Miralga Creek:

Subterranean Fauna Assessment

Biologic Environmental Survey

Report to Atlas Iron Limited

February 2020

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GLOSSARY

BC Act	*Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
DBCA	Department Biodiversity, Conservation and Attractions
EPA	Western Australian Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
PEC	Priority Ecological Communities
SRE	Short-range Endemic
TEC	Threatened Ecological Communities
WAM	Western Australian Museum

EXECUTIVE SUMMARY

Atlas Iron Pty Ltd (Atlas) proposes to develop the Miralga Creek Project, located approximately 100 km south-east of Port Hedland in the Pilbara bioregion of Western Australia. The Project comprises five satellite pits in three separate orebodies; Miralga East, Miralga West and Sandtrax. The Project involves mining above the water table and will be supplied with water from existing borefields in the area. Biologic Environmental Survey (Biologic) was commissioned by Atlas to undertake a two-season Level 2 subterranean fauna survey within the Miralga Creek Project. The survey was designed and conducted in accordance with relevant EPA guidelines for subterranean fauna assessments, and sampling included a balanced mix of sites in proposed impact areas as well as reference (non-impact) sites. The survey aimed to provide a comprehensive assessment of all subterranean species and habitats occurring within the Study Area and immediate surrounds and assess the potential risks to subterranean species and habitats from the proposed developments at the Miralga Creek Project.

No previous subterranean fauna sampling has been undertaken within the Study Area. The nearest subterranean fauna survey was conducted 4 km south-east of the Study Area at Sulphur Springs which detected a diverse stygofauna assemblage in the alluvial aquifer systems associated with the upper catchment tributaries of the East Strelley and Shaw Rivers. In contrast, only one species of troglofauna was recorded, a subterranean *Nocticola* cockroach. Database searches revealed seven troglofauna (including potential troglofauna) taxa belonging to four taxonomic groups, and 55 stygofauna (including potential stygofauna) taxa from 12 taxonomic groups within 40 km of the Study Area. None of the troglofauna or stygofauna taxa recorded from the database searches were recorded within the Study Area.

The current survey sampled a total of 148 bores and holes throughout all prospects within the Study Area, resulting in 292 troglofauna samples (151 trapping, 138 scraping and 3 root samples respectively) and 110 stygofauna samples (96 net-hauls, 10 Karamans, 3 pumps and 1 creek flow). A total of 5266 subterranean fauna specimens were recorded, comprising approximately 96% stygofauna (5078 specimens) and 4% troglofauna (188 specimens).

Taxonomic experts morphologically identified 25 morphospecies of troglofauna (including potential troglofauna) taxa comprising pseudoscorpions, palpigrades, harvestmen, spiders, isopods, diplopods, chilopods, polyxenids, pauropods, symphylans, diplurans, silverfish, cockroaches, hemipterans, coleopterans and dipterans. Diplopoda, Blattodea and Zygentoma were the three most abundant groups, collectively accounting for more than 63% of all troglofauna specimens recorded. Of the 25 troglofauna morphospecies recorded, two taxa were known to be widespread in the Pilbara. Six taxa were recorded from multiple locations within the Study Area, with distributions ranging from 0.45 km to 44 km. Fourteen troglofauna taxa were singleton records or taxa known only from single sites. The remaining three groups represented indeterminate taxa that could not be resolved to species-level due to specimens being immature, in poor/damaged condition or the wrong sex for species-level identifications.

Taxonomic identifications of stygofauna (including potential stygofauna) revealed 60 morphospecies and 22 indeterminate taxa comprising oligochaete worms, mites, ostracods, cyclopoid and harpacticoid

copepods, syncarids, amphipods and isopods. This represents a rich stygofauna species assemblage compared to other nearby surveys. Copepods were the most abundant group, accounting for more than half (52%) of all stygofauna collected. Of the 60 stygofauna morphospecies recorded, approximately a third (19) were widespread taxa known to occur regionally or throughout the Pilbara. Sixteen taxa were recorded from multiple locations within the Study Area. Of these, 13 taxa were recorded more widely throughout the Study Area, with linear ranges ranging from 15 to 49 km. The remaining three taxa recorded from multiple locations had more restricted distributions, with linear ranges ranging from 0.2 to 10 km. Twenty-two stygofauna taxa were singleton records or taxa known only from single sites, whereas the remaining three taxa represented unique higher-level taxa that could not be identified to species level.

The risk assessment for subterranean fauna was based on current taxonomic and ecological information, available habitat information (including 3D habitat modelling based on detailed drill log data) and the likelihood that any species of troglofauna or stygofauna would be limited to habitats directly impacted by the proposed development. For troglofauna, the direct impact area comprised the proposed pit boundaries, while for stygofauna the estimated groundwater drawdown (based on hydrogeological modelling) comprised the direct impact area.

Six (6) troglofauna taxa are currently known only from the direct impact areas of the proposed development. The potential risks to these taxa from mining were characterised using a five-point risk classification system (i.e. high, moderate-high, moderate, low-moderate, or low risk) as follows:

Low risk (4 taxa): *Dodecastyla* sp. indet., *Nocticola currani* s.l., *Phaconeura* sp. indet. and Phalangodidae sp. indet.

These taxa were assessed as ‘low risk’ due to current knowledge of taxonomy and because their known records were located in Cleaverville formation BIF habitat which extends extensively beyond impact areas.

Low-moderate risk (2 taxa): *Tyrannochthonius* `BPS228` and *Tyrannochthonius?* sp. indet. (Sandtrax)

These taxa were assessed ‘as low-moderate’ risk as they are more likely to represent troglobitic SRE fauna and stem from groups more prone to have small distributions, although their habitat is modelled to continue well beyond impact areas.

Twelve stygofauna taxa recorded during the current survey of the Study Area are known only from within the estimated groundwater drawdown. Based on current taxonomic and ecological information, modelling of groundwater drawdown and the likely extent of suitable habitats for stygofauna beyond the modelled extent of drawdown, all twelve taxa were assigned as being at ‘low risk’ from the proposed Miralga Creek Project:

Low risk (12 taxa): *Wandesia* sp. indet., Candonidae `BOS1332`, *Ilyodromus* sp. indet., *Pescecyclops* `BCY065`, *Parastenocaris* `BHA266`, Bathynellidae sp. VLS, nr *Billibathynella* sp. indet., nr *Hexabathynella* sp. indet., Bogidiellidae sp. indet., Melitidae `BAM160` (sp. 1 group), Paramelitidae `BAM162`, and Paramelitidae Genus 2 `BAM164`.

All twelve stygofauna taxa were assessed as ‘low risk’ due to current knowledge of taxonomy, the minimal predicted depth (1.6 m) of the groundwater drawdown, and the likely extent of suitable stygofauna habitats (both within alluvials as well as fractured rock aquifers) beyond drawdown impacts.

1 INTRODUCTION

1.1 Background

Atlas Iron Pty Ltd (Atlas) proposes to develop the Miralga Creek Project (The Project), located approximately 100 km south-east of Port Hedland in the Pilbara bioregion of Western Australia (Figure 1.1). The Project comprises five satellite pits in three separate orebodies which are spread over 30 km (Figure 1.2). All three orebodies and associated mining pits are expected to be relatively small and are described as follows:

- Miralga East: 3 small pits along an east to west trending ridgeline. Each pit extends less than 400 m long and 150 m wide, covering a total area of ~10.2 ha;
- Miralga West: Single pit along a north-east to south-west trending ridgeline extending approximately 620 m long by 190 m wide (~6.9 ha); and
- Sandtrax: Single small pit along an east to west trending ridgeline. Small pit measuring approximately 370 m long by 70 m wide (~3.3 ha).

Owing to the locations of all orebodies atop high, narrow ridgelines, proposed mining is above water table (AWT), with maximum pit depths expected to be well above groundwater levels. However, the Miralga Creek Project requires water supply to support mining operations including; ore processing, earthworks and construction purposes, campsite purposes, dust suppression and other general mining purposes. To meet these requirements, water supply will be sourced from three existing borefields in the area, resulting in radially extending groundwater drawdown (DD) in three areas of the Project. For the purposes of this report, the groundwater drawdown impact areas are referred to as “Northern DD”, “Central DD” and “Southern DD” (Figure 1.2).

Biologic Environmental Survey (Biologic) was commissioned by Atlas to undertake a two-season Level 2 subterranean fauna (troglofauna and stygofauna) survey within the Miralga Creek Project. The area of interest, hereafter referred to as the Study Area, covers approximately 502,654 hectares (ha) (Figure 1.1). However, field sampling mainly focused on the predicted drawdown areas and areas in the vicinity of the proposed pits (Figure 1.2). Biologic’s (2019a) terrestrial fauna survey areas are shown for visual context in all figures.

1.2 Objectives

The overarching objective of this assessment was to identify the occurrence of any subterranean fauna assemblages within the Study Area, and their supporting habitats. Specifically, the key objectives of the assessment were to provide:

- a desktop review of all previous subterranean fauna surveys in the vicinity of the Study Area and existing subterranean fauna databases on the local/ sub-regional scale;
- results of a two-phase Level 2 stygofauna and troglofauna survey throughout the Study Area, including detailed identifications of all species collected;

- an assessment of the likely local occurrence of stygofauna and troglofauna species relative to key habitat units and proposed impact areas, and a discussion of their conservation status and wider potential distribution with reference to regional taxonomic comparisons; and
- a detailed risk assessment of key subterranean fauna values (species and habitat) in relation to the potential impacts of the proposed mining development.

1.3 Legislation and guidance

Western Australia's subterranean fauna is considered globally-significant due to an unprecedented richness of species and high levels of short-range endemism (EPA, 2016c). The EPA's environmental objective for subterranean fauna is to "protect subterranean fauna so that biological diversity and ecological integrity are maintained" (EPA, 2016a, p2). In this context, the EPA defines ecological integrity as "the composition, structure, function and processes of ecosystems, and the natural range of variation of these elements" (EPA, 2016a, p2).

Protection for conservation significant subterranean species and/ or Threatened or Priority Ecological Communities (TECs and PECs) is provided under State and Federal legislation, comprising:

- *Environmental Protection Act 1986* (*EP Act 1986*) (WA);
- *Biodiversity Conservation Act 2016* (*BC Act 2016*) (WA); and
- *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act 1999*) (Commonwealth).

Most subterranean species and assemblages are not listed under these Acts, due to incomplete taxonomic or ecological knowledge. Consideration of range-restricted subterranean fauna is therefore also important, including species that only occur within restricted habitats, as these have a higher potential of being Short-Range Endemic (SRE) species (Eberhard *et al.*, 2009; Harvey, 2002).

This assessment has been undertaken in consideration of the following EPA guidance statements:

- EPA (2016a) Environmental Factor Guideline Subterranean Fauna;
- EPA (2016c) Technical Guidance Subterranean Fauna Survey; and
- EPA (2016b) Technical Guidance Sampling Methods for Subterranean Fauna.

1.3.1 Threatened and Priority Ecological Communities

No TECs or PECs occur within or have previously been recorded within 100 km of the Study Area (DBCA, 2019b).

1.4 Subterranean fauna

Subterranean fauna are animals that live underground. In Western Australia, subterranean fauna are mainly invertebrates such as crustaceans, insects, arachnids, myriapods, worms, and snails, but a small number of vertebrate taxa such as fish and reptiles have also been found (EPA, 2013; Humphreys, 1999). Subterranean fauna are grouped into two major ecological categories:

- stygofauna - aquatic animals that inhabit groundwater in caves, aquifers and water-saturated interstitial voids; and
- troglofauna - air-breathing animals that inhabit air-filled caves and smaller voids above the water table.

Nevertheless, there are some taxa which cross-over between these categories and are known to occur in groundwater as well as air-filled subterranean habitats (*e.g.* enchytraeid worms), and yet other species that occur within subterranean habitats for only part of their lifecycles (stygoxenes/ stygophiles, and trogloxenes/ troglophiles respectively).

Following EPA (EPA, 2016c) guidelines, obligate subterranean fauna (known respectively as stygobites and troglobites) are defined as species that live their entire lives underground and are completely dependent upon, or restricted to, subterranean habitats. Such species are considered to have a high likelihood of being limited to very narrow ranges (*i.e.* short-range endemic (SRE) species), and therefore may be at greater risk of impacts from proposed developments (EPA, 2016c). SRE species as described by (Harvey, 2002), are species whose natural ranges are limited to <10,000 km^2 (or <100 km x 100 km), whereas Eberhard *et al.* (2009) regarded even this criterion as potentially too vast for range-restricted subterranean fauna, offering an alternative threshold of <1,000 km^2 for subterranean SRE species.

Troglobites and stygobites often display evolutionary adaptations to underground life; these include features such as reduced pigment, reduced or vestigial wings, reduced cuticle thickness, elongation of sensory appendages, and reduced eyes or eyelessness. Additional adaptations to underground life can include changes to physiology, lifecycle, metabolism, feeding and behaviour (Christiansen, 2005; Gibert & Deharveng, 2002).

As the darkness of hypogean environments precludes photosynthesis, subterranean ecosystems are generally dependent upon allochthonous inputs of nutrients and oxygen from the surface (except in cases where chemo-autotrophic bacteria are present) (Hahn, 2009). Energy and nutrients are generally transported into subterranean ecosystems by the infiltration of water, particularly via the roots of groundwater dependent vegetation (Howarth, 1983; Humphreys, 2006; Malard & Hervant, 1999; Poulson & Lavoie, 2000). Thus, the porosity (or otherwise) of the overlying geologies, the distance from the surface, and the presence/absence of caves or fissures that can provide a conduit for water and nutrients are important physical features that influence the suitability of underground habitats for subterranean fauna (Hahn & Fuchs, 2009; Strayer, 1994). Groundwater physicochemistry (including salinity, pH, dissolved oxygen and redox potential) is also an important determinant of habitat suitability for stygofauna (Eberhard *et al.*, 2009; Hahn, 2009; Humphreys, 2008; Watts & Humphreys, 2004).

700000 720000 740000 760000 780000 800000 820000 840000 860000

7720000
7700000
7680000
7660000
7640000

PORT HEDLAND
MARBLE BAR
TOM PRICE
NEWMAN
MARBLE BAR

Legend

- Pilbara Towns
- Road
- Creeklines
- Rail
- Study Area
- Terrestrial Survey Areas

IBRA Subregions

- Chichester
- Fortescue
- Hamersley
- Roebourne

N

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0 5 10 20 km

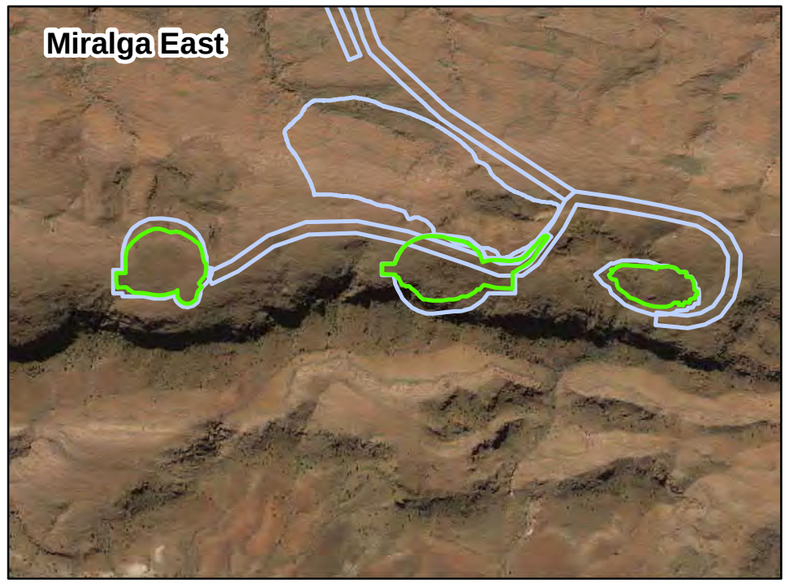
Atlas Iron Limited - Miralga Creek

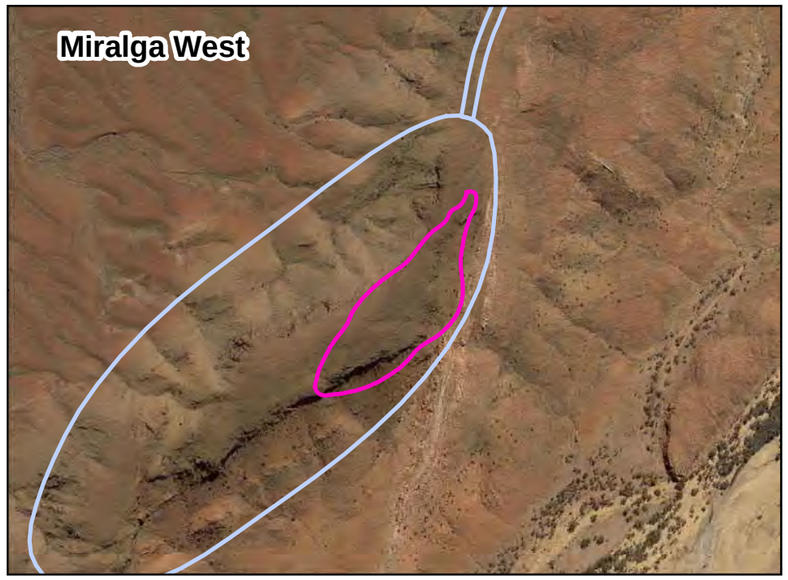
Subterranean Fauna Survey

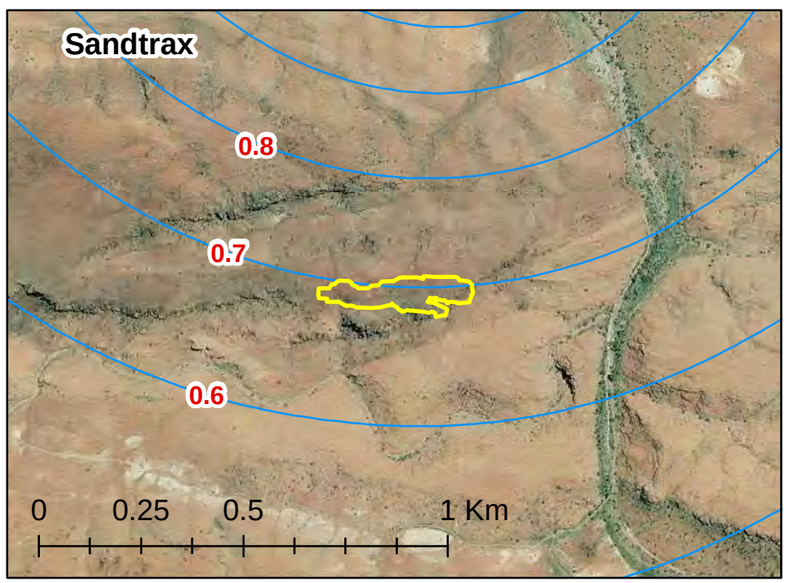
Fig 1.1: Regional location and IBRA subregions

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 22/01/2020







720000
740000
760000
7700000
7680000
Northern DD
0.2
0.3
0.4
Central DD
0.2
0.3
0.4
Southern DD
0.2
0.3
0.4
Miralga East
Miralga West
Sandtrax

Legend

- Miralga East
- Miralga West
- Sandtrax
- Miralga Drawdown
- Development Envelope
- Terrestrial Survey Areas

biologic

N

1:200,000

0 3 6 12 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig 1.2: Proposed developments

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 22/01/2020

2 ENVIRONMENT

2.1 Biogeography

The Study Area is located within the Pilbara bioregion (Figure 1.1), as defined by the Interim Biogeographic Regionalisation of Australia (IBRA; Thackway & Cresswell, 1995). The Pilbara bioregion is characterised by vast coastal plains and inland mountain ranges with cliffs and deep gorges (Thackway & Cresswell, 1995). Vegetation is predominantly mulga low woodlands or snappy gum over bunch and hummock grasses (Bastin & ACRIS Management Committee, 2008).

Within the Pilbara bioregion there are four subregions: Hamersley, Chichester, Roebourne and Fortescue Plains. The Study Area lies within the Chichester (PIL 1) subregion which comprises the northern section of the Pilbara Craton (Kendrick & McKenzie, 2001). Undulating Archaean granite and basalt plains include significant areas of basaltic ranges. The basalt plains host a shrub steppe characterised by *Acacia inaequilatera* over *Triodia* spp. hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on ranges. The Chichester subregion drains to the north via numerous rivers (e.g. De Grey, Oakover, Nullagine, Shaw, Yule, Sherlock) (Kendrick & McKenzie, 2001).

2.2 Climate

The Pilbara bioregion has a semi-desert to tropical climate, with rainfall occurring sporadically throughout the year, although mostly during summer (Thackway & Cresswell, 1995). Summer rainfall is usually the result of tropical storms in the north or tropical cyclones that impact upon the coast and move inland (Leighton, 2004). The winter rainfall is generally lighter and is the result of cold fronts moving north easterly across the state (Leighton, 2004). The average annual rainfall ranges from 200-350 mm, although there are significant fluctuations between years (van Etten, 2009), with up to 1,200 mm falling in some locations in some years (McKenzie *et al.*, 2009).

Long-term climatic data is not available for the Study Area itself; however, long term climatic data is available from the Bureau of Meteorology (BoM) weather station at Marble Bar located approximately 40 km south-east of the Study Area (Station 004106; BoM, 2019). The Marble Bar weather station is expected to provide the most accurate long-term average (LTA) dataset for climatic conditions experienced within the Study Area (Figure 2.1).

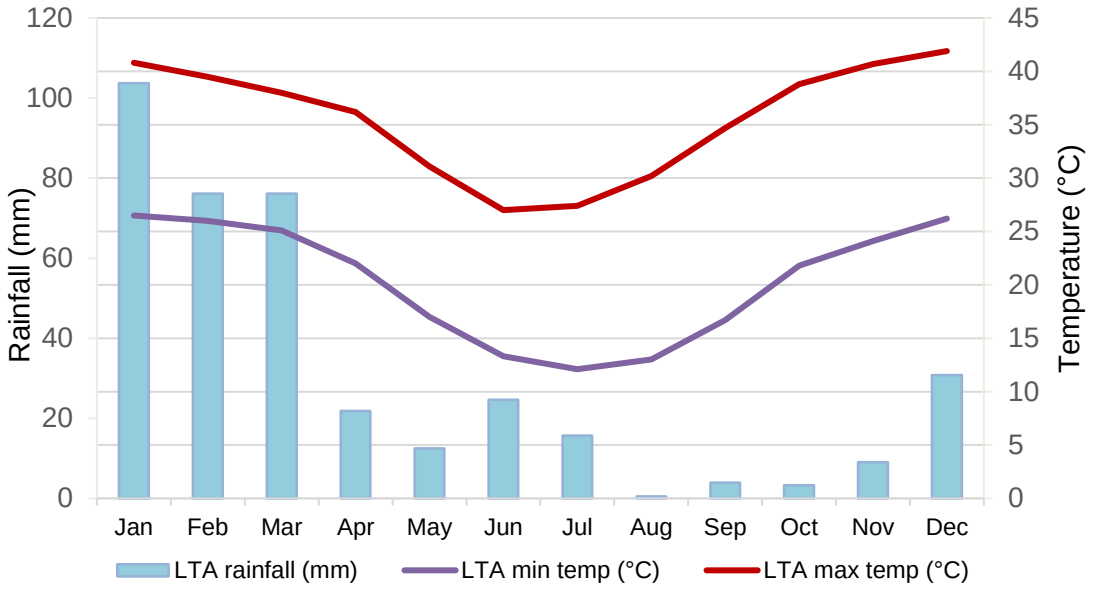


Figure 2.1: Long-term monthly average rainfall and temperature for Marble Bar (BoM, 2019)

2.3 Geology

The Project is located on the northern margin of the Panorama Greenstone Belt within the East Pilbara Domain of the Archean Pilbara Craton. The area is dominated by granite-greenstone terrain in which large granitic batholiths are disconnected by synclinally folded volcanic belts with interbedded volcaniclastic and clastic successions.

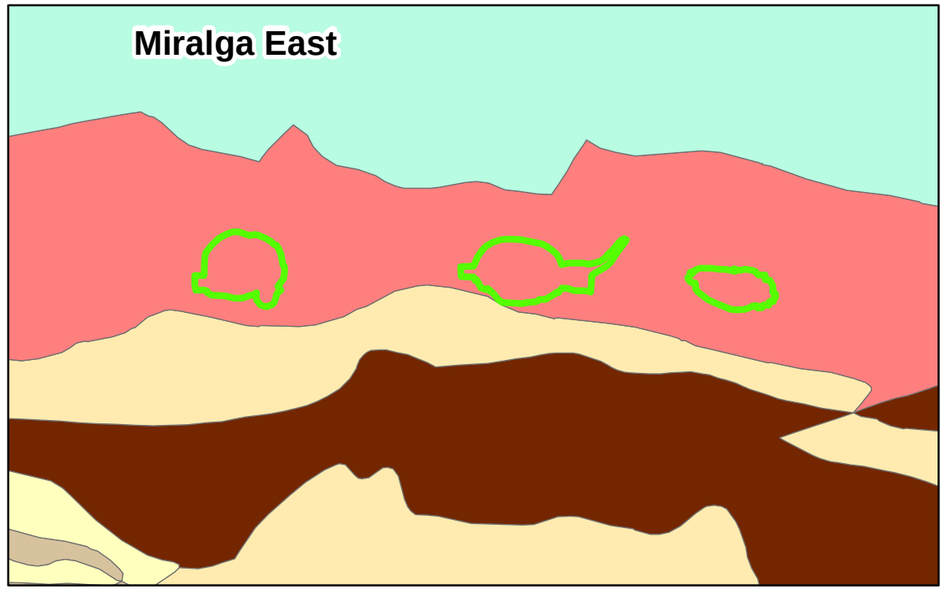
Figures 2.2a and 2.2b show the surface geology of the Project based on GSWA 1:250,000 mapping. The Miralga East, Miralga West and Sandtrax deposits are hosted by the Cleaverville formation (Gorge Creek group, De Grey Supergroup). At Miralga East, the banded-iron formation (BIF)- hosted iron ore mineralisation of the Cleaverville formation forms a prominent east-west striking ridge which dips steeply to the north (Figure 2.2a). The Miralga East deposit is bound to the north by the Lalla Rookh Sandstone, whereas superficial deposits of colluvium are found to the south of the deposit (Figure 2.2a). At Miralga West, the Cleaverville formation and associated BIF-hosted iron mineralisation form a prominent ridge striking north-east to south-west (Figure 2.2a), extending considerably to the south-west of the deposit. The Miralga West deposit is bound to the east by Lalla Rookh Sandstone whereas superficial deposits of colluvium are found to the west of the deposit. Finally, at the Sandtrax deposit, the BIF-hosted iron mineralisation, which contains sequences of black shale bands, forms an east to west trending ridge (Figure 2.2a).

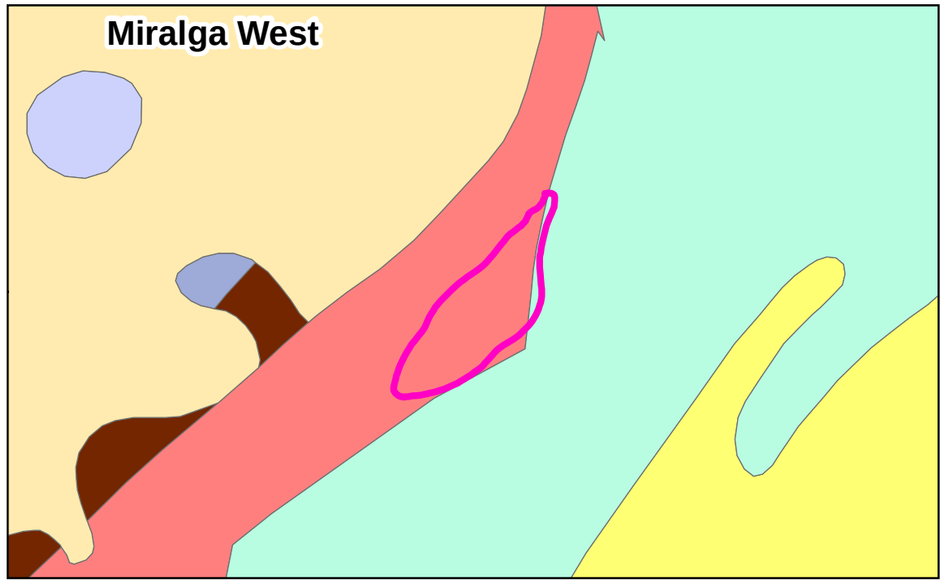
2.4 Surface drainage and hydrogeology

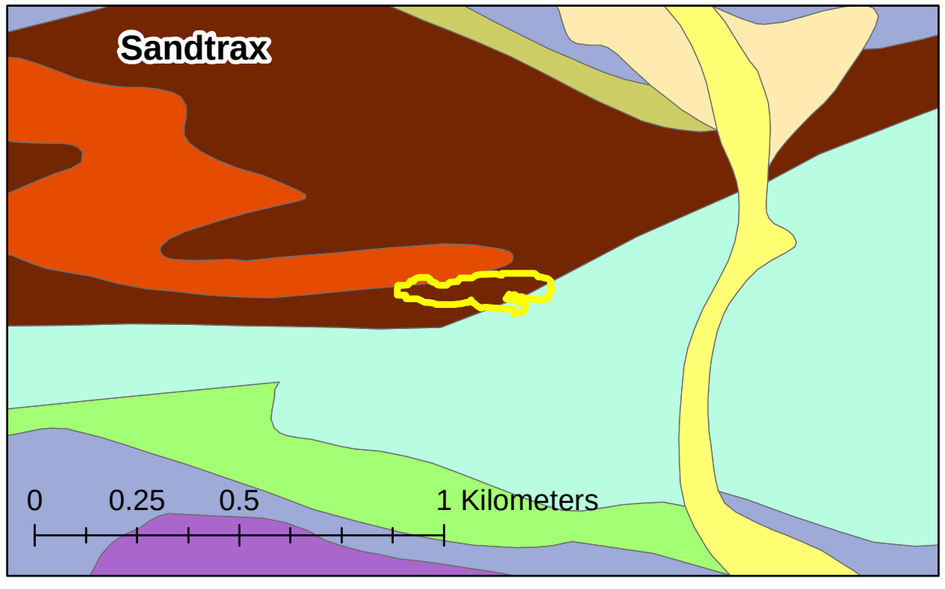
Three main ephemeral rivers flow through the Study Area, comprising Shaw River, Strelley River and Miralga Creek (Figure 2.3). Shaw River runs in a northernly fashion through the central part of the Study Area, passing deposit Miralga West before ultimately discharging into the De Grey River 70 km north of the Study Area. Strelley River flows parallel to Shaw River, approximately 15 km to its east. As Shaw River, Strelley River flows in a northernly fashion and discharges into the De Grey River. Finally, Miralga

Creek runs through the eastern part of the Study Area, passing the Miralga East deposits before joining with Shaw River. Both, Shaw River and Miralga Creek have the potential to flow for extended periods following significant rainfall events, with high levels of stream bed movement and erosion.

All three proposed developments are located atop of ridges, with elevations ranging from about RL 120 m to RL 310 m. At Miralga West, surface water drainage from the ridge flows both to the south (directly to the Shaw River) and along minor drainage lines which flow north before intersecting with a minor tributary of the Shaw River, 1.5 km north of the pit. At Miralga East, several semi-permanent and permanent pools are located in the vicinity of the pits within the Miralga Creek channel (2-9 km downstream of Miralga East) which are maintained by saturated alluvials (Atlas, 2019). Runoff to the north of the Miralga East ridge occurs though several small drainages which flow in a northerly direction for approximately 1.5 km before intersecting a westerly trending creek line, which in turn eventually intersects Miralga Creek. At Sandtrax, surface water drainage from the ridge flows down a narrow valley in a south-westerly direction, before intersecting a drainage which flows to the east then joins the northerly flowing Sulphur Springs Creek.

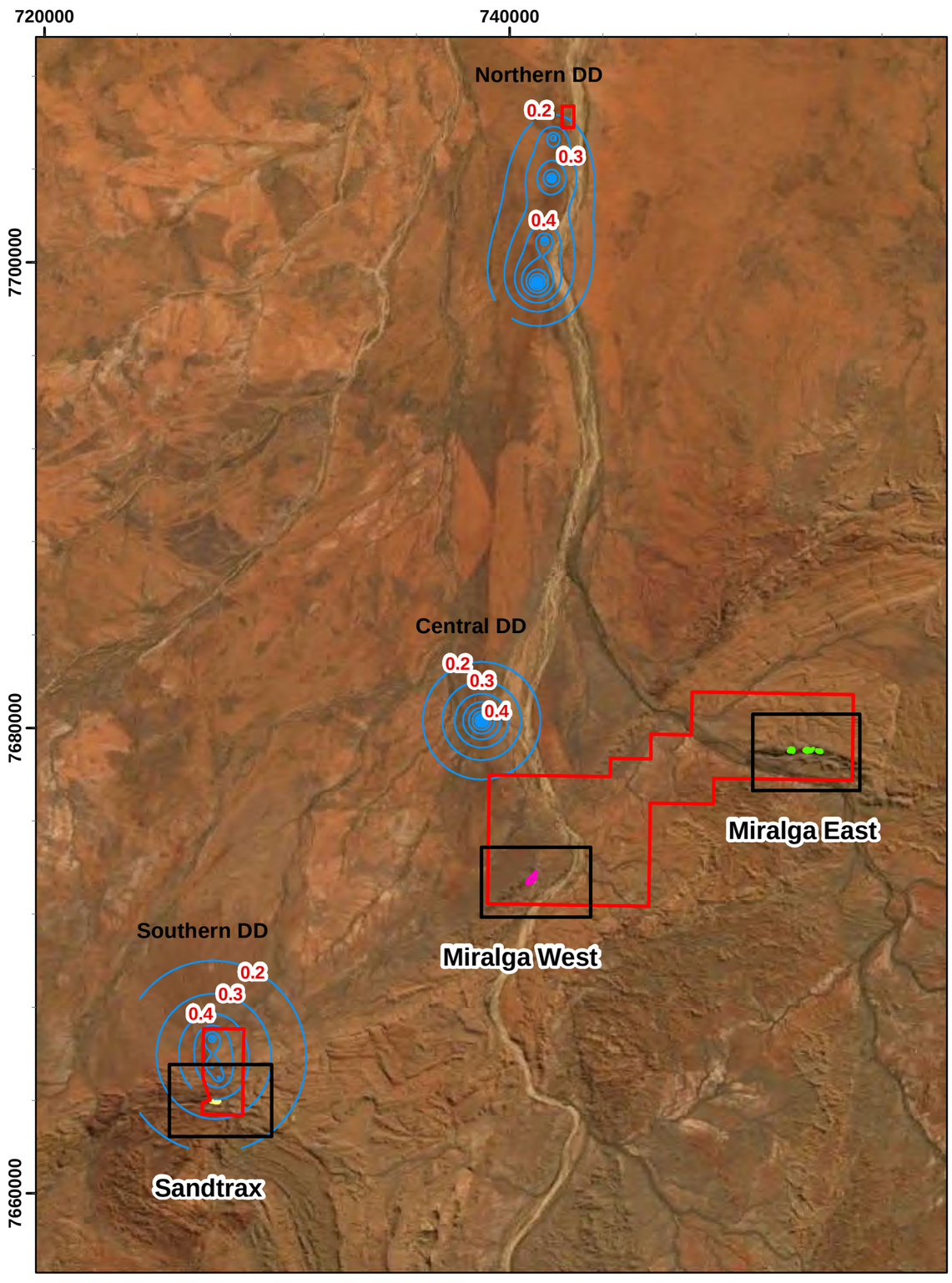






Legend

- Miralga East
- Miralga West
- Sandtrax
- Drawdown
- Terrestrial Survey Areas
- Basalt
- Cleaverville BIF, Chert, Quartz Magnetite
- Cleaverville Black Shales, Chert, BIF
- Colluvium; Sand, Silt, Gravel
- Dolerite
- Dalton Peridotite
- Farrel Sandstone
- Ferruginous Duricrust, Colluvium
- Lalla Rookh Sandstone; Conglomerate
- Regolith; Sand, Silt, Gravel



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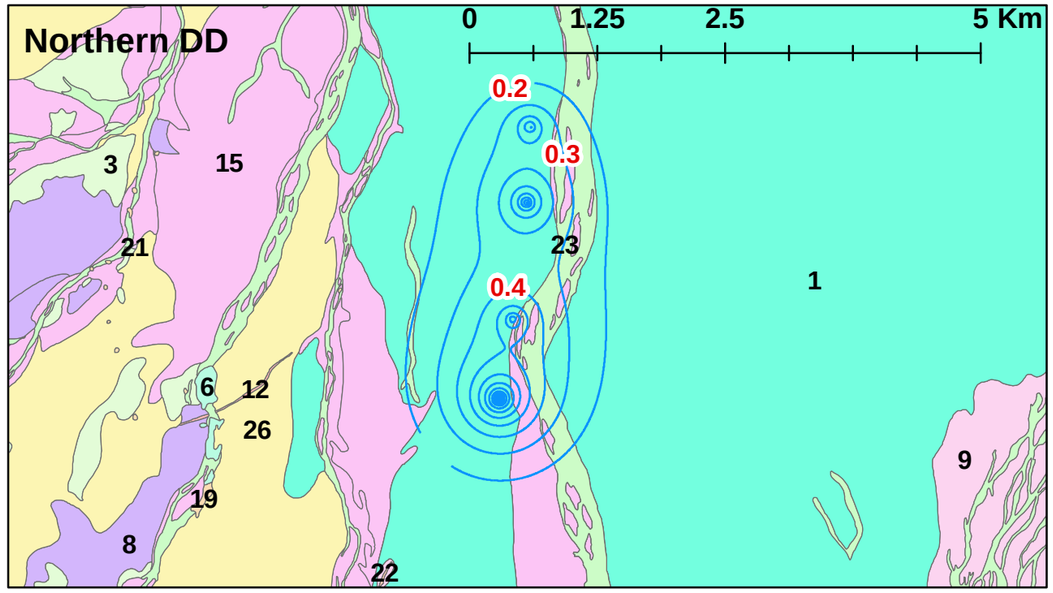
Atlas Iron Limited - Miralga Creek

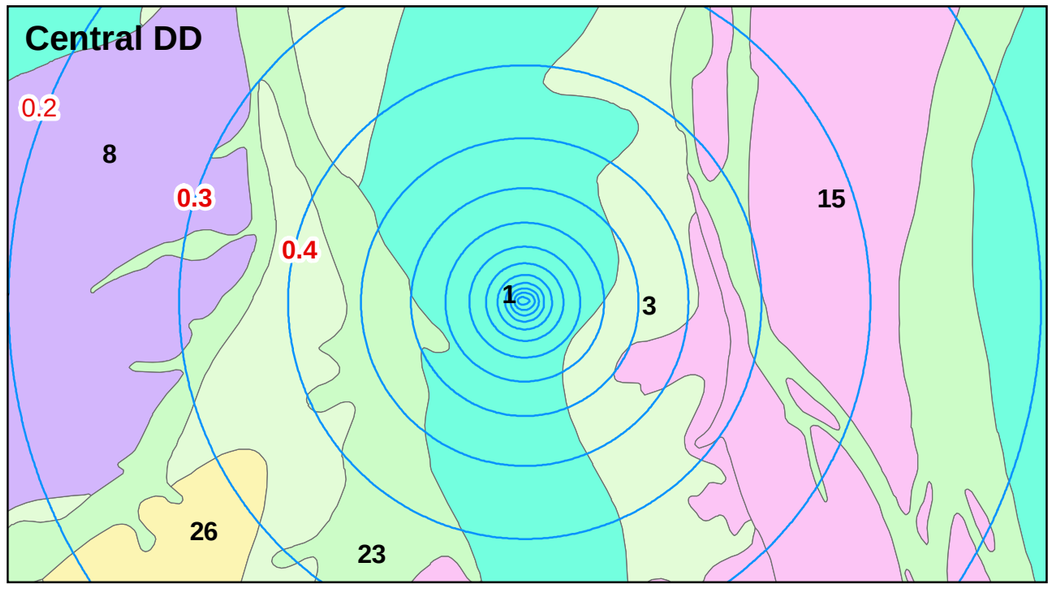
Subterranean Fauna Survey

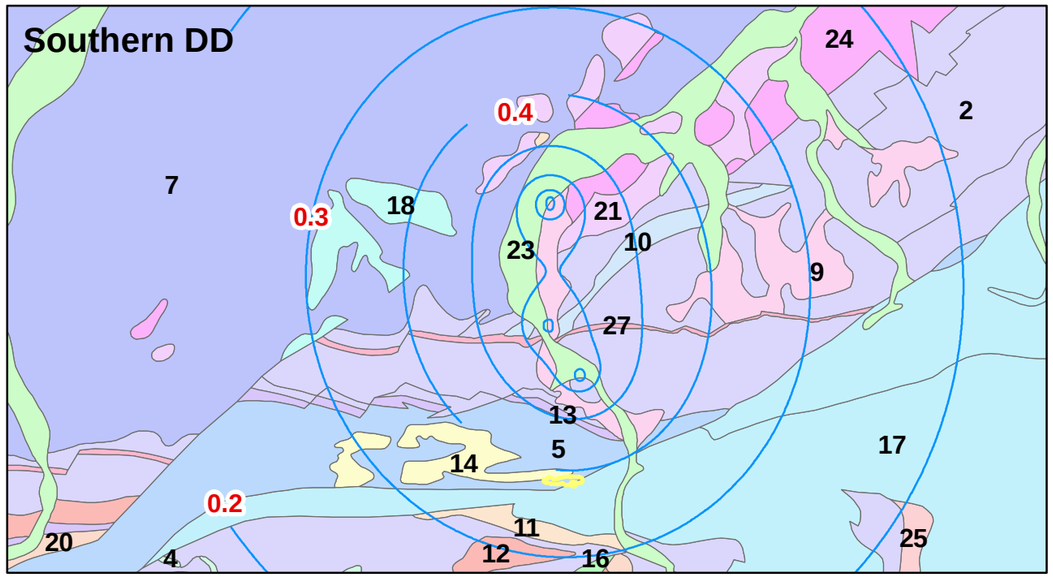
Fig 2.2a: Regional surface geology

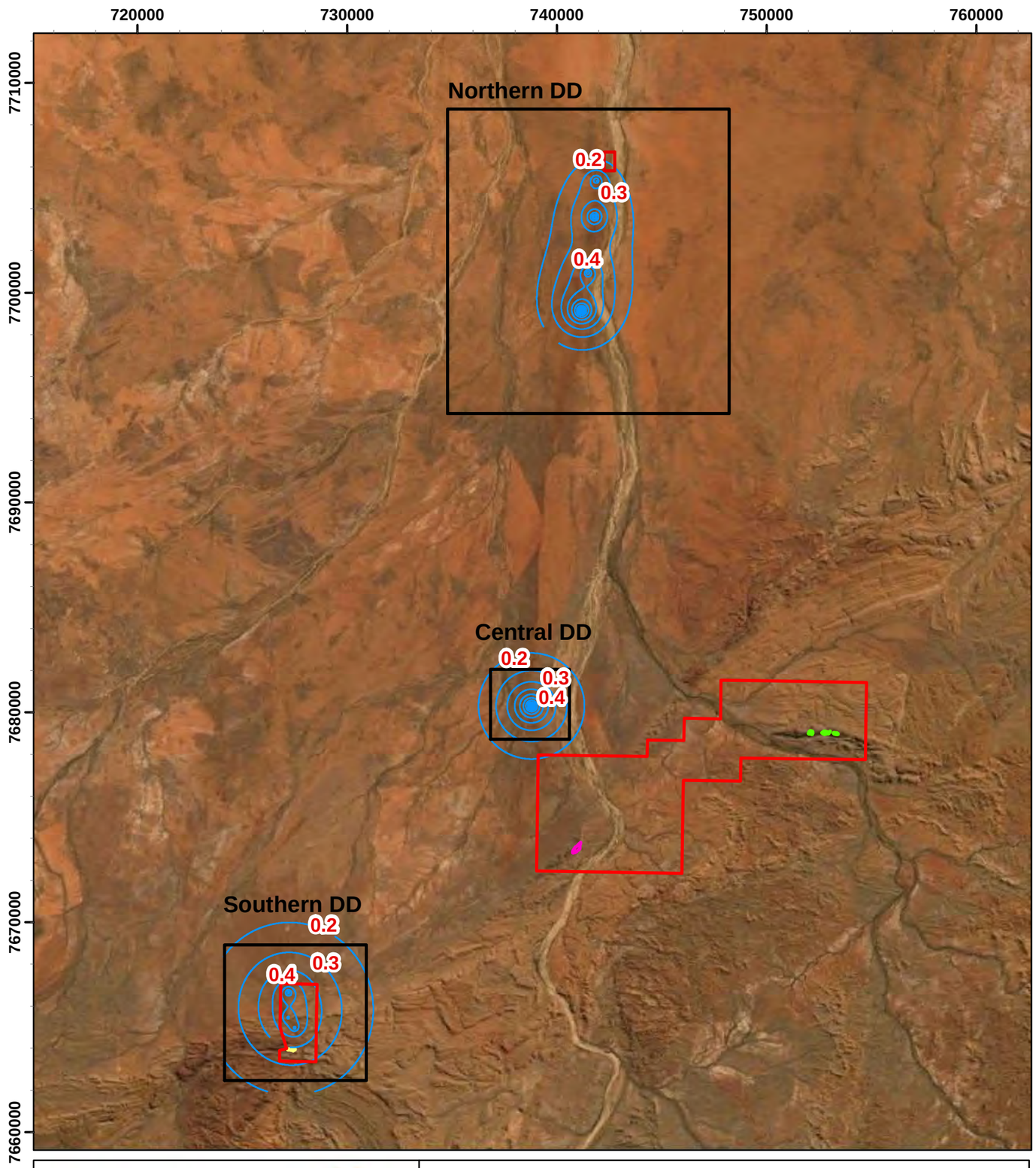
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 23/01/2020









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Atlas Iron Limited - Miralga Creek

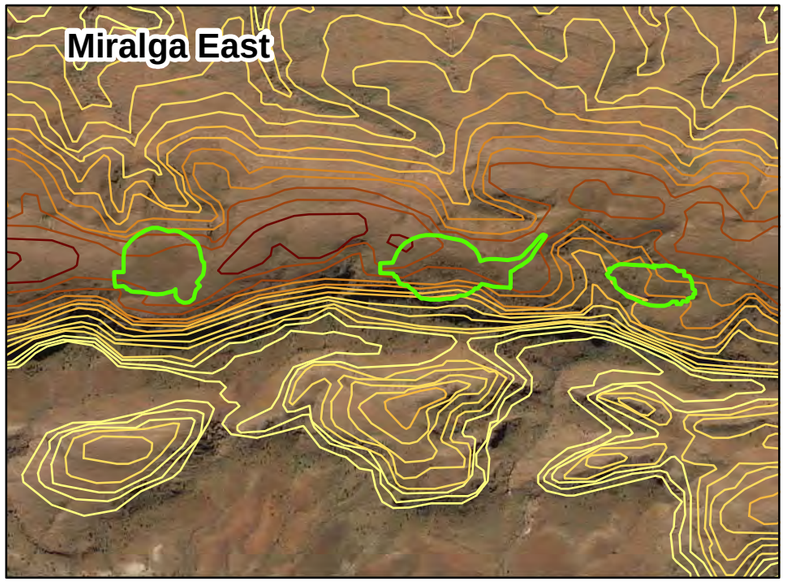
Subterranean Fauna Survey

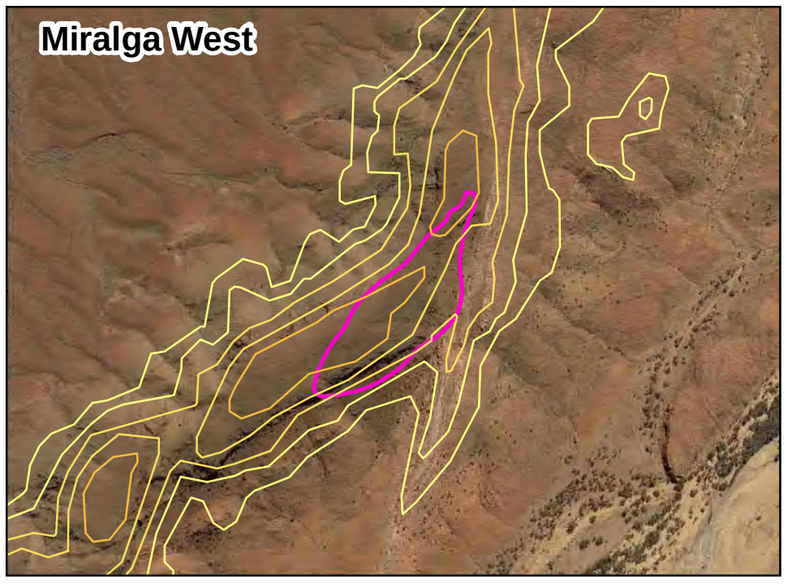
Fig 2.2b: Regional surface geology

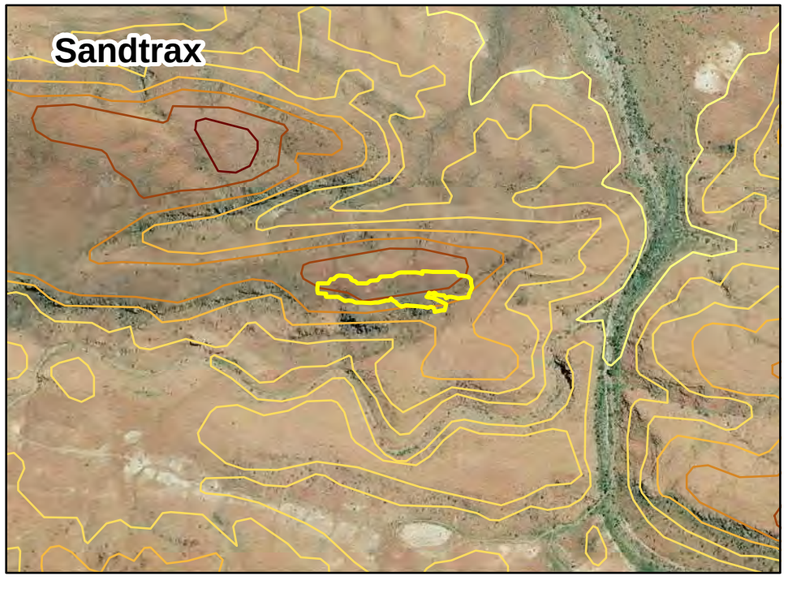
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 23/01/2020

Legend to Figure 2.2b







720000

740000

760000

7700000

7680000

7660000

Miralga East

Miralga West

Sandtrax

Legend

- Miralga East
- Miralga West
- Sandtrax
- Drainage Lines
- Terrestrial Survey Areas

Elevation contours

- 180 - 200
- 200 - 240
- 240 - 260
- 260 - 280
- 280 - 300
- 300 - 360

biologic

N

1:220,000

0 3.25 6.5 13 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig 2.3: Surface drainage of the Study Area and surrounds

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 23/01/2020

3 METHODS

3.1 Database search and review of previous reports

Five databases were searched for subterranean fauna records in April 2019 (Table 3.1):

- DBCA's NatureMap database (DBCA, 2019a);
- Western Australian Museum (WAM) Arachnida/ Myriapoda database (WAM, 2019a);
- WAM Crustacea database (WAM, 2019b);
- WAM Mollusca database (WAM, 2019c); and
- DBCA's Pilbara Stygofauna Survey species list (Halse & Eberhard, 2014).

