ADDITIONAL HABITAT ASSESSMENT FOR FIVE POTENTIALLY RESTRICTED TROGLOFAUNA SPECIES AT SOUTH FLANK

Environmental impact assessment carried out for troglofauna at South Flank determined five species that are potentially restricted to the South Flank disturbance boundary: *Prethopalpus* sp. B15, *Prethopalpus julianneae*, Philosciidae sp. B03, nr *Andricophiloscia* sp. B16, and Parajapygidae ‘DPL024’. An original habitat assessment carried out by BHP Billiton (BHPBIO, 2016), found that the likely preferred habitat of each of these species is discontinuous from the sample site directly to the north and south of the disturbance boundary.

This memo outlines the findings of additional, more targeted habitat assessment undertaken in early 2017 for each of these five species that focuses on the indicative pit boundaries as the primary area of impact. The aim was to use more innovative methods to enable visualisation, in the third dimension, of the nature and extent of troglofauna habitat. These methods were the creation of habitat models and the collection of optical televiewer (OTV) imagery.

**Optical televiewer (OTV) data collection**

Optical televiewer imagery provides an insight into the nature of the geology down a drill hole. The objective of collecting OTV data for troglofauna habitat assessment was to visually compare the nature of the geology from the area where the potentially restricted troglofauna species was found with areas outside of the indicative pit boundaries. The locations of OTV collection were planned using a number of assumptions and constraints:

1. OTV data collected from the drill hole where the species was found, or a nearby drill hole if the original hole could not be accessed.
2. Drill holes selected outside of the pit were no more than 1 km away from the troglofauna record to ensure the drill hole was likely to be within the dispersal range of the troglofauna species.
3. Drill holes selected outside of the pit intersected the habitat considered most suitable for troglofauna species in focus. This was determined using geological interpretations from the drill hole database, GBIS.
4. Presence of other troglofauna species was taken into account.
5. Age of drill hole was taken into consideration as a function of accessibility of the hole.

Twenty nine holes were planned, consisting of 17 target and 12 back-up locations. Of these 29, OTV data was collected from 13 drill holes. The remaining holes could not be accessed by the OTV.
operator due to collapse, rehabilitation etc. Unfortunately it was mostly the target drill holes that could not be accessed. No OTV data could be collected from drill holes relating to habitat for *Prethopalpus julianneae* or *Prethopalpus* sp. B15. There were a number of diamond drill holes with corresponding core photos available for the area around the sampling location of *Prethopalpus* sp. B15 and these are used in the analysis below.

**Habitat model**

It is often difficult to visualise extent of habitat in the third dimension, with geological mapping only representing where geological units outcrop at the surface and not the unit’s nature with depth or how it interacts with the water table. Each of the five species assessed were considered to inhabit the Mount Newman and/or West Angelas Members of the Marra Mamba Iron Formation. To enable visualisation of the habitat available, solids for the TD3 unit of the Tertiary Detritals (for Highway Deposit only), Mount Newman and the West Angelas were created in LeapfrogTM geological modelling software for South Flank. The Mount Newman solid combined the N3, N2 and N1 units and the West Angelas combined the WA1 and WA2 units. Solids were then clipped by water table and by topography. The result was a model that showed the extent of the Mount Newman and West Angelas habitat that occurs above the water table at South Flank and the TD3 at Highway Deposit.

Figures 1, 3, 5, 8, and 11 are in plan view and show the lateral extent of habitat in relation to the indicative pit designs. Figures 2, 4, 6, 9 and 12 are in section view taken north/south, facing west, through the South Flank range at the location of drill hole where the troglofauna species was collected.

The main limitation associated with this approach to habitat visualisation is that the model is bound by where geological information has been collected and where, in some cases, it is able to be extrapolated. At South Flank this is focussed around exploration drilling within the orebodies, with limited information collected outside of the indicative pit boundaries.

**Prethopalpus** sp. B15

This species is known from a single record collected from drill hole SF0260R in Highway Deposit. BHPBIO (2016) shows SF0260R collared into detritals, which overlie West Angelas Member above the water table. The West Angelas Member bedrock was considered to be the only suitable habitat available for the species. Further work suggests the detritals in the area, particularly the TD3 unit, may also be considered suitable habitat. In addition, the Mount Newman Member, although not present in SF0260R, appears to be accessible to *Prethopalpus* sp. B15.

Analysis of other troglofauna species that occur in the area showed that *Philosciidae* sp. B15 was recorded in a drill hole less than 100 m south of *Prethopalpus* sp. B15 and inhabits the detritals (only units available above the water table). This prompted investigation into the nature of the detritals in the area. Photos of drill core from two diamond holes in the vicinity (SF3709DT, ~100 m south and SF3705DT, south west of SF0260R) show the TD3 unit to be particularly vuggy (Appendix A) and larger cavities were also logged within these holes. TD3 extends continuously south of the indicative pit (Figure 1 and Figure 2). Please note that modelling data is limited in this area and does not show the complete extent of the TD3. Surficial geological mapping suggests a much wider distribution of the detrital units in this area (BHPBIO, 2016).

