



Attn: Sarah Williamson
BHP Billiton Iron Ore

From: Stuart Halse
Date 24 February 2017

ADDENDUM BASED ON UPDATED HABITAT ASSESSMENT Mining Area C and Southern Flank Troglifauna Environmental Impact Assessment

Introduction

This second Addendum should be read in conjunction with Bennelongia's (2016) report '*Mining Area C – Southern Flank: troglifauna assessment*', which provides an assessment of the potential impacts on troglifauna associated with the Mining Area C Southern Flank Proposal, and the memorandum from BHP Billiton Iron Ore describing the results of '*Additional habitat assessment for five potentially restricted troglifaunal species at South Flank*' (BHPBIO 2016a).

According to Bennelongia (2016) four species may possibly be restricted to the Southern Flank disturbance area (i.e. $\geq 40\%$ likelihood of restriction) and one species has an uncertain status (i.e. insufficient information to assign a probability of the species being restricted) and is treated as possibly restricted. The species are the spiders *Prethopalpus* sp. B15, *Prethopalpus julianneae*, the isopods Philosciidae sp. B03, nr *Andricophiloscia* sp. B16 and the dipluran Parajapygidae `DPL024`.

The additional habitat assessment conducted by BHPBIO (2016a) using an optical televiewer (OTV) has been used to further examine the likely ranges of the above five troglifaunal species. It builds upon earlier habitat characterisation by BHPBIO (2016b). In particular, this Addendum identifies whether the potential habitats of the five species (and therefore their likely ranges):

- are apparently restricted to an area within the proposed pit shells at Southern Flank;
- extend outside the proposed pit shells at Southern Flank but are still restricted to the buffer around the pit shells (termed mine pit buffer); or
- extend outside the mine pit buffer.

Habitat Surrogates

The EPA's (2016) Environmental Assessment Guideline 12, which deals with environmental impact assessment involving subterranean fauna, defines a surrogate as "*the use of information on one species to infer the likely distribution of another poorly sampled species*" and states that "*A surrogate can be based on either biological features of a species (or group of species) or physical characteristics of the habitat*". If a habitat supporting a particular species can be shown to occur continuously beyond the area surveyed, it may be inferred from a combination of "*habitat mapping, analysis of distributions and population genetic studies*" that the species has a range extending beyond the surveyed area.

Cores from diamond-drilled holes and OTV imagery were used by BHPBIO (2016a) to determine whether the geology in particular areas has a suitable physical structure to support troglifauna. These results were integrated with stratigraphic surfaces to identify three-dimensional blocks of suitable above-watertable habitat for each species using Leapfrog TM modelling software. The results of this geological investigation and modelling have been integrated here with biological information.

Updated Imagery

OTV imagery provides very useful information about the structure of subterranean habitat. While this structural information informs broader habitat characterisation and considerations of habitat connectivity, the OTV information is for single disconnected points. Subterranean habitat is usually

extremely heterogeneous at the scale relevant to subterranean fauna, with the small networks of vugs and other spaces used by animals occupying only a very small proportion of the mass of subterranean material. This heterogeneity is one of the reasons for variable troglofauna capture rates in different drill holes and variable stygofauna capture rates in different bores (Eberhard *et al.* 2009). Some holes intersect many networks used by subterranean fauna, while others either intersect unused networks or habitat without voids.

Thus, OTV information from a drill hole does not always reflect the prospectivity of the surrounding area for subterranean fauna. Sometimes a hole with no apparent vugs will yield troglofauna because the surrounding area is prospective and bait in a troglofaunal trap or the occurrence of tree roots will lead to animals entering the hole via an undetected microcavern-sized space (often substantially less than 5 mm across) (Howarth and Moldovan in prep.). These errors in assessment of overall habitat prospectivity of an area reduce as the number of holes examined by OTV increases but predictions of the situation in individual holes is always likely to be prone to error.

Similarly, unless a very large number of holes are examined, the likely extent of prospective habitat for a species is best estimated by geological mapping as well as OTV. It must be recognized that species do not always use all the apparently suitable habitat and a series of factors other than habitat connectivity (e.g. competition, dispersal capacity) may lead to a species' range being smaller than predicted (Connell 1983; Austin 2002; Lester *et al.* 2007). In addition, within large areas of apparently prospective habitat there may often be pockets of unsuitable habitat, as well as dykes, faults and other potential barriers to subterranean fauna movement.