All records were filtered based on collection methods and known stygofauna/ troglofauna taxonomic groups where information on subterranean status was not present in the data.

Table 3.1. Databases searched for subterranean fauna records

Database	Parameters
NatureMap	40 km radius around 20°59'14"S and 119°21'46"E
WAM Arachnida/ Myriapoda WAM Crustacea WAM Mollusca	40 km radius around 20°59'14"S and 119°21'46"E
DBCA's Pilbara Stygofauna Survey	40 km radius around 20°59'14"S and 119°21'46"E

Reports from subterranean fauna surveys within 60 km of the Study Area were reviewed for local and regional context. Reports from relevant surveys are listed below:

- Panorama Project Subterranean Fauna Survey Report 2 (Subterranean Ecology, 2007c);
- Panorama Project Subterranean Fauna Report 3 (Subterranean Ecology, 2007a);
- Panorama Project Subterranean Fauna Report 4 (Subterranean Ecology, 2007b);
- Abydos Troglofauna Survey (Subterranean Ecology, 2009);
- Abydos Troglofauna Survey 2010 (Subterranean Ecology, 2011);
- North Star Project Subterranean Fauna Survey and Assessment (Subterranean Ecology, 2012b);
- Warrawoona Gold Project: Subterranean Fauna Survey (Biologic, 2019b);
- Corunna Downs Subterranean Fauna Assessment (MWH, 2016); and
- Mount Webber Desktop Assessment of Subterranean Fauna (Subterranean Ecology, 2012a).

3.2 Survey timing

The Level 2 subterranean fauna survey was a two-phase survey, undertaken in accordance with guidelines for subterranean fauna assessments (EPA 2016*a*, 2016*b*, 2016*c*). The first phase of sampling was undertaken during the wet season months May – July 2018, with the second phase being undertaken in September – November 2019, representing a dry season survey. Each survey phase comprised two field trips as follows:

Phase 1

- Trip 1, 13th – 20th May 2019: trap deployment and scrape / haul / pump sampling; and
- Trip 2, 8th – 12th July 2019: trap retrieval and scrape / haul / pump sampling.

Phase 2

- Trip 3, 11th – 16th September 2019: trap deployment and scrape / haul / Karaman sampling; and
- Trip 4, 7th – 11th November 2019: trap retrieval and scrape / haul / Karaman sampling.

The daily maximum temperatures during Phase 1 (Trip 1: 13 – 20 May 2018) at the Study Area ranged from 35.1°C to 37.8°C, whereas the overnight minima ranged from 12.0°C to 14.0°C (Figure 3.1). These conditions were consistent with the long-term average temperatures for the same period (Figure 3.1). Marble Bar received no rainfall in the four weeks prior to Phase 1 trap deployment, and rainfall during the period Phase 1 troglofauna traps were deployed (13 May – 12 July 2019) was below average (2.8 mm; 50 mm below the long-term average). However, well above average rainfall was recorded in March 2019 (246 mm; 170 mm above the long-term average) due to Cyclone Veronica (BoM, 2019). This would be expected to have significantly recharged the subterranean habitats, and therefore fauna sampling during Phase 1 (wet season) survey was unlikely to have been limited by a lack of wet season rainfall.

The daily maximum and minimum temperatures during Phase 2 were on par with the long-term averages for September and November (Figure 3.1). No rainfall was recorded at Marble Bar in the six weeks prior to Phase 2 troglofauna trap deployment (Trip 3), nor was any rainfall recorded during the period Phase 2 troglofauna traps were deployed (Figure 3.1). However, these dry conditions are typical for this time of the year, are not expected to have limited the abundance or activity levels of subterranean fauna relative to other dry season surveys.

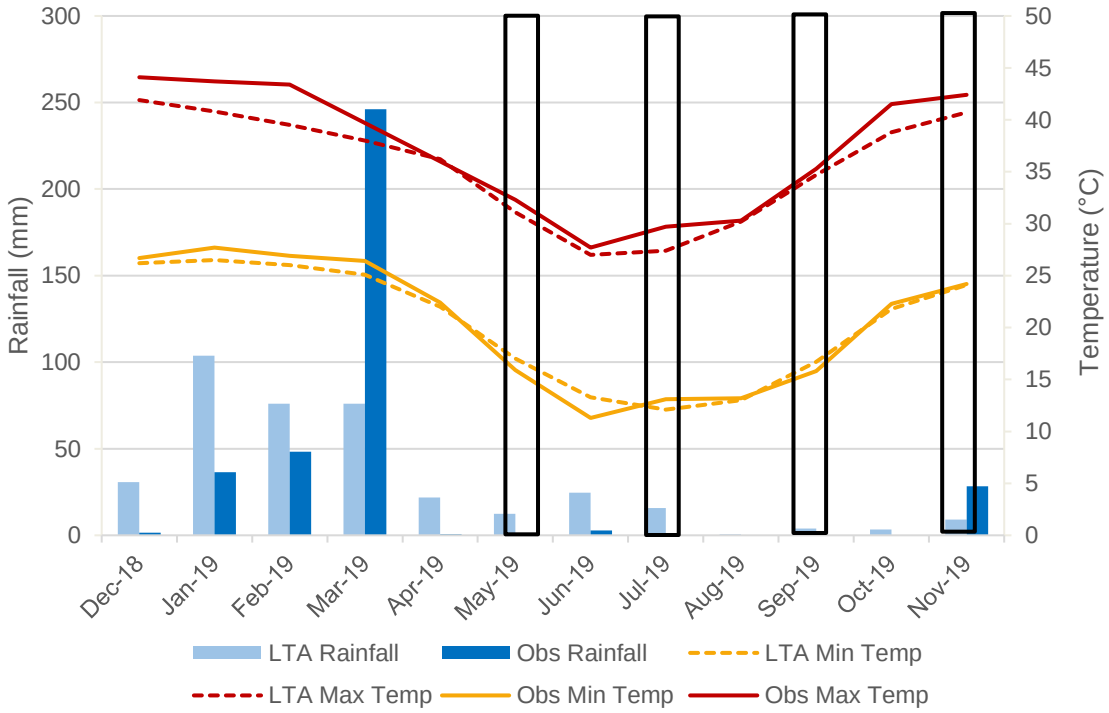


Figure 3.1: Long term average (LTA) and current (2018-2019) climatic data at Marble Bar (Station 004106) (data from BoM 2019*)*Note: Data includes total monthly rainfall (mm) and average monthly maximum and minimum temperatures (°C). Approximate survey timing is indicated by the black boxes.

3.3 Site selection and survey effort

Within the Study Area, site selection for subterranean fauna sampling was limited to accessible, vertical bores (*i.e.* cased, production or monitoring bores) and drill holes (uncased holes). The ratios of troglofauna trapping to scraping and net hauling within and near each deposit were dependent upon:

- drill hole construction (uncased required for troglofauna),
- angle (90° required for scraping and net hauling)
- time since drilling (>6 months required for stygofauna, following EPA 2016*b*), and
- whether the holes intercepted groundwater (required for stygofauna).

A total of 148 bores and holes were sampled throughout the Study Area over the course of the two survey phases. In total, 79 holes were sampled by troglofauna trapping, 93 holes were sampled by scraping for troglofauna, and 38 bores and holes were sampled by stygofauna net-hauling. Troglofauna root samples were collected from three holes. Karaman sampling for stygofauna was performed at 10 sites, one site was sampled *via* creek flow and an additional two active dewatering pump sites were sampled by running water from the pump release valve through a stygofauna net.

A total of 402 subterranean fauna samples were collected during the survey. This comprised 292 troglofauna samples collected by trapping (151 samples), scraping (138 samples) and from root samples (3 samples), and 110 stygofauna samples collected by net hauling (96 samples), Karaman sampling (10 samples), creek flow (1 sample) and pumping (3 samples). Tables 3.2 and 3.3 provide details of the

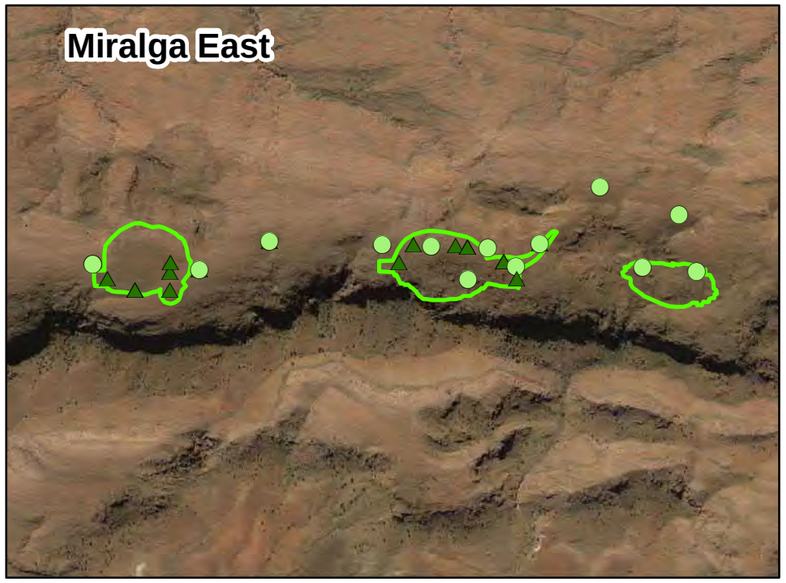
number of samples collected within and nearby each sampling area with respect to the methods employed, and Figures 3.2 and 3.3 show the location of holes visited and sampled throughout the Study Area. Details of bores and drill holes visited during the survey are provided in Appendix A.

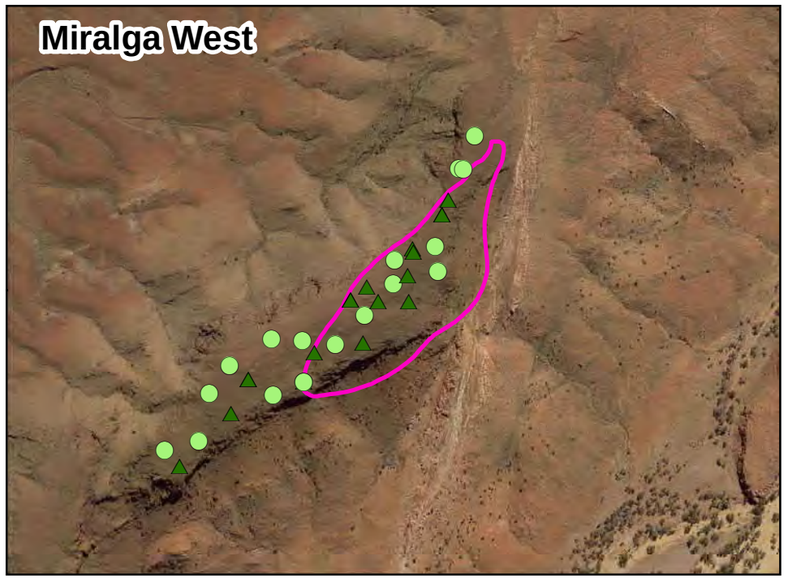
Table 3.2: Number of troglofauna samples collected within and near each deposit

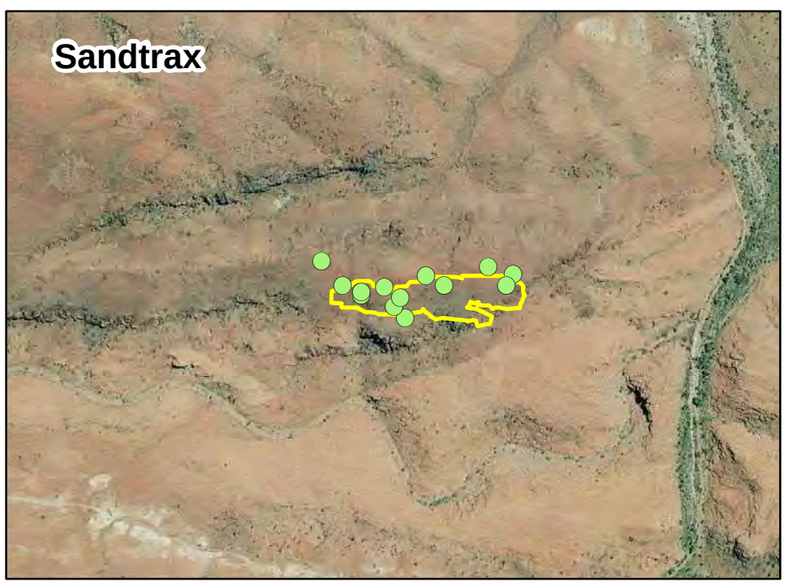
	Miralga East	Miralga West	Sandtrax	Outside	Total
PHASE 1					
Traps retrieved	17	11	1	21	**50**
Scrapes	23	17	-	19	**59**
Roots	-	-	-	-	**0**
PHASE 2					
Traps retrieved	14	14	16	57	**101**
Scrapes	17	14	11	37	**79**
Roots	-	-	1	2	**3**
Troglofauna total	**71**	**56**	**29**	**136**	**292**

Table 3.3: Number of stygofauna samples collected within the Study Area

	Northern DD	Central DD	Southern DD	Outside	Total
PHASE 1					
Net hauls	19	7	3	23	**52**
Karaman samples	-	-	3	5	**8**
Pump samples	1	-	1	-	**2**
Creek flows	-	-	1	-	**1**
PHASE 2					
Net hauls	14	7	1	22	**44**
Karaman samples	-	-	1	1	**2**
Pump samples	-	-	1	-	**1**
Creek flows	-	-	-	-	**0**
Stygofauna total	**34**	**14**	**11**	**51**	**110**







720000
740000
760000
7700000
7680000
7660000
Miralga East
Miralga West
Sandtrax

Legend

- Trapping
- Scraping
- Miralga East
- Miralga West
- Sandtrax
- Terrestrial Survey Areas

biologic

N

1:200,000

0 3 6 12 km

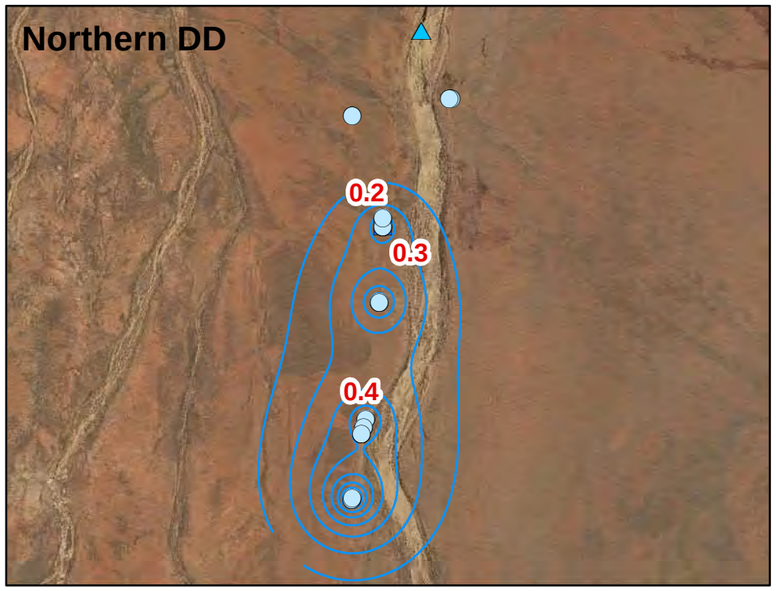
Atlas Iron Limited - Miralga Creek

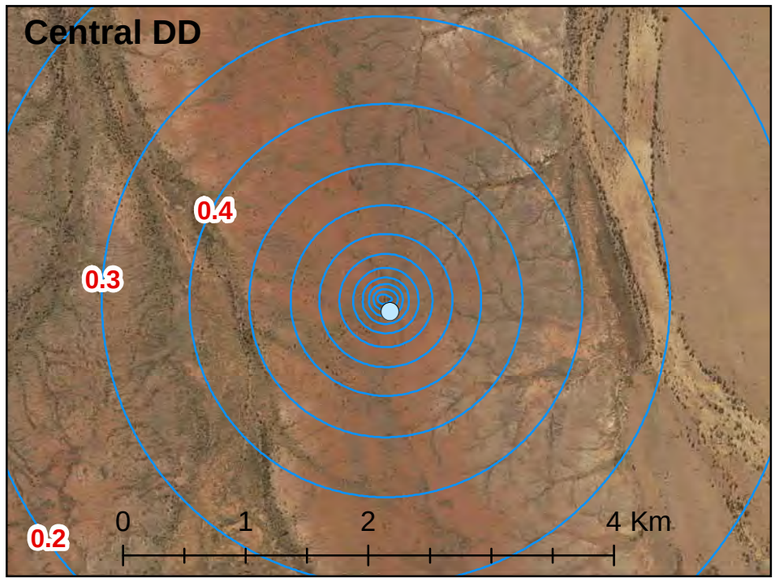
Subterranean Fauna Survey

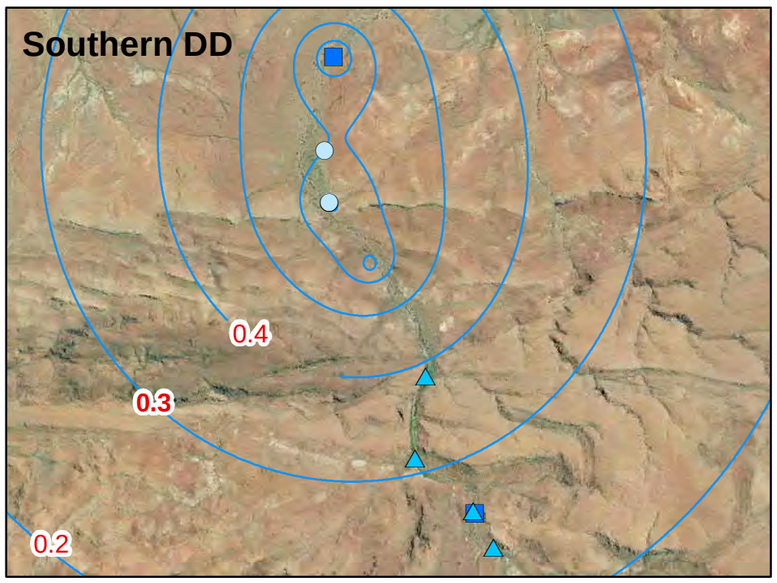
Fig 3.2: Sites sampled for troglofauna (current survey)

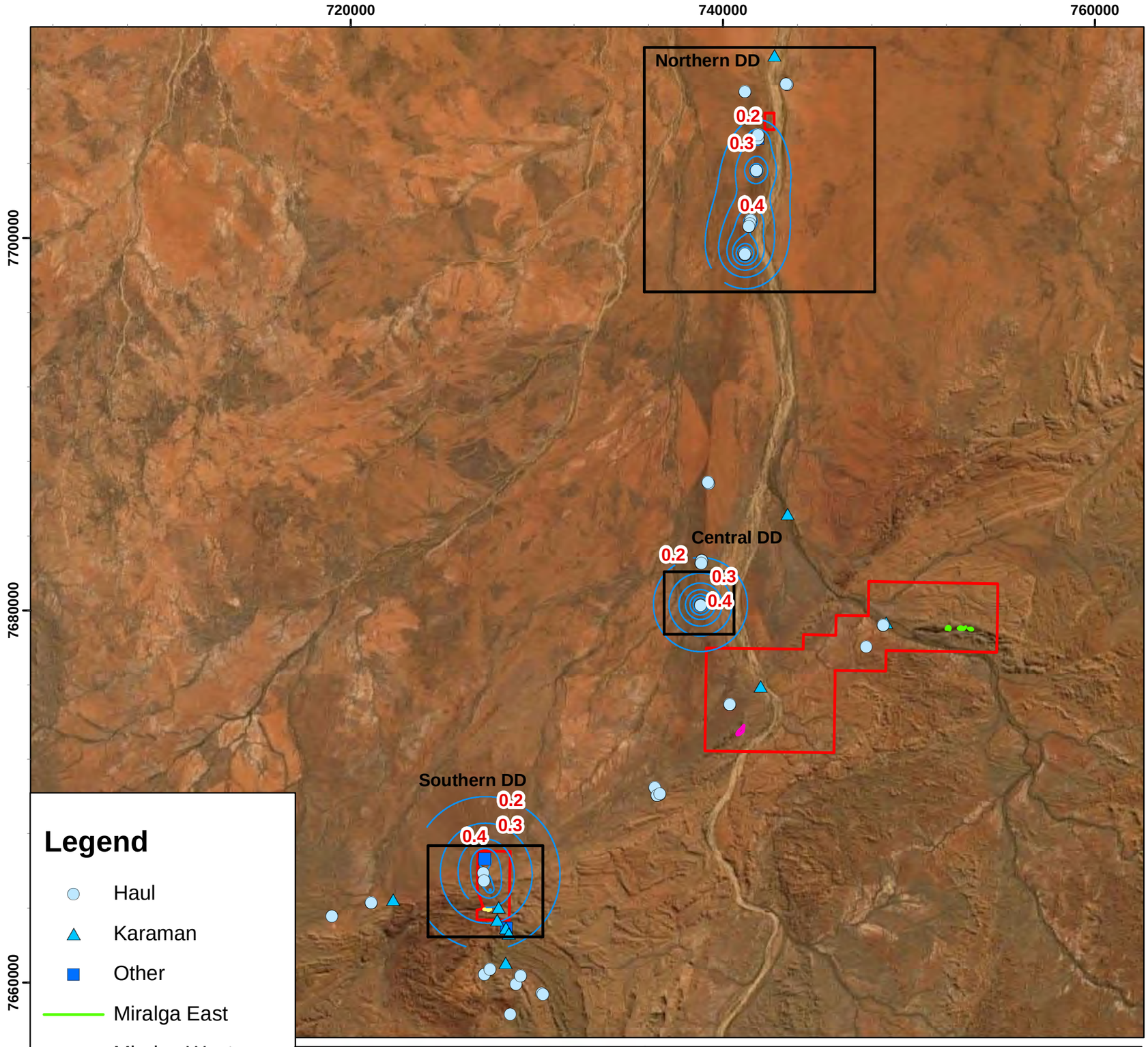
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 23/01/2020









Legend

- Haul
- Karaman
- Other
- Miralga East
- Miralga West
- Sandtrax
- Drawdown
- Terrestrial Survey Areas

biologic

N

1:225,000

0 3.5 7 14 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig 3.3: Sites sampled for stygofauna (current survey)

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 23/01/2020

3.4 Sampling methods

The sampling methods used were consistent with EAG #12 (EPA, 2016c), Guidance Statement #54A (EPA, 2016b) and the Stygofauna Sampling Protocol developed for the Pilbara Biodiversity Study Subterranean Fauna Survey (Eberhard *et al.*, 2005; Eberhard *et al.*, 2009). The field work was undertaken by Dean Main, Dr Fabian Rudin, Dr Phil Runham and Morgan Lythe. Laboratory sorting was undertaken by Dr Fabian Rudin, Mary van Wees, Juliana Pille Arnold, Stephanie Floeckner, Ashleigh Jenkins, Kaylin Geelhoed and Morgan Lythe.

3.4.1 Troglofauna trapping

Trapping utilised custom-made cylindrical PVC traps (approximately 50 mm x 300 mm) baited with decaying leaf litter (dead spinifex / acacia sourced from the Pilbara region), which were sterilised with boiling water. Traps were lowered *via* a nylon cord to a suitable depth and left in operation six to eight weeks, before being collected and transported back to the laboratory in Perth.

3.4.2 Troglofauna scraping

Scraping was undertaken at vertical, uncased drill holes using a reinforced 150 µm weighted stygofauna net, with a specialised scraping attachment used above the net to maximise gentle contact with the walls of the hole. The net was lowered and raised through the full length of the hole at least three (3) times for holes where no water was present, with each haul being emptied into a sample bucket as per net-hauling. Where the water table was intercepted, a combined net-haul / scrape sample was taken using the scraping attachment, comprising six (6) hauls throughout the full length of the hole from top to bottom, including both the air filled and below water subterranean habitats. The contents of the sample were elutriated, processed, and stored in 100 % ethanol as per net-hauling. This technique can frequently result in stygofauna by-catch where scraping nets are lowered below the water table to collect any invertebrates that may have fallen past the net.

3.4.3 Stygofauna net-hauling

Stygofauna were sampled by standard net-hauling methods, using a plankton net of a diameter to suit each bore or drill hole (in most cases 30-80 mm). Each haul sample comprised a total of six hauls from the bottom of the hole to the top, with three hauls using a 150 µm mesh and three hauls using a 50 µm mesh. The base of the net was fitted with a lead weight and a sample receptacle with a base mesh of 50 µm. To stir up sediments, the net was raised and lowered at the bottom of the hole prior to retrieval and hauled at an even pace through the water column to maximise filtration of the water.

The sample from each haul was emptied into a bucket, which was elutriated after the final haul to remove coarse sediments and filtered back through the 50 µm net/ sample receptacle to remove as much water as possible. The sample was transferred to a 50-120 mL preservation vial (depending upon the quantity of sediment) and preserved in 100% ethanol. The ethanol and the samples were kept chilled on ice to facilitate cool-temperature DNA fixation.

3.4.4 Water physicochemistry

Prior to stygofauna sampling, a groundwater sample was collected using a 1m plastic cylindrical bailer, for the purposes of physicochemical measurements. The bailer was lowered down the hole until reaching groundwater and a water sample was collected at a depth of 2 m below the surface. As such the results were not indicative of water parameters throughout the entire bore (or aquifer) but rather provide a general indication of near surface conditions. Conditions sampled during pumping were measured using a sample collected from the pump outflow, which would have artificially increased the dissolved oxygen readings. Groundwater physicochemical data (including EC, pH, TDS, Redox ORP, and dissolved O_2) was measured using a multi-parameter water meter. Constrictions in piezometer bores, blockages from root material, or excessive depths to groundwater inhibited the collection of physicochemical readings at some sites.

3.4.5 Sorting and taxonomy

Sorting and parataxonomy were undertaken in-house using dissecting microscopes. The personnel involved (F. Rudin, M. van Wees, J. Pille Arnold, S. Floeckner, A. Jenkins, K. Geelhoed and M. Lythe) were all suitably trained and experienced in sorting and parataxonomy of subterranean fauna.

Parataxonomy of the specimens utilised published literature and taxonomic keys where available. Each morphospecies from each sample was assigned a separate labelled vial and labelled with a specimen tracking code. Taxonomic groups were examined in as much detail as possible using in-house expertise, before sending a reference collection to specialist taxonomists for detailed taxonomic advice. Species comparisons and alignments were performed using regional specimens collected beyond the Study Area throughout the wider sub-regional area. Giulia Perina and Jane McRae provided specialist taxonomic identifications and regional alignments.

3.4.6 Conservation status and SRE classification

A few subterranean species and assemblages from the Pilbara region are listed under relevant legislation as threatened species, or as Threatened or Priority Ecological Communities in certain locations. Any listed subterranean species or community is regarded as conservation significant although, due to a lack of survey effort and taxonomic certainty for the majority of subterranean fauna in the Pilbara region, there are many potentially range-restricted (SRE) or conservation significant species and communities that do not appear on these lists.

The likelihood of taxa representing SRE species (*i.e.* distribution <10,000 km^2 following Harvey 2002, or <1,000 km^2 following Eberhard *et al.* 2009) was assessed based on the known local species distribution, and regional comparisons where data was available, following advice from the WAM and other relevant taxonomic specialists. The assessment of SRE status was highly dependent on:

1. the degree of taxonomic certainty at the genus and species levels;
2. the current state of taxonomic and ecological knowledge for each taxon (including whether a regional genetic context has been investigated);
3. the scale and intensity of the local and regional sampling effort; and
4. whether or not relevant taxonomic specialists were available to provide advice.

The SRE status categories used in this report follow the WAM's categorisation for SRE invertebrates. This system is based upon the 10,000 km^2 range criterion proposed by Harvey (2002), and uses three broad categories to deal with varying levels of taxonomic certainty that may apply to any given taxon (Table 3.4). Owing to the fact that the majority of subterranean fauna are poorly known taxonomically, and the general limitations to sampling subterranean fauna, the majority of morphospecies invariably fall within one (or several) of the five Potential SRE sub-categories.

Table 3.4: SRE categorisation used by WAM taxonomists

	Taxonomic Certainty	**Taxonomic Uncertainty**
Distribution <10 000km^2	Confirmed SRE • A known distribution of < 10,000km^2. • The taxonomy is well known. • The group is well represented in collections and/ or *via* comprehensive sampling.	Potential SRE • Patchy sampling has resulted in incomplete knowledge of geographic distribution. • Incomplete taxonomic knowledge. • The group is not well represented in collections. • Category applies where there are significant knowledge gaps. **SRE Sub-categories may apply:** A) Data Deficient B) Habitat Indicators C) Morphology Indicators D) Molecular Evidence E) Research & Expertise
Distribution >10 000km^2	Widespread (not an SRE) • A known distribution of > 10,000km^2. • The taxonomy is well known. • The group is well represented in collections and/ or *via* comprehensive sampling.	

The degree of stygomorphy or troglomorphy (observable physical adaptations to subterranean habitats such as eyelessness, depigmentation, elongation of sensory appendages and thinning of the cuticle) assessed to determine each morphospecies' 'subterranean status', *i.e.* whether a taxon was more or less likely to be an obligate subterranean species (stygobite/ troglobite). It is acknowledged that the current EPA guideline for subterranean fauna does not account for non-obligate subterranean fauna, stating, *"…subterranean fauna are defined as fauna which live their entire lives (obligate) below the surface of the earth.... Fauna that use a subterranean environment for only part of the day or season (e.g. soil-dwelling or burrowing species, cave-dwelling bats and birds) are not considered as subterranean fauna for this EAG*" (EPA, 2013).

Nevertheless, there may be fauna with restricted distributions <10,000 km^2 following Harvey (2002), or <1,000 km^2 following Eberhard *et al.* (2009) that are of interest because of their SRE status, regardless of whether they can be definitively regarded as 'obligate' subterranean fauna. For this reason, this report presents an assessment of both the subterranean status and the SRE status of each taxon collected, to the best available knowledge.

In some cases where thorough sampling has been conducted and sufficient habitat information and ecological information is available, the potential occurrence of a taxon at a local scale may be inferred *via* the extent of habitats, particularly where the rest of the assemblages are highly similar, and the

habitats appear well-connected. Despite the suggestion within the current EPA (2013) guidelines that related species' ranges may be used as surrogates for poorly-known species' ranges, the level of evidence required to support the identification of an appropriate surrogate is almost prohibitively high for most subterranean fauna, therefore this would only be investigated as a last resort.

4 RESULTS

4.1 Database searches

The WAM, NatureMap and DBCA's Pilbara Stygofauna Survey (PSS) records revealed seven troglofauna (including those taxa considered as 'potential' troglofauna) taxa belonging to four taxonomic groups, and 55 stygofauna (including taxa considered as 'potential' stygofauna) taxa from 12 taxonomic groups within 40 km of the Study Area (Table 4.1). The locations of these subterranean fauna records are shown in Figure 4.1 and 4.2. None of the troglofauna or stygofauna taxa recorded from the database searches were recorded within the Study Area, owing to the lack of previous sampling.

Based on current knowledge, none of the described troglofauna or stygofauna species appear on any threatened species lists. Particularly in relation to the stygofauna taxa, the majority of the records comprise widespread species known to occur beyond the Study Area. However, owing to the indeterminate identifications of many of the taxa recorded, a number of records cannot be assessed for wider local/ regional distributions. A list of all database search records is presented in Appendix B.

Table 4.1: Troglofauna and stygofauna morphospecies recorded in the databases within 40 km of the Study Area (search parameters as per Table 3.1)

Taxonomy	Likely subterranean status	SRE status where known	Source
Rotifera			
Bdelloidea sp. 2:2	Potential Stygofauna	Uncertain	NatureMap
Dissotrocha sp. indet.	Potential Stygofauna	Uncertain	NatureMap
Bdelloidea sp. indet.*	Potential Stygofauna	Uncertain	NatureMap, PSS
Platyhelminthes			
Turbellaria sp.D4:ED4:E278	Stygofauna	Widespread	PSS
Nematoda			
Nematoda sp. 2	Stygofauna	Widespread	NatureMap, PSS
Nematoda sp. 4	Stygofauna	Widespread	NatureMap, PSS
Nematoda sp. 14	Stygofauna	Uncertain	NatureMap
Nematoda sp. 17	Stygofauna	Uncertain	NatureMap, PSS
Polychaeta			
Aeolosoma sp. 1	Stygofauna	Widespread	NatureMap, PSS
Aeolosoma sp. 3	Stygofauna	Widespread	NatureMap
Oligochaeta			
Enchytraeus Pilbara sp. 1	Stygofauna	Widespread	NatureMap, PSS
Insulodrilus lacustris s.l. Pilbara type 2/3	Stygofauna	Widespread	NatureMap, PSS
Monopylephorus n. sp. WA29	Stygofauna	Widespread	NatureMap, PSS
Phreodrilid with dissimilar ventral chaetae	Stygofauna	Widespread	NatureMap, PSS
Phreodrilid with similar ventral chaetae	Stygofauna	Widespread	NatureMap, PSS
Naididae sp. indet.*	Stygofauna	Uncertain	NatureMap, PSS
Oligochaeta sp. indet.*	Potential Stygofauna	Uncertain	NatureMap
Acari			
Oribatida sp. 4	Potential Stygofauna	Uncertain	NatureMap

Taxonomy	Likely subterranean status	SRE status where known	Source
Oribatida group 1*	Potential Stygofauna	Uncertain	NatureMap
Oribatida group 5*	Potential Stygofauna	Uncertain	NatureMap
Acari sp. indet.*	Potential Stygofauna	Uncertain	WAM, NatureMap
Ostracoda			
Areacandona cf. sp. 1	Stygofauna	Widespread	NatureMap, PSS
Areacandona iuno	Stygofauna	Widespread	NatureMap, PSS
Candonopsis pilbarae	Stygofauna	Widespread	PSS, WAM, NatureMap
Cypretta seurati	Stygofauna	Widespread	PSS
Cyprinotus kimberleyensis	Stygofauna	Widespread	PSS
Deminutiocandona cf. *halsei*	Stygofauna	Potential SRE	NatureMap, PSS
Gomphodella hirsuta	Stygofauna	Widespread	NatureMap, PSS
Ilyodromus sp. BOS25	Potential Stygofauna	Uncertain	NatureMap
Ilyodromus sp. PB	Potential Stygofauna	Uncertain	NatureMap
Leicacandona halsei	Stygofauna	Potential SRE	PSS, WAM, NatureMap
Leicacandona jimi	Stygofauna	Potential SRE	PSS, WAM, NatureMap
Leicacandona lite	Stygofauna	Potential SRE	PSS, WAM, NatureMap
Limnocythere sp. 1	Stygofauna	Widespread	NatureMap, PSS
Strandesia sp. indet.	Potential Stygofauna	Uncertain	NatureMap, PSS
Vestalenula marmonieri	Stygofauna	Widespread	NatureMap
Ostracoda sp. indet.*	Potential Stygofauna	Uncertain	NatureMap, PSS
Cyclopoida			
Diacyclops cockingi	Stygofauna	Widespread	NatureMap, PSS
Diacyclops einslei	Stygofauna	Widespread	NatureMap, PSS
Diacyclops humphreysi humphreysi	Stygofauna	Widespread	NatureMap, PSS
Diacyclops scanloni	Stygofauna	Widespread	NatureMap, PSS
Diacyclops sobeprolatus	Stygofauna	Widespread	NatureMap, PSS
Meridiecyclops baylyi	Stygofauna	Widespread	NatureMap, PSS
Mesocyclops darwini	Stygofauna	Widespread	NatureMap
Metacyclops sp. indet.	Stygofauna	Uncertain	PSS
Microcyclops varicans	Stygofauna	Widespread	NatureMap
Thermocyclops decipiens	Stygofauna	Widespread	NatureMap
Harpacticoida			
Parastenocaris sp. indet.	Potential Stygofauna	Uncertain	PSS
Stygonitocrella bispinosa	Stygofauna	Widespread	NatureMap
Stygonitocrella trispinosa	Stygofauna	Widespread	NatureMap, PSS
Stygonitocrella unispinosa	Stygofauna	Widespread	NatureMap, PSS
Elaphoidella humphreysi	Stygofauna	Widespread	NatureMap, PSS
Gordanitocrella trajani	Stygofauna	Widespread	WAM
Stygonitocrella sp. indet.	Potential Stygofauna	Uncertain	NatureMap
Canthocamptidae sp. indet.*	Potential Stygofauna	Uncertain	PSS
Harpacticoida sp. indet.*	Potential Stygofauna	Uncertain	NatureMap, PSS
Calanoida			
Stygoridgewayia trispinosa	Stygofauna	Widespread	PSS

Taxonomy	Likely subterranean status	SRE status where known	Source
Amphipoda			
Melitidae sp. 1	Stygofauna	Widespread	NatureMap, PSS
Nedsia nr *hurlberti*	Stygofauna	Widespread	NatureMap, PSS
Paramelitidae sp. 7	Stygofauna	Widespread	NatureMap
Pilbarus sp. 2	Stygofauna	Potential SRE	NatureMap, PSS
Pilbarus millsi	Stygofauna	Widespread	PSS
Nedsia sp. indet.*	Potential Stygofauna	Uncertain	NatureMap, PSS
Paramelitidae sp. indet.*	Potential Stygofauna	Uncertain	NatureMap
Isopoda			
?*Troglarmadillo* sp. indet.	Troglofauna	Potential SRE	WAM
Microcerberidae sp. indet.	Potential Stygofauna	Uncertain	NatureMap, PSS, WAM
Philosciidae sp. indet.	Potential Stygofauna	Uncertain	NatureMap, PSS
Scolopendrida			
Cryptopidae sp. 'MN'	Troglofauna	Potential SRE	WAM
Pseudoscorpiones			
Tyrannochthonius `sp. AB A`	Troglofauna	Potential SRE	WAM
Tyrannochthonius `sp. AB B`	Troglofauna	Potential SRE	WAM
Tyrannochthonius `sp. AB`	Troglofauna	Potential SRE	WAM
Tyrannochthonius abydos	Troglofauna	Potential SRE	WAM
Tyrannochthonius sp. indet.*	Potential Troglofauna	Uncertain	WAM
Araneae			
Oonopidae?' blind sp. (juvenile)	Potential Troglofauna	Uncertain	WAM

Note: *Asterisk indicates indeterminate taxa such as '*Tyrannochthonius* sp. indet.' which are not included in species counts as they represent specimens that cannot be allocated to the other known species based on current taxonomic information.

700000
720000
740000
760000
780000
7700000
7680000
7660000

Northern DD
0.2
0.3
0.4

Central DD
0.2
0.3
0.4

Southern DD
0.2
0.3
0.4

Legend

Terrestrial Survey Areas
Miralga East
Miralga West
Sandtrax
Drawdown

Higher Order

Araneae
Pseudoscorpiones
Scolopendrida

N
1:250,000
0 3.75 7.5 15 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig 4.1: Previous troglofauna records within 40 km of the Study Area

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 22/01/2020

680000 700000 720000 740000 760000

7700000

7680000

7660000

Higher Order

- Acari
- Amphipoda
- Calanoida
- Cyclopoida
- Harpacticoida
- Isopoda
- Nematoda
- Oligochaeta
- Ostracoda
- Platyhelminthes
- Polychaeta
- Rotifera

Northern DD

0.2

0.3

0.4

Central DD

0.2

0.3

0.4

Southern DD

0.2

0.3

0.4

Legend

- Terrestrial Survey Areas
- Miralga East
- Miralga West
- Sandtrax
- Drawdown

biologic

N

1:250,000

0 3.75 7.5 15

km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig 4.2: Previous stygofauna records within 40 km of the Study Area

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 27/01/2020

4.3 Previous survey results

Reports from subterranean fauna surveys within 60 km of the Study Area were reviewed for local and regional context. None of the surveys sampled bores/ drill holes were within the Study Area.

The closest subterranean fauna survey was conducted at Sulphur Springs, located approximately 4 kilometres south-east of the Study Area. In total, 53 bores were sampled over three phases (Subterranean Ecology, 2007a, 2007b, 2007c), revealing a diverse stygofauna assemblage in the alluvial aquifer systems associated with the upper catchment tributaries of the East Strelley and Shaw Rivers. Stygofauna were also collected from deep fractured-rock aquifers (Subterranean Ecology, 2007a, 2007b, 2007c). In total, 27 stygofauna taxa from seven higher level taxonomic groups were recorded, comprising Acari, Amphipoda, Copepoda, Isopoda, Nematoda, Oligochaeta and Ostracoda. Of these, 20 taxa were found to have wide-ranging distributions extending beyond the Study Area. In contrast, only one species of troglofauna was recorded, a subterranean *Nocticola* cockroach. This specimen was mainly found in the volcanic-sedimentary units that overlay the granite-greenstone complex.

The two troglofauna surveys that have been conducted at Abydos, located approximately 8 km south-west of the Study Area, recorded a diverse troglofauna assemblage from Archean BIF deposits within the Paddy Market Formation (Subterranean Ecology, 2009, 2011). A total of 17 morphospecies from seven higher order groups (Oligochaeta, Pseudoscorpiones, Isopoda, Polyxenida, Polydesmida, Blattodea and Coleoptera) were collected across the two surveys. Diamond drill cores from the mineralised zones indicated relatively well-developed secondary porosity that extended to more than 50 mbgl. The distributions of troglofauna collected indicated that many species were not confined to individual deposit areas but were more widely dispersed along the ridge. This demonstrated that weathered and fractured geological units provided suitable habitat for troglofauna as well as BIF.

A subterranean fauna survey at North Star, located approximately 17 km south-west of the Study Area, recorded a diverse stygofauna assemblage and a moderately rich troglofauna assemblage (Subterranean Ecology, 2012b). Nineteen stygofauna taxa were identified, comprising Amphipoda, Cyclopoida, Harpacticoida, Syncarida, Ostracoda and Oligochaeta. Most of the stygofauna were recorded from the low-lying alluvial plains. Eleven species of troglofauna were identified, comprising Pseudoscorpiones, Blattodea, Coleoptera, Diplura, Hemiptera, Isopoda and Polyxenida. The troglofauna assemblage was predominantly associated with the Gorge Creek BIF orebody within North Star.

Biologic's subterranean fauna survey at the Warrawoona Gold Project, located approximately 50 km south-east of the Study Area, recorded a rich stygofauna species assemblage (Biologic, 2019b). Twenty-eight morphospecies and five indeterminate taxa from nine taxonomic groups were identified, comprising Nematoda, Polychaeta, Oligochaeta, Ostracoda, Cyclopoida, Harpacticoida, Syncarida, Amphipoda and Isopoda. The majority (14) of taxa were widespread and known to occur beyond the Warrawoona Gold Project. The stygofauna records were mostly associated with alluvial aquifer systems and deep fractured rock aquifers which have developed within several shear zones. The survey recorded a depauperate troglofauna assemblage, with only six morphospecies from five higher order groups identified. This was mainly attributed to limited prospective troglofauna habitat availability throughout the Study Area, as the

underlying geology is mostly impermeable and the groundwater table is close to the surface in several of the deposits. Troglofauna were mostly recorded from fractured rock habitats associated with shears, vertical fracture zones and faults, as well as from surface geologies (detritals).

A subterranean fauna survey at Corunna Downs, located approximately 55 km south-east of the Study Area, sampled 140 bores and drill holes for troglofauna and stygofauna (MWH, 2016). No stygofauna specimens were detected (MWH, 2016). In contrast, 13 troglofauna species from nine higher level taxonomic groups were recorded, comprising Blattodea, Coleoptera, Diplura, Isopoda, Polydesmida, Polyxenida, Pseudoscorpiones, Scolopendromorpha and Symphyla. Troglofauna were collected from geothite-hematite BIF habitat.

Subterranean fauna surveys at Mount Webber, located approximately 55 km to the south of the Study Area, revealed a moderately rich troglofauna assemblage, with 12 troglofauna species from nine orders being recorded (Subterranean Ecology, 2012a). The troglofauna were collected from geothite-hematite and chert-rich BIF habitat in the western part of the Mount Webber Project and fractured ultramafic/mafic rock type habitats to the east. A total of ten stygofauna morphospecies and six indeterminate stygofauna taxa were recorded at Mount Webber. Of these, two species were known only from the Study Area (*Billibathynella* sp. MW and *Dussartstenocaris* sp. MW).