The Mount Newman Member dips below water table in SF0260R but is present above water table, and underlies the West Angelas Member directly to the north (Figure 2). Core photos from SF1022DTM, approximately 100 m north of SF0260R, show both the West Angelas and Mount Newman Members to
be vuggy in nature (Appendix B). Furthermore, there does not appear to be any geological structures present that might prevent *Prethopalpus* sp. B15 from moving between units of the West Angelas and Mount Newman. An un-identified specimen of *Prethopalpus* was collected from Mount Newman habitat outside of the indicative pit boundary to the north-west of SF0260R (Figure 1) suggesting that this should be considered suitable habitat for *Prethopalpus* sp. B15. Habitat modelling shows the Mount Newman Member to continuously extend outside of the pits to the west, north, north-west and west (Figure 1 and Figure 2).

![Figure 1: Location of Prethopalpus sp. B15 in relation to indicative pit boundaries, Prethopalpus sp. indet. and modelled extent of TD3 habitat (orange), West Angelas habitat (red) and Mount Newman habitat (beige) above water table at Highway Deposit.](image)

![Figure 2: Cross section showing available habitat for Prethopalpus sp. B15 above the water table. Mount Newman Member (beige) extends north beyond the indicative pit. TD3 detritals (orange) extend south of the indicative pit design. Connectivity between West Angelas (red) and Mount Newman.](image)
**Prethopalpus julianneae**

This species is known from a single record collected from drill hole SF0569R within Highway Deposit. BHPBIO (2016) found that *Prethopalpus julianneae* inhabits the Mount Newman Member. Figure 3 and Figure 4 show that there is laterally approximately 25 m of Mount Newman habitat south of the pit and 50 m north. Furthermore, indicative pit designs in this area are relatively shallow, leaving Mount Newman habitat available below the pit and above the water table (Figure 4). Additionally, approximately 600 m to the north-west of the *Prethopalpus julianneae* record, a large area of Mount Newman habitat is found above the water table outside of the pit (Figure 3).

![Figure 3: Location of Prethopalpus julianneae in relation to modelled Mount Newman Member (beige), Tertiary Detrital (orange) and West Angelas Member (red) habitats available above water table at Highway Deposit.](image)

![Figure 4: Cross section facing west showing location of Prethopalpus julianneae record against the indicative pit design. Mount Newman member habitat (beige) extends south, north and below the indicative pit design above the water table.](image)
Philosciidae sp. B03

Philosciidae sp. B03 is recognised from three sampling occurrences within one drill hole, GLR002, at Grand Central Deposit. Two samples were collected from traps at 20 m and 48 m depth below ground surface, which correlates to the N2 and N1 units of the Mount Newman Member respectively. Figure 5 and Figure 6 show the records of Philosciidae sp. B03 close to the pit boundary. Mount Newman (beige) extends to the north-west of GLR002 between indicative pits and directly to the west outside of the indicative pit boundary. Figure 6 shows Mount Newman habitat available above water table directly to the north of GLR002 and this extends further to the north below a relatively shallow indicative pit. West Angelas Member (red) is continuous to the south (Figure 6) and south-west (Figure 5) outside of the indicative pit boundary. There does not appear to be any structures that may restrict movement of troglofauna between the Mount Newman and West Angelas habitat.

Figure 5: Location of Philosciidae sp. B03, Mount Newman (beige) and West Angelas (red) habitats available above water table and extent outside of indicative pits.

Figure 6: Location of Philosciidae sp. B03 records within indicative pit boundary. Mount Newman (beige) extends above water table out of and below indicative pit boundaries to the north. West Angelas Member (red) extends outside of indicative pit boundaries to the south.
OTV imagery was collected from SF5826R, which is approximately 25 m south west of GLR002. GLR002 was not accessible by the OTV operators. Due to the thicker detrital sequence observed in SF5826R and the Mount Newman Member dipping away to the south (Figure 6), the relative depths of geological units do not align to GLR002. To account for this, images from intervals representative of the geological unit where the traps were located, rather than depth of trap, are provided in Figure 7. The top image is from 27 m to 29.4 m below ground level. This interval consists of limonitic goethite from N2 and is representative of the top (27 – 36 m) section of N2 in SF5826R. The lower 36 to 46.8 m of N2 appears to be more siliceous un-mineralised banded iron formation (BIF). There does not appear to be any vugs or cavities present within this interval or throughout the depth of the drill hole (Figure 7). The second image is from 46 m to 48.6 m below ground level and shows un-mineralised siliceous BIF from the N1. This interval is typical of the N1 unit intersected in SF5826R, which occurs from 46 m to 57 m depth below ground level (Figure 7).