Species Ranges

***Prethopalpus* sp. B15**

This species is known from a single specimen collected during stygofauna sampling at drill hole SF0260R (Figure 1) at the western end of Southern Flank. The hole has also yielded the dipluran Japygidae `DPL005` and the beetles Zuphiini sp. and Curculionidae Genus 1 sp. B02. Japygidae `DPL005` is also known from drill hole SF0180R (15 km east) at Southern Flank, while Curculionidae Genus 1 sp. B02 has been recorded throughout Mining Area C. It was suggested by Bennelongia (2016) that Japygidae `DPL005` may have above-ground dispersal to account for its current range or has a distribution reflecting some of its original surface distribution prior to colonising subterranean habitat.

The factors controlling the distribution of Curculionidae Genus 1 sp. B02 are probably similar to those affecting Japygidae `DPL005`. Nothing can be said about the distribution of Zuphiini sp., which was a juvenile animal identified only to the level of tribe.

The original habitat characterisation undertaken by BHPBIO (2016b) showed the top 21 m of substratum at SF0260R consists of detritals, which overlie 40 m of West Angelas Member. As a result of being collected as bycatch during stygofauna sampling, the geological unit in which *Prethopalpus* sp. B15 occurs is uncertain but the species is considered likely to have been living in the West Angelas Member because most (though not all) *Prethopalpus* species have been collected from bedrock habitats. Photos of the drill core of SF1022DTM, approximately 100 m north of SF0260R, show the West Angelas Member is vuggy and suggests this member provides potential habitat for troglofauna at SF0260R. However, photos of cores from two diamond holes in the vicinity (SF3709DT and SF3705DT) show that the TD3 detritals unit is also particularly vuggy. If the TD3 detritals at SF0260R are similarly vuggy, detritals may be used by *Prethopalpus* sp. B15, in which case continuous habitat extends south of the proposed pit shell and also the mine pit buffer.

The Mount Newman Member lies below water table in SF0260R but is present above the water table at the nearby drill hole SF1022DTM, where it is vuggy. Furthermore, a juvenile specimen of

Prethopalpus was collected 700 m north-west of SF0260R from Mount Newman Member in drill hole SF0448R. If the specimen at drill hole SF0448R belongs to *Prethopalpus* sp. B15, then habitat connectivity between the West Angelas Member and Mount Newman Member to the north can be assumed. More importantly, there would be sampling evidence that *Prethopalpus* sp. B15 occurs outside the proposed pit shell. However, most *Prethopalpus* species have small ranges and it is quite possible that the specimen in SF0448R represents another, new species of *Prethopalpus* rather than *Prethopalpus* sp. B15. Current information suggests that the genus mostly contains species with small, non-overlapping ranges that geographically replace one another, although *Prethopalpus maini* has a larger range. Species level identification of the *Prethopalpus* specimen in SF0448R has been attempted on two occasions using DNA analysis but both attempts failed to obtain a sequence.

In summary, it is considered more likely that *Prethopalpus* sp. B15 was collected from the West Angelas Member than detritals but the detritals provides continuous potential habitat to the south of the proposed pit shell and buffered mine pit (Table 1). However, if the specimen at drill hole SF0448R belongs to *Prethopalpus* sp. B15, then the species occurs outside the proposed pit shell with habitat connectivity between the West Angelas Member and Mount Newman Member to the north.

Prethopalpus julianneae

This species is known from a single specimen collected by scraping from drill hole SF0569R (Figure 1). Based on an assessment of habitats within this drill hole, the specimen appears to have been inhabiting Mount Newman Member (BHPBIO 2016b). Two other troglofauna species have been collected from this hole but both (Hemiptera sp. B02 and the cockroach Blattidae sp.) are troglaphiles with distributions that appear to be controlled by surface dispersal rather than the connectivity of subterranean habitat (Halse in prep.).

It is planned that, after excavation of the proposed mine pit, a strip of approximately 25 m of Mount Newman Member habitat will remain on the southern side of the pit shell and a 50 m strip will be left on the north side (both within the mine pit buffer). Furthermore, the proposed pit shell will be relatively shallow and thus it is likely that potential Mount Newman Member habitat will be available between the pit floor and the watertable, although the suitability of this habitat for *Prethopalpus julianneae* is likely to decline after pit excavation as a result of surface compaction of the pit floor and reduced organic matter inputs. This is likely to reduce the abundances of the species under the pit rather than result in the loss of all individuals.

