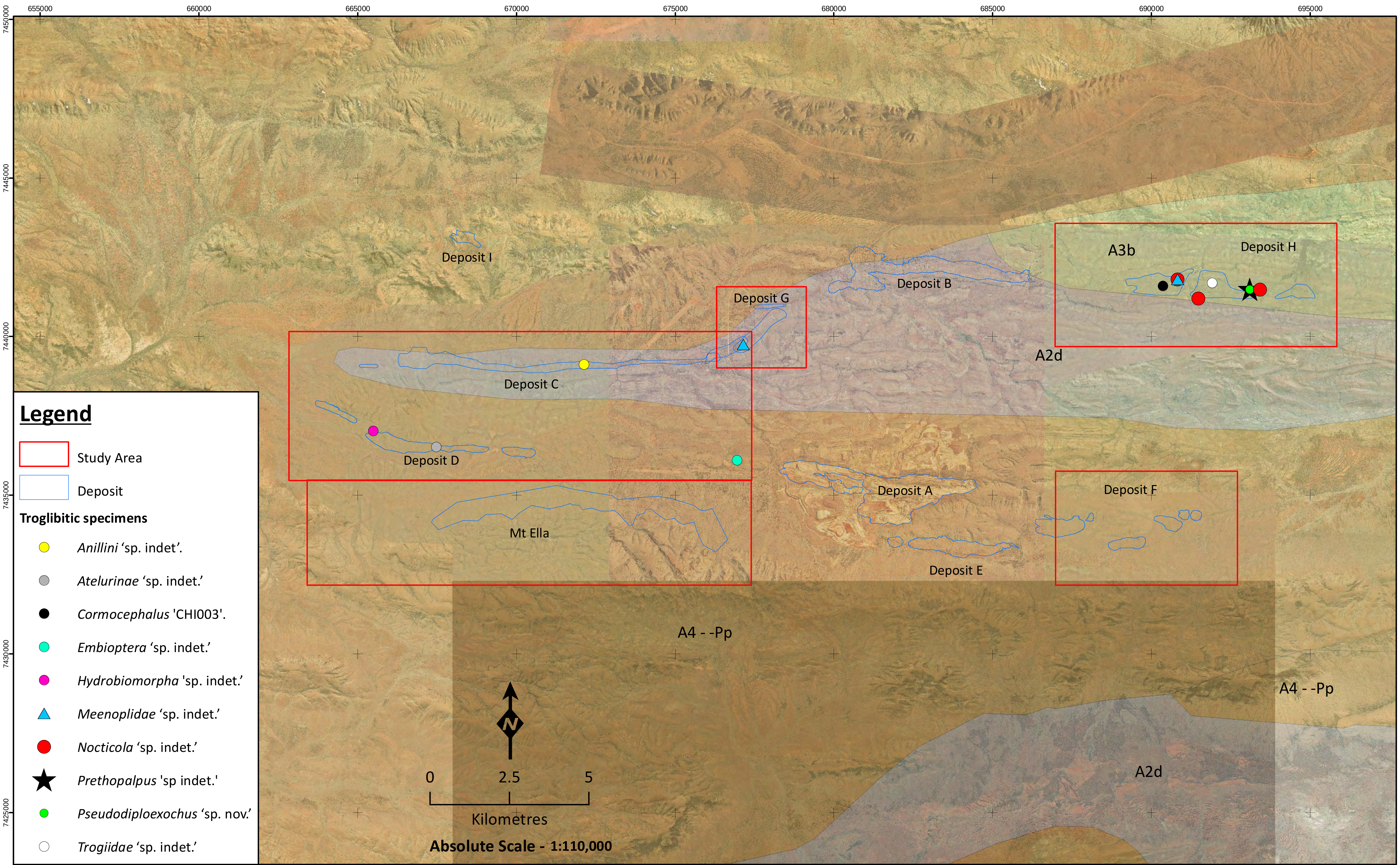

ecologia ENVIRONMENT

Troglobitic specimens recorded

Figure: 4.3
Project ID: 1459

Drawn: BG
Date: 12/2/2013

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

Unique Map ID: BG282

A3

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4.3 SUMMARY OF TROGLOFAUNA GROUPS RECORDED

4.3.1 Thysanura

FAMILY NICOLETIIDAE

***Atelurinae* 'sp. Indet.'**

A single specimen was collected from Deposit D in bore WAD 358. Pilbara thysanurans are poorly known and the taxonomy of Nicoletiidae is based on their DNA sequences rather than published species descriptions. Subterranean *Atelurinae* are well known throughout the Pilbara; however, nearly all of the species recognised to date appear to be range restricted. This specimen appears to be characteristic of the Pilbara nicoletiids. This species is a **likely SRE.**

4.3.2 Psocoptera

FAMILY TROGIIDAE

***Trogiidae* 'sp. indet.'**

A single specimen was collected from Deposit D in bore DDRC 006. Only identification to family level was possible. This family of Psocoptera posses vestigial or no wings and are commonly found in soils, leaf litter and subterranean systems (Phoenix 2013). This unidentified species is likely to be a troglobite and is a **potential SRE.**

4.3.3 Hemiptera

FAMILY MEENOPLIDAE

***Meenoplidae* 'sp. indet.'**

Two specimens were collected from two bore holes within Deposits G and H, WAG 307 and WAH 189, respectively. The two specimens could not be identified to species level due to lack of taxonomic information. However, this family is considered moderately diverse in Western Australia and contains both SRE and troglobitic species. The species is considered a **potential SRE**.

4.3.4 Embioptera

FAMILY EMBIOPTERA FAM. INDET

***Embioptera* 'sp. indet.'**

A single juvenile specimen was collected from Deposit D Extension in bore DExt 13. Classification to family level was not possible because only adult males can be taxonomically identified. Little is known about troglobitic Embioptera. Generally they have limited distribution due to the flightless nature of the females, and morphologically distinct groups appear to be geographically restricted (Phoenix 2013). This species is thus considered to represent a **potential SRE**.

4.3.5 Blattodea

FAMILY NOCTICOLIDAE

***Nocticola* 'sp. indet.'**

Thirteen specimens were collected from Deposit H in bores WAH048 (8 specimens), WAH189 (3 specimens) and DHRC010 (2 specimens). The family Nocticolidae is represented by a single genus, *Nocticola.* This genus is distinguished by its small size (< 10 mm), males with membranous wings and relatively unspecialised abdominal sclerites, and wingless females. Species level identification is only possible from adult males, which are often absent in subterranean survey samples. For this reason, genomic analyses are essential in identification of *Nocticola* species (Phoenix 2013). This species is considered a **likely SRE**.

4.3.6 Coleoptera

Beetles inhabit a wide range of habitats and are the only insect order known to have both stygobitic and troglobitic representatives. A total of 28 specimens, representing two families were recorded from within the Study Area.

FAMILY CARABIDAE

***Anillini* 'sp. indet.'**

A total of 26 specimens were collected from Deposit C in bore WACRC 332. This tiny troglobitic beetle occurs in soils and leaf litter, as well as in subterranean microcaverns and voids. Very little is known about *Anillini* and hence this species is considered a **likely SRE**.

FAMILY HYDROPHILIDAE

***Hydrobiomorpha* 'sp. indet.'**

Two specimens were collected from Deposit D in bore WAD 329. This family is made up largely of aquatic species, however there are several terrestrial species that inhabit moist environments of high humidity. This *Hydrobiomorpha* specimen has no eyes and is pale in appearance, features that identify it as a possible subterranean inhabitant. As subterranean Hydrophilidae appear to be unknown from the Pilbara, despite extensive surveying of these habitats, this species is considered a **potential SRE**.

4.3.7 Araneae

FAMILY OONOPIDAE

***Prethopalpus* 'sp.indet.'**

Two specimens (male and female, Figure 4.4) were collected from Deposit H in bore WAH 017. They could not be identified to species level, as they did not key out to any species in the latest key (Baehr *et al.* 2012), which may indicate a new species. This genus is considered an obligate troglobite (WAM 2012) and a **likely SRE**.

(Photo © Western Australian Museum 2012).

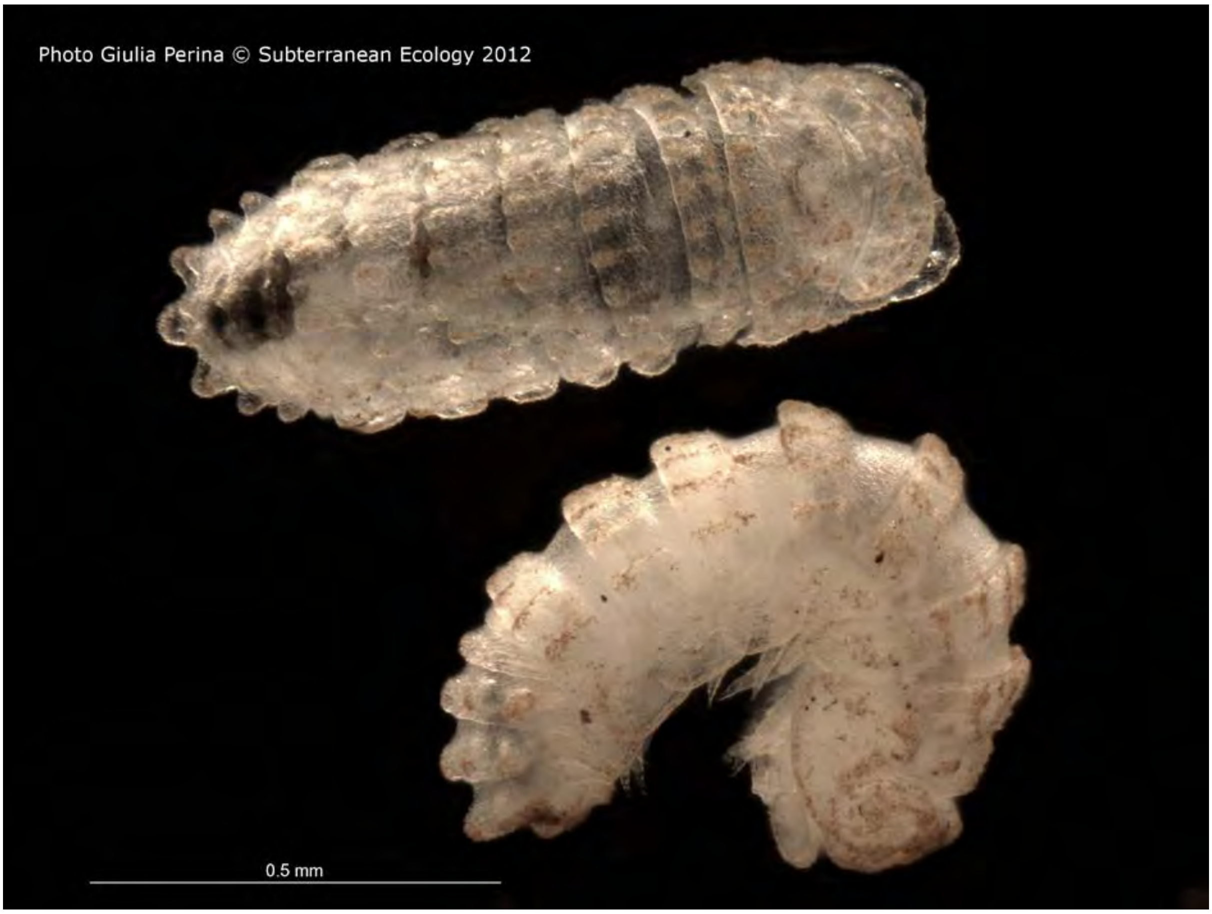
Figure 4.4 – Image of the two *Prethopalpus* 'sp. indent.' collected

4.3.8 Isopods

FAMILY ARMADILLIDAE

***Pseudodiploexochus* ‘sp. nov.’**

Two specimens (one male and one female) representing a single species were recorded from Deposit H Both specimens show troglobitic characteristics such as non-pigmented bodies and extended appendages (Figure 4.5). The specimens represent a new, blind species, and the first troglobitic *Pseudodiploexochus* recorded from the region. Historically , this genus has been found more commonly in the high rainfall areas of the south-west and a number are known SRE species (Judd 2013). Other SRE *Pseudodiploexochus* species are known from the Yeelirrie/Yakabindi area and from Tropicana (previously collected by *ecologia*). As no previous records of *Pseudodiploexochus* are known from the Pilbara this species is highly **likely a SRE**.



(Photo © Subterranean Ecology 2012).

Figure 4.5 – Image of the two troglobitic *Pesudodiploexochus* ‘sp. nov.’ collected

4.3.9 Chilopoda

FAMILY SCOLOPENDRIDAE

***Cormocephalus* ‘CHI003’**

A single specimen was collected from Deposit H in bore WAH 192. Scolopendrids are not generally considered SREs, however this specimen showed distinguishable troglobitic morphology with pale pigmentation and no eyes (Figure 4.4). This specimen is, therefore, likely to have a more restricted distribution than most scolopendrids (WAM 2012). This is the first eyeless scolopendrid specimen to be submitted to the WAM, and is considered a **likely SRE**.

(Photo © Western Australian Museum 2012).

Figure 4.6 – Image of head of troglobitic *Cormocephalus* 'CHI003' collected

4.4 SUMMARY OF STYGOFAUNA SAMPLING

Only four bores were sampled successfully for stygofauna due to poor bore conditions and lack of information on existing bores. All four bores (WAF1152, WAF 2081, WAFRC 1089 and WAFRC 1992) occur in Deposit F, the only deposit where the water table was accessible. No stygofauna were detected in any of the four bores.

4.5 GROUNDWATER PHYSICO-CHEMISTRY

Groundwater quality is measured by extracting water using sterile bailers. However, out of the four bores sampled, only one water quality reading was obtained (bore WAFCR 1152, Table 4.2), due to inability to collect water in the bailer.

Table 4.3 – Groundwater physico-chemistry data at Deposit F

Bore ID	Easting	Northing	Temperature (°C)	Conductivity (mS/cm)	Ph	D.O. (mg/L)	D.O. (% sat.)	Redox (mV)
WAFRC 1152	687438	7433973	27.8	0.003	6.43	5.59	65	201

Bore WAFRC 1152 recorded a temperature (27.8 °C) which probably reflected the atmospheric conditions at the time of day when sampling occurred. Water salinity/conductivity for the bore (0.003 mS/cm) and pH (6.43) indicates that the groundwater was fresh and mildly acidic. Dissolved oxygen (5.59mg/L at 65 % saturation) and positive redox potential (201 mV), indicating the presence of aerobic conditions in the bore.

4.6 SURVEY LIMITATIONS

The limitations of the survey are provided below in Table 4.4.

Table 4.4 – Limitations of the Subterranean Survey at the Study Area

Aspect	Limitation	Comment
Survey Adequacy	Yes	The results from the SAC analysis suggest that the survey was not adequate (24% efficiency). Drilling and bulldozing occurred at some of the survey areas, which could affect capture rates.
Method Efficiency	Possible	Survey methods complied with the EPA Guidance Statement 54a (EPA 2007). However, water quality readings were not possible due to the inability to collect water in bailers.
Seasonality	No	The survey occurred during the wet seasons and after an unusually wet period during dry season and therefore was compliant with the EPA Guidance Statement 54a (EPA 2007).
Field Personal Experience	No	Field personnel had adequate experience in subterranean surveys.
Species Identification Resolution	Yes	None of the troglobitic specimens collected could be identified to species level. The taxonomic resolution of species thus remains one of the largest limitations of the survey.
Adverse Weather Conditions	No	Weather conditions did not influence the survey

5 DISCUSSION

5.1 TROGLOFAUNA

Database searches of previous troglofauna records within the West Angelas area revealed that species of isopods, spiders and polyxenid millipedes have previously been collected in the area. Species recorded in the surrounding region also include pseudoscorpions, schizomids, harvestmen and cryptopid centipedes. In the current survey, a large proportion of the species collected were insects (orders Thysanura, Psocoptera, Hemiptera, Embioptera, Blattodea and Coleoptera), which have not been previously collected in the West Angelas area or the surrounding region.

The remainder of species recorded comprised of spiders, isopods and scolopendrid centipedes. Of these, six species are likely to have restricted distribution ranges and four are potentially restricted (Table 5.1). Only *Prethopalpus* and *Cormocephalus* have been recorded previously in the area and the remaining eight genera/families represent new records. In addition, the spider *Prethopalpus* 'sp indet.' and the isopod *Pseudodiploexochus* 'sp. nov.' (first to be recorded in the Pilbara region) represent new species. The centipede *Cormocephalus* ‘CHI003' represents the first eyeless scolopendrid specimen to be presented to WAM.

Table 5.1 – Summary of troglobitic fauna

Order	Genus/Species	SRE status	Geology*	Deposit
Blattodea	*Nocticola* ‘sp. indet.’	Likely	MV	H
Araneae	*Prethopalpus* 'sp indet.'	Likely	MV	H
Isopoda	*Pseudodiploexochus* ‘sp. nov.’	Likely	MV	H
Chilopoda	*Cormocephalus* ‘CHI003’.	Likely	MV	H
Thysanura	*Atelurinae* ‘sp. indet.’	Likely	S	D
Coleoptera	*Anillini* ‘sp. indet’.	Likely	DG	C
Coleoptera	*Hydrobiomorpha*’sp. indet.’	Potential	S	D
Embioptera	*Embioptera* ‘sp. indet.’	Potential	S	D ext
Hemiptera	*Meenoplidae* ‘sp. indet.’	Potential	DG, MV	G,H
Psocoptera	*Trogiidae* ‘sp. indet.’	Potential	MV	H

*S – sedimentary, DG – Dolerites and Gabbros, MV – mafic volcanics

Such a diverse sample indicates a rich fauna assemblage. Furthermore, a closer examination of the species distribution within the geological units of the Study Area (i.e. sedimentary, mafic volcanics and dolerites and gabbros, Figure 4.3 shows that, with the exception of Meenoplidae sp. indet., there is no overlap of species between different geological units. In other words, each geological unit seems to harbour a different troglofauna assemblage.

Importantly, such results may be an artefact of a low sample size, because the survey efficiency has been estimated by SACs to be 24%, which suggests that only a quarter of the diversity has been sampled. Influences such as survey effort and seasonality may have impacted on capture rates, although survey timing was consistent with relevant guidelines (Section 1.2). Relatively low survey adequacy (based on SACs) is common in pilot subterranean surveys, such as this.