Table 4.2: Summary of previous subterranean fauna survey effort and results within 100 km of the Study Area

Previous survey	Panorama Project Subterranean Fauna Survey Reports 2, 3 & 4	Abydos Troglofauna Survey	Abydos Troglofauna Survey	North Star Project: Subterranean Fauna Survey	Warrawoona Gold Project: Subterranean Fauna Survey	Corunna Downs Subterranean Fauna Assessment	Mount Webber Desktop Assessment of Subterranean Fauna (EIA)
Author, year	**Subterranean Ecology 2007a,b,c**	**Subterranean Ecology 2009**	**Subterranean Ecology 2011**	**Subterranean Ecology 2012b**	**Biologic 2019**	**MWH 2016**	**Subterranean Ecology 2012a**
Distance from Study Area	4 km SE	8 km SW	8 km SW	17 km SW	50 km SE	55 km SE	55 km S
Geology	Alluvium, calcrete, chert, shales, sandstone, VMS deposit: Archean granite-greenstone	BIF, minor shale, siltstone	BIF, minor shale, siltstone	Mineralised BIF, shales, cherts, alluvium, colluvium,	Detritals, sandstone, shale, basalt	Goethite-hematite BIF	Goethite-hematite and chert-rich BIF, ultramafic/mafic
Fauna targeted	Troglofauna & Stygofauna	Troglofauna	Troglofauna	Troglofauna & Stygofauna	Troglofauna & Stygofauna	Troglofauna & Stygofauna	Troglofauna & Stygofauna
Areas sampled	Sulphur Springs	Abydos	Abydos	North Star	Warrawoona Gold Project	Corunna Downs	Mount Webber
Bores sampled	53	183	95	83	118	140	109
Bores sampled in current deposits	0	0	0	0	0	0	0
Methods	Trapping, Scraping, Net hauling	Trapping	Trapping, Scraping	Trapping, Scraping, Net hauling	Trapping, Scraping, Net hauling	Trapping, Scraping, Net hauling	Trapping, Scraping, Net hauling
Troglofauna collected	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Araneae							•
Blattodea	•	•	•	•	•	•	•
Coleoptera		•		•	•	•	•
Diplura				•		•	
Diptera					•		
Hemiptera				•			•
Isopoda		•	•	•		•	•
Oligochaeta			•				•

Previous survey **Author, year**	Panorama Project Subterranean Fauna Survey Reports 2, 3 & 4 **Subterranean Ecology 2007a,b,c**	Abydos Troglofauna Survey **Subterranean Ecology 2009**	Abydos Troglofauna Survey **Subterranean Ecology 2011**	North Star Project: Subterranean Fauna Survey **Subterranean Ecology 2012b**	Warrawoona Gold Project: Subterranean Fauna Survey **Biologic 2019**	Corunna Downs Subterranean Fauna Assessment **MWH 2016**	Mount Webber Desktop Assessment of Subterranean Fauna (EIA) **Subterranean Ecology 2012a**
Polydesmida		•	•			•	
Polyxenida		•	•	•		•	•
Pseudoscorpiones		•	•	•	•	•	•
Schizomida							•
Scolopendrida						•	
Zygentoma					•		
Stygofauna collected	Yes	No	No	Yes	Yes	Not found	Yes
Acari	•						•
Amphipoda	•			•	•		
Bathynellacea				•			
Copepoda	•			•	•		
Cyclopoida				•			•
Harpacticoida				•			•
Isopoda	•				•		•
Nematoda	•				•		
Oligochaeta	•			•	•		•
Ostracoda	•			•	•		•
Polychaeta					•		
Syncarida					•		•

4.4 Current survey results

The current survey recorded a total of 5266 subterranean fauna specimens, comprising approximately 96% stygofauna (5078 specimens) and 4% troglofauna (188 specimens). The records were collected from 85 bores and holes throughout the Study Area.

4.4.1 Troglofauna results

A total of 188 troglofauna or potential troglofauna specimens were collected during the current survey, representing 25 unique morphospecies belonging to the following 16 taxonomic groups: Pseudoscorpiones, Palpigradi, Opiliones, Araneae, Isopoda, Diplopoda, Chilopoda, Polyxenida, Pauropoda, Symphyla, Diplura, Zygentoma, Blattodea, Hemiptera, Coleoptera and Diptera (Table 4.3, Figure 4.3). A further four indeterminate taxa were identified belonging to the aforementioned groups, though could not be resolved to species-level identifications due to specimens being immature, in poor/damaged condition or the wrong sex for species-level identifications (Table 4.4, Figure 4.4).

Diplopoda (55 specimens), Blattodea (43 specimens) and Zygentoma (22 specimens) were the three most abundant groups, collectively accounting for more than 63% of all troglofauna specimens recorded (Table 4.3, Table 4.4). Each of the remaining 13 groups accounted for less than 6% of all troglofauna specimens recorded.

The troglofauna species assemblage recorded during the current survey is slightly richer compared to other subterranean fauna surveys within the wider area. Comparatively, surveys at Sulphur Springs (1 taxon), Abydos (17 taxa), North Star (11 taxa), Warrawoona Gold Project (6 taxa), Corunna Downs (13 taxa) and Mount Webber (12 taxa) recorded fewer troglofauna morphospecies (see section 4.3).

Of the 25 troglofauna morphospecies recorded, two taxa; polyxenid *Lophoturus madecassus* and Sciaridae sp. B01, are known to be widespread troglophile/trogloxene fauna with linear ranges exceeding 400+ km (Table 4.3). Six (6) taxa were recorded from multiple locations within the Study Area, as shown in Table 4.3 and Figure 4.3. Of these, five taxa (*Prosopodesmus* nr `OES8`, Pauropodidae `BPU083`, *Scolopendrellopsis* sp. indet., *Nocticola quartermainei* s.l. and Cryptorhynchinae `BCO192`) were recorded more widely throughout the Study Area, with linear ranges ranging from 13 to 44 km. The remaining taxon recorded from multiple locations (*Trinemura* `BZY088`) had a more restricted distribution, with linear ranges from 0.45 to 5 km (Table 4.3). Fourteen (14) troglofauna taxa were singleton records or taxa known only from single sites and as such, their distributions are currently unknown. Three further groups; Phalangodidae sp. indet., *Troglarmadillo* sp. indet. and Projapygidae sp. indet. represent unique higher-order taxa recorded from multiple sites throughout the Study Area. Species-level identifications were unable to be achieved due to specimens being immature, in poor/damaged condition or the wrong sex for species-level identifications.

The survey results identified six troglofauna taxa that are currently known only from the proposed mining pits within the Study Area, as shown in red font in Table 4.3 and listed below:

- *Tyrannochthonius* `BPS228`

- *Tyrannochthonius*? sp. indet. (Sandtrax)
- Phalangodidae sp. indet.
- *Dodecastyla* sp. indet.
- *Nocticola currani* s.l.
- *Phaconeura* sp. indet.

Further details relating to these taxa are discussed in Section 6.

Table 4.3: Troglofauna results to date, taxonomic and distribution comments, known linear ranges and collection locations. Red fonts indicate taxa detected only within proposed impact areas.

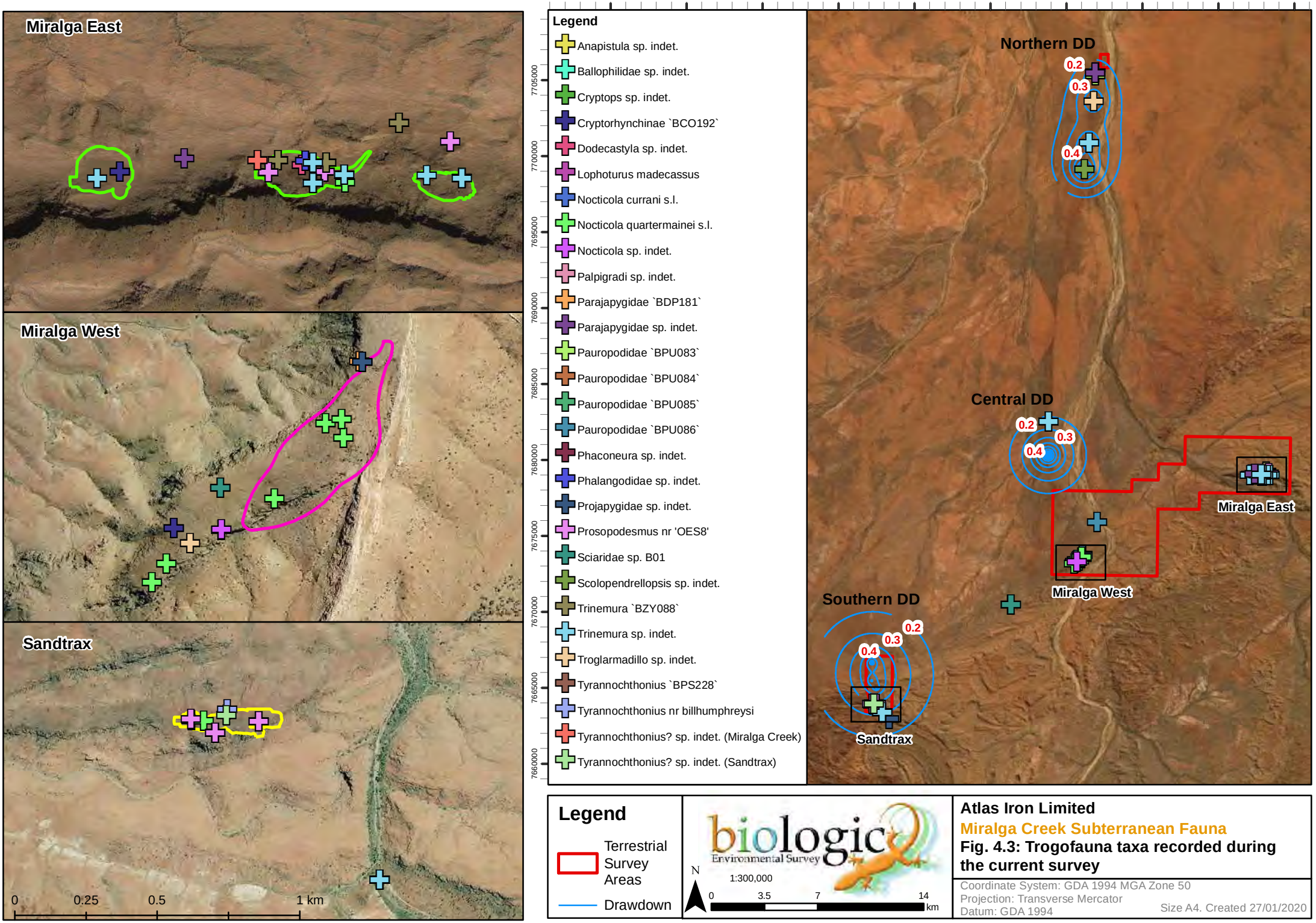
Taxonomy	ME	MW	ST	Out	Total	Taxonomic comments	Subterranean status, SRE status	Distribution comments	Known linear range (km)
ARACHNIDA									
Pseudoscorpiones									
Tyrannochthonius `BPS228`	1				**1**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	Singleton	-
Tyrannochthonius nr *billhumphreysi*				1	**1**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	Singleton	-
Tyrannochthonius? sp. indet. (Sandtrax)			**2**		**2**	Indeterminate genus-level taxon (juvenile specimens)	Troglofauna, Potential SRE	Single site	Uncertain
Palpigradi									
Palpigradi sp. indet. *				1	**1**	Indeterminate order-level taxon (damaged specimen)	Potential Troglofauna, Uncertain	Putative singleton	Uncertain
Opiliones									
Phalangodidae sp. indet. *	1			1	**2**	Indeterminate family-level taxon (juvenile specimen)	Troglofauna, Uncertain	2 sites	Uncertain
Araneae									
Anapistula sp. indet. *				1	**1**	Indeterminate genus-level taxon (juvenile specimen)	Troglofauna, Uncertain	Putative singleton	Uncertain
MALACOSTRACA									
Isopoda									
Troglarmadillo sp. indet. *				2	**2**	Indeterminate genus-level taxon	Troglofauna, Uncertain	2 sites	Uncertain
MYRIAPODA									
Diplopoda									
Prosopodesmus nr `OES8`	10		24	21	**55**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	10 sites, locally Widespread	30
Chilopoda									-
Ballophilidae sp. indet. *				1	**1**	Indeterminate family-level taxon	Troglofauna, Potential SRE	Putative singleton	-
Cryptops sp. indet. *				1	**1**	Indeterminate genus-level taxon	Troglofauna, Potential SRE	Putative singleton	-
Polyxenida									
Lophoturus madecassus				10	**10**	Morphologically identified, unique morphospecies	Troglophile/xene, Widespread	Single site, Widespread	1000+[1]
Pauropoda									
Pauropodidae `BPU083`				3	**3**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	2 sites, locally Widespread	44
Pauropodidae `BPU084`				1	**1**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	Singleton	-
Pauropodidae `BPU085`				1	**1**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	Singleton	-
Pauropodidae `BPU086`				1	**1**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	Singleton	-
Symphyla									

Taxonomy	ME	MW	ST	Out	Total	Taxonomic comments	Subterranean status, SRE status	Distribution comments	Known linear range (km)
Scolopendrellopsis sp. indet. *				7	**7**	Indeterminate genus-level taxon (damaged specimens)	Troglofauna, Potential SRE	2 sites, locally Widespread	38
ENTOGNATHA									
Diplura									
Parajapygidae `BDP181`				1	**1**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	Singleton	-
Projapygidae sp. indet. *				5	**5**	Indeterminate family-level taxon	Troglofauna, Potential SRE	3 sites	Uncertain
INSECTA									
Zygentoma									
Dodecastyla sp. indet. *	1				**1**	Indeterminate genus-level taxon (juvenile specimen)	Potential Troglofauna, Potential SRE	Putative singleton	-
Trinemura `BZY088`	4			6	**10**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	3 sites	0.45
Blattodea									
Nocticola currani s.l.	2				**2**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	Single site	-
Nocticola quartermainei s.l.	13	6	2	9	**30**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	15 sites, locally Widespread	30
Hemiptera									
Phaconeura sp. indet. *	11				**11**	Indeterminate genus-level taxon (juvenile specimens and nymphs)	Troglofauna, Potential SRE	Single site	-
Coleoptera									
Cryptorhynchinae `BCO192`	2			1	**3**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	2 sites	13
Diptera									
Sciaridae sp. B01				9	**9**	Morphologically identified, unique morphospecies	Troglofauna, Potential SRE	Widespread	400+
TOTAL	**45**	**6**	**28**	**83**	**162**				

Note: indeterminate taxa with asterisk (*) were included in species count, as they were regarded as distinct taxa. All other indeterminate taxa were not included, as there was insufficient information to exclude the possibility that they may be the same as other specimens collected. Known linear range based on [1] Car *et al.* (2013). ME = Miralga East, MW = Miralga West, ST = Sandtrax and OUT = outside of pits.

Table 4.4: Higher level troglofauna identifications in the Study Area

Taxonomy	ME	MW	ST	Out	Total	Taxonomic comments	Probable species
Tyrannochthonius? sp. indet. (Miralga East)	1			1	**2**	Indeterminate genus-level taxon. Likely to represent *Tyrannochthonius* `BPS228`, located 70 m to the west of one of the records.	*Tyrannochthonius* `BPS228`
Parajapygidae sp. indet.				2	**2**	Indeterminate family-level taxon. May represent Parajapygidae `BDP181` recorded from the Study Area (within 12 – 30 km of the two records).	Parajapygidae `BDP181`
Trinemura sp. indet.	8			3	**11**	Indeterminate genus-level taxon (immature and wrong sex specimens for species-level ID). Likely to represent *Trinemura* `BZY088` from the same deposit.	*Trinemura* `BZY088`
Nocticola sp. indet.	10			1	**11**	Indeterminate genus-level taxon (juvenile specimens). May represent *Nocticola currani* s.l. or *Nocticola quartermainei* s.l. from the same deposit.	*Nocticola currani* s.l. *Nocticola quartermainei* s.l.
TOTAL	**19**	**0**	**0**	**7**	**26**		


Miralga East
Miralga West
Sandtrax
0
0.25
0.5
1 km
710000
715000
720000
725000
730000
735000
740000
745000
750000
755000
7705000
7700000
7695000
7690000
7685000
7680000
7675000
7670000
7665000
7660000
Legend
Anapistula sp. indet.
Ballophilidae sp. indet.
Cryptops sp. indet.
Cryptorhynchinae `BCO192`
Dodecastyla sp. indet.
Lophoturus madecassus
Nocticola currani s.l.
Nocticola quartermainei s.l.
Nocticola sp. indet.
Palpigradi sp. indet.
Parajapygidae `BDP181`
Parajapygidae sp. indet.
Pauropodidae `BPU083`
Pauropodidae `BPU084`
Pauropodidae `BPU085`
Pauropodidae `BPU086`
Phaconeura sp. indet.
Phalangodidae sp. indet.
Projapygidae sp. indet.
Prosopodesmus nr 'OES8'
Sciaridae sp. B01
Scolopendrellopsis sp. indet.
Trinemura `BZY088`
Trinemura sp. indet.
Troglarmadillo sp. indet.
Tyrannochthonius `BPS228`
Tyrannochthonius nr billhumphreysi
Tyrannochthonius? sp. indet. (Miralga Creek)
Tyrannochthonius? sp. indet. (Sandtrax)
Northern DD
0.2
0.3
0.4
Central DD
0.2
0.3
0.4
Miralga East
Miralga West
Southern DD
0.2
0.3
0.4
Sandtrax
Legend
Terrestrial Survey Areas
Drawdown
biologic
Environmental Survey
N
1:300,000
0
3.5
7
14
km
Atlas Iron Limited
Miralga Creek Subterranean Fauna
Fig. 4.3: Trogofauna taxa recorded during the current survey
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A4. Created 27/01/2020

4.4.2 Stygofauna results

A total of 5078 stygofauna or potential stygofauna specimens were collected during the current survey, representing 60 unique morphospecies belonging to the following eight taxonomic groups: Oligochaeta, Acari, Ostracoda, Cyclopoida, Harpacticoida, Syncarida, Amphipoda, and Isopoda (Table 4.5, Figure 4.4a-f). A further 22 indeterminate taxa were identified belonging to the aforementioned groups, however they could not be resolved to species-level identifications due to specimens being immature, in poor/damaged condition or the wrong sex for species-level identifications (Table 4.6, Figure 4.4a-f).

Copepods were the most abundant group, accounting for more than 52% of all stygofauna collected. The copepods included 60% Cyclopoida (1595 specimens) and 40% Harpacticoida (1073 specimens). The remaining stygofauna comprised; Ostracoda (17%, 875 specimens), Oligochaeta (15%, 744 specimens). Amphipoda (10%, 533 specimens) and Syncarida (4%, 184 specimens), with the Isopoda and Acari accounting for less than 2% (64 and 2 specimens respectively).

Compared to other subterranean fauna surveys within the wider area, the stygofauna species assemblage recorded during the current survey is considered very rich. Comparatively, surveys at Sulphur Springs, North Star, Warrawoona Gold Project and Mount Webber recorded half or less the number of stygofauna morphospecies, with 27, 19, 28, and 10 species recorded respectively (see Section 4.3).

Of the 60 stygofauna morphospecies recorded, approximately a third (19) were widespread taxa known to occur regionally or throughout the Pilbara (Table 4.5). This includes two stygofauna taxa; Phreodrilidae sp. AP DVC s.l. and Phreodrilidae sp. AP SVC s.l., representing species complexes that have historically been extensively recorded, with widespread distributions throughout the Pilbara (Halse & Eberhard, 2014). Sixteen (16) taxa were recorded from multiple locations within the Study Area, as shown in Table 4.5 and Figures 4.4a-f. Of these, 13 taxa were recorded more widely throughout the Study Area, with linear ranges ranging from 15 to 49 km. The remaining three taxa recorded from multiple locations (*Parastenocaris* `BHA266`, Paramelitidae `BAM162` and Paramelitidae Genus 2 `BAM163`) had more restricted distributions, with linear ranges ranging from 0.2 to 10 km (Table 4.5).

Twenty-two (22) stygofauna taxa were singleton records or taxa known only from single sites and as such, their distributions are currently unknown. The remaining three stygofauna taxa (*Atopobathynella* sp. indet., nr *Billibathynella* sp. indet. and Bogidiellidae sp. indet.) represent unique higher-order taxa recorded from multiple sites throughout the Study Area. Species-level identifications were unable to be achieved due to the current poor taxonomic framework that exists for the groups as well as specimens being in poor condition or juvenile.

Twelve (12) stygofauna taxa are currently known only from within the estimated groundwater drawdown and are therefore considered at risk of impacts:

- *Wandesia* sp. indet.
- Candonidae `BOS1332`
- *Ilyodromus* sp. indet.
- *Pescecyclops* `BCY065`

- *Parastenocaris* `BHA266`
- Bathynellidae sp. VLS
- nr *Billibathynella* sp. indet.
- nr *Hexabathynella* sp. indet.
- Bogidiellidae sp. indet.
- Melitidae `BAM160` (sp. 1 group)
- Paramelitidae `BAM162`
- Paramelitidae Genus 2 `BAM164`

Further details relating to the potential wider occurrence of these taxa are discussed in Section 6.

Table 4.5:Stygofauna results to date, taxonomic and distribution comments, known linear ranges and collection locations. Red fonts indicate taxa detected only within proposed impact areas.

Taxonomy	Northern DD	Central DD	Southern DD	Out	Total	Taxonomic comments	Subterranean status, SRE status	Distribution comments	Known linear range (km)
OLIGOCHAETA									
Enchytraeidae									
Enchytraeidae `3 bundle` s.l. (short sclero)		9		89	**98**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	6 sites	15
Naididae									
Monopylephorus sp. nov. WA29 (ex Pristina WA3) (PSS)	265	1		24	**290**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	9 sites, Widespread	325[1]
Phreodrilidae									
Phreodrilidae sp. AP DVC s.l.	2			66	**68**	Morphologically identified to widespread species complex	Stygophile/xene, species complex Widespread	3 sites, Widespread	1000+[1]
Phreodrilidae sp. AP SVC s.l.		5	3	2	**10**	Morphologically identified to widespread species complex	Stygophile/xene, species complex Widespread	3 sites, Widespread	1000+[1]
Tubificidae									
Tubificidae `BOL049`	1			3	**4**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	3 sites	32
Tubificidae `BOL050`				44	**44**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
ACARI									
Hydryphantidae									
Wandesia sp. indet. *			1		**1**	Indeterminate genus-level taxon	Potential Stygofauna, Uncertain	Putative singleton	Uncertain
OSTRACODA									
Candonidae									
Candonidae `BOS1332`		30			**30**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Candonidae `BOS1333`				3	**3**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Candonopsis tenuis			3	32	**35**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	5 sites, Widespread	360[1]
Leicacandona `BOS1343`		16	1	5	**22**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	5 sites	26
Leicacandona `BOS1354`				43	**43**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Leicacandona `BOS1356`				16	**16**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Leicacandona `BOS1357`				8	**8**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-

Taxonomy	Northern DD	Central DD	Southern DD	Out	Total	Taxonomic comments	Subterranean status, SRE status	Distribution comments	Known linear range (km)
Leicacandona lite				15	**15**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	15+[1]
Cyprididae									
?*Ampullacypris* `BOS1341`				15	**15**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Cypretta `BOS1353`				4	**4**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Cypridopsis `BOS1337`				20	**20**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Cyprinotus kimberleyensis s.l.				5	**5**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	Single site, Widespread	
Heterocypris sp. indet. *				1	**1**	Indeterminate genus-level taxon	Stygofauna, Potential SRE	Putative singleton	Uncertain
Ilyodromus sp. indet. *			7		7	Indeterminate genus-level taxon	Stygofauna, Potential SRE	Single site	Uncertain
Riocypris fitzroyi			2	65	**67**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	2 sites	500+[1]
Stenocypris major				21	**21**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	2 sites	1000+
Darwinulidae									
Penthesilenula brasiliensis	1			20	**21**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	2 sites, Widespread	1000+[2]
Vestalenula matildae			2	100	**102**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	3 sites, Widespread	440[3]
Limnocytheridae									
Gomphodella pilbarensis			8	39	**47**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	4 sites	70[4]
Limnocythere dorsosicula				25	**25**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	2 sites, Widespread	1000+[5]
Ilyocyprididae									
Ilyocypris sp. indet. *				1	**1**	Indeterminate genus-level taxon	Stygofauna, Potential SRE	Putative singleton	Uncertain
CYCLOPOIDA									
Cyclopidae									
Diacyclops humphreysi s.l.	365	7	47	158	**577**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	21 sites, Widespread	700+[1]
Diacyclops scanloni		39		24	**63**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	3 sites, Widespread	450[1]
Dussartcyclops nr *uniarticulatus*				3	**3**	Morphologically identified, unique morphospecies	Potential Stygofauna, Potential SRE	Single site	-
Mesocyclops brooksi			6		**6**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	Single site, Widespread	600[1]
Mesocyclops notius	55			1	**56**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	3 sites, Widespread	1000+[1]

Taxonomy	Northern DD	Central DD	Southern DD	Out	Total	Taxonomic comments	Subterranean status, SRE status	Distribution comments	Known linear range (km)
Microcyclops varicans			230	71	**301**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	10 sites, Widespread	1000+[1]
Pescecyclops `BCY065`		4	6		**10**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	3 sites	21
Pescecyclops `BCY066`				10	**10**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
HARPACTICOIDA									
Ameiridae									
Megastygonitocrella trispinosa	251	32		52	**336**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	15 sites, Widespread	500+[1,6]
Megastygonitocrella unispinosa	2			1	**3**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	2 sites, Widespread	600+[1]
Canthocamptidae									
Canthocamptidae `BHA267`				1	**1**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Singleton	-
Elaphoidella humphreysi	42		76	104	**222**	Morphologically identified, unique morphospecies	Stygophile/xene, Widespread	14 sites, Widespread	550[1]
Parastenocarididae									
Parastenocaris `BHA266`	15				**15**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	2 sites	0.2
Parastenocaris `BHA268`				3	**3**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Parastenocarididae n. gen. `BHA265`			3	14	**17**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	2 sites	48
SYNCARIDA									
Bathynellidae									
Bathynellidae sp. "3 spines"			2	3	**5**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	2 sites	19
Bathynellidae sp. "Long A2"				1	**1**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Singleton	-
Bathynellidae sp. L			39	6	**45**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	3 sites	49
Bathynellidae sp. S				11	**11**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Bathynellidae sp. VLS			2		**2**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Single site	-
Parabathynellidae									
Atopobathynella sp. indet. *			11	24	**35**	Indeterminate genus-level taxon	Stygofauna, Potential SRE	4 sites	Uncertain
nr *Billibathynella* sp. indet. *	81	2			**83**	Indeterminate genus-level taxon	Stygofauna, Potential SRE	7 sites	Uncertain
nr *Hexabathynella* sp. indet. *	2				**2**	Indeterminate genus-level taxon	Stygofauna, Potential SRE	Single site	Uncertain
AMPHIPODA									
Bogidiellidae									

Taxonomy	Northern DD	Central DD	Southern DD	Out	Total	Taxonomic comments	Subterranean status, SRE status	Distribution comments	Known linear range (km)
Bogidiellidae sp. indet. *	9	2	1	1	**13**	Indeterminate family-level taxon	Stygofauna, Potential SRE	7 sites	Uncertain
Eriopsidae									
Nedsia `hurlberti group` sp. 1 spine		42		1	**43**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	4 sites	28
Melitidae									
Melitidae `BAM160` (sp. 1 group)	8	1			**9**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	3 sites	23
Paramelitidae									
Paramelitidae `BAM161`	104	28		7	**139**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	10 sites	46
Paramelitidae `BAM162`	5				**5**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	3 sites	6.5
Paramelitidae Genus 2 `BAM163`		5		3	**8**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	2 sites	10
Paramelitidae Genus 2 `BAM164`			1		**1**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	Singleton	-
ISOPODA									
Microcerberidae									
Microcerberidae `BIS356` (B01 gp)	2			6	**8**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	3 sites	30
Microcerberidae `BIS357`		7		10	**17**	Morphologically identified, unique morphospecies	Stygofauna, Potential SRE	2 sites	26
TOTAL	**1210**	**30**	**348**	**1485**	**3073**				

Note: indeterminate taxa with asterisk (*) were included in species count, as they were regarded as distinct taxa. All other indeterminate taxa were not included, as there was insufficient information to exclude the possibility that they may be the same as other specimens collected. Known linear range based on [1] Halse & Eberhard (2014), [2] Pinto *et al.* (2004), [3] Martens & Rossetti (2002), [4] Karanovic (2009), [5] De Deckker (1982), [6] Karanovic (2006).

Table 4.6: Higher level stygofauna identifications in the Study Area

Taxonomy	Northern DD	Central DD	Southern DD	Out	Total	Taxonomic comments	Probable species
Enchytraeidae sp. indet.		20		82	**102**	Indeterminate family-level taxon. Likely to represent Enchytraeidae `3 bundle` s.l. (short sclero) collected from some of the same sites.	Enchytraeidae `3 bundle` s.l. (short sclero)
Naididae sp. indet.	77			16	**93**	Indeterminate family-level taxon. Likely to represent *Monopylephorus* sp. nov. WA29 (ex Pristina WA3) (PSS) collected from some of the same sites.	*Monopylephorus* sp. nov. WA29 (ex Pristina WA3) (PSS)
Phreodrilidae sp. indet.				35	**35**	Indeterminate family-level taxon (specimens damaged and/or juvenile). May represent other Phreodrilidae sp. collected from the Study Area.	Phreodrilidae sp. AP DVC s.l. Phreodrilidae sp. AP SVC s.l.
Acari sp. indet.		1			**1**	Indeterminate higher-order taxon. Uncertain whether Stygofauna. May represent *Wandesia* sp. indet. collected from the Study Area.	*Wandesia* sp. indet.
Candonidae sp. indet.		55		14	**69**	Indeterminate family-level taxon. May represent other Candonidae sp. collected from the Study Area, some of which were collected from the same sites.	Candonidae `BOS1332` Candonidae `BOS1333` *Candonopsis tenuis* *Leicacandona* `BOS1343` *Leicacandona* `BOS1354` *Leicacandona* `BOS1356` *Leicacandona* `BOS1357` *Leicacandona lite*
Candoninae sp. indet.			1		**1**	Indeterminate sub-family-level taxon. May represent other Candonidae sp. collected from the Study Area, particularly Leicacandona `BOS1343` collected from the same site.	*Leicacandona* `BOS1343`
Leicacandona? sp. indet.		32			**32**	Indeterminate family-level taxon. Likely to represent *Leicacandona* `BOS1343` collected from the same site.	*Leicacandona* `BOS1343`
Cypretta sp. indet.				20	**20**	Indeterminate genus-level taxon. May represent *Cypretta* `BOS1353` collected from the Study Area.	*Cypretta* `BOS1353`
Cypridopsis sp. indet.				50	**50**	Indeterminate genus-level taxon. May represent *Cypridopsis* `BOS1337` collected from the Study Area.	*Cypridopsis* `BOS1337`
Cyprididae sp. indet.				170	**170**	Indeterminate family-level taxon. May represent other Cyprididae sp. collected from the Study Area, some of which were collected from the same sites.	?*Ampullacypris* `BOS1341` *Cypretta* `BOS1353` *Cypridopsis* `BOS1337` *Cyprinotus kimberleyensis* s.l. *Heterocypris* sp. indet. *Ilyodromus* sp. indet. *Riocypris fitzroyi* *Stenocypris major*
Cyprinotus sp. indet.	1			20	**21**	Indeterminate genus-level taxon. May represent *Cyprinotus kimberleyensis* s.l. collected from the Study Area.	*Cyprinotus kimberleyensis* s.l.
Darwinulidae sp. indet.				1	**1**	Indeterminate family-level taxon. May represent widespread *Penthesilenula brasiliensis* or *Vestalenula matildae* collected from the Study Area.	*Penthesilenula brasiliensis* *Vestalenula matildae*
Ostracoda sp. indet.	2			1	**3**	Indeterminate higher-order taxon (juvenile specimens). Likely to represent some of the Ostracoda sp. listed to the right which were all collected from the same sites.	?*Ampullacypris* `BOS1341` *Gomphodella pilbarensis* *Leicacandona* `BOS1343` *Leicacandona lite* *Penthesilenula brasiliensis*

Taxonomy	Northern DD	Central DD	Southern DD	Out	Total	Taxonomic comments	Probable species
Mesocyclops sp. indet.				1	**1**	Indeterminate genus-level taxon. May represent *Mesocyclops brooksi* or *Mesocyclops notius* collected from the Study Area.	*Mesocyclops brooksi* *Mesocyclops notius*
Cyclopoida sp. indet.	235	91	39	203	**568**	Indeterminate higher-order taxon. May represent other Cyclopoida sp. collected from the Study Area, some of which were collected from the same sites.	*Diacyclops humphreysi* s.l. *Diacyclops scanloni* *Dussartcyclops* nr *uniarticulatus* *Mesocyclops brooksi* *Mesocyclops notius* *Microcyclops varicans* *Pescecyclops* `BCY065` *Pescecyclops* `BCY066`
Parastenocarididae sp. indet.			1	1	**2**	Indeterminate family-level taxon. May represent other Parastenocarididae sp. collected from the Study Area.	*Parastenocaris* `BHA266` *Parastenocaris* `BHA268` Parastenocarididae n. gen. `BHA265`
Harpacticoida sp. indet.	124	142	13	187	**466**	Indeterminate higher-order taxon. May represent other Harpacticoida sp. collected from the Study Area, some of which were collected from the same sites.	*Megastygonitocrella trispinosa* *Megastygonitocrella unispinosa* Canthocamptidae `BHA267` *Elaphoidella humphreysi* *Parastenocaris* `BHA266` *Parastenocaris* `BHA268` Parastenocarididae n. gen. `BHA265`
Copepoda sp. indet.				16	**16**	Indeterminate higher-order taxon. May represent other Cyclopoida sp. or Harpacticoida sp. collected from the Study Area.	Other Cyclopoida and/or Harpacticoida sp.
Melitidae sp. indet.	6	5			**11**	Indeterminate family-level taxon. Likely to represent Melitidae `BAM160` (sp. 1 group) collected from some of the same sites.	Melitidae `BAM160` (sp. 1 group)
Paramelitidae Genus 2 sp. indet.		1		1	**2**	Indeterminate family-level taxon. May represent Paramelitidae Genus 2 `BAM163` or Paramelitidae Genus 2 `BAM164` collected from the Study Area.	Paramelitidae Genus 2 `BAM163` Paramelitidae Genus 2 `BAM164`
Paramelitidae sp. indet.	89	189	1	23	**302**	Indeterminate family-level taxon. May represent Paramelitidae `BAM161` or Paramelitidae `BAM162` collected from some of the same sites.	Paramelitidae `BAM161` Paramelitidae `BAM162`
Microcerberidae sp. indet.	15	11		13	**39**	Indeterminate family-level taxon. May represent other Microcerberidae sp. collected from the Study Area, particularly Microcerberidae `BIS357` collected from the same sites.	Microcerberidae `BIS356` (B01 gp) Microcerberidae `BIS357`
TOTAL	**549**	**29**	**7**	**1420**	**2005**		

714781 720781 726781 732781 738781 744781 750781

7706387 7700387 7694387 7688387 7682387 7676387 7670387 7664387 7658387

Legend

Cyclopoida Records

- Copepoda sp. indet.
- Cyclopoida sp. indet.
- Diacyclops humphreysi s.l.
- Diacyclops scanloni
- Dussartcyclops nr uniarticulatus
- Mesocyclops brooksi
- Mesocyclops notius
- Mesocyclops sp. indet.
- Microcyclops varicans
- Pescecyclops `BCY065`
- Pescecyclops `BCY066`

Northern DD
0.2
0.3
0.4

Central DD
0.2
0.3
0.4

Southern DD
0.2
0.3
0.4

Legend

- Terrestrial Survey Areas
- Miralga East
- Miralga West
- Sandtrax Pit
- Drawdown

biologic Environmental Survey

N

1:150,000

0 1.5 3 6 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig. 4.4a: Cyclopoida taxa recorded during the current survey

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 20/02/2019

714559 720559 726559 732559 738559 744559 750559

7706630 7700630 7694630 7688630 7682630 7676630 7670630 7664630 7658630

Legend

Harpacticoida Records

- Copepoda sp. indet.
- Canthocamptidae `BHA267`
- Elaphoidella humphreysi
- Harpacticoida sp. indet.
- Megastygonitocrella trispinosa
- Megastygonitocrella unispinosa
- Parastenocarididae n. gen. `BHA265`
- Parastenocarididae sp. indet.
- Parastenocaris `BHA266`
- Parastenocaris `BHA268`

Northern DD
0.2
0.3
0.4

Central DD
0.2
0.3
0.4

Southern DD
0.2
0.3
0.4

Legend

- Terrestrial Survey Areas
- Miralga East
- Miralga West
- Sandtrax Pit
- Drawdown

biologic Environmental Survey

N

1:150,000

0 1.5 3 6 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig. 4.4b: Harpacticoida taxa recorded during the current survey

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 20/02/2019

714257 720257 726257 732257 738257 744257 750257

7706581 7700581 7694581 7688581 7682581 7676581 7670581 7664581 7658581

Legend

Ostracoda Records

- ?Ampullacypris `BOS1341`
- Candonidae `BOS1332`
- Candonidae `BOS1333`
- Candonidae sp. indet.
- Candonopsis tenuis
- Cypretta `BOS1353`
- Cypretta sp. indet.
- Cypididae sp. indet.
- Cypridopsis `BOS1337`
- Cypridopsis sp. indet.
- Cyprinotus kimberleyensis s.l.
- Cyprinotus sp. indet.
- Darwinulidae sp. indet.
- Gomphodella pilbarensis
- Heterocypris sp. indet.
- Ilyocypris sp. indet.
- Ilyodromus sp. indet.
- Leicacandona `BOS1343`
- Leicacandona `BOS1354`
- Leicacandona `BOS1356`
- Leicacandona `BOS1357`
- Leicacandona lite
- Leicacandona? sp. indet.
- Limnocythere dorsosicula
- Ostracoda sp. indet.
- Penthesilenula brasiliensis
- Riocypris fitzroyi
- Stenocypris major
- Vestalenula matildae

Northern DD
0.2
0.3
0.4

Central DD
0.2
0.3
0.4

Southern DD
0.2
0.3
0.4

Legend

- Terrestrial Survey Areas
- Miralga East
- Miralga West
- Sandtrax
- Drawdown

biologic Environmental Survey

N

1:150,000

0 1.5 3 6 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig. 4.4c: Ostracoda taxa recorded during the current survey

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 20/02/2019

714257 720257 726257 732257 738257 744257 750257

7706581 7700581 7694581 7688581 7682581 7676581 7670581 7664581 7658581

Legend

Amphipoda Records

- Bogidiellidae sp. indet.
- Melitidae `BAM160` (sp. 1 group)
- Melitidae sp. indet.
- Nedsia `hurlberti group` sp. 1 spine
- Paramelitidae Genus 2 `BAM163`
- Paramelitidae Genus 2 `BAM164`
- Paramelitidae Genus 2 sp. indet.
- Paramelitidae `BAM161`
- Paramelitidae `BAM162`
- Paramelitidae sp. indet.

Northern DD

0.2

0.3

0.4

Central DD

0.2

0.3

0.4

Southern DD

0.2

0.3

0.4

Legend

- Terrestrial Survey Areas
- Miralga East
- Miralga West
- Sandtrax
- Drawdown

biologic Environmental Survey

N

1:150,000

0 1.5 3 6 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig. 4.4d: Amphipoda taxa recorded during the current survey

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 27/01/2020

714257 720257 726257 732257 738257 744257 750257

7706581 7700581 7694581 7688581 7682581 7676581 7670581 7664581 7658581

Legend

Acari

- Acari sp. indet.
- Wandesia sp. indet.

Oligochaeta

- Enchytraeidae `3 bundle` s.l. (short sclero)
- Enchytraeidae sp. indet.
- Monopylephorus sp. nov. WA29 (ex Pristina WA3) (PSS)
- Naididae sp. indet.
- Phreodrilidae sp. AP DVC s.l.
- Phreodrilidae sp. AP SVC s.l.
- Phreodrilidae sp. indet.
- Tubificidae `BOL049`
- Tubificidae `BOL050`

Northern DD

0.2

0.3

0.4

Central DD

0.2

0.3

0.4

Southern DD

0.2

0.3

0.4

Legend

- Terrestrial Survey Areas
- Miralga East
- Miralga West
- Sandtrax
- Drawdown

biologic Environmental Survey

N

1:150,000

0 1.5 3 6 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig. 4.4e: Acari & Oligochaeta taxa recorded during the current survey

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 27/01/2020

714257 720257 726257 732257 738257 744257 750257

7706581 7700581 7694581 7688581 7682581 7676581 7670581 7664581 7658581

Legend

Isopoda

- Microcerberidae `BIS356` (B01 gp)
- Microcerberidae `BIS357`
- Microcerberidae sp. indet.

Syncarida

- Atopobathynella sp. indet.
- Bathynellidae sp. "3 spines"
- Bathynellidae sp. "Long A2"
- Bathynellidae sp. L
- Bathynellidae sp. S
- Bathynellidae sp. VLS
- nr Billibathynella sp. indet.
- nr Hexabathynella sp. indet.

Northern DD

0.2

0.3

0.4

Central DD

0.2

0.3

0.4

Southern DD

0.2

0.3

0.4

Legend

- Terrestrial Survey Areas
- Miralga East
- Miralga West
- Sandtrax
- Drawdown

biologic Environmental Survey

N

1:150,000

0 1.5 3 6 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig. 4.4f: Isopoda & Syncarida taxa recorded during the current survey

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 27/01/2020

5 SUBTERRANEAN HABITAT ASSESSMENT

The habitat assessment for potentially restricted species within the Study Area is based upon available geological and hydrogeological reports, surface geology maps (GSWA 1: 250,000) and three-dimensional geological mapping based on drill-hole logging data in the program Leapfrog® (provided by Atlas Iron). Groundwater physicochemical measurements taken during the survey were incorporated into the stygofauna habitat assessment where appropriate.

5.1 Troglofauna habitats (AWT)

Potential AWT habitats for troglofauna (*i.e.* caves, cavities, fractures, vugs, and pore spaces) within the Study Area occur mainly within the BIF dominated Cleaverville formation. The Cleaverville formation consists of a package of banded-iron formations (BIF), cherts and shales which locally form prominent ridgelines throughout which the proposed deposits are located. The secondary weathering processes that drive enrichment of the orebodies contribute to the occurrence of subterranean fauna habitat by dissolving cavities, vugs, and pore spaces within the BIF.

Unconsolidated colluvial layers in detrital valleys below the ridgelines and along the flanks of ridges, as well as alluvial layers in adjacent drainage lines, may also provide moderately to highly suitable habitats for troglofauna where sufficient vugs and pore spaces occur AWT. These types of deposits may be depth constrained by near surface groundwater tables, and if adjacent drainage lines, there may be periodic inundation from floods. Nevertheless, such deposits can still provide highly suitable AWT habitats for many troglofauna species.

Other geological units, such as the Lalla Rookh Sandstone which flanks and overlies the Cleaverville formation near the proposed deposits, are less likely to host significant AWT habitats for troglofauna based on their physical characteristics. However, localised troglofauna habitat may still occur where geologies are sufficiently fractured and/or faulted.

Details regarding AWT habitats for each major survey area are noted further below.

5.1.1 Miralga East deposit

Figure 5.1 shows the modelled AWT habitats throughout the Miralga East deposit in relation to surface geological mapping (GSWA 1:250,000). Detailed longitudinal and cross sections of modelled AWT habitats are provided in Appendix D.

At the Miralga East deposit, prospective medium to highly suitable habitats for troglofauna have been modelled along the BIF-hosted iron ore mineralisation of the Cleaverville formation. The Cleaverville formation forms an east to west striking band which hosts the three proposed deposits and extends well beyond the deposits to the west and east (Figure 5.1). Highly mineralised zones occur within the Cleaverville formation BIF band, both near the surface (hydrated mineralisation at surface) as well as at greater depths (primary BIF) (Appendix D, LS_1-LS_8). These zones of highly suitable prospective troglofauna habitat have mainly been modelled within the three proposed pits (Appendix D, CS_1-CS_10) However, it is considered likely that pockets of highly mineralised BIF occur throughout the Cleaverville

formation BIF band outside of the confidence area of the 3D modelling. Whilst highly mineralised BIF zones represent the most highly suitable AWT habitats for troglofauna, modelling indicates that these habitats are well-connected by medium suitable habitats along the BIF band.

Next to the east-west extending prospective troglofauna habitats within the Cleaverville formation band, there is the potential for further suitable troglofauna habitat to the south of the deposits, hosted by superficial deposits of colluvium.

5.1.2 Miralga West deposit

Figure 5.2 shows the modelled AWT habitats throughout Miralga West in relation to surface geological mapping (GSWA 1:250,000). Detailed longitudinal and cross sections of modelled AWT habitats are provided in Appendix E.

As for Miralga East deposit, prospective medium to highly suitable habitats for troglofauna at Miralga West have been modelled along the BIF-hosted iron ore mineralisation of the Cleaverville formation. At Miralga West, the Cleaverville formation band strikes from north-east to south-west through the Miralga West pit as well as extending well beyond the pit to the south-west and, to a lesser extent, the north-east. Within the Cleaverville formation BIF band, supergene weathering has created highly mineralised zones which represent highly suitable prospective troglofauna habitat as they contain many voids, vugs and cavities. These highly mineralised zones have mainly been modelled within the Miralga West pit, with two smaller pockets of highly suitable prospective troglofauna habitat also occurring to the south-west of the pit (Appendix E, LS_1-LS_6). Modelling indicates that these habitats are well-connected by medium suitable habitats along the BIF band (Appendix E, CS_1-CS_5). Further pockets of highly mineralised BIF may occur throughout the Cleaverville formation BIF band outside of the confidence area of the 3D modelling.

