



PHOENIX

ENVIRONMENTAL SCIENCES

Targeted Ghost Bat survey for the Lamb Creek Iron Ore Project

Prepared for Mineral Resources Ltd

May 2023

Final



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Prepared for Mineral Resources Ltd

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EXECUTIVE SUMMARY

Process Minerals International, a wholly owned subsidiary of Mineral Resources Ltd, is seeking to develop the Lamb Creek Iron Ore Project, located approximately 130 kilometres by road northwest of Newman, Western Australia. In September 2022, Phoenix Environmental Sciences Pty Ltd was commissioned by Mineral Resources Ltd to undertake a Targeted Ghost Bat (*Macroderma gigas*; VU) survey for Lamb Creek Iron Ore Project. The study area is located in the Shire of East Pilbara and the Eremaean Climatic Region.

This report considers the following historical fauna surveys:

- Level 2 Fauna Survey and Targeted Northern Quoll Survey of the Lamb Creek (Rapallo 2012)
- Lamb Creek Flora and Fauna Desktop Survey Review (Environmental 2017)
- Lamb Creek and Wedge Project: Vertebrate Fauna Desktop Assessment (Western Wildlife 2020)
- Detailed vertebrate fauna survey of the Lamb Creek Project (Rapallo 2022)
- Lamb Creek Project: Detailed and Targeted Flora and Vegetation survey (Umwelt Pty Ltd 2022).

Previous Detailed fauna surveys for the Lamb Creek Iron Ore Project found that 5 caves are utilised by Ghost Bat. Two caves are located within the Project area (Cave 1; Category 2, Cave 3; Category 3) and 3 caves are located within the vicinity of the Project (Cave 2; Category 3, Cave 4; Category 3 in an 'apartment block', Cave 5; Category 2). Of these, Caves 1, 4 and 5 are considered Critical Ghost Bat habitat. Vegetation and habitat mapping was recently undertaken for the Lamb Creek Iron Ore Project, which intersects approximately 754.7 ha (9.4%) of the study area; most of this area comprises open Eucalypt woodland over scattered Acacia shrubs over grasslands including *Triodia* spp.

The Targeted survey was undertaken from 12-14 September and 18 October 2022. The purpose of the survey was to complete supplementary survey work to meet regulatory standards, including evaluating the distribution, cave usage (potential to support reproducing females versus day roost) and abundance of Ghost Bats from known caves around the Lamb Creek Iron Ore Project area, describe and map habitats and features important for Ghost Bats, and undertake additional searches for Ghost Bat caves nearby the Project area.

Four of the caves visited during the field survey showed prospective features and were assessed (including deployment of ultrasonic recorders, estimates of cave metrics, and scat collection where feasible); these comprised 2 known Ghost Bat caves (LC001, Cave 3; LC002, Cave 1), a cave initially surveyed in 2012 (no Ghost Bats detected at the time) and resurveyed this year (LC003), and a potential roost cave identified during this survey (LC005). Song Meter SM4 and MiniBat detectors were deployed outside caves and left for 34 to 35 nights.

A total of 7 microchiropteran bat species were identified including the regionally significant Ghost Bat; 18 calls were detected from Cave 3 over 4 nights, and 26 calls from Cave 1 over 4 nights. Calls were detected on consecutive nights from Cave 1, indicating a likely diurnal roost cave used intermittently. Two Ghost Bats were directly sighted in Cave 3 during the survey, which in conjunction with confirmed ultrasonic records, reiterated its usage as an intermittent diurnal roost. Fresh Ghost Bat scats were collected from LC001 and older scats from LC003 and LC005. Genetic analyses of scats from LC001 and LC005 samples were undertaken at the Department of Biodiversity, Conservation and Attractions, identifying genotypes of 3 individuals at LC001. One of these individuals was confirmed to be female (the others indeterminate), indicating some level of use of this cave during the reproductive season, although the hormonal status of the female has not been confirmed. One of the indeterminate sex individuals from LC001 was also identified from scat at LC005, approximately 9 km distant. The absence of ultrasonic detections and sightings from LC005 complicates assigning an accurate cave status, however, the presence of old scat indicates it may belong to either Category 3 or 4.

No changes to the status of known Ghost Bat caves were made following the provision of metric estimates; Cave 1 (LC002) remains a Category 2 and therefore Critical habitat, and Cave 3 (LC001) a Category 3 and therefore important habitat for the long-term regional preservation of the species. Management implications and recommendations for caves in the vicinity of the Lamb Creek Iron Ore Project have been provided in a standalone document issued by Bat Call WA. Despite active searches in the gorge systems to the south and east of the Gaguna heritage area, no other Ghost Bat roosts were identified. However, a large proportion of the study area comprises the Brockman Land System, a preferred roosting formation for Ghost Bats in the Hamersley subregion, while potential foraging habitat is also widespread in the area.

Due to limited access to the study area owing to heritage constraints, not all aspects of the survey scope were completed. If needed to develop management controls for limiting potential impacts from the Lamb Creek Iron Ore Project to Ghost Bats, it is recommended that supplementary surveys (Song Meter deployment, collection of cave metrics, scat sequencing and hormone analysis) of inaccessible caves (Caves 2, 4 and 5) could be undertaken. However, these caves are fairly removed from the potential impact source (i.e. mine area/processing plant) and are likely not affected by these disturbances. Results from such surveys would contribute to our understanding of the population dynamics (i.e. population sex ratios, effective population size, etc), reproductive status and cave usage by Ghost Bats in the area, and the overall conservation of the species in an area where local extinction is possible in the future. Lastly, if needed to further define management controls, cave searches among the Gaguna heritage area are recommended, as this region represents the most prospective and under-surveyed area within the vicinity of the Project.

CONTENTS

Executive summary	ii
Contents.....	iv
Acronyms and abbreviations	vii
1 Introduction	1
1.1 Background	1
1.2 Objectives and scope of work	1
1.3 Study area	2
2 Legislative context	4
2.1 Commonwealth.....	4
2.2 State	4
2.2.1 Threatened and Priority species.....	4
2.2.2 Critical habitat	5
2.2.3 Other significant fauna	5
2.2.4 Environmentally Sensitive Areas	5
3 Existing environment	7
3.1 Interim Biogeographic Regionalisation of Australia.....	7
3.2 Land systems and surface geology.....	7
3.3 Climate and weather	11
3.4 Land use	12
3.5 Conservation reserves and ESAs	12
4 Ghost Bat Ecology	14
5 Methods.....	18
5.1 Desktop review	18
5.2 Field survey	18
5.2.1 Survey timing	18
5.2.2 Habitat assessment.....	19
5.2.3 Habitat/cave searches	19
5.2.4 Bat echolocation recordings	19
5.2.5 Scat collection and analysis	20
5.2.6 Cave status assessment	20
5.2.7 Survey personnel	20
6 Results.....	23
6.1 Desktop review	23
6.2 Field survey	29
6.3 Survey limitations.....	30
7 Discussion.....	32
8 Conclusion.....	36
References	37

LIST OF FIGURES

Figure 1-1	Project location and study area	3
Figure 3-1	Study area in relation to IBRA bioregions and subregions.....	9
Figure 3-2	Land systems and surface geology in the study area.....	10
Figure 3-3	Annual climate and weather data for Newman Aero (no. 007176) and mean monthly data for the 12 months preceding the survey (BoM 2023).....	11
Figure 4-1	Ghost Bat (<i>Macroderma gigas</i>) showing characteristic features (Duncan Mackenzie photo).....	15
Figure 5-1	Terrestrial fauna survey sites and cave search effort	22
Figure 6-1	Lamb Creek Project: vegetation mapping (Umwelt Pty Ltd 2022) and targeted survey effort (Rapallo 2012, 2020, 2022); Phoenix, this survey) Previous Targeted survey effort and vegetation mapping at Lamb Creek	27
Figure 6-2	Desktop records of Ghost Bats and known caves in the vicinity of the Project.....	28
Figure 7-1	Regional distribution of Banded Iron Formations and fauna desktop records.....	35

LIST OF TABLES

Table 3-1	Land systems and extent in the study area.....	7
Table 3-2	Surface geology of the study area, extent by deposit type	8
Table 3-3	Land use in the PIL03 subregion and study area.....	12
Table 3-4	Conservation Reserves and ESA in the desktop search extent.....	12
Table 3-5	Areas PFC in the desktop search extent.....	12
Table 4-1	Approximate breeding cycle for Ghost Bat in the Pilbara.....	16
Table 4-2	Ghost Bat cave categories, in decreasing significance (Bat Call WA 2021b).....	17
Table 4-3	Bat Call WA Cave Habitat Classifications (Bat Call WA 2021b)	17
Table 5-1	Database searches conducted for the desktop review.....	18
Table 5-2	Survey reports included in the desktop review	18
Table 5-3	Field survey dates.....	19
Table 5-4	Terrestrial fauna survey effort	19
Table 5-5	Song Meter survey effort	20
Table 5-6	Survey personnel.....	20
Table 6-1	Summary of Ghost Bat monitoring at Lamb Creek from 2012 – 2021.....	23
Table 6-2	Ghost Bat cave Category and coordinates in the vicinity of the Project (Bullen 2023; Rapallo 2022).....	24
Table 6-3	Vegetation mapping in the vicinity of the study area (Umwelt Pty Ltd 2022).....	25
Table 6-4	Microchiropteran species by site based on ultrasonic call analysis (Bullen 2022)	30
Table 6-5	Targeted Ghost Bat call analysis (Bullen 2022)	30
Table 6-6	Consideration of potential survey limitations.....	31

LIST OF APPENDICES

- Appendix 1 Terrestrial fauna survey site descriptions
- Appendix 2 Cave locations and approximate dimensions

Appendix 3 Fauna species by site matrix

Appendix 4 Identification of Ghost Bat (*Macroderma gigas*) individuals from scats collected from Lamb Creek, Pilbara WA - Diana Prada and Kym Ottewell (DBCA)

Appendix 5 Lamb Creek Ghost Bat Significance Assessment (Bullen 2023)

ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
BC	Biodiversity Conservation
BIF	Banded Ironstone Formation
BoM	Bureau of Meteorology
CALM Act	Conservation and Land Management Act 1984
CAPAD	Collaborative Australian Protected Areas Database
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DPIRD	Department of Primary Industries and Regional Development
EIA	Environmental Impact Assessment
EP	Environmental Protection
EPA	Environmental Protection Authority
EPBC	Environmental Protection of Biodiversity and Conservation
ESA	Environmentally Sensitive Area
Exclusion zone	Gaguna Heritage Zone
ha	hectares
IBRA	Interim Biogeographic Regionalisation of Australia
kHz	Kilohertz
km	Kilometre
LCGBSA	Lamb Creek Ghost Bat Significance Assessment
m	Metre
MinRes	Mineral Resources Ltd
mm	Millimetre
Mtpa	Million wet tonnes per annum
NES	National Environmental Significance
OS	Special Protection
PFC	Proposed for conservation
Phoenix	Phoenix Environmental Sciences Ltd
PILO3	Hamersley IBRA subregion
PMI	Process Minerals International
Project	Lamb Creek Iron Ore Project
Project area	Lamb Creek Iron Ore Project area
SP	Specially Protected
Survey area	Study area external to the exclusion zone
TEC	Threatened Ecological Community
TPFA	Threatened and Priority Fauna database
UCL	Unallocated Crown Land
VU	Vulnerable
WA	Western Australia

1 INTRODUCTION

Process Minerals International (PMI), a wholly owned subsidiary of Mineral Resources Ltd (MinRes), is seeking to develop the Lamb Creek Iron Ore Project (the 'Project'), located approximately 130 kilometres (km) by road northwest of Newman, Western Australia (WA; Figure 1-1). The Project comprises a small open-cut iron ore mine, crushing and screening process plant and associated infrastructure; the Project is expected to produce up to 10 million wet tonnes per annum (Mtpa) of iron ore over a period of 3 to 4 years. It is expected that up to approximately 660 hectares (ha) of vegetation will be cleared as a result of the Project.

In September 2022, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by MinRes to undertake a Targeted Ghost Bat survey for the Project.

The purpose of the survey was to complete supplementary survey work to meet regulatory standards, including evaluating the distribution, cave usage (potential to support reproducing females versus day roost) and abundance of Ghost Bats (*Macroderma gigas*, family Megadermatidae) from known caves around the Project and describe and map habitats and features important for Ghost Bats. Additional searches for Ghost Bat caves were undertaken adjacent to the Project area and previously surveyed areas.

The study area (see Section 1.3) is located in the Shire of East Pilbara and the Eremaean Climatic Region as defined by EPA (2020).

1.1 BACKGROUND

A Detailed fauna survey was undertaken across the Project area in 2012 (Rapallo 2012) to support Environmental Impact Assessments (EIA). A second Detailed fauna survey was undertaken in April 2020 along with supplementary ultrasonic recordings in February 2021 (Rapallo 2022). The surveys identified that the State and Commonwealth listed species, Ghost Bat, occurs within the Project area.

Since the referral of the Project to the WA Environmental Protection Authority (EPA) in 2013, the conservation status of the species has changed to Vulnerable (VU) under the *Environmental Protection of Biodiversity and Conservation Act 1999* (EPBC Act) and the *WA Biodiversity Conservation Act 2016* (BC Act)

In November 2021, Phoenix was commissioned by MinRes to undertake a gap analysis assessment of historical fauna surveys to determine whether they satisfy applicable survey and assessment standards for Ghost Bat and complete an assessment of the potential impacts of the Project on the species (Phoenix 2021a). While low-negligible impacts from the Project on the species are possible with adequate management practices implemented, it was decided that gathering further information on the area was warranted. Phoenix was further commissioned to determine principally what Ghost Bats were using each cave for, e.g. potential to support reproducing females versus day roost; the former being considered a much more important asset to the species locally.

1.2 OBJECTIVES AND SCOPE OF WORK

The objectives for the Targeted Ghost Bat survey included:

- complete additional survey work required to meet regulatory standards
- determine the distribution, cave usage (potential to support reproducing females versus day roost) and abundance of Ghost Bats in and around the Project
- describe and map habitats or features that are important to Ghost Bats, such as caves for breeding and day roosting
- inform an EIA for the Project.

The scope of work for the Targeted Ghost Bat survey included:

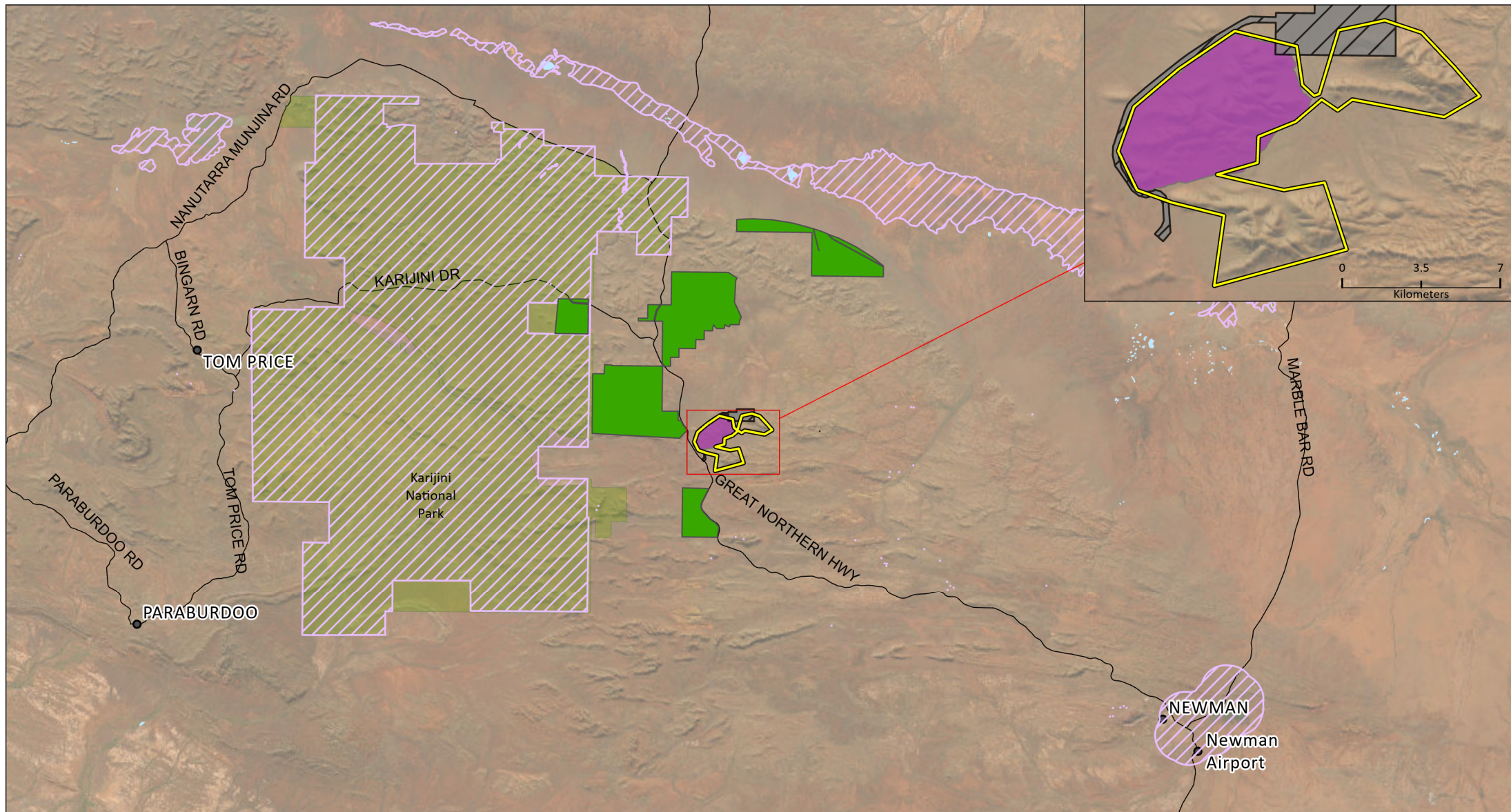
- undertake a Targeted field survey to collect detailed information on Ghost Bats, comprising searches for roost sites, ultrasonic recordings and scat collection and analysis
- complete a technical report suitable for inclusion in environmental approval documentation.

1.3 STUDY AREA

The Lamb Creek Iron Ore Project area (the 'Project area') is a greenfield site and covers a total area of approximately 2,197 hectares (Figure 1-1). No infrastructure currently exists within the Project area.

The study area covers a total area of approximately 8,010 ha and is located southeast of the Project area (Figure 1-1). Much of the study area encompasses the previously surveyed area by Rapallo (2012, 2020, 2022) excluding the southernmost section. This area represents the most prospective habitat for suitable caves in the vicinity of the indicative Project location (Figure 1-1).

Permission to survey within the Gaguna Heritage Zone (the 'exclusion zone', Figure 1-1), a large area of cultural significance located to the southeast of tenements L47/640 and L47/637 which covers approximately 3,691 ha (45.1% of the study area; 3,613 ha), was not given. Consequently, only areas of the study area external to the exclusion zone were surveyed (the 'survey area'; see Section 6.3). The survey area contains 2 isolated gorge systems to the south and east of the exclusion zone and covers a total area of 4,397 ha (54.9% of the study area).



Mineral Resources Ltd Lamb Creek Iron Ore Project		
Project No	1535	
Date	2/17/2023	
Drawn by	BK	
Map author	WP	
1:1,071,300 (at A4)		GDA 1994 MGA Zone 50

- Study area
- Lamb Creek Iron Ore Project area
- Heritage Exclusion Zone
- DBCA managed land
- Lake
- Environmentally sensitive areas
- Areas proposed for conservation

Figure 1-1
Project location and study area



All information within this map is current as of 2/17/2023. This product is subject to COPYRIGHT and is property of Phoenix Environmental Sciences (Phoenix). While Phoenix has taken care to ensure the accuracy of this product, Phoenix make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.

2 LEGISLATIVE CONTEXT

The protection of fauna in WA is principally governed by 3 acts:

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

The BC Act came into full effect on 1 January 2019 and replaced the functions of the *Wildlife Conservation Act 1950* (WC Act).

2.1 COMMONWEALTH

The EPBC Act is administered by the Federal Department of Climate Change, Energy, the Environment and Water (DCCEEW). The EPBC Act provides for the listing of Threatened fauna as matters of National Environmental Significance (NES). Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of NES, requires approval from the Australian Government Minister for the Environment through a formal referral process.

Conservation categories applicable to Threatened fauna species under the EPBC Act are as follows:

- Extinct (EX)¹ – there is no reasonable doubt that the last individual has died
- Extinct in the Wild (EW) – taxa known to survive only in captivity
- Critically Endangered (CR) – taxa facing an extremely high risk of extinction in the wild in the immediate future
- Endangered (EN) – taxa facing a very high risk of extinction in the wild in the near future
- Vulnerable (VU) – taxa facing a high risk of extinction in the wild in the medium-term
- Conservation-Dependent (CD)¹ – taxa whose survival depends upon ongoing conservation measures; without these measures, a conservation-dependent taxon would be classified as Vulnerable, Endangered or Critically Endangered.

The EPBC Act is also the enabling legislation for the protection of Migratory species as matters of NES under several international agreements:

- Japan-Australia Migratory Bird Agreement
- China-Australia Migratory Bird Agreement
- Convention on the Conservation of Migratory Species of Wild Animals
- Republic of Korea-Australia Migratory Bird Agreement.

2.2 STATE

2.2.1 Threatened and Priority species

In WA, the BC Act provides for the listing of Threatened fauna species (Government of Western Australia 2018a, b)² in the following categories:

¹ Species listed as Extinct and Conservation Dependent are not matters of NES and therefore do not trigger the EPBC Act.

² The *Wildlife Conservation (Specially Protected Fauna) Notice 2018* and the *Wildlife Conservation (Rare Flora) Notice 2018* have been transitioned under regulations 170, 171 and 172 of the *Biodiversity Conservation Regulations 2018* to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the BC Act.

- Critically Endangered (CR) – species facing an extremely high risk of extinction in the wild in the immediate future³
- Endangered (EN) – species facing a very high risk of extinction in the wild in the near future³
- Vulnerable (VU) – species facing a high risk of extinction in the wild in the medium-term future³.

Species may also be listed as Specially Protected (SP) under the BC Act in one or more of the following categories:

- species of special conservation interest (conservation-dependent fauna, CD) – species with a naturally low population, restricted natural range, of special interest to science, or subject to or recovering from a significant population decline or reduction in natural range
- migratory species (Mig.), including birds subject to international agreement
- species otherwise in need of Special Protection (OS).

The Department of Biodiversity, Conservation and Attractions (DBCA) administers the BC Act and also maintains a non-statutory list of Priority fauna. Priority species are still considered to be of conservation significance – that is they may be Threatened – but cannot be considered for listing under the BC Act until there is adequate understanding of the threat levels imposed on them. Species on the Priority fauna list are assigned to one of 4 Priority (P) categories, P1 (highest) – P4 (lowest), based on level of knowledge/concern.

2.2.2 Critical habitat

Under the BC Act, habitat is eligible for listing as Critical habitat if it is critical to the survival of a Threatened species or a Threatened Ecological Community (TEC) and its listing is otherwise in accordance with the ministerial guidelines.

2.2.3 Other significant fauna

Under the EPA's environmental factor guidelines, fauna may be considered significant for a range of reasons other than listing as a Threatened or Priority species.

In addition to listing as Threatened or Priority, EPA (2016) identifies the following attributes that constitute significant fauna:

- species with restricted distribution
- species subject to a degree of historical impact from threatening processes
- providing an important function required to maintain the ecological integrity of a significant ecosystem.

2.2.4 Environmentally Sensitive Areas

Under Section 51B of the EP Act, the Minister for Environment may declare by notice either a specified area of the State or a class of areas of the State to be Environmentally Sensitive Areas (ESAs). ESAs are declared in the *Environmental Protection (Environmentally Sensitive Areas) Notice 2005*, which was gazetted on 8 April 2005 (Government of Western Australia 2005).

ESAs are areas where the vegetation has high conservation value. Several types of areas are declared ESAs including:

³ As determined in accordance with criteria set out in the ministerial guidelines.

- the area covered by vegetation within 50 metres (m) of Threatened flora, to the extent to which the vegetation is continuous with the vegetation in which the Threatened flora is located
- the area covered by a TEC
- a defined wetland (Ramsar wetlands, conservation category wetlands and nationally important wetlands) and the area within 50 m of the wetland
- Bush Forever sites.

3 EXISTING ENVIRONMENT

3.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation of Australia (IBRA) classifies Australia’s landscapes into large ‘bioregions’ and ‘subregions’ based on climate, geology, landform, native vegetation and species information (DoEE 2016). The study area is located in the Hamersley subregion (PIL03) of the Pilbara bioregion (Figure 3-1) which is characterised as (Kendrick 2001):

“PIL03 is the southern section of the Pilbara Craton. Mountainous area of Proterozoic sedimentary ranges and plateaux, dissected by gorges (basalt, shale and dolerite). Mulga low woodland over bunch grasses on fine-textured soils in valley floors, and Eucalyptus leucophloia over Triodia brizoides on skeletal soils of the ranges. The climate is Semi-desert tropical, with an average of 300 mm rainfall, usually in summer cyclonic or thunderstorm events. Winter rain is not uncommon. Drainage into either the Fortescue (to the north), the Ashburton to the south, or the Robe to the west. Subregional area is 6,215,092ha.”

3.2 LAND SYSTEMS AND SURFACE GEOLOGY

The Department of Primary Industries and Regional Development (DPIRD) undertakes land system mapping for WA using a nesting soil-landscape mapping hierarchy (Schoknecht & Payne 2011). While the primary purpose of the mapping is to inform pastoral and agricultural land capability, it is also useful for informing biological assessments. Under this hierarchy, land systems are defined as areas with recurring patterns of landforms, soils, vegetation and drainage (Payne & Leighton 2004).