Further sampling could potentially establish records of most species across all geologies, demonstrating that all species belong to the same troglofauna assemblage. This argument could also be reversed, however, as it is also possible that the SAC’s algorithm has been influenced by the concentration of species in certain locations (i.e. geological units), in which case the SAC curve would be an artefact of the pooling together of separate troglofauna assemblages. In this case, further sampling would deepen the species diversification between geological units, demonstrating little or no connectivity between different geologies.

The majority of species were recorded from Deposit H, which is the only deposit of the current Study Area located within mafic volcanic rocks. This type of rock can be very porous, and thus it probably presents the most suitable troglofauna habitat in the Study Area. Geologically, there is some overlap with Deposit B (not part of this survey).

Deposits C and G were found to harbour one species each and are located within dolerites and gabbros. These types of rocks are usually solid with little porosity therefore fractures within the rock probably present the only suitable troglofauna habitat.

Deposit D and D extension are located within sedimentary rocks and collectively recorded three species. The sedimentary rocks can range from solid and compact (e.g. shale) to loose (e.g. breccia) and/or cavernous (e.g. karst limestone), and thus present potentially suitable troglofauna habitat. Geologically, there is overlap with Deposit A (not part of this survey).

In summary, the troglofauna species collected from the Study Area were of conservation significance. Further sampling is recommended to clarify the composition and the extent of the troglobitic assemblage, its potential restriction to the geological units and the impact that the Project may have on the species

As many troglobitic species are understudied or yet to be discovered, it is also recommended that all specimens (those already collected as well as any future collections) undergo DNA assessment to ascertain correct species matching and thus their true distribution in the Study Area and its surrounds. Given that the mafic volcanics and dolerite and gabbros geological units found in the Study Area are completely surrounded by sedimentary rocks (Figure 2.3), it is likely that species inhabiting them are restricted to these island-like, isolated units; especially if further evidence suggests that each geology harbours different troglofauna assemblages.

5.2 STYGOFAUNA

Historically, stygofauna surveys have focused on two borefields adjoining the West Angelas area; Turee Creek B and West Angelas (Biota 2003; *ecologia* 1998b),. While the borefields were located within open aquifers and their sampling has yielded amphipods, cyclopoid copepods and bathynelaceae (*ecologia* 1998b), the sampling within Deposit A returned no stygofauna (Biota 2003, 2008). Biota (2008) assessed the Deposit A as a closed aquifer - i.e. low hydraulic connectivity aquifer, also called an aquitard; (Hahn and Fuchs 2009) and unlikely to contain any stygofauna.

The current survey was limited to four accessible bores in Deposit F. No stygofauna was collected from any of the four bores.

Given that the geology of deposits D and D extension and F are dominated by sedimentary rocks, as is Deposit A (Figure 2.2), it is possible that these deposits will have similarly low hydraulic conductivity and thus be less suitable for stygofauna. The remaining deposits, on the other hand, are composed of intrusive igneous rocks (dolerites and gabbros; deposits C and G) and extrusive igneous rocks (mafic volcanics; Deposit H) and thus may form different types of aquifers, potentially suitable for stygofauna.

In summary, the current stygofauna sampling cannot be considered adequate due to its low sample size and limited spatial coverage. Further sampling is recommended, particularly in deposits C, D, D extension, G and H

6 CONCLUSIONS

The main conclusions of the baseline subterranean survey carried out at the Greater West Angelas Study Area are as follows:

- The survey methods were consistent with the EPA Guidance Statements 54 and 54a;
- No species listed under the EPBC Act, WC Act or by the DEC as critical, endangered or vulnerable were recorded during the survey;
- The troglofauna survey yielded 109 invertebrate specimens representing 11 orders. Of these, 10 species were identified as troglobitic, comprising Thysanura (silverfish), Psocoptera (booklice), Hemiptera (true bugs), Embioptera (webspinners), Blattodea (cockroaches), Coleoptera (beetles), Araneae (spiders), Isopoda (slaters) and Chilopoda (centipedes). Non-troglobitic specimens included Collembola (springtails), Blattodea, Coleoptera, Araneae and Diplopoda (millipedes);
- Only *Prethopalpus* and *Cormocephalus* have been recorded previously in the area, the remaining eight genera/families represent new records. In addition, the spider *Prethopalpus* 'sp indet.' and the isopod *Pseudodiploexochus* 'sp. nov.' (first to be recorded in the Pilbara region) represent new species. The centipede *Cormocephalus* 'CHI003' represents the first eyeless scolopendrid specimen. Most species were collected in low abundance (singletons and doubletons) and they mostly originated from inside deposit areas.
- There was little overlap of species between different geological units, suggesting potential barriers in habitat connectivity and implying isolated species assemblages. However, this could be an artefact of low sample size (i.e. 24 % survey efficiency), which can be resolved with further sampling;
- The species accumulation curve (SAC) indicated that the troglofauna survey was not adequate (24% efficiency), however such result could be skewed in case troglofauna was partitioned into separate, isolated assemblages.
- It is recommended that all troglofauna specimens (those already collected as well as any future collections) undergo DNA assessment to ascertain correct species matching and thus their true distribution in the Study Area and its surrounds for future impact assessment; and
- The stygofauna survey was limited to four accessible bores in Deposit F. No stygofauna was collected from any of the four bores. Thus, the stygofauna sampling cannot be considered adequate. Further sampling is recommended, particularly in deposits C, D, D extension, G and H.

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7 STUDY TEAM

The Rio Tinto Greater West Angelas Subterranean Fauna Survey described in this document was planned, coordinated, and executed by:

ecologia Environment

1025 Wellington Street

WEST PERTH WA 6005

Project Staff:

Lazaro Roque-Albelo,	BSc, MSc, PhD, Principal Zoologist
Kellie Honczar	BSc, Principal Ecologist
Magdalena Davis	BSc, MSc, PhD, Senior Invertebrate Zoologist
MC Leng	BSc (Hon), Invertebrate Zoologist
Bruce Greatwich	BSc, Zoologist
Sean White	Invertebrate Zoologist

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APPENDIX A SUBTERRANEAN SAMPLING SITES AND NOTES

Subterranean sampling sies in the Study Area (bold indicates stygofauna sampling)

Deposit Bore Name	Latitude	Longitude	Easting	Northing	Zone	Trog Trap Depth (m)	Total Bore Depth (m)	Depth to Water (m)	Notes
Deposit C									
DCDD002	23°8`44.755``S	118°38`19.973``E	667790	7439400	50	20	30		
DCDD003	23°8`48.691``S	118°38`47.298``E	668565	7439270	50	20	31		
DCDD006	23°8`54.335``S	118°40`25.892``E	671368	7439065	50	50	77	60.5	
DCRC001	23°8`44.377``S	118°37`37.035``E	666568	7439425	50				could not be located
DCRC001	23°8`40.477``S	118°37`51.61``E	666984	7439541	50	15	20		
DCRC002	23°8`42.111``S	118°37`51.408``E	666978	7439490	50				blocked @ 2m
DCRC004	23°8`55.317``S	118°39`29.699``E	669769	7439053	50	40	48		
DCRC005	23°8`57.293``S	118°39`58.182``E	670579	7438983	50				blocked @ 15m
DCRC007	23°8`49.647``S	118°37`23.148``E	666172	7439268	50	20	25		
DCRC008	23°8`46.082``S	118°37`23.161``E	666173	7439377	50				plug stuck
DCRC009	23°8`44.541``S	118°37`23.289``E	666177	7439425	50				could not be located
DCRC010	23°8`42.847``S	118°37`23.266``E	666177	7439477	50	30	35		
WAC071	23°8`44.063``S	118°37`37.284``E	666576	7439435	50	10	16.6		
WAC077	23°8`40.854``S	118°37`37.258``E	666576	7439534	50				blocked @ 10m
WAC089	23°8`54.175``S	118°39`1.3``E	668962	7439097	50	30	41		
WAC197	23°10`39.036``S	118°42`32.592``E	674934	7435802	50	20	28		
WAC283	23°8`54.463``S	118°40`26.001``E	671371	7439061	50				blocked
WAC301	23°8`44.666``S	118°38`4.93``E	667362	7439408	50	30	35		
WAC306	23°8`47.887``S	118°38`33.141``E	668163	7439299	50	30	36		original depth 146m
WAC313	23°8`53.692``S	118°39`15.423``E	669364	7439107	50	10	14		original depth 144m
WAC318	23°8`57.087``S	118°39`45.195``E	670209	7438993	50	40	50		original depth 52m
WAC321	23°8`57.306``S	118°39`58.231``E	670580	7438982	50	40	52		original depth 100m
WAC324	23°8`55.312``S	118°40`11.572``E	670960	7439039	50	20	26.9		
WAC329	23°8`51.181``S	118°40`39.625``E	671760	7439157	50	40	58	54	

Deposit Bore Name	Latitude	Longitude	Easting	Northing	Zone	Trog Trap Depth (m)	Total Bore Depth (m)	Depth to Water (m)	Notes
WAC335	23°8`50.885``S	118°41`6.814``E	672533	7439157	50	40	60	54	
WACRC332	23°8`52.314``S	118°40`52.694``E	672131	7439118	50	40	46		
Deposit D									
DD002	23°9`46.652``S	118°36`4.26``E	663908	7437539	50				could not be located
DD004	23°10`18.429``S	118°37`10.617``E	665785	7436541	50				could not be located
DD005	23°10`15.343``S	118°37`11.082``E	665799	7436635	50				could not be located
DDDD001	23°9`38.231``S	118°36`4.522``E	663919	7437798	50	40	45		no plug
DDRC003	23°10`20.374``S	118°37`10.573``E	665783	7436481	50				blocked @ 7m
DDRC006	23°10`16.981``S	118°37`10.549``E	665783	7436585	50	10	20		
WAD148	23°10`18.216``S	118°38`9.789``E	667468	7436528	50				blocked @ 2m
WAD152	23°10`19.782``S	118°38`9.712``E	667465	7436480	50				blocked @ 10 m
WAD201	23°10`7.257``S	118°36`59.892``E	665484	7436888	50	10	17		
WAD225	23°9`39.969``S	118°36`4.455``E	663916	7437745	50	20	34		
WAD235	23°10`41.951``S	118°43`14.85``E	676135	7435698	50	40	59		
WAD256	23°10`12.782``S	118°37`27.779``E	666275	7436709	50	10	17		
WAD259	23°10`19.185``S	118°38`9.71``E	667465	7436499	50				blocked at surface
WAD273	23°10`17.802``S	118°37`27.651``E	666269	7436555	50		1		blocked
WAD328	23°10`26.984``S	118°41`13.943``E	672702	7436199	50				plug stuck
WAD329	23°10`2.67``S	118°37`0.115``E	665491	7437029	50	40	44		
WAD331	23°10`9.294``S	118°36`59.96``E	665485	7436825	50				blocked @ 8m
WAD333	23°10`13.212``S	118°37`0.168``E	665489	7436704	50	40	44		original depth 46
WAD334	23°10`18.479``S	118°37`10.565``E	665783	7436539	50				blocked @ 10 m
WAD343	23°10`17.782``S	118°37`27.688``E	666270	7436555	50	40	46		original depth 106
WAD346	23°10`22.641``S	118°37`27.742``E	666270	7436406	50	30	46		
WAD354	23°10`19.018``S	118°37`41.837``E	666672	7436513	50	50	64	61	original depth 112m
WAD358	23°10`18.251``S	118°38`9.905``E	667471	7436527	50	10	15		original depth 46m
WAD361	23°10`22.214``S	118°38`24.102``E	667873	7436401	50	50	68	58	original depth 106m

Deposit Bore Name	Latitude	Longitude	Easting	Northing	Zone	Trog Trap Depth (m)	Total Bore Depth (m)	Depth to Water (m)	Notes
WAD363	23°10`20.386``S	118°38`37.468``E	668254	7436453	50	20	29		original depth 64m
WAD366	23°10`19.528``S	118°38`52.037``E	668669	7436475	50	50	72	60.4	original depth 82m
WAD374	23°10`25.453``S	118°39`35.203``E	669894	7436278	50	20	31		
WAD379	23°10`25.013``S	118°39`49.898``E	670312	7436287	50	50	64	61	
Deposit D and D extension									
WAD379B	23°10`24.959``S	118°40`17.702``E	671103	7436280	50	40	50		
WAD383	23°10`28.511``S	118°41`14``E	672703	7436152	50	30	68		
WAD396	23°10`41.472``S	118°43`42.918``E	676933	7435704	50	50	70		
WAD400	23°10`40.942``S	118°43`57.244``E	677341	7435715	50	40	75		
WAD439	23°10`28.597``S	118°41`0.132``E	672308	7436154	50	30	39		
WAD441	23°10`27.917``S	118°40`46.074``E	671909	7436179	50	40	82	80	
WAD447	23°10`28.869``S	118°40`32.076``E	671510	7436155	50	20	83	76	
WADRC0425	23°10`34.547``S	118°41`53.246``E	673817	7435953	50	60	64		
WADRC0432	23°10`34.684``S	118°41`41.914``E	673494	7435953	50	40	94	86	
WADRC0436	23°10`31.627``S	118°41`28.052``E	673101	7436051	50				plug stuck
WADRC438	23°10`34.848``S	118°41`28.215``E	673105	7435952	50	50	89	78	
DExt01	23°10`33.656``S	118°42`4.581``E	674139	7435977	50	30	35		
DExt02	23°10`34.484``S	118°42`18.786``E	674543	7435947	50				could not be located
DExt03	23°10`35.23``S	118°42`18.599``E	674538	7435924	50				plug blocked
DExt04	23°10`37.788``S	118°42`18.607``E	674537	7435845	50	50	60		
DExt05	23°10`40.086``S	118°42`46.741``E	675336	7435765	50	50	61		
DExt06	23°10`42.577``S	118°43`0.872``E	675737	7435684	50				could not be located
DExt07	23°10`40.895``S	118°43`0.872``E	675738	7435735	50				blocked at surface
DExt08	23°10`28.127``S	118°43`28.733``E	676535	7436119	50				blocked at surface
DExt09	23°10`34.625``S	118°43`28.728``E	676532	7435919	50		2		blocked
DExt10	23°10`37.733``S	118°43`28.837``E	676534	7435823	50				blocked at surface
DExt11	23°10`45.763``S	118°43`28.985``E	676535	7435576	50	60	73		

Deposit Bore Name	Latitude	Longitude	Easting	Northing	Zone	Trog Trap Depth (m)	Total Bore Depth (m)	Depth to Water (m)	Notes
DExt12	23°10`21.704``S	118°43`42.995``E	676943	7436312	50	10	17		
DExt13	23°10`28.278``S	118°43`43.149``E	676945	7436109	50	10	14		
DExt14	23°10`26.977``S	118°41`14.029``E	672704	7436199	50				could not be located
DExt15	23°10`22.727``S	118°40`4.089``E	670717	7436353	50				could not be located
Deposit F									
DFRC001	23°11`44.748``S	118°51`0.044``E	689340	7433604	50	40	62		
F475	23°11`44.593``S	118°51`7.167``E	689543	7433606	50	40	64		
F98	23°11`14.903``S	118°52`24.61``E	691756	7434492	50	30	72		
WAF1098	23°11`45.23``S	118°51`15.499``E	689779	7433584	50		16		original depth 120m
WAF1152	**23°11`33.555``S**	**118°49`53.001``E**	**687438**	**7433973**	**50**		**111**	**96.4**	**6 hauls 90mm nets**
WAF2081	**23°11`50.139``S**	**118°51`19.55``E**	**689892**	**7433431**	**50**		**127**	**117**	**6 hauls 90mm nets**
WAFPLF438	23°11`47.315``S	118°50`58.35``E	689291	7433526	50		104		
WAFRC1076	23°11`34.233``S	118°49`47.883``E	687292	7433954	50	80	118	95	
WAFRC1089	**23°11`54.473``S**	**118°50`47.448``E**	**688978**	**7433310**	**50**	**80**	**160**	**113**	**6 hauls 90mm nets**
WAFRC1141	23°11`35.81``S	118°49`51.144``E	687384	7433904	50	40	87		
WAFRC1159	23°11`29.294``S	118°49`56.619``E	687542	7434102	50	40	64		
WAFRC1164	23°11`38.105``S	118°50`0.216``E	687641	7433830	50	40	58		
WAFRC1267	23°11`44.023``S	118°50`58.42``E	689294	7433627	50		56		
WAFRC1299	23°11`56.185``S	118°50`49.313``E	689030	7433256	50		76		original depth 124m
WAFRC1361	23°11`49.511``S	118°51`14.114``E	689738	7433453	50	80	124.8	116	
WAFRC1464	23°11`21.563``S	118°51`44.4``E	690610	7434301	50	20	35		original depth 52m
WAFRC1510	23°11`33.688``S	118°51`49.612``E	690754	7433926	50	60	106		
WAFRC1558	23°11`26.142``S	118°51`54.978``E	690909	7434157	50	80	88		
WAFRC1590	23°11`18.382``S	118°52`1.745``E	691105	7434393	50	20	30		original depth 52m
WAFRC1640	23°11`16.213``S	118°52`19.395``E	691608	7434453	50	40	80		
WAFRC1902	23°11`45.002``S	118°50`40.37``E	688780	7433604	50	10	12		original depth 40m
WAFRC1991	23°11`35.875``S	118°49`42.502``E	687138	7433905	50	80	130	92	

Deposit Bore Name	Latitude	Longitude	Easting	Northing	Zone	Trog Trap Depth (m)	Total Bore Depth (m)	Depth to Water (m)	Notes
WAFRC1992	**23°11`39.252``S**	**118°49`42.705``E**	**687143**	**7433801**	**50**		**111**	**91**	**original depth 112m, 6 hauls 90mm nets**
WAFRC821	23°11`21.015``S	118°51`44.474``E	690613	7434318	50				could not be located
WFPC1297	23°11`58.026``S	118°50`47.585``E	688980	7433200	50		93		blocked
Deposit G									
WAG068	23°8`32.715``S	118°43`41.73``E	676946	7439665	50	40	52		
WAG070	23°8`29.513``S	118°43`41.872``E	676952	7439763	50	10	15		
WAG304	23°8`36.374``S	118°43`34.502``E	676739	7439554	50	30	40		
WAG307	23°8`29.688``S	118°43`48.58``E	677142	7439755	50	15	19		
WAG319	23°8`29.94``S	118°43`34.522``E	676742	7439752	50	50	110	60	original depth 112m
WAGRC321	23°8`28.349``S	118°43`34.417``E	676740	7439801	50	50	84	68	original depth 113m
Deposit H									
DHRC001	23°7`32.768``S	118°53`8.149``E	693083	7441309	50	50	60	56	
DHRC002	23°7`26.743``S	118°52`55.498``E	692726	7441499	50	40	45		
DHRC003	23°7`19.3``S	118°52`41.218``E	692322	7441733	50	40	64	57	
DHRC004	23°7`22.716``S	118°52`40.879``E	692311	7441628	50	30	41		
DHRC005	23°7`26.58``S	118°52`26.818``E	691910	7441514	50				blocked @ 8m
DHRC006	23°7`20.887``S	118°52`26.996``E	691917	7441689	50	40	72	52	
DHRC008	23°7`30.014``S	118°52`12.496``E	691501	7441414	50	50	68		
DHRC009	23°7`33.397``S	118°52`11.925``E	691483	7441310	50				blocked
DHRC010	23°7`36.683``S	118°52`12.232``E	691491	7441209	50	20	25		
DHRC011	23°7`25.113``S	118°52`1.156``E	691180	7441569	50				blocked
WAH 193	23°7`31.464``S	118°51`8.236``E	689672	7441393	50	50	67		
WAH002	23°7`18.062``S	118°52`12.053``E	691493	7441782	50	50	70		
WAH017	23°7`26.829``S	118°53`9.081``E	693112	7441491	50	30	44	40	
WAH047	23°7`30.333``S	118°53`20.034``E	693422	7441379	50				blocked
WAH048	23°7`27.11``S	118°53`20.279``E	693430	7441478	50	30	35		

Deposit Bore Name	Latitude	Longitude	Easting	Northing	Zone	Trog Trap Depth (m)	Total Bore Depth (m)	Depth to Water (m)	Notes
WAH054	23°7`23.865``S	118°51`49.05``E	690836	7441612	50	60	95	85	
WAH176	23°7`28.737``S	118°51`40.573``E	690593	7441465	50	20	24		
WAH179	23°7`31.662``S	118°51`20.463``E	690020	7441382	50	20	28		
WAH189	23°7`17.599``S	118°51`48.804``E	690832	7441805	50	40	46		
WAH192	23°7`24.416``S	118°51`32.646``E	690369	7441601	50	10	13		
WAH194	23°7`18.269``S	118°51`33.269``E	690389	7441790	50	40	52		

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APPENDIX B TOTAL INVERTEBRATE SPECIMENS COLLECTED

Invertebrate specimens collected from Deposits C, D, D extension, F, G and H, with troglobitic specimens in bold.