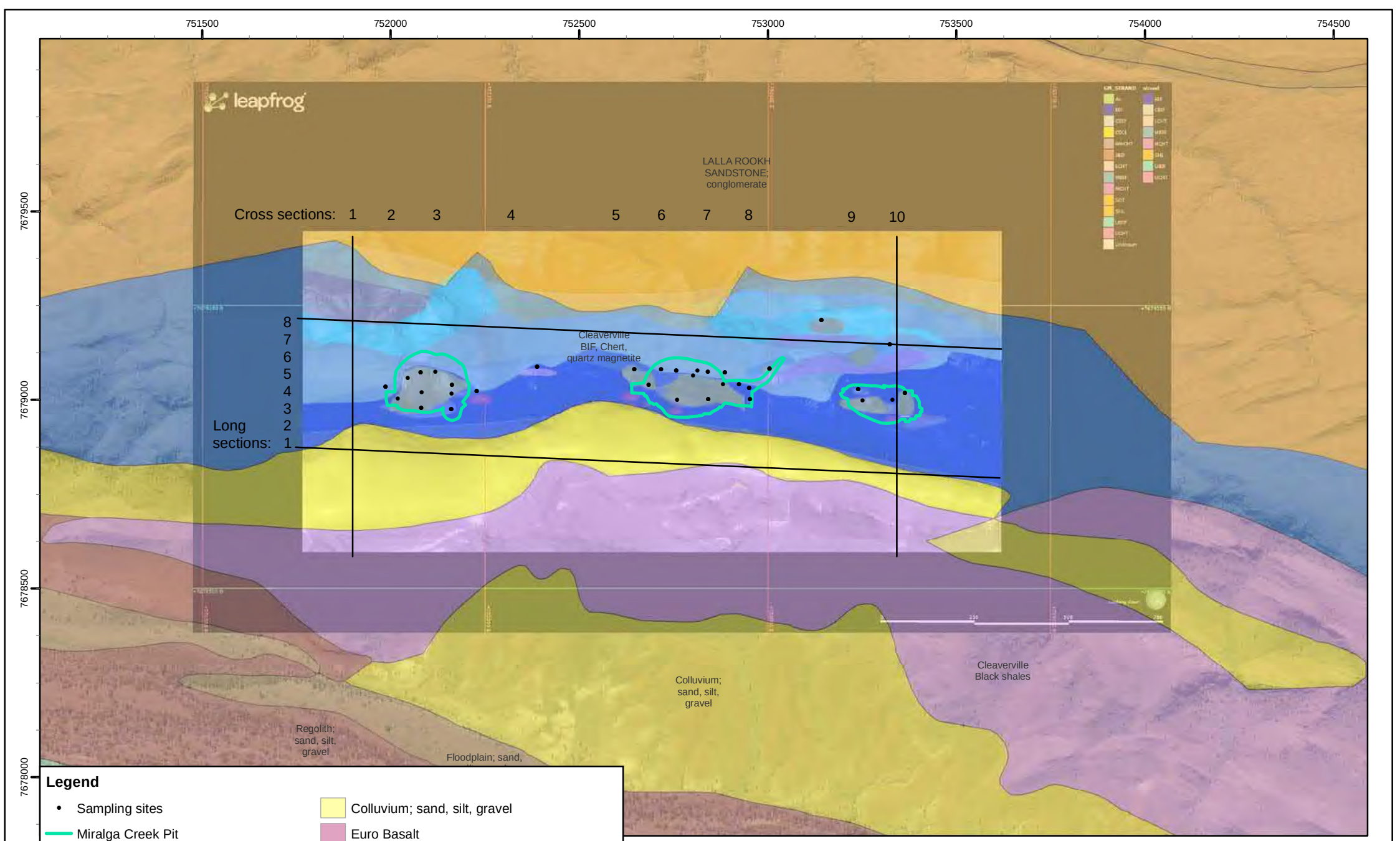
Further, more superficial prospective troglofauna habitat may also occur to the west of the Miralga West pit within superficial deposits of colluvium, where sufficient vugs and pore spaces occur AWT. Localised troglofauna habitat may also occur to the east of the pit within the Lalla Rookh Sandstone if geologies are sufficiently fractured and/or faulted.

5.1.3 Sandtrax deposit

Figure 5.3 shows the surface geological habitat units (GSWA 1:250,000) near the Sandtrax pit, as detailed three-dimensional geological mapping was not available for this area.

Geological mapping indicates that at the Sandtrax deposit, prospective suitable AWT habitats for troglofauna also occurs throughout the Cleaverville BIF which forms an east to west trending ridge. The Cleaverville BIF band, which contains sequences of black shales, extends considerably to the west and north/north-east of the pit (Figure 5.3). Potential compartmentalisation of habitat (or habitat barriers) may occur throughout the ridge due to less permeable shale bands present within the Cleaverville BIF band.

Secondarily weathered deposits of ferruginous duricrust, and unconsolidated layers of colluvium occur immediately to the north of the Sandtrax pit (Figure 5.3) which have the potential to represent further suitable troglofauna habitat near subsurface.



Legend

- Sampling sites
- Miralga Creek Pit

Geological description

- Alluvial; sand, silt, gravel
- Calcrete
- Cleaverville BIF, Chert, quartz magnetite
- Cleaverville Black shales, chert
- Colluvium; sand, silt, gravel
- Euro Basalt
- Euro Basalt; chert
- Floodplain; sand, silt, gravel
- LALLA ROOKH SANDSTONE; conglomerate
- Regolith; sand, silt, gravel

biologic Environmental Survey

N

1:12,500

0 0.125 0.25 0.5 km

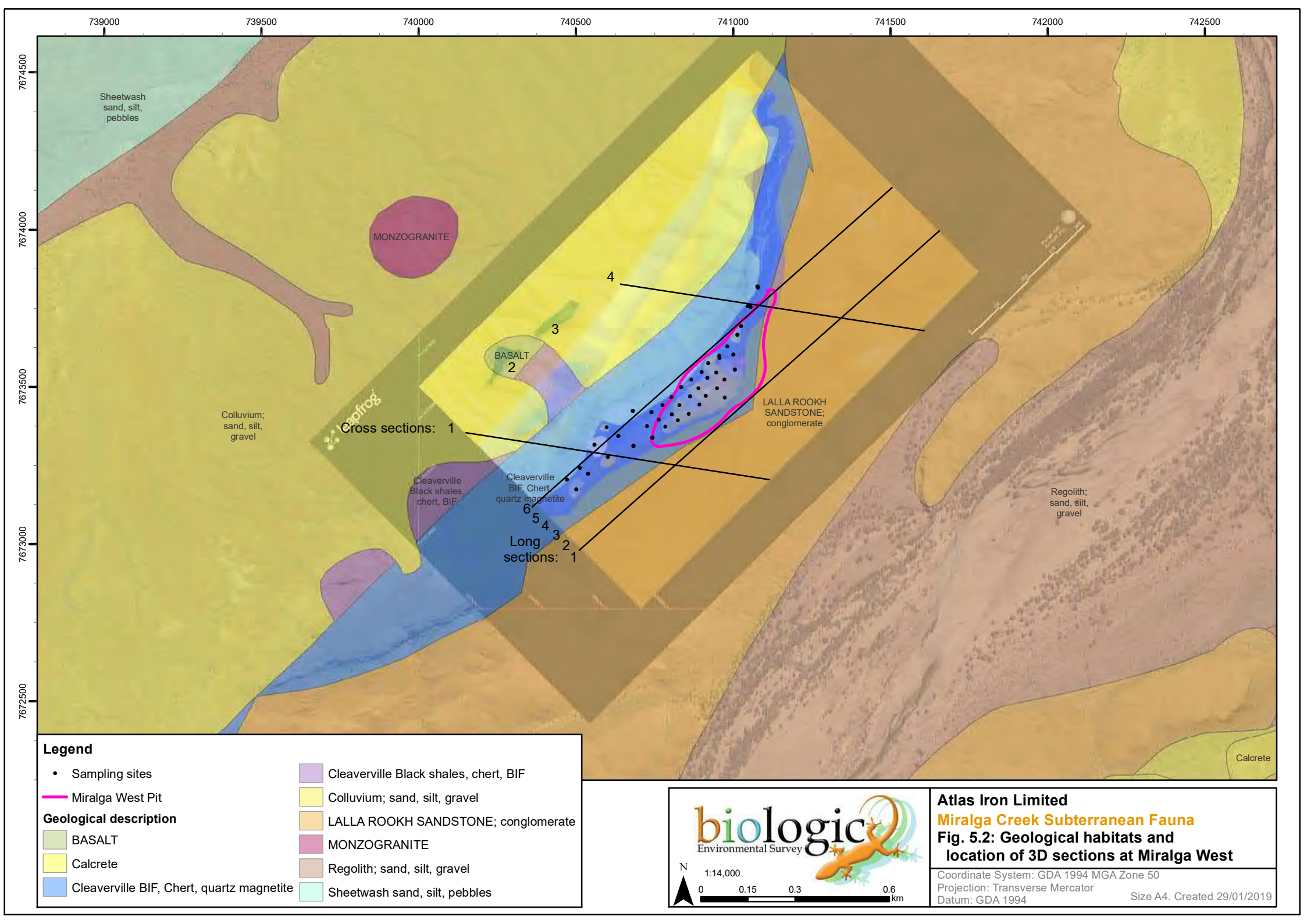
Atlas Iron Limited

Miralga Creek Subterranean Fauna

Fig. 5.1: Geological habitats and location of 3D sections at Miralga Creek

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 29/01/2019



biologic Environmental Survey

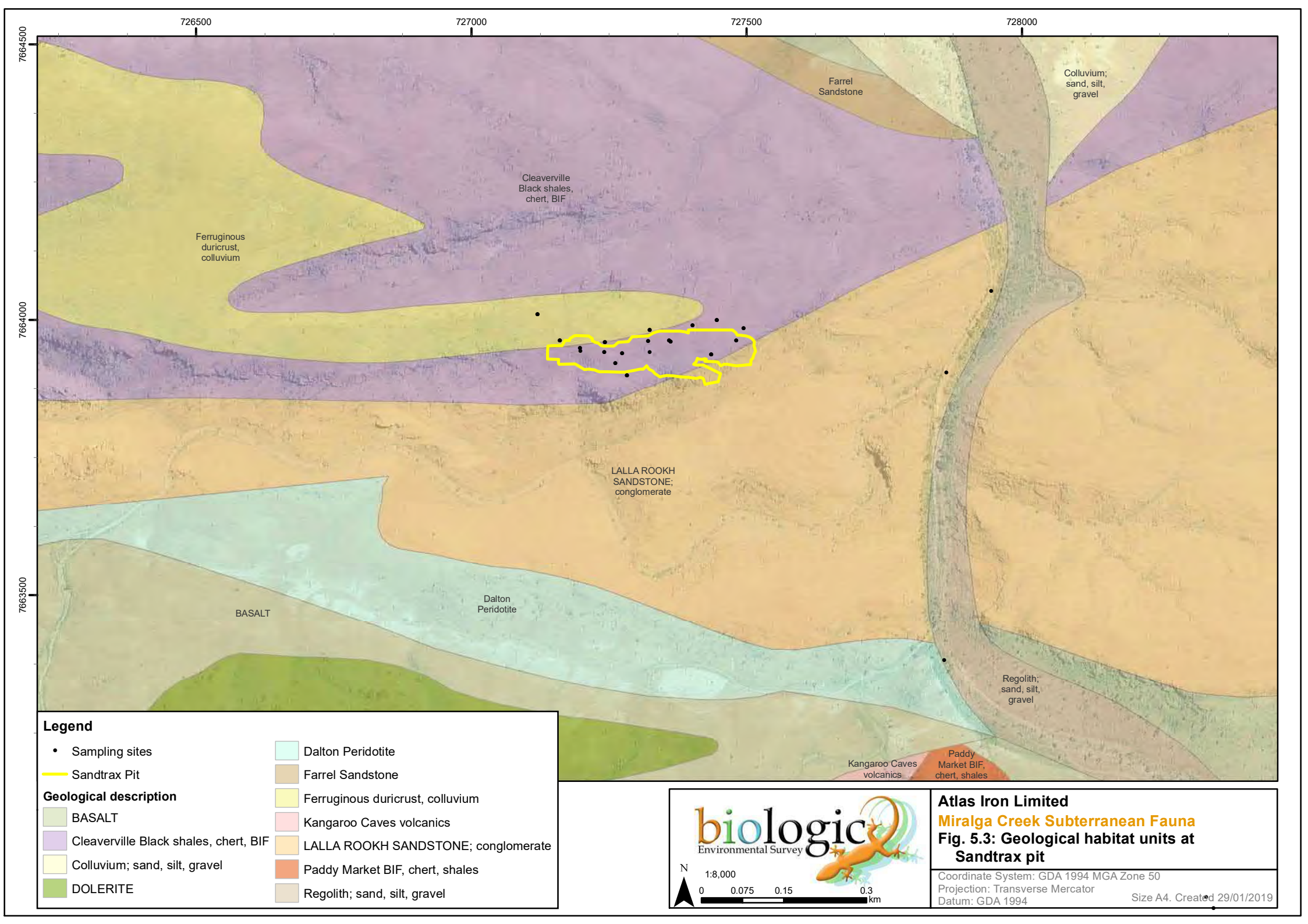
Atlas Iron Limited

Miralga Creek Subterranean Fauna

Fig. 5.2: Geological habitats and location of 3D sections at Miralga West

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 29/01/2019



Atlas Iron Limited

Miralga Creek Subterranean Fauna

Fig. 5.3: Geological habitat units at Sandtrax pit

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 29/01/2019

5.2 Stygofauna habitats

The hydrogeology of the Study Area is dominated by the Shaw River palaeochannel which hosts extensive interconnected detrital and fractured/ weathered rock aquifers. Superficial aquifers (including hyporheic aquifers) are hosted in detrital alluvium within the channel, forming an extensive interconnected aquifer throughout the channel. Zones of very high porosity/ transmissivity are supported by patches of secondarily weathered calcrete deposits which lie below the alluvium and locally outcrop at surface. Deeper aquifers are hosted within fractured/ weathered rock aquifers below the detritals and calcrete.

Details regarding BWT habitats for each drawdown area are noted further below.

5.2.1 Northern and Central DD

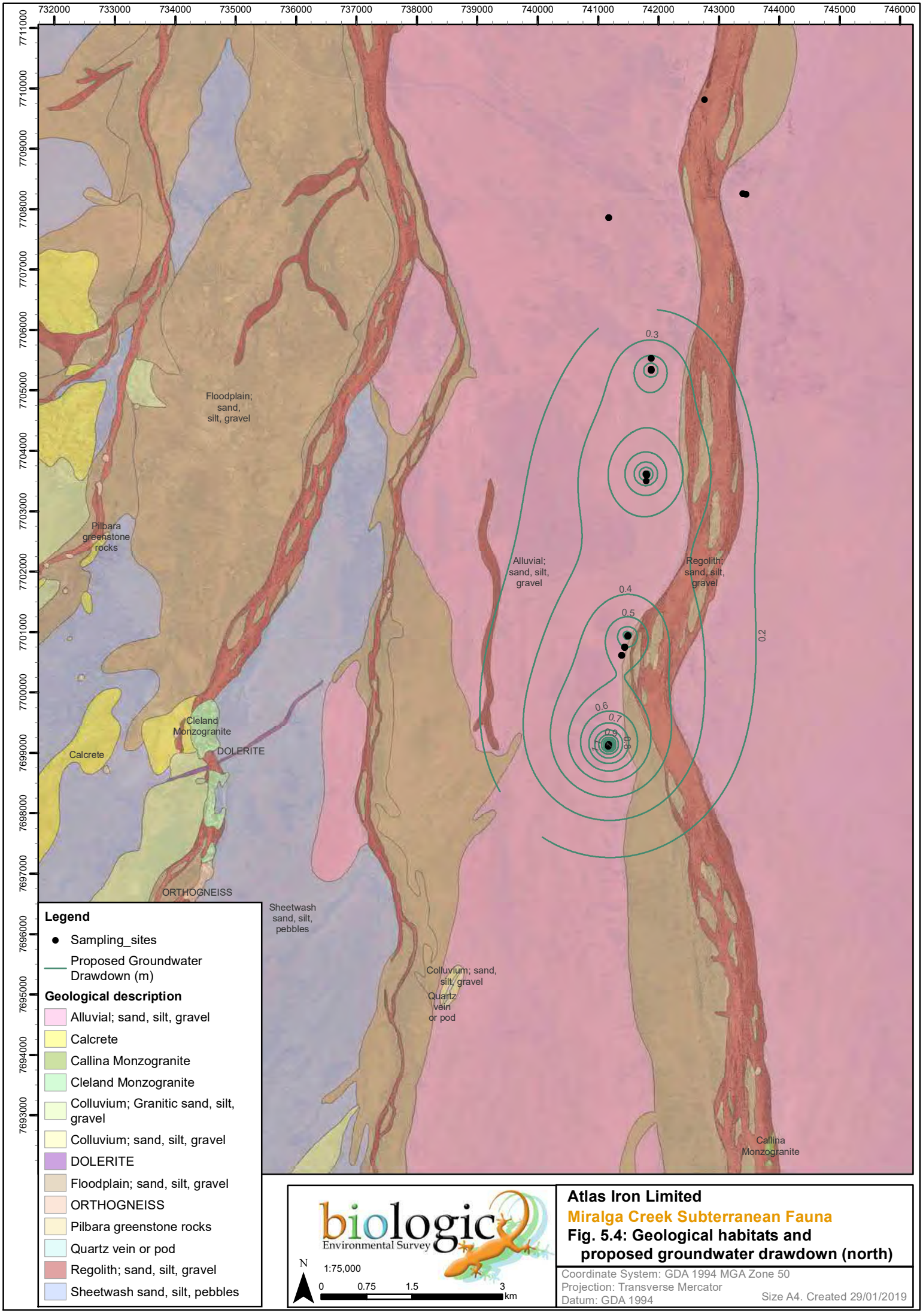
In the Northern and Central DD area, the most superficial groundwater zone in the channel is the hyporheic zone beneath Shaw River, which is supported by rapid recharge from direct infiltration and surface flows in the creek following rainfall events. The hyporheic zone provides a degree of interconnectivity between surface waters and the underlying groundwater saturated alluvial detrital aquifer (Figure 5.4, Figure 5.5). Patches of secondarily weathered calcrete deposits lie below the alluvium and locally outcrop at surface (Figure 5.4, Figure 5.5). All of these geological units provide a network of highly suitable habitat for stygofauna extending throughout the Shaw River paleochannel, connecting the Northern and Central DD areas and extending further to the north and south.

At greater depths below the alluvium, deeper prospective stygofauna habitats are hosted within fractured/weathered aquifers within the basement geology. Fractured rock aquifers may be locally compartmentalised by dykes which largely strike from south-west to north-east (Figure 5.4, Figure 5.5). However, the overlying groundwater saturated detrital layers provide extensive pathways for stygofauna species to disperse between deeper fractured rock habitats.

5.2.2 Southern DD

All stygofauna records at Sandtrax were collected from unconsolidated regolith (sand, silt, gravel) habitats (Figure 6.2c), suggesting that the prospective BWT stygofauna habitat at Sandtrax primarily comprises shallow regolith aquifers. The groundwater saturated superficial deposits of regolith extend considerably to the north, forming an extensive interconnected aquifer along the Shaw River paleochannel.

At greater depths below the regolith, deeper prospective stygofauna habitats may be hosted within fractured/weathered aquifers within the basement geology.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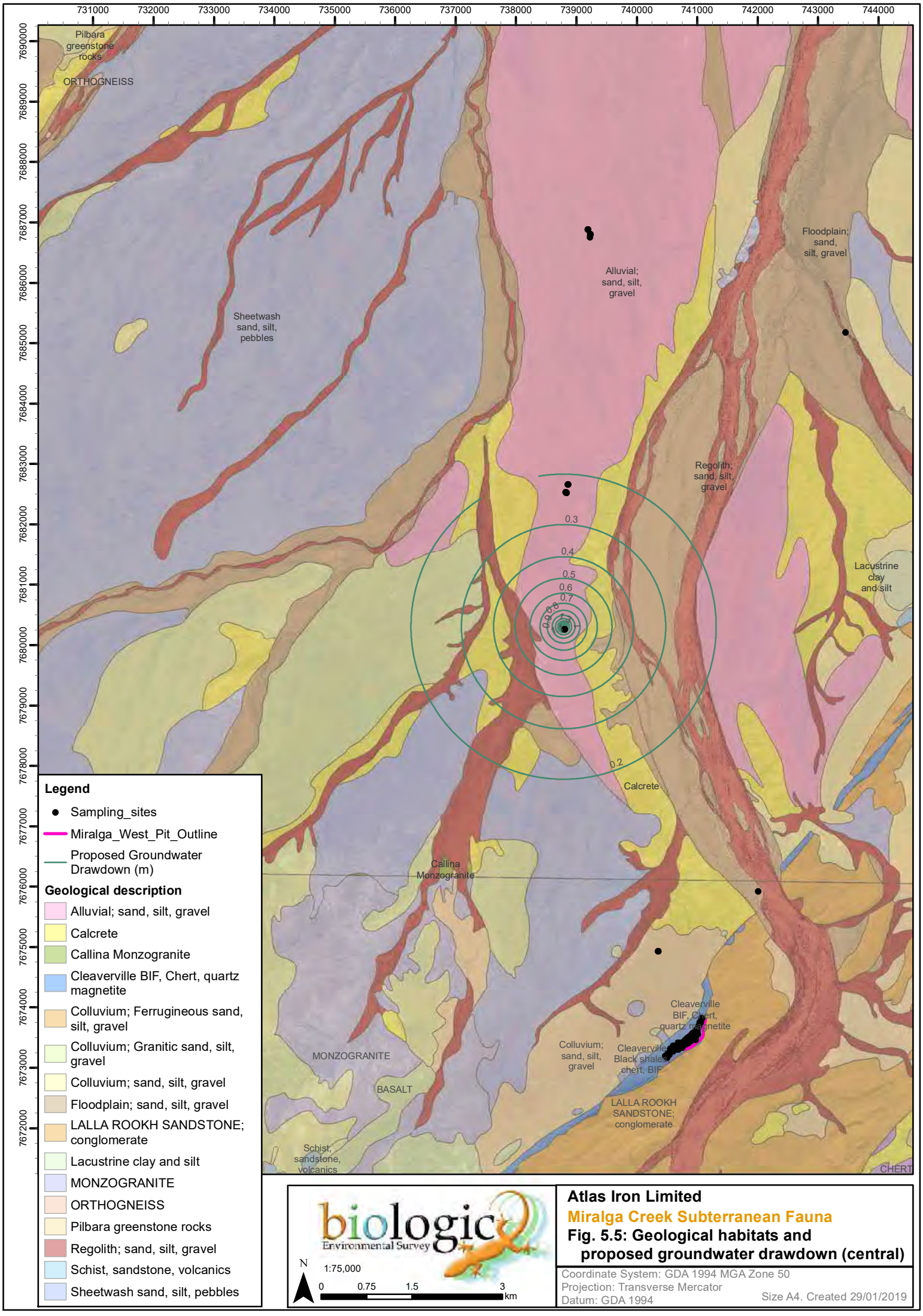
7695000
7694000
7693000
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.2
Floodplain; sand, silt, gravel
Pilbara greenstone rocks
Alluvial; sand, silt, gravel
Regolith; sand, silt, gravel
Cleland Monzogranite
DOLERITE
Calcrete
ORTHOGNEISS
Sheetwash sand, silt, pebbles
Colluvium; sand, silt, gravel
Quartz vein or pod
Callina Monzogranite
Legend
Sampling_sites
Proposed Groundwater Drawdown (m)
Geological description
Alluvial; sand, silt, gravel
Calcrete
Callina Monzogranite
Cleland Monzogranite
Colluvium; Granitic sand, silt, gravel
Colluvium; sand, silt, gravel
DOLERITE
Floodplain; sand, silt, gravel
ORTHOGNEISS
Pilbara greenstone rocks
Quartz vein or pod
Regolith; sand, silt, gravel
Sheetwash sand, silt, pebbles
biologic
Environmental Survey
N
1:75,000
0
0.75
1.5
3
km
Atlas Iron Limited
Miralga Creek Subterranean Fauna
Fig. 5.4: Geological habitats and proposed groundwater drawdown (north)
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A4. Created 29/01/2019



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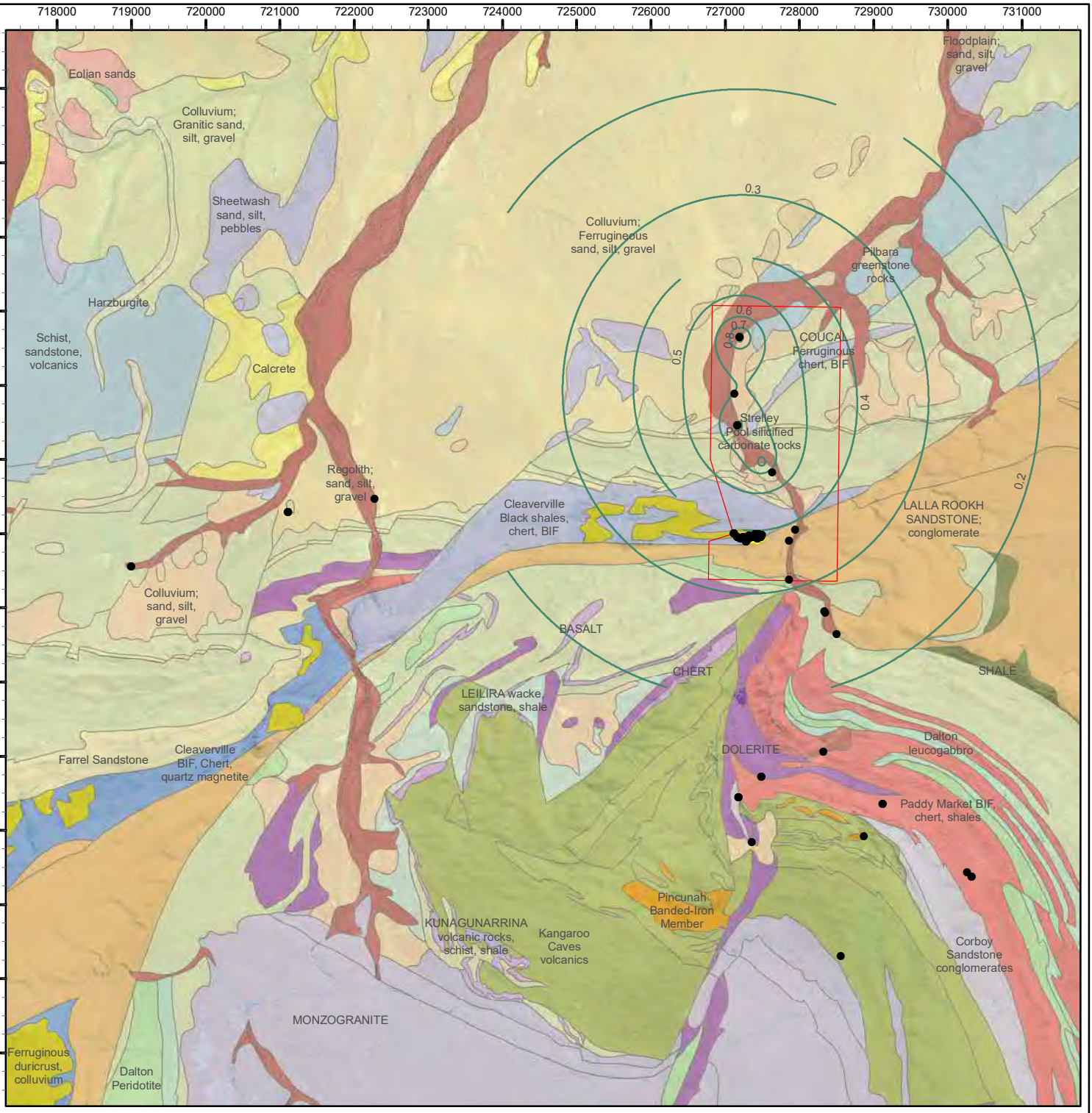
Miralga Creek Subterranean Fauna

Fig. 5.5: Geological habitats and proposed groundwater drawdown (central)

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 29/01/2019



Legend

- Sampling_sites_from_MAST...
- Sandtrax Pit
- Proposed Groundwater Drawdown (m)
- Study Area

Geological description

- BASALT
- CHERT
- COUCAL Ferruginous chert, BIF
- Calcrete
- Cleaverville BIF, Chert, quartz magnetite
- Cleaverville Black shales, chert, BIF
- Colluvium; Ferrugineous sand, silt, gravel
- Colluvium; Granitic sand, silt, gravel
- Colluvium; sand, silt, gravel
- Corboy Sandstone conglomerates
- DOLERITE
- Dalton Peridotite
- Dalton leucogabbro
- Eolian sands
- Farrel Sandstone
- Ferruginous duricrust, colluvium
- Floodplain; sand, silt, gravel
- Harzburgite
- KUNAGUNARRINA volcanic rocks, schist, shale
- Kangaroo Caves volcanics
- LALLA ROOKH SANDSTONE; conglomerate
- LEILIRA wacke, sandstone, shale
- MONZOGRANITE
- Paddy Market BIF, chert, shales
- Pilbara greenstone rocks
- Pincunah Banded-Iron Member
- Regolith; sand, silt, gravel
- SHALE
- Schist, sandstone, volcanics
- Sheetwash sand, silt, pebbles
- Strelley Pool silicified carbonate rocks

biologic Environmental Survey

N

1:75,000

0 0.75 1.5 3 km

Atlas Iron Limited

Miralga Creek Subterranean Fauna

Fig. 5.6: Geological habitats and proposed groundwater drawdown (south)

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 29/01/2019

5.3 Groundwater characteristics

Figure 5.7 shows mean (and standard deviation as error bars) temperature, pH, EC (as a proxy for salinity), ORP (redox potential) and DO (dissolved oxygen) for bores within the northern groundwater drawdown, the central groundwater drawdown, the southern groundwater drawdown and areas outside of drawdown impacts.

The average groundwater temperature ranged 26.8 - 30.6°C and showed relatively little variability across all sites (Figure 5.7A). The pH of the groundwater (Figure 5.7B) ranged from 7.3 to 7.5 across all sites, indicating neutral conditions suitable for stygofauna. The EC measurements (Figure 5.7C) showed that the salinity of the groundwater was low in all sampling areas, with most sites containing fresh water (EC <1,500 uS/cm) or being slightly brackish (EC ~2500 uS/cm). These levels are well within the range suitable for stygofauna and can support rich stygofauna assemblages, which are known to occur up to approximately double the salinity of sea water (EC 60,000 uS/cm).

Redox and DO measurements (Figure 5.7D & E) are typically variable between sites due to individual bore conditions rather than overall aquifer conditions. Most bores contained groundwater with sufficient dissolved oxygen for stygofauna to occur (> 1ppm), with the exception of a few bores within the northern and central groundwater drawdown as well as outside of groundwater drawdown impacts. The redox potential of groundwater is a measure of the system's capacity to oxidise materials through chemical reactions and has important implications for metal mobility, bio-availability and toxicity (Schuring *et al.*, 1999). All areas surveyed showed positive or near positive ORP's, suitable for stygofauna occurrence.

The full range of physicochemical data for all sites (bores and drill holes) measured during the survey can be found in Appendix C.

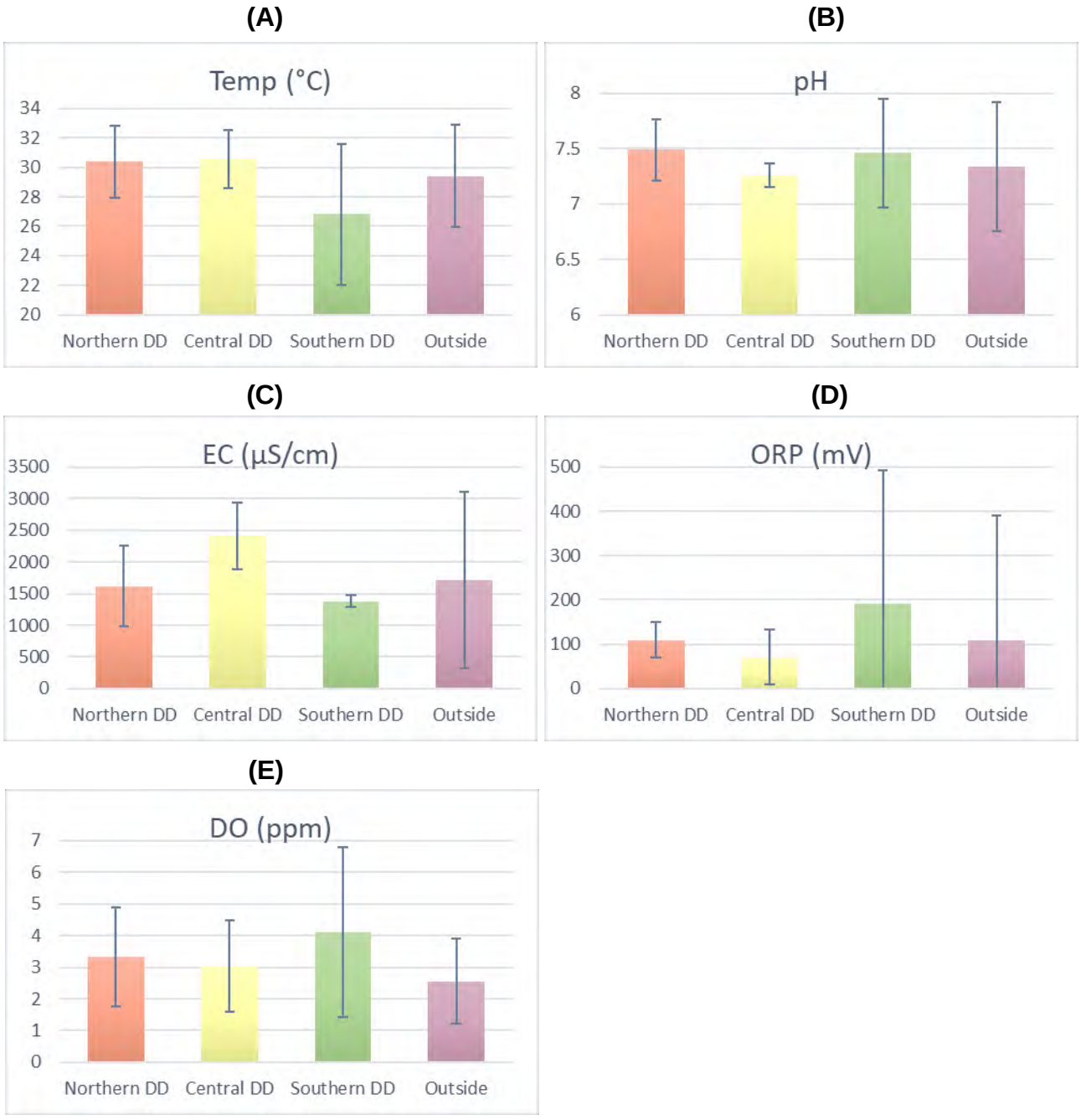


Figure 5.7: Groundwater physicochemical measurements recorded during the survey. Mean values are shown as bars, standard deviations as error bars

6 RISK ASSESSMENT

6.1 Impacts to troglofauna

Direct impacts to troglofauna assemblages and habitats occur as a result of the excavation and removal of subterranean habitat during mining. It can therefore be inferred that the direct impact areas for troglofauna are the proposed pit boundaries at each of the deposits. Although indirect impacts such as shock and vibration from blasting, changes to infiltration beneath stockpiles and waste dumps, and habitat desiccation from pit walls or groundwater drawdown may extend beyond the pit boundaries, these risks are generally considered minor, manageable, and/ or difficult to measure and assess, therefore this section has focussed on the direct impacts of mining only.

6.2 Risks to troglofauna species

Six (6) troglofauna taxa recorded during the current surveys of the Study Area are known only from within proposed pit boundaries, comprising:

- Two (2) pseudoscorpions: *Tyrannochthonius* `BPS228` and *Tyrannochthonius*? sp. indet. (Sandtrax);
- One (1) harvestmen: Phalangodidae sp. indet.;
- One (1) silverfish: *Dodecastyla* sp. indet.;
- One (1) cockroach: *Nocticola currani* s.l.; and
- One (1) planthopper: *Phaconeura* sp. indet.

The current occurrence of these four troglofauna taxa within the proposed deposits is at least partly attributable to sampling artefacts such as the higher numbers of suitable bores/ drill holes within deposit boundaries. Many troglofauna taxa are rare and difficult to detect, especially when primarily using litter traps. Particularly for the rarer and less vagile taxa, detecting a species throughout the full extent of its potential habitat or range can require a very high, repeated survey effort over a long period of time, and even in this case, the extent of sampling is still constrained by the locations of suitable drill holes.

The risks to these taxa from the proposed development are presented in Table 6.1, based on current taxonomic and ecological information and the likely extent of suitable habitats beyond pit boundaries. Figure 6.1 shows the current records of each of these taxa relative to the proposed impact areas.

Four of the six troglofauna taxa; *Dodecastyla* sp. indet., *Nocticola currani* s.l., *Phaconeura* sp. indet. and Phalangodidae sp. indet., were assessed as ‘low risk’ due to current knowledge of taxonomy, species distributions and the extent of prospective habitats.

The silverfish *Dodecastyla* sp. indet. belongs to the subfamily Atelurinae whose members are most frequently known from surface soil habitats or as co-habitors to termites and ants, though some subterranean species are known to occur also (Smith & McRae, 2014). Due to the likelihood that this taxon may represent a troglophile/ trogloxene (based on current taxonomic/ ecological knowledge), its close proximity to the pit boundary (40 m) and location within the Cleaverville formation BIF habitat which extends extensively to the east, north and west of the record, it is considered a ’low risk’ the taxon may potentially be restricted to mining impacts (Table 6.1).

Similarly, the planthopper *Phaconeura* sp. indet. belongs to the family Meenoplidae whose members are frequently found to be regionally wide ranging troglophiles/ trogloxenes. As such, two species of *Phaconeura*, "*Phaconeura* sp. WAM-PHAC001" and "*Phaconeura* sp. WAM-PHAC002" have recently been found to be regionally widespread in the Paraburdoo and Greater Brockman area (confirmed via DNA), with linear ranges well-exceeding 80 km (Cullen & Harvey, 2018). Due to the likelihood that this taxon may represent a troglophile/ trogloxene (based on current taxonomic/ ecological knowledge), its close proximity to the pit boundary (33 m) and location within the Cleaverville formation BIF habitat which extends extensively to the east and west of the record, it is considered a 'low risk' the taxon may potentially be restricted to mining impacts (Table 6.1).

The harvestmen Phalangodidae sp. indet. could not be resolved to species level due to the immaturity of the specimen. This record was observed to have rudimentary eyespots and may thus represent a juvenile terrestrial or troglophile/xene species. Together with geological mapping indicating that the habitat extends extensively beyond the proposed impacts, its risk from the proposed developments as assessed as 'low'.

While the distribution ranges of subterranean *Nocticola* are frequently within the nominal limits for SRE species (following Harvey 2002), these taxa are known to be more highly vagile than other troglofauna taxa, and can occur throughout a wide variety of subterranean habitats including superficial unconsolidated alluvium (E. Volschenk pers. comm. 2019). As such, one of the two *Nocticola* species collected during the current survey, *Nocticola quartermainei* s.l., has been found in all three deposit areas with a distribution spanning approximately 30 km (Table 4.3). Together with geological mapping indicating that the habitat extends extensively to the east and west of the record, it is considered likely that *Nocticola currani* s. l. collected from a single site within the proposed Miralga East pit occurs outside of the impact zone also.

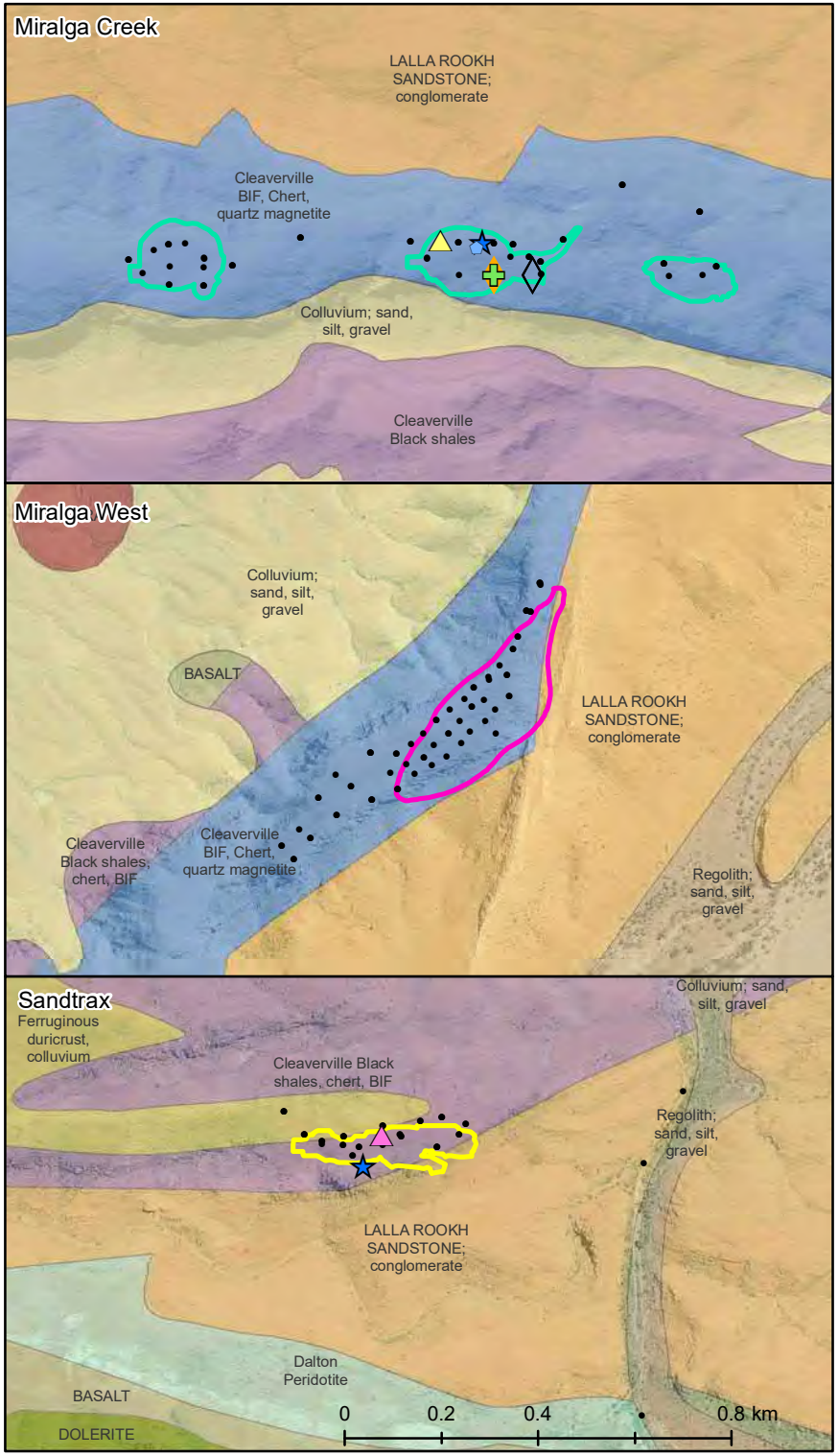
The remaining three troglofauna taxa; *Tyrannochthonius* `BPS228`, *Tyrannochthonius?* sp. indet. (Sandtrax) and Phalangodidae sp. indet. were assessed as 'low – moderate' risk as these taxa are more likely to represent troglobitic SRE fauna, although their habitat is likely to continue well beyond impact areas and all records were from close the pit boundary (Table 6.1).

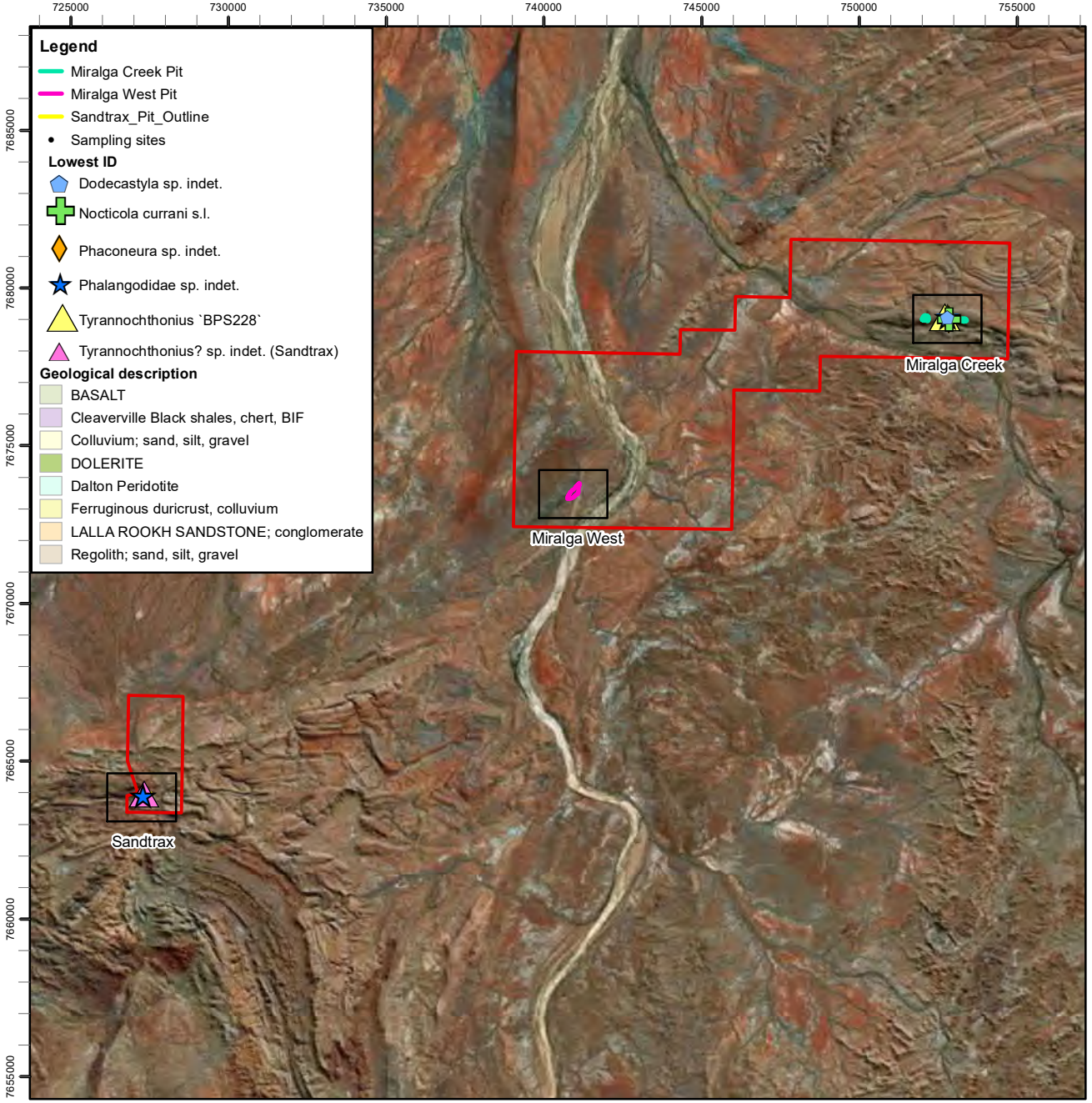
Troglobitic pseudoscorpions are commonly recorded only from single habitats or single sites and owing to the dispersal limitations known throughout the group, and are almost always regarded as highly restricted SREs. While *Tyrannochthonius* `BPS228` and *Tyrannochthonius*? sp. indet. (Sandtrax) may occur more widely than currently recorded within the local extent of their habitat, there is a low likelihood of regionally or locally widespread taxa in this group. However, both pseudoscorpion taxa were found very close to the pit boundary (8-17 m), with geological mapping indicating that suitable habitat extends extensively beyond pit boundaries. Furthermore, an indeterminate *Tyrannochthonius* genus-level record (*Tyrannochthonius*? sp. indet. (Miralga East)) was found just 70 m west of the *Tyrannochthonius* `BPS228` record. This record was located outside of the pit boundary, and it is considered likely that it may represent the same species.