The Project area intersects 5 land systems (Table 3-1; Figure 3-2). The dominant system represents the Booldeega system (1,329.4 ha, 60.6%) which is distributed over much of the western portion of the Project area. The next most extensive is the Newman system (488.2 ha, 22.7%), occurring in 5 isolated pockets throughout the Project area. The residual area comprises the McKay (44.0 ha, 2.0%), Platform (198.1 ha, 9.0%) and Wannamunna land systems (126.3 ha, 5.7%), located in small continuous pockets in the northeast and southwest.

The study area intersects 4 land systems (Table 3-1; Figure 3-2). The most extensive is the Newman system (6,560.0 ha, 81.9%), comprising 3 major packets throughout the interior of the study area. The next largest represents the Boolgeeda System (1,372.4 ha, 17.1%) which is distributed around much of the study area perimeter and disrupts the near-continuous Newman system. The residual area comprises the Platform (72.3 ha, 0.9%) and Wannamunna land systems (5.6 ha, 0.1%) which are restricted to 3 pockets in the northeast and one pocket in the south, respectively.

Table 3-1 Land systems and extent in the study area

Land system	Description	Project area		Study area	
		Area (ha)	% of study area	Area (ha)	% of study area
Boolgeeda System	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.	1,329.4	60.6	1,372.4	17.1
McKay System	Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands with acacias and occasional eucalypts.	44.0	2.0	-	-
Newman System	Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.	499.2	22.7	6,560.0	81.9

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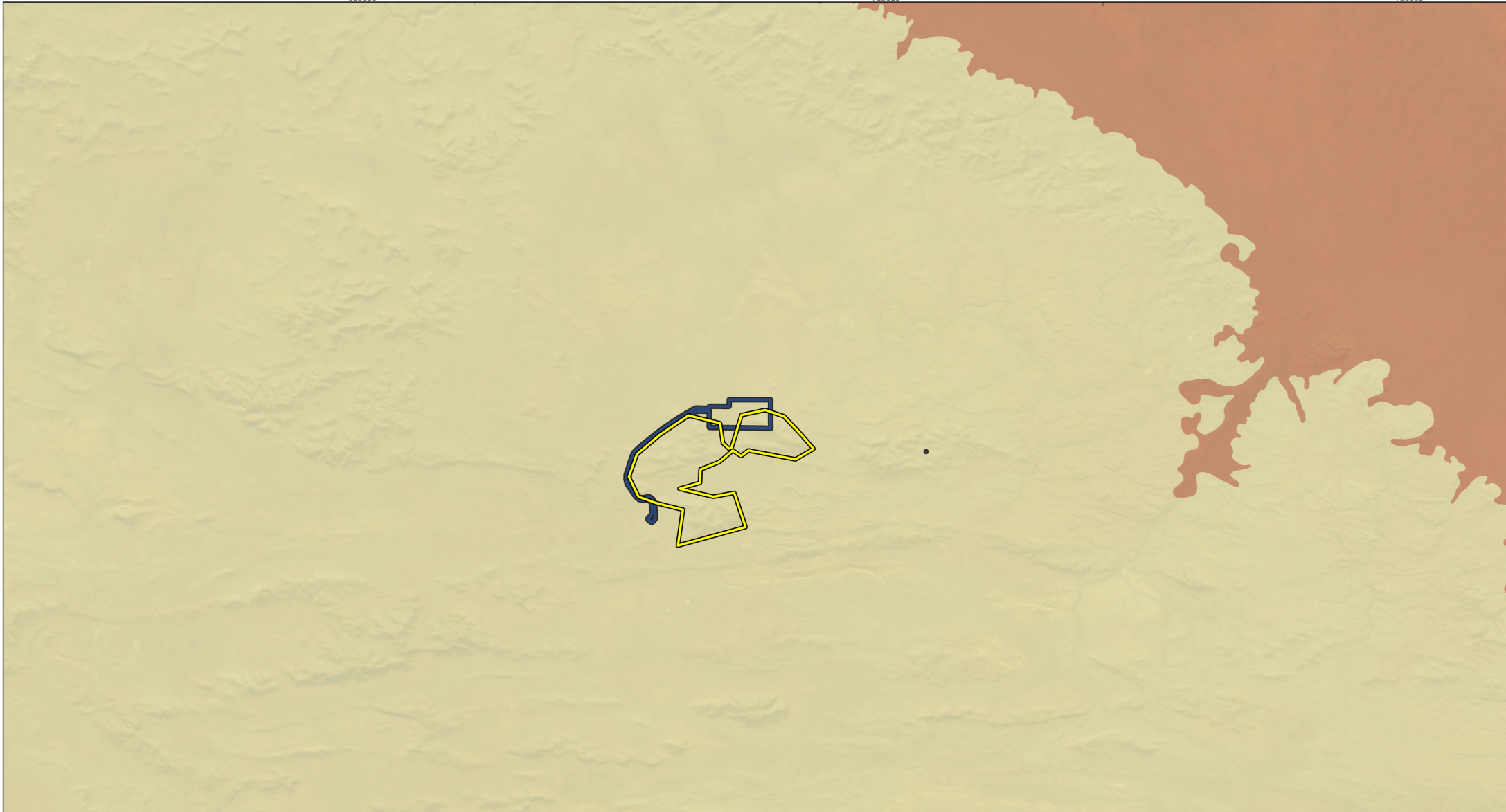
Land system	Description	Project area		Study area	
		Area (ha)	% of study area	Area (ha)	% of study area
Platform System	Dissected slopes and raised plains supporting shrubby hard spinifex grasslands.	198.1	9.0	72.3	0.9
Wannamunna System	Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands and occasionally Eucalypt woodlands.	126.3	5.7	5.6	0.1
Total		2,197.0	100.0	8,010.3	100.0


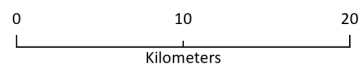
According to the Surface Geology of Australia 1:1,000,000 scale, WA database (Stewart *et al.* 2008), the Project area intersects 4 geological formations (Table 3-2; Figure 3-2). The dominant surface geology represents colluvium 38491 (1,456.4 ha, 66.3%) and is distributed across the entire Project area, followed by the Brockman Iron Formation (660.9 ha, 30.1%) which occurs in 4 pockets. Alluvium 38485 (79.7 ha, 3.6%) and the Weeli Wolli Formation (0.1 ha, <0.1%) comprise a trivial portion of the Project area in the northeast.

The study area intersects 3 geological formations (Table 3-2; Figure 3-2). The dominant surface geology represents the Brockman Iron Formation (7,099.9 ha, 88.6%). The remaining surface geology consists of colluvium 38491 (834.9 ha, 10.4%) and the Weeli Wolli Formation (75.6 ha, 0.9%); the former straddles most of the study area perimeter whereas the latter is isolated to 2 pockets in the east and southeast.

Table 3-2 Surface geology of the study area, extent by deposit type

Surface geology	Abv	Description	Project area		Study area	
			Area (ha)	% of study area	Area (ha)	% of study area
Alluvium 38485	Qa	Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted.	79.7	3.6	-	-
Brockman Iron Formation	Lchk	Banded iron formation, chert, mudstone and siltstone.	660.9	30.1	7,099.9	88.6
colluvium 38491	Qrc	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite.	1,456.4	66.3	834.9	10.4
Weeli Wolli Formation	Lchw	Banded iron formation (commonly jaspilitic), mudstone, siltstone; common interlayered metadoleritic sills.	0.1	0	75.6	0.9
Total			2,197.0	100.0	8,010.3	100.0



Mineral Resources Ltd Lamb Creek Iron Ore Project		
Project No	1535	
Date	30/01/2023	
Drawn by	BK	
Map author	WP	
		
1:454,000 (at A4)		GDA 1994 MGA Zone 50






-  Study area
-  Lamb Creek Iron Ore Project area
- Region, subregion**
-  Pilbara, Fortescue
-  Pilbara, Hamersley

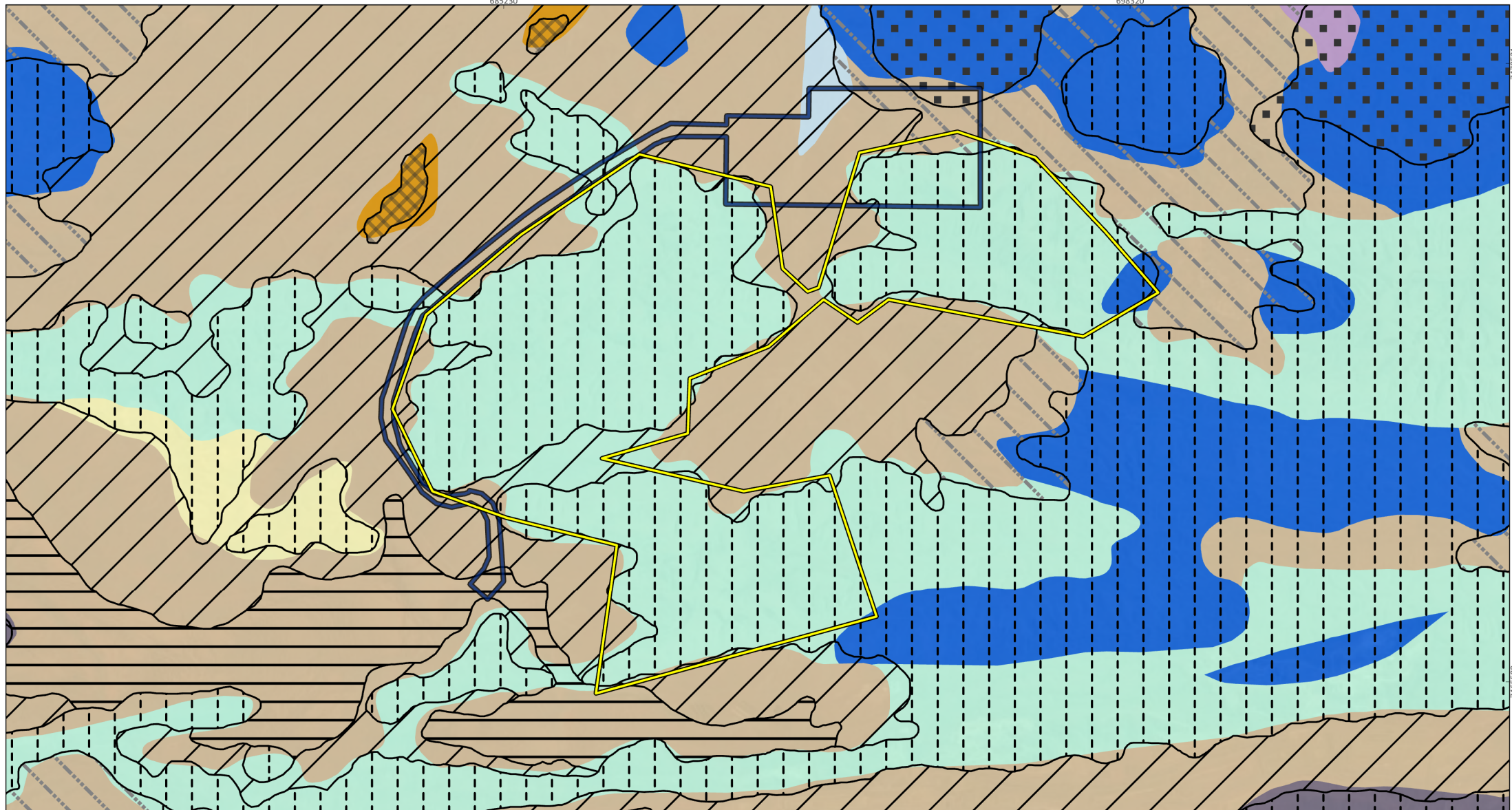
Figure 3-1


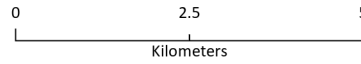
Study area in relation to IBRA bioregions and subregions












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Mineral Resources Ltd Lamb Creek Iron Ore Project	
Project No	1535
Date	22/03/2023
Drawn by	BK
Map author	WP
	
	
1:108,800 (at A4) GDA 1994 MGA Zone 50	

-  Study area
-  Lamb Creek Iron Ore Project area
- Land system**
-  Boolgeeda System
-  Calcrete System
-  McKay System
-  Newman System
-  Platform System
-  Robe System
-  Wannamunna System

- Surface geology**
-  Achm
-  Adf
-  Ashm
-  Czk
-  Czlr
-  Lchk
-  Lchw
-  Qa
-  Qrc

Figure 3-2
Land systems and surface geology
in the study area

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3.3 CLIMATE AND WEATHER

The climate of the PIL03 subregion is described as Semi-desert tropical (Kendrick 2001). The nearest Bureau of Meteorology (BoM) weather station with comprehensive data collection and recent historic climate data is Newman Aero (no. 007176), Latitude: 23.42°S Longitude 119.80°E, located approximately 115 km southeast of the study area.

Newman Aero records the highest mean maximum monthly temperature (39.3°C) in December (lowest in June, 23.1°C) and the lowest minimum mean monthly temperature (6.5°C) in July (highest in January, 25.1°C) (BoM 2023) (Figure 3-3). Median annual rainfall is 321.9 mm with January and February recording the highest monthly median (41.2 and 44.1 mm respectively; Figure 3-3). The majority of rainfall occurs during summer cyclonic and thunderstone events; however, winter rainfall is not uncommon (Kendrick 2001).

Daily mean maximum temperatures at Newman Aero immediately preceding the survey were similar to long-term averages for the region. In the 3 months preceding the survey, on average the mean minimum and maximum temperatures were 0.63°C warmer and 0.13°C cooler than the long-term averages, respectively. The mean minimum temperature of June 2022 showed the highest divergence from the long-term average, having been on average 2.3°C warmer over the month, while July was 0.8°C cooler than the long-term average (Figure 3-3).

For the 12 months preceding the survey, the monthly mean maximum and minimum temperatures were predominately higher than the long-term averages, excluding October and November 2021 which were both cooler than the average for those months (Figure 3-3).

Rainfall records from Newman Aero were broadly consistent with the long-term monthly medians except for September which received 57.2 mm early in the month (Figure 3-3). Newman Aero received a total of 286 mm in the 12 months preceding the survey, 35.9 mm less than the long-term median.

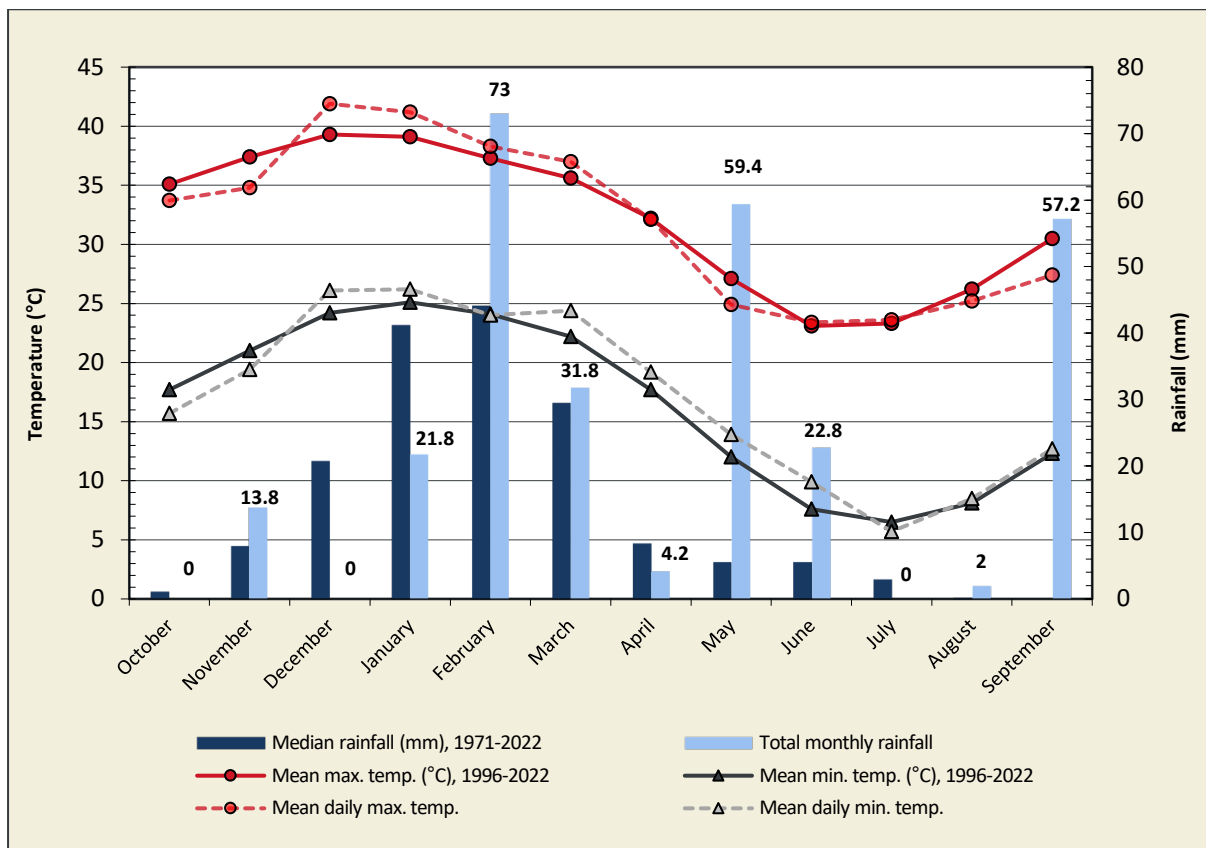


Figure 3-3 Annual climate and weather data for Newman Aero (no. 007176) and mean monthly data for the 12 months preceding the survey (BoM 2023)

3.4 LAND USE

The dominant land use within the PIL03 subregion comprises grazing, Unallocated Crown Land (UCL) and Crown reserves, native pastures, conservation, mining leases and urban development (Kendrick 2001). As per land use summaries extracted from the Catchment Scale Land Use Mapping for WA 2008-2017 (

) (ABARES 2018), the majority of the subregion comprises conservation from natural environments (3,207,595.5 ha; 56.9%) and production from relatively natural environmental (2,394,191.7 ha; 42.5%); the residual area is subject to intensive uses (16,601.7 ha; 0.3%), irrigated agriculture and plantations (829.7 ha; <0.1%) and production from dryland agriculture and plantations (5.2 ha; <0.1%), while a portion of the area comprises water bodies (13,388.9 ha; 0.2%). Within the study area, production from relatively natural environments is the dominant land use (2,044.7 ha; 93.1%), while a considerably smaller area represents conservation and natural environments (147.8 ha; 6.7%) and intensive uses (4.5 ha; 0.2%).

Table 3-3 Land use in the PIL03 subregion and study area

Land Use	PIL03		Study Area	
	Area (ha)	% Area	Area (ha)	% Area
Conservation and natural environments	3,207,595.5	56.9	147.8	6.7
Intensive uses	16,601.7	0.3	4.5	0.2
Production from dryland agriculture and plantations	5.2	0.0	-	-
Production from irrigated agriculture and plantations	829.7	0.0	-	-
Production from relatively natural environments	2,394,191.7	42.5	2,044.7	93.1
Water	13,388.9	0.2	-	-
Total	5,632,612.6	100	2,197.0	100

3.5 CONSERVATION RESERVES AND ESAS

No conservation reserves or ESAs intersect the study area. Two conservation reserves (R 30082 and R 41696) and one ESA (12692) occur within the desktop search extent, protected under the *EP Act* and the *Conservation and Land Management Act 1984* (CALM Act) (Figure 1-1, Table 3-4).

Six zones of UCL proposed for conservation (PFC) occur in the desktop search extent (Table 3-5); zones LR3162/304 and LR3162/305 occur approximately 2.4 km west and 4.1 km south of the study area, respectively.

Table 3-4 Conservation Reserves and ESA in the desktop search extent

Identity	Name	Category	Name type	Tenure	Relevant act and section	Area (ha)
R 30082	Karijini National Park	National Park	Gazetted	-	CALM Act 1984 – Section 5(1)(c) National Park	624,199.6
R 41696	Un-named	Section 5(1)(g) Reserve	-	Crown Land	CALM Act 1984 - Section 5(1)(g) Reserve	4,852.9
12692	Un-named	ESA	-	-	EP Act 2004	495.1

Table 3-5 Areas PFC in the desktop search extent

Identity	Name	Category	Tenure	Relevant act and section	Area (ha)*	Distance to study area
LR3162/302	Un-named	PFC	UCL	LAA - UCL	687.4	~24.3 km NNW
LR3162/303					20,698.5	~14.5 NNW

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Prepared for Mineral Resources Ltd

Identity	Name	Category	Tenure	Relevant act and section	Area (ha)*	Distance to study area
LR3162/304					22,272.6	~2.4 km W
LR3162/305					5,504.2	~4.1 km S
LR3161/595					12,984.2	~31.3 km NE
LR3162/301					4,541.9	~31.9 km NW

* Total area (ha) within the desktop review area

4 GHOST BAT ECOLOGY

The Ghost Bat (*Macroderma gigas*; Figure 4-1) is a monotypic species of bat in the family Megadermatidae. It is endemic to northern Australia and is the largest microchiropteran species in Australia (Van Dyck *et al.* 2013). The species etymology is of Greek origin, where the genus *Macroderma* is derived from the words *macros* ('large') and *derma* ('skin') in reference to their large, partially conjoined ears, while the species name *gigas* ('giant') denotes it being the largest member of the family. The species is listed as VU under the EPBC and BC Acts.

Individuals vary in size from 130 to 175 grams (Van Dyck *et al.* 2013) and have white, pale grey or light brown fur; they can be diagnosed by a combination of their large elongated ears joined together at the lower half, comparatively large eyes, simple nose-leaf, no tail but a full tail membrane, forked skin flap within the pinna (Van Dyck *et al.* 2013) and their extremely thin wing membrane giving them a 'ghostly' white appearance. Sexual dimorphism is low to absent although females may be slightly larger on average (Hand & York 1990).

Ghost Bats are Australia's only strictly carnivorous bat, foraging nocturnally for small mammals including other bats, frogs, small birds, lizards, spiders and large insects (Bullen 2021a; Churchill 2008; Richards *et al.* 2008). Much of its prey is captured on the ground and taken to an established feeding site, often a rocky overhang or cave which are easily recognised by the accumulation of discarded prey, middens, and scat piles. Unlike other zoophagous bats, they are proficient in navigating and hunting using their vision and acute hearing without the need to constantly echolocate (Bullen 2021a; Richards *et al.* 2008). They demonstrate 2 foraging strategies: perching on vegetation to ambush prey passing by (either on the ground or in the air) and gleaning surfaces while in flight (Bullen 2021a). Recently, the Pilbara population was found to have a diet of predominantly small mammals and birds, with a lesser contribution from reptiles and amphibians (Claramunt *et al.* 2019).

There is minimal confirmed data on the foraging habitat of the Ghost Bat. Recent unpublished data suggest in the Pilbara they prefer to forage on productive plains with thin mature woodland over patchy or clumped tussock or hummock grass (*Triodia spp.*) on sand or stony ground, likely 1-2 metres (m) above ground (Augusteyn *et al.* 2018).

Ghost Bats use a variety of echolocation and social call frequencies ranging between 1 to 60 kilohertz (kHz) (Bullen 2021a). The typical call characterisation within roosts and while foraging is a series of low-intensity, brief and steep frequency-modulated pulses from approximately 15 to 60 kHz (Bullen 2021b). Extensive use of variable social vocalisations between 1 and 15 kHz has been observed but is poorly understood.



Figure 4-1 Ghost Bat (*Macroderma gigas*) showing characteristic features (Duncan Mackenzie photo)

Fossil evidence indicates Ghost Bats were formerly distributed over much of Australia and contracted northwards during the Holocene period; a study (Thomson *et al.* 2012) using genetic data from extinct southern populations and extant northern populations of Ghost Bats, in combination with ecological niche modelling based on past and present climate, suggested that the Ghost Bat historically expanded southwards in response to periods of increased humidity and contracted northward as a result of aridification. Ghost Bats prefer areas of higher humidity, and relictual populations in the south have persisted as a result of suitable roosting microhabitats; however, since European settlement, their population has contracted further north, with much of their distribution across the central arid zones having disappeared in the past few decades for reasons currently not understood. The last central desert specimen was collected in 1961 (Butler 1962). The species' current range comprises geographically discontinuous and genetically distinct populations across northern Australia (Armstrong & Anstee 2000). In WA, Ghost Bats occur within the Pilbara and Kimberley regions (Woinarski *et al.* 2014); the Pilbara population is geographically isolated and genetically distinct from the Kimberley and the remaining, continuous population in the north (Worthington Wilmer *et al.* 1999).

Although the exact reason for their decreased range is unknown, it is certain that Ghost Bats are sensitive to disturbance (Richards *et al.* 2008). The key threats to Ghost Bats as listed in Federal conservation advice (Threatened Species Scientific Committee 2016) are:

- habitat loss (destruction of, or disturbance to, roost sites and nearby areas) due to mining
- disturbance of (human visitation at) breeding sites
- modification to foraging habitat
- collision with fences, especially those with barbed wire
- collapse or reworking of old mine adits
- contamination by mining residue at roost sites
- disease
- poisoning by cane toads (*Rhinella marina*)
- competition for prey with foxes and feral cats.

Little information is known about the types of disturbances that lead Ghost Bats to abandon their roosts. It is thought that repeated human visitation during the breeding season is a primary cause of roost abandonment (TSSC 2016). Ghost Bats have demonstrated tolerance to some audio disturbance from machinery, and disturbance from drilling is much less likely to cause abandonment than blasting impacts. Recent work has shown that caves located between 0.4 and 1.8 km from active mining continue to be used by Ghost Bats (Biologic 2016). If abandoned, so long as caves remain unblocked, the structural integrity is maintained and the microclimate is not disrupted, Ghost Bats are likely to re-occupy caves once mining disturbance moves away (Bullen 2021a).

Ghost Bats require a range of cave sites, moving between numerous caves seasonally or as dictated by weather conditions, moonlight, rainfall and fire (Woinarski *et al.* 2014). Ghost Bats may move in small groups between caves, making it difficult to determine whether their absence at monitoring sites between years is due to natural movements or anthropogenic impacts (Armstrong & Anstee 2000).