		Bore ID Deposit C																		
Order	**Family/Genus/Species**	**DCRC001**	**DCDD003**	**DCDD006**	**DCRC004**	**DCRC007**	**DCRC010**	**WAC071**	**WAC089**	**WAC197**	**WAC301**	**WAC306**	**WAC313**	**WAC318**	**WAC321**	**WAC324**	**WAC329**	**WAC335**	**WACRC332**	**DDRC006**
Symphypleona	Sminthuridae 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0
Thysanura	**Atelurinae 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Psocoptera	**Trogiidae 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Hemiptera	**Meenoplidae 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Embioptera	**Embioptera 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Blattodea	Blattaria 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blattodea	**Nocticola 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coleoptera	**Anillini 'sp. indet'.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**26**	**0**
Coleoptera	Hydrobiomorpha'sp. indet.'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Araneae	Gnaphosidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Araneae	**Prethopalpus 'sp indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Araneae	Theridiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda	**Pseudodiploexochus 'sp. nov.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Chilopoda	**Cormocephalus 'sp.indet'.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Diplopoda	Lophoproctidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	2	0

		Bore ID Deposit D																						
Order	**Family/Genus/Species**	**WAD201**	**WAD225**	**WAD235**	**WAD256**	**WAD329**	**WAD333**	**WAD343**	**WAD346**	**WAD354**	**WAD358**	**WAD361**	**WAD363**	**WAD366**	**WAD374**	**WAD379**	**WAD379B**	**WAD383**	**WAD396**	**WAD400**	**WAD439**	**WAD441**	**WAD447**	**WADR0425**
Symphypleona	Sminthuridae 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thysanura	**Atelurinae ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Psocoptera	**Trogiidae ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Hemiptera	**Meenoplidae ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Embioptera	**Embioptera ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Blattodea	Blattaria 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blattodea	**Nocticola ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coleoptera	**Anillini ‘sp. indet’.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coleoptera	Hydrobiomorpha’sp. indet.’	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Araneae	Gnaphosidae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Araneae	**Prethopalpus 'sp indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Araneae	Theridiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda	**Pseudodiploexochus ‘sp. nov.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Chilopoda	**Cormocephalus 'sp.indet'.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Diplopoda	Lophoproctidae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0

		Bore ID Deposit D continued																							Bore ID Deposit D Extension						
Order	**Family/Genus/Species**	**WAD201**	**WAD225**	**WAD235**	**WAD256**	**WAD329**	**WAD333**	**WAD343**	**WAD346**	**WAD354**	**WAD358**	**WAD361**	**WAD363**	**WAD366**	**WAD374**	**WAD379**	**WAD379B**	**WAD383**	**WAD396**	**WAD400**	**WAD439**	**WAD441**	**WAD447**	**WADR0425**	**WADR0432**	**WADRC438**	**DExt01**	**DExt05**	**DExt11**	**DExt12**	**DExt13**
Symphypleona	Sminthuridae 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thysanura	**Atelurinae ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Psocoptera	**Trogiidae ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Hemiptera	**Meenoplidae ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Embioptera	**Embioptera ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Blattodea	Blattaria 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blattodea	**Nocticola ‘sp. indet.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coleoptera	**Anillini ‘sp. indet’.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coleoptera	Hydrobiomorpha’sp. indet.’	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Araneae	Gnaphosidae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Araneae	**Prethopalpus 'sp indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Araneae	Theridiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda	**Pseudodiploexochus ‘sp. nov.’**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Chilopoda	**Cormocephalus 'sp.indet'.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Diplopoda	Lophoproctidae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	3	0	0	0	0	0	1	0	3

		Bore ID Deposit F																			Bore ID Deposit G					
Order	**Family/Genus/Species**	**DFRC001**	**F475**	**F98**	**WAFRC1076**	**WAFRC1089**	**WAFRC1141**	**WAFRC1159**	**WAFRC1164**	**WAFRC1267**	**WAFRC1361**	**WAFRC1464**	**WAFRC1510**	**WAFRC1558**	**WAFRC1590**	**WAFRC1640**	**WAFRC1902**	**WAFRC1991**	**WAFRC1992**	**WFPC1297**	**WAG068**	**WAG070**	**WAG304**	**WAG307**	**WAG319**	**WAGRC321**
Symphypleona	Sminthuridae 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thysanura	**Atelurinae 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Psocoptera	**Trogiidae 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Hemiptera	**Meenoplidae 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Embioptera	**Embioptera 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Blattodea	Blattaria 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Blattodea	**Nocticola 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coleoptera	**Anillini 'sp. indet'.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coleoptera	Hydrobiomorpha'sp. indet.'	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Araneae	Gnaphosidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Araneae	**Prethopalpus 'sp indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Araneae	Theridiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda	**Pseudodiploexochus 'sp. nov.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Chilopoda	**Cormocephalus 'sp.indet'.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Diplopoda	Lophoproctidae	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	1	0	0	0	1	4	0	9	0	0

		Bore ID Deposit H																
Order	**Family/Genus/Species**	**DHRC001**	**DHRC002**	**DHRC003**	**DHRC004**	**DHRC006**	**DHRC008**	**DHRC010**	**WAH002**	**WAH017**	**WAH048**	**WAH054**	**WAH176**	**WAH179**	**WAH189**	**WAH192**	**WAH193**	**WAH194**
Symphypleona	Sminthuridae 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thysanura	**Atelurinae 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Psocoptera	**Trogiidae 'sp. indet.'**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Hemiptera	**Meenoplidae 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
Embioptera	**Embioptera 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Blattodea	Blattaria 'sp. epigean'	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Blattodea	**Nocticola 'sp. indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**8**	**0**	**0**	**0**	**3**	**0**	**0**	**0**
Coleoptera	**Anillini 'sp. indet'.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coleoptera	Hydrobiomorpha'sp. indet.'	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Araneae	Gnaphosidae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Araneae	**Prethopalpus 'sp indet.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Araneae	Theridiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Isopoda	**Pseudodiploexochus 'sp. nov.'**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Chilopoda	**Cormocephalus 'sp.indet'.**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Diplopoda	Lophoproctidae	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

APPENDIX C PREVIOUS SUBTERRANEAN RESULTS

Class (order)	Family	Taxa
Arachnida (Prostigmata)		
	Bdellidae	not specified
Arachnida (Oribatida)		
	not specified	not specified
Arachnida (Trombidioidea)		
	not specified	not specified
Arachnida (Palpigradida)		
	not specified	not specified
Arachnida (Schizomida)		
	Hubbardiidae	not specified
Arachnida (Pseudoscorpiones)		
	Olpiidae	Sub-adult
Chilopoda (Scolopendrida)		
	Cryptopidae	*Cryptops* sp.
Diplopoda (Polyxenida)		
	not specified	not specified
	Polyxenidae	not specified
Insecta (Hemiptera)		
	Emesinae	not specified
Insecta (Coleoptera)		
	not specified	not specified
Insecta (Blattodea)		
	Nocticolidae	*Nocticola* sp.
Malacostraca (Bathynellacea)		
	Parabathynellidae	not specified
Malacostraca (Amphipoda)		
	not specified	not specified
Malacostraca (Bathynellacea)		
	Bathynellidae	not specified
	Parabathynellidae	*Billibathynella* new species 3
		Billibathynella n. sp. 2 & 3
Malacostraca (Isopoda)		
	not specified	not specified
	Oniscoid	not specified
Oligochaeta (Haplotaxida)		
	Phreodrilidae	*Insulodrilus angela*
	Phreodrilidae	immature
	Enchytraeidae	spp.
Pauropoda (Pauropodina)		
		Allopauropus n. sp. 2
		Allopauropus n. sp. 1

West Angelas

Deposits C, D & G

Subterranean Fauna Survey 2016

Biologic Environmental Survey

Rio Tinto Iron Ore Pty Ltd

WEST ANGELAS DEPOSITS C, D & G SUBTERRANEAN FAUNA SURVEY 2016

DOCUMENT STATUS				
Revision No.	Author	Review/ Approved for Issue	Approved for Issue to	
			Name	Date
1	S. Callan, J. Barnett	B. Durrant, M. O'Connell	Carly Nixon (RTIO)	13/07/2016
Final	S. Callan	B. Durrant	Caitlin O'Neill (RTIO)	1/09/2016

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EXECUTIVE SUMMARY

Rio Tinto Iron Ore Pty Ltd (Rio Tinto) operates the West Angelas Iron Ore mine on behalf of the participants in the Robe River Joint Venture, in the Pilbara region of Western Australia approximately 110 kilometres (km) north west of the town of Newman. Active mining is currently undertaken at West Angelas Deposits A, B, and E, Deposit F is currently under construction, and pre-feasibility studies are underway to evaluate the potential development of the adjacent Deposits C, D and G.

Rio Tinto commissioned Biologic Environmental Survey to undertake a survey and assessment for troglofauna and stygofauna throughout a Study Area surrounding Deposits C, D and G (approximately 9,014 ha). The objective of the survey was to provide a summary of the results of all subterranean sampling at West Angelas to date, and an assessment of the potential risks to subterranean species and their habitats from the proposed development of Deposits C, D and G.

A total of 7 previous stygofauna surveys and 2 previous troglofauna surveys have been undertaken at West Angelas, of which only one survey sampled holes within the current deposits, using troglofauna traps. Previous stygofauna surveys at West Angelas detected amphipods, bathynellaceans, copepods, oligochaetes and ostracods, although these taxa were not identified to species-level, therefore the results are not easily compared to current results. Previous troglofauna surveys at West Angelas detected slaters, spiders, pseudoscorpions, palpigrades, polyxenid millipedes, centipedes, silverfish, book-lice, beetles, plant bugs, cockroaches and web-spinners.

The current survey sampled a total of 100 bores and holes within and nearby the three deposits, resulting in 43 troglofauna trap samples, 71 troglofauna scrape samples and 28 stygofauna net haul samples. Subterranean fauna were detected at nine holes inside and near Deposit C, 10 holes inside and near Deposit D, and three holes inside and near Deposit G. The fauna comprised 28 morphospecies (14 stygofauna and 14 troglofauna) of worms (four morphospecies), crustaceans (12 morphospecies), arachnids (five morphospecies), hexapods (five morphospecies), and myriapods (two morphospecies). There were also a number of higher-level indeterminate copepod specimens that could not be allocated to any of the other morphospecies based on current information.

Subterranean habitat assessment using geological cross-sections, bore logs, and available reports revealed a range of suitable habitats for troglofauna (above water table) and stygofauna (below water table) at each of the deposits and nearby areas, comprising:

- Surficial detritals (primary stygofauna habitat) – near-surface groundwater within the alluvial gravels (hyporheos) beneath drainage lines nearby Deposit C and D;
- Calcrete and pisolite deposits (primary troglofauna and stygofauna habitat) – porous / cavernous detrital layers occurring at or near the water table within each of the proposed deposits and in the flanking valleys;
- Mineralised 'high-grade' ore zone and 'hydrated' hardcap (primary troglofauna and stygofauna habitat) –porous / weathered layers occurring in the upper parts of the Marra Mamba Formation on either side of the water table at Deposits C and D, and above water table at Deposit G; and
- Fractured Banded Iron Formations (BIF) (secondary troglofauna habitat) – where exposed near the surface in the higher parts of the landscape (south of Deposit C and north of Deposit D), deep fracture zones within the BIF bedrock may provide some habitat for troglofauna.

The risk assessment for subterranean fauna was based upon the likelihood that any species of troglofauna or stygofauna would be limited to habitats likely to be directly impacted by the proposed development. For troglofauna, the direct impact area comprised the proposed deposit (pit) boundaries. In the absence of detailed groundwater drawdown modelling, the likely propagation of drawdown within areas of relevance to stygofauna was inferred based on available hydrogeological information.

Nine troglofauna morphospecies are only known from within the proposed deposits, and are considered to be at moderate risk of impact, as shown in the table below.

Troglofauna morphospecies potentially at risk of impact

Taxon	Inside Deposit	Outside Deposit	Subterranean status	SRE Status	Risk of impact
Coleoptera					
Anillini sp. indet.	C		Troglobite	Potential SRE (data deficient)	Moderate
Hydrobiomorpha sp. indet.	D		Potential troglobite	Potential SRE (data deficient)	Moderate
Collembola					
Cyphoderidae sp. indet.	C		Potential troglobite	Potential SRE (data deficient)	Moderate
Hemiptera					
Meenoplidae sp. indet.*	C, D, *G	*H	Potential troglobite	Potential SRE (data deficient)	Moderate
Isopoda					
Armadillidae sp. indet	D		Troglobite	Confirmed SRE	Moderate
Isopoda sp. indet.	D		Potential troglobite	Potential SRE (data deficient)	Moderate
Symphyla					
Scutigerellidae sp. indet.*	C	*F	Potential troglobite	Potential SRE (data deficient)	Moderate

Taxon	Inside Deposit	Outside Deposit	Subterranean status	SRE Status	Risk of impact
Symphyla sp. indet.	C		Potential troglobite	Potential SRE (data deficient)	Moderate
Thysanura					
Atelurinae sp. indet.*	*D	D	Potential troglobite	Potential SRE (data deficient)	Moderate
* Asterisk indicates taxa where occurrence inside / outside deposits is yet to be confirmed due to unresolved species-level identifications.					

Based on current geological information, the primary habitats for troglofauna (comprising the mineralised orebodies and hydrated hardcap, calcrete, pisolite, and Mt Newman Member BIF [where sufficiently fractured and faulted]) extend well beyond the boundaries of the proposed deposits. While some heterogeneity within and between these strata would be expected, there does not appear to be any clear geological barriers between the various suitable habitat layers inside and outside of the proposed deposits.

Based on current taxonomic information and the likely extent of a range of suitable geological habitats beyond the deposit boundaries, the risk of impact to any of the nine troglofauna morphospecies currently known only from within the proposed deposits is considered to be moderate.

For stygofauna, the risk assessment is currently constrained by the lack of groundwater drawdown modelling. As such, the current assessment is based on the inferred direction and rate of drawdown propagation (based on available hydrogeological data) within the three major groundwater habitats at West Angelas, comprising:

- the central plateau area (Jeerinah Formation) in the middle of the Wonmunna Anticline – this aquifer is hydrogeologically separated from the proposed deposits and unlikely to be affected by drawdown,
- the orebody aquifers at Deposits C and D,– these aquifers are likely to be dewatered to approximately 63 m and 115 m below current water levels (based on the indicative depth of mining at Deposit C and D respectively). Drawdown in this area should propagate mainly along strike (east-west) and be contained within the Wonmunna Anticline; and
- the detrital aquifers (calcrete, pisolite, and unconsolidated alluvials) in the flanking valleys to the north of Deposit C and south of Deposit D – these aquifers are expected to be intercepted by excavation of pits and therefore dewatered in the vicinity of the deposits, with groundwater drawdown propagating radially throughout the valley to an unknown extent.

On current information, 11 stygofauna morphospecies occur within aquifers that are likely to be affected by groundwater drawdown, as shown in the table below.