Table 6.1: Troglofauna risk assessment based on current taxonomic factors, habitat factors, and distribution relative to impacts

Taxon	Taxonomic factors	Distribution factors	Habitat factors	Risk level
Pseudoscorpiones				
Tyrannochthonius `BPS228`	Troglobite Morphologically unique, based on regional comparisons. Indeterminate genus-level taxon "*Tyrannochthonius*? sp. indet. (Miralga East)" was found 70 m west of the record (outside of impact) as well as 120 m east of the record within the pit and may represent the same species.	Singleton known only from within the proposed Miralga East pit (MRRC0035). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Genus includes many restricted species in the Pilbara.	Record located near pit boundary (17 m) Record located in band of Cleaverville formation BIF (outside of highly mineralised zone). Potential habitat extends extensively to the east, north and west of the record.	LOW-MODERATE
Tyrannochthonius? sp. indet. (Sandtrax)	Troglobite Indeterminate family-level taxon (juvenile specimens).	Known from single site within the proposed Sandtrax pit (ABRC637). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Genus includes many restricted species in the Pilbara.	Record located near pit boundary (8 m) Record located in band of Cleaverville Black shales. Potential habitat extends extensively to the west and north/north-east of the record.	LOW-MODERATE
Opiliones				
Phalangodidae sp. indet.	Potential Troglobite (rudimentary eyespots) Indeterminate family-level taxon (juvenile specimens).	Known from 2 sites within the proposed Miralga East pit (MRRCUNK01) and outside of impact (ABRC631) near the Sandtrax deposit. Potential linear range is 29.7 km (assuming specimens belong to the same species). Taxonomic uncertainty precludes assessment of taxon distribution.	Record located near pit boundary (24 m). Record located in band of Cleaverville formation BIF (outside of highly mineralised zone). Potential habitat extends extensively to the east, north and west of the record.	LOW

Taxon	Taxonomic factors	Distribution factors	Habitat factors	Risk level
Zygentoma				
Dodecastyla sp. indet.	Potential troglofauna (possible trogloxene/troglophile). Sub-family Atelurinae known from soil and termite nests as well as subterranean habitats. Indeterminate genus-level taxon (juvenile specimen).	Putative singleton known only from within the proposed Miralga East pit (MRRC0012). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Genus includes both widespread and restricted species.	Record located 40 m from pit boundary. Record located in band of Cleaverville formation BIF (within highly mineralised zone). Potential habitat extends extensively to the east, north and west of the record.	LOW
Blattodea				
Nocticola currani s.l.	Troglobite Morphologically unique, based on regional comparisons.	Known from single site within the proposed Miralga East pit (MRRC0041). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Both short-ranging and widespread species collected throughout the Pilbara.	Record located 33 m from pit boundary. Record located in band of Cleaverville formation BIF (within highly mineralised zone). Potential habitat extends extensively to the east and west of the record.	LOW
Hemiptera				
Phaconeura sp. indet.	Potential troglofauna (possible trogloxene/troglophile). Indeterminate genus-level taxon (juvenile specimens and nymphs).	Known from single site within the proposed Miralga East pit (MRRC0041). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Meenoplidae known to include regionally wide ranging troglophiles/ trogloxenes as well as more restricted lineages/ species.	Record located 33 m from pit boundary. Record located in band of Cleaverville formation BIF (within highly mineralised zone). Potential habitat extends extensively to the east and west of the record.	LOW





biologic Environmental Survey

N

1:200,000

0 2.25 4.5 9 km

Atlas Iron Limited

Miralga Creek Subterranean Fauna

Fig. 6.1: Troglofauna taxa potentially at risk of impact from the proposed project

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 29/01/2019

6.3 Impacts to stygofauna

Direct impacts to stygofauna assemblages and habitats associated with the Miralga Creek Project comprise the depletion of groundwater by abstraction from three existing borefields for operational uses. The propagation of groundwater drawdown throughout all suitable, connected hydrogeological habitats is considered to be a direct impact, regardless of distance from the mine or whether the drawdown propagates through strata with different porosities.

6.4 Risks to stygofauna species

Twelve (12) stygofauna taxa recorded during the current survey of the Study Area are known only from within the estimated groundwater drawdowns (Northern, Central, and Southern DD), comprising:

- One (1) mite: *Wandesia* sp. indet.;
- Two (2) ostracods: Candonidae `BOS1332` and *Ilyodromus* sp. indet.;
- One (1) cyclopoid: *Pescecyclops* `BCY065`;
- One (1) harpacticoid: *Parastenocaris* `BHA266`;
- Three (3) syncarids: Bathynellidae sp. VLS, nr *Billibathynella* sp. indet., and nr *Hexabathynella* sp. indet.;
- Four (4) amphipods: Bogidiellidae sp. indet., Melitidae `BAM160` (sp. 1 group), Paramelitidae `BAM162`, and Paramelitidae Genus 2 `BAM164`.

The current occurrence of these taxa is at least partly attributable to sampling artefacts such as the high proportion of bores/ drill holes within the three groundwater drawdown impact areas. It is also worth noting that the Northern, Central and Southern groundwater drawdowns are predicted to be minimal, with maximum expected groundwater drawdown depth not exceeding 1.6 m. These levels are likely within the natural fluctuations of the groundwater table (*i.e.* due to seasonal differences in temperature and rainfall) which was factored into the risk assessment. As such, groundwater levels in the Pilbara (near Mount Bruce) have been found to fluctuate by approximately 1 m in response to natural recharge from rain (Waterhouse & Howe, 1994) and in the current survey, depth to water in bores sampled was found to differ by up to 4.5 m between seasonal sampling trips.

Based on current taxonomic and ecological information, modelling of groundwater drawdown and the likely extent of suitable habitats for stygofauna beyond these impacts, the risks to these taxa are presented in Table 6.2. Figures 6.2a-c show the current records of each of these taxa relative to the proposed impact areas. All stygofauna risk levels are contingent upon the extent of groundwater drawdown as modelled. Any new information/ new modelling that changes the spatial extent or magnitude of drawdown, the duration of drawdown, or the duration of subsequent recovery of aquifer habitats following the end of project may result in changes to the potential risks to stygofauna taxa.

All twelve stygofauna taxa were assessed as ‘low risk’ due to current knowledge of taxonomy, the minimal predicted depth of the groundwater drawdown and the modelled extent of suitable stygofauna habitats beyond drawdown impacts.

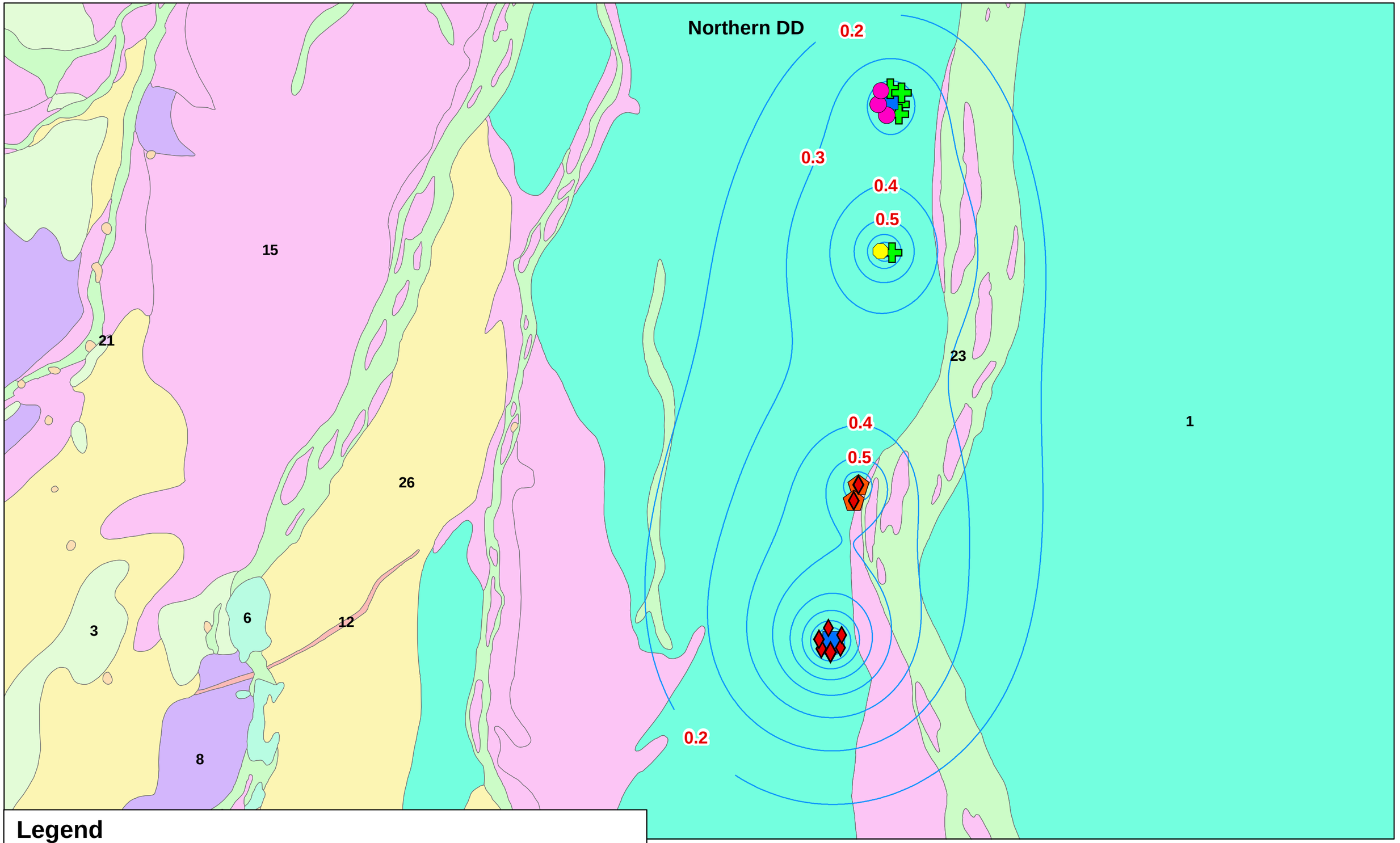
Table 6.2: Stygofauna risk assessment based on current taxonomic factors, habitat factors, and distribution relative to impacts

Potentially restricted taxon	Taxonomic factors	Distribution factors	Habitat factors	Risk level
Acari				
Wandesia sp. indet.	Potential Stygobite Indeterminate genus-level taxon.	Putative singleton known only from within the predicted groundwater drawdown (Southern DD, SSKK02). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Genus includes both widespread and restricted species.	Predicted drawdown at location of record minimal (~0.25 m). Drawdown is comparable to seasonal fluctuations in groundwater levels at this location. Regolith aquifer habitat extends extensively to the north and south, beyond drawdown impacts.	LOW
Ostracoda				
Candonidae `BOS1332`	Stygobite Morphologically unique, based on regional comparisons.	Known from a single site within the predicted groundwater drawdown (Central DD, ALB0007). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Family includes both widespread and restricted species.	Predicted drawdown at location of record minimal (~0.2 m). Drawdown is comparable to seasonal fluctuations in groundwater levels at this location. Detritals/ fractured rock habitats extend extensively along the Shaw River paleochannel to the north and south, beyond drawdown impacts.	LOW
Ilyodromus sp. indet.	Potential Stygobite Indeterminate genus-level taxon (shells only).	Known from a single site within the predicted groundwater drawdown (Southern DD, SSKK01). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Genus includes both widespread and restricted species.	Predicted drawdown at location of record minimal (~0.3 m). Drawdown is comparable to seasonal fluctuations in groundwater levels at this location. Regolith aquifer habitat extends extensively to the north and south, beyond drawdown impacts.	LOW

Potentially restricted taxon	Taxonomic factors	Distribution factors	Habitat factors	Risk level
Cyclopoida				
Pescecyclops `BCY065`	Stygobite Morphologically unique, based on regional comparisons.	Known from 3 sites within predicted groundwater drawdowns (Central and Southern DD); current linear range 21 km. Potential SRE (C- Morphology Indicators, E- Research and Expertise). Genus includes both widespread and restricted species.	Predicted drawdown at locations of record minimal (~0.2 m at Central DD, ~0.7 m at Southern DD). Drawdown is comparable to seasonal fluctuations in groundwater levels at this location. Detritals/ fractured rock habitats extend extensively along the Shaw River paleochannel to the north and south, beyond the Central drawdown impacts.	LOW
Harpacticoida				
Parastenocaris `BHA266`	Stygobite Morphologically unique, based on regional comparisons.	Known from 2 sites within the predicted groundwater drawdown (Northern DD); current linear range 0.2 km. Potential SRE (C- Morphology Indicators, E- Research and Expertise). Most representatives of the genus are widespread in the Pilbara.	Predicted drawdown at locations of record minimal (<1 m). Detritals/ fractured rock habitats extend extensively along the Shaw River paleochannel to the north and south, beyond drawdown impacts.	LOW
Syncarida				
Bathynellidae sp. VLS	Stygobite Morphologically unique, based on regional comparisons.	Known from a single site within the predicted groundwater drawdown (Southern DD, SSK002). Potential SRE (D- Molecular Evidence, E– Research and Expertise). Research is ongoing, but most known species/ lineages of Bathynellidae are considered SRE in the Pilbara region (G. Perina pers. comm.).	Predicted drawdown at location of record minimal (~0.25 m). Drawdown is comparable to seasonal fluctuations in groundwater levels at this location. Regolith aquifer habitat extends extensively to the north and south, beyond drawdown impacts.	LOW

Potentially restricted taxon	Taxonomic factors	Distribution factors	Habitat factors	Risk level
nr *Billibathynella* sp. indet.	Stygobite Indeterminate genus-level taxon. Poor taxonomic framework currently exists for the group.	Known from 7 sites within predicted groundwater drawdowns (Northern and Central DD). Potential linear range is 20.5 km (assuming specimens belong to the same species). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Bathynellacea generally considered to have short ranges due to limited dispersal ability (Coineau & Camacho, 2013).	Predicted drawdown at locations of record minimal (<1.3 m). Detritals/ fractured rock habitats extend extensively along the Shaw River paleochannel to the north and south, beyond drawdown impacts.	LOW
nr *Hexabathynella* sp. indet.	Stygobite Indeterminate genus-level taxon. Poor taxonomic framework currently exists for the group.	Known from a single site within the predicted groundwater drawdown (Northern DD, ALB0004). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Bathynellacea generally considered to have short ranges due to limited dispersal ability (Coineau & Camacho, 2013).	Predicted drawdown at location of record minimal (~0.9 m). Detritals/ fractured rock habitats extend extensively along the Shaw River paleochannel to the north and south, beyond drawdown impacts.	LOW
Amphipoda				
Bogidiellidae sp. indet.	Potential Stygobite Indeterminate family-level taxon. Poor taxonomic framework currently exists for the group.	Known from 7 sites within and outside predicted groundwater drawdowns (Northern, Central, and Southern DD). Potential linear range is 23 km (assuming specimens belong to the same species). Taxonomic uncertainty precludes assessment of taxon distribution.	Predicted drawdown at locations of record minimal (<1 m). Detritals/ fractured rock habitats extend extensively along the Shaw River paleochannel to the north and south of the Northern and Central DD, beyond drawdown impacts.	LOW

Potentially restricted taxon	Taxonomic factors	Distribution factors	Habitat factors	Risk level
Melitidae `BAM160` (sp. 1 group)	Stygobite Morphologically unique, based on regional comparisons.	Known from 3 sites within predicted groundwater drawdowns (Northern and Central DD); current linear range 23 km. Potential SRE (C- Morphology Indicators, E- Research and Expertise). Family includes both widespread and restricted species.	Predicted drawdown at locations of record minimal (<1 m). Detritals/ fractured rock habitats extend extensively along the Shaw River paleochannel to the north and south, beyond drawdown impacts.	LOW
Paramelitidae `BAM162`	Stygobite Morphologically unique, based on regional comparisons.	Known from 3 sites within predicted groundwater drawdowns (Northern DD), current linear range 6.5 km. Potential SRE (C- Morphology Indicators, E- Research and Expertise). Family includes both widespread and restricted species.	Predicted drawdown at locations of record minimal (~1.5 m). Detritals/ fractured rock habitats extend extensively along the Shaw River paleochannel to the north and south, beyond drawdown impacts.	LOW
Paramelitidae Genus 2 `BAM164`	Stygobite Morphologically unique, based on regional comparisons.	Singleton known only from within the predicted groundwater drawdown (Southern DD). Potential SRE (C- Morphology Indicators, E- Research and Expertise). Family includes both widespread and restricted species.	Predicted drawdown at location of record minimal (~0.7 m). Regolith aquifer habitat extends extensively to the north and south, beyond drawdown impacts.	LOW



Legend

Drawdown

Stygofauna at risk

- Bogidiellidae sp. indet.
- Melitidae `BAM160` (sp. 1 group)
- Paramelitidae `BAM162`
- Parastenocaris `BHA266`
- nr Billibathynella sp. indet.
- nr Hexabathynella sp. indet.

biologic

N 1:40,000

0 0.5 1 2 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig 6.2a: Locations of stygofauna taxa at risk from proposed impacts - Northern Drawdown

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 23/01/2020

Central DD

0.2

0.3

0.4

0.5

0.6

8

26

3

15

23

1

Legend

Stygofauna at risk

- Bogidiellidae sp. indet.
- Candonidae `BOS1332`
- Melitidae `BAM160` (sp. 1 group)
- Pescecyclops `BCY065`
- nr Billibathynella sp. indet.
- Drawdown

N

1:25,000

0 0.375 0.75 1.5 km

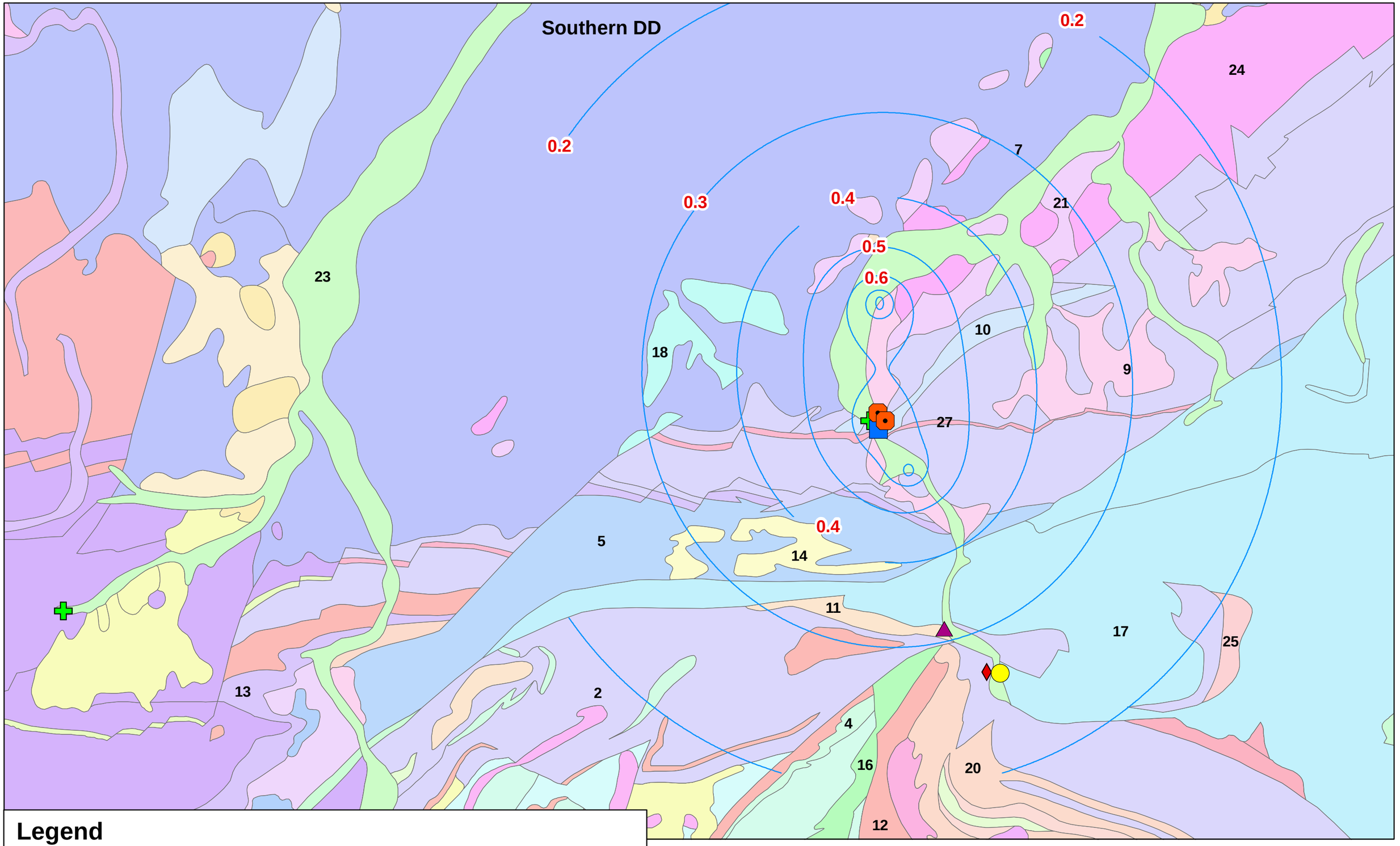
Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig 6.2b: Locations of stygofauna taxa at risk from proposed impacts - Central Drawdown

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 23/01/2020



Legend

- Drawdown

Stygofauna at risk

- Bathynellidae sp. VLS
- Bogidiellidae sp. indet.
- Ilyodromus sp. indet.
- Paramelitidae Genus 2 `BAM164`
- Pescecyclops `BCY065`
- Wandesia sp. indet.

biologic

N

1:35,000

0 0.5 1 2 km

Atlas Iron Limited - Miralga Creek

Subterranean Fauna Survey

Fig 6.2c: Locations of stygofauna taxa at risk from proposed impacts - Southern Drawdown

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A3. Created 23/01/2020

Legend to Figure 6.2a, b and c

7 KEY FINDINGS

The key findings are based on results of all sampling to date (previous and current surveys), available habitat information and current knowledge of the impacts to subterranean fauna from the proposed mining at the Study Area. These findings may be subject to change following the receipt of further molecular studies of subterranean fauna from the Study Area and beyond.

7.1.1 Risks to Troglofauna Species

Six (6) troglofauna taxa are currently known only from the direct impact areas of the proposed developments at Miralga East, Miralga West and Sandtrax and were therefore considered to be potentially at risk. The potential risks to these taxa were characterised as follows, using a five-point risk classification system (i.e. high, moderate-high, moderate, low-moderate, or low risk):

Low risk (4 taxa): *Dodecastyla* sp. indet., *Nocticola currani* s.l., *Phaconeura* sp. indet. and Phalangodidae sp. indet.

These taxa were assessed as 'low risk' due to current knowledge of taxonomy and because their known records were located in Cleaverville formation BIF habitat which extends extensively beyond impact areas.

Low-moderate risk (2 taxa): *Tyrannochthonius* `BPS228` and *Tyrannochthonius?* sp. indet. (Sandtrax)

These taxa were assessed 'as low-moderate' risk as they are more likely to represent troglobitic SRE fauna and stem from groups more prone to have small distributions, although their habitat is likely to continue well beyond impact areas.

7.1.2 Risks to Stygofauna Species

The current survey recorded twelve (12) stygofauna taxa known only from within the estimated groundwater drawdown. Based on current taxonomic and ecological information, modelling of groundwater drawdown and the likely extent of suitable habitats for stygofauna beyond the modelled extent of drawdown, all twelve taxa were assigned as being at 'low risk' from the proposed Miralga Creek Project:

Low risk (12 taxa): *Wandesia* sp. indet., Candonidae `BOS1332`, *Ilyodromus* sp. indet., *Pescecyclops* `BCY065`, *Parastenocaris* `BHA266`, Bathynellidae sp. VLS, nr *Billibathynella* sp. indet., nr *Hexabathynella* sp. indet., Bogidiellidae sp. indet., Melitidae `BAM160` (sp. 1 group), Paramelitidae `BAM162`, and Paramelitidae Genus 2 `BAM164`.

All twelve stygofauna taxa were assessed as 'low risk' due to current knowledge of taxonomy, the minimal predicted depth of the groundwater drawdown and the likely extent of suitable stygofauna habitats (both within detritals as well as fractured rock aquifers) beyond drawdown impacts.

8 REFERENCES

Atlas, Iron Limited Pty Ltd. (2019). *Miralga Creek DSO Project. Miralga Creek Initial Water Management Assessment. June 2019.*

Bastin, G., & ACRIS Management Committee. (2008). *Rangelands 2008 – Taking the Pulse*. Canberra: National Land and Water Resources Audit.

Biologic, Environmental Survey. (2019a). *Miralga Creek Project: Level 2 Vertebrate Fauna and Short-range Endemic Invertebrate Fauna Assessment*. Unpublished report preapred for Atlas Iron.

Biologic, Environmental Survey. (2019b). *Warrawoona Gold Project: Subterranean Fauna Survey*. Unpublished report for Calidus Resources Ltd.

BoM, Bureau of Meteorology. (2019). Climate Data Online. Retrieved 2019 http://www.bom.gov.au./climate/data/index.shtml

Car, C. A., Short, M., Huynh, C., & Harvey, M. S. (2013). The millipedes of Barrow Island, Western Australia (Diplopoda). *Records of the Australian Museum*, 209-219.

Christiansen, K. A. (2005). Morphological adaptations. In D. C. Culver & D. B. White (Eds.), *Encyclopedia of Caves*: Elsevier.

Coineau, N., & Camacho, A. I. (2013). Superorder Syncarida Packard, 1885. In M. von Vaupel Klein, M. Charmantier-Daures, & F. R. Schram (Eds.), *The Crustacea - Treatise on Zoology - Anatomy, Taxonomy, Biology* (Vol. 4, pp. 357-449). Brill, Leiden/Boston.

Cullen, K., & Harvey, M. (2018). *Molecular systematics of subfauna from Greater Paraburdoo – Final Report.* Unpublished report prepared for Rio Tinto. December 2018.:

DBCA, Department of Biodiversity, Conservation and Attractions. (2019a). NatureMap: Mapping Western Australia's biodiversity (custom search). Retrieved 2019 http://naturemap.dec.wa.gov.au./default.aspx

DBCA, Department of Biodiversity, Conservation and Attractions. (2019b). Threatened and Priority Ecological Communities Database (custom search). Retrieved 2019 http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals

De Deckker, P. (1982). Late quaternary ostracods from Lake George, New South Wales. *Alcheringa, 6*, 305–318.

Eberhard, S. M., Halse, S. A., & Humphreys, W. F. (2005). Stygofauna in the Pilbara region, north-west Western Australia: A review. *Journal of the Royal Society of Western Australia, 88*(4), Page 167-Page 176.

Eberhard, S. M., Halse, S. A., Williams, M. R., Scanlon, M. D., Cocking, J., & Barron, H. J. (2009). Exploring the relationship between sampling efficiency and short-range endemism for groundwater fauna in the Pilbara region, Western Australia. *Freshwater Biology, 54*, Page 885-Page 901. doi:http://doi.org/10.1111/j.1365-2427.2007.01863.x

EPA, Environmental Protection Authority. (2013). *Draft Environmental Assessment Guideline for consideration of subterranean fauna in environmental impact assessment in Western Australia. March 2013*. Perth, Western Australia: The Government of Western Australia.

EPA, Environmental Protection Authority. (2016a). *Environmental Factor Guideline: Subterranean Fauna*. Perth, Western Australia: The Government of Western Australia.

EPA, Environmental Protection Authority. (2016b). *Technical Guidance: Sampling Methods for Subterranean Fauna*. Perth, Western Australia: The Government of Western Australia.

EPA, Environmental Protection Authority. (2016c). *Technical Guidance: Subterranean Fauna Survey*. Perth, Western Australia: The Government of Western Australia.

Gibert, J., & Deharveng, L. (2002). Subterranean ecosystems: A truncated functional biodiversity. *BioScience, 52*(6), 473-481.

Hahn, H. J. (2009). A proposal for an extended typology of groundwater habitats. *Hydrogeology Journal, 17*, 77-81.

Hahn, H. J., & Fuchs, A. (2009). Distribution patterns of groundwater communities across aquifer types in south-western Germany. *Freshwater Biology*(54), 848-860.

Halse, S., & Eberhard, S. (2014). Pilbara stygofauna: deep groundwater of an arid landscape contains globally significant radiation of biodiversity. *Records of the Western Australian Museum, Supplement 78*, 443-483.

Harvey, M. S. (2002). Short range endemism in the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics, 16*, 555-570.

Howarth, F. G. (1983). Ecology of cave arthropods. *Annual Review of Entomology, 28*(1), 365-389.

Humphreys, W. F. (1999). The distribution of Australian cave fishes. *Records of the Western Australian Museum, 19*, 469-472.

Humphreys, W. F. (2006). Aquifers: the ultimate ground-water dependent ecosystems. *Australian Journal of Botany, 54*, 115-132.

Humphreys, W. F. (2008). Rising from Down Under: developments in subterranean biodiversity in Australia from a groundwater fauna perspective. *Invertebrate Systematics, 22*, 85-101.

Karanovic, I. (2009). Four new species of *Gomphodella* De Deckker, with a phylogenetic analysis and a key to the living representatives of the subfamily Timiriaseviinae (Ostracoda). *Crustaceana, 82*(9), 1133-1176.

Karanovic, T. (2006). Subterranean copepods (Crustacea, Copepoda) from the Pilbara region in Western Australia. *Records of the Australian Museum, Supplement 70*, 1-239.

Kendrick, P., & McKenzie, N. L. (2001). Pilbara 1 (PIL1 - Chichester subregion). In *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002* (pp. 547-558). Kensington, Western Australia: Department of Conservation and Land Management.

Leighton, K. A. (2004). Climate. In A. M. E. van Vreeswyk, A. L. Payne, K. A. Leighton, & P. Hennig (Eds.), *An Inventory and Condition Survey of the Pilbara Region, Western Australia*. Perth, Western Australia: Technical Bulletin No. 92. Western Australian Department of Agriculture.

Malard, F., & Hervant, F. (1999). Oxygen supply and the adaptations of animals in groundwater. *Freshwater Biology, 41*, 1-30.

Martens, K., & Rossetti, G. (2002). On the Darwinulidae (Crustacea: Ostracoda) from Oceania. *Invertebrate Systematics, 16*(2), 195-208.

McKenzie, N. L., van Leeuwen, S., & Pinder, A. M. (2009). Introduction to the Pilbara Biodiversity Survey, 2002-2007. *Records of the Western Australian Museum Supplement, 78*, 3-89.

MWH, Australia. (2016). *Corunna Downs Subterranean Fauna Assessment. November 2016*.

Pinto, R. L., Rocha, C. E. F., & Martens, K. (2004). On the genus *Penthesilenula* Rossetti and Martens, 1998 (Crustacea, Ostracoda, Darwinulidae) from (semi-) terrestrial habitats in São Paulo State (Brazil), with the description of a new species. *Journal of Natural History, 38*, 2567–2589.

Poulson, T. L., & Lavoie, K. H. (2000). The trophic basis of subterranean ecosystems. In H. Wilkens, D. C. Culver, & W. F. Humphries (Eds.), *Ecosystems of the World 30: Subterranean Ecosystems* (pp. 231-249). Amsterdam: Elsevier.

Schuring, J., Schulz, H. D., Fischer, W. R., Böttcher, J., & Duijnisveld, W. H. M. (1999). *Redox: Fundamentals, Processes and Applications*. Berlin, Heidelberg, New York: Springer-Verlag.

Smith, G. B., & McRae, J. M. (2014). New species of subterranean silverfish (Zygentoma: Nicoletiidae: Atelurinae) frm Western Australia's semi-arid Pilbara region. *Records of the Western Australian Museum, 29*, 105-127.

Strayer, D. L. (1994). Limits to biological distributions in groundwater. In J. Gibert, D. L. Danielopol, & J. A. Stanford (Eds.), *Groundwater Ecology* (pp. 287-310). San Diego: Academic Press.

Subterranean Ecology. (2007a). *Panorama Project Subterranean Fauna Report 3: Troglofauna Phase 2 Results Phase 3 Sites. October 2007*.

Subterranean Ecology. (2007b). *Panorama Project Subterranean Fauna Report 4: Troglofauna Phase 3 Survey. November 2007*.

Subterranean Ecology. (2007c). *Panorama Project Subterranean Fauna Survey Report 2. July 2007*.

Subterranean Ecology. (2009). *Abydos DSO Project Troglofauna Survey. May 2009*.

Subterranean Ecology. (2011). *Abydos DSO Project Troglofauna Survey 2010. August 2011*.

Subterranean Ecology. (2012a). *Mount Webber DSO Project. Stage 1 and Public Road Upgrade. Desktop Assessment of Subterranean Fauna. September 2012*.

Subterranean Ecology. (2012b). *North Star Project Subterranean Fauna Survey and Assessment. May 2012*.

Thackway, R., & Cresswell, I. D. (1995). *An Interim Biogeographical Regionalisation for Australia*. Canberra, Australian Capital Territory: Australian Nature Conservation Agency.

van Etten, E. J. B. (2009). Inter-annual rainfall variability of arid Australia: greater than elsewhere? *Australian Geographer, 40*(1), 109-120. doi:10.1080/00049180802657075

WAM, Western Australian Museum. (2019a). Arachnid and Myriapod Collection Database (custom search). Retrieved 2019 http://www.museum.wa.gov.au

WAM, Western Australian Museum. (2019b). Crustacea Collection Database (custom search). Retrieved 2019 http://www.museum.wa.gov.au

WAM, Western Australian Museum. (2019c). Mollusc Collection Database (custom search). Retrieved 2019 http://www.museum.wa.gov.au

Waterhouse, J. D., & Howe, P. J. (1994). An Environmental Hydrogeological Study near Mount Bruce, Pilbara Region of Western Australia. *Water Down Under 94: Groundwater Papers, 94*(14), 551-556.

Watts, C. H. S., & Humphreys, W. F. (2004). Thirteen new Dytiscidae (Coleoptera) of the genera *Boongurrus* Larson, *Tjirtudessus* Watts & Humphreys and *Nirripirti* Watts and Humphreys, from underground waters in Australia. *Transactions of the Royal Society of South Australia, 128*, 99-129.

9 APPENDICES

Appendix A – Sampling effort

APPENDIX A: Bores and drill holes visited during the survey

Hole ID	Easting	Northing	Drawdown	Pit	Phase 1			Phase 2		
					Trapping	Scraping	Hauling	Trapping	Scraping	Hauling
6MILEK001	-21.1074	119.1399	Outside	Outside			✓			
ABMB02	-21.1092	119.1286	Outside	Outside			✓✓			✓
ABRC628	-21.1116	119.1877	Southern DD	Sandtrax				✓	✓✓	
ABRC629	-21.1114	119.1877	Southern DD	Outside	✓			✓	✓✓	
ABRC631	-21.1119	119.1881	Southern DD	Outside	✓			✓	✓✓	
ABRC637	-21.1114	119.1885	Southern DD	Sandtrax				✓	✓✓	
ABRC638	-21.1112	119.1885	Southern DD	Outside	✓			✓	✓✓	
ABRC644	-21.1111	119.1893	Southern DD	Outside				✓	✓✓	
ABRC645	-21.1116	119.1896	Southern DD	Sandtrax				✓	✓✓	
ABRC648	-21.111	119.1897	Southern DD	Outside	✓			✓	✓✓	
ABRC664	-21.1116	119.1873	Southern DD	Sandtrax	✓					
ABRC673	-21.111	119.1866	Southern DD	Outside	✓			✓	✓✓	
ABRC688	-21.1114	119.187	Southern DD	Outside	✓			✓	✓✓	
ALB0001	-20.736	119.3228	Northern DD	Outside			✓✓			✓✓
ALB0003	-20.9628	119.2967	Central DD	Outside			✓✓			✓✓
ALB0004	-20.7516	119.3223	Northern DD	Outside			✓✓			✓
ALB0006	-20.7358	119.3228	Northern DD	Outside			✓			✓
ALB0007	-20.9422	119.2966	Central DD	Outside			✓✓			✓
ALB0009	-20.7515	119.3222	Northern DD	Outside			✓✓			✓
ALB0010	-20.792	119.3169	Northern DD	Outside			✓✓			✓
ALB0023	-20.941	119.2969	Central DD	Outside			✓✓			✓✓
ALB0044	-21.0544	119.2771	Outside	Outside			✓✓			✓
ALB0045	-21.0552	119.2756	Outside	Outside			✓✓			✓
ALB0052	-20.7342	119.3228	Northern DD	Outside			✓✓			✓
ALB0054	-20.9036	119.2999	Outside	Outside			✓✓			✓
ALB0063	-20.7757	119.3197	Northern DD	Outside			✓			✓

Hole ID	Easting	Northing	Drawdown	Pit	Phase 1			Phase 2		
					Trapping	Scraping	Hauling	Trapping	Scraping	Hauling
ALB0064	-20.7774	119.3192	Northern DD	Outside			✓			✓
ALB0065	-20.7786	119.3188	Northern DD	Outside			✓✓			✓✓
ALB0066	-20.7757	119.3197	Northern DD	Outside			✓✓			✓
ALB0067	-20.7774	119.3192	Northern DD	Outside			✓✓			✓
ALMB02	-20.9423	119.2967	Central DD	Outside			✓			✓✓
ALMB05	-20.7923	119.3169	Northern DD	Outside			✓			✓
CBMB03	-21.116	119.1084	Outside	Outside						✓✓
KWSS Bore	-21.1437	119.2063	Outside	Outside			✓			✓
LRUNK001	-21.0513	119.2743	Outside	Outside			✓	✓	✓	✓
LRUNK002	-21.0512	119.2745	Outside	Outside				✓		
LRUNK003	-21.0512	119.2751	Outside	Outside				✓		
MCK001	-20.9695	119.3926	Outside	Outside			✓			
MCK002	-21.0015	119.3282	Outside	Outside			✓			
MCK003	-20.9177	119.3408	Outside	Outside			✓			
MCK004	-20.6954	119.3307	Outside	Outside			✓			
MCUNK001	-20.9709	119.3912	Outside	Outside			✓			✓✓
MCWIND001	-20.9029	119.2995	Outside	Outside			✓			✓✓
MRRC0001	-20.9722	119.4245	Outside	Miralga East	✓	✓				
MRRC0003	-20.9726	119.4245	Outside	Miralga East		✓			✓	
MRRC0004	-20.9722	119.4253	Outside	Miralga East		✓				
MRRC0005	-20.972	119.4253	Outside	Miralga East	✓	✓			✓	
MRRC0006	-20.9726	119.4253	Outside	Miralga East		✓		✓	✓✓	
MRRC0007	-20.9723	119.4239	Outside	Miralga East		✓				
MRRC0008	-20.9716	119.4299	Outside	Outside	✓	✓		✓	✓	
MRRC0012	-20.9717	119.4314	Outside	Miralga East	✓	✓				
MRRC0013	-20.9719	119.4322	Outside	Miralga East	✓	✓				
MRRC0014	-20.9722	119.4358	Outside	Miralga East	✓	✓				

Hole ID	Easting	Northing	Drawdown	Pit	Phase 1			Phase 2		
					Trapping	Scraping	Hauling	Trapping	Scraping	Hauling
MRRC0015	-20.972	119.4357	Outside	Miralga East	✓	✓		✓	✓	
MRRC0016	-20.972	119.4368	Outside	Miralga East	✓	✓		✓	✓	
MRRC0020	-20.9703	119.4347	Outside	Outside	✓	✓		✓	✓	
MRRC0021	-20.9709	119.4364	Outside	Outside	✓	✓		✓	✓	
MRRC0022	-20.9722	119.4365	Outside	Outside						
MRRC0023	-20.9722	119.4329	Outside	Miralga East	✓	✓			✓	
MRRC0027	-20.9717	119.4245	Outside	Miralga East	✓	✓		✓	✓✓	
MRRC0033	-20.9719	119.4303	Outside	Miralga East	✓	✓			✓	
MRRC0035	-20.9716	119.4306	Outside	Miralga East	✓	✓			✓	
MRRC0041	-20.9723	119.4318	Outside	Miralga East	✓	✓		✓	✓	
MRRC0042	-20.972	119.4329	Outside	Miralga East	✓	✓		✓	✓	
MRRC0044	-20.9716	119.431	Outside	Miralga East	✓	✓		✓	✓	
MRRC0045	-20.9719	119.4326	Outside	Miralga East		✓			✓	
MRRC0055	-21.0236	119.3183	Outside	Miralga West					✓	
MRRC0056	-21.0233	119.318	Outside	Miralga West				✓	✓	
MRRC0057	-21.0231	119.3178	Outside	Miralga West	✓	✓				
MRRC0058	-21.0238	119.3175	Outside	Miralga West				✓	✓	
MRRC0059	-21.0236	119.3172	Outside	Miralga West		✓			✓	
MRRC0060	-21.0245	119.3171	Outside	Miralga West	✓	✓				
MRRC0061	-21.0243	119.3169	Outside	Miralga West				✓✓	✓	
MRRC0062	-21.0241	119.3166	Outside	Miralga West	✓	✓				
MRRC0063	-21.024	119.3178	Outside	Miralga West	✓	✓				
MRRC0064	-21.0238	119.3185	Outside	Miralga West	✓	✓				
MRRC0065	-21.023	119.3188	Outside	Miralga West				✓	✓	
MRRC0067	-21.0226	119.3183	Outside	Miralga West		✓				
MRRC0068	-21.022	119.3189	Outside	Miralga West		✓			✓	
MRRC0071	-21.025	119.3163	Outside	Miralga West		✓		✓		

Hole ID	Easting	Northing	Drawdown	Pit	Phase 1			Phase 2		
					Trapping	Scraping	Hauling	Trapping	Scraping	Hauling
MRRC0072	-21.0253	119.3158	Outside	Outside	✓	✓		✓	✓	
MRRC0073	-21.0247	119.3162	Outside	Outside	✓	✓				
MRRC0074	-21.0243	119.3157	Outside	Outside	✓	✓		✓	✓	
MRRC0075	-21.025	119.3153	Outside	Outside		✓			✓	
MRRC0076	-21.0247	119.3149	Outside	Outside	✓					
MRRC0077	-21.0256	119.315	Outside	Outside	✓	✓			✓	
MRRC0079	-21.0252	119.3146	Outside	Outside				✓	✓	
MRRC0080	-21.0212	119.3192	Outside	Outside	✓	✓		✓	✓	
MRRC0081	-21.0206	119.3195	Outside	Outside				✓	✓	
MRRC0082	-21.0206	119.3195	Outside	Outside	✓	✓		✓	✓	
MRRC0083	-21.0212	119.3193	Outside	Outside				✓	✓	
MRRC0084	-21.0261	119.3144	Outside	Outside				✓	✓	
MRRC0085	-21.0259	119.3141	Outside	Outside	✓	✓				
MRRC0086	-21.0265	119.314	Outside	Outside	✓	✓			✓	
MRRC0087	-21.0263	119.3137	Outside	Outside				✓	✓	
MRRC0088	-21.0247	119.3167	Outside	Miralga West	✓	✓				
MRRC0089	-21.0245	119.3165	Outside	Miralga West					✓	
MRRC0090	-21.0243	119.3163	Outside	Outside				✓	✓	
MRRC0091	-21.0243	119.3174	Outside	Miralga West		✓				
MRRC0092	-21.0241	119.3171	Outside	Miralga West	✓	✓				
MRRC0094	-21.0238	119.3169	Outside	Outside	✓	✓				
MRRC0095	-21.0238	119.3179	Outside	Miralga West	✓	✓				
MRRC0096	-21.0236	119.3177	Outside	Miralga West					✓	
MRRC0097	-21.0233	119.3175	Outside	Miralga West		✓				
MRRC0098	-21.0233	119.3185	Outside	Miralga West	✓	✓				
MRRC0099	-21.0231	119.3183	Outside	Miralga West					✓	
MRRC0103	-21.0227	119.3184	Outside	Miralga West					✓	

Hole ID	Easting	Northing	Drawdown	Pit	Phase 1			Phase 2		
					Trapping	Scraping	Hauling	Trapping	Scraping	Hauling
MRRC0104	-21.0226	119.3188	Outside	Miralga West				✓	✓	
MRRC0105	-21.0224	119.3186	Outside	Miralga West	✓	✓				
MRRC0107	-21.0218	119.319	Outside	Miralga West	✓	✓			✓	
MRRC0108	-20.9721	119.4236	Outside	Outside	✓			✓		
MRRC0109	-20.9719	119.4242	Outside	Miralga East	✓	✓				
MRRC0112	-20.9721	119.4259	Outside	Outside		✓		✓	✓	
MRRC0115	-20.9717	119.4249	Outside	Miralga East	✓	✓				
MRRC0116	-20.9715	119.4275	Outside	Outside		✓		✓	✓	
MRRC0118	-20.9716	119.4318	Outside	Miralga East		✓			✓	
MRRC0119	-20.9723	119.431	Outside	Miralga East	✓	✓				
MRRC0120	-20.9716	119.4323	Outside	Outside	✓	✓		✓	✓	
MRRC0121	-20.9715	119.4334	Outside	Outside		✓		✓	✓	
MRRC0123	-21.1115	119.1873	Southern DD	Sandtrax				✓	✓	
MRRC0124	-21.1118	119.1879	Southern DD	Sandtrax				✓	✓	
MRRC0125	-21.1116	119.188	Southern DD	Sandtrax				✓	✓	
MRRC0127	-21.1114	119.1889	Southern DD	Sandtrax				✓	✓	
MRRC0128	-21.1112	119.1902	Southern DD	Outside				✓	✓	
MRRC0129	-21.1113	119.19	Southern DD	Sandtrax				✓	✓	
MRRCUNK01	-20.9716	119.4316	Outside	Miralga East					✓	
MRWB0001	-20.9815	119.3824	Outside	Outside						✓
MW026	-21.0228	119.318	Outside	Miralga West				✓	✓	
P12	-21.0107	119.3124	Outside	Outside			✓✓			✓
SRBORE001	-20.7095	119.3374	Outside	Outside			✓			✓
SRBORE002	-20.7094	119.337	Outside	Outside			✓			✓
SRWIND001	-20.7133	119.3157	Outside	Outside			✓			✓✓
SS Creek Flow	-21.1205	119.1985	Southern DD	Outside			✓			
SSBWB38	-21.0978	119.1868	Southern DD	Outside			✓✓			✓

Hole ID	Easting	Northing	Drawdown	Pit	Phase 1			Phase 2		
					Trapping	Scraping	Hauling	Trapping	Scraping	Hauling
SSK001	-21.1165	119.1938	Southern DD	Outside			✓			
SSK002	-21.1204	119.1984	Southern DD	Outside			✓			
SSK0020	-21.1374	119.1985	Outside	Outside						✓
SSK0021	-21.1231	119.2	Southern DD	Outside						✓
SSUNK001	-21.1524	119.218	Outside	Outside		✓	✓		✓	✓
SSUNK002	-21.1519	119.2174	Outside	Outside		✓	✓			
SSUNK003	-21.1431	119.1876	Outside	Outside			✓			✓✓
SSUNK004	-21.1406	119.1905	Outside	Outside			✓			✓
SSUNK005	-21.1623	119.2012	Outside	Outside			✓			
SSUNK006	-21.1476	119.2039	Outside	Outside			✓			
SSWB36	-21.0871	119.1869	Southern DD	Outside			✓			✓
SSWB39	-21.094	119.1863	Southern DD	Outside			✓			
STXKARA01	-21.1105	119.1945	Southern DD	Outside			✓			
TN0 Pump	-20.7525	119.3222	Northern DD	Outside			✓			

Note: Some holes were scraped or hauled during both trips within a given phase; this is indicated by double ticks