Roost sites include sheltered rock formations such as caves, rock crevices and unused mine adits. In the Hamersley Range of the Pilbara, Ghost Bats appear to prefer sheltered caves beneath bluffs of larger hills of the Brockman Iron Formation (Threatened Species Scientific Committee 2016).

The species' persistence in the arid Pilbara depends on a stable microclimate. Ideally, caves will have temperatures between 23°C and 28°C, with 28°C being optimal for the maintenance of body temperature (Baudinette *et al.* 2000; Threatened Species Scientific Committee 2016). The preferred range of humidity varies widely between 14 and 84% (Armstrong & Anstee 2000).

In the Pilbara, Ghost Bats exhibit vagrant behaviours where they move periodically dependent on the seasonality or prey availability, which has been shown to correlate with the patchy, locally unreliable rainfall events (and corresponding prey biomass) across much of its foraging habitat (Bullen 2021a). Consequently, in these areas Ghost Bats tend to occur singly or in small groups (up to 15 individuals), to exploit these ephemeral patchy food resources (Bullen 2021a). In other regions however, they tend to disperse widely to forage when they are not breeding; here, during the breeding cycle, distribution is determined by the presence of suitable roosting sites; females are likely to stay close to preferred maternity roosts, a cause for serious conservation concern (Richards *et al.* 2008).

While roosting, they are particularly sensitive to disturbance. If disturbed, young may be dislodged by adults in rapid take-off (Toop 1985) and may not return (Woinarski *et al.* 2014). Such susceptibility to disturbance also threatens the viability of roosts with unregulated human visitation, including surveys that target caves and may inadvertently flush individuals into daylight. For this reason, it is recommended that entrance to known caves during the breeding period is prohibited (Bullen 2021a).

Mating is thought to occur in the dry season from July to August. Females have a gestation period of 3 months (Richards *et al.* 2008). Parturition varies with latitude and is often delayed to late spring months of mid-October to late November in southern populations. Young are weaned on prey by their mothers and begin hunting as juveniles until they are completely independent.

Table 4-1 Approximate breeding cycle for Ghost Bat in the Pilbara

Month	Breeding Stage
July – August	Mating
August – October	Gestation
October – December	Parturition

Ghost Bat caves can be categorised based on their usage (Table 4-2) and the timing and frequency of occupancy (Table 4-3) (Bat Call WA 2021b). Maternity roosts are considered the most significant cave type, followed by diurnal roosts and night roosts. 'Potential' is used to denote the highest Category based on the information collected where insufficient information to confirm the Category has been recorded (e.g., potential roost contains attributes and/or evidence to suggest diurnal roosting though

no diurnal roosting has been confirmed). Caves can be categorised accordingly by assessing the structure of the cave in combination with monitoring Ghost Bat signs.

Table 4-2 Ghost Bat cave categories, in decreasing significance (Bat Call WA 2021b)

Category	Description
Maternity roosts	In addition to being used for shelter during the day, these caves have attributes suitable to support breeding, and Ghost Bats have been recorded in these caves during the breeding season, including pregnant females or females with pups.
Diurnal roosts	Used for shelter during the day.
Night roosts	Only utilised during the night, mostly to feed on prey items or to rest, and are typically shallow caves and shelters/overhangs that can be well-lit during the day.

Bat Call WA (2021b) has categorised Ghost Bat caves according to their habitat value, established by occupancy and usage (Table 4-3).

Table 4-3 Bat Call WA Cave Habitat Classifications (Bat Call WA 2021b)

Category	Description	Significance*
Category 1	Diurnal roost caves with permanent Ghost Bat occupancy. Caves and historical underground mines (adits and declines) that are used continuously as diurnal roosts by large numbers of Ghost Bats for long periods.	Must all be assumed to be maternity caves and are Critical habitat for the species.
Category 2	Diurnal roost caves with regular occupancy. Caves that are used regularly as diurnal roosts by small numbers of Ghost Bats but not continuously. These tend to be deep caves with ceiling heights in rear chambers of at least 1.5 m allowing multiple roosting opportunities out of reach of predators. These caves typically have several other caves, shelters, and overhangs within a few hundred metres.	Must be assumed to be capable of supporting one or more reproducing females and their offspring. These caves are Critical habitat for the species.
Category 3	Roost caves with occasional occupancy. Caves that are occasionally used as diurnal roosts and as nocturnal roosts for feeding and resting more frequently.	When directly associated with a Category 2 cave, they form an apartment block grouping that is considered Critical habitat. Isolated caves are important habitat for the long-term preservation of the species in the area.
Category 4	Nocturnal roost caves with opportunistic usage. This may be anything from a single foraging visit to a longer visit with a resting period or possibly a feeding session.	These caves are not important habitat for the long-term preservation of the species in the area.

* All Category 1, 2 and 3 caves in apartment blocks are considered to be Critical habitat.

5 METHODS

The Targeted Ghost Bat survey was conducted in accordance with relevant survey guidelines and guidance, including:

- EPA Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020)
- Survey guidelines for Australia's Threatened bats: guidelines for detecting bats listed as Threatened under the Environmental Protection and Biodiversity Conservation Act 1999 (DEWHA 2010)
- A review of Ghost Bat ecology, threats and survey requirements (Bullen 2021a).

5.1 DESKTOP REVIEW

Searches of several biological databases were undertaken to identify and map records of Ghost Bats within the desktop review area (Table 5-1). A literature search was conducted for previous surveys undertaken for the Project to build on these records developed from the database searches and to evaluate previous survey efforts (Table 5-2).

Table 5-1 Database searches conducted for the desktop review

Database	Target group/s	Search coordinates and extent
Protected Matters Search Tool DCCEEW (2023)	EPBC Act Threatened fauna	Approximate centre point of study area (118.85°S, 22.85°E) with 40 km buffer
DBCA Threatened and Priority Fauna Database (TPFA) (DBCA 2021)	Ghost Bat records	study area plus a 40 km buffer
Atlas of Living Australia (Atlas of Living Australia 2023)		study area plus a 40 km buffer

Table 5-2 Survey reports included in the desktop review

Report author	Survey description	Project
Rapallo (2012)	Level 2 fauna survey and Targeted Northern Quoll survey	Lamb Creek Iron Ore Project
Rapallo (2022)	Detailed vertebrate fauna survey	
Phoenix (2021b)	Ghost Bat mitigation and management techniques	
Phoenix (2021a)	Ghost Bat impact assessment	
Western Wildlife (2020)	Vertebrate fauna desktop assessment	
Rapallo (2020)	Detailed and Targeted fauna survey	
Umwelt Pty Ltd (2022)	Detailed and Targeted flora and vegetation survey	

5.2 FIELD SURVEY

5.2.1 Survey timing

Field survey dates are provided in Table 5-3.

Table 5-3 Field survey dates

Survey type	Season	Dates
Targeted Ghost Bat survey	Spring	12-14 September 2022
		18 October 2022

5.2.2 Habitat assessment

Initial habitat characterisation was undertaken using various remote geographical tools, including aerial photography (Google Earth®), land system maps, topographic maps, and vegetation and habitat mapping by Rapallo (2022). Detailed vegetation mapping has been undertaken by Umwelt Pty Ltd (2022), the results of which were provided after the field survey (see Table 6-3). Habitats in the survey area with the potential to support Ghost Bat caves were identified based on the known roosting ecology of the species within the Pilbara bioregion and previous survey results.

Habitat descriptions and characteristics were recorded at all survey sites, including known Ghost Bat caves (Figure 5-1; Table 5-4; Appendix 1). Details on cave metrics including estimated height, diameter and depth along with coordinates were collected. A total of 5 survey sites were sampled (Figure 5-1; Table 5-4).

Table 5-4 Terrestrial fauna survey effort

Site	Site description (#)	Ultrasonic recording (nights)	Scat collection (#)	Cave metric assessment
LC001 (Cave 3*)	1	35	13 (12)	1
LC002 (Cave 1*)	1	35		1
LC003	1	34		1
LC004	1			1
LC005	1	34	6 (3)	1

* Cave name as per Rapallo (2012, 2020, 2022). Rows highlighted in grey represent Critical habitat as defined by Bat Call WA (2021a) and the LCGBSA (Bullen 2023). Values in parentheses indicate the number of scats successfully sequenced from each site (Appendix 4).

5.2.3 Habitat/cave searches

Active searches for suitable roosting caves were undertaken in areas with the potential to support them, primarily in gorges and deep gullies flanked by rocky outcrops on foot and by helicopter in inaccessible areas. Search areas were concentrated in the gorge systems to the east and southeast of the exclusion zone (i.e. the survey area; Figure 1-1, Figure 5-1).

5.2.4 Bat echolocation recordings

Song Meter SM4 and MiniBat ultrasonic recording devices were used to record bat echolocation calls at 4 sites (Figure 5-1, Table 5-4, Table 5-5). These included 2 known roosting locations, Cave 1 (Category 2; LC002) and Cave 3 (Category 3; LC001) identified during previous surveys for the Project (Rapallo 2012). They also included one previously surveyed (no Ghost Bats recorded) but prospective cave located by Rapallo (2012) (LC003) and one potential roost cave found during this survey (LC005). Recording devices were deployed at each site for 34-35 nights of recording for between 8 and 12 continuous hours per night. Devices were positioned at the entrance of caves and were aimed at a 45° angle to the ground. No Song Meters were deployed in the surrounding habitat due to the tendency of Ghost Bats to forage primarily using visual input rather than echolocation (Bullen 2021a). MiniBat

ultrasonic recording devices were considered appropriate for this survey as previous surveys for the Project confirmed the absence of the Pilbara Lead-nosed Bat (*Rhinonicteris aurantia*, VU).

Table 5-5 Song Meter survey effort

Site	Recording unit ID	Deployment date	Collection date	Latitude	Longitude	Ultrasonic recording (nights)
LC001 (Cave 3*)	S4U11933	13/09/2022	18/10/2022	-22.8075	118.8912	35
LC002 (Cave 1*)	SMU07811	13/09/2022	18/10/2022	-22.8101	118.8846	35
LC003	S4U11917	14/09/2022	18/10/2022	-22.8132	118.8886	34
LC004				-22.8781	118.8187	
LC005	S4U11854	14/09/2022	18/10/2022	-22.8879	118.8890	34

* Cave name as per Rapallo (2012, 2020, 2022). LC004 was assessed and deemed unsuitable for Ghost Bat occupancy, hence no ultrasonic recording at this site. Rows highlighted in grey represent Critical habitat as defined by Bat Call WA (2021a) and the LCGBSA (Bullen 2023).

5.2.5 Scat collection and analysis

Where middens and scats were found at the entrance to and inside caves, the material was collected using a sterilised pair of tweezers, placed in vials with dehydration powder and separated by a layer of cotton, and frozen, as per personal communication with Dr Kym Ottewell from the DBCA. A total of 19 scat samples were collected from 2 locations; 13 from LC001 (Cave 3) and 6 from LC005 (Table 5-4). Samples were sent to DBCA for genetic analysis; detailed methods are described in Appendix 4 (Prada & Ottewell 2023). Fifteen samples were suitable for further analysis; 12 were from LC001 and 3 were from LC005.

5.2.6 Cave status assessment

The cave metric estimates recorded during the field survey at the 2 known Ghost Bat caves (LC001; Cave 3, and LC002; Cave 1) and the 2 additional caves (LC003 and LC005), in conjunction with other field results (echolocation recordings, direct sightings), were used to reevaluate the status of caves and determine their eligibility for listing as Critical habitat. These re-evaluations were undertaken by B. Bullen of Bat Call WA and are detailed in the Lamb Creek Ghost Bat Significance Assessment (LCGBSA; Appendix 5) (Bullen 2023).

5.2.7 Survey personnel

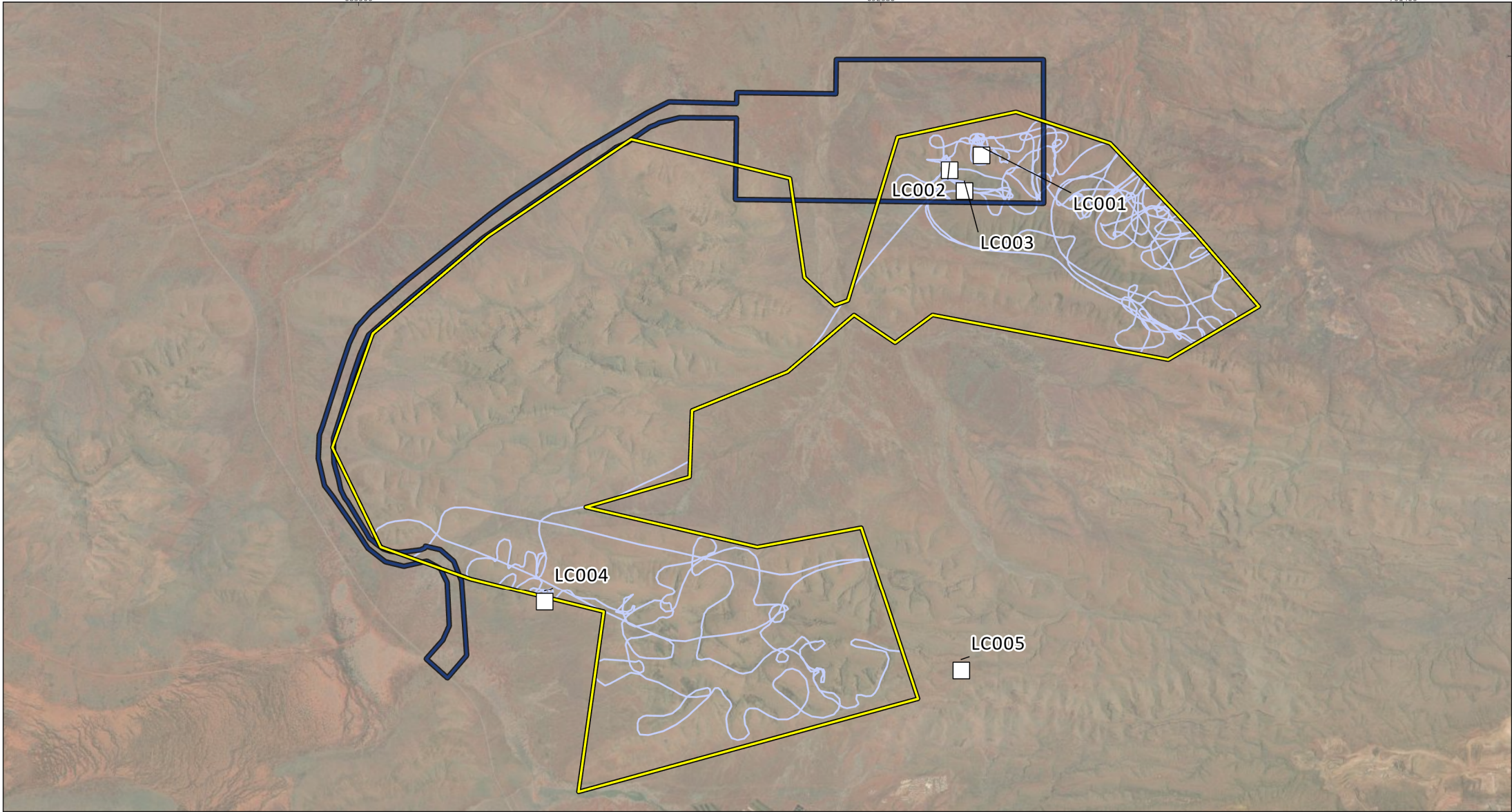
The personnel involved in the surveys are listed in Table 5-6. All survey work was carried out under the relevant licence issued by DBCA under the BC Act.


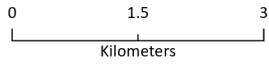
Table 5-6 Survey personnel

Name	Permit	Qualifications / Department	Role/s
Dr John Scanlon	Authorisation to take or disturb Threatened species license no. TFA 2223-0062	PhD Zoology	Field survey, reporting
Dr Floyd Holmes		PhD Biological Sciences	Field survey
Will Purser		MSc Biological Sciences (Zoology)	Field survey, reporting
Jarrad Clark	Not applicable	BSc Environmental Management	Project management, reporting
Brooke Quick		BSc Environmental Sciences	Desktop review

**Targeted Ghost Bat survey for the Lamb Creek Iron Ore Project
Prepared for Mineral Resources Ltd**

Name	Permit	Qualifications / Department	Role/s
Brigitte Kovar		MSc Geographical Information Systems	GIS
Farzam Khosraviani		MSc Geographical Information Systems	GIS
Dr Kym Ottewell		DBCA	Genetic analysis
Dr Diana Prada			
Bob Bullen		Bat Call WA	Song Meter analysis, LCGBSA



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Project No	1535	
Date	2/17/2023	
Drawn by	BK	
Map author	WP	
		
1:90,200 (at A4)		GDA 1994 MGA Zone 50





-  Study area
-  Lamb Creek Iron Ore Project area
-  Survey sites
-  Helicopter search tracks

Figure 5-1
Terrestrial fauna survey sites and cave search effort



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6 RESULTS

6.1 DESKTOP REVIEW

The desktop review identified 113 records of Ghost Bat within the desktop search extent (ALA 2023; DBCA 2021), comprising 3 located within the survey area and 110 in the wider desktop search extent (Figure 6-2). Over 95% of these records have been documented since 2012 (DBCA 2021).

The microchiropteran bat assemblage of the survey area was assessed using ultrasonic echolocation recorders during 3 field deployments by Rapallo; a Level 2 fauna survey and a Targeted Northern Quoll survey (Rapallo 2012), and a Detailed vertebrate fauna survey that included ultrasonic echolocation recorder deployments for detecting Ghost Bats in April 2020 and February 2021 (Rapallo 2022) (Table 6-1).

A Level 2 fauna survey was conducted for the Project from 26 March to 12 April 2012 (Rapallo 2012). Ultrasonic recorders were placed in 7 suitable locations for one night (Rapallo 2012) (Table 6-1). No unambiguous calls attributable to the Ghost Bat could be determined in the recordings made during the survey (with the techniques available at the time). Individuals were sighted at 3 caves in the survey area: 2 within the Project area (Cave 1 and Cave 3) and one within the vicinity of the Project (Cave 2) (Rapallo 2012). Seven individuals were recorded at 2 of these caves: 5 within the Project area (Cave 1 and Cave 3) and 2 individuals within the vicinity of the Project (Cave 2). There was no evidence of middens within either cave.

Caves surveyed in 2012 were revisited in 2020 and 2021 and ultrasonic recorders were deployed during field trips from 16 to 28 April 2020 and 20 to 24 February 2021 (Rapallo 2022) (Table 6-1). In 2020, 17 detectors were installed, including 14 to record ultrasonic calls and 3 to record Night Parrot and Ghost Bat social calls in gullies. Of the 14 echolocation sites surveyed in 2020, 3 detectors were deployed at cave entrances, 4 deployed in thin woodland, 3 in shrubland, one in spinifex plain, 2 in minor drainage lines and one in an incised gully (Figure 6-1). Detectors were left between one and 4 nights. Ultrasonic calls of Ghost Bats were recorded at Cave 1, Cave 2, and Cave 3. No ultrasonic or social call recordings of Ghost Bats were made at any other site in the 2020 survey (Rapallo 2022). Middens were present at Cave 1 (Rapallo 2022).

In February 2021, additional data on Ghost Bat presence was collected while on-site for other studies. Four detectors were installed to record ultrasonic calls, all deployed at cave sites (Table 6-1; Figure 6-1) and left between 2 and 3 nights. Ultrasonic calls of Ghost Bats were recorded at Cave 3, Cave 4 and Cave 5 (Rapallo 2022), consistent with the known population and dispersal of Ghost Bats observed in the 2012 field survey (Rapallo 2012).

Table 6-1 Summary of Ghost Bat monitoring at Lamb Creek from 2012 – 2021

Survey	Season	Records	Comments from report
Level 2 Fauna Survey and Targeted Northern Quoll Survey of the Lamb Creek (Rapallo 2012)	Autumn	Ultrasonic recorders were deployed for one night at 7 suitable locations. Ghost Bats were observed roosting in 2 caves within the Project area (Cave 1 and Cave 3) and one within the survey area (Cave 2) (Figure 6-1).	Several small cave systems within the survey area are likely to be used as roosts by Ghost Bat (Rapallo 2012).

**Targeted Ghost Bat survey for the Lamb Creek Iron Ore Project
Prepared for Mineral Resources Ltd**

Survey	Season	Records	Comments from report
Detailed vertebrate fauna survey of the Lamb Creek Project (Rapallo 2022)	Autumn	Ultrasonic recorders were deployed between one and 4 nights at 14 locations. Ghost Bats were visually recorded roosting in 2 caves within the Project area (Cave 1 and Cave 3) and one within the vicinity of the Project area (Cave 2) (Figure 6-1).	At Cave 1 both social and ultrasonic calls were recorded before dawn followed by similar numbers of calls soon after dusk. Calls consistent with foraging Ghost Bats were detected at Caves 2 and 3 on one night each (Rapallo 2022).
	Summer	Ultrasonic recorders were deployed between 2 and 3 nights at 4 locations. Ultrasonic recordings of Ghost Bats were recorded at 2 caves within the Project area (Cave 1 and Cave 3) and 2 caves within the vicinity of the Project (Cave 4 and Cave 5).	Calls consistent with foraging visits were detected at Caves 3 and Cave 4. Calls consistent with diurnally roosting Ghost Bats detected at Cave 5 (Rapallo 2022). Rapallo (2022) concluded their survey area (but not the Project area) was fully surveyed. Approximately 555 hectares (25%) of the current Project area has not been covered by fauna surveys and is considered a 'partial' limitation. There was also a 'partial' limitation for the timing/rainfall/seasonality of the fauna work due to lower-than-average rainfall preceding the survey (Rapallo 2022).

Table 6-2 Ghost Bat cave Category and coordinates in the vicinity of the Project (Bullen 2023; Rapallo 2022)

Cave	Category	Latitude	Longitude
Cave 1 ⁺ (LC002)	Category 2	118.88598	-22.81003
Cave 2 ⁺	Category 3	118.85829	-22.83301
Cave 3 ⁺ (LC001)	Category 3	118.89125	-22.80741
Cave 4 ⁺	Category 3 (apartment block)	118.79202	-22.87002
Cave 5 ⁺	Category 2*	118.79205	-22.86967

* Name as per Rapallo (2012, 2020, 2022). Rows in grey indicate Caves are Critical habitat, as defined in Bat Call WA (2021b) and the LCGBSA (Bullen 2023).

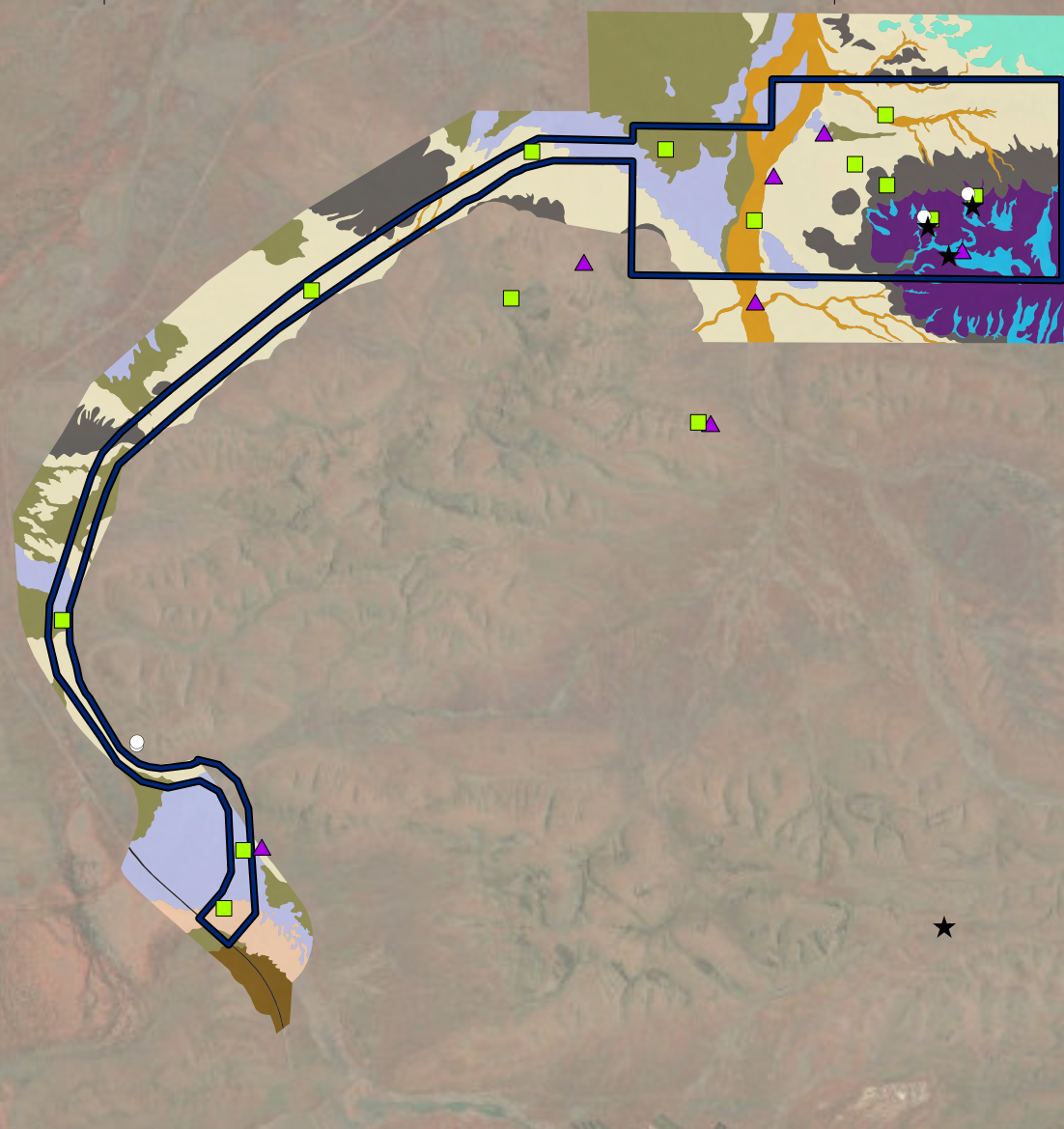
Broad-scale vegetation mapping has previous been undertaken by Umwelt Pty Ltd (2022) for the Project area (and beyond, 'Mapped area'), which described 10 broad vegetation types and covers a total area of 3784.6 ha (Table 6-3, Figure 6-1). The mapped area intersects 754.7 ha (9.4%) of the study area. Seven vegetation types were identified; the area predominately comprises low to open *Eucalyptus* woodland (some *Corymbia*) over isolated *Acacia* and *Grevillea* shrubs over hummock grasslands (including *Triodia* spp.).