While there is no direct continuity between the residual Mount Newman Member habitat around the pit shell and other areas of Mount Newman Member, a large amount of Mount Newman habitat occurs within the mine pit buffer (but outside the proposed pit shell) about 600 m to the north-west of the *Prethopalpus julianneae* record. This may represent additional habitat for *Prethopalpus julianneae* on the basis that troglofaunal spiders known from multiple records in the Pilbara have a median range of 3.7 km² (Halse and Pearson 2014), so that it is reasonable to assume species will be found up to 1 km from existing records.

In summary, a small amount of suitable Mount Newman Member habitat, that is directly connected to the drill hole where *Prethopalpus julianneae* was recorded, will be preserved under the pit and adjacent to the pit shell (Table 1). There is additional potential habitat outside the proposed pit shell to the north-west, although this not directly connected to the known location of *Prethopalpus julianneae*.

Philosciidae sp. B03

Philosciidae sp. B03 species was collected in abundance from drill hole GLR002 (Figure 2) on one sampling date in a scrape and two traps. Two subsequent sampling events failed to re-collect the species at GLR002. The traps collecting Philosciidae sp. B03 were set at depths of 20 m and 48 m in

Mount Newman Member, which is considered likely to be the habitat the species was using. OTV footage from drill hole SF5826R, which is 25 m south-west of GLR002 and in Mount Newman Member, showed no evidence of vugs although presumably vugs are present in GLR002 or its surroundings. This highlights the complicated nature of habitat connectivity and the difficulty of inferring habitat characteristics over even short distances. Attempts were made to obtain OTV footage from GLR002, but this was not possible for logistical reasons.

The proposed pit shell from which *Philosciidae* sp. B03 was recorded will not extend to the watertable, leaving undisturbed Mount Newman Member below the pit floor. In fact, the pit void extends only 25 m below ground level at GLR002, where *Philosciidae* sp. B03 was recorded, so that the animals collected at 40 m depth were well below the pit floor. There is likely to be a considerable amount of suitable habitat for *Philosciidae* sp. B03 below the pit floor and probably also to the east of the pit in Mount Newman Member (see Figure 7 in BHPBIO 2016a). While the two drill holes east of the pit examined by OTV (SF5673R, SF5672R) showed no evidence of vugs in Mount Newman Member, the area may contain a mosaic of habitats, with patches of vuggy prospective habitat yielding *Philosciidae* sp. B03 while adjacent less prospective areas do not.

The other troglofauna species collected at GRL002 is a hemipteran belonging to the family Meenoplidae. The troglomorphic insects of this family usually have distributions determined by surface dispersal rather than below ground movement (Halse in prep.), so their pattern of distribution provides no information about the likely overall range of *Philosciidae* sp. B03).

In summary, it is considered likely there is suitable habitat for *Philosciidae* sp. B03 below the eastern side of the proposed pit shell floor and to the east of the proposed mine pit shell in Mount Newman Member (Table 1).

nr *Andricophiloscia* sp. B16

This species is known from a single animal collected from drill hole GSR0013 within the proposed mine pit at the eastern end of Southern Flank (Figure 2). No other troglofauna were collected from the hole. nr *Andricophiloscia* sp. B16 was collected in a trap set at 40 m depth in Mount Newman Member. OTV imagery provided no evidence of vugs anywhere in this hole (BHPBIO 2016a), perhaps because the vugs used by animals were only a couple of millimetres wide and were hidden under small rocky projections or overhangs within the hole.

Three holes outside the proposed pit shell were also examined with OTV. Drill hole SF4555R, about 500 m north-west of GSR0013, contains extensive vugs in Mount Newman Member and SF4575R about 600 m north contains more limited vugs in Mount Newman Member. This Mount Newman Member extends north of both the proposed pit shell and the mine pit buffer. The third hole, SF0186R just south of the proposed pit shell, intercepts only detritals above the watertable. These detritals showed "little evidence of vugs or cavities" (BHPBIO 2016a).

In summary, while there is uncertainty about the habitat being used by *Andricophiloscia* sp. B16 where it was collected in drill hole GSR0013, there is evidence of potential habitat for *Andricophiloscia* sp. B16 in Mount Newman Member north of the proposed pit shell and mine pit buffer (Table 1).