Stygofauna morphospecies potentially at risk of impact

Taxon	Within likely drawdown	Beyond likely drawdown	Subterranean status	SRE status	Risk of impact
Amphipoda*		*Dep B, CP, TCB			
Kruptus sp. \`WA\`	C, D		Stygobite	Potential SRE (research / expertise)	Mod - High
Maarrka sp. \`WA\`	D		Stygobite	Potential SRE (research / expertise)	Mod - High
Bathynellacea*		*Dep B, CP, TCB			
Atopobathynella sp. \`WA\`	C		Stygobite	Potential SRE (research / expertise)	High
Bathynellidae sp. \`WA\`	C		Stygobite	Potential SRE (research / expertise)	High
Cyclopoida*		*CP, TCB			
Thermocyclops sp. \`WA\`	C		Stygobite	Potential SRE (research / expertise)	Mod - High
Harpacticoida*		*CP, TCB			
Australocamptus sp. \`B13\`	C		Stygobite	Potential SRE (research / expertise)	High
Parastenocaris sp. indet.	C		Stygobite	Potential SRE (data deficient)	Mod - High
Polychaeta					
Aeolosomatidae sp. indet.	C		Potential stygobite	Potential SRE (data deficient)	Mod - High
Haplotaxida					
Enchytraeidae sp. indet.*	C, D	*Dep. F, CP	Stygophile/ Troglophile	Potential SRE (data deficient)	Mod- Low
Oligochaeta*		*Dep B, CP			
Oligochaeta sp. indet.	C, D		Potential stygobite	Potential SRE (data deficient)	Mod- High
Turbellaria*		*Dep B, CP			
Turbellaria sp. indet.	C		Potential stygobite	Potential SRE (data deficient)	Mod- High

* Note: Occurrence inside / outside deposits is yet to be confirmed due to unresolved species-level identifications. 'CP' = Central Plateau, 'TCB' = Turee Creek Bore Field.

Based on current information, the risks of impact to stygofauna taxa found at or near the proposed deposits range from moderate-high to high (with the exception of Enchytraeidae sp. indet., which may to be restricted to groundwater), based mainly on the likelihood of each taxon to be a SRE.

While it is possible that these morphospecies may occur further afield within the valley detrital aquifers beyond the Study Area, the extent to which this area would be affected by groundwater drawdown is currently unclear. There is also a possibility that some of these morphospecies may have been previously collected from unidentified higher taxa collected from the central plateau, although this is unable to be confirmed on the basis of current taxonomic information.

2 INTRODUCTION

Rio Tinto Iron Ore Pty Ltd (Rio Tinto) operates the West Angelas Iron Ore mine on behalf of the participants in the Robe River Joint Venture, in the Pilbara region of Western Australia approximately 110 kilometres (km) north west of the town of Newman (Figure 2.1).

Active mining is currently underway at three West Angelas deposits, (Deposit A, B and E), Deposit F is currently under construction, while pre-feasibility studies are currently underway to evaluate the potential development of the adjacent Deposits C, D and G. A single phase of sampling for subterranean fauna (troglofauna and stygofauna) has been previously conducted at Deposits C, D and G, although additional sampling was required to meet the Environmental Protection Authority's (EPA) guidelines for Environmental Impact Assessment (EPA 2009, 2013).

Rio Tinto commissioned Biologic Environmental to undertake the second phase of sampling for troglofauna and stygofauna throughout a Study Area surrounding Deposits C, D and G at West Angelas (approximately 9,014 ha) (Figure 2.2). This report provides:

- a desktop review of all previous subterranean fauna surveys at West Angelas and existing data within the Study Area and the surrounding local area;
- an assessment of the suitability and extent of subterranean habitats within the Study Area based on available geological and hydrogeological information;
- a description of the methods and results of the survey within the Study Area, including a discussion of the conservation status of all troglofauna and stygofauna species detected; and
- an assessment of the potential risks to troglofauna and stygofauna species and their habitats arising from the proposed development of Deposits C, D and G.

2.1 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 (Humphreys 1999, EPA 2013). 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.

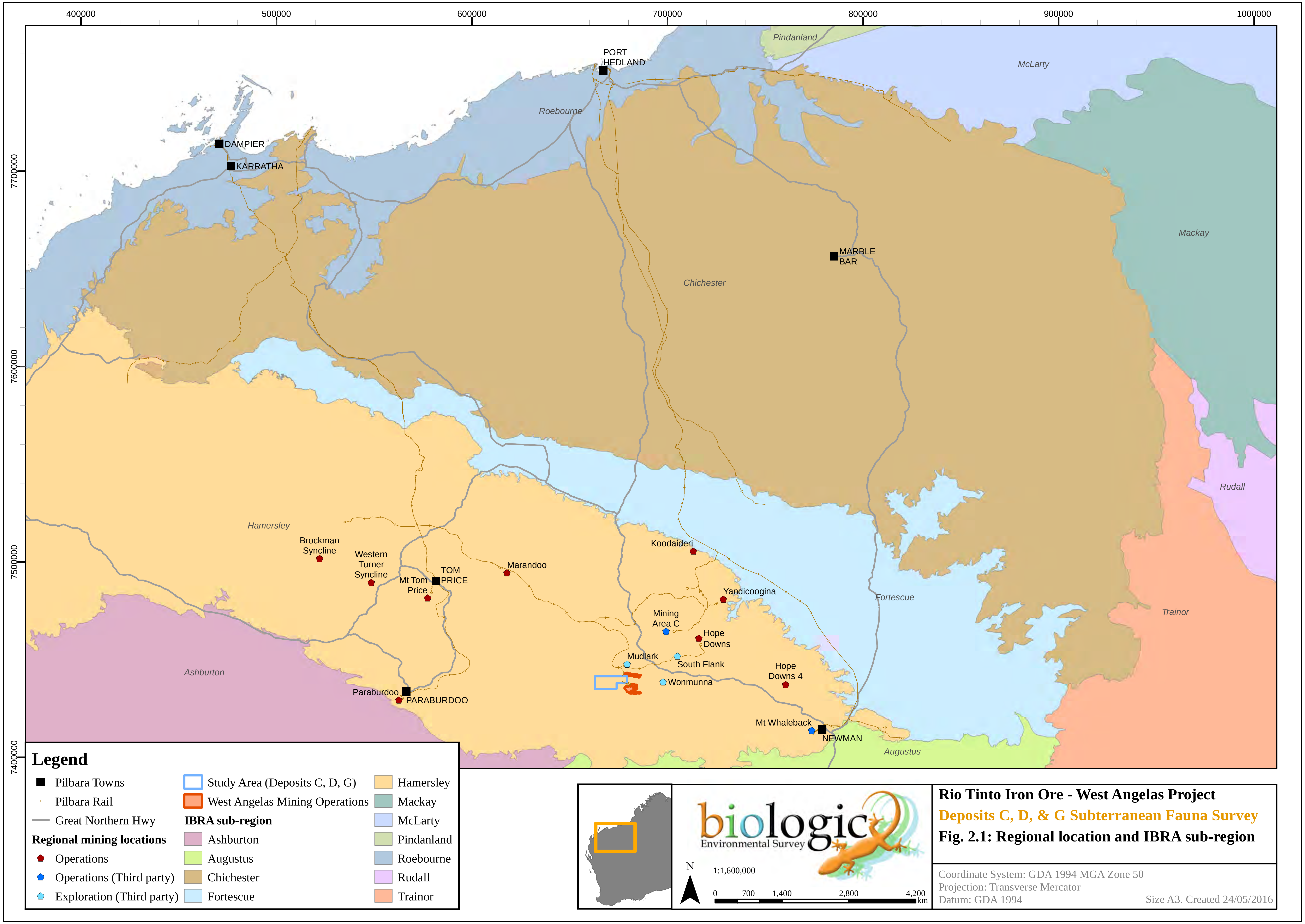
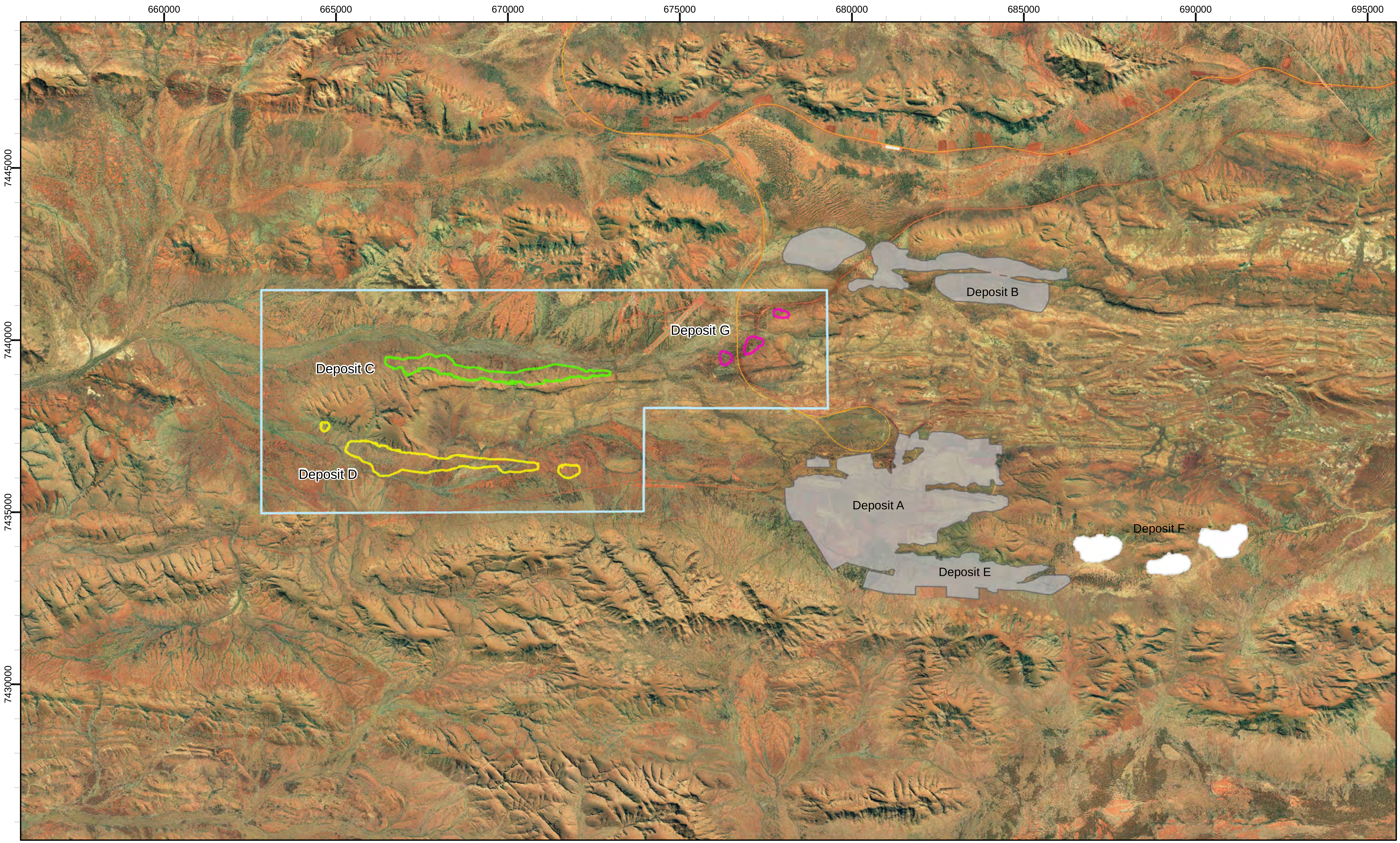


Fig. 2.1: Regional location and IBRA sub-region



Legend

- Pilbara Rail
- West Angelas Current Mining Operations
- Proposed Deposit F Pits
- Study Area (Deposits C, D, G)
- Proposed Deposit C Pit
- Proposed Deposit D Pit
- Proposed Deposit G Pit

biologic Environmental Survey

N

1:100,000

0 700 1,400 2,800 4,200 km

Rio Tinto Iron Ore - West Angelas Project

Deposits C, D, & G Subterranean Fauna Survey

Fig. 2.2: Study Area and current and proposed mining deposits

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

Size A3. Created 24/05/2016

Terrestrial and sub-surface habitats exist within a series of environmental gradients from fully aquatic (groundwater) to fully terrestrial (air-filled cavities), as well as fully above-ground (epigean) to fully below-ground (hypogean). There are some types of fauna that move between these habitats at different times in their life cycles (trogloxenes and stygoxenes), and others that can be found within any of these habitat strata at any given time (troglophiles or stygophiles) (Christiansen 2005, Stanford and Ward 1993). The EPA (2013) assessment guidelines consider only obligate subterranean fauna during environmental impact assessment (EIA); comprising troglobites and stygobites (*i.e.* animals which live their entire lives in the hypogean zone).

Obligate subterranean species, which cannot occur on the surface or in soil habitats, are considered most likely to be short-range endemic (SRE), based on the often restricted extent of their geological or hydrogeological habitats (Harvey 2002; Howarth 1983; Humphreys *et al.* 2009). This high propensity for short-range endemism in troglobites and stygobites increases the possibility that species may be negatively impacted as a result of a proposed development (EPA 2013).

Troglobites and stygobites often display evolutionary adaptations to underground life, for example 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 (Coineau 2000, Christiansen 2005, Gibert and Deharveng 2002).

2.1.1 Key Habitat Characteristics for Subterranean Fauna

The lack of light within hypogean environments precludes photosynthesis; therefore most subterranean ecosystems are dependent upon inputs of nutrients and oxygen from the surface (Hahn 2009). Oxygen, energy and nutrients are generally transported into subterranean ecosystems by the infiltration of water (Howarth 1983, Humphreys 2006, Malard and Hervent 1999, Poulson and Lavoie 2000). The porosity (or otherwise) of the target and overlying geologies, the depth from the surface, and the presence of caves or tree roots that can provide conduits for water and nutrients are therefore important features that can influence the suitability of habitats for subterranean fauna (Hahn and Fuchs 2006, Strayer 1994).

In the iron-ore bearing formations of the Hamersley Ranges, potential habitats for troglofauna can include weathered and fractured rocks such as banded iron formations (BIF), basalt, schist, chert and metamorphosed sedimentary rocks, as well as secondarily weathered deposits such as pisolitic hardcap, canga, channel iron deposits (CID) and karstic calcrete deposits. The suitability of habitat depends on the presence, abundance and interconnectedness of subterranean cavities, and on inputs of nutrients, water and oxygen from the surface via infiltration and conduits such as tree roots (Hahn and Fuchs 2006, Howarth 1983). Although troglofauna cannot live below the water table, they are particularly susceptible to desiccation and require a humid atmosphere close to 100 % saturation (Howarth 1983).

In the Hamersley Ranges, highly suitable habitats for stygofauna have been found within groundwater saturated CID, iron-enriched hardcap and karstic calcrete deposits in drainage valleys. However, stygofauna can also be found within fractured rock aquifers including BIF, basalt, schist, chert and metamorphosed sedimentary rocks, and in unconsolidated alluvial aquifers, particularly in groundwater-fed streams (*i.e.* hyporheic habitats) (Hancock *et al.* 2005). The differences in habitat suitability between different aquifers are partially attributed to the differences in hydraulic transmissivity (k) and storage potential (S) aquifers. In high transmissivity (high k) aquifers, rapid groundwater flows are facilitated by highly porous/ cavernous geologies and depth from the surface is not a limiting factor for stygofauna. Conversely, where aquifers are restricted by impermeable layers, or where transmissivity is low (low k, as in aquitard layers), the presence of stygofauna may be limited by a lack of porosity and dissolved oxygen.

Groundwater physicochemistry (including salinity, pH, dissolved oxygen and redox potential) can also be an important factor in habitat suitability for stygofauna (Eberhard *et al.* 2009, Hahn 2009, Humphreys 2008, Watts and Humphreys 2004). Very high groundwater salinity (> 60,000 mg/L TDS, or twice that of sea-water) is generally considered to be an upper limit for diverse stygofauna assemblages, but some saline-tolerant species have been found in groundwater in excess of 100,000 mg/L TDS (S. Thomas, DPaW pers. comm. 2011).

2.1.2 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 2013). The EPA's primary objective for subterranean fauna is to "maintain representation, diversity, viability and ecological function at the species, population and assemblage level" (EPA 2013). Protection for conservation significant subterranean species and/ or Threatened or Priority Ecological Communities (TEC's and PEC's) is provided under State and Federal legislation, comprising:

- *Environmental Protection Act 1986* (EP Act 1986) (WA);
- *Wildlife Conservation Act 1950* (WC Act 1950) (WA); and

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999) (Commonwealth).

The majority of subterranean species and assemblages are not listed under these legislation 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 SRE species (following Harvey 2002, and Eberhard *et al.* 2009).

This assessment was conducted in consideration of the following EPA guidance statements:

- EPA (2013) EAG12 Environmental Assessment Guideline for consideration of subterranean fauna in environmental impact assessment in Western Australia (this EAG supersedes Guidance Statement 54 (EPA 2003) – Consideration of Subterranean Fauna in Groundwater and Caves during Environmental Impact Assessment in Western Australia); and
- EPA (2007) Guidance Statement 54A (Draft) Sampling Methods and Survey Considerations for Subterranean Fauna in Western Australia (Technical Appendix to Guidance Statement No. 54).

3 ENVIRONMENT

3.1 Climate

The Pilbara region has a tropical semi-arid climate. Rainfall events within the region are sporadic and highly variable from year to year. Although considerable falls can occur within summer and winter months, most rainfall is during summer (Australian Natural Resources Atlas 2008).

Dodson (2006) suggested that average annual rainfall at West Angelas is in the order of 415 mm, based on mine site records. More detailed long-term climatic data is not available for West Angelas itself, although the nearest Bureau of Meteorology (BoM) weather station at Newman Aero (Station 7176), 135 km south west of the Study Area, provides an indication of the long term climatic conditions experienced (Figure 3.1). Recently, a new BoM weather station has been installed at Coondewanna airport (approximately 25 km north east of West Angelas), which provided a more accurate indication of conditions in the months leading up to and during the survey (Figure 3.1).

