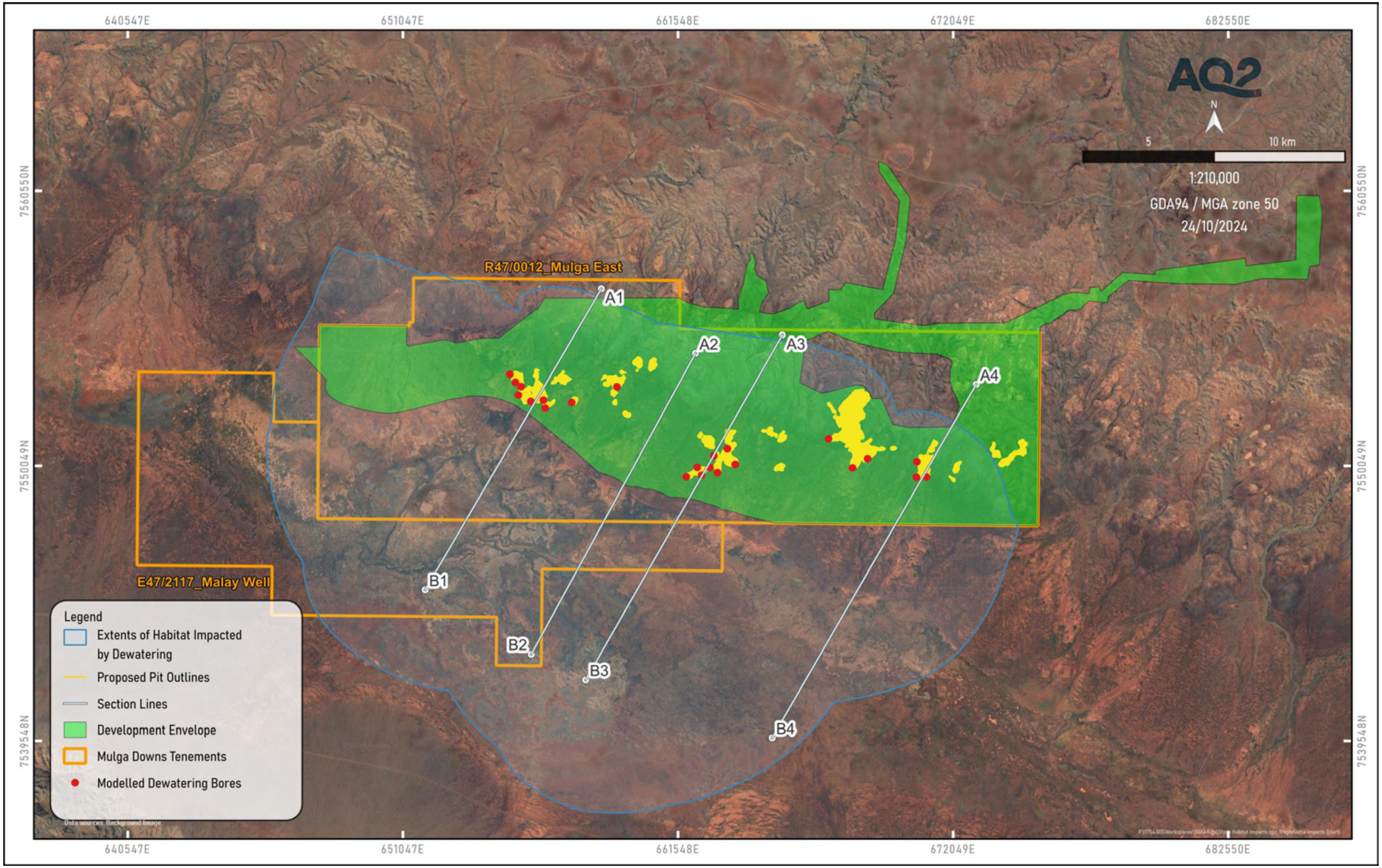



Figure 4.5 Predicted Areal Extent of Impact to Potential Stygofauna Habitat

For the Tertiary units, with a defined base, the percentage of habitat lost within the predicted area of impact has been calculated and is presented in Table 4.2. It should be noted that the percentage of habitat lost within the area of impact can not be calculated for the bedrock units (i.e. Mineralised Marra Mamba, Shaley / Unmineralised Marra Mamba and West Angela Member) as the base of these units extends below the model domain, meaning that a total 'static' (unimpacted) volume can not be determined.