OTV data was collected from two holes outside of the indicative pit boundary to compare the nature of the habitat with that seen within GLR002 (SF5826R as a surrogate) (Figure 7). The first, SF5673R, is located approximately 500 m east of GLR002. This is a relatively short drill hole that intersects three meters of surface scree overlying the N2 and N1 units. The top image shown in Figure 7 is from 15 to 17 m depth below ground level and is an interval representative of the N2 unit. This interval was described as goethitic BIF and is similar to the N2 seen in SF5826R. The lower image shows the N1 within an interval of 18 to 19. 6 m (Figure 7). Similar to SF5826R, this interval and the remaining N1 in SF5673R is characterised by cherty goethite BIF.

SF5672R is the second hole and is located approximately 560 m south east of GLR002 (Figure 7). It intersects a thicker sequence of detritals than GLR002 followed by West Angelas and N3. The WA is described as hardcapped and the porous vuggy texture can be seen in the OTV imagery from 21 – 33.8 m (Appendix C). In addition, a large cavity was encountered from 34 to 35.2 m depth. Figure 7 also shows an interval of N3 from 45 to 47 m depth that is mineralised and typical of the N3 in the hole down to 54 m depth. Although SF5672R does not intersect the N1 and N2 (the units where troglofauna traps were set), OTV imagery suggests that the vuggy West Angelas and N3 units comprise suitable troglofauna habitat.
Figure 7: OTV imagery from relevant intervals down selected drill holes. SF5826R is a surrogate for GLR002 where Philosciidae sp. B03 was collected and SF5672R and SF5673R represent potential habitat outside of the indicative pits. Locations of other troglobiota species are represented by yellow triangles.
Memorandum

nr Andricophiloscia sp. B16

This species is known from a single record within drill hole GSR0013 at Vista Oriental Deposit. The specimen of nr Andricophiloscia sp. B16 was collected from a troglofauna trap at 40 m depth below the ground surface, which corresponds to the Mount Newman Member.

Figure 8 and Figure 9 show that limited West Angelas habitat extends out beyond the indicative pit to the south and there is no Mount Newman habitat available above the water table to the south of the indicative pit boundary. The Mount Newman, however, extends continuously out of the indicative pit boundary to the north (Figure 8 and Figure 9).

Figure 8: Location of nr Andricophiloscia sp. B16, Mount Newman (beige) and West Angelas (red) habitats available above water table and extent outside of indicative pit designs.
OTV data was collected from GSR0013, where *nr Andricophiloscia* sp. B16 was sampled, and three holes outside of the indicative pit boundaries namely SF0186R, SF4555R and SF4575R. Imagery from an interval from 39.2 to 42 m, corresponding to N3 and the depth of trap where the specimen of *nr Andricophiloscia* was collected is shown in Figure 10. There is no evidence of vugs or cavities within this interval or throughout the hole.

SF4555R is a relatively short drill hole out of pit approximately 600 m to the north-west of GSR0013. The top 8 m of the hole intersects hardcapped N2 and N1 with 10 cm+ cavities visible in the OTV imagery (Figure 10, Appendix C). Porous vuggy texture is also evident from 12 to 14.8 m with large cavities (~80 cm) from 18.8 to 19.2 m (Appendix C). Hardcapping with minor vugs and cavities is also present within the N3 and N2 to a depth of 15 m within drill hole SF5475R (Figure 10, Appendix C). SF4575R is located approximately 600 m north of GSR0013 and 150 m north of the indicative pit boundary. The third hole outside of the pit, where OTV was collected, is SF0186R. This hole intersects a thick sequence of detritals covering the West Angelas and Mount Newman, which are below water table at depth. The nature of the detritals varies down hole and there is little evidence of vugs or cavities. The image presented on Figure 10 for SF0186R shows an interval (30 – 32 m) of TD3 that is described in the database as pisolitic with minor vitreous goethite.

Although it was not possible to directly compare the nature of the geological units in GSR0013 with the three drill holes outside of the indicative pit boundaries, review of the OTV imagery showed that suitable habitat is available outside of the indicative pit in the N2 and N1 units of SF4555R and N3 and N2 in SF4575R. It is still uncertain whether the detritals to the south of the indicative pit, as shown in SF0186R, should be considered suitable habitat.
Figure 10: OTV imagery from relevant intervals down selected drill holes. GSR0013 where nr Andricophiloscia was collected, SF0186R south, SF4555R north-west, and SF4575R north of the indicative pit represent potential habitat outside of the indicative pit. Locations of other troglofauna species are represented by yellow triangles.
Memorandum

Parajapygidae ‘DPL024’

This species is known from a single specimen collected from drill hole SF0196R in Vista Oriental. SF0196R intersects 6 m of surface scree followed by West Angelas and Mount Newman Members of the Marra Mamba Iron Formation above water table. Figure 11 shows both the West Angelas and Mount Newman Members continuously stretching south west of the indicative pit boundary. Both the West Angelas and Mount Newman dip below the water table to the south of the indicative pit under a thick cover of detritals (Figure 12).