Table 6-3 Vegetation mapping in the vicinity of the study area (Umwelt Pty Ltd 2022)

Vegetation unit	Vegetation description	Mapped area		Study area	
		Area (ha)	% of mapped area	Area (ha)	% of study area
1	Low open woodland of <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> and/or <i>Eucalyptus gamophylla</i> with isolated <i>Corymbia deserticola</i> subsp. <i>deserticola</i> over low to mid-sparse to open shrubland dominated by species including <i>Acacia atkinsiana</i> and <i>Acacia ancistrocarpa</i> over low open hummock grassland of <i>Triodia pungens</i> , <i>Triodia vanleeuwenii</i> and <i>Triodia wiseana</i> and low open tussock grassland of <i>Themeda</i> sp. Mt Barricade (M.E. Trudgen 2471) and <i>Paraneurachne muelleri</i> on red-brown sandy clay loam to clay loam on gently inclined mid to lower slopes and associated drainage lines.	1,429.0	37.8	185.1	24.5
2	Low open woodland of <i>E. l. leucophloia</i> with occasional <i>C. d. deserticola</i> and <i>Corymbia hamersleyana</i> over low sparse shrubland of <i>Acacia hilliana</i> and <i>Hakea chordophylla</i> over open hummock grassland of <i>T. vanleeuwenii</i> and <i>T. wiseana</i> on red-brown clay loam with ironstone pebbles on gently inclined lower to upper slopes.	382.2	10.1	135.1	17.9
3	Isolated trees of <i>C. hamersleyana</i> , <i>E. l. leucophloia</i> and <i>E. gamophylla</i> over low sparse shrubland of mixed <i>Acacia</i> species over low hummock grassland of <i>T. pungens</i> and <i>T. wiseana</i> on red-brown sandy clay loam on mid to lower slopes with ironstone pebbles.	48.1	1.3	-	-
4	Low open woodland of <i>Corymbia ferriticola</i> or <i>C. hamersleyana</i> and <i>E. l. leucophloia</i> with <i>Ficus brachypoda</i> occurring on gorge and gully areas, over low sparse shrubland of mixed species dominated by <i>Corchorus laniflorus</i> , <i>Dodonaea viscosa</i> subsp. <i>mucronata</i> and <i>Gossypium robinsonii</i> over sparse hummock grassland dominated by <i>T. pungens</i> with <i>T. wiseana</i> and tussock grasses including <i>Cymbopogon ambiguus</i> and <i>Aristida burbridgeae</i> on red-brown clay loam on steep upper slopes, gullies, breakaways and gorges with significant ironstone outcropping.	95.1	2.5	95.1	12.6
5	Occasional <i>E. l. leucophloia</i> and <i>C. hamersleyana</i> over mixed isolated shrubs including <i>Acacia inaequilatera</i> and <i>Senna artemisioides</i> subsp. <i>glutinosa</i> over low hummock grassland of <i>T. wiseana</i> on steep upper slopes and associated drainage lines on red-brown clay loam with exposed ironstone and dolerite.	100.9	2.7	-	-
6	Low woodland to open woodland of <i>C. hamersleyana</i> and <i>E. l. leucophloia</i> and occasional <i>Eucalyptus kingsmillii</i> over mid-isolated shrubs of <i>A. hamersleyensis</i> and <i>Grevillea wickhamii?</i> <i>hispidula</i> over low hummock grassland of <i>T. wiseana</i> on red-brown sandy clay loam on steep mid to upper slopes with exposed ironstone.	316.5	8.4	316.1	41.9
7	Isolated trees of <i>C. hamersleyana</i> , <i>E. l. leucophloia</i> and <i>Eucalyptus xerothermica</i> over low open to sparse shrubland dominated by <i>Acacia aptaneura</i> , <i>Acacia aneura</i> and <i>Acacia pruinocarpa</i> over low tussock grassland to sparse tussock grassland dominated by <i>Themeda</i> sp. Mt Barricade (M.E. Trudgen 2471), <i>Enneapogon polyphyllus</i> , <i>Chrysopogon fallax</i> and <i>Aristida</i> spp. with occasional <i>T. pungens</i> on red-brown clay loam with some ironstone pebbles on plains.	523.2	13.8	4.5	0.6

Targeted Ghost Bat survey for the Lamb Creek Iron Ore Project
Prepared for Mineral Resources Ltd

Vegetation unit	Vegetation description	Mapped area		Study area	
		Area (ha)	% of mapped area	Area (ha)	% of study area
8	Isolated trees of <i>E. xerothermica</i> over tall open to sparse shrubland of <i>Hakea lorea</i> subsp. <i>lorea</i> and <i>A. aptaneura</i> over low open tussock grassland of <i>Aristida contorta</i> , <i>Aristida inaequiglumis</i> and <i>Themeda triandra</i> on red-brown sandy clay to clay on plains.	68.9	1.8	-	-
9	Low open woodland of <i>C. hamersleyana</i> , <i>C. d. deserticola</i> , <i>E. gamophylla</i> and <i>E. l. leucophloia</i> over tall sparse shrubland of <i>Acacia atkinsoniana</i> and occasional <i>A. ancistrocarpa</i> and <i>A. aptaneura</i> over low hummock grassland dominated by <i>T. pungens</i> and occasional <i>T. wiseana</i> with <i>P. muelleri</i> also dominant on red-brown clay loam with ironstone pebbles on plains.	600.6	15.9	3.9	0.5
10	Low open woodland of <i>C. hamersleyana</i> with occasional <i>E. gamophylla</i> , <i>E. l. leucophloia</i> and <i>E. xerothermica</i> over tall open shrubland dominated by taxa including <i>Acacia cowleana</i> , <i>Acacia tumida</i> var. <i>pilbarensis</i> , <i>G. robinsonii</i> and <i>Acacia pyrifolia</i> over low open hummock grassland of <i>T. pungens</i> and tussock grassland dominated by <i>Themeda</i> sp. Mt Barricade (M.E. Trudgen 2471) and <i>Aristida</i> spp. on red-brown clay loam on major and minor drainage lines.	215.5	5.7	14.9	2.0
C	Cleared (access tracks).	4.6	0.1	-	-
Total		3,784.6	100.0	754.7	100.0



Umwelt habitat mapping

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- C



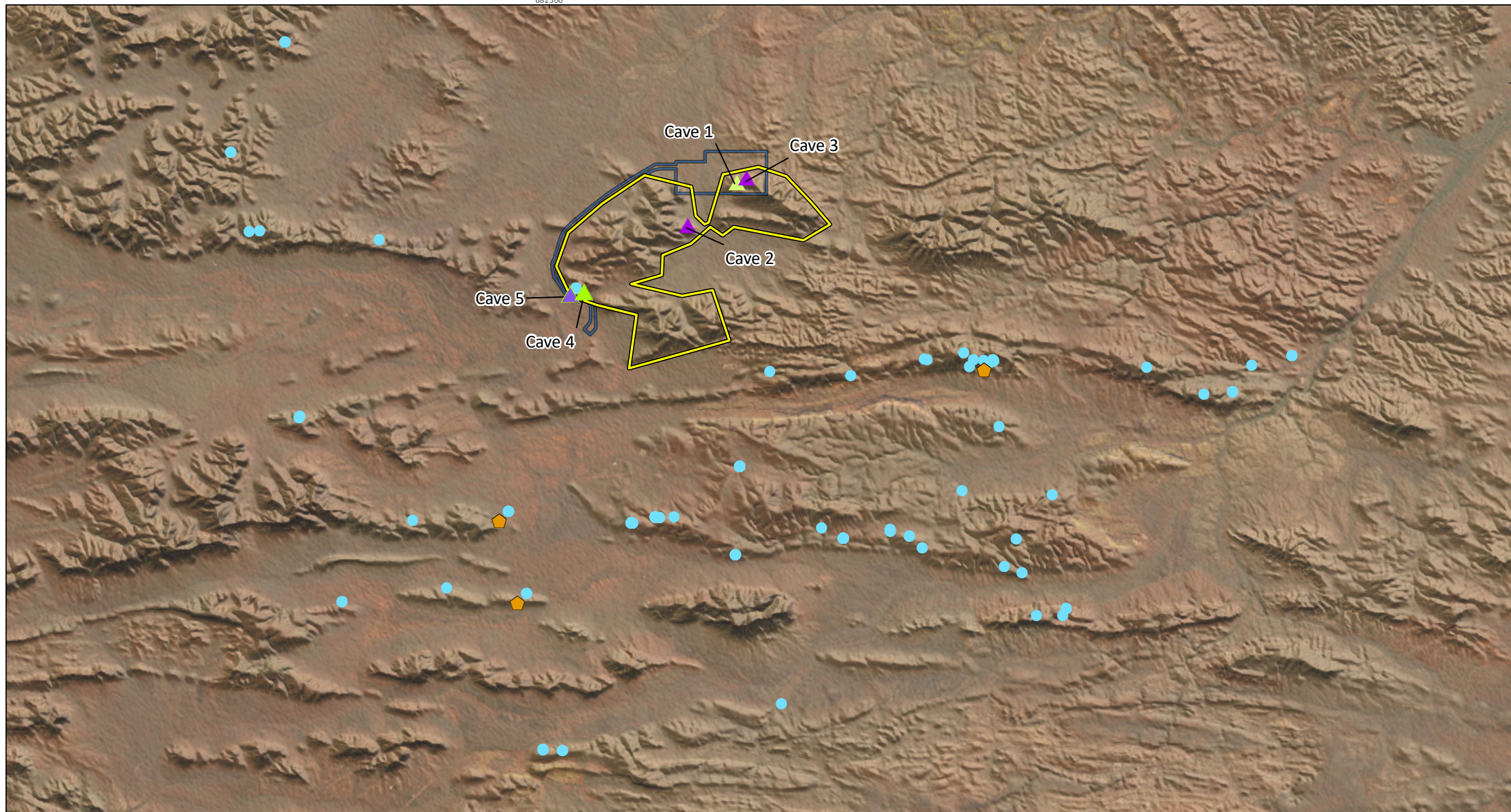
Mineral Resources Ltd Lamb Creek Iron Ore Project		
Project No	1535	
Date	4/05/2023	
Drawn by	BK	
Map author	WP	
1:90,200 (at A4)		GDA 1994 MGA Zone 50


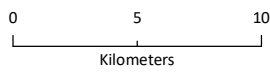
- Study area
- Lamb Creek Iron Ore Project area
- Ultrasonic recorder locations**
- 2012
- 2020
- 2021
- 2022

Figure 6-1
Lamb Creek Project: vegetation mapping (Umwelt Pty Ltd 2022) and targeted survey effort (Rapallo 2012, 2020, 2022; Phoenix, this survey)



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Mineral Resources Ltd Lamb Creek Iron Ore Project		
Project No	1535	
Date	1/31/2023	
Drawn by	FK	
Map author	WP	1:304,800 (at A4) GDA 1994 MGA Zone 50








-  Study area
 -  Lamb Creek Iron Ore Project area
 -  ALA records
 -  TFA records
- Ghost Bat Cave Locations**
-  Category 2
 -  Category 3

Figure 6-2

Desktop records of Ghost Bats and known caves in the vicinity of the Project



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6.2 FIELD SURVEY

The field survey assessed 5 caves (Table 5-4, Figure 5-1; locations and approximate dimensions described in Appendix 2):

- LC001 (Cave 3; Category 3); a known Ghost Bat cave initially surveyed by Rapallo (2012). Two Ghost Bats were directly sighted when flushed from the cave during the inspection, emerging one at a time and then circling together above the entrance before we lost sight of them. It appears that bats roost in the highest part of the cave on the right side, but the latrine (accumulation of fresh and older scats) was located close to the left wall. Scattered loose bone fragments imply the long-term use of the cave by Ghost Bats, but the number of intact scats suggests only a few individuals at any time. Fresh-appearing scats were collected and submitted for genetic analysis. Evidence of Euro (*Osphranter robustus*) was also present, and 2 sets of intact small dasyurid mandibles were collected from the surface (condition suggesting predation by owls, not Ghost Bat).
- LC002 (Cave 1; Category 2); a known Ghost Bat cave initially surveyed by Rapallo (2012). An indeterminate small brown bat was present. No signs of recent Ghost Bat use were observed in the upper part of the cave. Sticks and (possible) woven grass were present in the southern chamber. Cave was not explored thoroughly due to potential heritage material.
- LC003; a prospective roost cave previously surveyed by Rapallo (2012). The tunnel on the left had old granular scat detritus with small bone fragments, i.e. Ghost Bat has used it but no sign of fresh or current use. Scats were not considered suitable for genetic analysis.
- LC004; identified during this survey. No evidence of bats or other cave-associated fauna, assessed as not suitable for Ghost Bat occupancy.
- LC005; a potential roost cave identified during this survey. Ghost Bat scat (relatively old, but collected and submitted for genetic analysis) and smaller bat scat located in the upper rear part of the cave. Old Euro scats and bones throughout the cave. Several other horizontal pipes and side chambers were checked, but no other bat evidence was found.

Results of ultrasonic call analysis (Bullen 2022) are summarised in Table 6-4 and Table 6-5. A total of 7 microchiropteran bat species were recorded using ultrasonic detection across the 4 caves surveyed, representing 4 families (Appendix 3). Two species of *Taphozous* (family Emballonuridae) cannot always be distinguished but both were considered to be present (Bullen 2022). The regionally significant Ghost Bat (*Macroderma gigas*; VU) was recorded from 2 locations: LC001 (Cave 3; Category 3) from a total of 18 calls over 4 nights, and LC002 (Cave 1; Category 2) from a total of 26 calls over 4 nights.

Table 6-4 Microchiropteran species by site based on ultrasonic call analysis (Bullen 2022)

Family	Species	Vernacular	LC001	LC002	LC003	LC005
Megadermatidae	<i>Macroderma gigas</i>	Ghost Bat	•	•		
Molossidae	<i>Chaerephon jobensis</i>	Greater Northern Free-tailed Bat	•	•	•	•
Emballonuridae	<i>Taphozous georgianus</i>	Common Sheath-tailed Bat	•	•	•	•
	<i>Taphozous hilli</i>	Hill's Sheath-tailed Bat				
Vespertilionidae	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	•			•
	<i>Scotorepens greyii</i>	Little Broad-nosed Bat	•	•		•
	<i>Vespadelus finlaysoni</i>	Finlayson's Cave Bat	•	•	•	•

Table 6-5 Targeted Ghost Bat call analysis (Bullen 2022)

LC001 (Cave 3; Category 3)				
Metric	13-Sep-2022	17-Sep-2022	2-Oct-2022	9-Oct-2022
Earliest call	18:33	-	18:44	22:53
Latest call	-	04:57	-	02:47
Number of calls	2	10	8	6
LC002 (Cave 1; Category 2)				
Metric	13-Sep-2022	17-Sep-2022	18-Sep-2022	23-Sep-2022
Earliest call	18:46	-	22:21	-
Latest call	-	04:48	02:44	03:41
Number of calls	5	8	3	2

Nineteen scat samples were submitted to DBCA for genetic analysis, 13 from site LC001 (Cave 3) and 6 from LC005 (new cave identified in this survey); results were not available until April 2023 (Prada & Ottewell 2023; Appendix 4). DNA amplification was successful in 12 samples from LC001 and 3 from LC005, but genotyping and sex determination varied in success due to degradation in older samples. A total of 3 individual genotypes were identified, 1 female and 2 individuals with an inconclusive sexing result (sex undetermined). None of these genotypes were previously known from other regional surveys analysed by the DBCA lab. Two individuals (genotypes 870 and 872) were detected only in LC001, while 1 individual (genotype 871) was detected at both locations LC001 and LC005. Hormone analysis of scats was not conducted at this stage, due to only a single female being recorded from one site.

6.3 SURVEY LIMITATIONS

The limitations of the Targeted Ghost Bat survey have been considered in accordance with EPA (2020) (Table 6-6).

Table 6-6 Consideration of potential survey limitations

Limitations		Comments
Availability of contextual information at a regional and local scale	No	Previous surveys for the Project were available and reviewed in detail. Regional contextual information was available from database searches.
Competency/experience of the team carrying out the survey	No	All members of the survey team have had appropriate training, experience and mentoring in undertaking Targeted Threatened fauna surveys in the Hamersley subregion of the Pilbara.
Scope and completeness	Yes	Heritage access restrictions impeded surveys within the exclusion zone (where 3 known caves are located). The most prospective 'new' areas to the east and south were surveyed. Importantly, known caves east of the Project (Cave 1, Cave 3), and a formerly surveyed cave in 2012 (LC003) were investigated.
Proportion of fauna recorded and/or collected, any identification issues	No	Not applicable.
Access within the study area	Yes	A substantial section of the study area was not accessible due to heritage constraints; this area includes 3 previously known roosting caves intended for sampling and was to be searched for additional roost sites.
Timing, rainfall, season	No	Survey timing was appropriate for the proposed scope of work; the Targeted survey was undertaken during the Ghost Bat breeding season, allowing for the collection of scats suitable for hormone analysis. The survey occurred before the recommended cave exclusion period detailed in Bullen (2021a).
Disturbance that may have affected the results of the survey	No	No disturbance that could have impacted the results of the survey was observed in the study area.

7 DISCUSSION

Ghost Bats have been the focus of multiple surveys amounting to considerable survey effort and threat evaluation from anticipated Project disturbance over the last 10 years (Phoenix 2021a, b; Rapallo 2012, 2020, 2022; Western Wildlife 2020). These efforts successfully identified 5 roost caves within the vicinity of the Project; 2 caves occur within the Project area and 3 in the wider vicinity of the Project area (Table 6-2). Cave 1 and the 'apartment block' (Caves 4 and 5) were initially considered Critical habitat when identified by Rapallo (2012), while the remaining caves (Caves 2 and 3) represent important habitat for the long-term preservation of the species in the area (Table 4-2; Table 6-2).

This survey recorded Ghost Bats from 2 previously known locations: LC001 (Cave 3, Category 3) and LC002 (Cave 1, Category 2), and 2 new locations LC003 and LC005 (see Section 6.2).

For Cave 3, ultrasonic recordings alone would not imply its use as a diurnal roost, since Ghost Bat calls were not recorded on consecutive nights (Table 6-5). However, direct sightings of individuals in the cave during the field survey confirm usage by Ghost Bats as a diurnal roost on that occasion. Genetic analysis of scats identified genotypes of 3 individuals, one female and 2 of indeterminate sex.

For Cave 1, ultrasonic detections on consecutive nights (17-18 September 2022) indicate that Ghost Bats possibly use this cave intermittently as a diurnal roost (Table 6-5). No individuals were observed in this cave during the field survey, and no middens were found.

The limited number of calls detected from Caves 1 and 3 indicate that up to a few individuals were detected on each occasion. These findings reiterate the continued usage of these caves by Ghost Bats since their detection by Rapallo (2012) and resampling in 2020 and 2021 (Rapallo 2022). Results are consistent with current knowledge of the species in the Hamersley subregion, where colonies typically comprise 1 to 15 individuals, contrasting with other parts of the Pilbara such as the Chichester subregion, where colonies of up to 100 individuals have been observed (Bullen 2021a).

The re-evaluation of known Ghost Bat caves (LC001; Cave 3, and LC002; Cave 1) using metric estimates gathered during the field survey, in conjunction with echolocation recordings and direct sightings, found that the previously assigned statuses (Cave 1; Category 2, and Cave 3, Category 3) were accurate and did not change with the additional data (Bullen 2023). Therefore, Cave 1 remains as Critical habitat and Cave 3 important habitat for the long-term preservation of the species in the area. These statuses are consistent with the findings of the field survey and species knowledge in the Hamersley subregion in that diurnal roosting occurs occasionally, involving only small numbers of individuals per site.

While no Ghost Bats were recorded ultrasonically from LC003 either during this or previous surveys (Rapallo 2012), an old granular scat with small skeletal fragments was detected during this survey. The scat was not fresh enough for genetic confirmation but indicates occasional or opportunistic use subsequent to the 2012 survey. No Ghost Bats were detected ultrasonically at the newly identified cave site LC005, but genetic analysis of scat material detected one of the same individuals (genotype 871) from Cave 3 (LC001), 8.9 km distant. Hence LC003 and LC005, with some level of Ghost Bat occupancy indicated by scats but no ultrasonic detections or sightings, may belong to either Category 3 or 4; i.e. it is not known whether they are used as occasional diurnal roosts, or only opportunistically at night.

Ghost Bats have been previously recorded in the vicinity of the Project area, but only 3 of the records in the TPFA (DBCA 2021) occur within the study area, all located at Cave 5 (Figure 6-2). Most records occur south of the study area, although this pattern could result from non-uniform distribution of sampling effort. Negative results (species absence) are not recorded in available databases, so spatial bias may be difficult to detect (cf. Molloy *et al.* 2015).

Within the Hamersley subregion, caves with Ghost Bat roosts occur in banded ironstones of the Brockman, Weeli Wollli and Marra Mamba Formations (Armstrong & Anstee 2000; Threatened Species Scientific Committee 2016). The Brockman and Weeli Wollli Formations comprise more than 30% (661.0 ha) of the Project area and 89 % (7,175.5 ha) of the study area, while Marra Mamba forms

similar ranges of hills to the south. A review of aerial imagery, in combination with the extent and continuity of Banded Ironstone Formation (BIF) outside of the study area and wider Hamersley subregion, emphasises the amount of prospective roosting habitat available, most of which has been sparsely surveyed for fauna. To indicate the patchy distribution of previous survey efforts, Figure 7-1 shows fauna desktop records (all species, via Phoenix database) relative to BIF units and the study area.

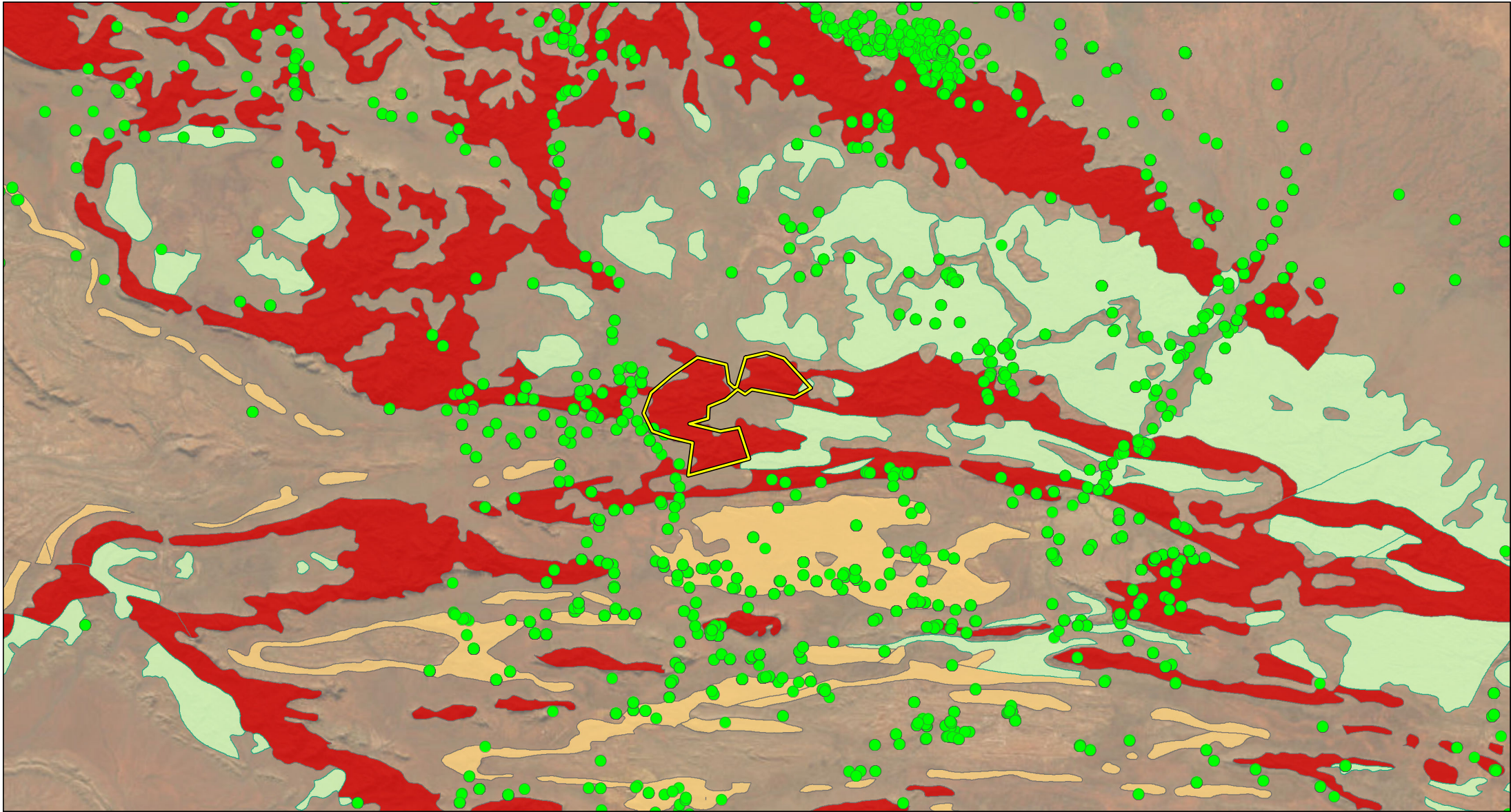
Current knowledge concerning Ghost Bat foraging habitats is limited (see Section 4). Habitat and vegetation mapping of the Project area was initially completed by Rapallo (2012) and has since been expanded on by Umwelt Pty Ltd (2022); a total of 3784.6 ha were mapped, intersecting 754.7 ha (9.4%) of the study area, however, most of the study area remains unmapped. Of the mapped portion of the study area, the dominant fauna habitat represents open mixed *Eucalyptus* and *Corymbia* woodland over scattered *Acacia* shrubs and mixed hummock grasslands (including *Triodia* spp.). According to regional land system summaries (Schoknecht & Payne 2011), the study area predominantly supports the Newman systems, which is described as “Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands”, while the remaining area supports a mosaic of hard spinifex grasslands, mulga woodlands, and occasional *Eucalyptus* woodlands (Table 3-1). Together, these data imply potential foraging habitat (see Section 4) is widespread across the study area; however, definitive conclusions cannot be drawn due to inconclusive research concerning Ghost Bat foraging ecology to date, and the lack of fauna habitat ground-truthing.