From Table 4.2, it can be seen that only 16% of the likely Upper Calcrete habitat and 4% of the likely CID/Pisolite habitat within the predicted impact area is anticipated to be lost as a result of dewatering. This is because, despite the areal extent of predicted drawdown, the vertical loss of potential habitat is minimal in the valley areas, away from the immediate mining / dewatering areas, as shown in the cross-sections (Figures 4.1 to 4.4). The cross-sections also show that much of the zone of "preferential conditions" (i.e. the 30 m thick zone below the No Development groundwater level) remains as a potential habitat despite dewatering drawdown.

The proposed pit voids will be backfilled after mining. Although the backfill material has the potential to allow stygofauna to reinhabit the pit areas, it is assumed that impacts relating to the direct removal of material are permanent in nature. Conversely, when dewatering ceases, groundwater levels will, over time, recover to pre-mining natural conditions, presumably allowing stygofauna habitats to re-establish. As such, the volumes of potential habitat impacted by dewatering are not permanently lost and the impact assessment results should be considered as worst-case.

### Table 4.1 Potential Stygofauna Habitat Loss During Mining

<table>
<tr><th>Stygofauna Habitat</th><th>Habitat Likelihood</th><th>Predicted Volume Impacted by Mining ($m^3$) (Permanent Loss)[1]</th><th>Predicted Volume Impacted by Dewatering ($m^3$) (Temporary Impact)[2]</th><th>Total Predicted Volume Impacted ($m^3$)</th></tr>
<tr><td>Upper Calcrete</td><td rowspan="3">Likely</td><td>0</td><td>556,380,000</td><td rowspan="3">670,449,100</td></tr>
<tr><td>CID / Pisolite</td><td>3,273,500</td><td>109,496,500</td></tr>
<tr><td>Mineralised Marra Mamba</td><td>550,280</td><td>748,820</td></tr>
<tr><td>Undifferentiated Tertiary</td><td rowspan="2">Possible</td><td>1,415,200</td><td>481,514,800</td><td rowspan="2">482,930,000</td></tr>
<tr><td>Basal Crete</td><td>0</td><td>0</td></tr>
<tr><td>Alluvium</td><td rowspan="3">Unlikely</td><td>0</td><td>3,776</td><td rowspan="3">533,134,266</td></tr>
<tr><td>West Angela Member</td><td>11,438</td><td>79,052</td></tr>
<tr><td>Shaley / Unmineralised Marra Mamba</td><td>13,937,000</td><td>519,103,000</td></tr>
<tr><td>Total</td><td></td><td>19,187,418</td><td>1,667,325,948</td><td>1,686,513,366</td></tr>
</table>

[1] Permanent impact resulting from direct removal of habitat associated with extracting ore.
[2] Non-permanent (temporary) impact resulting from drawdown in groundwater levels associated with dewatering.

### Table 4.2 Predicted Percentage of Habitat Lost within the Area of Impact

| Stygofauna Habitat | Habitat Likelihood | Total Pre-mining Habitat Volume Within the Predicted Area of Impact ($m^3$) | Predicted Volume Impacted by Dewatering ($m^3$) | Predicted Percentage of Habitat Lost within the Area of Impact |
|---|---|---|---|---|
| Alluvium | Unlikely | 3,776 | 3,776 | 100% |
| Upper Calcrete | Likely | 3,554,200,000 | 556,380,000 | 16% |
| Undifferentiated Tertiary | Possible | 7,687,100,000 | 482,930,000 | 6% |
| CID / Pisolite | Likely | 2,978,200,000 | 112,770,000 | 4% |
| Basal Crete | Possible | 2,151,500,000 | 0 | 0% |
| Total | | 16,371,003,776 | 1,152,083,776 | 10% |

## 5. SUMMARY

Based on the stygofauna surveys conducted to date and available geological / lithological logging of drillholes, potential stygofauna habitats are inferred in several lithological units within the Project area. These units are areally extensive and continuous over a wide area.