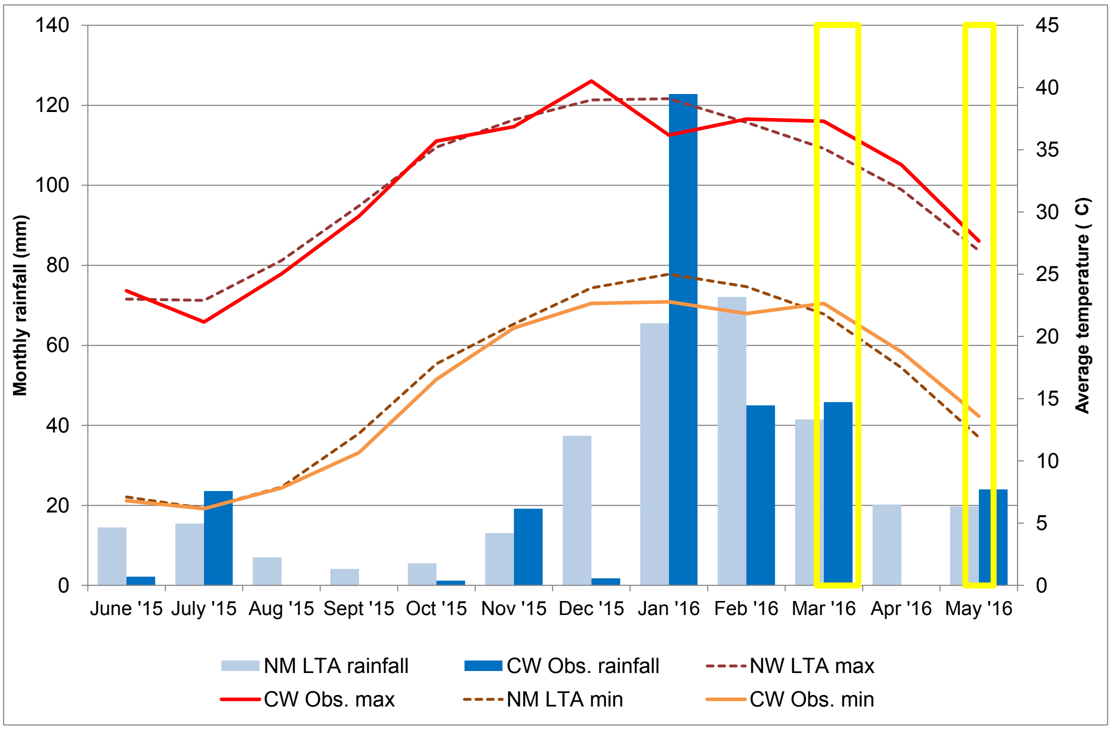


Figure 3.1: Long term average (LTA) climate data for Newman Aero (NM) compared against recent (2015-2016) observations for Coondewanna (CW) (data from BoM 2016*).

*Note: Data includes total monthly rainfall (mm) and average monthly maximum and minimum temperatures (°C). Approximate survey timing is indicated by yellow boxes.

The daily maximum temperatures during the first field trip at Deposits C, D and G (ranging from 35°C to 37.7°C between 15 - 23 March 2016) reflected slightly warmer than average (35.1°C) temperatures experienced during March 2016. Conversely, during the second trip in May (between 10 - 13 May 2016), the daily maximum temperatures (ranging from 22.8°C to 26.5°C) were slightly cooler than the average during May 2016 (27.6°C). Approximately 45 mm of rainfall fell at Coondewanna in the two weeks prior to the first survey (slightly above average for March), and 122 mm was recorded in January, which was the most significant rainfall in the 2015 - 2016 wet season. Based largely on falls during January and March, the wet season of 2016 received slightly above average rainfall. After the first survey, only 0.6 mm of rain fell at Coondewanna until five days before the second survey when 20.4 mm fell over the period of three days. This was slightly higher than the average for May (19.7 mm); however, during April there was no rain, compared to an average of 20.2 mm (BoM 2016).

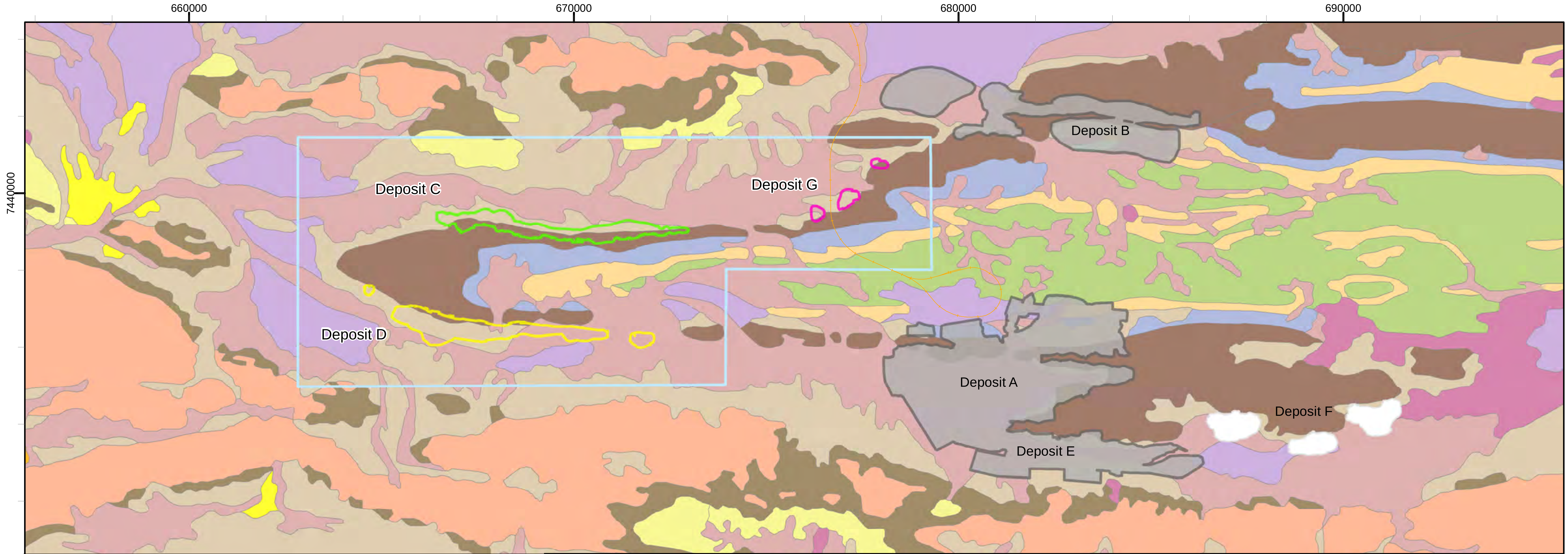
3.2 Geology

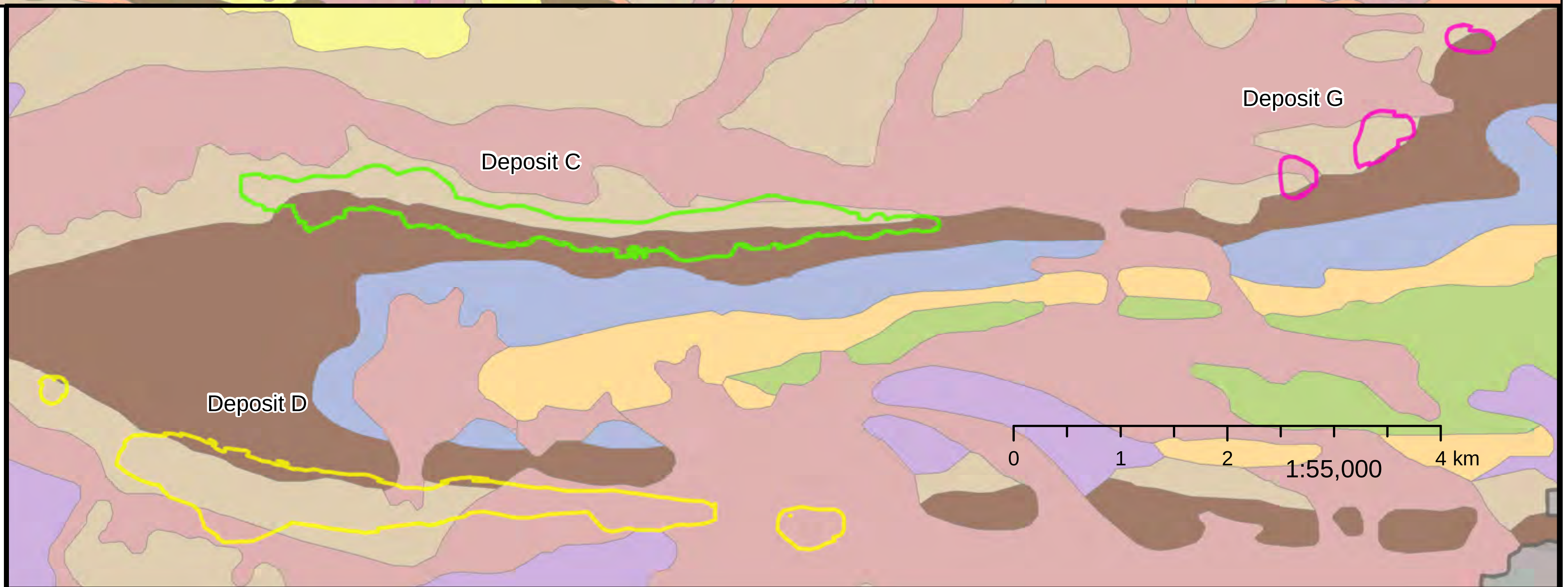
The geology of the West Angelas area is dominated by the Wonmunna Anticline, which has an east-west axis and plunges towards the west. The current deposits (C, D and G) are distributed on the northern and southern limbs of the Anticline near the western tip; Deposit C on the north side, Deposit D on the south. Deposit G is further to the east on the north side (Figure 3.2).

The centre of the Anticline comprises a low lying plateau of Jeerinah Formation (mudstone and siltstone with sills of metabasalt) which is bounded to the north and south by younger units of the Hamersley Group (Dodson 2006). A northern and a southern flanking valley (both running roughly east-west, comprised of Tertiary detrital infill) lie either side of the Anticline. On the southern and northern catchment margins, the valleys are bound by high ridges of Brockman Iron Formation (Figure 3.2).

The West Angelas deposits are formed in Marra Mamba Iron Formation (which comprises three major Members from top to bottom, the Mt Newman Member, the MacLeod Member and the Nammuldi Member) as well as the West Angela Member of the overlying Wittenoom Formation. The lower Marra Mamba Iron Formation Members contain significant proportions of shale, chert and dolomites, while the upper Member contains more BIF. Weathering of the Marra Mamba formation has also produced a significant hydrated/ mineralised zone (goethite-martite hardcap) over the bedrock.

Tertiary and quaternary detritals (colluvium/ alluvium) cover the lower slopes and valley floors, occasionally featuring secondary deposits such as pisolite/ channel iron deposit (CID) and calcrete deposited in areas near the historic (and in some cases present) water table (Figure 3.2).



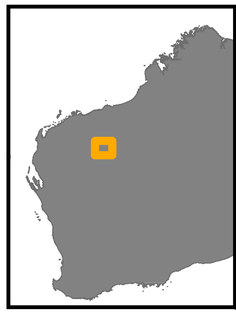


Legend

- Pilbara Rail
- West Angelas Current Mining Operations
- Study Area (Deposits C, D, G)
- Proposed Deposit C Pit
- Proposed Deposit D Pit
- Proposed Deposit G Pit
- Proposed Deposit F Pits

Geology (GSWA 1:250,000)

- Czc; Colluvium (partly consolidated)
- Czk; Calcrete
- Czr; Laterite, inc. surficial hematite-goethite deposits on BIF
- Fd; Metadolerite sills, massive, foliated
- Fj; JEERINAH Fm. mudstone, siltstone and chert; tuff, dolomite and sandstone
- Fjb; Metabasalt; pillows well developed
- Hb; BROCKMAN IRON Fm. BIF, chert, minor shale
- Hd; WITTENOOM Fm. dolomite; thin chert, shale
- Hj; WEELI WOLLI Fm. interlayered BIF and metadoleritic sills, shale
- Hm; MARRA MAMBA Fm. chert, ferruginous chert and BIF, shale
- Hs; MT McRAE_MT SYLVIA Fm. interbedded shale, chert and BIF
- Qa; Alluvium - unconsolidated silt, sand and gravel
- Qc; Colluvium - unconsolidated quartz and rock fragments in soil
- Qw; Alluvium and colluvium - red-brown sandy and clayey soil



biologic Environmental Survey

N

1:100,000

0 700 1,400 2,800 4,200 km

Rio Tinto Iron Ore - West Angelas Project

Deposits C, D, & G Subterranean Fauna Survey

Fig. 3.2: Surface geology (GSWA 1:250k)

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

Size A3. Created 24/05/2016

3.3 Topography

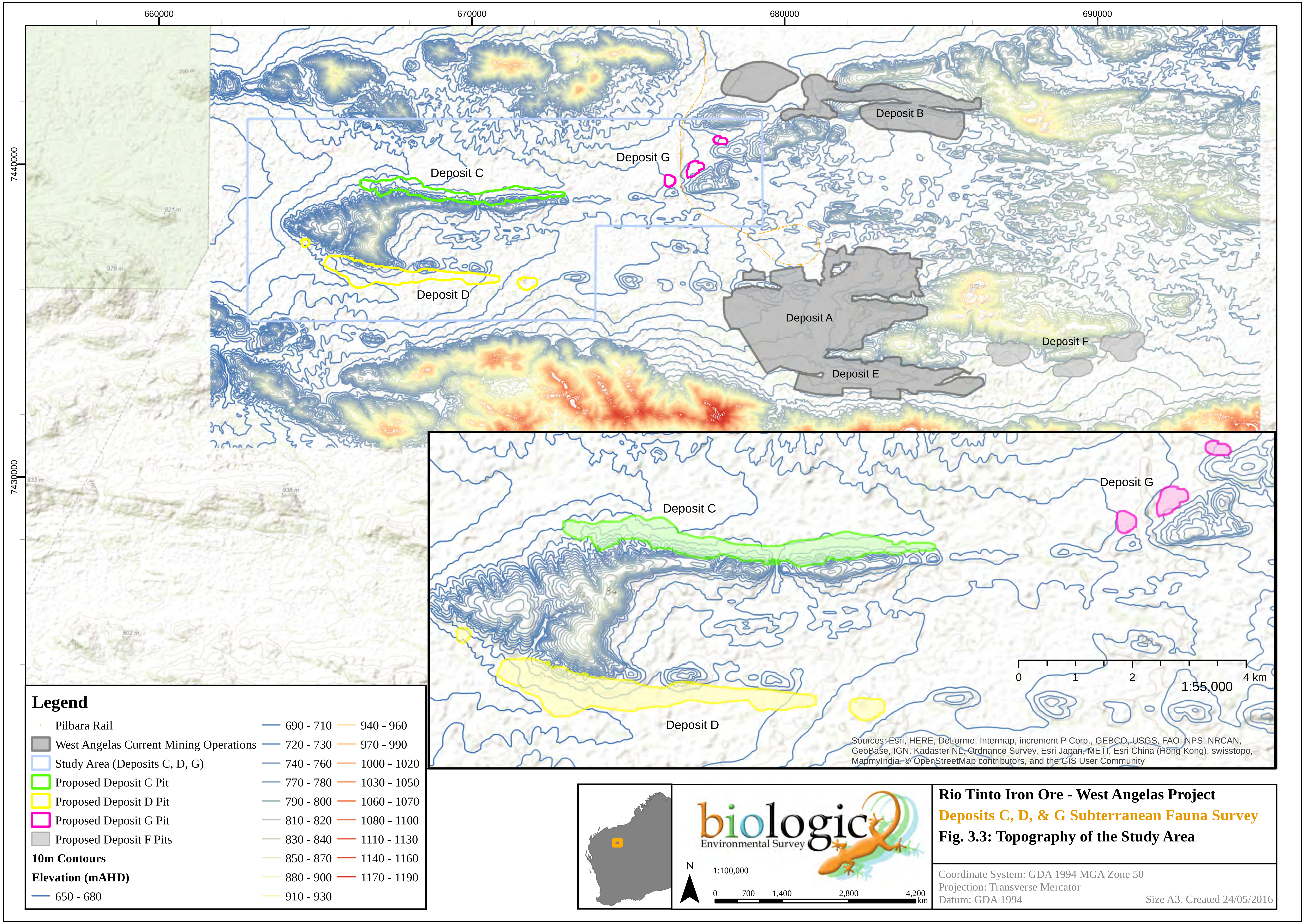
The Wonmunna Anticline dominates the topography of the Study Area comprising a low, east-west striking, rounded range extending from the central/ west corner of the Study Area to the eastern parts (splitting into a northern and a southern limb in the area of Deposits C and D) (Figure 3.3). The centre of the Anticline has been eroded to form a low and mostly flat central plateau.

Two taller ranges flank the northern and southern margins of the Study Area. The northern range comprises several rounded hills (up to approximately 1,000 mAHD) rising moderately steeply from the valley floor (below 700 mAHD). The range to the south is a much steeper, taller range rising to over 1,080 mAHD, also striking approximately east-west. The valley floors that dominate the majority of the Study Area decrease gradually in slope to the western section of the Study Area and beyond.

3.4 Drainage and indicative catchments

The Study Area is located within the Turee Creek Catchment, adjacent to the regional catchment divide between the Ashburton River and Fortescue River catchments. Deposits C, D and G are located in the upper reaches of Turee Creek, and are intersected by minor creeks which flow into the east branch of Turee Creek (Turee Creek East). The major ranges within and adjacent to the Study Area dominate the local runoff patterns, shedding water from their flanks via steep gullies on to the valley floor and into Turee Creek East via two main tributaries, one in the northern section of the Study Area (running east-west to the immediate north of Deposits C and G) and one in the South, running south of Deposit D (Figure 3.4).

Turee Creek East extends from the relatively low lying hills and central plateau formed in Jeerinah Formation (in the centre of the Anticline), flowing north west to exit the plateau in the vicinity of Deposit G. The main creek line meanders past the northern margin of Deposit C in a westerly direction, before joining other tributaries coming from the southern flanking valley adjacent Deposit D, and further to the south. To the west of the Study Area, Turee Creek East turns south-westerly and descends through Karijini Gorge, emptying onto a wide floodplain several kilometres across, before merging with the main arm of Turee Creek (Figure 3.4).