Appendix B – Database search results

APPENDIX B: Database search results

Order	Lowest ID	Likely subterranean status (Biologic)	Site/ Well	Latitude	Longitude	Source
Acari	Acari sp. indet.	Stygofauna	90 km NW. of Newman, Yandi, Ministers North	-20.8203	119.0908	WAM
Araneae	'Oonopidae?' blind sp. (juvenile).	Troglofauna	Yandi mine lease, c. 61 km NW. of Marble Bar, site WW2	-20.8375	119.2725	WAM
Harpacticoida	*Gordanitocrella trajani*	Stygofauna	Pilbara	-20.9516	119.156	WAM
Isopoda	?*Troglarmadillo* sp. indet.	Troglofauna	Pilbara, Abydos	-21.1472	119.088	WAM
Isopoda	?*Troglarmadillo* sp. indet.	Troglofauna	Pilbara, Abydos	-21.1488	119.085	WAM
Isopoda	?*Troglarmadillo* sp. indet.	Troglofauna	Pilbara, Abydos	-21.1477	119.089	WAM
Isopoda	?*Troglarmadillo* sp. indet.	Troglofauna	Pilbara, Abydos	-21.1447	119.103	WAM
Isopoda	?*Troglarmadillo* sp. indet.	Troglofauna	Pilbara, Abydos	-21.1486	119.084	WAM
Isopoda	Microcerberidae sp. indet.	Stygofauna	Camp5, bore NPM04	-21.1032	119.408	WAM
Isopoda	Microcerberidae sp. indet.	Stygofauna	Carlinde Station, bore MBSLK356A	-20.8087	119.492	WAM
Ostracoda	*Candonopsis pilbarae*	Stygofauna	Mickey`S Well, Npm02, Pilbara Region	-21.0969	119.352	WAM
Ostracoda	*Candonopsis pilbarae*	Stygofauna	Mickey`S Well, Npm02, Pilbara Ergion	-21.0969	119.352	WAM
Ostracoda	*Leicacandona halsei*	Stygofauna	Carlinde Station, Mbslk356a, Pilbara Region	-20.8087	119.492	WAM
Ostracoda	*Leicacandona halsei*	Stygofauna	Carlinde Station, Mbslk356a, Pilbara Region	-20.8087	119.492	WAM
Ostracoda	*Leicacandona halsei*	Stygofauna	Carlinde Station, Mbslk356a, Pilbara Region	-20.8087	119.492	WAM
Ostracoda	*Leicacandona jimi*	Stygofauna	Pear Creek, Mbslk344, Pilbara Region	-20.8395	119.607	WAM
Ostracoda	*Leicacandona jimi*	Stygofauna	Pear Creek, Mbslk344, Pilbara Region	-20.8395	119.607	WAM
Ostracoda	*Leicacandona lite*	Stygofauna	Camp 5, Npm04, Pilbara Region	-21.1033	119.408	WAM
Ostracoda	*Leicacandona lite*	Stygofauna	Camp 5, Npm04, Pilbara Region	-21.1033	119.408	WAM
Pseudoscorpiones	*Tyrannochthonius* `sp. AB A`	Troglofauna	Abydos: Leightons, 96.8 km SE. of South Hedland, COF01-AB851	-21.1267	119.1346	WAM
Pseudoscorpiones	*Tyrannochthonius* `sp. AB B`	Stygofauna	Abydos: Leightons, 96.8 km SE. of South Hedland, COF01-AB859	-21.1272	119.1358	WAM
Pseudoscorpiones	*Tyrannochthonius* `sp. AB`	Stygofauna	Abydos: Leightons, 96.8 km SE. of South Hedland, COF01-AB699	-21.1267	119.1346	WAM
Pseudoscorpiones	*Tyrannochthonius abydos*	Stygofauna	ca. 35 km NE. of Abydos Homestead, Mettams deposit, bore hole ABRC104	-21.1481	119.0856	WAM
Pseudoscorpiones	*Tyrannochthonius* sp. indet.	Stygofauna	ca. 35 km NE. of Abydos Homestead, Mullaloo deposit, bore hole ABRC026	-21.1417	119.1133	WAM
Pseudoscorpiones	*Tyrannochthonius* sp. indet.	Stygofauna	ca. 35 km NE. of Abydos Homestead, Mullaloo deposit, bore hole ABRC031	-21.1411	119.115	WAM
Scolopendrida	Cryptopidae sp. 'MN'	Stygofauna	Yandi, 90 km NW. of Newman	-20.83	119.11	WAM

Order	Lowest ID	Likely subterranean status (Biologic)	Site/ Well	Latitude	Longitude	Source
Amphipoda	Melitidae sp. 1	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Amphipoda	Melitidae sp. 1	Stygofauna	NPM02	-21.0969	119.3663	PSS
Amphipoda	*Nedsia* nr *hurlberti*	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Amphipoda	*Nedsia* sp.	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Amphipoda	*Nedsia* sp.	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Amphipoda	*Nedsia* sp.	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Amphipoda	*Nedsia* sp.	Stygofauna	MBSLK376B	-20.7096	119.3372	PSS
Amphipoda	*Nedsia* sp.	Stygofauna	MBSLK376B	-20.7096	119.3372	PSS
Amphipoda	*Nedsia* sp.	Stygofauna	MBSLK376A	-20.7096	119.3372	PSS
Amphipoda	*Nedsia* sp.	Stygofauna	MBSLK376A	-20.7096	119.3372	PSS
Amphipoda	*Nedsia* sp.	Stygofauna	LALLA1	-20.9027	119.013	PSS
Amphipoda	*Pilbarus millsi*	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Amphipoda	*Pilbarus millsi*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Amphipoda	*Pilbarus millsi*	Stygofauna	NPM01	-21.0973	119.4065	PSS
Amphipoda	*Pilbarus* sp. 2	Stygofauna	LALLA1	-20.9027	119.013	PSS
Calanoida	*Stygoridgewayia trispinosa*	Stygofauna	MBSLK356A	-20.8088	119.492	PSS
Cyclopoida	*Diacyclops cockingi*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Cyclopoida	*Diacyclops cockingi*	Stygofauna	NPM01	-21.0973	119.4065	PSS
Cyclopoida	*Diacyclops cockingi*	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Cyclopoida	*Diacyclops einslei*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Cyclopoida	*Diacyclops humphreysi humphreysi*	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Cyclopoida	*Diacyclops humphreysi humphreysi*	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Cyclopoida	*Diacyclops humphreysi humphreysi*	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Cyclopoida	*Diacyclops humphreysi humphreysi*	Stygofauna	MBSLK356A	-20.8088	119.492	PSS
Cyclopoida	*Diacyclops humphreysi humphreysi*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Cyclopoida	*Diacyclops humphreysi humphreysi*	Stygofauna	LALLA1	-20.9027	119.013	PSS

Order	Lowest ID	Likely subterranean status (Biologic)	Site/ Well	Latitude	Longitude	Source
Cyclopoida	*Diacyclops humphreysi humphreysi*	Stygofauna	NPM04	-21.1032	119.4076	PSS
Cyclopoida	*Diacyclops humphreysi humphreysi*	Stygofauna	NPM02	-21.0969	119.3663	PSS
Cyclopoida	*Diacyclops scanloni*	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Cyclopoida	*Diacyclops scanloni*	Stygofauna	MBSLK356B	-20.8088	119.492	PSS
Cyclopoida	*Diacyclops sobeprolatus*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Cyclopoida	*Diacyclops sobeprolatus*	Stygofauna	NPM02	-21.0969	119.3663	PSS
Cyclopoida	*Diacyclops sobeprolatus*	Stygofauna	MBSLK356A	-20.8088	119.492	PSS
Cyclopoida	*Meridiecyclops baylyi*	Stygofauna	NPM02	-21.0969	119.3663	PSS
Cyclopoida	*Metacyclops*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Harpacticoida	*Parastenocaris*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Harpacticoida	*Stygonitocrella trispinosa*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Harpacticoida	*Stygonitocrella trispinosa*	Stygofauna	MBSLK376A	-20.7096	119.3372	PSS
Harpacticoida	*Stygonitocrella trispinosa*	Stygofauna	NPM02	-21.0969	119.3663	PSS
Harpacticoida	*Stygonitocrella trispinosa*	Stygofauna	MBSLK356A	-20.8088	119.492	PSS
Harpacticoida	*Stygonitocrella trispinosa*	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Harpacticoida	*Stygonitocrella trispinosa*	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Harpacticoida	*Stygonitocrella trispinosa*	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Harpacticoida	*Stygonitocrella unispinosa*	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Harpacticoida	*Stygonitocrella unispinosa*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Harpacticoida	Canthocamptidae sp.	Stygofauna	NPM02	-21.0969	119.3663	PSS
Harpacticoida	*Elaphoidella humphreysi*	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Harpacticoida	*Elaphoidella humphreysi*	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Harpacticoida	*Elaphoidella humphreysi*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Harpacticoida	*Elaphoidella humphreysi*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Harpacticoida	Harpacticoida	Stygofauna	NPM04	-21.1032	119.4076	PSS
Isopoda	Microcerberidae sp.	Stygofauna	MBSLK356A	-20.8088	119.492	PSS
Isopoda	Microcerberidae sp.	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Isopoda	Microcerberidae sp.	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS

Order	Lowest ID	Likely subterranean status (Biologic)	Site/ Well	Latitude	Longitude	Source
Isopoda	Microcerberidae sp.	Stygofauna	NPM04	-21.1032	119.4076	PSS
Isopoda	Philosciidae sp.	Stygofauna	MBSLK356B	-20.8088	119.492	PSS
Isopoda	Philosciidae sp.	Stygofauna	MBSLK356A	-20.8088	119.492	PSS
Nematoda	Nematoda sp. 17	Stygofauna	NPM03	-21.1253	119.3596	PSS
Nematoda	Nematoda sp. 2	Stygofauna	MBSLK356B	-20.8088	119.492	PSS
Nematoda	Nematoda sp. 4	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Oligochaeta	*Enchytraeus* Pilbara sp. 1	Stygofauna	MBSLK356B	-20.8088	119.492	PSS
Oligochaeta	*Enchytraeus* Pilbara sp. 1	Stygofauna	MBSLK356B	-20.8088	119.492	PSS
Oligochaeta	*Insulodrilus lacustris* s.l. Pilbara type 2/3	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Oligochaeta	*Monopylephorus* n. sp. WA29	Stygofauna	NPM04	-21.1032	119.4076	PSS
Oligochaeta	*Monopylephorus* n. sp. WA29	Stygofauna	NPM04	-21.1032	119.4076	PSS
Oligochaeta	*Monopylephorus* n. sp. WA29	Stygofauna	NPM01	-21.0973	119.4065	PSS
Oligochaeta	*Monopylephorus* n. sp. WA29	Stygofauna	MBSLK356A	-20.8088	119.492	PSS
Oligochaeta	*Monopylephorus* n. sp. WA29	Stygofauna	MBSLK356A	-20.8088	119.492	PSS
Oligochaeta	*Monopylephorus* n. sp. WA29	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Oligochaeta	*Monopylephorus* n. sp. WA29	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Oligochaeta	Phreodrilid with dissimilar ventral chaetae	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Oligochaeta	Phreodrilid with dissimilar ventral chaetae	Stygofauna	MBSLK344	-20.8394	119.6072	PSS
Oligochaeta	Phreodrilid with dissimilar ventral chaetae	Stygofauna	LALLA1	-20.9027	119.013	PSS
Oligochaeta	Phreodrilid with dissimilar ventral chaetae	Stygofauna	NPM01	-21.0973	119.4065	PSS
Oligochaeta	Phreodrilid with similar ventral chaetae	Stygofauna	MBSLK356B	-20.8088	119.492	PSS
Oligochaeta	Phreodrilid with similar ventral chaetae	Stygofauna	NPM02	-21.0969	119.3663	PSS
Ostracoda	*Areacandona* cf. sp. 1	Stygofauna	MBSLK344	-20.8394	119.6072	PSS
Ostracoda	*Areacandona iuno*	Stygofauna	MBSLK388B	-20.6801	119.2453	PSS
Ostracoda	*Candonopsis pilbarae*	Stygofauna	NPM02	-21.0969	119.3663	PSS

Order	Lowest ID	Likely subterranean status (Biologic)	Site/ Well	Latitude	Longitude	Source
Ostracoda	*Cypretta seurati*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Ostracoda	*Cypretta seurati*	Stygofauna	LALLA1	-20.9027	119.013	PSS
Ostracoda	*Cyprinotus kimberleyensis*	Stygofauna	NPM03	-21.1253	119.3596	PSS
Ostracoda	*Cyprinotus kimberleyensis*	Stygofauna	NPM03	-21.1253	119.3596	PSS
Ostracoda	*Deminutiocandona* cf. *halsei*	Stygofauna	MBSLK376B	-20.7096	119.3372	PSS
Ostracoda	*Gomphodella hirsuta*	Stygofauna	MBSLK344	-20.8394	119.6072	PSS
Ostracoda	*Gomphodella hirsuta*	Stygofauna	MBSLK344	-20.8394	119.6072	PSS
Ostracoda	*Leicacandona halsei*	Stygofauna	MBSLK356B	-20.8088	119.492	PSS
Ostracoda	*Leicacandona halsei*	Stygofauna	MBSLK356A	-20.8088	119.492	PSS
Ostracoda	*Leicacandona jimi*	Stygofauna	MBSLK344	-20.8394	119.6072	PSS
Ostracoda	*Leicacandona lite*	Stygofauna	NPM04	-21.1032	119.4076	PSS
Ostracoda	Limnocythere sp. 1	Stygofauna	MBSLK344	-20.8394	119.6072	PSS
Ostracoda	Ostracoda sp. indet.	Stygofauna	MBSLK388A	-20.6801	119.2453	PSS
Ostracoda	Ostracoda sp. indet.	Stygofauna	MBSLK376B	-20.7096	119.3372	PSS
Ostracoda	Ostracoda sp. indet.	Stygofauna	MBSLK376A	-20.7096	119.3372	PSS
Ostracoda	*Strandesia*	Uncertain	NPM02	-21.0969	119.3663	PSS
Ostracoda	*Strandesia*	Uncertain	NPM02	-21.0969	119.3663	PSS
Platyhelminthes	Turbellaria sp.D4:ED4:E278	Stygofauna	LALLA1	-20.9027	119.013	PSS
Polychaeta	*Aeolosoma* sp. 1	Stygofauna	LALLA1	-20.9027	119.013	PSS
Rotifera	Bdelloidea sp.	Stygofauna	MBSLK344	-20.8394	119.6072	PSS
Acari	Acariformes sp.	Stygofauna				NatureMap
Acari	*Oribatida* group 1	Stygofauna				NatureMap
Acari	*Oribatida* group 5	Stygofauna				NatureMap
Acari	*Oribatida* sp. 4	Stygofauna				NatureMap
Amphipoda	Melitidae sp. 1	Stygofauna				NatureMap
Amphipoda	*Nedsia* nr *hurlberti*	Stygofauna				NatureMap
Amphipoda	*Nedsia* sp.	Stygofauna				NatureMap
Amphipoda	Paramelitidae sp.	Stygofauna				NatureMap
Amphipoda	Paramelitidae sp. 7	Stygofauna				NatureMap

Order	Lowest ID	Likely subterranean status (Biologic)	Site/ Well	Latitude	Longitude	Source
Amphipoda	*Pilbarus* sp. S2	Stygofauna				NatureMap
Cyclopoida	*Diacyclops cockingi*	Stygofauna				NatureMap
Cyclopoida	*Diacyclops einslei*	Stygofauna				NatureMap
Cyclopoida	*Diacyclops humphreysi humphreysi*	Stygofauna				NatureMap
Cyclopoida	*Diacyclops scanloni*	Stygofauna				NatureMap
Cyclopoida	*Diacyclops sobeprolatus*	Stygofauna				NatureMap
Cyclopoida	*Meridiecyclops baylyi*	Stygofauna				NatureMap
Cyclopoida	*Mesocyclops darwini*	Stygofauna				NatureMap
Cyclopoida	*Metacyclops/Pescecyclops* sp.	Stygofauna				NatureMap
Cyclopoida	*Microcyclops varicans*	Stygofauna				NatureMap
Cyclopoida	*Thermocyclops decipiens*	Stygofauna				NatureMap
Harpacticoida	*Stygonitocrella bispinosa*	Stygofauna				NatureMap
Harpacticoida	Stygonitocrella sp.	Stygofauna				NatureMap
Harpacticoida	*Stygonitocrella trispinosa*	Stygofauna				NatureMap
Harpacticoida	*Stygonitocrella unispinosa*	Stygofauna				NatureMap
Harpacticoida	*Elaphoidella humphreysi*	Stygofauna				NatureMap
Harpacticoida	Harpacticoida sp	Stygofauna				NatureMap
Isopoda	Microcerberidae sp.	Stygofauna				NatureMap
Isopoda	Philosciidae sp.	Stygofauna				NatureMap
Nematoda	Nematoda sp. 14	Stygofauna				NatureMap
Nematoda	Nematoda sp. 17	Stygofauna				NatureMap
Nematoda	Nematoda sp. 2	Stygofauna				NatureMap
Nematoda	Nematoda sp. 4	Stygofauna				NatureMap
Oligochaeta	*Enchytraeus* Pilbara sp. 1	Stygofauna				NatureMap
Oligochaeta	*Insulodrilus lacustris* s.l. Pilbara type 2/3 = WA35	Stygofauna				NatureMap
Oligochaeta	*Monopylephorus* n. sp. WA29 (ex Pristina WA3)	Stygofauna				NatureMap
Oligochaeta	Naididae (ex Tubificidae)	Stygofauna				NatureMap

Order	Lowest ID	Likely subterranean status (Biologic)	Site/ Well	Latitude	Longitude	Source
Oligochaeta	Oligochaeta sp.	Stygofauna				NatureMap
Oligochaeta	Phreodrilid with dissimilar ventral chaetae	Stygofauna				NatureMap
Oligochaeta	Phreodrilid with similar ventral chaetae	Stygofauna				NatureMap
Ostracoda	*Areacandona* cf. 'iuno'	Stygofauna				NatureMap
Ostracoda	*Areacandona* cf. sp. 1	Stygofauna				NatureMap
Ostracoda	*Candonopsis 'pilbarae'*	Stygofauna				NatureMap
Ostracoda	*Deminutiocandona* cf. *'halsei'*	Stygofauna				NatureMap
Ostracoda	*Gomphodella 'hirsuta'*	Stygofauna				NatureMap
Ostracoda	*Ilyodromus* sp BOS25	Stygofauna				NatureMap
Ostracoda	*Ilyodromus* sp. PB	Stygofauna				NatureMap
Ostracoda	*'Leicacandona' 'halsei'*	Stygofauna				NatureMap
Ostracoda	*'Leicacandona' 'jimi'*	Stygofauna				NatureMap
Ostracoda	*'Leicacandona' 'lite'*	Stygofauna				NatureMap
Ostracoda	Limnocythere sp. 1	Stygofauna				NatureMap
Ostracoda	Ostracoda sp. indet.	Stygofauna				NatureMap
Ostracoda	*Strandesia* sp.	Uncertain				NatureMap
Ostracoda	*Vestalenula marmonieri*	Stygofauna				NatureMap
Polychaeta	*Aeolosoma* sp. 1	Stygofauna				NatureMap
Polychaeta	*Aeolosoma* sp. 3	Stygofauna				NatureMap
Rotifera	Bdelloidea sp.	Stygofauna				NatureMap
Rotifera	Bdelloidea sp. 2:2	Stygofauna				NatureMap
Rotifera	*Dissotrocha* n. sp. (Pilbara stygo)	Stygofauna				NatureMap

Appendix C – Water physicochemistry

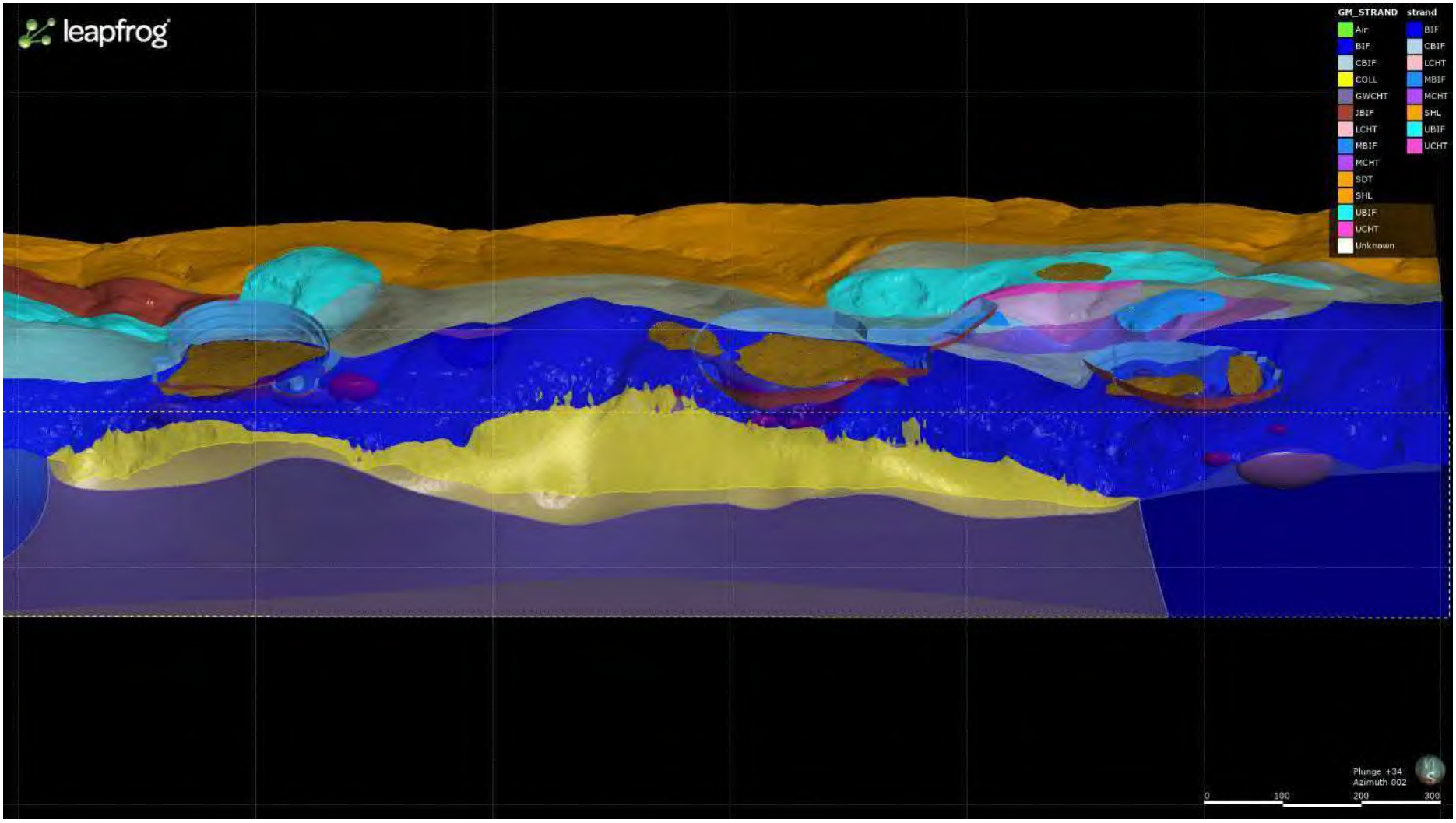
APPENDIX C: Water physicochemical measurements observed during the current survey

Area	Bore/ site No.	Date	DTW (m)	Temp (°C)	EC (µS/cm)	Salinity (ppm)	Acidity (pH)	Redox (mV)	Dissolved oxygen (ppm)	Appearance
Northern DD	ALB0001	2019-07-10	8.0	30.6	2417	1.10	7.50	143.4	3.22	Fresh clean odor
Northern DD	ALB0001	2019-05-16	8.0	29.2	242	1.14	7.68	89.1	5.40	Fresh clean odor
Northern DD	ALB0001	2019-11-11	9.0	31.4	2165	0.97	7.46	27.8	0.55	Fresh clean odor
Northern DD	ALB0001	2019-09-12	8.0	29.9	1359	1.06	7.72	100.5	3.67	Fresh clean odor
Northern DD	ALB0004	2019-07-10	8.0	30.9	1991	0.90	7.43	122.1	4.25	Fresh clean odor
Northern DD	ALB0004	2019-05-16	8.0	29.6	1967	0.91	7.53	91.5	5.09	Fresh clean odor
Northern DD	ALB0004	2019-11-07	8.0	33.5	1791	0.77	7.18	205.6	1.12	Fresh clean odor
Northern DD	ALB0006	2019-05-16	0.0	20.9	1898	1.05	7.39	102.2	3.58	Fresh clean odor
Northern DD	ALB0006	2019-11-07	8.0	33.2	2131	0.92	7.16	221.5	1.24	Fresh clean odor
Northern DD	ALB0009	2019-07-10	8.0	31.6	2050	0.91	7.50	126.2	4.20	Fresh clean odor
Northern DD	ALB0009	2019-05-16	8.0	30.8	2035	0.92	7.50	92.6	5.22	Fresh clean odor
Northern DD	ALB0009	2019-09-12	8.0	30.6	1196	0.92	7.60	105.1	3.84	Fresh clean odor
Northern DD	ALB0010	2019-07-11	8.5	29.2	1591	0.73	7.96	94.9	4.12	Fresh clean odor
Northern DD	ALB0010	2019-05-16	8.5	30.6	1747	0.79	7.55	85.2	5.14	Fresh clean odor
Northern DD	ALB0010	2019-09-12	8.5	30.8	1027	0.79	7.64	112.0	3.16	Fresh clean odor
Northern DD	ALB0052	2019-07-10	8.0	30.3	2325	1.07	7.42	133.8	3.28	Fresh clean odor
Northern DD	ALB0052	2019-05-16	8.0	27.7	2246	1.08	7.53	89.7	5.54	Fresh clean odor
Northern DD	ALB0052	2019-09-12	8.0	29.8	1378	1.07	7.57	100.0	3.65	Fresh clean odor
Northern DD	ALB0063	2019-07-10	7.0	30.5	969	0.43	7.45	103.7	3.27	Fresh clean odor
Northern DD	ALB0063	2019-09-12	7.0	31.3	605	0.45	7.68	94.6	3.71	Fresh clean odor
Northern DD	ALB0064	2019-07-10	7.0	31.8	1965	0.87	7.54	112.7	3.90	Fresh clean odor
Northern DD	ALB0064	2019-09-12	7.0	30.6	1125	0.86	7.45	110.6	3.56	Fresh clean odor
Northern DD	ALB0065	2019-05-16	7.5	31.2	1962	0.88	7.53	95.1	4.70	Fresh clean odor
Northern DD	ALB0065	2019-11-11	9.0	32.1	1566	0.68	7.54	15.2	0.55	Fresh clean odor
Northern DD	ALB0065	2019-09-12	9.0	31.1	1540	0.76	7.76	109.0	3.58	Fresh clean odor
Northern DD	ALB0066	2019-07-10	7.0	30.3	922	0.41	7.33	101.7	1.26	Fresh clean odor
Northern DD	ALB0066	2019-05-16	7.0	31.3	936	0.40	7.71	80.3	3.87	Fresh clean odor
Northern DD	ALB0066	2019-11-07	7.0	33.3	1119	0.47	6.86	152.3	0.71	Fresh clean odor
Northern DD	ALB0067	2019-07-10	7.5	30.8	2091	0.95	7.39	105.1	3.92	Fresh clean odor
Northern DD	ALB0067	2019-05-16	7.5	30.2	2110	0.97	7.60	90.5	5.65	Fresh clean odor
Northern DD	ALB0067	2019-11-07	8.0	33.2	1837	0.79	6.86	185.0	0.91	Fresh clean odor
Northern DD	ALMB05	2019-07-11	8.0	28.3	1760	0.83	7.52	99.4	2.12	Fresh clean odor
Northern DD	ALMB05	2019-11-07	8.0	32.5	1645	0.71	6.89	142.5	0.72	Fresh clean odor
Northern DD	TN0 Pump	2019-05-16	0.0	23.7	2896	1.54	8.22	82.5	4.33	Fresh clean odor
Central DD	ALB0003	2019-07-11	7.5	27.8	2640	1.28	7.32	95.3	3.59	
Central DD	ALB0003	2019-05-16	7.5	31.1	2859	1.31	7.29	85.7	4.05	
Central DD	ALB0003	2019-11-10	12.0	32.5	2484	1.11	7.10	-18.5	0.89	
Central DD	ALB0003	2019-09-12	7.5	30.8	1645	1.29	7.33	121.5	3.60	
Central DD	ALB0007	2019-07-11	6.5	28.4	2060	0.98	7.39	96.7	3.40	Fresh clean odor
Central DD	ALB0007	2019-05-16	6.5	32.0	2165	0.96	7.46	78.9	3.95	Fresh clean odor
Central DD	ALB0007	2019-11-07	7.0	32.3	2013	0.87	7.05	111.2	0.71	Fresh clean odor
Central DD	ALB0023	2019-07-11	7.5	31.7	1759	0.77	7.33	82.7	3.49	Fresh clean odor
Central DD	ALB0023	2019-05-16	7.5	31.7	1759	0.77	7.33	82.7	3.49	Fresh clean odor

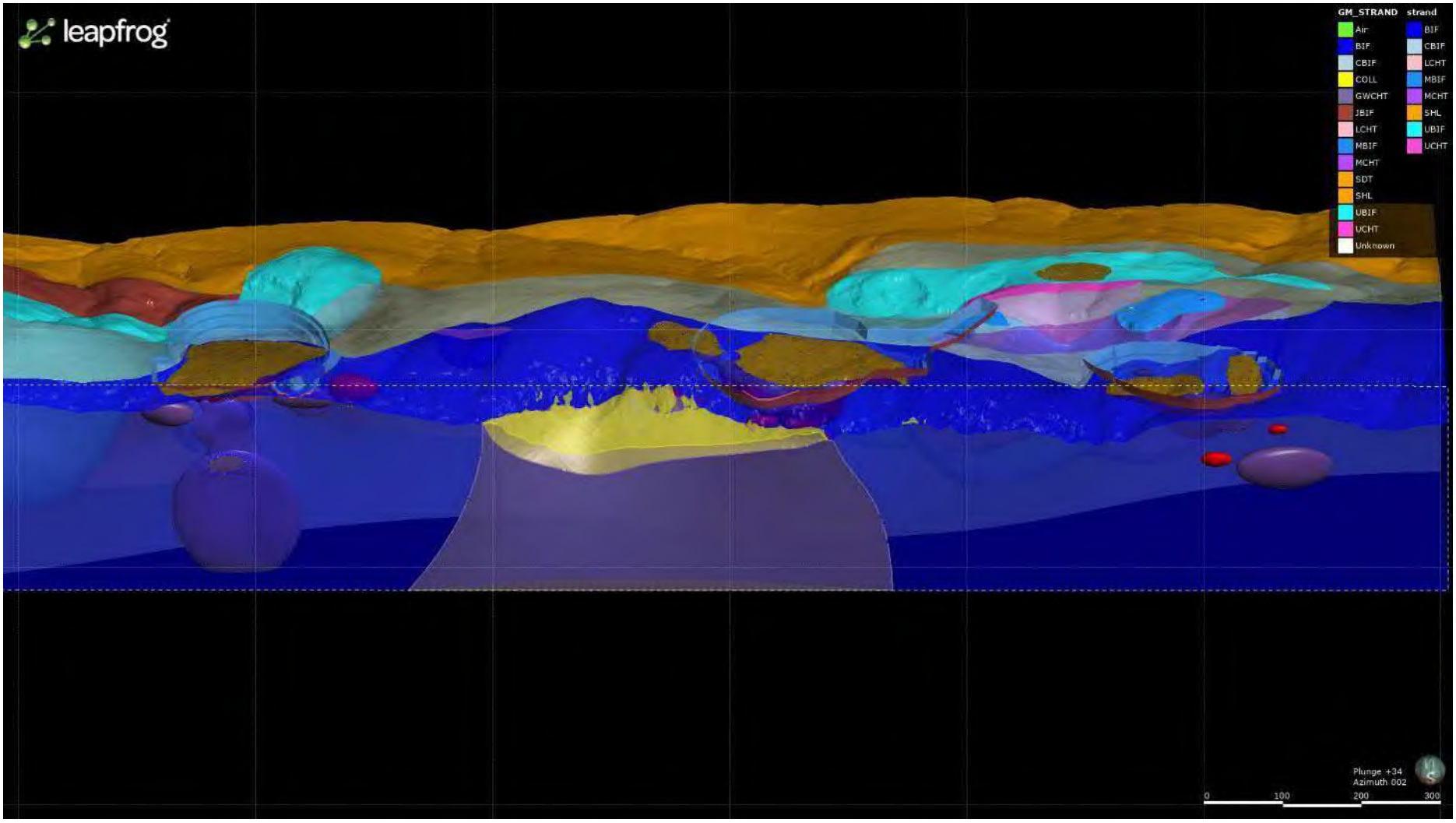
Area	Bore/ site No.	Date	DTW (m)	Temp (°C)	EC (µS/cm)	Salinity (ppm)	Acidity (pH)	Redox (mV)	Dissolved oxygen (ppm)	Appearance
Central DD	ALB0023	2019-11-10	8.0	33.2	1641	0.70	7.03	-28.8	0.68	Fresh clean odor
Central DD	ALB0023	2019-09-12	7.5	32.1	1830	0.80	7.36	117.5	1.96	Fresh clean odor
Central DD	ALMB02	2019-07-11	7.0	27.7	2084	1.00	7.39	100.5	3.65	Fresh clean odor
Central DD	ALMB02	2019-11-11	8.0	31.8	1991	0.88	7.15	31.5	0.42	Fresh clean odor
Central DD	ALMB02	2019-09-12	7.0	31.0	1037	1.02	7.34	115.6	2.71	Fresh clean odor
Southern DD	SSBWB38	2019-05-16		32.0	1432	0.62	6.98	88.3	2.72	Fresh clean odor
Southern DD	SSBWB38	2019-07-11		26.7	1240	0.59	7.17	76.1	1.78	Fresh clean odor
Southern DD	SSBWB38	2019-09-13	10.0	31.1	1311	0.58	7.16	101.7	1.73	Fresh clean odor
Southern DD	SSK001	2019-07-12	0.1	22.8	1478	0.78	7.79	77.1	5.01	Fresh clean odor
Southern DD	SSK002	2019-07-12	0.1	19.8	1515	0.85	8.01	61.2	3.59	Fresh clean odor
Southern DD	SSK0021	2019-09-15	0.1	25.3	1977	1.00	7.96	95.9	2.04	Fresh clean odor
Southern DD	SSWB39	2019-05-16	13.0	31.7	1487	0.65	7.02	40.5	2.13	Biological odor
Southern DD	STXKARA01	2019-05-17	0.3	21.8	1393	0.75	8.01	873.0	7.74	Fresh clean odor
Southern DD	STXKARA02	2019-05-17	0.3	21.6	1319	0.71	8.11	81.4	7.66	Fresh clean odor
Outside	6MILEK001	2019-07-11	0.2	18.6	1560	0.91	7.41	96.7	2.33	
Outside	ABMB02	2019-07-12	11.0	26.6	1448	0.70	7.25	84.7	2.06	Fresh clean odor
Outside	ABMB02	2019-05-17	12.0	30.3	1592	0.72	6.99	88.8	1.85	Biological odor
Outside	ABMB02	2019-09-12	11.0	31.5	1579	0.69	7.13	81.9	1.86	Fresh clean odor
Outside	ALB0044	2019-07-11	20.0	29.7	720	0.32	6.61	68.8	1.81	Fresh clean odor
Outside	ALB0044	2019-05-16	20.0	33.0	782	0.32	6.86	90.7	3.57	Fresh clean odor
Outside	ALB0044	2019-09-12	20.0	31.9	817	0.35	6.71	115.3	1.61	Fresh clean odor
Outside	ALB0045	2019-07-11	17.0	27.9	745	0.34	6.82	-2.1	1.99	Fresh clean odor
Outside	ALB0045	2019-05-16		32.4	802	0.34	6.87	88.6	2.34	Fresh clean odor
Outside	ALB0045	2019-09-12	17.0	32.1	822	0.35	6.89	-124.6	1.20	Biological odor
Outside	ALB0054	2019-07-11	9.0	26.5	1514	0.74	7.49	93.1	3.84	Fresh clean odor
Outside	ALB0054	2019-05-16	9.0	31.6	1698	0.75	7.43	74.5	5.62	Fresh clean odor
Outside	ALB0054	2019-09-12	9.0	31.4	969	0.74	7.36	116.1	3.26	Fresh clean odor
Outside	CBMB03	2019-11-11	10.0	32.2	1590	0.69	9.98	23.4	0.40	Fresh clean odor
Outside	CBMB03	2019-09-14	7.0	31.0	1794	0.80	7.15	96.2	1.47	Fresh clean odor
Outside	KWSS Bore	2019-07-08	11.0	31.1	1292	0.57	6.92	30.5	3.69	Fresh clean odor
Outside	KWSS Bore	2019-11-09	15.0	33.4	1183	0.50	7.76	-38.1	0.76	Fresh clean odor
Outside	LRUNK001	2019-07-11	15.0	27.1	1506	0.72	7.46	74.9	3.57	Fresh clean odor
Outside	MCK001	2019-07-09	0.2	19.3	848	0.47	6.77	157.4	3.16	Fresh clean odor
Outside	MCK002	2019-07-09	0.2	21.7	661	0.35	6.79	156.2	2.45	Fresh clean odor
Outside	MCK003	2019-07-09	0.2	22.5	1069	0.56	6.80	105.7	1.48	Fresh clean odor
Outside	MCK004	2019-07-10	0.1	24.1	722	0.36	7.59	132.6	2.41	Fresh clean odor
Outside	MCUNK001	2019-07-09	2.0	29.4	902	0.40	6.86	152.2	2.96	Fresh clean odor
Outside	MCUNK001	2019-11-08	2.0	32.3	1096	0.47	6.75	-42.6	0.75	Fresh clean odor
Outside	MCUNK001	2019-09-13	2.0	30.9	1181	0.52	7.25	34.6	2.26	Fresh clean odor
Outside	MCWIND001	2019-07-11	8.5	26.8	1486	0.72	8.01	97.6	4.37	Biological odor
Outside	MCWIND001	2019-11-07	10.0	31.5	1439	0.63	7.23	151.6	0.86	Biological odor
Outside	MCWIND001	2019-09-12	8.5	29.1	936	0.72	8.20	99.9	4.23	Biological odor
Outside	P12	2019-05-14	6.0	31.0	7272	3.53	7.19	121.5	5.36	Fresh clean odor
Outside	P12	2019-07-11	6.0	31.0	7503	3.65	7.06	97.6	4.28	Fresh clean odor

Area	Bore/ site No.	Date	DTW (m)	Temp (°C)	EC (µS/cm)	Salinity (ppm)	Acidity (pH)	Redox (mV)	Dissolved oxygen (ppm)	Appearance
Outside	P12	2019-09-12	6.0	32.4	6866	3.23	7.15	131.2	3.44	Fresh clean odor
Outside	SRBORE001	2019-07-10	7.0	30.2	238	0.10	6.63	130.4	3.29	Fresh clean odor
Outside	SRBORE001	2019-11-07	7.0	31.2	305	0.13	6.55	2218.0	1.09	Fresh clean odor
Outside	SRBORE002	2019-07-10	7.0	29.5	707	0.31	7.96	132.0	3.84	Fresh clean odor
Outside	SRBORE002	2019-09-12	7.0	28.5	723	0.33	8.17	77.4	3.98	Fresh clean odor
Outside	SRWIND001	2019-07-10	7.0	30.0	1319	0.59	7.74	141.2	3.55	Fresh clean odor
Outside	SRWIND001	2019-11-07	7.0	31.2	3035	1.38	6.95	245.4	1.17	Fresh clean odor
Outside	SRWIND001	2019-09-12	7.0	28.6	1378	1.08	8.21	95.7	3.43	Fresh clean odor
Outside	SSK0020	2019-09-15	0.1	25.9	2509	1.26	8.04	79.6	4.18	
Outside	SSUNK001	2019-07-08	9.0	30.0	3061	1.44	6.84	157.1	1.10	Mineral odor
Outside	SSUNK001	2019-11-09	13.0	32.3	2768	1.23	6.92	-89.6	0.57	Mineral odor
Outside	SSUNK002	2019-07-08	9.0	30.4	1888	0.86	6.53	-129.9	0.74	Biological odor
Outside	SSUNK003	2019-07-08	7.0	30.1	1744	0.79	7.71	35.6	3.66	Fresh clean odor
Outside	SSUNK003	2019-11-09	9.0	32.5	1640	0.71	7.09	-39.4	0.78	Fresh clean odor
Outside	SSUNK003	2019-09-15	7.0	30.9	1797	0.80	7.50	80.3	2.81	Fresh clean odor
Outside	SSUNK004	2019-07-08	5.0	29.2	1168	0.53	8.51	45.5	4.81	Fresh clean odor
Outside	SSUNK004	2019-09-15	5.0	31.0	1275	0.56	7.89	74.7	3.21	Fresh clean odor
Outside	SSUNK005	2019-07-11	10.0	28.8	1176	0.54	6.94	-78.1	1.22	Biological odor
Outside	SSUNK006	2019-07-12	1.0	26.5	1790	0.83	7.84	20.1	1.13	Chemical odor

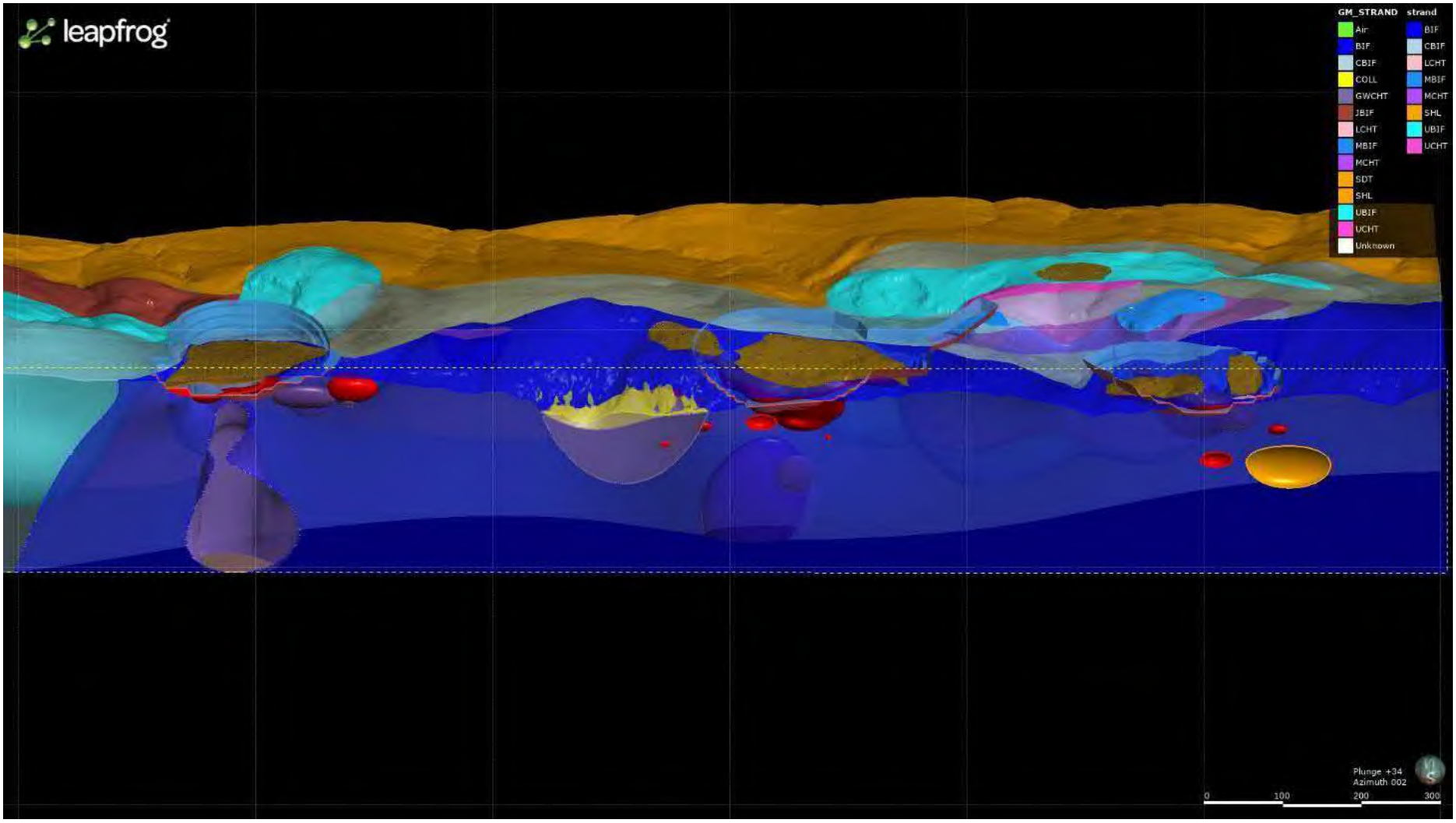
Appendix D – Miralga East: longitudinal and cross sections of prospective AWT habitats



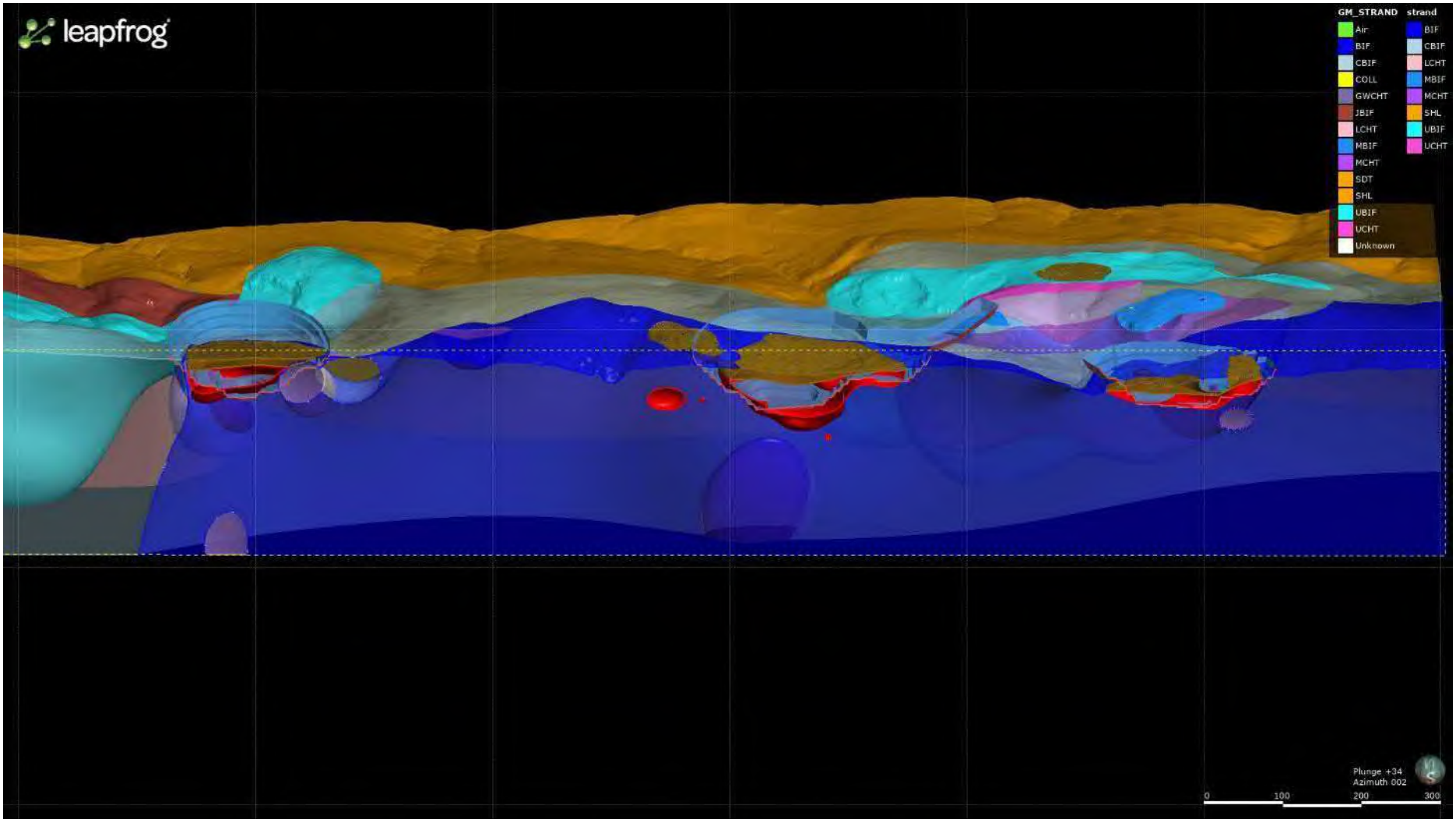
LS_1: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga East