A Leapfrog model has been developed to assess the potential loss of stygofauna habitat that results from the direct removal of material associated with mining, and predicted drawdown of groundwater levels associated with dewatering. Impacts from mining are assumed to be permanent, while impacts from dewatering are non-permanent as groundwater levels will, over time, return to pre-mining conditions.

Regards,

Alex Storey

Hydrogeologist

Emma Bolton

Consulting Hydrogeologist

Author: ATS (18/12/24)
Checked: EJB (18/12/24)
Reviewed: EJB (18/12/24)

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# Appendix 2 Salinity Tolerance Desktop Assessment (BEC, 2024)

Memo 675
For: JBS&G/HanRoy
Author: Stuart Halse
20 October 2024

# Salinity tolerance of stygofauna at Mulga Downs Iron Ore Mine

## Introduction

The Mulga Downs Iron Ore Mine (MDIOM) project proposed by Hancock Prospecting Pty Ltd (HPPL) consists of a series of above and below-water table, open mine pits and associated infrastructure to support the production of up to 12 million tonnes of iron ore per annum over a 30 year period. Dewatering will be required to support the open pit mining. It is proposed that when the volume of dewatering exceeds operational water demands, excess water will be disposed of by the injection of groundwater into deeper aquifers at the MDIOM, a process referred to as managed aquifer recharge (MAR). Groundwater reinjection usually results in a rise in the watertable around the sites of injection, even when injecting into deep aquifers. This is referred to as 'groundwater mounding'. The process usually also increases salinity in the surficial aquifer where the mounding occurs. For the purpose of this memo, groundwater mounding is considered to occur where there has been a rise of >1m in the water table and groundwater drawdown to occur where there has been a decline due to abstraction of >2m.

This memo considers the likely upper salinity tolerances of the nine stygofauna species known only from the areas of expected groundwater mounding of >1m at the two planned areas of MAR (Table 1). One of the MAR areas is mostly to the west of the proposed mine pits and the other is at the eastern end of the MDIOM Development. Three sections of the MAR areas are expected to have significant increase in salinity. These are named Murray's West MAR, Valley Near Murray's Hill and DB1 Far East in Figure 1. All three areas contain potentially restricted species (Table 1).

Over the total life of the MDIOM, there is substantial overlap of the areas of MAR and groundwater drawdown (Figure 1) as a result of sequential project development. The groundwater to be reinjected in MAR areas will come from nearby parts of the MDIOM as mine pits are dewatered during mining. All nine species being considered in relation to MAR will also experience groundwater drawdown. Some of the species also occur at sites where they will experience only drawdown (Table 1). The surveys during which the species were collected are described in Bennelongia (2023).

## Current Groundwater Salinity

The depth to water table across the MDIOM varies from approximately 3 m to10 m below ground level (mbgl). Mapping of current salinities in the first metre below the water table is provided in Figure 1. Within the mapped area, salinity ranges from 60 mg/L to approximately 10,800 mg/L total dissolved solids (TDS). Salinities are highest in the valley areas of the MDIOM, with a mound of saline groundwater originating from the overlying claypans and fresher groundwater occurring on the valley sides. As such, on the edges of the saline mound, there is a halocline, usually at a depth between 40 mbgl and 80 mbgl, with salinities usually being 20,000-30,000 mg/L at 120 mbgl (Figure 2).