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Deposit B
Deposit G
Deposit C
Deposit D
Deposit A
Deposit F
Deposit E
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Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Legend
Pilbara Rail
West Angelas Current Mining Operations
Study Area (Deposits C, D, G)
Proposed Deposit C Pit
Proposed Deposit D Pit
Proposed Deposit G Pit
Proposed Deposit F Pits
10m Contours
Elevation (mAHD)
650 - 680
690 - 710
720 - 730
740 - 760
770 - 780
790 - 800
810 - 820
830 - 840
850 - 870
880 - 900
910 - 930
940 - 960
970 - 990
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1030 - 1050
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1110 - 1130
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biologic Environmental Survey
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Rio Tinto Iron Ore - West Angelas Project
Deposits C, D, & G Subterranean Fauna Survey
Fig. 3.3: Topography of the Study Area
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 24/05/2016

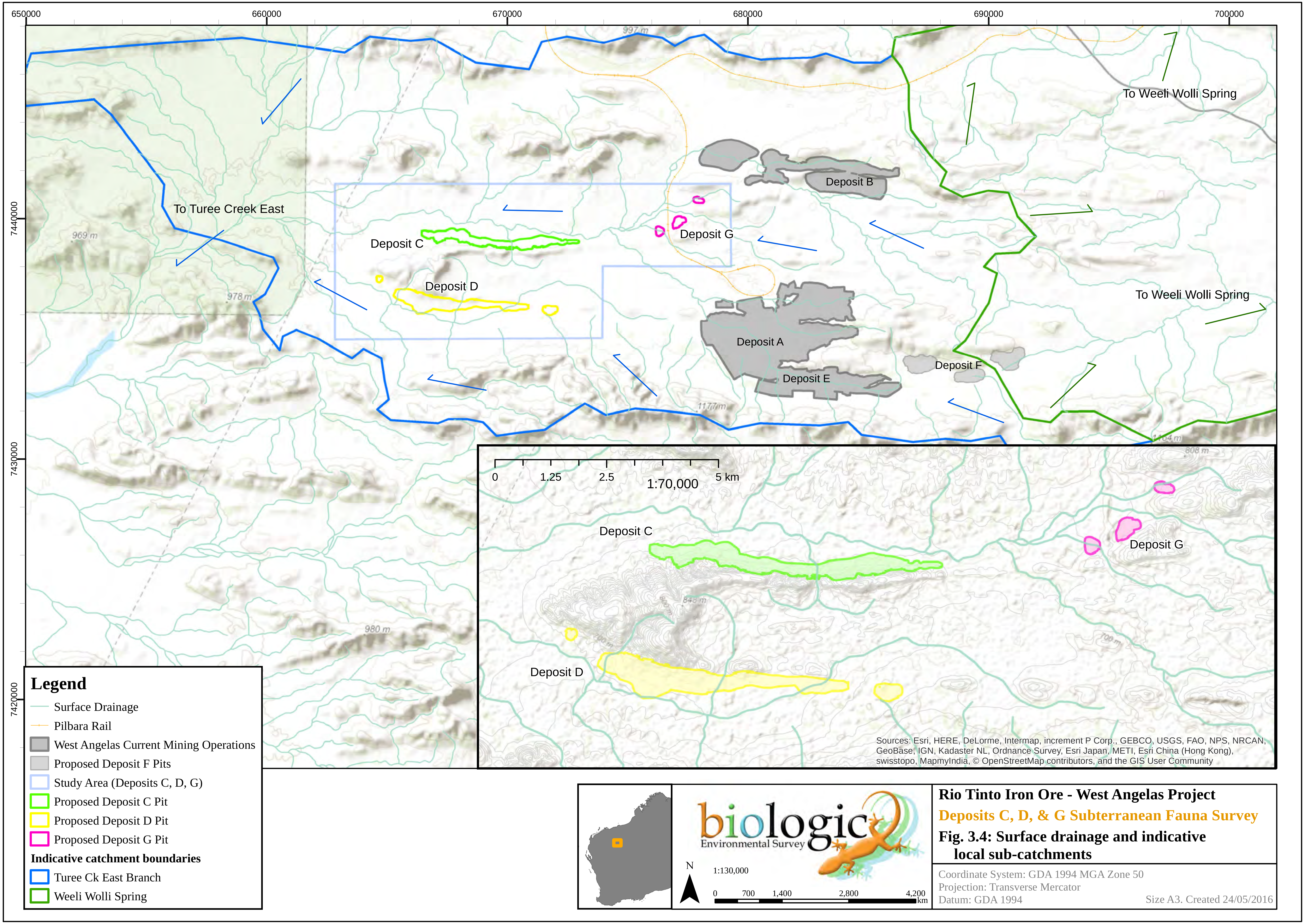


Fig. 3.4: Surface drainage and indicative local sub-catchments

3.5 Hydrogeology

The local hydrogeology around West Angelas is relatively complex, with a number of different formations forming aquifers of various permeability and depth, some of which also appear to be discontinuous from others nearby.

Central plateau (Jeerinah Formation)

Groundwater levels on the low lying central plateau are relatively shallow, ranging between 10-20 metres below ground level (mbgl) in the Jeerinah Formation, in stark contrast to the greater depths to water (up to 140 mbgl) within the flanking valleys. Groundwater levels decline steeply between the Jeerinah Formation of the central plateau and the mineralised Marra Mamba formation on its flanks (*i.e.* in a north-south cross section), indicating either very low permeabilities across the basal Marra Mamba Members, or potentially a lack of hydraulic connection altogether between the plateau and the southern flanking valley (Dodson 2006).

Groundwater flow in the West Angelas area is characterised by steep hydraulic gradients across the Jeerinah Formation, indicating relatively low permeability (Dodson 2006). Water flows from the Jeerinah Formation into the north and south flanking valleys, probably following surface watercourses, where groundwater levels are higher and permeability may be increased by unconsolidated alluvial deposits.

Flanking valleys (Tertiary detritals)

Within the flanking valleys groundwater levels are generally flat and very deep (generally 90-140 mbgl) and no major regional aquifer has been encountered to date. Groundwater flow in the flanking valleys is from east to west, and is generally characterised by very flat hydraulic gradients, with smaller areas of very steep gradients between deposits (particularly between Deposit A and E, and between Deposit F and E) and within some deposits (particularly Deposit A). These anomalies suggest a series of discontinuous porous zones at the bottom of the valley, separated by barriers of low permeability shale or banded iron as a result of structural folding (as if in a series of subterranean terraces or 'bath-tubs') (Dodson 2006).

From the western end of Deposit A throughout Deposit D (a distance of 12 km), the water table relative to ground level is almost flat, probably due to the higher permeability associated with the mineralised Newman Member of the Marra Mamba Formation.

Groundwater within the southern flanking valley has a TDS range of between 400 – 800 mg/L. The deep water table and low permeability Tertiary overburden would indicate very low recharge rates. Groundwater modelling indicates recharge rates in the order of 0.7% of annual rainfall, consistent with other sites across the Pilbara (Dodson 2006).

Ore bodies (Marra Mamba and Wittenoom formations)

The highest permeabilities are associated with the mineralised ore bodies (*i.e.* the Newman Member of the Marra Mamba Formation and West Angelas Member of the Wittenoom Formation). Recharge to the groundwater flow system would be anticipated from direct rainfall on outcropping Marra Mamba and as infiltration from ephemeral creek flows. Geological cross sections show that these orebodies variably extend below the Tertiary detritals along the flanks of the ranges (Rio Tinto Iron Ore 2015). Orebody aquifers may become confined at depth by clays or other low permeability substrates in such cases.

4 METHODS

4.1 Database review

Four databases were searched for subterranean fauna records in May 2016 (Table 4.1):

- Department of Parks and Wildlife NatureMap database (DPaW 2016);
- Atlas of Living Australia (ALA 2016);
- Western Australian Museum (WAM) Arachnida/ Myriapoda database; and
- WAM Crustacea database.

All records were filtered based on collection methods and known stygofauna/ troglofauna taxonomic groups where information on subterranean status (*i.e.* subterranean/ soil fauna/ surface fauna) was not present.

Table 4.1. Databases searched for subterranean fauna records

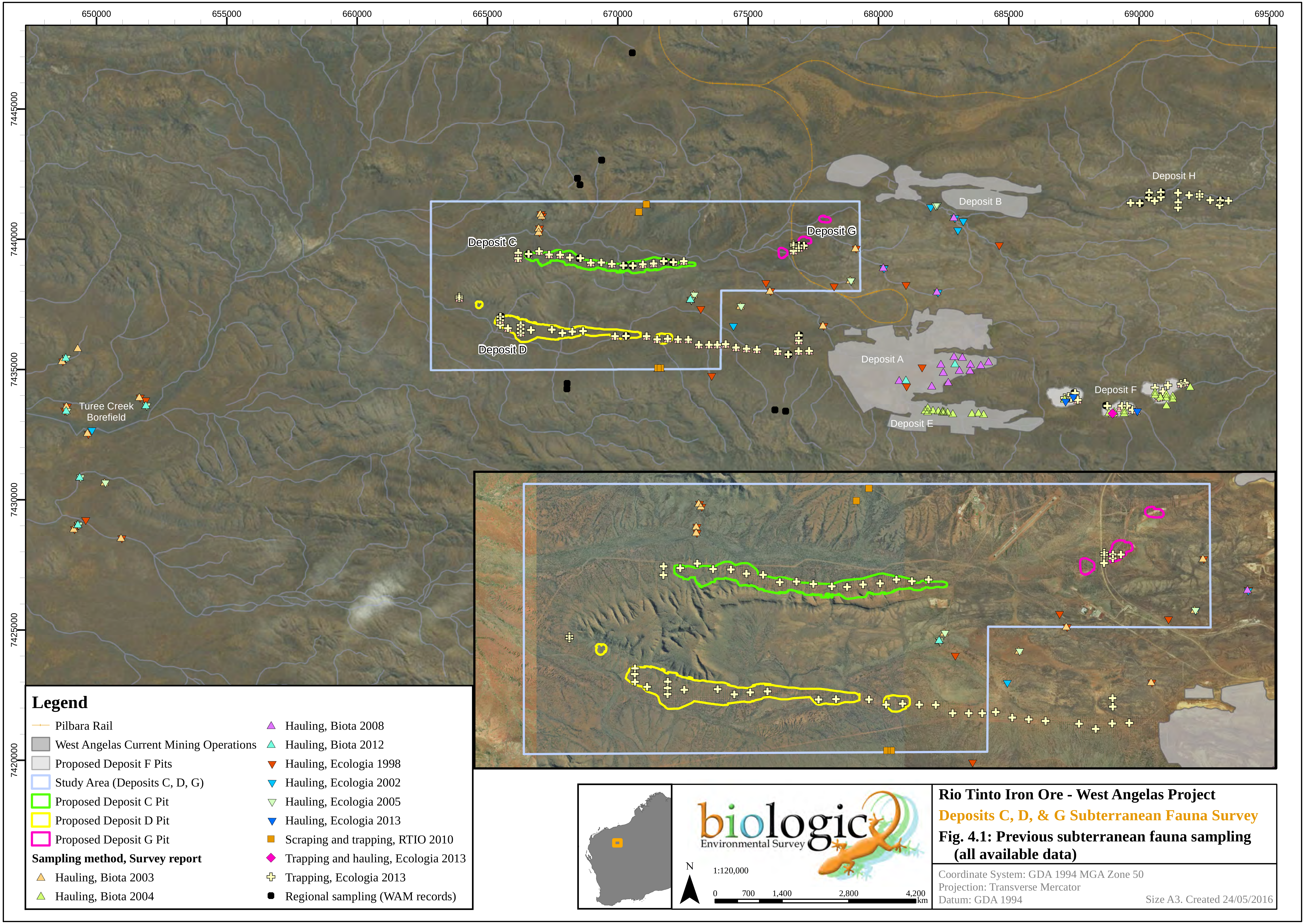
Database	Parameters
NatureMap	20 km radius around 23°09`52"S and 118°43`57"E
ALA	10 km radius around 23°09`52"S and 118°43`57"E
WAM Arachnida/ Myriapoda WAM Crustacea	Bounding box (approx.120 km x 80 km) Northwest 22°52`03"S and 118°10`50"E Southeast 23°29`20"S and 119°28`46"E

4.2 Previous reports

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

- West Angelas Iron Ore Project Stygofauna Assessment Survey (Ecologia 1998);
- West Angelas Iron Ore Project Stygofauna Assessment Survey (Ecologia 2002);
- West Angelas Stygofauna Survey (Biota 2003);
- Subterranean Fauna Survey West Angelas Expansion Deposits E and F (Biota 2004);
- West Angelas Stygofauna Monitoring Programme Report (Ecologia 2005);
- West Angelas and Deposit A Stygofauna Survey (Biota 2008);
- Rio Tinto Iron Ore Regional Troglofauna Sampling (RTIO 2010)
- West Angelas Stygofauna Survey 2012 (Biota 2012); and
- Greater West Angelas Subterranean Fauna Assessment (Ecologia 2013).

Figure 4.1 shows the locations of previous sampling based on available data from the reports listed above.


650000
655000
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665000
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675000
680000
685000
690000
695000
7445000
7440000
7435000
7430000
7425000
7420000
Deposit C
Deposit D
Deposit G
Deposit B
Deposit H
Deposit A
Deposit F
Deposit E
Turee Creek Borefield
Legend
Pilbara Rail
West Angelas Current Mining Operations
Proposed Deposit F Pits
Study Area (Deposits C, D, G)
Proposed Deposit C Pit
Proposed Deposit D Pit
Proposed Deposit G Pit
Sampling method, Survey report
Hauling, Biota 2003
Hauling, Biota 2004
Hauling, Biota 2008
Hauling, Biota 2012
Hauling, Ecologia 1998
Hauling, Ecologia 2002
Hauling, Ecologia 2005
Hauling, Ecologia 2013
Scraping and trapping, RTIO 2010
Trapping and hauling, Ecologia 2013
Trapping, Ecologia 2013
Regional sampling (WAM records)
biologic
Environmental Survey
N
1:120,000
0 700 1,400 2,800 4,200
km
Rio Tinto Iron Ore - West Angelas Project
Deposits C, D, & G Subterranean Fauna Survey
Fig. 4.1: Previous subterranean fauna sampling (all available data)
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 24/05/2016

Extensive previous surveys have also been undertaken in similar geologies further north of the Study Area at BHP Billiton Iron Ore's Mining Area C (Bennelongia 2011a), South Flank (Bennelongia 2011b), Coondewanna/ Mudlark (Bennelongia 2011c; Subterranean Ecology 2009), as well as nearby to the west at Wonmunna (E. Volschenk pers. comm. 2016), and south west at Angelo River (Subterranean Ecology 2012). Subterranean fauna records from these areas were included via the WAM database search, although the survey reports from these areas were not reviewed herein.

4.3 Site selection for sampling

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), and whether the holes intercepted groundwater (required for stygofauna).

Ninety-two (92) bores and holes were sampled over the course of two field trips, respectively 15 – 23 March 2016, and 10 – 12 May 2016. In total, 45 holes were sampled by troglofauna trapping (using a single trap), 54 bores and holes were sampled by scraping for troglofauna, and 25 were sampled by net hauling for stygofauna. Some holes were sampled during both trips while others were sampled using combined net hauling/ scraping/ trapping methods. Two troglofauna traps were lost to disturbance.

The final number of samples from the survey comprised 43 troglofauna traps, 71 troglofauna scrapes and 29 stygofauna net hauls. Tables 4.2 and 4.3 provide details of bores and drill holes visited sampled within the Study Area, with respect to the methods employed and the deposits targeted, and Figure 4.2 shows the location of holes visited and sampled throughout the Study Area.

Table 4.2: Numbers of samples collected within and near each deposit , over the course of two field trips

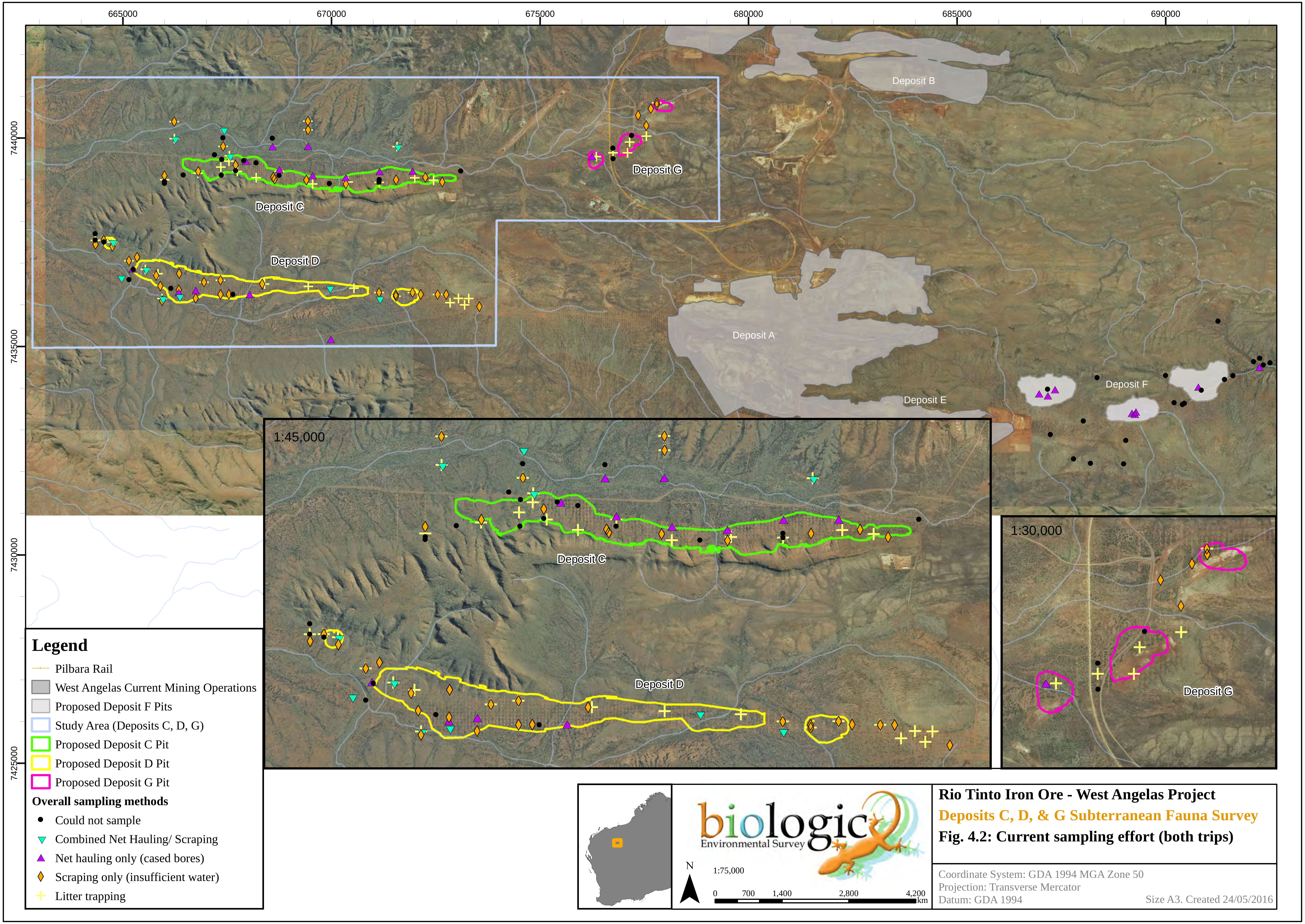
TRIP 1 SAMPLING	C deposit	C reference	D deposit	D reference	G deposit	G reference	Total
Net hauling	4	4	3	2	1		14
Scraping	9	2	9	7	2	3	32
Combined scrape/ net haul		4	2	2			8
Trap deployed	10	9	10	10	4	2	45
Total (exc. traps deployed)	**13**	**10**	**14**	**11**	**3**	**3**	**54**
TRIP 2 SAMPLING							
Scraping	6	5	6	7	1	1	25
Combined scrape/ net haul		2	2	2			7
Trap retrieved	9	9	10	9	4	2	43
Total (Trip 2)	**15**	**16**	**18**	**17**	**4**	**3**	**69**
Grand total, all samples	**28**	**22**	**32**	**28**	**7**	**6**	**123**
Total troglofauna samples	24	22	29	27	6	6	114
Total stygofauna samples	4	10	7	6	1	0	28