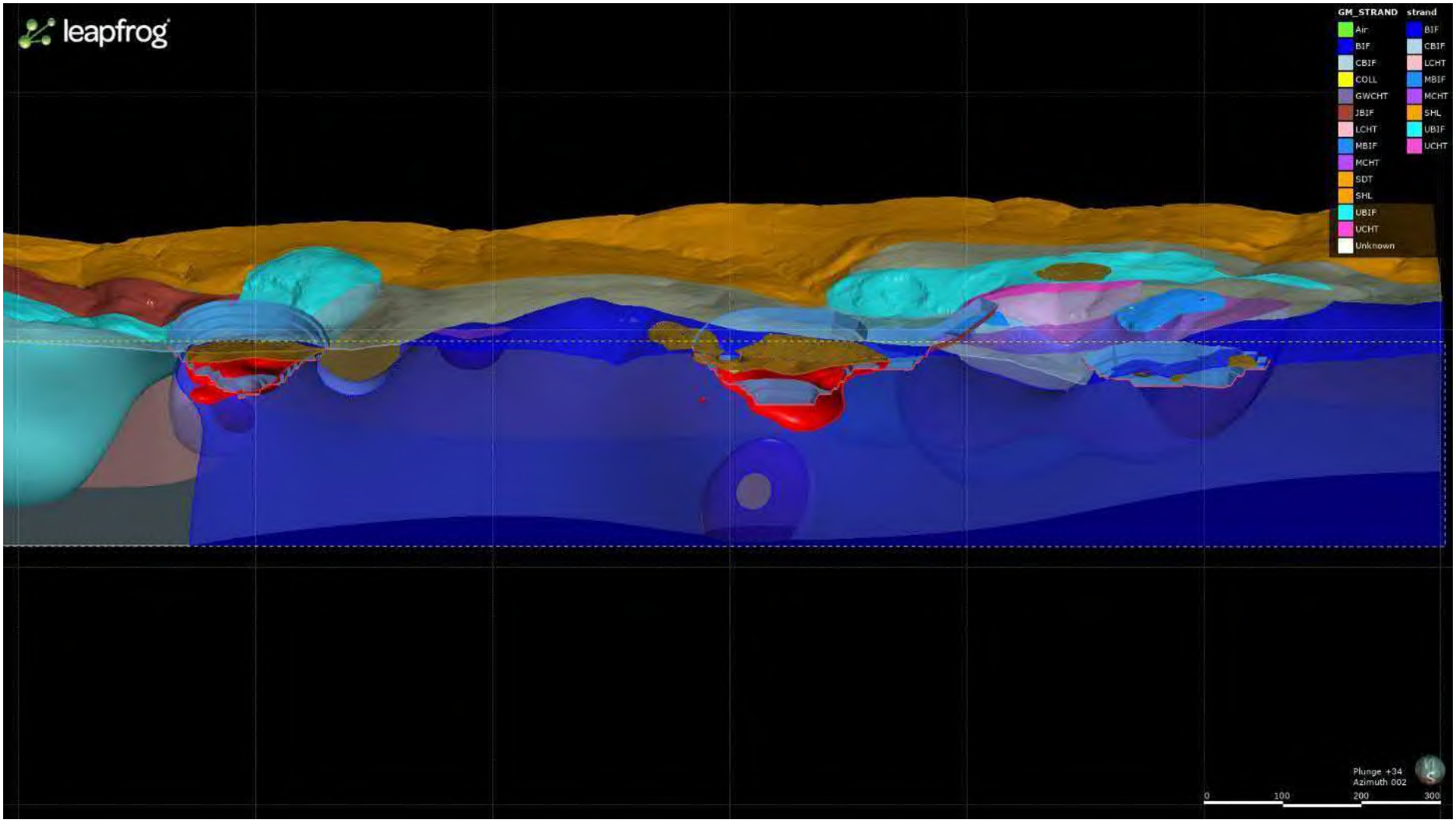
LS_2: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga East



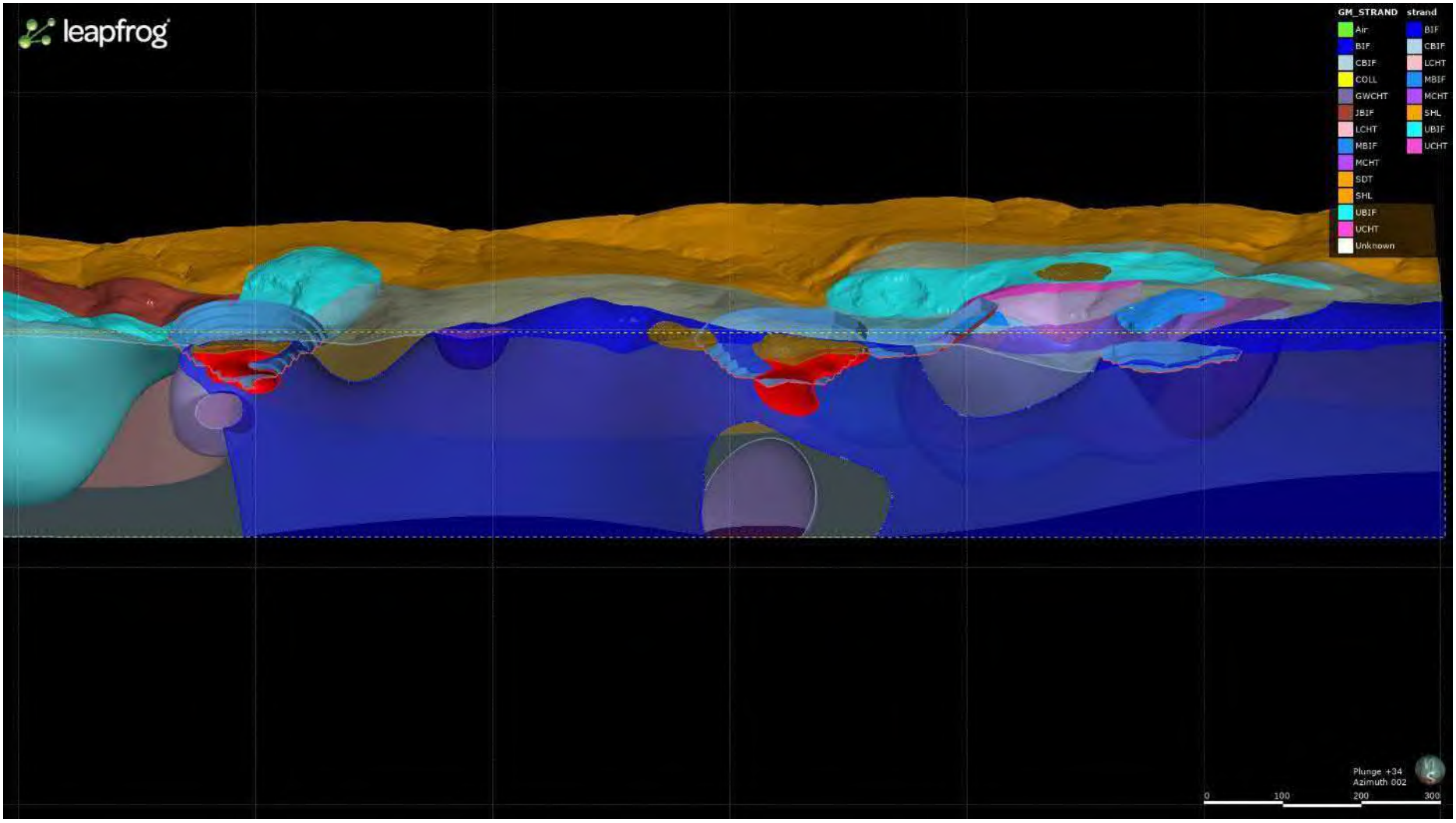
LS_3: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga East



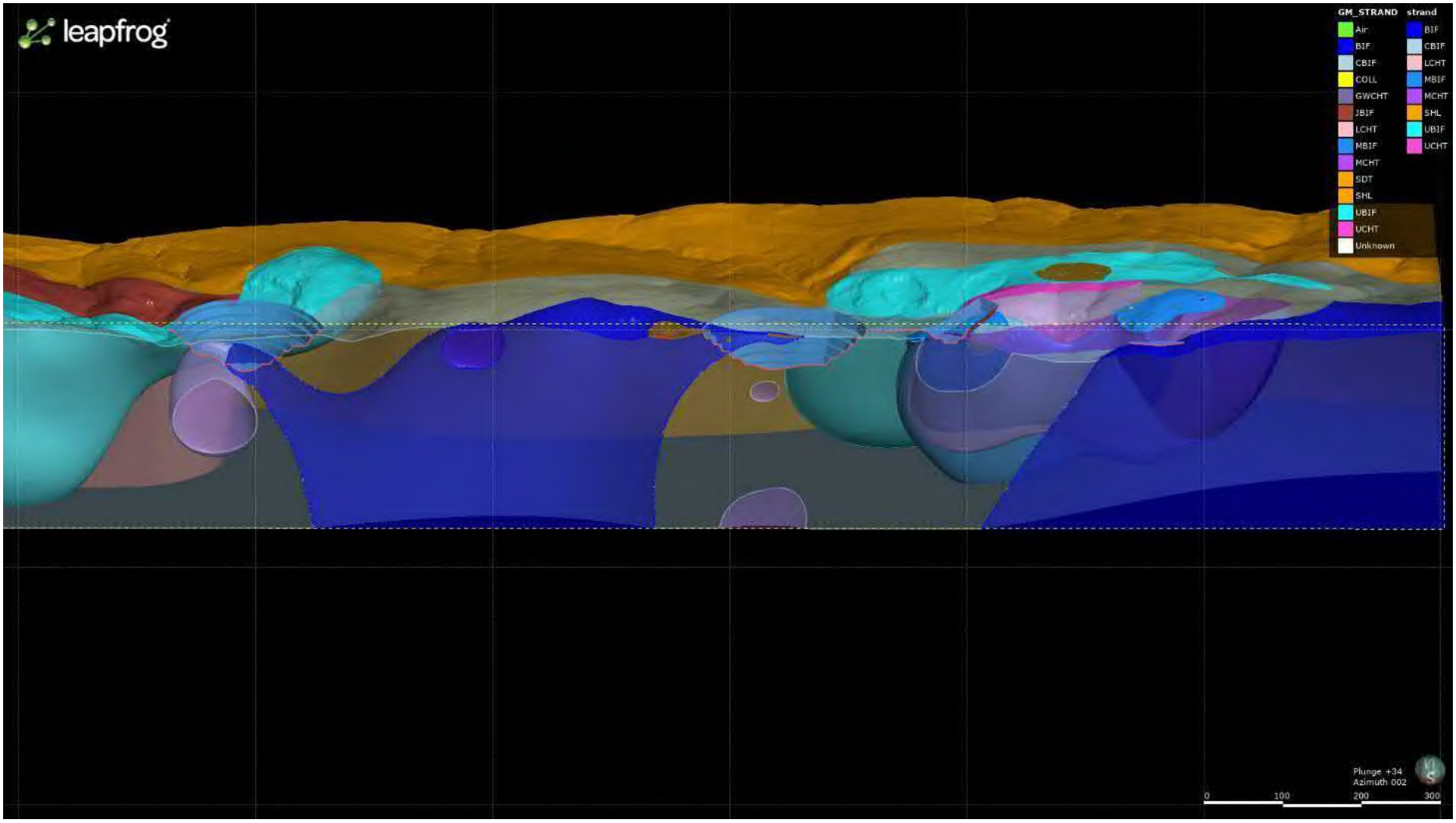
LS_4: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga East



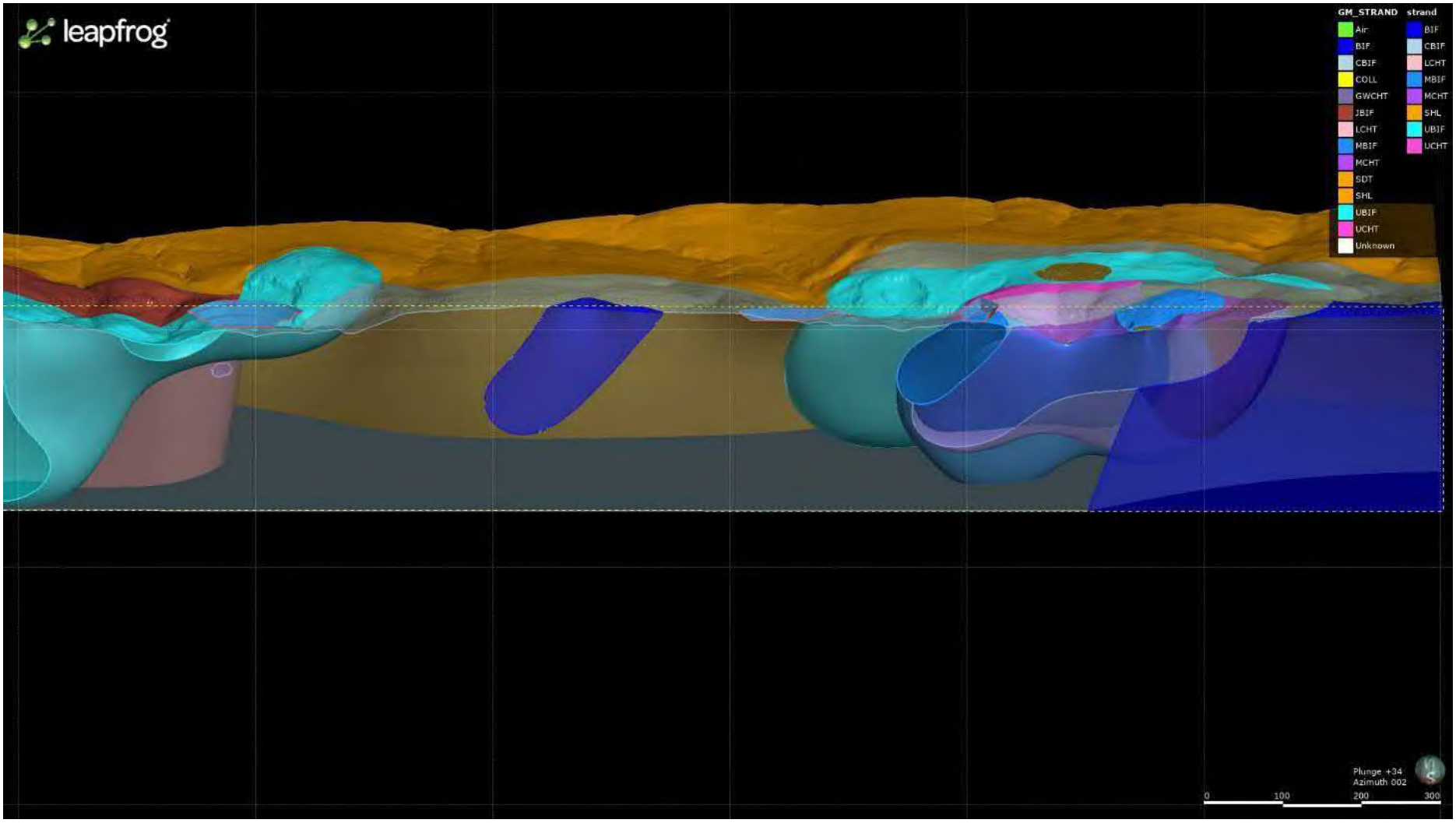
LS_5: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga East



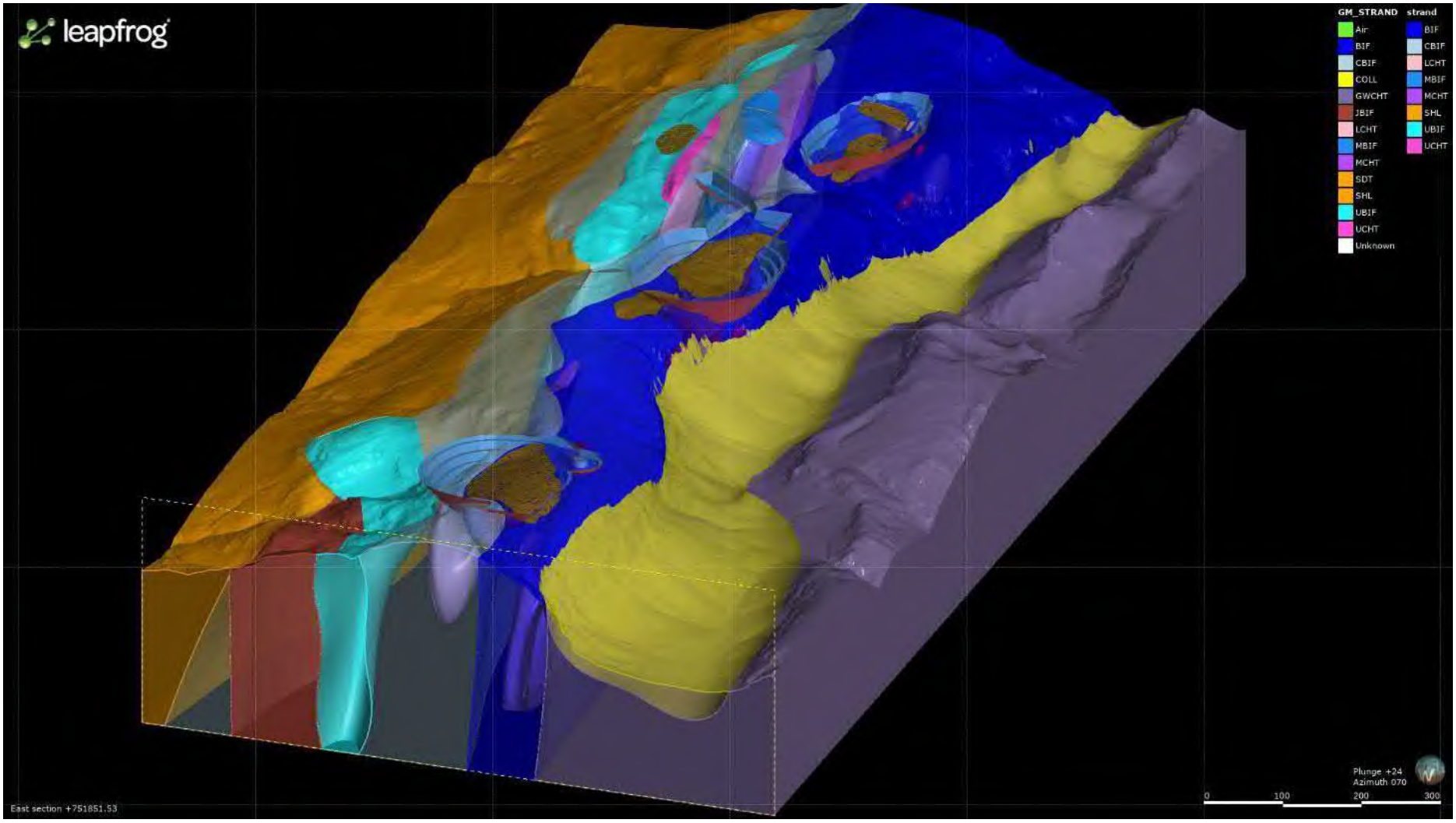
LS_6: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga East



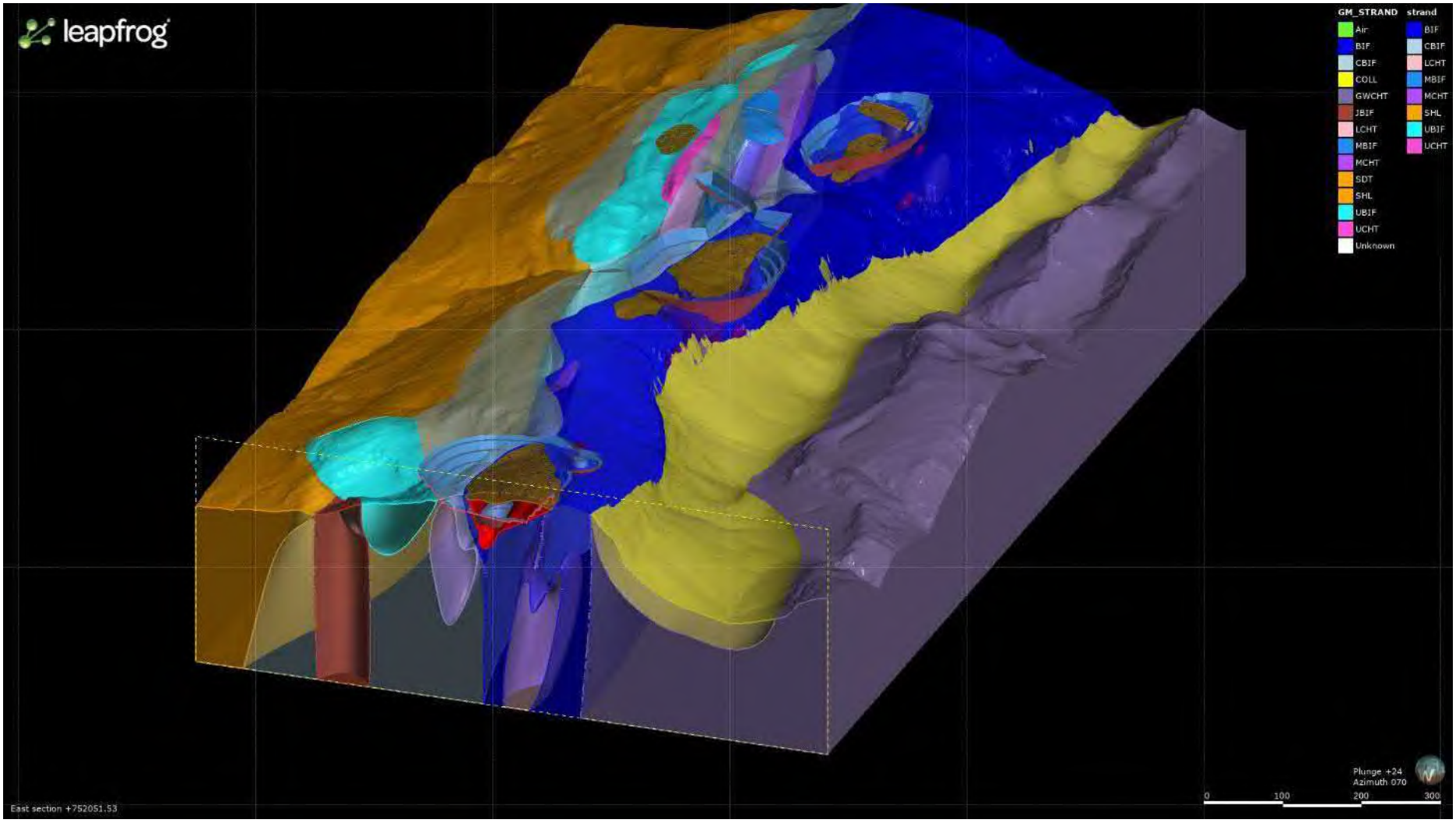
LS_7: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga East



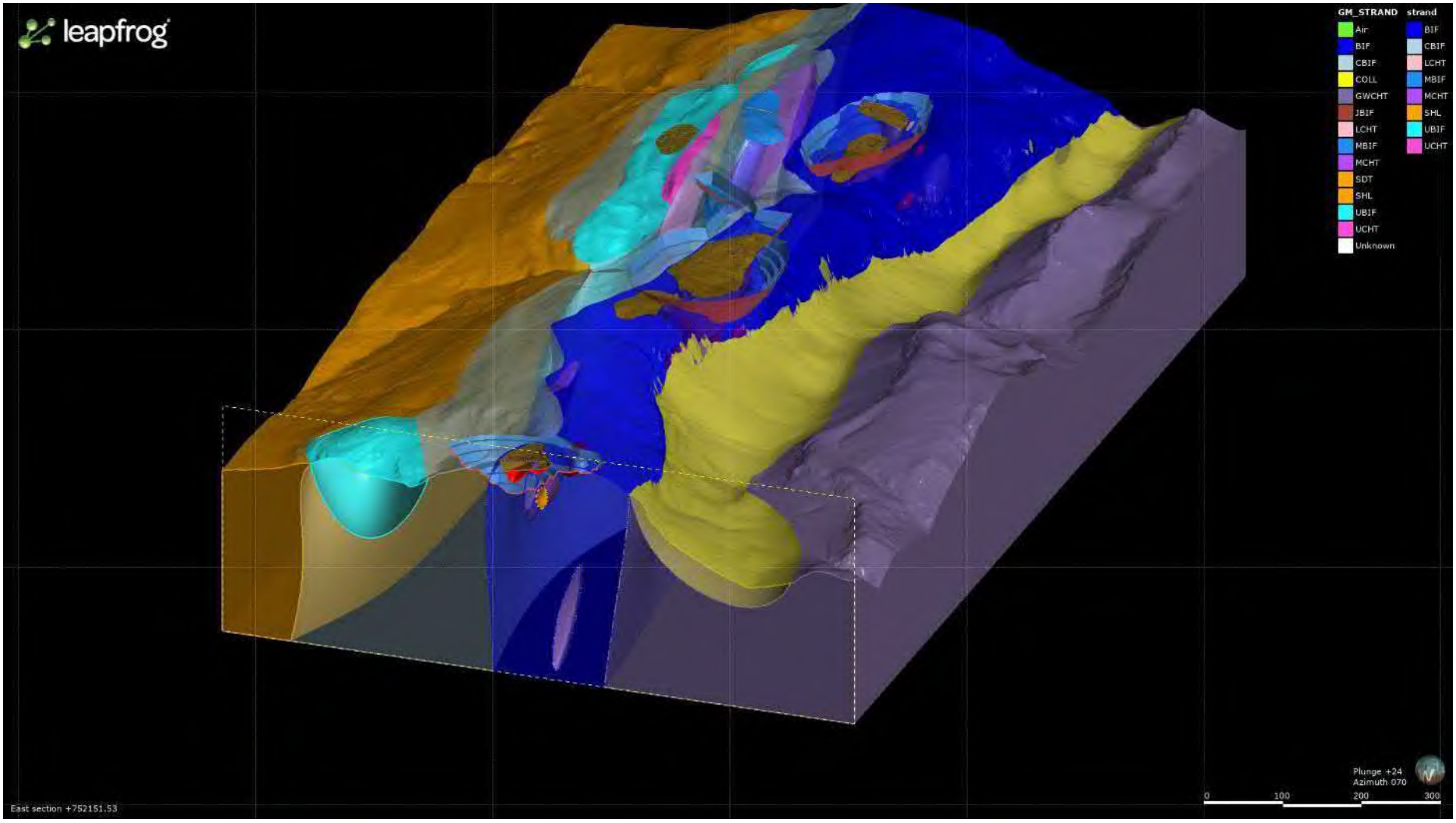
LS_8: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga East



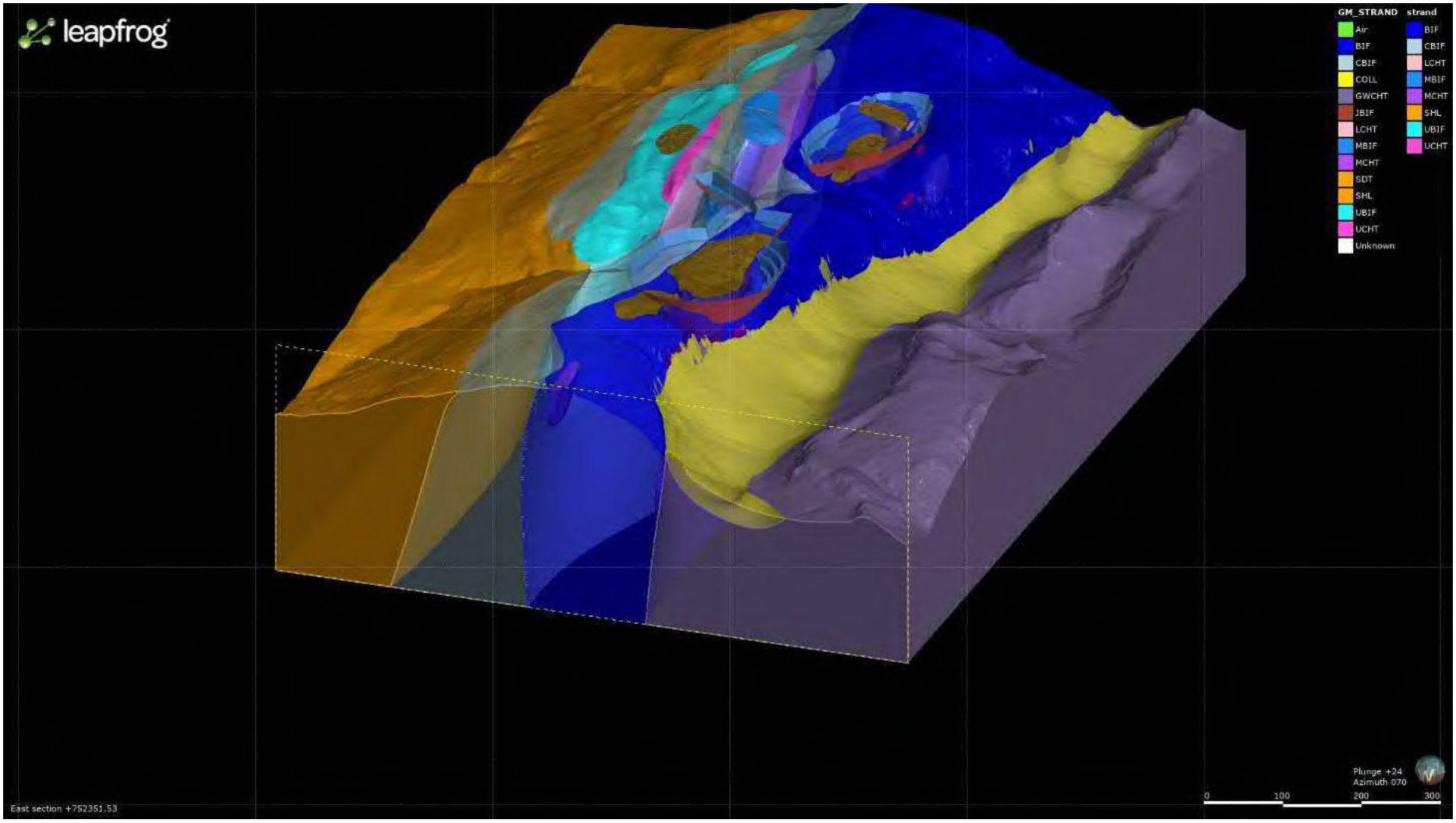
CS_1: Cross section of modelled prospective AWT troglofauna habitats at Miralga East



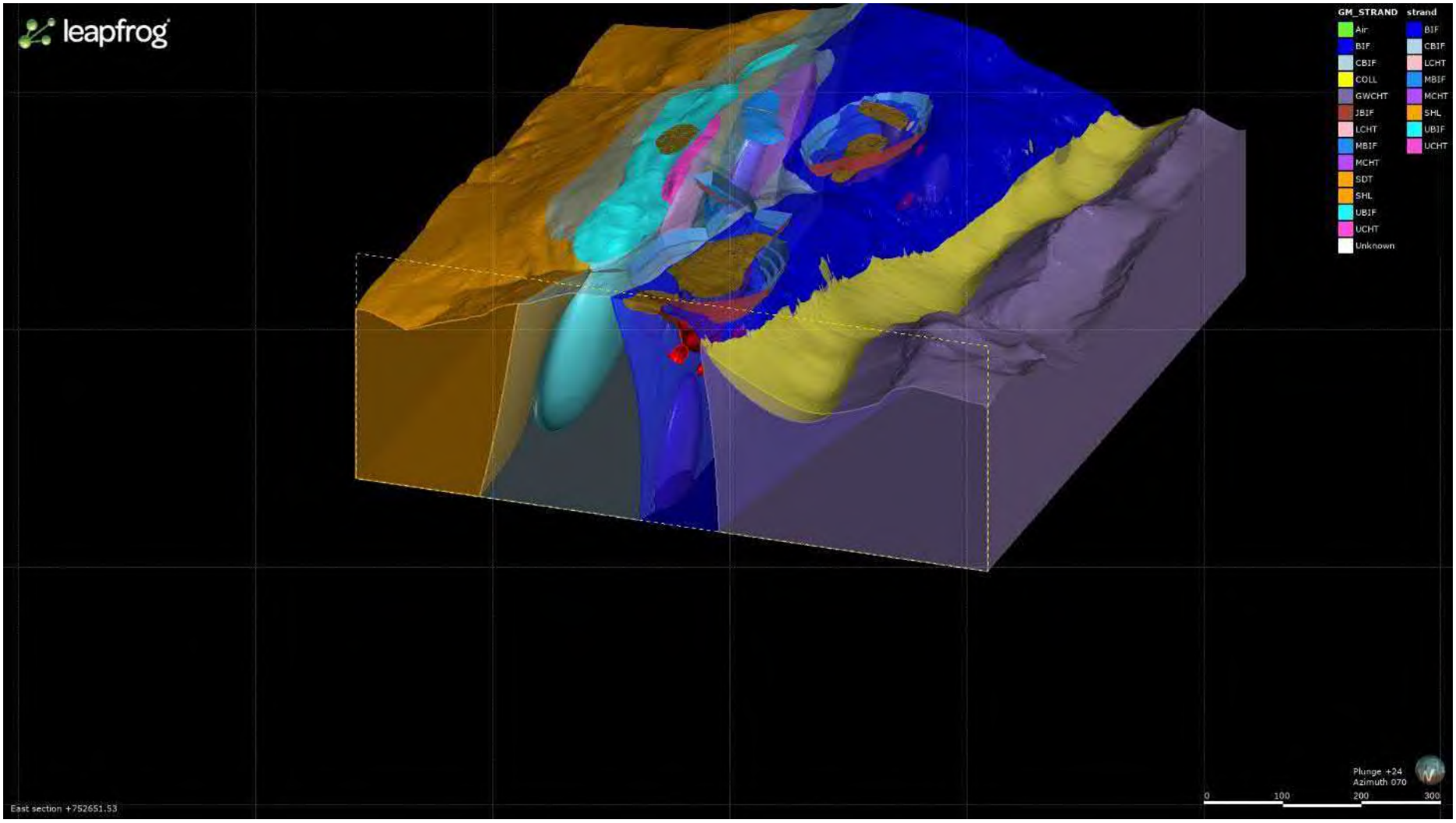
CS_2: Cross section of modelled prospective AWT troglofauna habitats at Miralga East



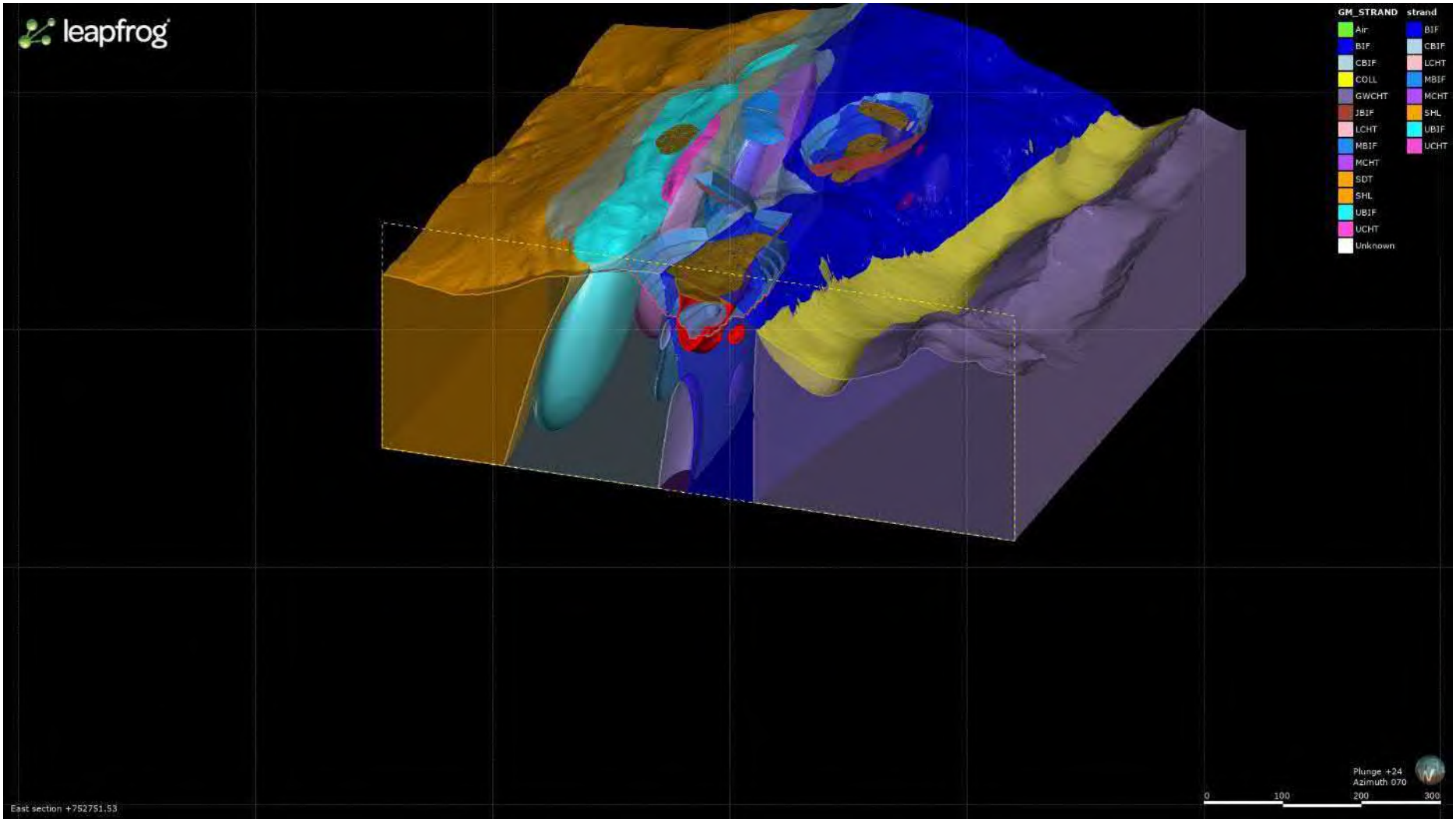
CS_3: Cross section of modelled prospective AWT troglofauna habitats at Miralga East



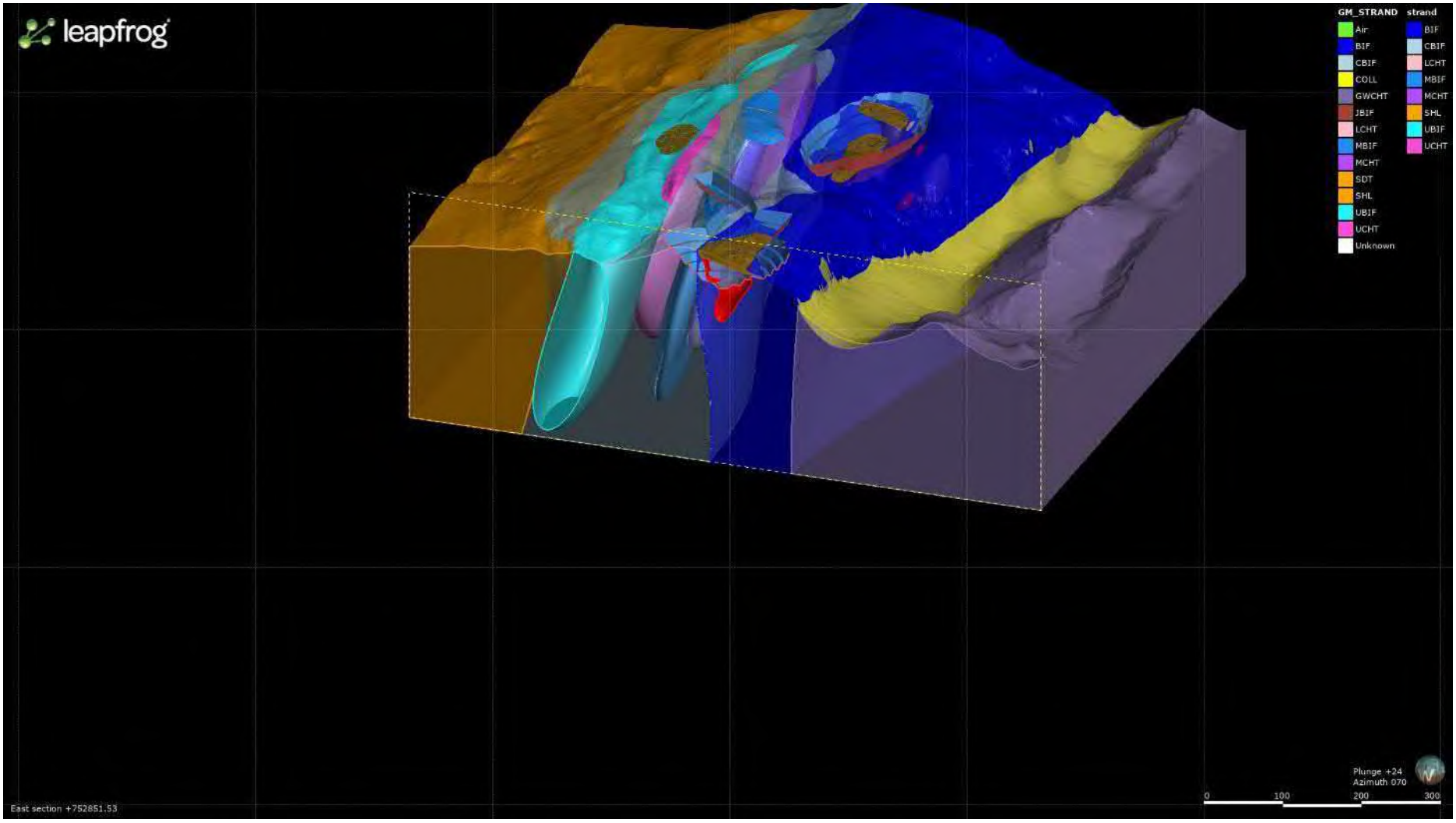
CS_4: Cross section of modelled prospective AWT troglofauna habitats at Miralga East



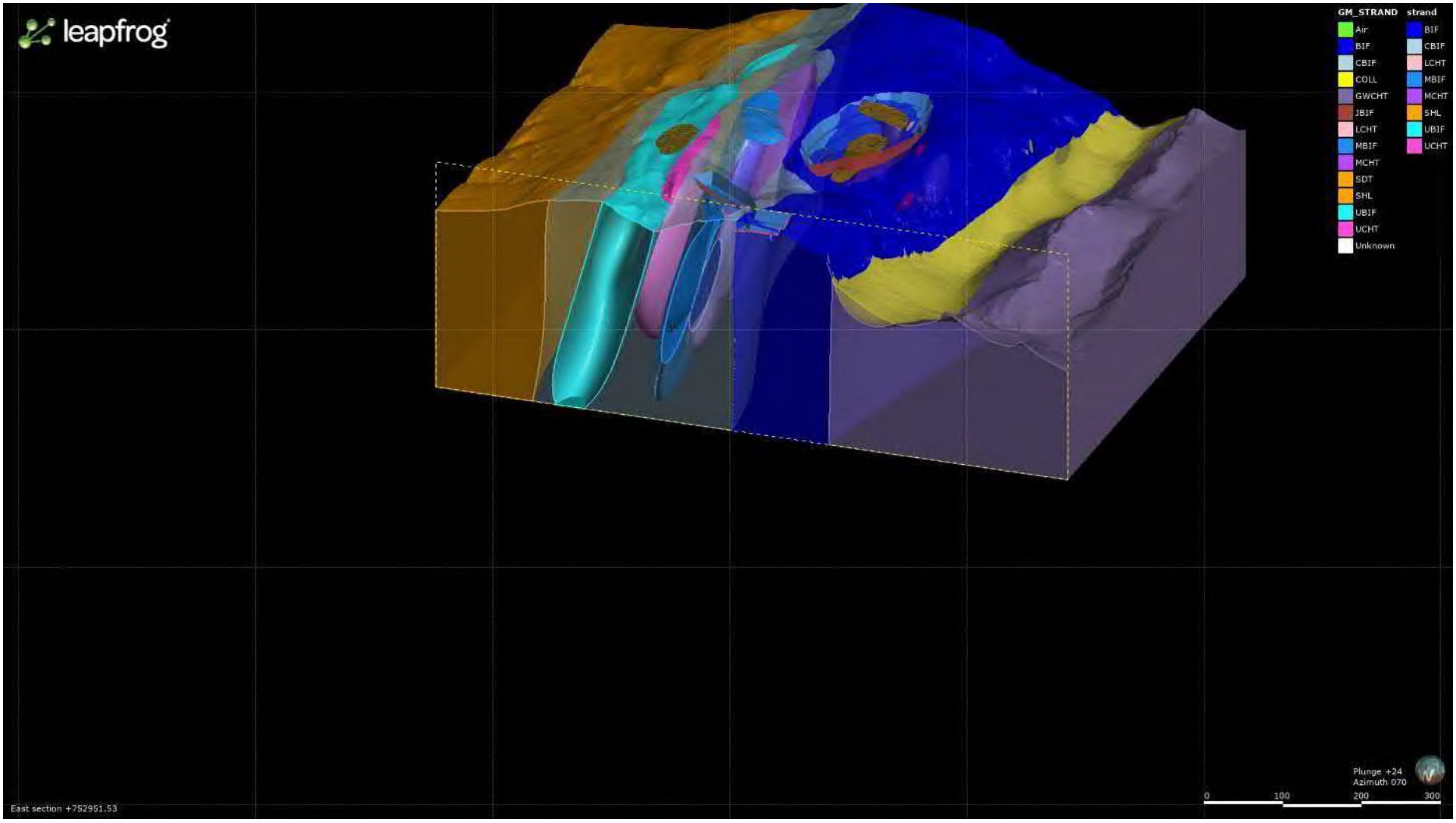
CS_5: Cross section of modelled prospective AWT troglofauna habitats at Miralga East



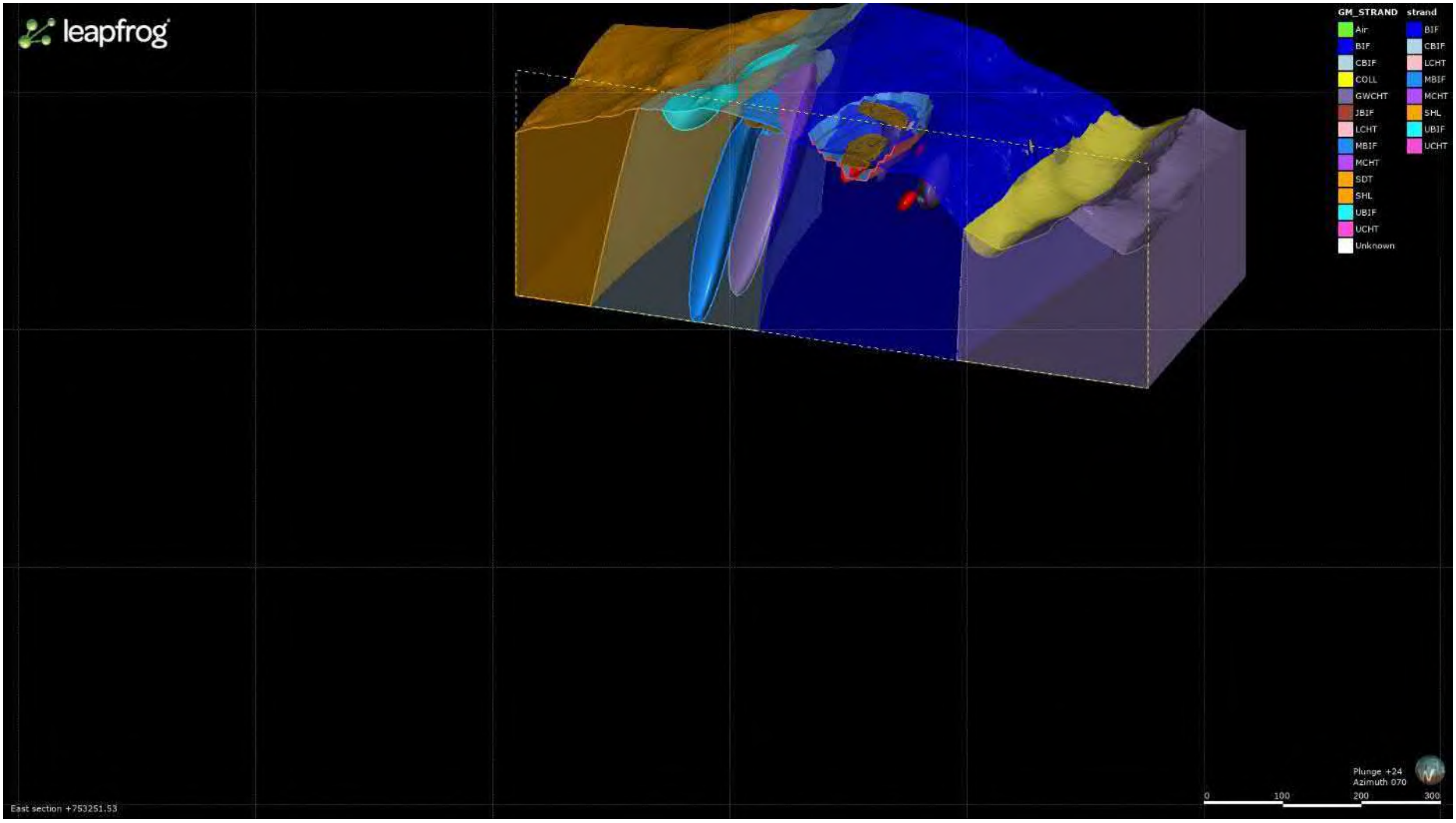
CS_6: Cross section of modelled prospective AWT troglofauna habitats at Miralga East