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**Table 1**. Numbers of sites where 'restricted 'species from drawdown areas were recorded.

| Species | Murray's West | Near Murray's Hill | DB1_Far East | Central Drawdown |
|---|---|---|---|---|
| **Oligochaeta** | | | | |
| *Achaeta* sp. | | 1 | 1 | 1 |
| **Hydracarina** | | | | |
| *Guineaxonopsis* sp. B03 | 1 | | 1 | |
| **Ostracoda** | | | | |
| *Areacandona* 'BOS1381' | | 1 | | 1 |
| **Syncarida** | | | | |
| *Pilbaranella* 'MH1' | | 2 | 1 | |
| *Pilbaranella* 'MH2' | | 1 | | |
| *Pilbaranella* 'sp. B18 | | 1 | | |
| *Atopobathynella* sp. B09 | | | 2 | |
| nr *Billibathynella* 'MH2' | | 3 | 2 | |
| Parabathynellidae 'MH3' | | 1 | | |

Note that in text and tables, salinity is expressed in mg/L total dissolved solids (TDS) while Figure 1 and Appendix 2 use electrical conductivity (µS/cm) as the unit of salinity. Units of µS/cm can be multiplied by 0.6 for approximate conversion to mg/L TDS (see Williams 1986).

### Stygofauna Salinity Tolerance

Salinity classification for aquatic invertebrates generally recognizes three broad classes of salinity tolerance, with two freshwater categories (Williams 1964; Hammer 1986):

- 'freshwater' species in salinity<3,000 mg/L TDS,
  - true freshwater species in salinity <500 mg/L (uncommon in Western Australia except perhaps the Kimberley),
  - oligohaline species in salinity of 500 – 3,000 mg/L (typical of most 'freshwater' species in Western Australia),
- hyposaline species in salinity 3,000-20,000 mg/L (many are much less tolerant), and
- saline species in salinity >20,000 mg/L.

These salinity categories are an attempt to characterize species according to physiology but they are approximate and many species will have occurrences in the salinity ranges of more than one category

Information on salinity tolerances of Pilbara stygofauna species is provided below. Using Bennelongia's database of stygofauna collected since 2007 and the results of the Pilbara Biological Survey (Halse *et al*. 2014), the mean, minimum and maximum salinity of occurrence was extracted for all Pilbara stygofauna having at least four records of occurrence accompanied by salinity measurements. As a general summary, apart from worms for which there is quite a lot of ecological uncertainty, approximately 83% of species have mean salinity occurrences of <1,800 mg/L. A further 7% have mean salinity tolerances below 3,000 mg/L.

The potentially restricted worm species, *Achaeta* sp., belongs to the family Enchytraeidae and is conventionally regarded as aquatic (or stygofauna if below ground) but may be more correctly treated as amphibious. All three records at the MDIOM were collected in troglofauna scrapes. The salinity tolerance of the species is not considered further.

Eighty-nine of the 110 ostracod species with at least four occurrences associated with salinity values belong to the family Candonidae. All but seven species have mean salinity occurrences of <1,800 mg/L, with the other seven having mean occurrence of <5,500 mg/L. All but four of the 21 non-candonid ostracods have mean salinity occurrences of <1,800 mg/L, with the remaining species having mean occurrences of <2,500 mg/L. The median ratio of maximum salinity to mean salinity for ostracods is 1.8 (range 1.0-7.3).

Many species of syncarid have been collected from the Pilbara but they are usually represented by few records and only 27 species (belonging to the families Bathynellidae and Parabathynellidae) have at least four salinity records. Syncarids also mostly have small ranges and six of the nine potentially restricted species at the MDIOM are syncarids. All have mean salinity occurrences of <1,800 mg/L. The median ratio of maximum salinity to mean salinity for syncarids is 1.4 (range1.1-14.0), which suggests that even small numbers of records probably provide a reasonably accurate guide to the upper salinity tolerance of syncarids.

Only five species of Hydracina have at least four occurrences associated with salinity values. Four of these have mean salinity occurrences of <1,800 mg/L. The other species has a mean salinity occurrence of 2,500 mg/L. The median ratio of maximum salinity to mean salinity for Hydracina, for which there are few records, is 1.8 (range 1.5-2.8).

### Stygofauna at MDIOM

The likely salinity tolerances for eight potentially restricted species of stygofauna (excluding *Achaeta* sp.) were calculated by multiplying the mean observed salinity of each species by the median ratio of maximum salinity to mean salinity for the appropriate taxonomic group (e.g. syncarids).