Table 4.3: Bores and drill holes visited and sampled during the survey

Hole ID	Latitude GDA94	Longitude GDA94	Deposit	Hole type	Trip 1 sampling	Trip 2 sampling
MB14WAC0001	-23.145318	118.6404098	C (inside)	Piezo bore; Collared; Monitoring	Net hauling	n/a
RC14WAC0019	-23.14898088	118.6756054	C (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC14WAC0030	-23.15000561	118.6638843	C (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC14WAC0033	-23.14862381	118.6638648	C (inside)	Piezo bore; Collared; Monitoring	Net hauling	n/a
RC14WAC0049	-23.1476605	118.6292731	C (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC14WAC0071	-23.1474852	118.6482517	C (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC14WAC0107	-23.14534605	118.6364701	C (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC14WAC0121	-23.1472141	118.6717256	C (inside)	Piezo bore; Capped; Cased bore	Net hauling	n/a
RC14WAC0122	-23.14711608	118.6794663	C (inside)	Piezo bore; Collared; Monitoring	Net hauling	n/a
RC14WAC0179	-23.1500861	118.6560801	C (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAC0060	-23.1495722	118.6643849	C (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAC0124	-23.14926792	118.6546109	C (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC15WAC0196	-23.14874652	118.6468826	C (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC15WAC0197	-23.14916763	118.64717	C (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC15WAC0214	-23.1488616	118.6428773	C (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAC0236	-23.1484983	118.6800041	C (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAC0272	-23.1489741	118.6844199	C (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAC0276	-23.14933661	118.6864305	C (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC15WAC0288	-23.14840291	118.6824687	C (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC15WAC0346	-23.1475739	118.6384563	C (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAC0354	-23.14619784	118.6380192	C (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC15WAC0377	-23.1466853	118.634575	C (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
GR15WAC0022	-23.1480455	118.6292399	C (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
MB14WAC0002	-23.147029	118.6482527	C (nearby)	Piezo bore; Collared; Monitoring	Net hauling	n/a
RC14WAC0092	-23.1495673	118.621438	C (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC14WAC0093	-23.1486607	118.6213898	C (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC14WAC0120	-23.1483061	118.6560689	C (nearby)	Piezo bore; Collared; Monitoring	Net hauling	n/a
RC15WAC0324	-23.1441859	118.6365285	C (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping, Net hauling	Trap retrieved, Scraping, Net hauling
RC15WAC0380	-23.1418025	118.675747	C (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping, Net hauling	Trap retrieved, Scraping, Net hauling
RC15WAC0383	-23.1421987	118.6350445	C (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC15WAC0384	-23.13858858	118.6350041	C (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping, Net hauling	n/a

Hole ID	Latitude GDA94	Longitude GDA94	Deposit	Hole type	Trip 1 sampling	Trip 2 sampling
RC15WAC0387	-23.1406219	118.6235951	C (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping, Net hauling	Trap retrieved, Scraping
RC15WAC0390	-23.1369128	118.6235258	C (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC15WAC0413	-23.14194771	118.6549089	C (nearby)	Uncased RC Hole; Capped; Rehab.	Net hauling	n/a
RC15WAC0414	-23.1384017	118.6548818	C (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	Trap retrieved, Scraping
RC15WAC0415	-23.1365315	118.6548295	C (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC15WAC0416	-23.1420916	118.646595	C (nearby)	Uncased RC Hole; Capped; Rehab.	Net hauling	n/a
DD12WAD0005	-23.17259698	118.6602198	D (inside)	Diamond drilled; Rehabilitated	Scraping, Net hauling	n/a
MB13WAD0012	-23.17345378	118.6290323	D (inside)	Piezo bore; Collared; Monitoring	Net hauling	n/a
MB13WAD0015	-23.17389693	118.6250382	D (inside)	Piezo bore; Collared; Monitoring	Net hauling	n/a
MB14WAD0001	-23.17415547	118.6416409	D (inside)	Piezo bore; Collared; Monitoring	Net hauling	n/a
RC12WAD0181	-23.1733677	118.6797704	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC12WAD0188	-23.1742194	118.6758824	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC12WAD0189	-23.17387212	118.675839	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC12WAD0293	-23.1641192	118.6093652	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC12WAD0295	-23.163184	118.6093315	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping, Net hauling
RC12WAD0338	-23.1689974	118.6171594	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping, Net hauling
RC12WAD0359	-23.1716732	118.6309154	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC12WAD0387	-23.17189151	118.6445629	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC13WAD0218	-23.1725988	118.6660572	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC13WAD0255	-23.17423338	118.6367515	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC13WAD0285	-23.17258734	118.6206952	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC13WAD0287	-23.17426527	118.6348287	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC13WAD0297	-23.17479132	118.6250782	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping, Net hauling	n/a
RC14WAD0098	-23.16982957	118.6250863	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC14WAD0131	-23.1699086	118.6201563	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC14WAD0217	-23.17031706	118.6196661	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC14WAD0278	-23.1711698	118.6347804	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC15WAD0041	-23.1718967	118.6451147	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAD0082	-23.17516725	118.6289899	D (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC15WAD0124	-23.1723069	118.6553487	D (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
MB14WAD0009	-23.18372475	118.660794	D (nearby)	Piezo bore; Collared; Monitoring	Net hauling	n/a
RC12WAD0166	-23.17373507	118.6876409	D (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a

Hole ID	Latitude GDA94	Longitude GDA94	Deposit	Hole type	Trip 1 sampling	Trip 2 sampling
RC12WAD0171	-23.1737531	118.6856437	D (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC12WAD0177	-23.1737497	118.6816791	D (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC12WAD0198	-23.1734661	118.6719363	D (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC12WAD0200	-23.17474404	118.6719209	D (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping, Net hauling	n/a
RC12WAD0298	-23.1627932	118.6073145	D (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	Trap retrieved, Scraping
RC12WAD0327	-23.1671802	118.6132603	D (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping
RC12WAD0402	-23.1637181	118.6054036	D (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC13WAD0276	-23.1752817	118.6211617	D (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved, Scraping, Net hauling
RC13WAD0277	-23.1757381	118.6211284	D (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC13WAD0294	-23.17339506	118.6250224	D (nearby)	Uncased RC Hole; Capped; Rehab.	n/a	Scraping
RC14WAD0006	-23.1762861	118.6954531	D (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC14WAD0220	-23.1754994	118.6885896	D (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC14WAD0346	-23.17088061	118.6113448	D (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping, Net hauling	Scraping, Net hauling
RC14WAD0350	-23.1663807	118.6151722	D (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC14WAD0389	-23.1744994	118.6905443	D (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC14WAD0424	-23.1759243	118.6920001	D (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC14WAD0439	-23.174539	118.6929827	D (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAD0103	-23.16894934	118.6141778	D (nearby)	Piezo bore; Collared; Monitoring	Net hauling	n/a
MB15WAG0002	-23.14346211	118.721472	G (inside)	Piezo bore; Collared; Monitoring	Net hauling	n/a
RC15WAG0160	-23.14255339	118.7297168	G (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAG0190	-23.14023759	118.7302222	G (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAG0243	-23.14344941	118.7224309	G (inside)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAG0280	-23.13211289	118.7364525	G (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC15WAG0281	-23.13162083	118.7364111	G (inside)	Uncased RC Hole; Capped; Rehab.	Scraping	Trap retrieved, Scraping
RC15WAG0175	-23.13888651	118.7340883	G (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAG0222	-23.14258813	118.7263305	G (nearby)	Uncased RC Hole; Capped; Rehab.	Trap deployed	Trap retrieved
RC15WAG0285	-23.13293628	118.7350308	G (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a
RC15WAG0290	-23.13661028	118.73405	G (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	Scraping
RC15WAG0296	-23.13438166	118.7320935	G (nearby)	Uncased RC Hole; Capped; Rehab.	Scraping	n/a



Rio Tinto Iron Ore - West Angelas Project

Deposits C, D, & G Subterranean Fauna Survey

Fig. 4.2: Current sampling effort (both trips)

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A3. Created 24/05/2016

4.4 Sampling methods

The sampling methods used were consistent with EAG #12 (EPA 2013), Guidance Statement #54A (EPA 2007) and the Stygofauna Sampling Protocol developed for the Pilbara Biodiversity Study Subterranean Fauna Survey (Eberhard *et al.* 2005, 2009).

The sampling was undertaken by Mr Shae Callan and Mr Erich Volschenk.

Water physicochemistry

Prior to stygofauna sampling, attempts were made to obtain a groundwater sample using a 1 m plastic cylindrical bailer, for the purposes of physicochemical measurements. Unfortunately, due to the considerable depth of the water table (80-120 m), none of the bailer samples reached the surface intact, due to the bailer contacting the sides of the bore/ drill hole, causing the seal to open and the water to be discharged.

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 80 mm). Each hauling sample comprised a total of six hauls from the bottom of the hole to the top, including 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 jug of water, which was elutriated after the final haul to remove coarse sediments, and filtered back through the 50 µm net/ sample receptacle to remove the majority of the water. 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.

Troglofauna sampling was undertaken using two separate collecting techniques; trapping and scraping.

Trapping

Trapping utilised custom made cylindrical PVC traps (approximately 50 mm x 300 mm) baited with decaying leaf litter (dead spinifex sourced from the Pilbara region), which had been sterilised with boiling water and inoculated with cooking yeast for a month leading up to the survey. Traps were lowered via a nylon cord to a depth approximately 25 – 30 m below surface, or within 1 m above the water table if closer. Holes were sealed while the traps were set, to minimise incursions of surface fauna and to maintain a humid atmosphere within the drill hole. The traps were collected after eight weeks, and stored in paper bags (to alleviate excess moisture) within zip-lock bags for transport back to the laboratory in Perth. Samples were kept cool in insulated boxes during transport.

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 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, six (6) hauls were conducted throughout the full length of the hole from top to bottom, representing a combined net haul/ scrape sample. The contents of the sample were elutriated, processed, and stored in 100 % ethanol as per net hauling.

4.5 Sorting and taxonomy

Sorting and parataxonomy were undertaken in-house using dissecting microscopes. The personnel involved (S. Callan and E. Volschenk) were suitably trained and experienced in both 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. Certain taxonomic groups (such as amphipods, bathynellaceans, copepods, ostracods, arachnids and myriapods) were examined in as much detail as possible using in-house expertise, before sending a reference collection to specialist taxonomists for detailed taxonomic advice. All troglofauna specimens were submitted to the WAM for verification of identifications and specialist advice where available.

The taxonomists undertaking specialist identifications included E. Volschenk (all parataxonomy, hexapod taxonomy), G. Perina (amphipods and bathynellaceans), J. McRae (copepods), S. Halse (ostracods), and T. Moulds and K. Abrams of the WAM (arachnids and myriapods). Specialist taxonomic reports are presented in Appendices E, F, and G.

4.6 Conservation status and SRE classification

A few subterranean species and assemblages are listed under relevant legislation as threatened species or Threatened or Priority Ecological Communities following various ranking systems described in detail in Appendix A. 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 4.4). 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 4.4: SRE categorisation used by WAM taxonomists

<table>
<tr><th></th><th>Taxonomic Certainty</th><th>Taxonomic Uncertainty</th></tr>
<tr><td>Distribution
<10 000km^2</td><td>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.</td><td rowspan="2">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</td></tr>
<tr><td>Distribution
>10 000km^2</td><td>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.</td></tr>
</table>

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.

4.7 Limitations

Many subterranean species (particularly troglofauna) are very rare and difficult to detect. Subterranean fauna inhabit cryptic, concealed habitats which renders them inherently difficult to assess. Much remains uncertain regarding the taxonomy and ecological status of many of the faunal groups, and for some groups, the taxonomic framework is very poorly developed or lacking entirely, which provides challenges for the interpretation of sampling results and species distributions.

These general factors were taken into account when designing the survey and analysing the data, although in some cases, residual uncertainty is unavoidable. The results and conclusions of the survey are based upon the best information available under these conditions, including independent advice from taxonomic specialists.

Specific limitations relating to the current and previous survey data include:

1. The majority of stygofauna sampled from previous surveys have not been identified to species-level. This may be because most of the previous surveys took place before the taxonomy of these groups was sufficiently developed to enable detailed identifications. The lack of species-level identifications (or genetic data) limits the current ability to compare local species distributions across different groundwater zones. The conclusions of the risk assessment may be subject to change if species-level identifications of the previously collected specimens are achievable.
2. At the time of writing, genetic analysis had not been undertaken for the majority of taxa collected during the survey. For some of the less common subterranean taxa, this would not materially change the assessment due to a lack of regional sequences to provide context for the current specimens; however, there are other groups for which regional context is available, and genetic analysis may provide additional information to aid the assessment of species boundaries and SRE statuses. The results of on-going genetic and taxonomic investigations will be added to this report as an addendum.
3. Not all holes are suitable for each of the various subterranean sampling techniques, and the layout of sampling sites was contingent upon the location and suitability of different types of bores and holes, inside and outside of the deposits. For example, within Deposits C and G, the high proportion of angled (rather than vertical) holes restricted scraping and net hauling to certain areas. Within Deposit G and at areas higher in the landscape at Deposit C and D, it was difficult to find holes that intercepted groundwater, which restricted net hauling to lower areas. Many holes that did intercept groundwater at Deposits C and D had been converted into 50 mm cased piezometers for groundwater monitoring. These bores were difficult to sample owing to their narrow diameter (resulting in nets becoming stuck), and the depth of their slotted interval, which excluded the superficial aquifers that are generally more suitable for stygofauna.
4. The habitat assessment was limited to available geological cross-sections, bore logs, and geological/ hydrogeological reports. Despite the variety of detailed information available to the assessment, there are always some residual knowledge gaps, and assessments rely upon inference between data points. The current assessment includes only limited groundwater physicochemical data, as the depth to groundwater in most areas made it difficult to obtain water samples using a bailer. In any case, the conditions within bores and drill holes may often be considerably different than those in the wider aquifer, owing to water mixing, presence of an open surface, and the characteristics of the casing, if present.

5. The risk assessment for stygofauna relies upon the area of groundwater dewatering/ drawdown, which can propagate well beyond the deposit boundaries. At the time of writing, no detailed groundwater drawdown modelling scenarios were available for the risk assessment of stygofauna. As a result, the likely extent of drawdown throughout the major groundwater habitats of relevance to stygofauna (in the area of the deposits) was inferred, based on available geological and hydrogeological information, and the proposed depth of mining. Nevertheless, without detailed modelling of the depth and extent of groundwater drawdown, the assessment is unable to precisely characterise the risk to stygofauna species and assemblages, and the conclusions of the assessment may be subject to change when the results of groundwater drawdown modelling are available.

5 FAUNAL RESULTS

5.1 Database searches

The NatureMap search revealed ten known stygofauna taxa from five orders (Ostracoda, Bathynellacea, Amphipoda, Harpacticoida, and Oligochaeta) within 20 km surrounding the West Angelas area (Table 5.1). There were also several higher taxa from the flatworms and mites that could potentially have been detected during stygofauna sampling. The ALA database search did not reveal any additional records of potentially subterranean invertebrates.

Table 5.1: Troglofauna and stygofauna morphospecies recorded in the NatureMap and ALA online databases (search parameters as per Table 4.1).