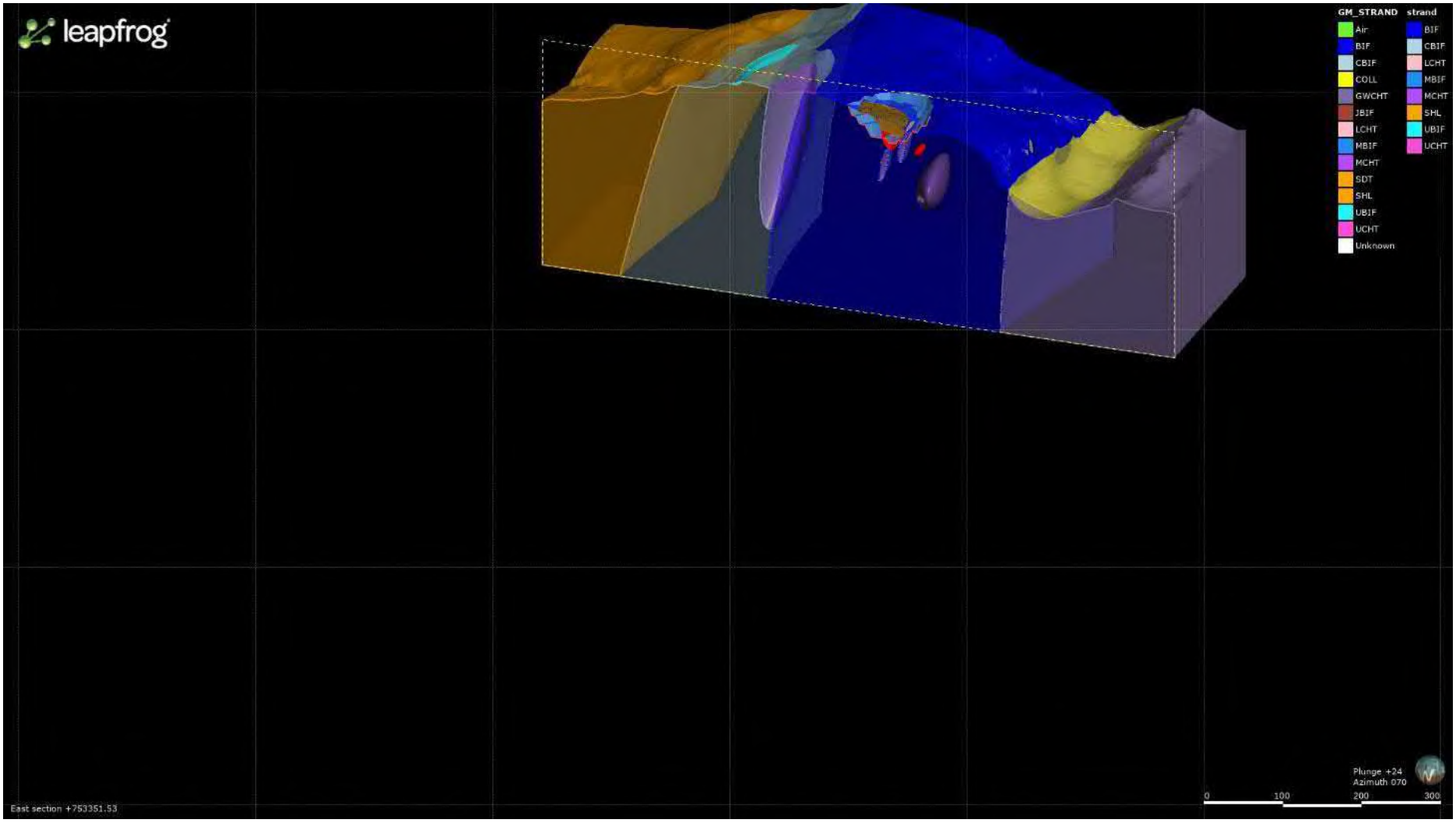
CS_7: Cross section of modelled prospective AWT troglofauna habitats at Miralga East



CS_8: Cross section of modelled prospective AWT troglofauna habitats at Miralga East

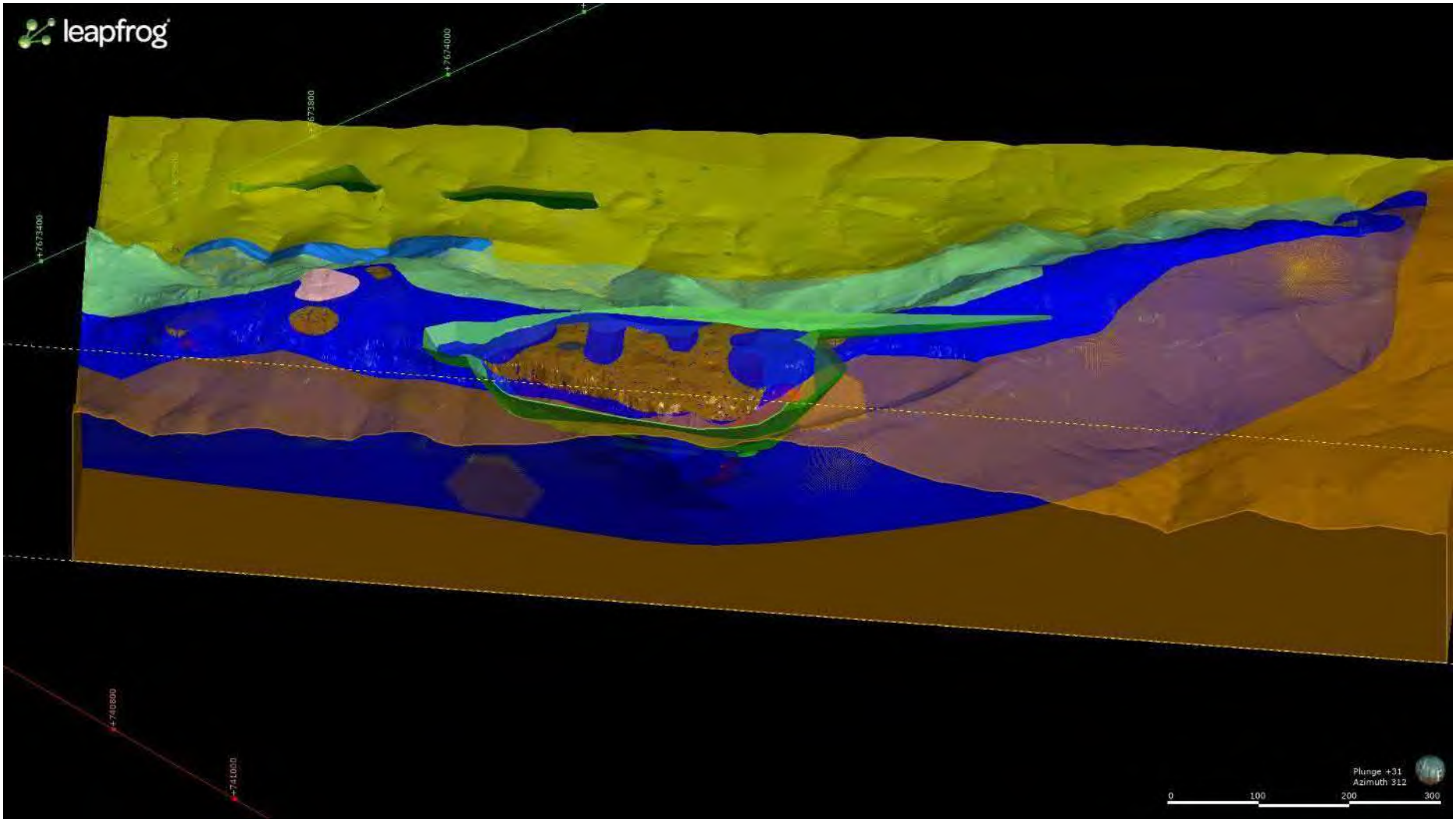


CS_9: Cross section of modelled prospective AWT troglofauna habitats at Miralga East

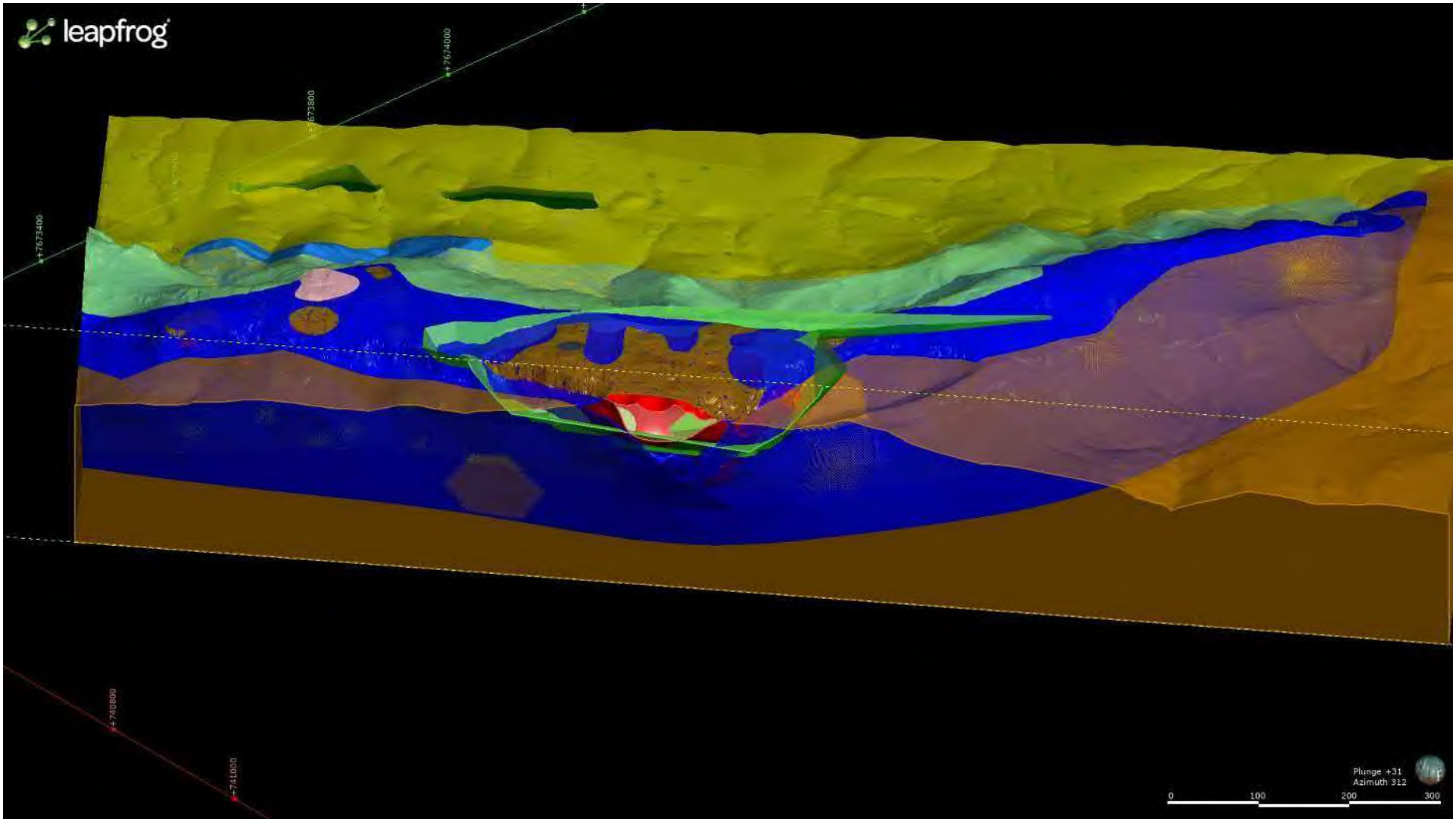


CS_10: Cross section of modelled prospective AWT troglofauna habitats at Miralga East

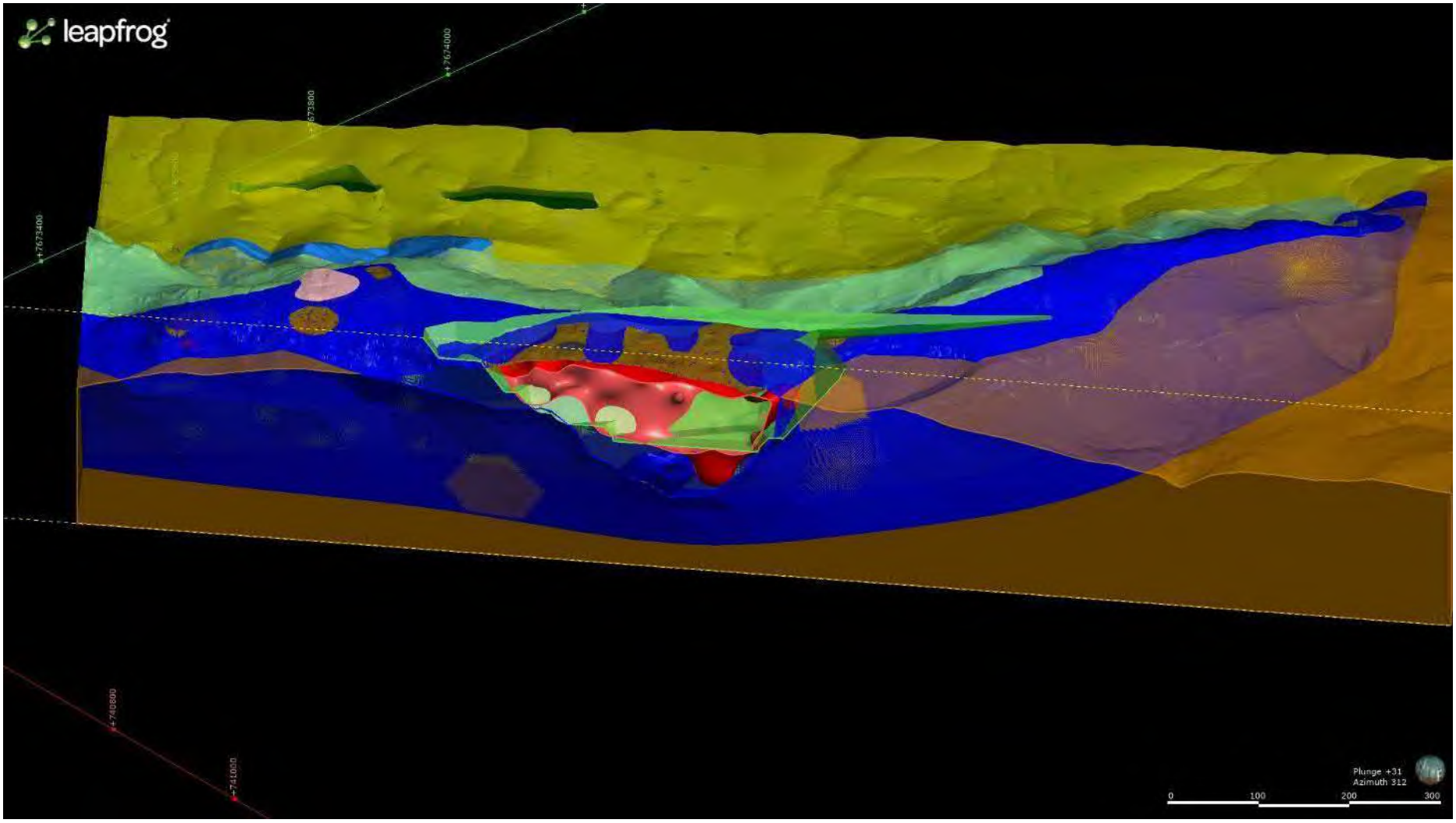
Appendix E – Miralga West: longitudinal and cross sections of prospective AWT habitats



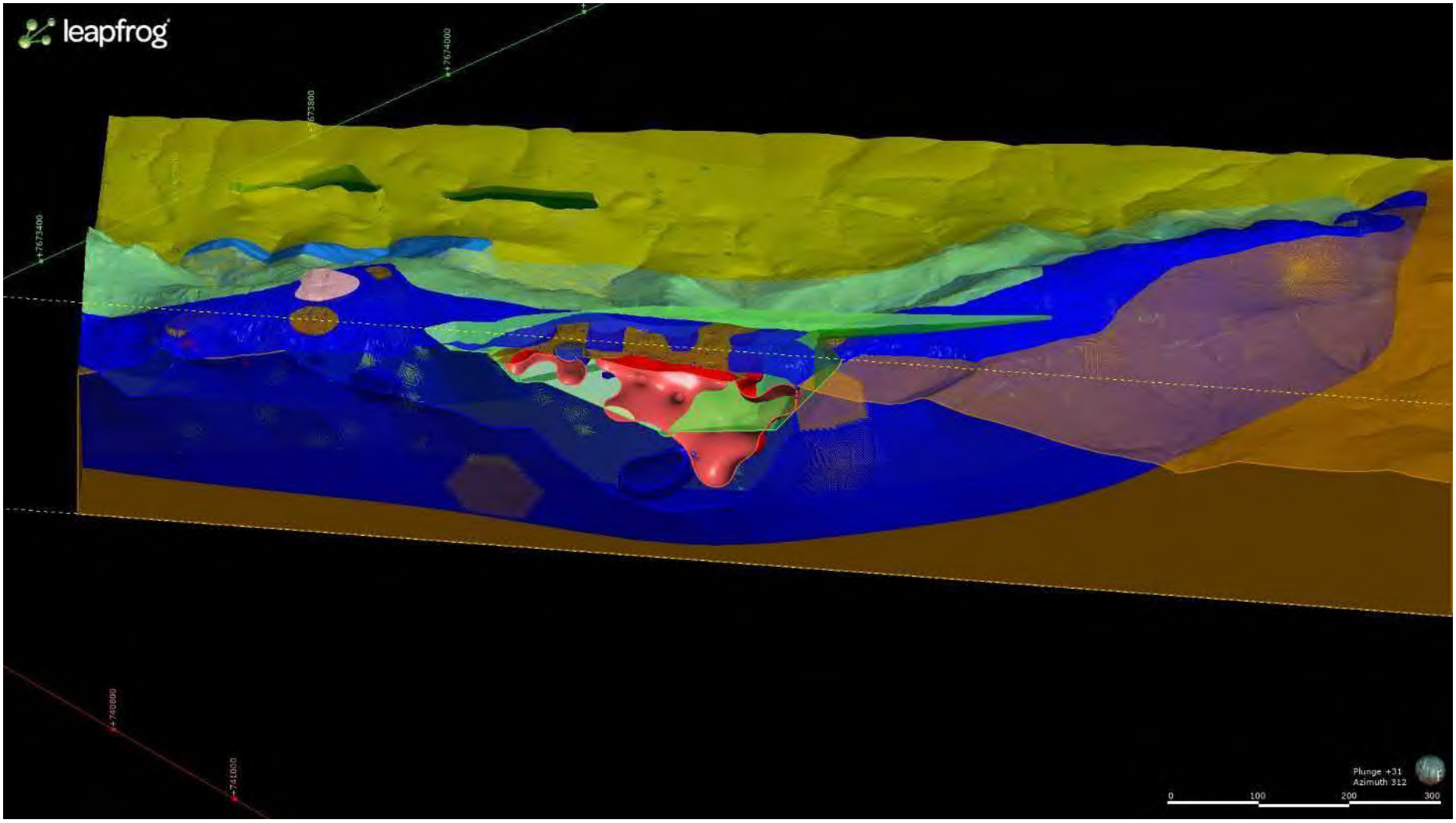
LS_1: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga West



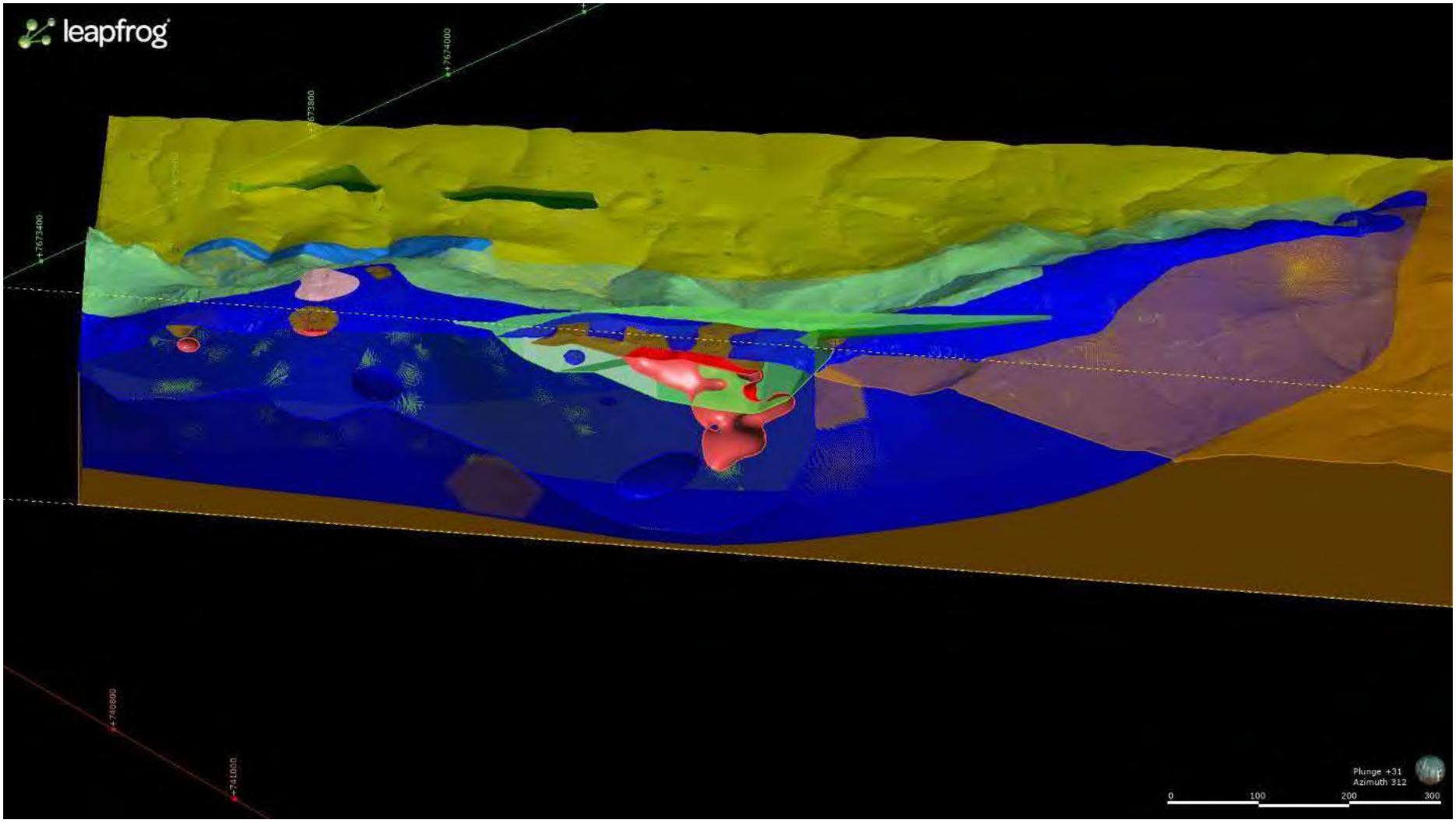
LS_2: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga West



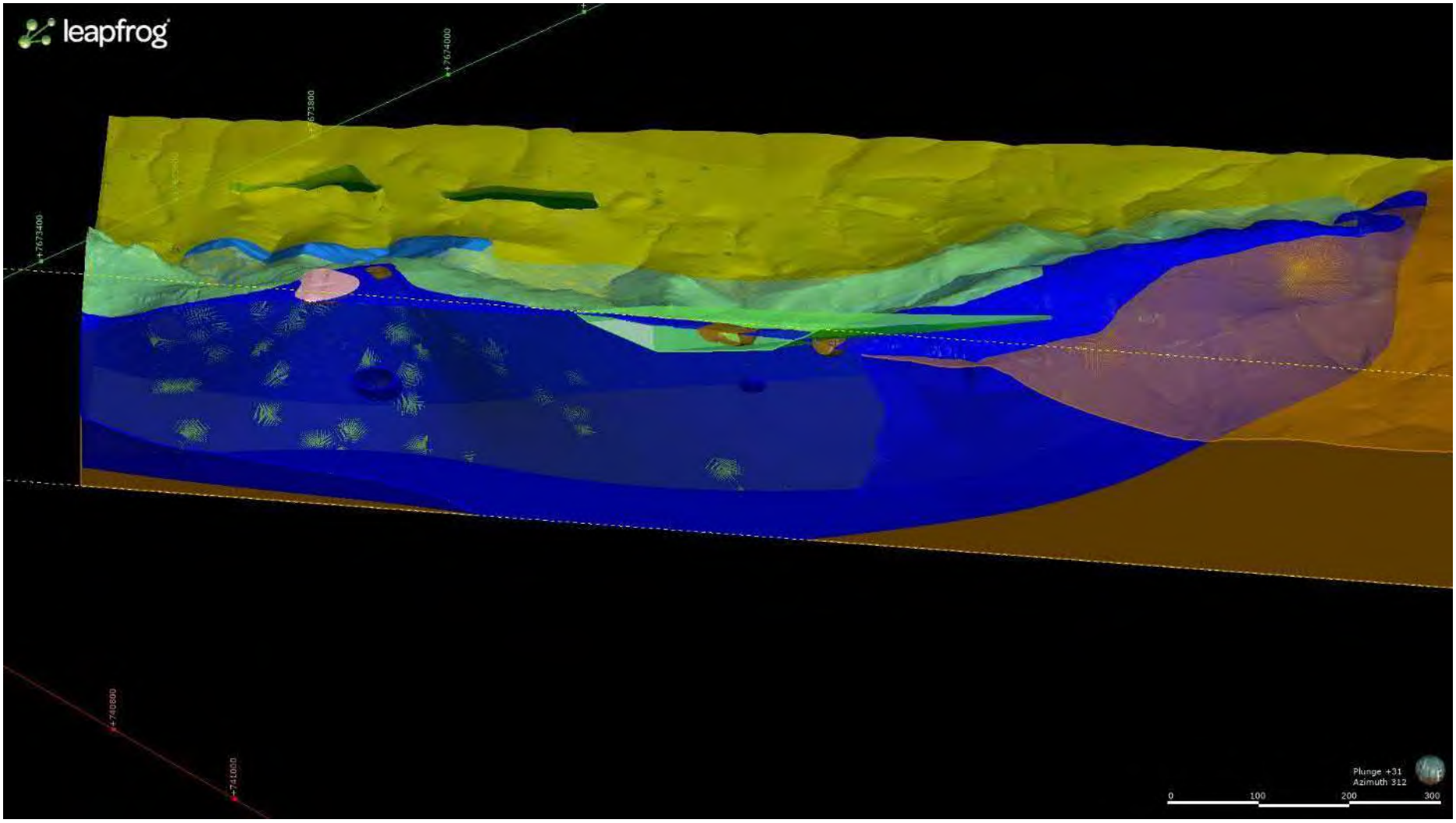
LS_3: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga West



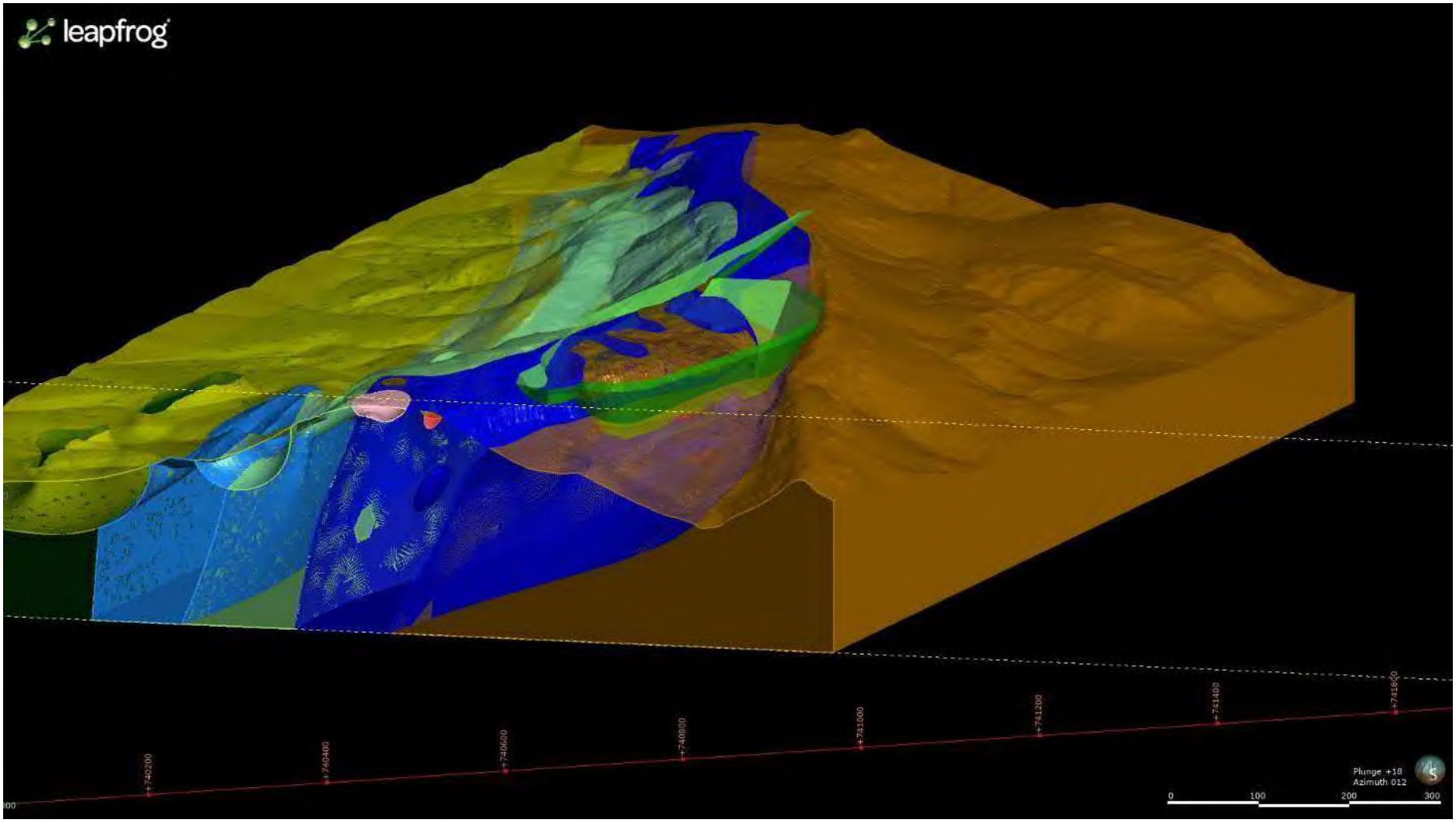
LS_4: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga West



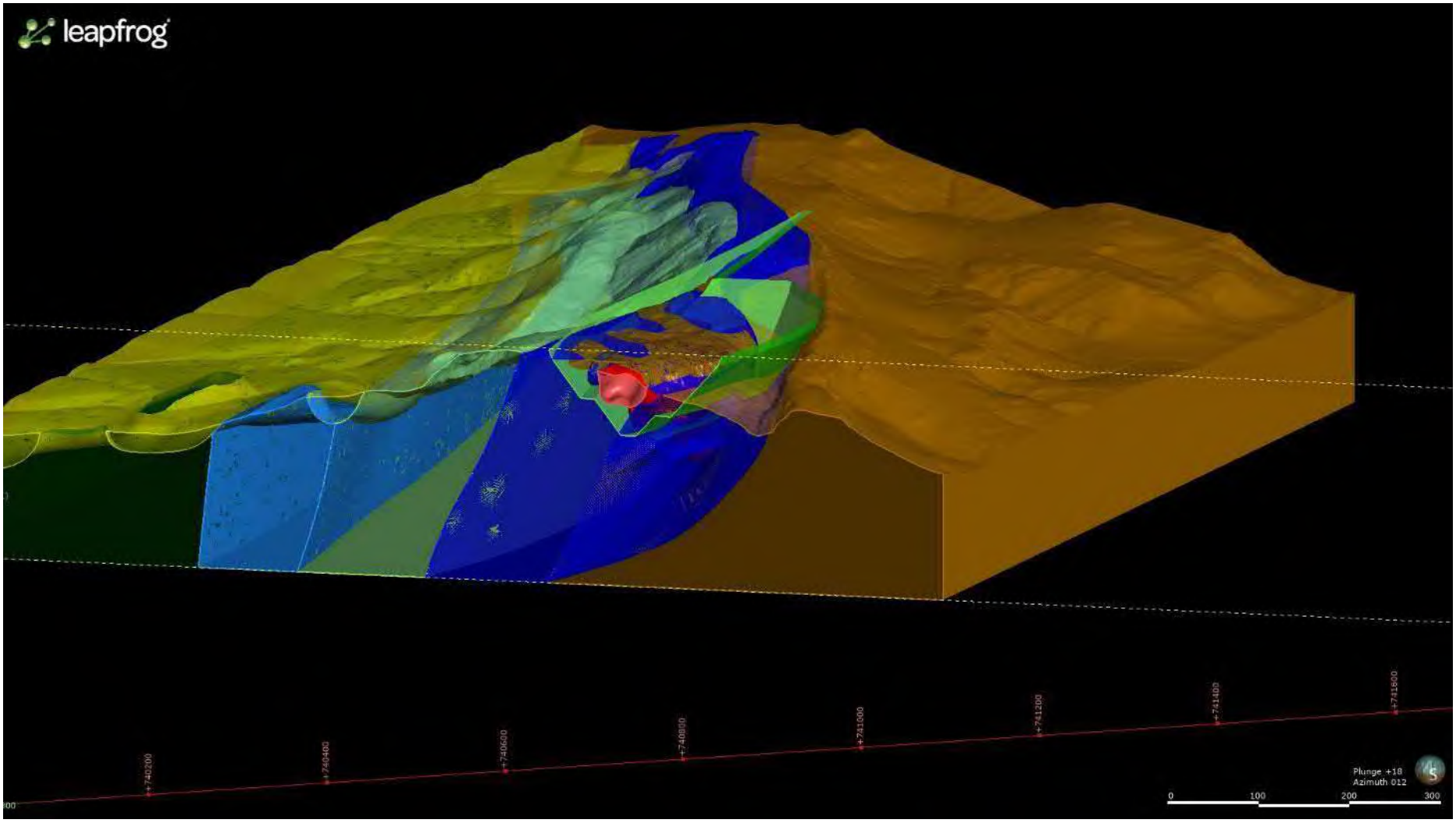
LS_5: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga West



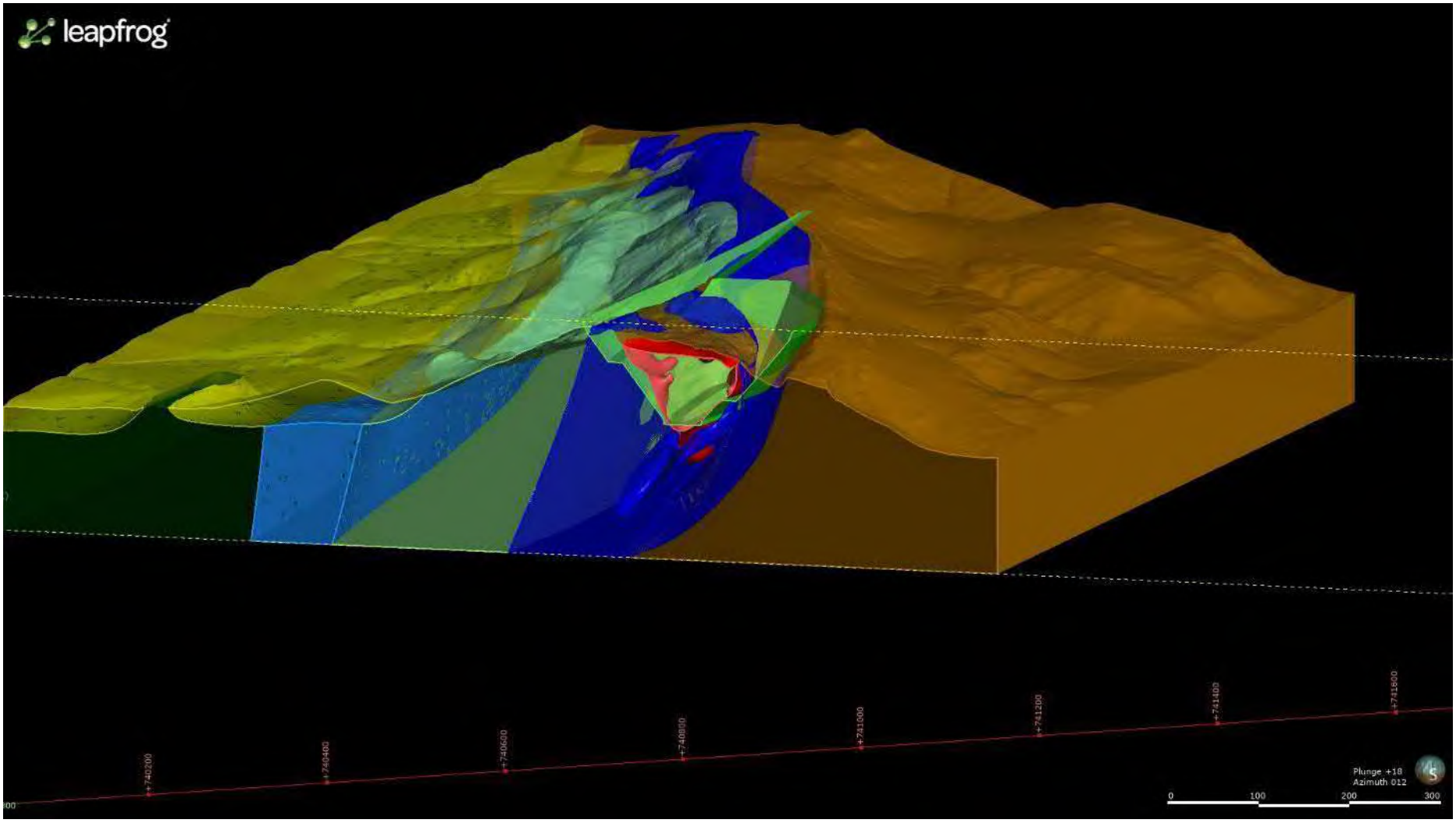
LS_6: Longitudinal section of modelled prospective AWT troglofauna habitats at Miralga West



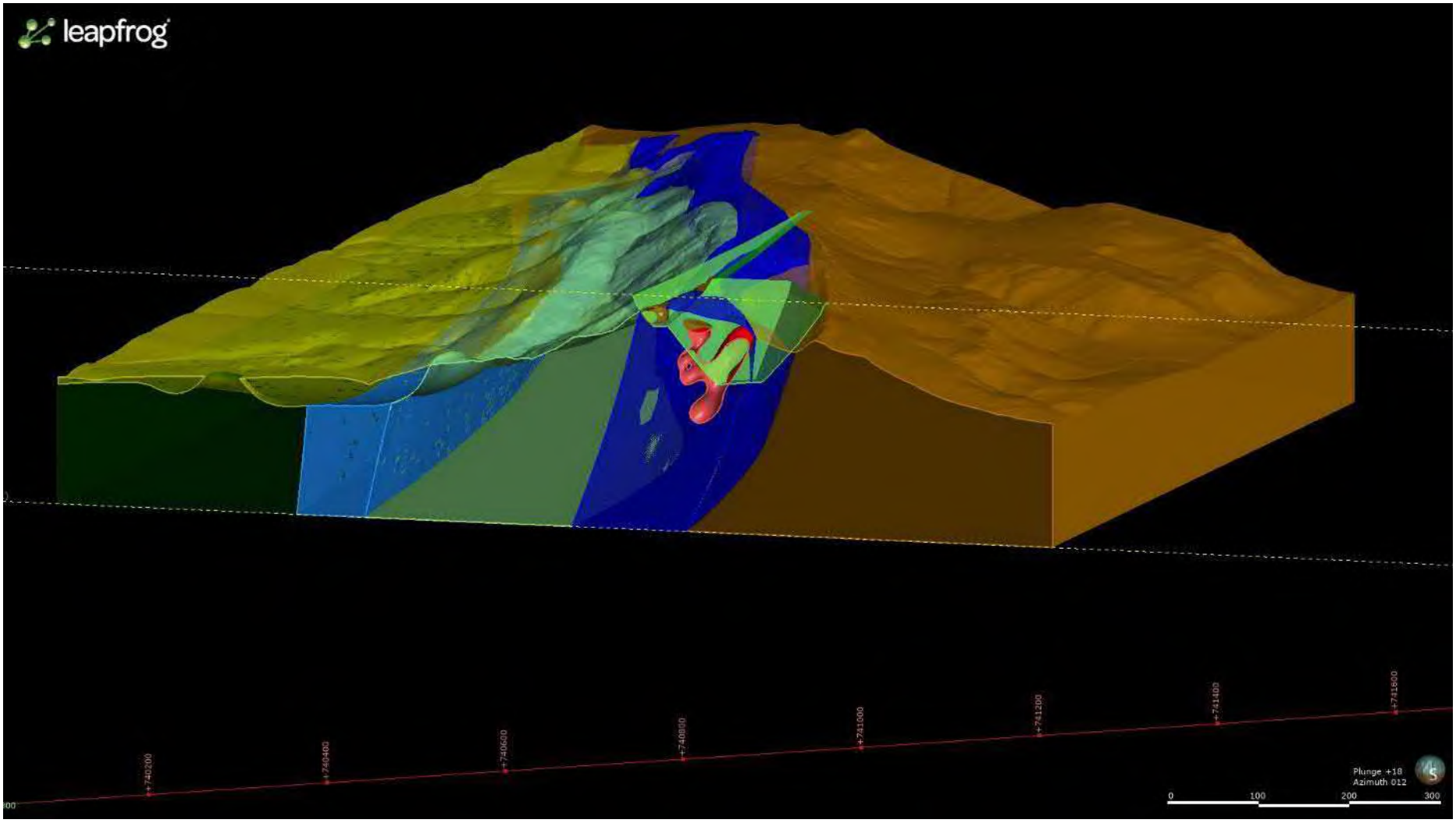
CS_1: Cross section of modelled prospective AWT troglofauna habitats at Miralga West



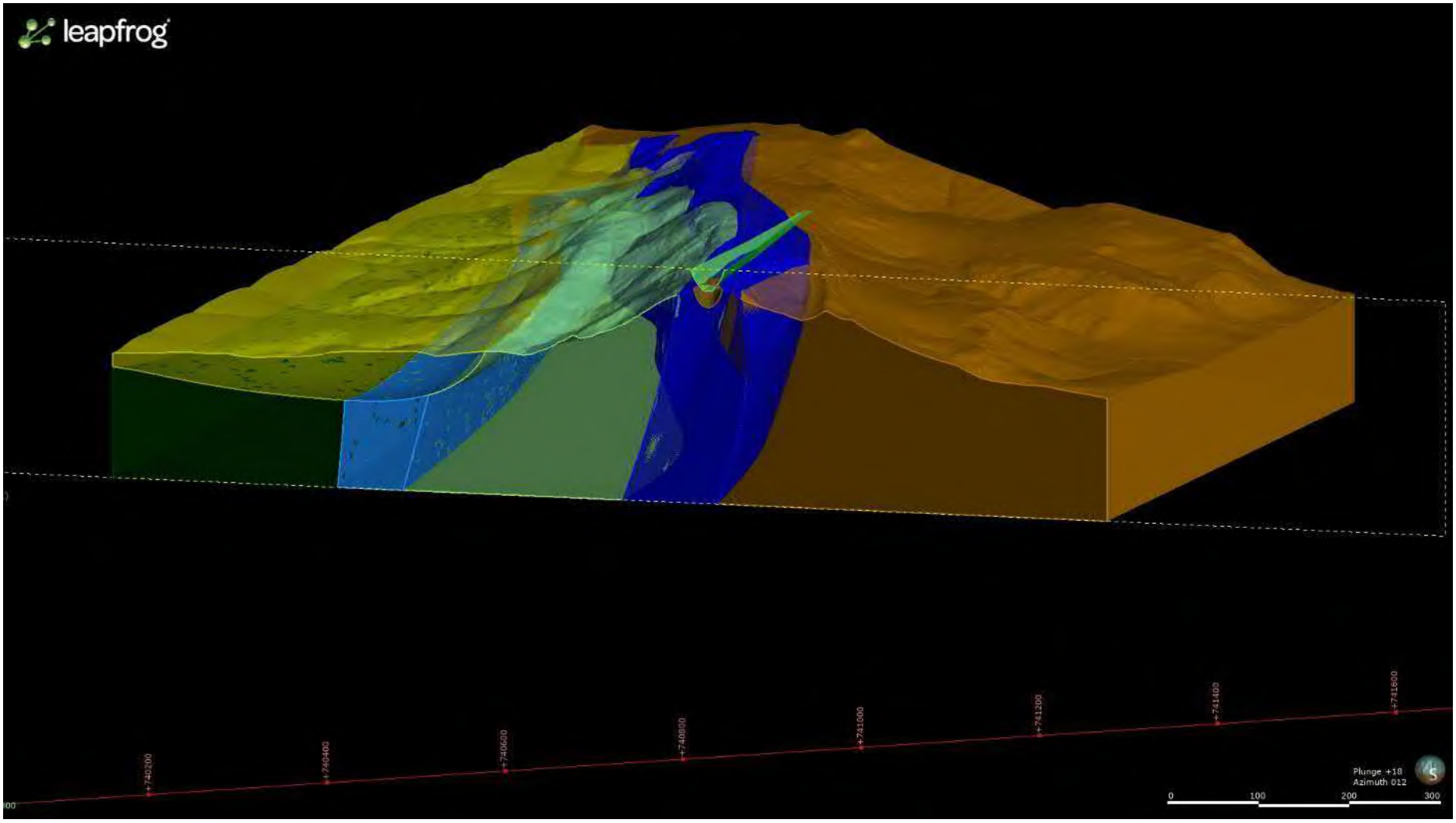
CS_2: Cross section of modelled prospective AWT troglofauna habitats at Miralga West



CS_3: Cross section of modelled prospective AWT troglofauna habitats at Miralga West



CS_4: Cross section of modelled prospective AWT troglofauna habitats at Miralga West



CS_5: Cross section of modelled prospective AWT troglofauna habitats at Miralga West