Recent trends in the Pilbara Ghost Bat population have indicated a likely decrease of greater than 30% in WA in the future, with local extirpation potentially occurring in areas such as the central and eastern Hamersley ranges (TSSC 2016). These projections emphasise the need to conserve and mitigate disturbance to known roosting sites and foraging habitats for Ghost Bats, particularly in the vicinity of external disturbances such as mining activities, to support their long-term conservation in the region. The management implications and recommendations for caves assessed during the field survey are detailed in the LCGBSA (Appendix 5) (Bullen 2023).

The proposed scat sequencing and hormone analysis, where scat samples from multiple caves are required, intends to make inferences concerning the local Ghost Bat population size and sex ratios, in conjunction with evaluating individual movement between caves (through identification of recaptures) and genetic neighbourhood size estimations within the Project area and surrounds. These population dynamics are considered critical factors when determining the potential survival of Threatened species, particularly for explicit carnivores such as the Ghost Bat which have intrinsically small effective numbers. In addition, the hormone analysis (i.e. detection of progesterone) is indicative of reproducing females from the sampled locations (i.e. caves). These analyses subsequently have the potential to establish a more precise determination of cave status (see Table 4-2) and thus the presence of Critical habitat for the species within the vicinity of the Project. Since minimal scat samples were found during this field survey, results from these analyses are limited (see Section 5.2.5). One individual (genotype 871) was recorded from 2 cave sites separated by 8.9 km, consistent with prior understanding of the foraging range of Ghost Bats and the use of multiple roost sites. While hormone analysis has not been conducted, evidence from LC001 indicates intermittent occupancy by small numbers of Ghost Bats including the presence of at least 1 female, likely to have been pregnant at the time of the survey (cf. Table 4-1).

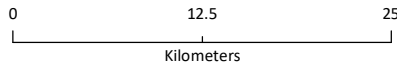
If needed to develop management controls for limiting the potential impact of the Project on Ghost Bats, it is recommended that further surveys take place throughout the exclusion zone (Figure 1-1), as this area represents the most under-surveyed area in the vicinity of the Project. This could include supplementary surveys (Song Meter deployment, cave metric assessments, scat sequencing and hormone analysis) of inaccessible caves (Caves 2, 4 and 5). However, these caves are fairly removed from the potential impact source (i.e. mine area/processing plant) and are likely not affected by these disturbances. Results from such surveys would contribute to our understanding of the population dynamics (i.e. population sex ratios, effective population size, etc), reproductive status and cave usage

by Ghost Bats in the vicinity of the Project, helping delineate what is considered Critical or important habitat for the persistence of Ghost Bats in the area. Lastly, if needed to further define management controls, cave searches among the exclusion zone are recommended, as this region represents the most prospective and under-surveyed area within the vicinity of the Project; if additional caves are detected, the methods described above are recommended. Any additional surveys of this nature would be considered an added benefit to the Project.



Mineral Resources Ltd
Lamb Creek Iron Ore Project

Project No	1535
Date	2/6/2023
Drawn by	FK
Map author	WP



1:500,000 (at A4) GDA 1994 MGA Zone 50

- Study area
- Desktop fauna records
- Geological formations**
- Brockman Iron Formation
- Marra Mamba Iron Formation
- Weeli Wollie Formation

Figure 7-1
Regional distribution of Banded Iron Formations and fauna desktop records



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8 CONCLUSION

Results from Song Meter deployment at 2 known caves within the Project area, in conjunction with direct sightings at one cave, indicate that Caves 1 and 3 (LC002 and LC001, respectively) are used by Ghost Bats intermittently as diurnal roosts. Genetic analysis of scats from LC001 identified 3 individual Ghost Bat genotypes, at least 1 of them female and likely to have been pregnant at the time of survey (see Table 4-1; not confirmed by hormonal analysis), but due to intermittent occupancy of the site it is not identified as a maternity roost. No changes to the statuses of known caves were made following the provision of cave metrics: Cave 1 remains Critical habitat (Category 2) and Cave 3 important habitat (Category 3).

At 2 additional sites, LC003 and LC005, occasional use by Ghost Bats are indicated by the presence of scats but the species was not detected by ultrasonic recordings in this survey. It is not known whether these caves have been used as diurnal roosts or only for nocturnal resting or foraging, hence could belong to either Category 3 or 4. One individual genotype (sex indeterminate) was identified in scat samples from both LC001 and LC005, approximately 9 km apart. No other Ghost Bat roosts were identified despite active cave searches among 2 of the 3 gorge systems comprising the survey area, which are predominantly composed of geological formations known to support Ghost Bats in the Hamersley subregion.

If needed to develop management controls for limiting potential impacts from the Project on Ghost Bats, it is recommended that supplementary surveys of inaccessible caves (Caves 2, 4 and 5) could be undertaken. Furthermore, if additional surveys in the exclusion zone are deemed necessary and undertaken, additional cave searches are recommended. The results of these surveys would contribute to a better understanding of the population dynamics and reproductive condition, along with the location and extent of Critical habitat, of the local Ghost Bat population, collectively to better conserve and mitigate any potential disturbance from the Project.

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Appendix 1 **Terrestrial fauna survey site descriptions**

Site details			
Site	LC001	Position (WGS84)	-22.807586, 118.891269
Topography	gorge	Soil texture	rocks
Slope	moderate	Rock type	ferrous - BIF
Soil colour	red-orange	Rock cover (%)	70

Sample and effort summary					
Visit	Sample method	Sample quant. (hrs)	Repliation	Date start	Date stop
1	Ultrasonic recording	840	1	13 Sep 2022	18 Oct 2022

Site description - visit 1 (13 Sep 2022)			
Open woodland with scattered low white Eucalypts and mid-level Acacia shrubs over spinifex on north-facing gully in tilted and folded Banded Ironstone Formation on red-orange sandy loam with lots of banded ironstone rocks. West-facing cave located at the base of a fan-shaped gorge.			
Habitat	open woodland		
Disturbance	exploration (drill pads and access tracks)		
Vegetation condition	Excellent	Fire age	moderate (>5 years)
Total veg. cover (%)	30	Litter distribution	under vegetation
Tree cover (%)	5	Litter depth(cm)	0
Shrub cover (%)	1	Litter cover (%)	0
Grass cover (%)	25		
Herb cover (%)	1		



Site details			
Site	LC002	Position (WGS84)	-22.809965, 118.885933
Topography	gorge	Soil texture	sandy loam, rocks
Slope	steep	Rock type	ferrous - BIF
Soil colour	red-orange, brown-grey	Rock cover (%)	70

Sample and effort summary					
Visit	Sample method	Sample quant. (hrs)	Repliation	Date start	Date stop
1	Ultrasonic recording	840	1	13 Sep 2022	18 Oct 2022

Site description - visit 1 (13 Sep 2022)			
Spinifex grassland with scattered low to mid-level white Eucalypts over scattered mid-level Acacia and Senna shrubs, Ptilotus and Solanum herbs and spinifex in Banded Ironstone Formation on red-brown and brown-grey sandy loam with lots of banded ironstone rocks. West-facing cave location on a vertical cliff at the top of a fan-shaped gorge.			
Habitat	spinifex grassland		
Disturbance	none evident		
Vegetation condition	Excellent	Fire age	moderate (>5 years)
Total veg. cover (%)	70	Litter distribution	under vegetation
Tree cover (%)	3	Litter depth(cm)	1
Shrub cover (%)	3	Litter cover (%)	1
Grass cover (%)	60		
Herb cover (%)	1		



Site details			
Site	LC003	Position (WGS84)	-22.813181, 118.888488
Topography	gorge	Soil texture	sandy loam, rocks
Slope	moderate	Rock type	ferrous - BIF
Soil colour	red-brown, red-orange	Rock cover (%)	70

Sample and effort summary					
Visit	Sample method	Sample quant. (hrs)	Repliation	Date start	Date stop
1	Ultrasonic recording	816	1	14 Sep 2022	18 Oct 2022

Site description - visit 1 (14 Sep 2022)			
Open woodland with Eucalypts over mixed mid-level shrubs over Tridioa sp. and other tussock grasses (Buffel?) on red-brown to red-orange sandy loam with banded ironstone rocks. West-facing cave located on the side of north side of east to west gully in top of range.			
Habitat	open woodland		
Disturbance	non-evident		
Vegetation condition	Excellent	Fire age	moderate (>5 years)
Total veg. cover (%)	70	Litter distribution	under vegetation
Tree cover (%)	15	Litter depth(cm)	2
Shrub cover (%)	20	Litter cover (%)	5
Grass cover (%)	50		
Herb cover (%)	1		



Site details			
Site	LC004	Position (WGS84)	-22.878122, 118.818728
Topography	gully	Soil texture	sandy loam, rocks
Slope	moderate	Rock type	ferrous - BIF
Soil colour	red-brown, red-orange	Rock cover (%)	70

Site description - visit 1 (14 Sep 2022)			
Open woodland with mid-level Eucalypts over wattles, etc. and tussock grasses in south-facing gully, spinifex on lower and higher sloped of gully, on red-brown to red-orange sandy loam with lots of banded ironstone rocks.			
Habitat	open woodland		
Disturbance	non-evident		
Vegetation condition	Excellent	Fire age	moderate (>5 years)
Total veg. cover (%)	75	Litter distribution	under vegetation
Tree cover (%)	20	Litter depth(cm)	2
Shrub cover (%)	10	Litter cover (%)	10
Grass cover (%)	50		
Herb cover (%)	1		





Site details			
Site	LC005	Position (WGS84)	-22.888038, 118.88898
Topography	gully	Soil texture	sandy loam, rocks
Slope	moderate	Rock type	ferrous - BIF, ferrous - ironstone
Soil colour	red-orange	Rock cover (%)	70



Sample and effort summary					
Visit	Sample method	Sample quant. (hrs)	Repliation	Date start	Date stop
1	Ultrasonic recording	816	1	14 Sep 2022	18 Oct 2022


Site description - visit 1 (14 Sep 2022)			
Open woodland with low to mid-level white Eucalypts over sparse Acacia and mixed shrubs over spinifex and tussock grasses on red-orange sandy loam with lots of banded ironstone rocks. Small, south-facing cave in weathered banded ironstone located at east end of valley.			
Habitat	open woodland		
Disturbance	non-evident		
Vegetation condition	Excellent	Fire age	moderate (>5 years)
Total veg. cover (%)	60	Litter distribution	under vegetation
Tree cover (%)	10	Litter depth(cm)	1
Shrub cover (%)	2	Litter cover (%)	1
Grass cover (%)	50		
Herb cover (%)	1		



Appendix 2 Cave locations and approximate dimensions

Site	Height (m)	Width (m)	Depth (m)	Additional notes	Photograph of entrance
LC001 (-22.8075, 118.8912; Rapallo Cave 3, Category 3)	4	4	15	The cave faces west inside of a narrow north-to-south gully on the northern slope of the range and slopes up at ~20°. Bats use a crevice in the upper right section of the cave. A latrine was located under the left wall.	
LC002 (-22.8101, 118.8846; Rapallo Cave 1, Category 2)	3	2	15	Cave facing west in a vertical cliff at top of a wide fan-shaped gorge high on the northern face of the range. The aperture of the cave entrance narrows abruptly and opens out and upward towards the back. Additional lower chamber to right (south).	

Site	Height (m)	Width (m)	Depth (m)	Additional notes	Photograph of entrance
LC003 (-22.8132, 118.8886; Rapallo prospective cave)	6	8	3	The cave faces west inside the gorge on the north side of an east-to-west valley at the top of the range. Two smaller tunnels at the rear of the cave; extend ~3 m and are located 3 m above the cave floor.	
LC004 (-22.8781, 118.8187; this survey)	2	8	2	Steep south-facing gully with 2 overhangs in the wall at the top, but both are shallow and slope only down from the entrance due to a dip of BIF strata. Smaller shallow overhangs are also present at the bottom of the gully.	

Site	Height (m)	Width (m)	Depth (m)	Additional notes	Photograph of entrance
LC005 (-22.8879, 118.8890; this survey)	4	4	8	The cave faces west at the end of an east-to-west shallow valley on the south slope of the range. Relatively small cave; the deepest part is a narrow horizontal pipe located near the roof level.	

Appendix 3 Fauna species by site matrix

Species	Common name	LC001	LC002	LC003	LC004	LC005
Class Mammalia; Order Chiroptera						
Family Emballonuridae						
<i>Taphozous georgianus</i>	Common Sheath-tailed Bat	•	•	•		•
<i>Taphozous hilli</i>	Hill's Sheath-tail-bat	•	•	•		•
Family Megadermatidae						
<i>Macroderma gigas</i>	Ghost Bat	•	•			•
Family Molossidae						
<i>Chaerephon jobensis</i>	Greater Northern Freetail-bat	•	•	•		•
Family Vespertilionidae						
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	•				•
<i>Scotorepens greyii</i>	Little Broad-nosed Bat	•	•			•
<i>Vespadelus finlaysoni</i>	Finlayson's Cave Bat	•	•	•		•

Appendix 4 Identification of Ghost Bat (*Macroderma gigas*) individuals from scats collected from Lamb Creek, Pilbara WA - Diana Prada and Kym Ottewell (DBCA)



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Identification of Ghost Bat (*Macroderma gigas*) individuals from scats collected from Lamb Creek, Pilbara WA

Diana Prada and Kym Ottewell

Introduction

Faecal (scat) DNA sampling is used as a method of 'molecular tagging' to identify individuals for mark-recapture analyses which offers less impact to animals compared to live-capture methods. This approach has been successfully used to detect the spatial and temporal movement patterns of individual ghost bats amongst roost sites at local scales (Ottewell et al., 2017, 2019a) as well as to assess genetic connectivity amongst populations at the landscape scale (Ottewell et al., 2017; Spencer & Tedeschi, 2016).

Here we derive the minimum number of unique ghost bats occupying two sites (LC001 and LC005) in Lamb Creek, Pilbara, Western Australia from 19 faecal samples (LC001 = 13, LC005 = 6) collected in September 2022 (Table A1). Samples were collected in a single envelope per location, instead of a single envelope per sample. Therefore, it is possible that DNA cross-contamination between samples occurred, and that biases have been introduced to the calculation of unique individuals reported here. We did not observe any obvious signs of cross-contamination (although this caveat remains for interpretation of results) and proceeded to identify unique individuals and their corresponding sex. We compared these to the DBCA ghost bat genotype database to determine whether any of the individuals had been previously detected. Detailed methods are provided at the end of this report.

Genotyping results

The samples provided were of good quality and on average the amplification rate for all samples across all loci was $70 \pm 0.7\%$. Samples and loci were quality controlled by keeping only those samples that amplified for at least 77% of the loci and keeping loci that amplified for at least 80% of the samples. Therefore, out of the 19 samples, 13 were suitable for further analysis and comparisons were made using 41 loci. Genotypes were subjected to clustering analysis; based on the binomial distribution of mismatches within replicates, and mismatches among samples, we determined that a threshold of $h=2$ (two samples with 2 or more mismatches are considered separate samples) was suitable to identify unique individuals.

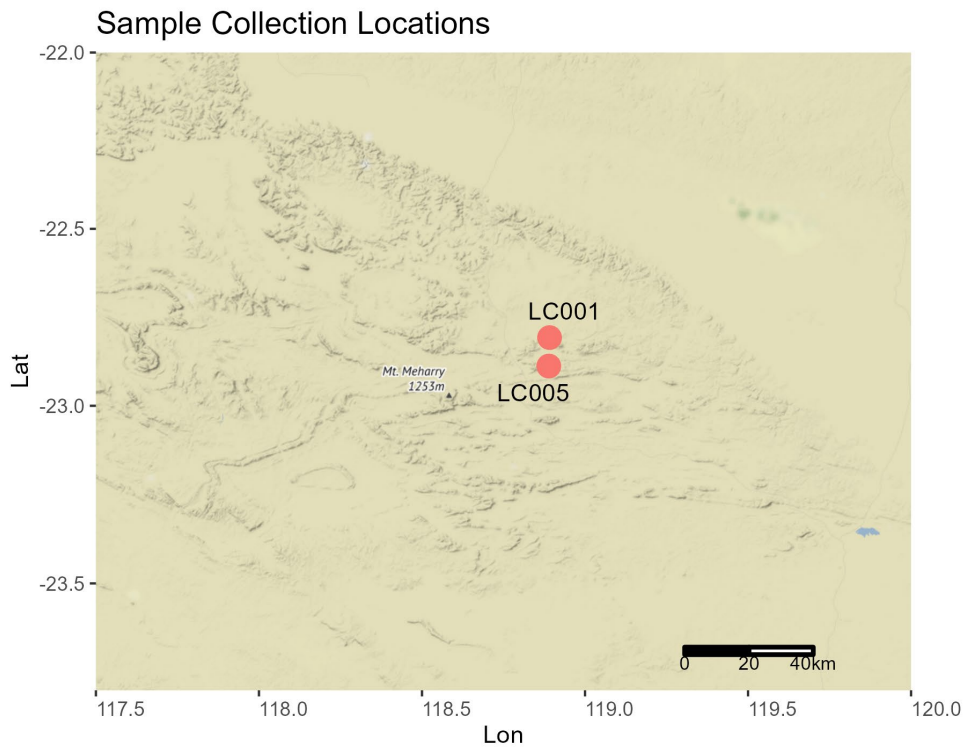


Figure 1: Map showing locations of collection sites. Circles show sites or proximate locations of captured individuals.

Identification of individuals

A total of three individuals were detected, one female and two individuals with an inconclusive sexing result (sex undetermined). Two individuals (genotypes 870 and 872) were detected only in LC001, while one individual (genotype 871) was detected at both locations LC001 and LC005.

Recaptures

Genotype matching against the DBCA ghost bat database indicated that the three individuals identified are new identifications and have not been previously detected.

Genetic diversity

Due to only three individuals being detected in the current survey, we do not report summary genetic diversity results.

Concluding remarks

Scats collected for this report were of good quality but stored together instead of individually. It is highly recommended that scats are stored individually (one scat per envelope) to minimize the risk of DNA cross contamination between samples, which may lead to the misidentification of individuals.

Three unique individuals were identified from the provided samples. Genotype 871 was represented by the greatest number of scats ($n=9$), while genotypes 870 and 872 were detected from three and one scats, respectively. It is difficult to determine the degree (if any) of DNA cross contamination between the supplied samples. The three genotypes are distinct with several differences across all the loci, and consistent allele calls for each locus were also observed. Thus, suggesting they are true instead of mixed profiles.

Only one individual was detected from both locations, albeit the great majority of the scats that were below the amplification threshold were collected from LC005. However, the detection of this one movement between suggests a degree of connectivity between these two sites. Similar patterns of

roost use, where individuals use cluster of sites <10 km apart is consistent with previous reports for the ghost bats in the Pilbara (Ottewell et al., 2019b, 2022; Ottewell, Thavornkanlapachai, & McArthur, 2020; Ottewell, Thavornkanlapachai, McArthur, & Byrne, 2020).

Yours sincerely,

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Research Scientist

and

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Senior Research Scientist

3 April 2023

APPENDIX

Detailed Methods and Analyses

Surface material was scraped from each scat using a blade and genomic DNA extracted using the Omega Biotek Mag-Bind Stool DNA 96 kit (Omega Cat No: M4016-01) with a modification of using 50% diluted elution buffer in the final elution step to reduce EDTA inhibition of downstream analyses.

All DNA samples were genotyped using DBCA's multiplexed panel of SNP markers ($n = 48$ SNP loci) on the MassARRAY System (Agena BioScience) at the Australian Genome Research Facility, Brisbane (AGRF). Sixty μl of each faecal DNA sample was sub-sampled from 100 μl extract and concentrated down to 20 μl for genotyping. PCR amplification and extension reactions were performed using the iPLEX Gold Reagent Kit with 1 μl of the concentrated DNA extract. Resultant SNP genotypes were identified by mass spectrometry and called using MassARRAY TYPERVIEWER 4.0 software (Agena Bioscience). Four samples were re-genotyped to calculate allelic dropout and false allele error rates. Samples left exposed to environmental conditions over 5-7 days are likely to have a lower amplification rate and high genotyping errors (Berry et al., 2007; Carpenter & Dziminski, 2017)

MassARRAY SNP results were processed in a custom R package 'ScatMatch' (Huntley, 2021) designed to group scats based on genotype similarity, i.e. by the number of allelic mismatches between samples. The identification of a suitable threshold mismatch number (h) by which scats are clustered into 'individuals' was done by comparing the number of groups or putative individuals identified for each h value (Figure A1). A clear flattened line after the mismatch threshold is reached indicates that scats were consistently assigned to the same individuals regardless of which mismatch threshold was used past this point. Second by a visual assessment of the clustered genotypes. We concluded that $h = 2$ was suitable for the analysis.

Molecular sexing of scat samples was carried out using four custom-designed ghost bat sex-linked primers and probes (DDX3Y, SRY, Zfy, and Zfx) (Ottewell, Thavornkanlapachai, McArthur, Spencer, et al., 2020) arranged in real-time PCR multiplex. Primers were amplified in 10 μl reactions using the PrimeTime™ Gene Expression Master Mix (Cat No: 1055772) with an annealing temperature of 60°C, 40 amplification cycles and 4 μl of unconcentrated DNA. The reactions were run in CFX96™ Real-Time System C1000 Touch Thermal Cycle (BIO-RAD, Singapore) and analysed in BioRad CFX Maestro software (BIO-RAD, Singapore). Sex is confidently allocated if all three Y-linked markers produced the same result and are consistent across multiple scats from the same individuals. Where inconsistencies are present (failed marker, mismatch between different scats) sex is indicated as "most likely" if 2 of 3 sex-linked markers amplify or "undetermined" if only 1 of 3 markers amplify.

Table A1: Sample information and genotype IDs for all 19 *Macroderma gigas* samples collected for this study.

DBCA ref	Sample	Roost	DATE	Lat	Long	Sex	Genotype
SC-02589	1	LC001	13/09/2022	-22.80754	118.891195	Female	870
SC-02590	2	LC001	13/09/2022	-22.80754	118.891195	Female	870
SC-02597	9	LC001	13/09/2022	-22.80754	118.891195	Female	870
SC-02591	3	LC001	13/09/2022	-22.80754	118.891195	Inconclusive	871
SC-02593	5	LC001	13/09/2022	-22.80754	118.891195	Inconclusive	871
SC-02594	6	LC001	13/09/2022	-22.80754	118.891195	Inconclusive	871
SC-02596	8	LC001	13/09/2022	-22.80754	118.891195	Inconclusive	871
SC-02598	10	LC001	13/09/2022	-22.80754	118.891195	Inconclusive	871
SC-02599	11	LC001	13/09/2022	-22.80754	118.891195	Inconclusive	871
SC-02600	12	LC001	13/09/2022	-22.80754	118.891195	Inconclusive	871
SC-02601	13	LC001	13/09/2022	-22.80754	118.891195	Inconclusive	871
SC-02592	4	LC001	13/09/2022	-22.80754	118.891195	Inconclusive	872
SC-02595	7	LC001	13/09/2022	-22.80754	118.891195	Failed	
SC-02602	1	LC005	14/09/2022	-22.88793	118.888999	Inconclusive	871
SC-02603	2	LC005	14/09/2022	-22.88793	118.888999	Female	
SC-02604	3	LC005	14/09/2022	-22.88793	118.888999	Failed	
SC-02605	4	LC005	14/09/2022	-22.88793	118.888999	Inconclusive	
SC-02606	5	LC005	14/09/2022	-22.88793	118.888999	Failed	
SC-02607	6	LC005	14/09/2022	-22.88793	118.888999	Failed	

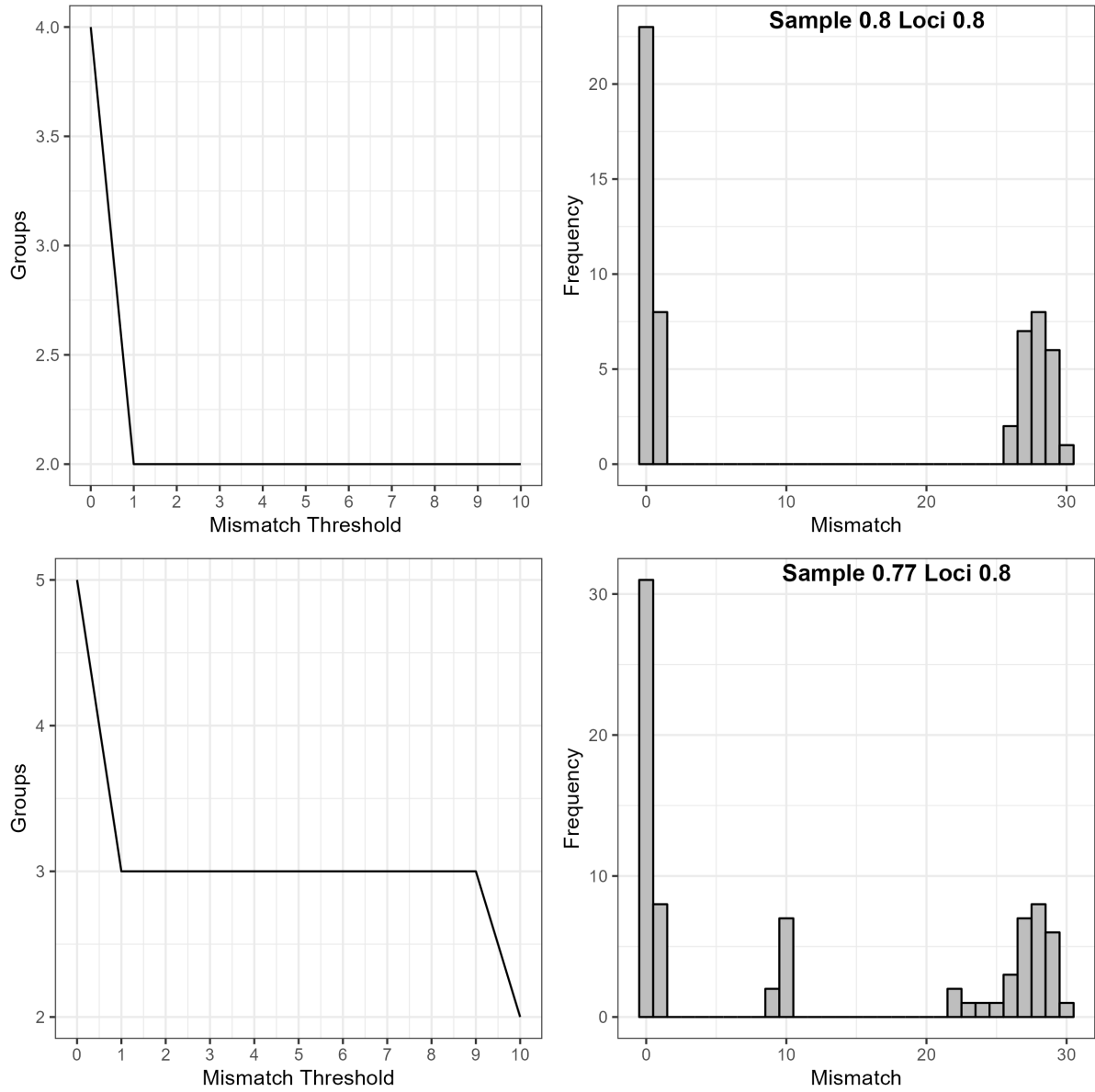


Figure A1: Threshold of allelic mismatch number to call *Macroderma gigas* scats from the same individuals with an amplification rate of 77% across samples and 80% across loci.