Higher taxon	Morphospecies	Likely subterranean status	SRE Status where known
Acari	Pezidae sp.	Potential Stygofauna	Unknown
Amphpoda	Paramelitidae sp.	Stygofauna	Unknown
Amphpoda	*Pilbarus millsi*	Stygofauna	Widespread
Bathynellacea	*Notobathynella* sp.	Stygofauna	Potential SRE (E)
Bathynellacea	Parabathynellidae sp.	Stygofauna	Potential SRE (E)
Harpacticoida	*Parastenocaris* sp.	Stygofauna	Unknown (likely Widespread)
Oligochaeta	*Insulodrilus angela*	Stygofauna	Widespread
Oligochaeta	Phreodrilid with dissimilar ventral chaetae	Stygofauna	Unknown
Oligochaeta	Phreodrilid with similar ventral chaetae	Stygofauna	Unknown
Turbellaria	Turbellaria sp.	Stygofauna	Unknown
Araneae	*Opopaea* sp.	Troglofauna	Potential SRE (E)
Pseudoscorpiones	*Indolpium* sp.	Potential Troglofauna	Unknown

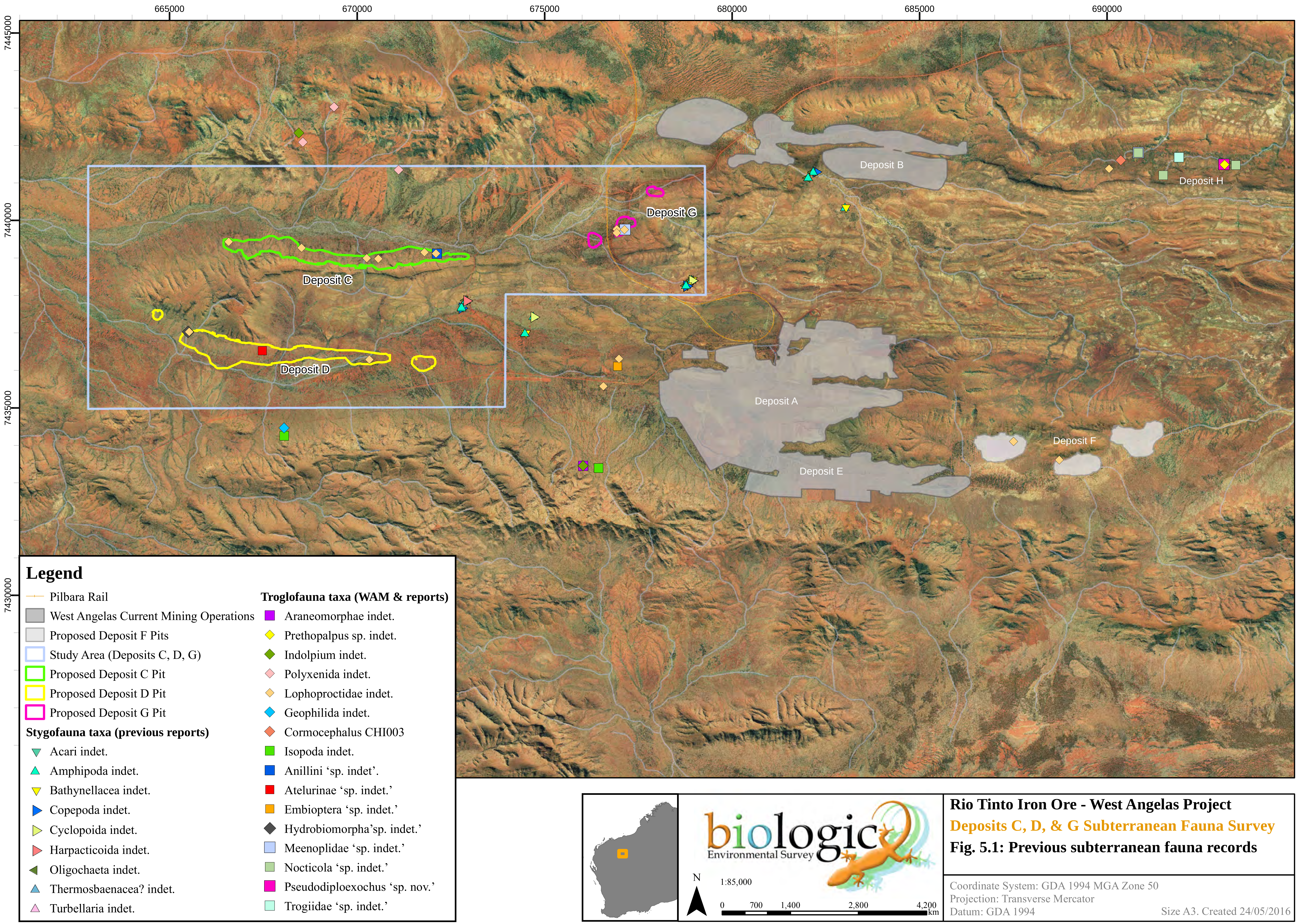
The WAM records revealed eight stygofauna (and possible stygofauna) taxa, and 11 troglofauna (and possible troglofauna) taxa detected within 10 km of the Study Area. The locations of stygofauna and troglofauna from the WAM records and previous surveys are shown in Figure 5.1 and Table 5.2. Particularly for the stygofauna taxa, the majority of the records comprise indeterminate order-level taxa from previous surveys at West Angelas, therefore the actual number of species may be underestimated.

Based on current knowledge, none of the named stygofauna or troglofauna taxa recorded from database searches appear on any of the threatened species lists; however, owing to the indeterminate identifications of most of the taxa recorded, a high proportion of records cannot be assessed.

The current lists of Threatened and Priority Ecological Communities (respectively June 2015 and December 2015) do not identify any subterranean communities of relevance to the West Angelas area.

Table 5.2: Troglofauna and stygofauna morphospecies recorded in the WAM databases (search parameters as per Table 4.1).

Higher taxon	Morphospecies	Likely subterranean status	SRE Status where known
Acari	Acari indet.	Possible stygofauna	Unknown
Amphipoda	Amphipoda indet.	Stygobite	Unknown
Bathynellacea	Bathynellacea indet.	Stygobite	Potential SRE (E)
Copepoda	Copepoda indet.	Likely stygofauna	Unknown
Cyclopoida	Cyclopoida indet.	Stygobite	Unknown
Harpacticoida	Harpacticoida indet.	Stygobite	Potential SRE (E)
Oligochaeta	Oligochaeta indet.	Stygobite	Unknown
Turbellaria	Turbellaria indet.	Likely stygofauna	Unknown
Isopoda	Isopoda sp. indet.	Troglobite	Potential SRE (E)
Araneae	Gnaphosidae indet.	Troglobite	Potential SRE (E)
Araneae	*Prethopalpus* sp. indet.	Troglobite	Potential SRE (E)
Araneae	Theridiidae indet.	Troglobite	Potential SRE (E)
Araneae	Araneomorphae indet.	Possible troglofauna	Unknown
Pseudoscorpiones	*Lagynochthonius* PSE041	Troglobite	Confirmed SRE
Pseudoscorpiones	*Indolpium* indet.	Troglobite	Potential SRE (E)
Palpigradi	Palpigradi indet.	Troglobite	Potential SRE (E)
Polyxenida	Lophoproctidae indet.	Likely soil fauna	Widespread
Polyxenida	Polyxenida indet.	Possible troglofauna	Unknown
Geophilida	Geophilida indet.	Troglobite	Potential SRE (E)
Scolopendromorpha	*Cormocephalus* CHI003	Troglobite	Potential SRE (E)



Rio Tinto Iron Ore - West Angelas Project

Deposits C, D, & G Subterranean Fauna Survey

Fig. 5.1: Previous subterranean fauna records

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

Size A3. Created 24/05/2016

5.2 Previous survey results

Of the 10 previous surveys conducted in the local area of West Angelas, only one has sampled bores/ drill holes within the current deposits. Ecologia's (2013) Greater West Angelas survey sampled extensively for troglofauna (trapping) within Deposits C, D and G (Table 5.3, Figure 4.1). A small number of sites in areas nearby the current deposits were also previously sampled, for example the Ecologia 1998 and Biota 2003 surveys sampled four holes to the immediate north of Deposit C, and most of the previous stygofauna surveys sampled extensively throughout the central plateau between Deposit C and D (and further to the east).

Ecologia (2013) recorded four taxa of interest from the current deposits (refer Figure 5.1; Table 5.3), comprising:

- Coleoptera: Anillini sp. indet. – likely troglobite detected within Deposit C, considered to be a 'likely' SRE;
- Coleoptera: *Hydrobiomorpha* sp. indet. – potential troglofauna detected within Deposit D, considered to be a potential SRE;
- Thysanura: Atelurinae sp. indet. – potential troglofauna detected within Deposit D, considered to be a 'likely' SRE; and
- Hemiptera: Meenoplidae sp. indet. – potential troglofauna detected within Deposit G, considered to be a potential SRE.

No stygofauna sampling has been conducted within any of the current deposits, therefore no previous records of stygofauna exist. Multiple previous stygofauna surveys detected stygofauna in the wider local area of the Study Area, including Ecologia 1998, 2002, 2005, and Biota 2003, 2008b, which sampled stygofauna from bores in the central plateau, near Deposits A and B, and also within the Turee Creek Bore field (ranging from approximately 15 - 35 km south east of West Angelas). Despite this, very little is known of the species occurring in the area as the majority of surveys were conducted at a time when identifications to species-level were not readily achievable.

With the exception of Thermosbaenacea (recorded at bore WB51 in Biota 2003), the higher level stygofaunal taxa detected in the local area of West Angelas broadly reflect the groups known throughout the Pilbara region (such as amphipods, bathynellaceans, copepods, oligochaetes and ostracods). In contrast, Thermosbaenacea are rarely collected, being known only from Cape Range, Barrow Island, and the Robe Valley (Eberhard *et al.* 2005). Owing to the absence of this taxon from any previous or subsequent surveys, as well as from the WAM database records, it is considered plausible that this record may have been the result of misidentified specimens.

Table 5.3: Summary of previous subterranean fauna survey effort and results at West Angelas

Previous survey	West Angelas Iron Ore Project Stygofauna Assessment Survey	West Angelas Iron Ore Project Stygofauna Assessment Survey	West Angelas Stygofauna Survey	West Angelas Expansion Deposits E/ F Subterranean Fauna Survey	West Angelas Stygofauna Monitoring Programme Report	West Angelas and Deposit A Stygofauna Survey	West Angelas Operations Stygofauna Compliance Review	Rio Tinto Iron Ore Regional Troglofauna Sampling	West Angelas Stygofauna Survey 2012	Greater West Angelas Subterranean Fauna Assessment
Author, year	**Ecologia 1998**	**Ecologia 2002**	**Biota 2003**	**Biota 2004**	**Ecologia 2005**	**Biota 2008a**	**Biota 2008b**	**RTIO 2010**	**Biota 2012**	**Ecologia 2013**
Fauna targeted	Stygofauna	Stygofauna	Stygofauna	Stygofauna	Stygofauna	Stygofauna	Stygofauna	Troglofauna	Stygofauna	Stygofauna and Troglofauna
Areas sampled	Dep. A, B, C CP, TCB	Dep. A, B CP, TCB	Dep. A, B CP, TCB	Dep. E, F	Dep. A, B CP, TCB	Dep. A	Dep. A, B CP	Beyond Study Area	Dep. A TCB	Dep. C, D, G, F, H
Bores sampled	44	20	30	28	14	17	unknown (3 records)	4	3	95
Bores sampled in current deposits										40
Methods	Net hauling	Net hauling	Net hauling	Net hauling	Net hauling	Net hauling	Net hauling	Trapping	Net hauling	Net hauling, Trapping, Scraping
Stygo collected	Yes	Yes	Yes	No	Yes	No	Yes	No	No	No
Acari		●								
Amphipoda	●	●	●		●		●			
Bathynellacea	●	●					●			
Copepoda	●	●	●		●		●			
Isopoda		●								
Oligochaeta	●	●	●				●			
Ostracoda	●									
Platyhelminthes	●		●							
Thermosbaenacea*			●*							

* Note: Thermosbaenacea may have been the result of misidentified specimens. 'CP' = Central Plateau, 'TCB' = Turee Creek Bore Field.

Table 5.3 Continued.

Previous survey	West Angelas Iron Ore Project Stygofauna Assessment Survey	West Angelas Iron Ore Project Stygofauna Assessment Survey	West Angelas Stygofauna Survey	West Angelas Expansion Deposits E/ F Subterranean Fauna Survey	West Angelas Stygofauna Monitoring Programme Report	West Angelas and Deposit A Stygofauna Survey	West Angelas Operations Stygofauna Compliance Review	Rio Tinto Iron Ore Regional Troglofauna Sampling	West Angelas Stygofauna Survey 2012	Greater West Angelas Subterranean Fauna Assessment
Author, year	**Ecologia 1998**	**Ecologia 2002**	**Biota 2003**	**Biota 2004**	**Ecologia 2005**	**Biota 2008a**	**Biota 2008b**	**RTIO 2010**	**Biota 2012**	**Ecologia 2013**
Trog collected	No	No	No	No	No	No	No	Yes	No	Yes
Isopoda										•
Araneae										•
Pseudoscorpiones										•
Palpigradi										•
Chilopoda										•
Thysanura										•
Psocoptera										•
Coleoptera										•
Hemiptera										•
Blattodea										•
Embioptera										•

Note: Red text denotes taxa collected within the current deposits (refer Figure 5.1).

5.3 Current faunal results

The current survey detected subterranean fauna from 22 bores and holes throughout the Study Area, comprising nine holes at Deposit C, 10 holes at Deposit D, and three at Deposit G (each 'deposit' respectively including nearby areas). In comparison to other regional surveys, a moderately rich fauna of 28 confirmed morphospecies was detected.

The morphospecies comprised four worms, 12 crustaceans, five arachnids, five hexapods, and two myriapods (Table 5.4). One additional, indeterminate taxon (Cyclopoida indet.) refers to a group of specimens that could not be reasonably allocated to the other existing cyclopoid morphospecies due to the need for specialist dissections for identification. This taxon could potentially comprise multiple species, as three morphospecies from this group are already known to occur.

Table 5.4 shows a summary of the morphospecies detected and their subterranean and SRE status, while further details on each of the taxa are presented below, in order of their higher faunal group.

Table 5.4: Subterranean fauna collected from the Study Area during the current survey

Higher taxon	Morphospecies	Subterranean status	SRE Status
Worms			
Haplotaxida			
Enchytraeidae	Enchytraeidae sp. indet.	Stygophile/ Troglophile	Potential SRE (A)
Polychaeta			
Aeolosomatidae	Aeolosomatidae sp. indet.	Stygobite	Potential SRE (A)
Oligochaeta			
	Oligochaeta sp. indet.	Stygobite/ Stygophile	Potential SRE (A)
Turbellaria			
	Turbellaria sp. indet.	Stygobite/ Stygophile	Potential SRE (A)
Crustaceans			
Amphipoda			
Paramelitidae	*Kruptus* sp. \`WA\`	Stygobite	Potential SRE (E)
Paramelitidae	*Maarrka* sp. \`WA\`	Stygobite	Potential SRE (E)
Bathynellacea			
Parabathynellidae	*Atopobathynella* sp. \`WA\`	Stygobite	Potential SRE (E)
Bathynellidae	Bathynellidae sp. \`WA\`	Stygobite	Potential SRE (E)
Cyclopoida			
Cyclopidae	*Metacyclops* sp. \`B01\` (nr. pilbaricus)	Stygobite	Widespread
Cyclopidae	*Microcyclops varicans*	Stygobite	Widespread
Cyclopidae	*Thermocyclops* sp. \`WA\`	Stygobite	Potential SRE (E)
Indeterminate specimens	Cyclopoida indet.*	Stygobite	Potential SRE (A)
Harpacticoida			
Canthocamptidae	*Australocamptus* sp. \`B13\`	Stygobite	Potential SRE (E)

Higher taxon	Morphospecies	Subterranean status	SRE Status
Parastenocaridae	*Parastenocaris* sp. indet.	Stygobite	Potential SRE (A)
Ostracoda			
Candonidae	*Notacandona gratia*	Stygobite	Widespread
Isopoda			
Armadillidae	Armadillidae sp. indet.	Troglobite	Confirmed SRE (previous regional sequencing)
	Isopoda indet. (damaged)	Potential troglobite	Potential SRE (A)
Arachnids			
Araneae			
Gnaphosidae	Gnaphosidae sp. indet.	Troglobite	Potential SRE (E)
Oonopidae	Oonopidae sp. indet.	Troglobite	Potential SRE (E)
Pseudoscorpiones			
Chthoniidae	*Lagynochthonius* sp. \`PSE101\`	Troglobite	Confirmed SRE
Chthoniidae	*Tyrannochthonius* sp. \`PSE102\`	Troglobite	Confirmed SRE
Schizomida			
Hubardiidae	*Draculoides* sp. \`SCH051\`	Troglobite	Confirmed SRE
Hexapods			
Diplura			
Campodeidae	Campodeidae sp. indet.	Potential troglobite	Potential SRE (A)
Hemiptera			
Meenoplidae	Meenoplidae sp. indet.	Potential troglobite	Potential SRE (A)
Thysanura			
Nicoletiidae	Atelurinae sp. indet.	Potential troglobite	Potential SRE (A)
Collembola			
Cyphoderidae	Cyphoderidae sp. indet.	Potential troglobite	Potential SRE (A)
Sminthuridae	Sminthuridae sp. indet.	Potential troglobite	Potential SRE (A)
Myriapods			
Symphyla			
Scutigerellidae	Scutigerellidae sp. indet.	Potential troglobite	Potential SRE (A)
	Symphyla indet. (damaged)	Potential troglobite	Potential SRE (A)
Total	**28 morphospecies***		

*Note: total number of morphospecies excludes indeterminate copepod specimens grouped together under ‘Cyclopoida indet.’, as multiple species may occur within this group.

5.3.1 Worms

Four morphospecies of worms (considered here to comprise Annelida and Platyhelminthes) were detected at Deposits C, D and the nearby areas. The taxa comprised Enchytraeidae sp. indet. (Haplotaxida), Aeolosomatidae sp. indet. (Polychaeta), Oligochaeta sp. indet. (Oligochaeta), and Turbellaria sp. indet. (Turbellaria) (Figure 5.2, Table 5.5). These taxonomic groups are often inherently small, eyeless (excluding Turbellaria), narrow, and pale or white, therefore morphological features cannot be used to determine their subterranean status.

Table 5.5: Worms detected at each deposit and nearby areas during the survey

Taxon	C inside	C nearby	D inside	D nearby	Total	Subterranean status	SRE Status
Haplotaxida							
Enchytraeidae sp. indet.		35	77	12	115	Stygophile/ Troglophile	Potential SRE (A)
Polychaeta							
Aeolosomatidae sp. indet.	34				34	Stygobite	Potential SRE (A)
Oligochaeta							
Oligochaeta sp. indet.		28		1	29	Stygobite/ Stygophile	Potential SRE (A)
Turbellaria							
Turbellaria sp. indet.		13			13	Stygobite/ Stygophile	Potential SRE (A)
Total	**34**	**76**	**77**	**13**	**191**		

Enchytraeid worms are regularly detected from both troglofauna and stygofauna surveys throughout the Pilbara due to their ability to inhabit water films within air-filled subterranean cavities as well as groundwater (A. Pinder pers. comm. 2011). This ability to inhabit, and potentially move between water and air-filled subterranean habitats, complicates the assessment of subterranean status, although it does not necessarily make them less likely to be SRE (A. Pinder pers. comm. 2011).

A previous genetic study from the Yilgarn region (Subterranean Ecology 2011a) showed very high levels of divergence (using the barcoding gene COI) between enchytraeids from the same catchment (notwithstanding potential habitat barriers). In contrast, a more recent study from the Pilbara (Brown *et al.* 2015) showed that several widespread species were distributed throughout the region (or across several catchments), while others were limited to a single drainage system or locality.

Enchytraeid worms were detected from one hole inside Deposit D, four holes in areas near Deposits C and D (Figure 5.2), and two holes during the concurrent survey at Deposit F (Biologic 2016). Many specimens were collected by scraping drill holes which did not intercept the water table, or from troglofauna traps, while others were collected from holes that did intercept groundwater. As a result, it is unknown whether these worms are potentially stygophilic or troglophillic, and owing to the poor state of taxonomy in the group, it is also unclear to what extent the multiple different species may occur within this taxon. Based on current information, Enchytraeidae sp. indet. is considered to be a Potential SRE (data deficient) (E. Volschenk pers. comm. 2016, Appendix E).