Parajapygidae `DPL024`

This species is known from one specimen collected during stygofauna sampling at drill hole SF0196R (Figure 2) in the proposed mine pit at the eastern end of Southern Flank. The hole has also yielded the symphylan *Hanseniella* sp. B07 and a juvenile spider *Prethopalpus* sp. Bennelongia (2016) suggested that detritals is probably the preferred habitat of *Hanseniella* sp. B07, giving the species a relatively wide distribution at Southern Flank and Deposit R. No range information is available for *Prethopalpus* sp., which was a juvenile and identified only to genus level.

The life history characteristics of Parajapygidae `DPL024` are unclear. Some parajapygid species with multiple records are troglaphiles with an above ground dispersal phase that enables them to be moderately widespread but other parajapygids, especially some of the species represented by single records, are probably troglobites with restricted ranges. Although not a fixed rule, it is likely that in many cases troglaphilic species inhabit detritals and troglobitic species inhabit deeper rock layers (see Culver and Pipan 2008; Ortuño *et al.* 2013).

Drill hole SF0196R passes through detritals, West Angelas Member and Mount Newman Member. OTV imagery was not available for SF0196R but the imagery from drill hole SF0197R, 40 m south of SF0196R, showed both West Angelas Member and Mount Newman Member to be vuggy. It did not show the nature of the detritals habitat (which is less extensive than the 6 m of detritals at SF0196R). Significantly, there is a fault between SF0196R and SF0197R that causes the geology at SF0197R to repeat, which may possibly affect the connectivity of habitat between the two drill holes.

OTV imagery is available for two other drill holes approximately 800 m south-east of SF0196R which are outside the proposed pit shell and buffered mine pit. The imagery showed limited vugs in one of the holes (SF4697R) and no vugs in the other (SF1584R), suggesting the West Angelas and Mount Newman Members at some distance east of the proposed pit shell have very limited potential to support troglafauna. However, various other troglafaunal species were collected from holes between SF4697R and SF1584R and the pit shell, suggesting there is suitable habitat for troglafaunal closer to and SF1584R and the pit shell, suggesting there is suitable habitat for troglafaunal closer the pit shell, including south of the mine pit buffer. Unfortunately, OTV imagery could not be obtained in this area for logistical reasons.

Table 1. Summary of information on likely ranges of the five species.

Species	Habitat present outside		Comment
	Pit shell	Mine pit buffer	
<i>Prethopalpus</i> sp. B15	Detritals: Yes West Angelas: No Mount Newman: Uncertain	Detritals: Yes West Angelas: No Mount Newman: Uncertain	Yes, if species occurs in detritals suitable habitat exists outside the buffered mine pit. Uncertain, if species occurs in Mt Newman Member then habitat occurs outside pit shell/pit buffer only if specimen at SF0448R is <i>Prethopalpus</i> sp. B15.
<i>Prethopalpus julianneae</i>	Mount Newman: Yes	Mount Newman: Uncertain	Yes, the species is likely to occur below the pit and in the small amount of Mount Newman Member that will remain intact outside the pit shell. There is also potentially suitable, unconnected habitat to the north-west.
Philosciidae sp. B03	Mount Newman: Yes	Mount Newman: Yes	Yes, there is evidence Philosciidae sp. B03 occurs below the pit shell. Yes, Mount Newman extends outside of the pit shell to the east and it is considered that a network of suitable habitat occurs within this member.
nr <i>Andricophiloscia</i> sp. B16	Mount Newman: Yes	Mount Newman: Yes	Potential habitat occurs outside the mine pit buffer.
Parajapygidae `DPL024`	Detritals: Yes West Angelas: Uncertain Mount Newman: Uncertain	Detritals: Yes West Angelas: Uncertain Mount Newman: Uncertain	Yes, if species occurs in detritals. Both West Angelas Member and Mount Newman Member extend outside of the pit shell and pit buffer, however connectivity is uncertain.

In summary, if Parajapygidae `DPL024` occurs in detritals it is likely to have a range extending outside the proposed pit shell and the mine pit buffer. If it occurs in West Angelas Member and Mount Newman Member, the extent and connectivity of suitable habitat for the species outside the proposed pit shell is uncertain (Table 1).