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Appendix 5 Lamb Creek Ghost Bat Significance Assessment (Bullen 2023)

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Significance Assessment regarding Ghost bat presence at Lamb Creek.

Carl,

Mineral Resources Limited (MinRes) have requested a Subject Matter Expert Review from Bat Call WA on the existing Significance Assessment and Significant Fauna Management Plan of MNES bat presence, specifically Ghost Bat (*Macroderma gigas*) (PGb) but also Pilbara leaf-nosed bat (*Rhinonictoris aurantia*) (PLNb), at their Lamb Creek project. The review shall include aspects of presence and management (SOW (MinRes 2023a)).

The review relied on the following material that was provided:

- Lamb Creek Iron Ore Mine, Significant Fauna management Plan (MinRes 2021).
- Lamb Creek Iron Ore Project Supporting Document; Referral under section 38 Environmental Protection Act 1986., Significant Fauna management Plan (MinRes 2022).
- Ghost bat significance assessment for the Lamb Creek Iron Ore Project. (Phoenix 2022)
- Targeted Ghost bat survey for the Lamb Creek Iron Ore Project. (Phoenix 2023)
- Shape files of Development Envelope and Indicative Footprint. (MinRes 2023b).

Having completed my review of the data set I can advise the following substantial conclusions:

1. There are two bat species listed as MNES under federal and state legislation at potentially at Lamb Creek. The Pilbara leaf-nosed bat and the Ghost bat. There are no records of the PLNb at or nearby Lamb Creek and minimal non roosting records within 15 km in the project's various fauna surveys and in Bat Calls data base, the subject of the SOW is the PGb.

2. Phoenix (2022; 2023) have completed a comprehensive desk top review of earlier surveys completed by Rapallo between 2012 and 2021, a field survey campaign and post survey analysis using industry standard methods and techniques for bat identification that are in accordance with current national and state guidelines. The equipment used (Songmeter SM series detectors by Wildlife Acoustics, USA) is current and provides accurate bat call recordings. All echolocation-based surveys carried out were analysed and bat species identified by experienced bat specialists familiar with cryptic PGb calls. DNA from scats collected was analysed by the DBCA laboratory at Kensington WA. Internal cave dimensional characteristics were reported by Phoenix that together with echolocation and scat DNA results confirm cave categorisations.
3. A series of PGb presence records were identified by Phoenix from observational records, echolocation call analysis and DNA analysis from scats indicating that the bats were present across the Lamb Creek study area in small numbers and based on the desktop review, over multiple years. Caves where PGb presence was recorded were given usage classifications based on TSSC (2016) and Bat Call WA (2021), i.e., maternity, day and night and categories 2, 3 and 4 that confirm importance of usage.
4. Phoenix (2022; 2023) have identified four roost caves that are category 2 or 3 roosts within the study area. LC001 (isolated Cat. 3, also Rapallo cave 3), LC002 (isolated Cat. 2, also Rapallo cave 1), Rapallo cave 4 (Cat. 3) and Rapallo cave 5 (Cat.2). Rapallo caves 4 and 5 are in an apartment block complex within a steep gully. No PGb calls were reported for caves LC003 and LC005 and so insufficient information is presented to categorise caves LC003, LC004 and LC005. Of the four categorised caves, three are assessed as critical habitat after Bat Call (2021) being the isolated category 2 cave LC002 (Rapallo Cave 1) and the Rapallo caves 4 and 5. Cave LC001 is assessed as an isolated cat 3 cave and is therefore not critical habitat.
5. Phoenix (2022; 2023) does not address the caves at Lamb Creek in respect to the potential cumulative loss of PGb habitat. Potential mid-timeframe extirpation of PGb from the Hamersley Range east of Karijini NP is noted in TSSC (2016) and must therefore be considered.
6. Of the seven caves nominated in Phoenix (2023) all are proposed to be retained as viable roosts and it is expected that any caves within the Heritage Exclusion Zone (Phoenix 2023, figure 1-1) will also be retained. This is considered to be an acceptable outcome for the long-term protection of PGb presence at Lamb Creek post mining.

7. Several of the documents include a statement that damage to critical habitat and other caves due to the mining operations is “considered unlikely. This statement appears to be based on the planned distances of 280 m from the Development Envelope (DE) and 750 m from the current pit design. No professional geotechnical assessment of the critical habitat cave 1 appears to be available to back up this statement. Current best practice therefore would recommend that mine planning be carried out with conservative limitations on in-ground vibration (PPV) so that this cave remains as a viable roost post mining.

8. MinRes (2021,2022) are silent on whether mining is planned to be a 24/7 operation however this is expected normal mining practice therefore the caves and any bats within proximity to mining operations may be subject to impacts such as vehicle strike, in-ground vibration, sound, artificial light and airborne dust. These impacts are recognised and addressed. It is expected that these impacts will cause the temporary abandonment of some or all of the roosts within or immediately adjacent to the DE while operations are underway. Further, recent evidence has shown that PGB will recolonise roosts after mining operations cease as long as the caves remain in a viable condition. Temporary closure during the critical female breeding period of October to December may be required to ensure that no inadvertent loss of mothers and/or pups will occur in the event of mining activity (e.g., blasting, excavation, haulage, overburden stacking) in proximity to caves (see further discussion below).

8. None of the documents address the issue of loss of any critical foraging habitat. They correctly note that all foraging habitat to be impacted is potentially used by Ghost bats. MinRes (2021, 2022) state that management mitigation strategies are planned to minimise this impact. These are considered adequate (see further discussion below).

9. Fencing is integral to good land and stock management in the pastoral, mining lands of the Pilbara, but it needs to be built in a manner compatible with wildlife, including Ghost bats. Recognising that the project includes pastoral lands as well as ridge lines, it is recommended that three and four strand wire fencing in the Pilbara be built according to the perceived risk area that applies. PGB in particular are known to become entangled in barbed wire fencing during commuting and/or foraging. There are numerous records of fatalities resulting from entanglement (TSSC 2016; Bat Call 2021). Phoenix (2022) addresses this risk with a statement in Table 5.8 that is both naive and misleading. I have three records of PGB entanglement in barbed wire fencing within 50 km of the project. Further, no reference is made to any agreement with the managing

pastoralist regarding the building of fencing without barbed wire, in particular along the haul road. I consider the areas along the perimeter the DE and the haul road to have high to moderate risk of entanglement, and therefore the potential for use of barbed wire in a limited manner, together with suitable bat deflectors, is acceptable. Phoenix (2021) should be corrected and MinRes 2021 and 2022 should be modified suitably to reflect this.

In addressing these points of discussion in the following paragraphs, my comments are based on the following hierarchy of objectives. Firstly, protect the caves considered to be critical habitat for the MNES species, in this case the PGB. Secondly, protect PGB that may be roosting in these caves. Thirdly understand the impact of the project on the PGB's foraging areas surrounding the caves in question and maintain adequate area for the future.

Item 1. General comments regarding buffers around PGB roosts at Lamb Creek.

Category 2 roosts such as the isolated cave 1 at Lamb Creek, ~270 m from the DE, are those with regular diurnal occupancy, typically between 25 and 75 % of days (Bat Call 2021, Sect 5.1). Category 3 such as the isolated Cave 3, ~520 m from the DE, are those with occasional diurnal occupancy. One apartment block including a Cat. 2 and a Cat. 3 cave has been identified at Lamb Creek ~150 m from the planned haul road. Note also that all Cat. 2 roosts and apartment blocks are designated as critical habitat (Bat Call 2021 Sect 5.1). There is no other critical roosting habitat identified.

Following numerous discussions on the subject with several proponents and based on field work at several unrelated projects acceptable buffers can be proposed around PGB critical habitat roosts that remain open during mining operations. These buffers are acceptable based on the following:

1. Category 2 and 3 caves are not permanently occupied therefore it has been proven that the PGB can easily relocate away if disturbed by the pre-mining or pit development operations.
2. Retention of roosting viability of the Cat. 2 and 3 caves can be shown by Geotech Engineering assessment and /or professional Blast Engineering planning before and during the occurrence of mining operations nearby.

3. Blast planning shall be based on maximum Peak Particle Velocity (PPV) limits that provide protection for any roosting bats, reproducing females in particular, that remain in open roosts when mining ops are nearby. The limiting PPV for critical habitat caves shall be 10 mm/sec from 1st October to 31st December to protect heavily pregnant females and newborn young. For critical habitat caves from 1st January to 30th September the limiting PPV shall be based on retaining the roost as viable. When no professional engineering assessments are available, the default conservative limit shall be 25 mm/sec for Cat. 2 caves and 50 mm/sec for Cat 3 caves. With professional Geotech assessment and blast engineering modelling, these limits may be higher (Bat Call 2021, sect 6.2.3) as allowed by those assessments. The Cat 2 caves at Lamb Creek have been assessed as remaining viable as roost structures but no professional assessment(s) are presented in support. Therefore, the lower default values of limiting PPV should apply.
4. It is well documented that high or unusual levels of ambient noise have been shown to cause PGB to temporarily abandon diurnal roosts. Bat Call (2021, sect 6.2.2) recommends current best practice for sound levels at open Cat. 2 roost entrances of 70 dB(Z) during mining operations. This is based on Bullen and Creese (2014) supplemented by more recent unpublished author's observations. This default limitation should apply to Cave 1 if it remains open during mining.
5. Current best practice for exclusion buffers at open critical habitat PGB caves is 200 m (Bat Call 2021) and 100 m for Cat 3 caves. At Lamb Creek Cave 1 and the Cave 4/5 apartment block, 150 m is considered adequate for mining activities and 100 m for other forms of ground disturbance.
6. As noted above, current field work (Bullen *et al.* 2023 and other personal observation sessions at PGB roost entrances) has shown that the species does not begin to forage from the ground immediately upon exiting the roost but departs the local area.

If during mine planning, limits for avoidance buffers, continuous ambient noise or in-ground vibration as defined above (default or specific) are not able to be met, an acceptable solution is to close off the entrances. PPV limits designed to retain the cave as a viable roost post mining to allow recolonisation shall then be enforced. It is expected that noise and vibration levels during the project may necessitate temporary closure at Cave 1. I recommend that while construction and mining operations are underway in proximity to this cave, and the displacement of bats is considered likely, the cave be closed to PGB occupation during the October to December breeding

season as a minimum to avoid impacts to breeding PGB individuals while mining is carried out at the project. Caves 1 and 3 may also be closed year-round during mining operations to minimise impacts to PGB individuals. Cave closure is viable due to the proximity of Ghost bat habitat within 25 km to the east, south and west that will allow the bats to relocate away during the mining operations and return to the retained DE caves once mining is completed.

Item 2. Impact of temporary closure of specific roost Cave 1.

This natural cave, together with the two caves 4 and 5 to the south, constitute the identified critical roosting habitat at and adjacent to the DE and haul road. With the possible closure of Cave 1 and the level of noise, dust and in-ground vibration during mining operations including mine closure possible, it is foreseen that the local population of PGB at Lamb Creek will relocate away from the DE and the colony at the project will contract to close to zero. Experience has shown at other iron ore projects with PGB colonies pre-mining, e.g. Poondanno project (Bullen and Creese 2014), 30 kilometres south-east of Port Hedland, that has been mined out for approximately seven years, that this level of abandonment is not permanent and the PGB return to roost in the viable caves that are retained (author's unpublished observations). Further numerous caves in mined out Pisolite mesas along the Robe River (Bat Call 2017), 50-year-old Hamersley Range adits in iron stone (author's unpublished data) and East Pilbara abandoned underground gold mines (Bat Call 2021) support healthy PGB colonies providing further evidence to the recolonisation ability of the PGB. It is also believed that the ranges that extend to the east, west and south of Lamb Creek contain additional Cat. 2 roost caves. Any long-term impact of the Lamb Creek project on the Hamersley Range PGB population east of Karijini is therefore foreseen to be minimal, limited only to the potential loss of foraging habitat within the DE.

Item 3. Comments regarding foraging habitat at and near Lamb Creek.

The DE at Lamb Creek is an area of 895 ha that is aligned east to west and 3.5 km long by 2.5 km wide. It is made up of high, moderate and low value PGB foraging habitat (MinRes 2022, table 8-3). These assessments are supported by recent field work results using VHF (e.g. Biologic, 2019) and/or GPS satellite tagged bats (Bullen *et al.*, 2023). These recent studies have shown that bats regularly forage up to 12 km from their diurnal roost caves and prefer more productive areas with scattered, patchy or more continuous woodland coverage. Also, these results show that the concept

of “critical foraging habitat” does not apply to PGB. Maximum flight path distances flown in a night are typically in excess of 20 km and can be over 40. Of the area surrounding Lamb Creek within range of the project’s PGB roost caves, some 70,000 ha, I assess the majority, over 60,000 ha, as high value for PGB foraging. This is based on numerous past visits to the region supplemented by a review of available aerial imagery. The 895 ha therefore represents only ~1.5% of that available to PGB at Lamb Creek. Significantly, current field work involving numerous personal observation sessions at PGB roost entrances has shown that the species does not begin to forage from the ground immediately upon exiting the roost but departs the local area and begins to forage from the ground some distance away. This is supplemented by satellite tracking GPS tagged PGB (Bullen *et al.* 2023) and VHF and GPS data from Augusteyn *et al.* (2018, Figure 5). These studies show initial foraging from the ground very occasionally begins at distances of over 400 m and usually over 750 m from the roost. The PGB then remain at greater distances until returning to the roost. VHF data from Biologic (2019) also supports this. An additional comment can be made regarding foraging by PGB’s at cleared areas within the high value areas. Once cleared of trees and large shrubs the bats are only likely to use the periphery of the cleared area, however, observations during the clearing activities have sometimes shown that PGB can be temporarily attracted to forage, presumably due to the number of terrestrial prey disturbed by the clearing that become easy prey (author’s unpublished observations).

Item 4. Current understanding of habitat requirements for transiting to other roosts.

Currently there is limited data on the routes taken by PGB when transiting to other roosts. Recent Bullen *et al.* (2023) supported by data in Augusteyn (2018) indicate that long distance flights away from an initial diurnal roost involve a number of foraging stops at high and medium quality sites. It can be inferred from this together with the nightly flight distances covered noted above, that there are no specific habitats required to support commuting long distances.

Item 5. Additional comments relevant to MinRes’ proposed mitigation for Cat 2 caves.

- a. Subject to mine planning, Cave 1 may be retained with non-mining buffer of 150 m, however as noted above, this distance will be contingent on the closure of the cave to PGB for the duration of mining operations together with PPV limits consistent with retaining the cave’s structure as a viable diurnal roost, see item 1 above.

- b. Blast monitoring, PGB usage monitoring and cave entry protocols are recommended to be applied to cave 1 if it is to remain open.

Best regards



R. Bullen

Managing Director / Principal Ecologist

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PHOENIX

ENVIRONMENTAL SCIENCES

Ghost Bat Significance Assessment for the Lamb Creek Iron Ore Project

Prepared for Mineral Resources Limited

February 2022

Final



Ghost Bat Significance Assessment for the Lamb Creek Iron Ore Project
Prepared for Mineral Resources Limited

Version history

Author/s	Reviewer/s	Version	Version number	Date submitted	Submitted to
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EXECUTIVE SUMMARY

The Lamb Creek Iron Ore Project (LCIOP) is situated approximately 130 kilometres by road northwest of Newman, Western Australia. Process Minerals International (PMI), a wholly owned subsidiary of Mineral Resources Limited (MRL) is seeking to develop the Lamb Creek Iron Ore Project (LCIOP).

Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by MRL to undertake a significance assessment to examine the potential impacts of the Project on Ghost Bat (*Macroderma gigas*) assemblage.

This report considers the following historical fauna surveys:

- Level 2 Fauna Survey and Targeted Northern Quoll Survey of the Lamb Creek for PMI, Oct 2012 (Rapallo 2012)
- Lamb Creek Flora and Fauna Desktop Survey Review, Sept 2017 (MBS Environmental 2017)
- Lamb Creek and Wedge Project Vertebrate Fauna Desktop Assessment, March 2020 (Western Wildlife 2020)
- J020348 – Detailed vertebrate fauna survey of the Lamb Creek project, Jan 2022 (Rapallo 2022).

Detailed fauna surveys for the Project found that five caves are utilised by Ghost bat. Two caves are located within the Project area (Cave 1; Provisional Category 2, Cave 3; Provisional Category 3) and three caves are located within the vicinity of the Project (Cave 2; Provisional Category 3, Cave 4; Category 3 in an ‘apartment block’, Cave 5; Category 2). The closest distance from the proposed mine pit to a Ghost Bat cave is 729 m (Cave 1; Category 2). The same cave is located 350 m from a waste rock landform and diversion bund. The remaining caves in proximity to the operational areas are greater than 1km away. Cave 4 and Cave 5 are located 202 and 237 m, respectively, from the access road.

While the gap analysis has found that survey effort does not strictly comply with State and Federal requirements for three of the five caves this is not considered important as each was ultimately identified as a Ghost Bat roost cave. The objective of field surveys in the context of environmental impact assessment is to determine whether caves support significant species; to that end the surveys achieved their aim.

Analysis of the Project against the EPBC Act significant impact criterion for Vulnerable species has concluded that no criteria are met.

Further, analysis of the Project against each of the key threats to Ghost Bats identified by the Threatened Species Scientific Committee (TSSC 2016) reveals the Project represents negligible to low risk to the species. Indirect impact is also expected to be nil or negligible.

Therefore, on the basis of the historic survey effort achieved, and low risk the Project represents to the species, referral to DAWE under the EPBC Act is not considered necessary.

CONTENTS

Executive summary	ii
Contents	iii
1 Introduction	1
1.1 Background	1
1.1.1 Historical approvals	1
1.1.2 Historical fauna surveys	1
1.1.3 Knowledge and data gaps	3
1.2 Scope of work	3
1.3 Study area	3
2 Legislative context	5
2.1 Commonwealth	5
2.2 State	5
2.2.1 Threatened and Priority species	5
2.2.2 Critical habitat	6
2.2.3 Threatened and Priority Ecological Communities	6
2.2.4 Other fauna	6
3 Existing environment	7
3.1 Land systems and surface geology	7
4 Methods	11
4.1 Gap analysis	11
4.2 Significance assessment	11
5 Results	12
5.1 Ghost Bat biology	12
5.2 Desktop review	14
5.3 Gap analysis	18
5.4 Significance assessment	18
5.4.1 EPBC Act significant impact criteria assessment	19
5.4.2 Assessment of impacts against Key Threats	22
5.5 Discussion and conclusion	24
6 References	25

LIST OF FIGURES

Figure 1-1 Project location and study area	2
Figure 1-2 Active mine sites within the vicinity of the Project	4
Figure 3-1 Project area in relation to IBRA bioregions and subregions	9
Figure 3-2 Land systems and surface geology in the Project area	10
Figure 5-1 Ghost Bat records for the Project and within the vicinity of the Project	16
Figure 5-2 Development footprint for the Lamb Creek Iron Ore Project, November 2021	17

LIST OF TABLES

Table 3-1	Land systems and extent in Project area	7
Table 3-2	Surface geology of the Project area, extent by deposit type	8
Table 5-1	Approximate breeding cycle for Ghost Bat in the Pilbara.....	13
Table 5-2	Ghost Bat cave categories, in decreasing significance (Bat Call WA 2021).....	13
Table 5-3	Bat Call WA Cave Habitat Classifications (Bat Call WA 2021)	14
Table 5-4	Summary of Ghost Bat monitoring at Lamb Creek from 2012 – 2021.....	15
Table 5-5	Summary of survey effort at Ghost Bat caves (Rapallo 2012, 2022).	18
Table 5-6	Caves recorded in the survey area and their distance to nearest proposed structure and pit of Nov 2021 footprint	19
Table 5-7	EPBC Act: Significant Impact Criteria for Vulnerable Listed Species (DoE 2013)	20
Table 5-8	Potential threats to Ghost Bat from implementation of the Project (TSSC 2016).....	22

1 INTRODUCTION

Process Minerals International (PMI), a wholly owned subsidiary of Mineral Resources Limited (MRL) is seeking to develop the Lamb Creek Iron Ore Project (the 'Project'; LCIO), a new iron ore mine situated approximately 130 kilometres (km) by road northwest of Newman, Western Australia (WA; Figure 1-1).

The key components of the Project include a small open cut iron ore mine, crushing and screening process plant, and associated infrastructure. The Project will produce up to 10 million tonnes per annum (Mtpa) of iron ore over a period of 3 to 4 years.

Fauna surveys were undertaken across the Project area in 2012 to support environmental impact assessments. Further fauna surveys were undertaken in 2020 and 2021. The surveys identified that the State and Commonwealth listed species, Ghost Bat (*Macroderma gigas*), occurs within the Project area.

Since referral of the Project under the Environmental Protection and Biodiversity Conservation Act (EPBC Act) in 2012, the Ghost Bat has been listed as Vulnerable under the Western Australian Wildlife Conservation Act 1950 (WC Act) and the EPBC Act.

In November 2021, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by MRL to undertake a significance assessment to examine the potential impacts of the Project on Ghost Bat (*Macroderma gigas*) assemblage.

1.1 BACKGROUND

1.1.1 Historical approvals

The Project was referred under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2012 and was determined as not a Controlled Action. Environmental impact assessments indicated that the Project would not result in significant impacts that would trigger referral under the *Environmental Protection Act 1986* (EP Act).

The Project was then put on hold until 2020, when MRL re-evaluated the LCIO and resolved to progress the Project with a smaller disturbance footprint.