Based on sampling results, three of the potentially restricted species at the MDIOM (all syncarids) are inferred to be true freshwater species with upper salinity tolerances of <500 mg/L (Table 2), four species (three syncarids and the water mite) are inferred to have upper salinity tolerances of 500-1500 mg/L, and the single potentially restricted ostracod species has an inferred upper salinity tolerance (3,101 mg/L) just beyond the 'freshwater' range.

**Table 2**. Observed salinity occurrence and inferred salinity tolerance, together with types of impact, for 'restricted' stygofauna species.

Salinity values mg/L TDS. *, Inferred upper salinity tolerance (see text). ‡, used maximum observed.

| Species | Mean salinity | Maximum salinity | Minimum salinity | *Inferred upper salinity tolerance |
|---|---|---|---|---|
| **Oligochaeta** | | | | |
| *Achaeta* sp. | - | - | - | - |
| **Hydracarina** | | | | |
| *Guineaxonopsis* sp. B03 | 406 | 719 | 92 | 731 |
| **Ostracoda** | | | | |
| *Areacandona* 'BOS1381' | 1723 | 2394 | 1052 | 3101 |
| **Syncarida** | | | | |
| *Pilbaranell*a 'MH1' | 197 | 257 | 110 | 276 |
| *Pilbaranella* 'MH2' | 1066 | - | - | 1492 |
| *Pilbaranella* sp. B18 | 155 | - | - | 217 |
| *Atopobathynella* sp. B09 | 73 | 92 | 54 | 102 |
| nr *Billibathynella* 'MH2' | 589 | 1049 | 110 | 1049‡ |
| Parabathynellidae 'MH3' | 632 | - | - | 885 |

### Discussion

The inferred upper salinity tolerances of the eight potentially restricted stygofauna species were estimated using a formal methodology that is likely to be accurate for most species collected from a large number of sites. However, the species in Table 2 were collected from few sites (1-5) and in such circumstances the inferred upper salinity tolerance of species may be underestimated for some species. At the same time, in agreement with values in Table 2, there is broad-based information suggesting more than 80% of Pilbara stygofauna species have mean occurrence of <1,800 mg/L.

*Implications*
AQ2 (*in litt*.) predicts that the weighted average salinity of groundwater abstracted at the MDIOM will periodically reach 3,000 mg/L through the life of the mine. Under one porosity scenario, it will reach 4,200 mg/L during the first half of mine life.

It is also predicted that most of the MAR area will, on average, experience relatively small salinity increases of approximately 500 mg/L (AQ2 *in litt*.). However, at Murray's West (which supports only one record of *Guineaxonopsis* sp. B03 (S01 group) salinity is expected to increase by 2,550 mg/L. to 3,800 mg/L. The resultant salinity exceeds the inferred upper salinity tolerance of *Guineaxonopsis* sp. B03 (S01 group).

At Valley Near Murray's Hill, salinity is predicted to increase 1000 mg/L from 3,600 to 4,600 mg/L, although the salinity contours and the salinities at which species were recorded show that current salinity in most of the area, except to the south, is considerably lower than 3,600 mg/L,. Even *Areacandona* 'BOS1831', the most salt tolerant of the eight restricted species with an estimated upper tolerance of 3101, is unlikely to tolerate the predicted salinity increase at Valley Near Murray's Hill, although salinity at particular sites may remain lower than suggested by the broad salinity predictions available. The other six species recorded at Valley Near Murray's Hill have inferred salinity tolerances of 217-1,492 mg/L.

At DB1 Far East, salinity is expected to increase by 1,300 mg/L from 1,400 to 2,700 mg/L. The one species collected only from DB1 Far East, *Atopobathynella* sp. B09, has an inferred upper salinity tolerance of 102 mg/L and is highly unlikely to persist at 2,700 mg/L. One of the other species occurring at DB1 Far East (as well as Velley Near Murray's Hill) is also unlikely to persist, with the inferred upper salinity tolerance of *Pilbaranella* 'MH1' being 276 mg/L. The second species, nr *Billibathynella* 'MH2' with an upper salinity tolerance of 1,049 mg/L will probably also not persist, although it is not a robust prediction.