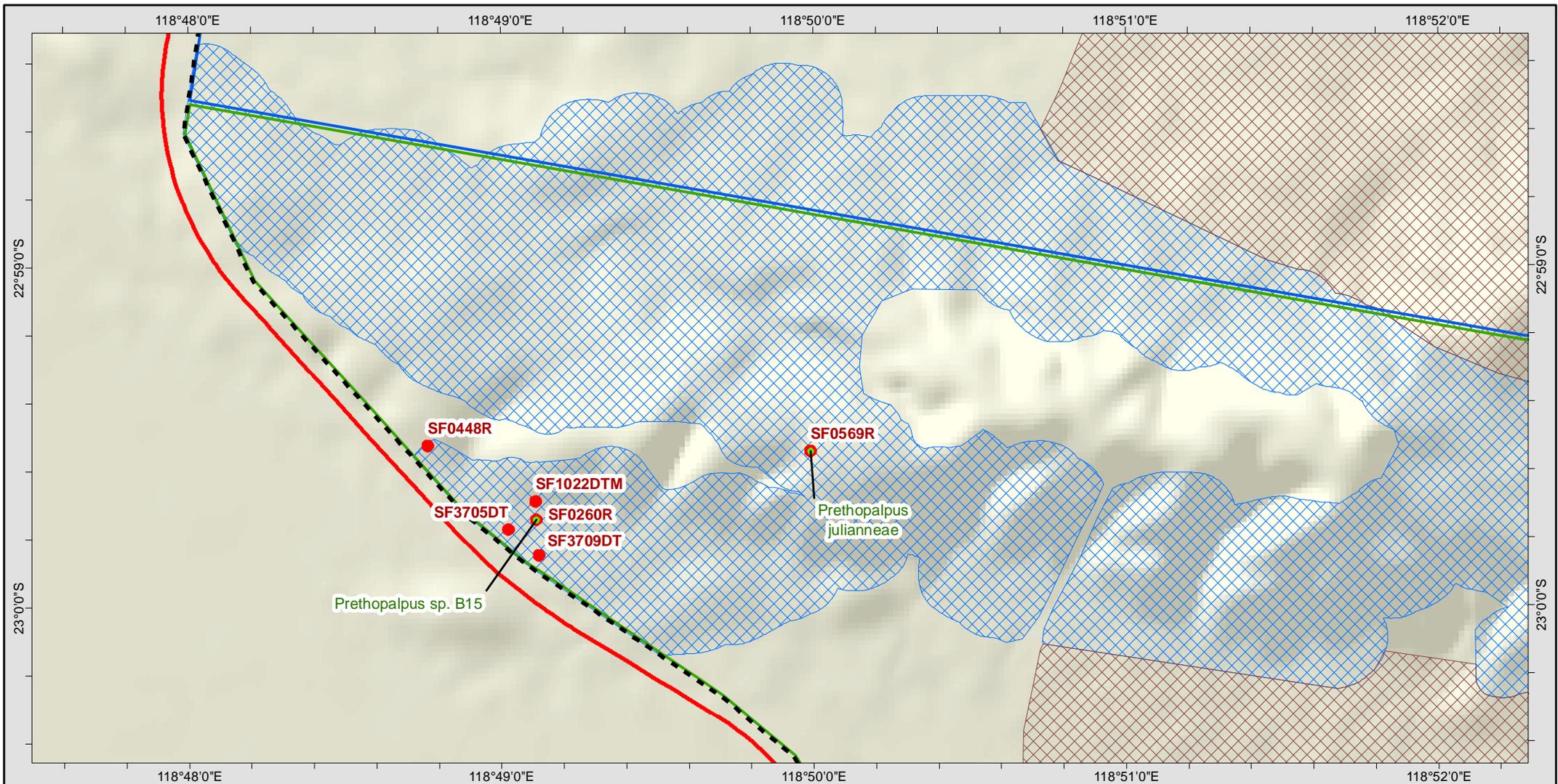
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Figures

Figure 1. Location of western drill holes at Southern Flank (the modified indicative additional pit includes the mine pit buffer).

Figure 2. Location of more eastward drill holes at Southern Flank (the modified indicative additional pit includes the mine pit buffer).