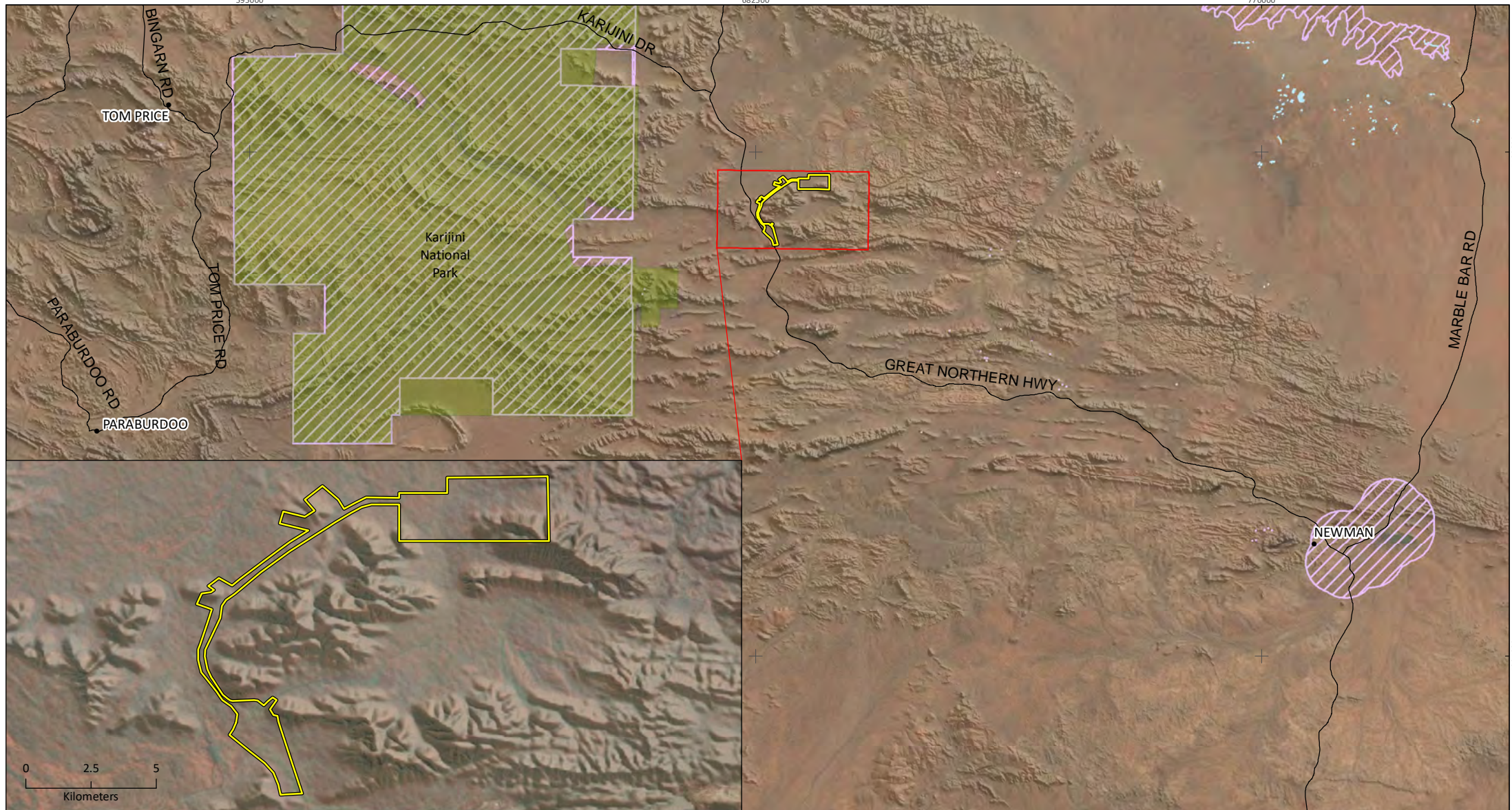
The intention was to seek only secondary approvals (Mining Proposal, Works Approval, Native Vegetation Clearing Permit). However, the Department of Mines, Industry Regulation and Safety indicated that it would be likely to refer the Mining Proposal submission under the EP Act.

Accordingly, MRL are now proposing to self-refer the Project under s38 of the EP Act.

1.1.2 Historical fauna surveys

Historical fauna surveys for the Project have included the following:

- Level 2 Fauna Survey and Targeted Northern Quoll Survey of the Lamb Creek for PMI, Oct 2012 Rapallo (2012)
- Lamb Creek Flora and Fauna Desktop Survey Review, Sept 2017 (MBS Environmental 2017)
- Lamb Creek and Wedge Project Vertebrate Fauna Desktop Assessment, March 2020 (Western Wildlife 2020)
- J020348 – Detailed vertebrate fauna survey of the Lamb Creek project, Jan 2022 (Rapallo 2022).



Mineral Resources Ltd Lamb Creek and Wedge deposits		
Project No	1462-LCW-MRL-VER	
Date	24/11/2021	
Drawn by	IN	
Map author	BQ	1:900,000 (at A4)
		GDA 1994 MGA Zone 50

- Study area
- Environmentally sensitive areas
- DBCA managed land
- Lake
- Road

Figure 1-1
Project location and study area



All information within this map is current as of 24/11/2021. This product is subject to COPYRIGHT and is property of Phoenix Environmental Sciences (Phoenix). While Phoenix has taken care to ensure the accuracy of this product, Phoenix make no representations or warranties about its accuracy, completeness or suitability for any particular purpose.

Five significant vertebrate fauna species have been recorded from the Lamb Creek study area to date:

- Northern quoll (*Dasyurus hallucatus*) (EN, EPBC and BC Acts) – recorded in 2012
- **Ghost Bat (*Macroderma gigas*) (VU, EPBC and BC Acts) – recorded in 2012, 2020 and 2021**
- Pilbara olive python (*Liasis olivaceus barroni*) (VU, EPBC and BC Acts) – recorded in 2012
- Western pebble-mound mouse (*Pseudomys chapmani*) (Priority 4) – recorded throughout the Project area in 2012 and 2020
- Fork-tailed Swift (*Apus pacificus*) (Mig. and Mar., EPBC Act) – recorded in 2012.

This report is concerned only with the Ghost Bat.

1.1.3 Knowledge and data gaps

Since referral of the Project under the EPBC Act in 2012, the Ghost Bat (*Macroderma gigas*) has been listed as Vulnerable under the *Western Australian Wildlife Conservation Act 1950* and the EPBC Act. At the time of referral, it was listed by the Department of Biodiversity, Conservation and Attractions (DBCA) as a Priority 4 species.

Accordingly, MRL wishes to understand:

- The potential significance of the Project on the Ghost Bat.

1.2 SCOPE OF WORK

The scope of work comprised:

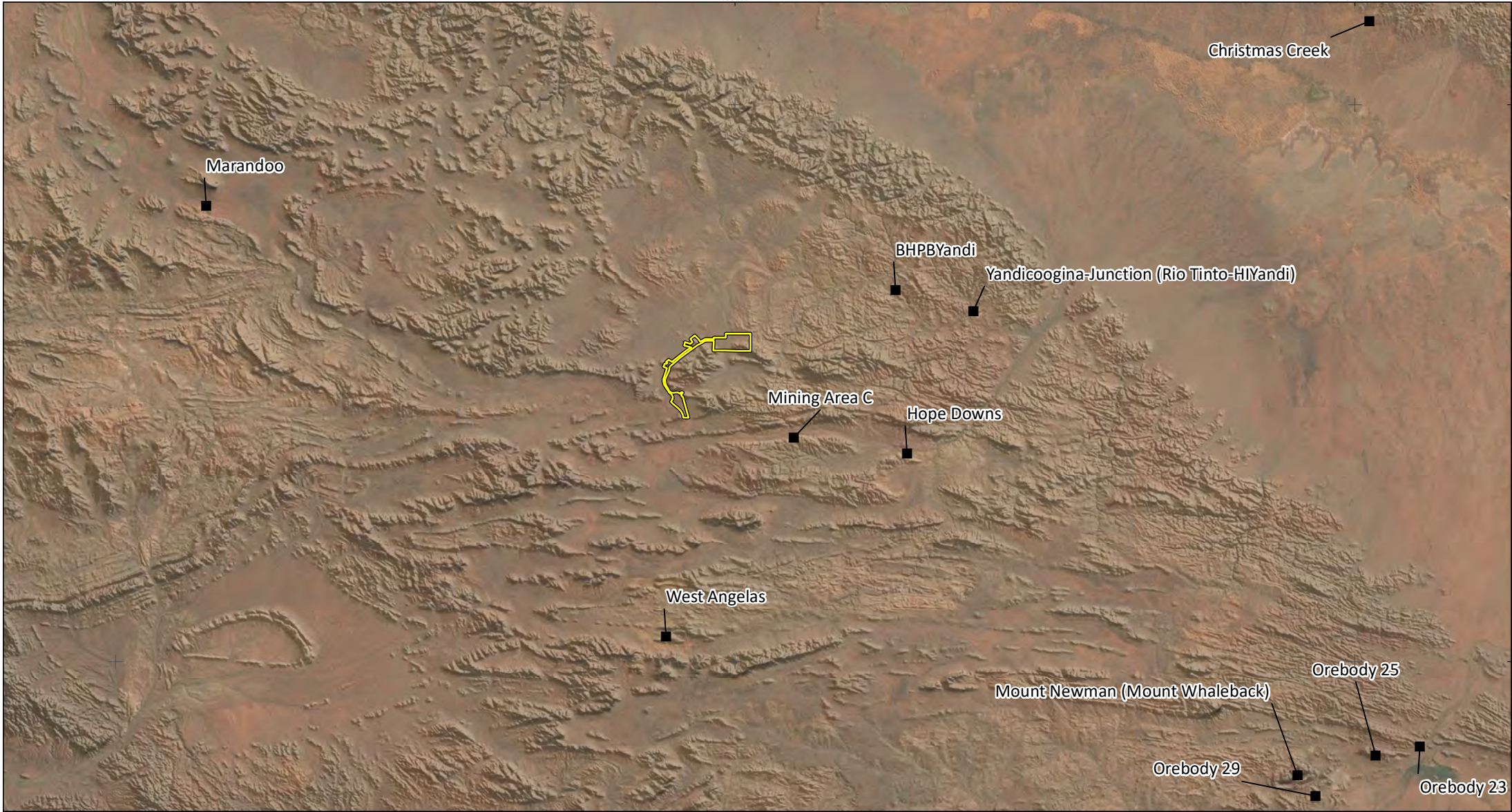
- complete a stand-alone desktop assessment report suitable for inclusion in environmental approval documentation that included –
 - an analysis of the Project against the EPBC Act significant impact criterion (VU) and key threats identified by the Threatened Species Scientific Committee (TSSC 2016), with consideration of historical and recent fauna assessments.


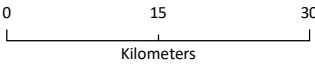
1.3 STUDY AREA


The Project is located within 50 km of the following active mine sites: Mining Area C, Yandi mine, Hope Downs, West Angelas and Yandicoogina mine (Figure 1-2). It is a greenfield site, and the current land use is pastoral. No infrastructure currently exists within the Project area. The Project has a total area of approximately 2,197 ha, and it is expected that up to approximately 657 ha of vegetation will be cleared as a result of its implementation.

A detailed fauna survey was completed in April 2020, with supplementary data collected in April 2021 (Rapallo 2022). The survey area was 1,645 hectares in size, comprising retention licence R47/19 (1,200 hectares), miscellaneous licence L47/736 (388 hectares), and an alternative area for the haul road to intersect with the Great Northern Highway, referred to as intersection version B (58 hectares) (Rapallo 2022). An earlier Level 2/detailed fauna survey was completed in 2012 (Rapallo 2012) over an area that partially overlaps with the current, 2020-2021 survey area (Rapallo 2022).

The Project area has changed since the latest surveys were completed (Rapallo 2022), with tenements L47/974, L47/1008 and M47/1592 added in December 2021, expanding the Project area. Hence, the 2020-2021 fauna survey covered 1,220 hectares (75%) of the current project area, with 555 hectares (25%) unsurveyed. The November 2021 footprint (657 hectares) extends outside the survey area by 24 hectares (4% of total footprint), with most of the unsurveyed area comprising the southern section of the proposed haul road (Figure 1-1)(Rapallo 2022).



Mineral Resources Ltd Lamb Creek and Wedge deposits		
Project No	1462-LCW-MRL-VER	
Date	24/11/2021	
Drawn by	IN	
Map author	BQ	
		
1:750,000 (at A4)		GDA 1994 MGA Zone 50

 Study area

 Active mine site

Figure 1-2
Active mine sites within the vicinity of the Project



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2 LEGISLATIVE CONTEXT

The protection of flora and fauna in WA is principally governed by three acts:

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

The BC Act came into full effect on 1 January 2019 and replaced the functions of the *Wildlife Conservation Act 1950* (WC Act).

2.1 COMMONWEALTH

The EPBC Act is administered by the Federal Department of Agriculture, Water and the Environment (DAWE). The EPBC Act provides for the listing of Threatened fauna and Threatened Ecological Communities (TECs) as matters of National Environmental Significance (NES). Under the EPBC Act, actions that have, or are likely to have, a significant impact on a matter of NES, require approval from the Australian Government Minister for the Environment through a formal referral process.

Conservation categories applicable to Threatened fauna species under the EPBC Act are as follows:

- Extinct (EX)¹ – there is no reasonable doubt that the last individual has died
- Extinct in the Wild (EW) – taxa known to survive only in captivity
- Critically Endangered (CR) – taxa facing an extremely high risk of extinction in the wild in the immediate future
- Endangered (EN) – taxa facing a very high risk of extinction in the wild in the near future
- Vulnerable (VU) – taxa facing a high risk of extinction in the wild in the medium-term
- Conservation Dependent (CD)¹ – taxa whose survival depends upon ongoing conservation measures; without these measures, a conservation dependent taxon would be classified as Vulnerable, Endangered or Critically Endangered.

2.2 STATE

2.2.1 Threatened and Priority species

In WA, the BC Act provides for the listing of Threatened fauna species (Government of Western Australia 2018a, b)² in the following categories:

- Critically Endangered (CR) – species facing an extremely high risk of extinction in the wild in the immediate future³
- Endangered (EN) – species facing a very high risk of extinction in the wild in the near future³

¹ Species listed as Extinct and Conservation Dependent are not matters of NES and therefore do not trigger the EPBC Act.

² The *Wildlife Conservation (Specially Protected Fauna) Notice 2018* and the *Wildlife Conservation (Rare Flora) Notice 2018* have been transitioned under regulations 170, 171 and 172 of the *Biodiversity Conservation Regulations 2018* to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the BC Act.

³ As determined in accordance with criteria set out in the ministerial guidelines.

- Vulnerable (VU) – species facing a high risk of extinction in the wild in the medium-term future³.

Species may also be listed as specially protected (SP) under the BC Act in one or more of the following categories:

- species of special conservation interest (conservation dependent fauna, CD) – species with a naturally low population, restricted natural range, of special interest to science, or subject to or recovering from a significant population decline or reduction in natural range
- migratory species (Mig.), including birds subject to international agreement
- species otherwise in need of special protection (OS).

DBCA administers the BC Act and also maintains a non-statutory list of Priority fauna. Priority species are still considered to be of conservation significance – that is they may be Threatened – but cannot be considered for listing under the BC Act until there is adequate understanding of threat levels imposed on them. Species on the Priority fauna list are assigned to one of four Priority (P) categories, P1 (highest) – P4 (lowest), based on level of knowledge/concern.

2.2.2 Critical habitat

Under the BC Act, habitat is eligible for listing as critical habitat if it is critical to the survival of a Threatened species or a TEC and its listing is otherwise in accordance with the ministerial guidelines.

2.2.3 Threatened and Priority Ecological Communities

The BC Act provides for the listing of TECs in the following categories:

- Critically Endangered – facing an extremely high risk of becoming eligible for listing as a collapsed ecological community in the immediate future³
- Endangered – facing a very high risk of becoming eligible for listing as a collapsed ecological community in the near future³
- Vulnerable – facing a high risk of becoming eligible for listing as a collapsed ecological community in the medium-term future³.

An ecological community may be listed as a collapsed ecological community under the BC Act if there is no reasonable doubt that the last occurrence of the ecological community has collapsed or the ecological community has been so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure.

The DBCA also maintains a non-statutory list of Priority Ecological Communities (PECs), which may become TECs in the future; however, do not currently meet survey criteria or that are not adequately defined. PECs are assigned to one of five categories depending on their priority for survey or definition, with Priority 1 of highest concern and Priority 5 of lowest concern.

2.2.4 Other fauna

Under the Environmental Protection Authority's (EPA) environmental factor guidelines fauna may be considered significant for a range of reasons other than listing as a Threatened or Priority species. EPA (2016) identifies the following attributes that constitute significant fauna:

- species with restricted distribution
- species subject to a degree of historical impact from threatening processes
- providing an important function required to maintain the ecological integrity of a significant ecosystem.

3 EXISTING ENVIRONMENT

3.1 LAND SYSTEMS AND SURFACE GEOLOGY

DPIRD undertakes land system mapping for WA using a nesting soil-landscape mapping hierarchy (Schoknecht & Payne 2011). While the primary purpose of the mapping is to inform pastoral and agricultural land capability, it is also useful for informing biological assessments. Under this hierarchy, land systems are defined as areas with recurring patterns of landforms, soils, vegetation and drainage (Payne & Leighton 2004).

The Project area is located within the Hamersley subregion of the Pilbara region (Figure 3-1) and intersects five land systems (Table 3-1) of which the Boolgeeda System comprises over 60%.

Table 3-1 Land systems and extent in Project area

Land system	Description	Area (ha)	% of Project area
Boolgeeda System	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.	1,329.4	60.6
McKay System	Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands with acacias and occasional eucalypts.	44.0	2.0
Newman System	Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.	499.2	22.7
Platform System	Dissected slopes and raised plains supporting shrubby hard spinifex grasslands.	198.1	9.0
Wannamunna System	Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands and occasionally eucalypt woodlands.	126.3	5.7
Total		2,197.0	100.0

According to the Surface Geology of Australia 1:1,000,000 scale, Western Australia database (Stewart et al. 2008), the LCIOP intersects four geological formations (Table 3-2; Figure 3-2), of which Colluvium represents over 60% of the Project area.

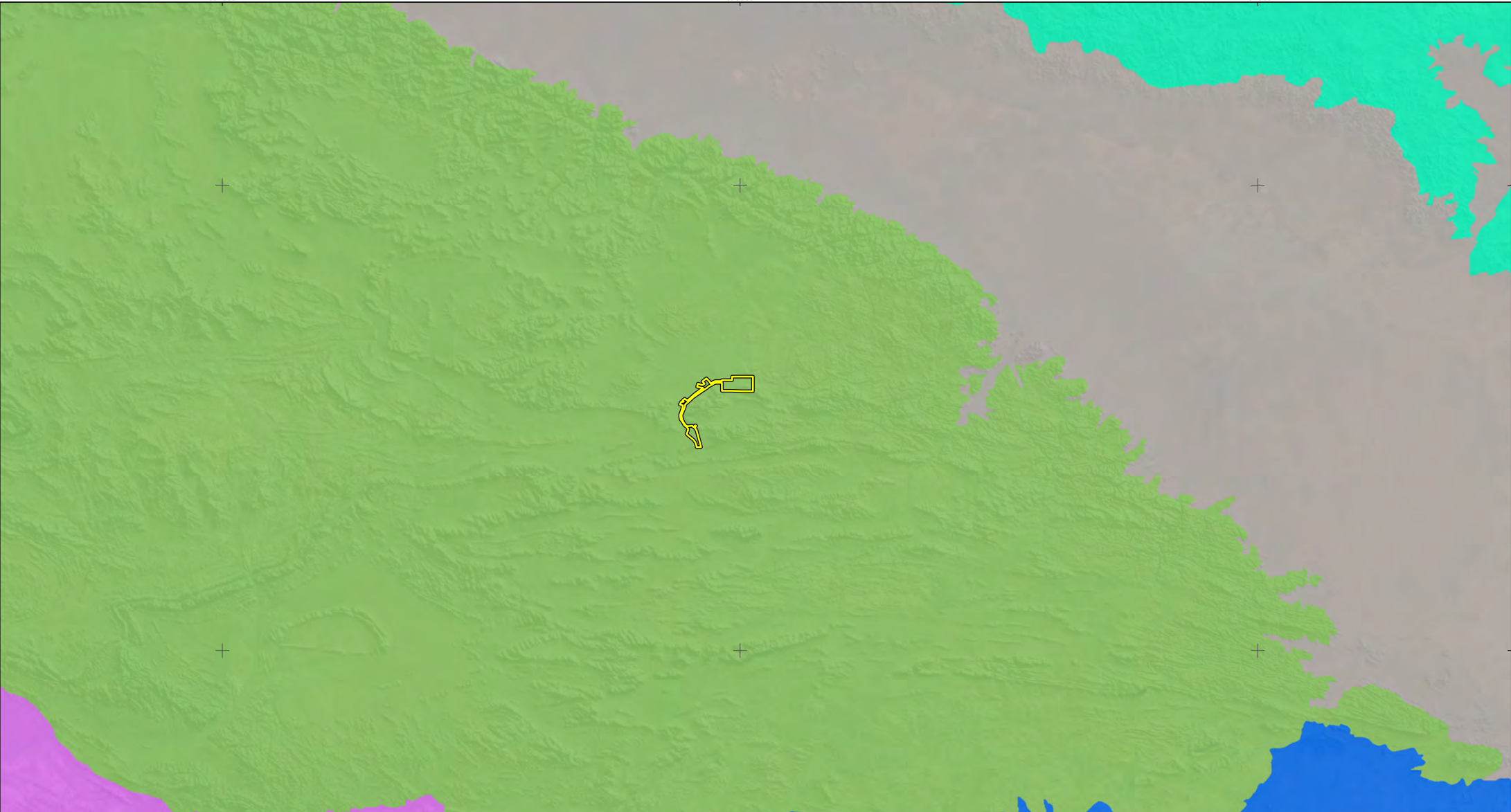
Table 3-2 Surface geology of the Project area, extent by deposit type

Surface geology	Abbreviation	Description	Area (ha)	% of Project area
Alluvium 38485	Qa	Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted.	79.7	3.6
Brockman Iron Formation	Lchk	Banded iron-formation, chert, mudstone and siltstone.	660.9	30.1
Colluvium 38491	Qrc	Colluvium, sheetwash, talus; gravel piedmonts and aprons over and around bedrock; clay-silt-sand with sheet and nodular kankar; alluvial and aeolian sand-silt-gravel in depressions and broad valleys in Canning Basin; local calcrete, reworked laterite.	1,456.4	66.3
Weeli Wolli Formation	Lchw	Banded iron-formation (commonly jaspilitic), mudstone, siltstone; common interlayered metadoleritic sills.	0.1	0
Total			2197.0	100.0

604000

693000

782000



7510930

7430920



Mineral Resources Ltd Lamb Creek and Wedge deposits		
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Date	24/11/2021	
Drawn by	IN	
Map author	BQ	
1:900,000 (at A4)		GDA 1994 MGA Zone 50

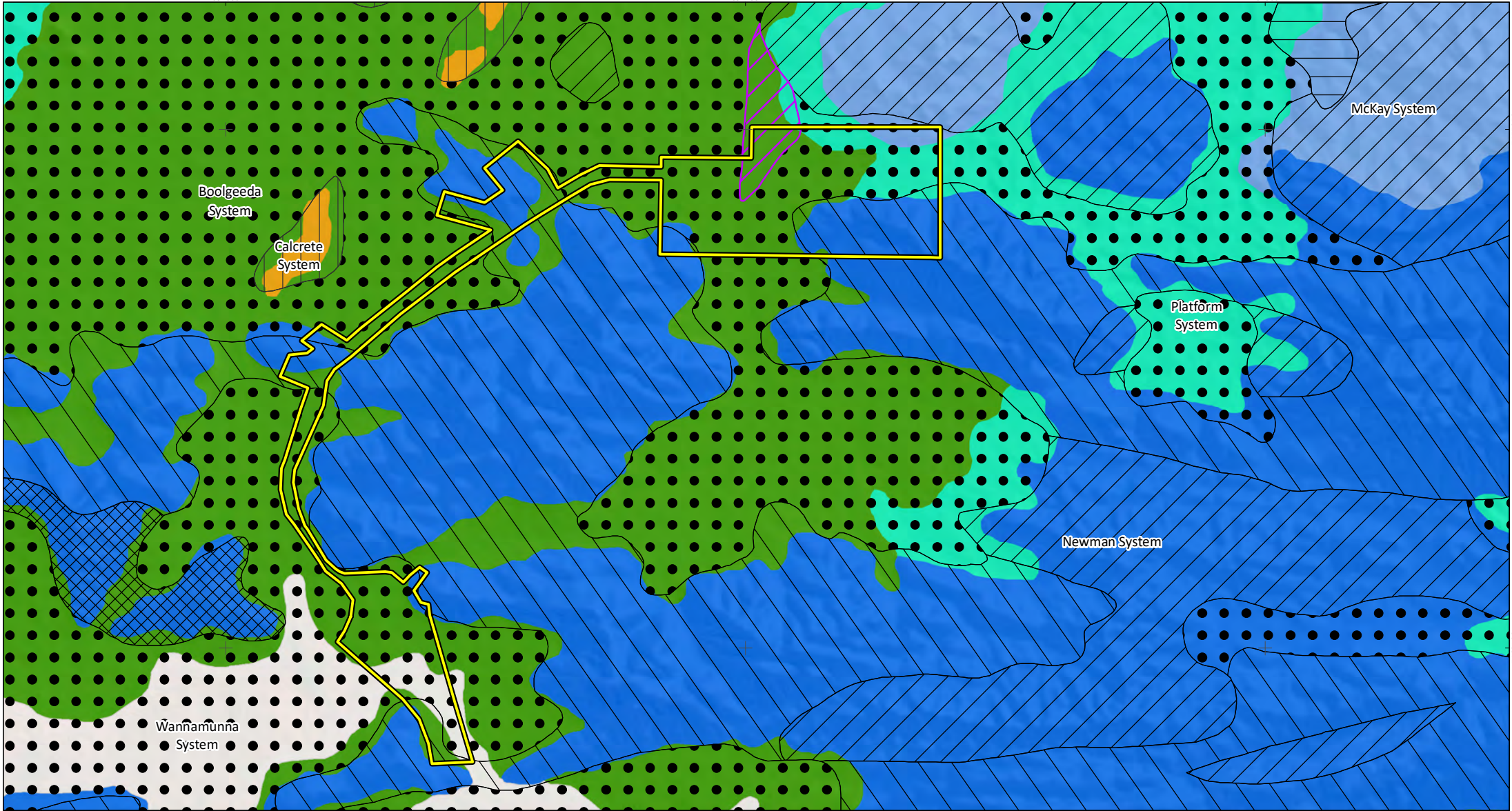
- Study area
- IBRA region and subregion**
- Pilbara, Hamersley
- Pilbara, Fortescue
- Pilbara, Chichester
- Gascoyne, Ashburton
- Gascoyne, Augustus

Figure 3-1

Study area in relation to IBRA bioregions and subregions

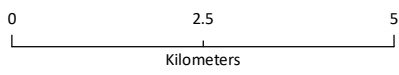
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Mineral Resources Ltd
Lamb Creek and Wedge deposits

Project No	1462-LCW-MRL-VER
Date	24/11/2021
Drawn by	IN
Map author	BQ



1:99,000 (at A4) GDA 1994 MGA Zone 50

- Study area
- Surface geology**
- Ashm
- Czr
- Lchk
- Lchw
- Qa
- Qrc
- Czr

- Land system**
- Boolgeeda System
- Calcrete System
- McKay System
- Newman System
- Platform System
- Wannamunna System

Figure 3-2
Land systems and surface geology in the study area



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4 METHODS

The significance assessment has been conducted in the context of various relevant State and Commonwealth survey guidelines, including:

- EPA Environmental Factor Guideline: Terrestrial fauna (EPA 2016)
- Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020)
- Survey guidelines for Australia's threatened bats: guidelines for detecting bats listed as threatened under the Environmental Protection and Biodiversity Conservation Act 1999 (DEWHA 2010)
- Conservation Advice. *Macroderma gigas*: Ghost Bat (Threatened Species Scientific Committee 2016)

A review of DBCA's Threatened and Priority fauna database (DBCA 2021) has also been undertaken to identify Ghost Bat records within 40km of the Project area.