## References


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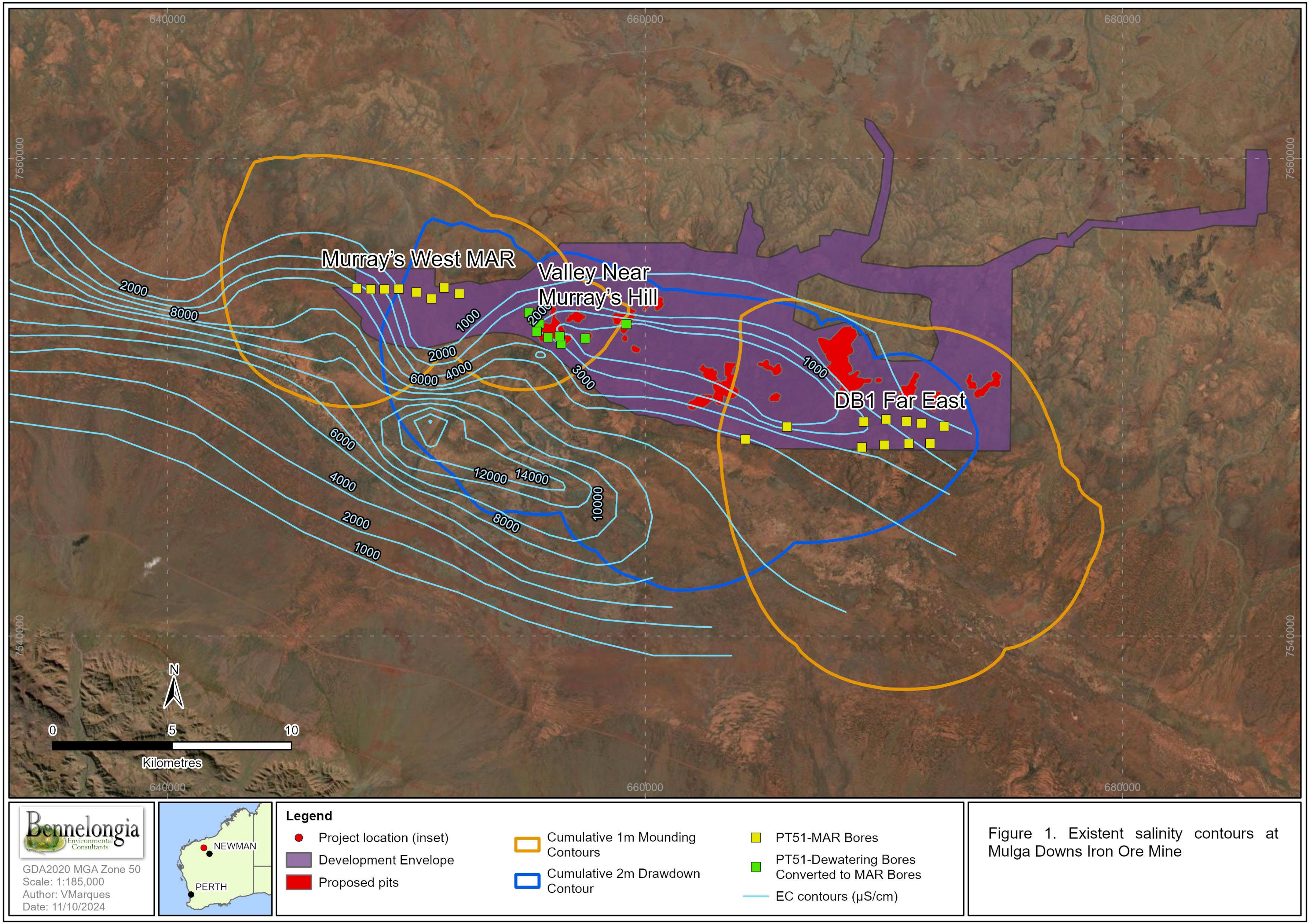