Figure 11: Location of Parajapygidae DPL024, Mount Newman (beige) and West Angelas (red) habitats available above the water table and extent outside of indicative pit designs.

Figure 12: Location of Parajapygidae DPL024 in relation to indicative pit boundaries. Limited Mount Newman (beige) to the north and limited Mount Newman and West Angelas (red) habitats directly to the south of the indicative pit.
OTV imagery was available for SF0197R, which is approximately 40 m south of SF0196R. For the purpose of this assessment, imagery from SF0197R is used as a surrogate to inform the nature of the habitat where Parajapygidae DPL024 was collected and compare to imagery from selected holes outside of the indicative pit. A direct comparison of geological unit with depth cannot be made due to the presence of fault offset that repeats the WA and N3 in SF0196R, however it is assumed that the nature of the material is similar. Imagery shows that SF0197R is vuggy from surface to 30 m depth (WA and N3) (Appendix C). Figure 13 shows an interval of vuggy N3 from 26.7 to 29.5 m depth.

SF4697R and SF1584R are located approximately 800 m south-west of SF0196R, outside of the indicative pit (Figure 13). Unfortunately OTV operators could not access drill holes where many species of troglofauna have been found outside of the indicative pit (yellow triangles on Figure 13). The occurrence of these other troglofauna species suggests that suitable troglofauna habitat is present outside of the indicative pit area. Both drill holes intersect detritals over N1. Geological interpretation from the drill hole database describes SF4697R as being harcapped from 16 to 24 m. OTV imagery shows some small cavities from 18.2 to 18.6 m and a large cavity from 20.3 – 21 m but little evidence of vuggy texture (Figure 13, Appendix C). The nature of the N1 in SF1584R appears similar to SF4697R, however no vugs are evident (Figure 13).

SF4697R and SF1584R do not compare well with SF0196R due to their intersection of detritals and N1, which is below the water table in SF0196R. Review of the OTV images does suggest, however, that suitable troglofauna habitat exists in the N1 a considerable distance from the indicative pit boundary. This is supported by the recovery of many troglofauna species from other holes in the area (Figure 13).
Figure 13: OTV imagery for relevant intervals from selected drill holes. SF0197R as a surrogate for SF0196R where Parajapygidae DPL024 was collected and SF4697R and SF1584R south west of SF0196R and outside of the indicative pit boundary.
Memorandum

Summary
Creation of the habitat model and OTV images enabled understanding of the nature and extent of troglofauna habitat in the third dimension. Table 1 summarises the findings in relation to the extent of suitable habitat available outside of the indicative pit boundaries for each of the five troglofauna species.

Table 1: Summary of findings

<table>
<thead>
<tr>
<th>Species</th>
<th>Suitable habitat extends out of pit?</th>
<th>Summarised explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prethopalpus sp. B15</td>
<td>Yes</td>
<td>Mount Newman (known to be vuggy) extends continuously out of pit to the north and north west. Vuggy TD3 extends continuously outside of the indicative pit to the south.</td>
</tr>
<tr>
<td>Prethopalpus julianneae</td>
<td>Yes but immediate extent is limited</td>
<td>Mount Newman extends approximately 25 m south and 50 m north of the indicative pit. There is also Mount Newman habitat available below the pit but above the water table.</td>
</tr>
<tr>
<td>Philosciidae sp. B03</td>
<td>Yes</td>
<td>Mount Newman habitat extends north-east, east and south-east beyond the indicative pit. West Angelas extends south-east beyond the indicative pit. Due to a shallow pit design there is also a large expanse of Mount Newman habitat available to the north below pit but above the water table.</td>
</tr>
<tr>
<td>nr. Andricophiloscia sp. B16</td>
<td>Yes</td>
<td>Mount Newman habitat extends continuously north beyond the indicative pit and disturbance boundary.</td>
</tr>
<tr>
<td>Parajapygidae sp. DPL024</td>
<td>Yes</td>
<td>Mount Newman and West Angelas habitat extends continuously out of the indicative pit boundary and the disturbance boundary to the south-east.</td>
</tr>
</tbody>
</table>

Regards

Tanya Carroll
Specialist Biodiversity
Memorandum

Appendix A: core photos from TD3 in SF3709DT and SF3705DT
Appendix B: core photos from SF1022DTM showing vuggy Mount Newman
Appendix C: Re-processed OTV imagery for SF5672R, SF4555R, SF4575R, SF4697R and SF1097R