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MINING AREA C - SOUTHERN FLANK Troglifauna Habitat Assessment

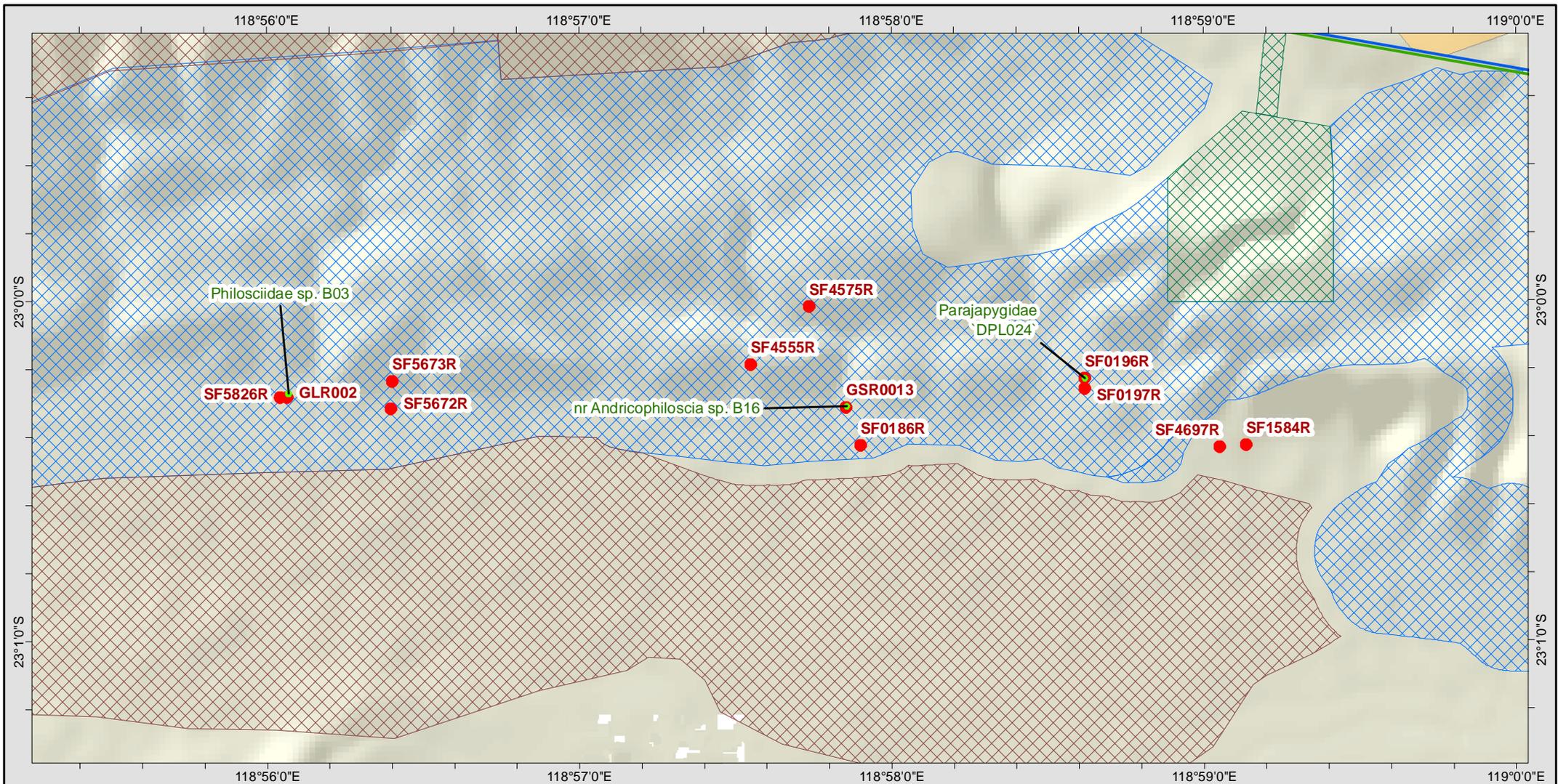
Scale @ A4: 1:30,000	Prepared: M. LYTTLE	Project No: A780/064 REV A
Date: 24/01/2017	Checked: R. GREGORY	Figure: 1
Revision: Rev A	Reviewed: T. CARROLL	

- Restricted Troglifauna
- Drill holes
- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Modified Indicative Additional OSA and Topsoil Area
- Modified Indicative Additional Pit
- Great Northern Highway

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Kilometres
Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994



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MINING AREA C - SOUTHERN FLANK Troglofauna Habitat Assessment

Scale @ A4: 1:30,000	Prepared: M. LYTTLE	Project No: A780/065 REV A
Date: 23/01/2017	Checked: R. GREGORY	Figure: 2
Revision: Rev A	Reviewed: T. CARROLL	

- Restricted Troglofauna
- Drill holes
- Proposed Mining Area C Development
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- Modified Indicative Additional Infrastructure
- Modified Indicative Additional OSA and Topsoil
- Modified Indicative Additional Pit

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