Figure 1. Existent salinity contours at Mulga Downs Iron Ore Mine

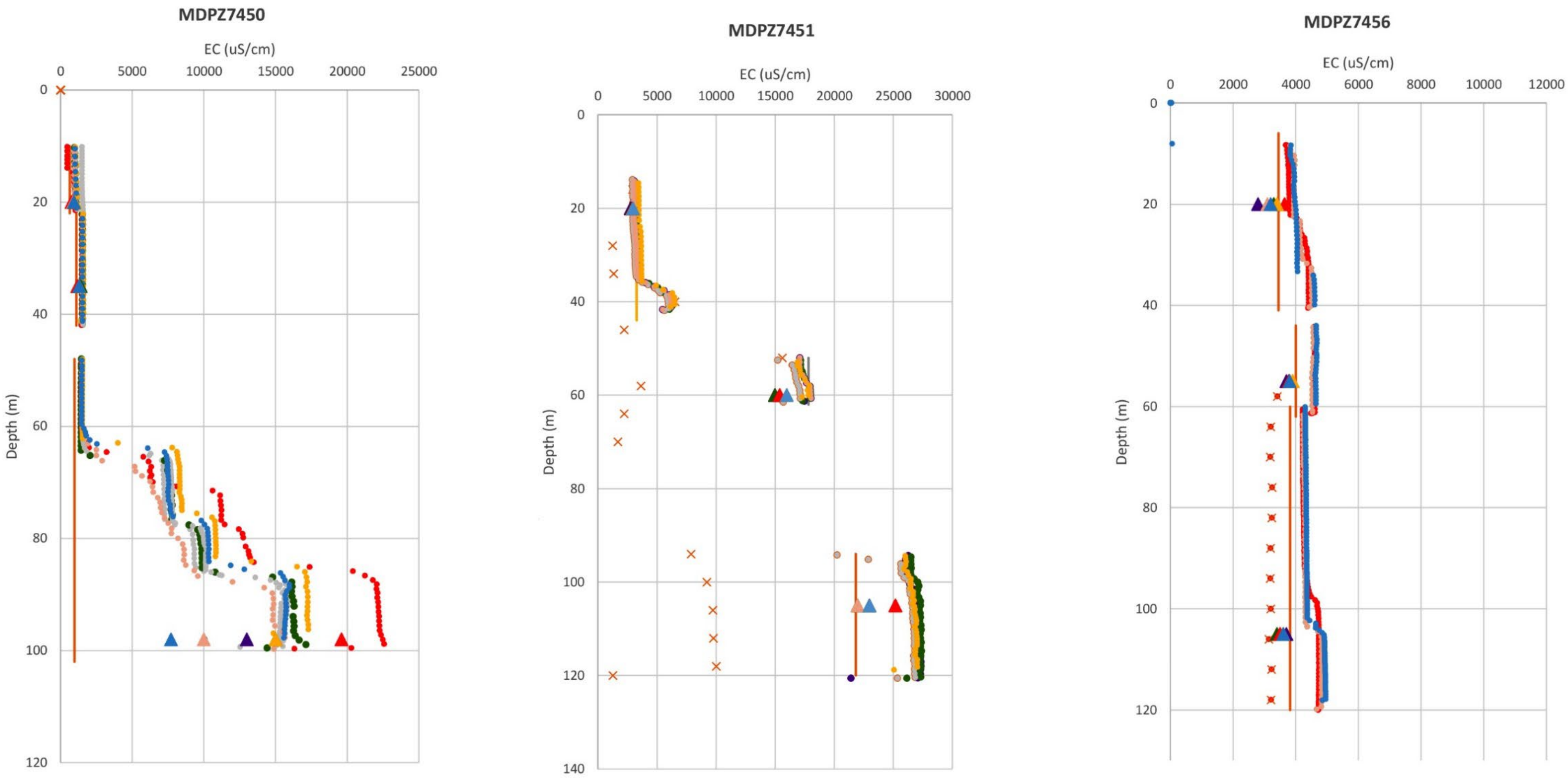


**Figure 2.** Salinity profiles (µS/cm) of three MDIOM bores (data from AQ2).

AQ2

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**Appendix 2. Locations and salinity (as µS/cm EC) records for the nine potentially restricted species and associated salinity contours (µS/cm).**

Note that some species names shortened from database versions (this has been done in text as well)..

| Bore | Latitude | Longitude | Species | EC | Contours |
|---|---|---|---|---|---|
| MD2971 | -22.14915 | 118.54551 | Achaeta sp. | - | - |
| MD3394 | -22.1489 | 118.65496 | Achaeta sp. | | - |
| MD0901 | -22.10535 | 118.5048 | Achaeta sp. | - | - |
| Robinsons Well | -22.1646 | 118.56882 | Areacandona `BOS1381` | 3990 | 4000-6000 |
| MD0462 | -22.12218 | 118.51367 | Areacandona `BOS1381` | 1754 | 1000-2000 |
| md_kar7 | -22.1366 | 118.6353 | Atopobathynella sp. B09 (Para'`MH1`) | 89.4 | 1000-2000 |
| MD0429 | -22.1593 | 118.6515 | Atopobathynella sp. B09 (Para'`MH1`) | 153.2 | 2000-3000 |
| MD0429 | -22.1593 | 118.6515 | Guineaxonopsis sp. B03 (S01 group) | 153.2 | 2000-3000 |
| Hesters Bore | -22.1059 | 118.4670 | Guineaxonopsis sp. B03 (S01 group) | 1158 | <1000 |
| Hesters Bore | -22.1059 | 118.4670 | Guineaxonopsis sp. B03 (S01 group) | 1199 | <1000 |
| Hesters Bore | -22.1059 | 118.4670 | Guineaxonopsis sp. B03 (S01 group) | 1242 | <1000 |
| md_kar6 | -22.1489 | 118.6534 | nr Billibathynella `MH2` (Para'`MH2`) | 183.4 | 1000-2000 |
| MD0509 | -22.1190 | 118.5256 | nr Billibathynella `MH2` (Para'`MH2`) | 485.7 | 1000-2000 |
| MD0533 | -22.1176 | 118.5266 | nr Billibathynella `MH2` (Para'`MH2`) | 796 | 1000-2000 |
| MD0533 | -22.1176 | 118.5266 | nr Billibathynella `MH2` (Para'`MH2`) | 812 | 1000-2000 |
| MD0509 | -22.1190 | 118.5256 | nr Billibathynella `MH2` (Para'`MH2`) | 1006 | 1000-2000 |
| MD0562 | -22.1252 | 118.5079 | nr Billibathynella `MH2` (Para'`MH2`) | 1163 | 2000-3000 |
| MD0396 | -22.1612 | 118.6785 | nr Billibathynella `MH2` (Para'`MH2`) | 1720 | 1000-2000 |
| MD0396 | -22.1612 | 118.6785 | nr Billibathynella `MH2` (Para'`MH2`) | 1748 | 1000-2000 |
| MD0525 | -22.11422 | 118.51489 | Parabathynellidae `MH3` | 1054 | 1000-2000 |
| md_kar6 | -22.1489 | 118.6534 | Pilbaranella `MH1` | 183.4 | 1000-2000 |
| MD0499 | -22.1154 | 118.5046 | Pilbaranella `MH1` | 371.9 | 2000-3000 |
| MD0499 | -22.1154 | 118.5046 | Pilbaranella `MH1` | 376.2 | 2000-3000 |
| MD0577 | -22.1048 | 118.5074 | Pilbaranella `MH1` | 428.7 | <1000 |
| MD0577 | -22.1048 | 118.5074 | Pilbaranella `MH1` | 1555 | <1000 |
| MD0462 | -22.12218 | 118.51367 | Pilbaranella `MH2` | 1776 | 1000-2000 |
| MD0974 | -22.11325 | 118.53701 | Pilbaranella sp. B18 | 258 | 1000-2000 |