4.1 GAP ANALYSIS

The gap analysis was primarily concerned with reviewing the methods employed to detect Ghost Bat presence with respect to relevant survey guidelines, to determine if surveys undertaken to date were compliant with those guidelines:

- Technical Guidance: Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA 2020)
- Survey guidelines for Australia's threatened bats: guidelines for detecting bats listed as threatened under the Environmental Protection and Biodiversity Conservation Act 1999 (DEWHA 2010).

The following reports detail the survey methods undertaken for the Project:

- Detailed vertebrate fauna survey of the Lamb Creek project (Rapallo 2022)
- Level 2 Fauna Survey and Targeted Northern Quoll Survey of the Lamb Creek (Rapallo 2012).

4.2 SIGNIFICANCE ASSESSMENT

The significance of the potential direct and indirect impacts of the Project on Ghost bat was assessed against the EPBC Act significant impact criterion (VU) and key threats identified by the Threatened Species Scientific Committee (TSSC 2016), with consideration of Project design, Indicative Disturbance Footprint (IDF) and the biological characteristics of Ghost bat.

5 RESULTS

5.1 GHOST BAT BIOLOGY

The Ghost Bat (*Macroderma gigas*) is a large carnivorous bat, weighing approximately 140 – 165 g (Richards *et al.* 2008). Individuals have light grey to dark grey fur and a paler underbelly, with large, partially fused ears, large eyes, a simple nose-leaf, and no tail.

They are Australia's only strictly carnivorous bat, feeding nocturnally for small terrestrial mammals, amphibians, small birds, other bats, lizards, spiders and large insects (Churchill 2008; Richards *et al.* 2008). Much of its prey is captured on the ground and taken to an established feeding site, usually a rocky overhang or cave which are easily recognised by the accumulation of discarded prey, middens, and scat piles. Unlike the majority of microbats, Ghost bat are proficient in navigating and hunting visually without the need to constantly echolocate (Richards *et al.* 2008).

The Ghost Bat was once found across most of mainland Australia, but are now restricted to northern Australia across a range of habitats, such as the arid Pilbara region to the tropical region of northern Queensland (Richards *et al.* 2008). In WA, Ghost bat occur within the Pilbara and Kimberley regions (Woinarski *et al.* 2014). Although the exact reason for their decreased range is unknown, it is certain that Ghost bat are sensitive to disturbance (Richards *et al.* 2008).

The key threats to Ghost bat as listed in Federal conservation advice (Threatened Species Scientific Committee 2016) are:

- Habitat loss (destruction of, or disturbance to, roost sites and nearby areas) due to mining
- Disturbance of (human visitation at) breeding sites
- Modification to foraging habitat
- Collision with fences, especially those with barbed wire
- Collapse or reworking of old mine adits
- Contamination by mining residue at roost sites
- Disease
- Poisoning by cane toads (*Rhinella marina*)
- Competition for prey with foxes and feral cats.

Little information is known about the types of disturbances that lead Ghost bat to abandon their roosts. It is thought that repeated human visitation during the breeding season is a primary cause of roost abandonment (TSSC 2016). Ghost bat is shown to tolerate some audio disturbance from machinery, and disturbance from drilling is much less likely to cause abandonment than blasting impacts. Recent work has shown that caves located within 0.4 and 1.8 km from active mining continue to be used by Ghost bat (Biologic 2016). If abandoned, so long as caves remain unblocked, structural integrity maintained and the microclimate is not disrupted, Ghost bat are likely to re-occupy caves once mining disturbance moves away.

The distribution of Ghost bat in the Pilbara is largely determined by the presence of suitable caves, as they rely on caves for roosting and breeding. There are currently no studies on the home range of Ghost bat in the Pilbara (Biologic 2018), although Tidemann *et al.* (1985) recorded an average foraging area of 61 ha, typically located 1.9 km from a diurnal roost. Individuals were found to return to the same foraging area each night with multiple bats using the same foraging areas.

Ghost bat require a range of cave sites, moving between numerous caves seasonally or as dictated by weather conditions, moonlight, rainfall and fire (Woinarski *et al.* 2014). Ghost Bat may move in small groups between caves, making it difficult to determine whether their absence at monitoring sites between years is due to natural movements or to anthropogenic impacts (Armstrong & Anstee 2000).

Roost sites include sheltered rock formations such as caves, rock crevices and unused mine adits. In the Hamersley Range of the Pilbara, Ghost bat appears to prefer sheltered caves beneath bluffs of larger hills of Brockman Iron formation (Threatened Species Scientific Committee 2016); Brockman Iron and Weeli Wollli Iron formations (both types of Banded ironstone) comprise over 30% of the Project area (Table 3-2).

The species' persistence in the arid Pilbara depends on a stable microclimate. Ideally caves will have temperatures between 23 and 28°C, with 28°C being the optimal maintenance of body temperature (Baudinette *et al.* 2000; Threatened Species Scientific Committee 2016). The preferred range of humidity varies widely between 14 and 84% (Armstrong & Anstee 2000).

Ghost bat disperse widely to forage when they are not breeding. However, during the breeding cycle (Table 5-1), distribution is determined by the presence of suitable roosting sites, few of which are known (Richards *et al.* 2008). Females are likely to stay close to preferred maternity roosts, a cause for serious conservation concern (Richards *et al.* 2008).

Whilst roosting, they are particularly sensitive to disturbance. If disturbed, young may be dislodged by adults in rapid take-off (Toop 1985) and may not return to roosting sites (Woinarski *et al.* 2014). Such susceptibility to disturbance also threatens the viability of roosts with unregulated human visitation, including surveys which target caves and may inadvertently flush individuals into daylight.

Mating is thought to occur during July and August, females bearing one young three months later between September and November (Richards *et al.* 2008) (Table 5-1). Young are weaned on prey by their mothers and begin hunting as juveniles, until they are completely independent.

Table 5-1 Approximate breeding cycle for Ghost Bat in the Pilbara

Month	Breeding Stage
July – August	Mating
August – October	Gestation
September – November	Birth

Ghost Bat caves can be categorised based on their usage (Table 5-2) and the timing and frequency of occupancy (Bat Call WA 2021) Table 5-3). Maternity roosts are considered the most significant cave type, followed by diurnal roosts and night roosts. 'Potential' is used to denote the highest Category based on the information collected where insufficient information to confirm the Category has been recorded (e.g., potential roost contains attributes and/or evidence to suggest diurnal roosting though no diurnal roosting has been confirmed). Caves can be categorised accordingly via assessing the structure of the cave in combination with monitoring of Ghost Bat signs.

Table 5-2 Ghost Bat cave categories, in decreasing significance (Bat Call WA 2021)

Category	Description
Maternity roosts	In addition to being used for shelter during the day, these caves have attributes suitable to support breeding, and Ghost bat have been recorded in these caves during the breeding season, including pregnant females or females with pups.
Diurnal roosts	Used for shelter during the day.
Night roosts	Only utilised during the night, mostly to feed on prey items or to rest, and are typically shallow caves and shelters/overhangs that can be well lit during the day.

Bat Call WA (2021) has categorised Ghost Bat caves according to their habitat value, established by occupancy and usage (Table 5-3).

Table 5-3 Bat Call WA Cave Habitat Classifications (Bat Call WA 2021)

Category	Description	Significance*
Category 1	Diurnal roost caves with permanent Ghost Bat occupancy. Caves and historical underground mines (adits and declines) that are used continuously as diurnal roosts by large numbers of Ghost Bat for long periods of time.	Must all be assumed to be maternity caves and are critical habitat for the species.
Category 2	Diurnal roost caves with regular occupancy. Caves that are used regularly as diurnal roosts by small numbers of Ghost bat but not continuously. These tend to be deep caves with ceiling heights in rear chambers of at least 1.5 m allowing multiple roosting opportunities out of reach of predators. These caves typically have a number of other caves, shelters, and overhangs within a few hundred meters.	Must be assumed to be capable of supporting one or more reproducing females and their offspring. These caves are critical habitat for the species.
Category 3	Roost caves with occasional occupancy. Caves that are occasionally used as diurnal roosts and as nocturnal roosts for feeding and resting more frequently.	When directly associated with a Category 2 cave, they form an apartment block grouping that is considered critical habitat. Isolated caves are important habitat for the long-term preservation of the species in the area.
Category 4	Nocturnal roost caves with opportunistic usage. This may be anything from a single foraging visit to a longer visit with a resting period or possibly a feeding session.	These caves are not important habitat for the long-term preservation of the species in the area.

* All Category 1, 2 and 3 caves in apartment blocks are considered to be critical habitat.

5.2 DESKTOP REVIEW

The desktop review identified 113 records of Ghost Bat within 40 km of the Project area (DBCA 2021) (Figure 5-1), found at an average distance of 17.85 km from the Project area. Over 95% of these records have been made since 2012 (DBCA 2021).

Further, the bat assemblage of the survey area was assessed using ultrasonic echolocation recorders during three field deployments by Rapallo; a Level 2 fauna survey and targeted Northern Quoll survey (Rapallo 2012), and a detailed vertebrate fauna survey that included ultrasonic echolocation recorder deployments for detecting Ghost bat in April 2020 and February 2021 (Rapallo 2022)(Table 5-4).

In 2012, a Level 2 fauna survey was conducted at the LCIOP on the 26 March to 12 April. Ultrasonic recorders were placed in seven suitable locations for one night (Rapallo 2012)(Table 5-4). No unambiguous calls attributable to the Ghost Bat could be determined in the recordings made during the survey (with the techniques available at the time). Individuals were sighted at three caves in the survey area: two within the Project area (Cave 1 and Cave 3) and one within the vicinity of the Project (Cave 2) (Rapallo 2012). Seven individuals were recorded at two of these caves: five within the Project and two individuals within the vicinity of the Project (Cave 2). There was no evidence of middens within either cave.

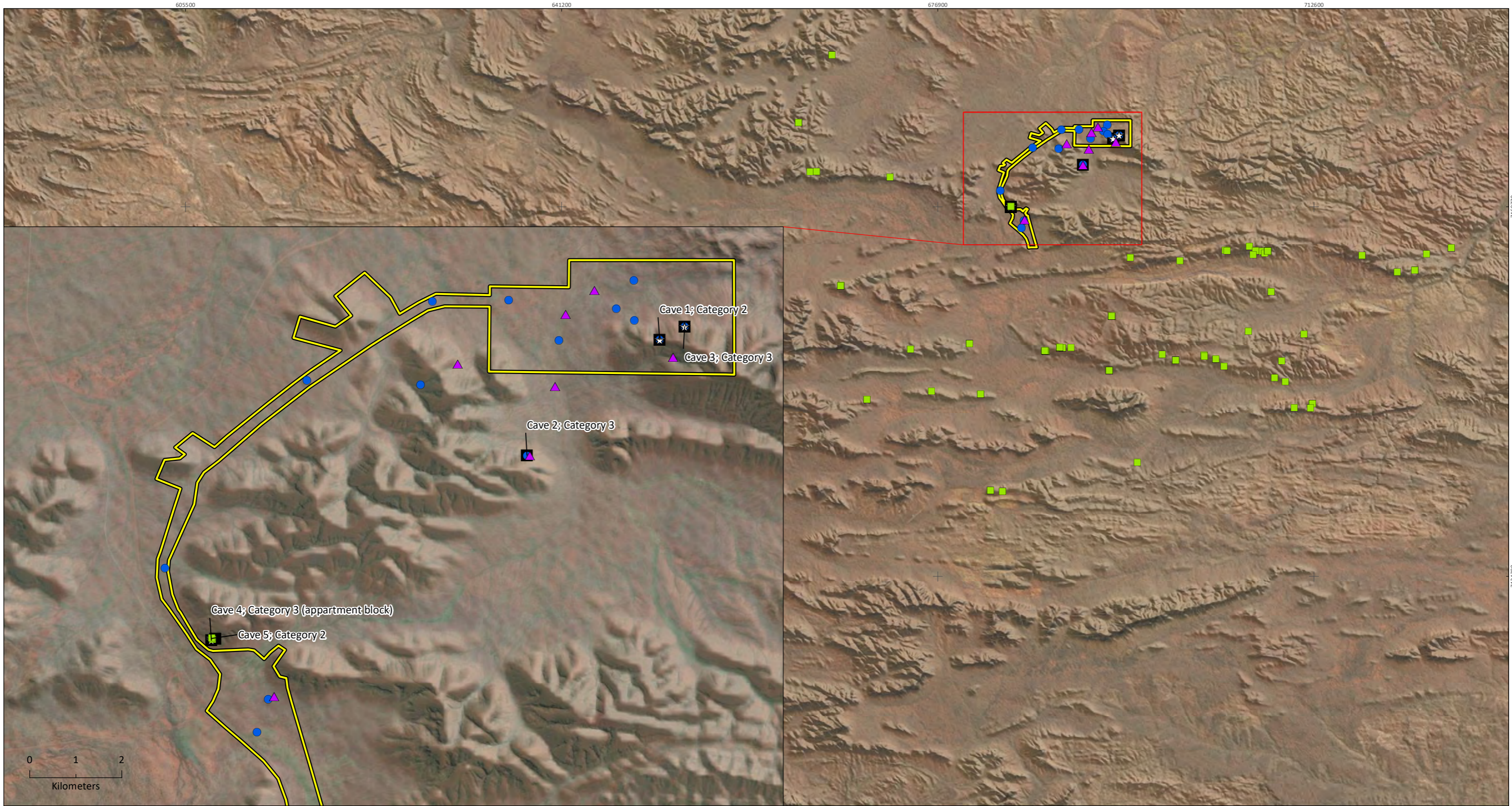
Caves surveyed in 2012 were revisited in 2020 and 2021 and ultrasonic recorders deployed during field trips from the 16 to 28 April 2020 and 20 to 24 February 2021 (Rapallo 2022)(Table 5-4). In 2020, 17 acoustic detectors were installed; 14 set to record ultrasonic calls and three set to record Night


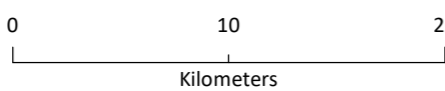
Parrot and Ghost Bat social calls in gullies. Of the 14 echolocation sites surveyed in 2020, three detectors were deployed at cave entrances, four deployed in thin woodland, three in shrubland, one in spinifex plain, two in minor drainage lines and one in an incised gully (Figure 5-2). Detectors were left between one and four nights. Ultrasonic calls of Ghost bat were recorded at Cave 1, Cave 2, and Cave 3. No ultrasonic or social call recordings of Ghost bat were made at any other site in the 2020 survey (Rapallo 2022). Middens were present at Cave 1 (Rapallo 2022).

In February 2021, additional data on Ghost Bat presence was collected while on-site for other studies. Four acoustic detectors were installed to record ultrasonic calls, all deployed at cave sites (Table 5-4; Figure 5-2). Detectors were left between two and three nights. Ultrasonic calls of Ghost Bat were recorded at Cave 3, Cave 4 and Cave 5 (Rapallo 2022), consistent with the known population and dispersal of Ghost Bat observed in the 2012 field survey (Rapallo 2012).

Table 5-4 Summary of Ghost Bat monitoring at Lamb Creek from 2012 – 2021

Survey	Season	Records	Comments from report
Level 2 Fauna Survey and Targeted Northern Quoll Survey of the Lamb Creek (Rapallo 2012)	Autumn	Ultrasonic recorders were deployed one night at seven suitable locations. Ghost Bat were observed roosting in two caves within the Project area (Cave 1 and Cave 3) and one within the survey area (Cave 2) (Figure 5-2).	There are several small cave systems within the survey area that are likely to be used as roosts by Ghost Bat (Rapallo 2012).
Detailed vertebrate fauna survey of the Lamb Creek project (Rapallo 2022)	Autumn	Ultrasonic recorders were deployed between one and four nights at 14 locations. Ghost bat were visually recorded roosting in two caves within the Project area (Cave 1 and Cave 3) and one within the vicinity of the Project area (Cave 2) (Figure 5-2).	At Cave 1 both social and ultrasonic calls were recorded before dawn followed by similar numbers of calls soon after dusk. Calls consistent with foraging Ghost Bats was detected at Caves 2 and 3 on one night each (Rapallo 2022).
	Summer	Ultrasonic recorders were deployed between two and three nights at four locations. Ultrasonic recordings of Ghost bat were recorded at two caves within the Project area (Cave 1 and Cave 3) and two caves within the vicinity of the Project (Cave 4 and Cave 5).	Calls consistent with foraging visits detected at Caves 3 and Cave 4. Calls consistent with diurnally roosting Ghost bat detected at Cave 5 (Rapallo 2022). Rapallo (2022) concluded the survey area (but not Project area) was fully surveyed. Approximately 555 hectares (25%) of the current Project area has not been covered by fauna surveys and is considered a 'partial' limitation. There was also a 'partial' limitation for the timing/rainfall/seasonality of the fauna work due to lower than average rainfall preceding the survey (Rapallo 2022).



Mineral Resources Ltd Lamb Creek and Wedge deposits		
Project No Date Drawn by Map author	1462-LCW-MRL-VER 16/12/2021 IN BQ	
		
1:350,000 (at A3)		GDA 1994 MGA Zone 50







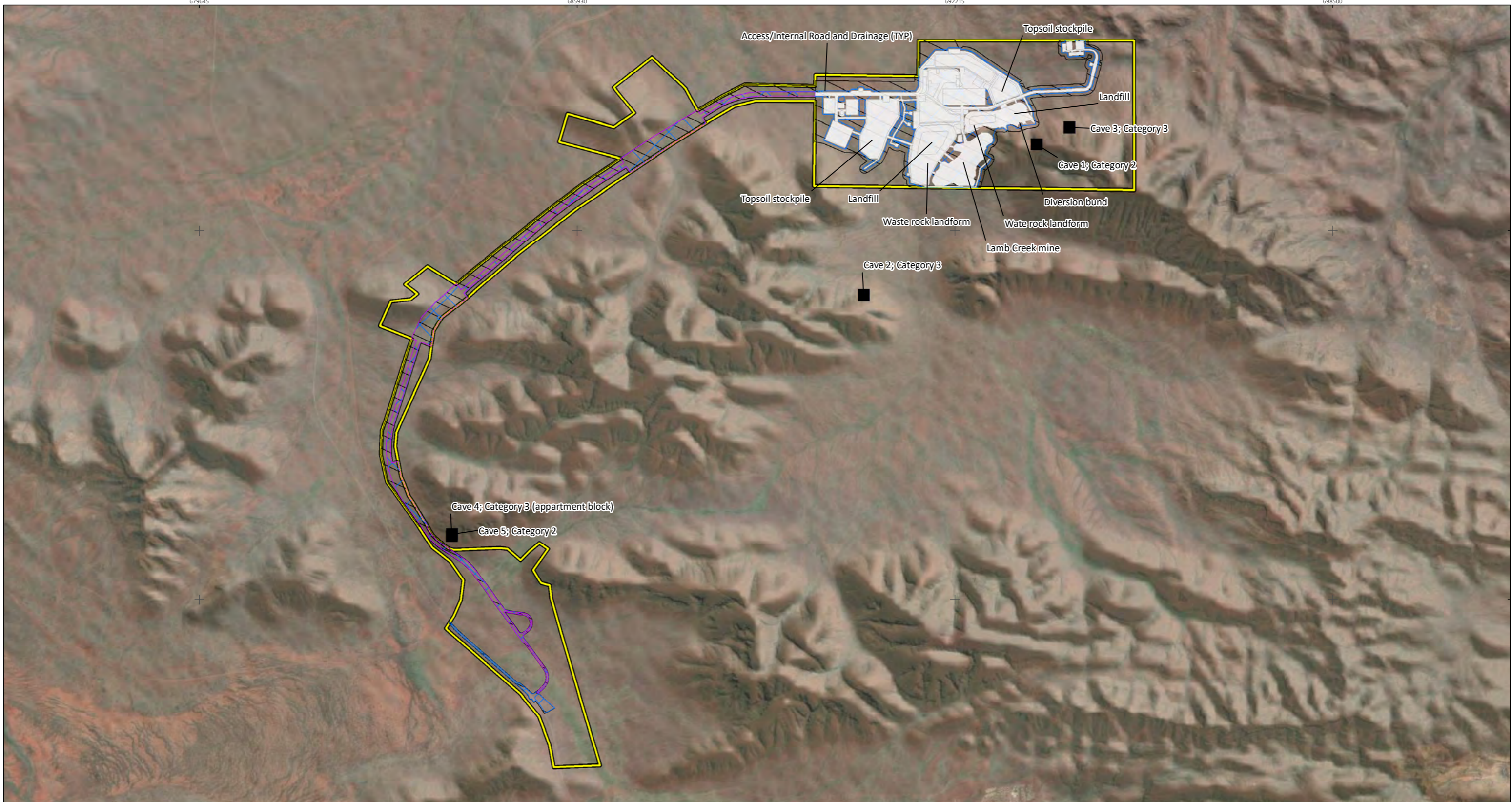
-  Study area
-  Desktop record - *Macroderma gigas*, VU (EPBC Act; BC Act)
-  Cave
-  2021 ultrasonic echolocation recorders
-  2020 ultrasonic echolocation recorders
-  2012 ultrasonic echolocation recorders

Figure 5-1
Ghost Bat records for the Project and within the vicinity of the Project



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Mineral Resources Ltd Lamb Creek and Wedge deposits		
Project No	1462-LCW-MRL-VER	
Date	16/12/2021	
Drawn by	IN	
Map author	BQ	
1:61,400 (at A3)		GDA 1994 MGA Zone 50

- Study area
- Development envelope
- Indicative footprint, November 2021
- Site layout
- Access/ internal road and drainage (TYP)
- Cave

Figure 5-2

Development footprint for the Lamb Creek Iron Ore Project, November 2021

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5.3 GAP ANALYSIS

The bat survey effort achieved during the 2012 and 2020/2021 field work for the LCIOP is outlined in Table 5-4 and Table 5-5 (Rapallo 2012, 2022). The survey work completed on Ghost Bats in 2012, 2020 and 2021 was with a component of a detailed survey or opportunistic record.

Table 5-5 Summary of survey effort at Ghost Bat caves (Rapallo 2012, 2022).

Site	Rapallo (2012)		Rapallo (2022)			
	No. of nights ultrasonic recorder deployed	Compliant	2020 data collected		2021 data collected	
			No. of nights ultrasonic recorder deployed	Compliant	No. of nights ultrasonic recorder deployed	Compliant
Cave 1	0	No	4	Yes	3	Yes
Cave 2	1	No	2	No	0	No
Cave 3	0	No	4	Yes	3	Yes
Cave 4	0	No	0	No	2	No
Cave 5	0	No	0	No	2	No

Survey effort for two of the five Ghost Bat caves met Commonwealth (DEWHA 2010) and State (DEWHA 2010) survey requirements for bats (Table 5-5)(Cave 1 and Cave 3). All other sites were not surveyed an adequate number of nights to meet bat survey requirements (Table 5-5).

Rapallo (2022) concluded the survey area (but not Project area) was fully surveyed. Approximately 555 hectares (25%) of the current Project area has not been covered by fauna surveys and is considered a ‘partial’ limitation. There was also a ‘partial’ limitation for the timing/rainfall/seasonality of the fauna work due to lower than average rainfall preceding the survey (Rapallo 2022).

5.4 SIGNIFICANCE ASSESSMENT

Five caves were found to be utilised by Ghost bat within or in the vicinity of the Project area. Bat Call WA assigned the five Ghost Bat caves as the following cave type and habitat classification (Pers. Comm., R. Bullen, in Rapallo 2021):

- Within Project area
 - Cave 1 – Provisional Category 2
 - Cave 3 – Provisional Category 3
- Outside Project area
 - Cave 2 – Provisional Category 3
 - Cave 4 – Category 3 (apartment block)
 - Cave 5 – Category 2.

The distance from Ghost Bat caves to the proposed operational and infrastructure areas are provided in Table 5-4. The closest distance from the proposed mine pit to a Ghost Bat cave is 729 m (Cave 1; Category 2). The same cave is located 350 m from a waste rock landform and diversion bund (Table 5-4). The remaining caves in proximity to the mine pit are greater than 1 km away (Table 5-4). Cave 4 and Cave 5 are located 202 m and 237 m, respectively, from the access road.

Table 5-6 Caves recorded in the survey area and their distance to nearest proposed structure and pit of Nov 2021 footprint

Site	Habitat value and use by Ghost Bat	Habitat assessment	Within Project area	Distance (m) from cave to nearest structure as per Nov 2021 footprint		Distance (m) from cave to proposed pit
				Structure	Distance (m)	
Cave 1	Provisional Category 2- Diurnal roost with regular but not continuous occupancy	Potentially critical	Y	Waste rock landform and diversion bund	350	729
Cave 2	Provisional Category 3- Roost caves with occasional occupancy	Noncritical	N	Waste rock landform and diversion bund	1,960	2,049
Cave 3	Provisional Category 3- Nocturnal roost caves with opportunistic usage	Noncritical	Y	Waste rock landform and diversion bund	583	1,285
Cave 4	Category 3 (apartment block)- Nocturnal roost caves with opportunistic usage	Critical	N	Access road	202	9,932
Cave 5	Category 2- Diurnal roost with regular but not consistent occupancy	Critical	N	Access road	237	9,902

The current November 2021 footprint extends outside the survey area by 24 hectares (4% of the total footprint), mostly comprising the southern end of the proposed haul road (Rapallo 2022). At present, no Ghost Bat cave is located within the November 2021 development footprint (Figure 5-2) and there is a 100m buffer around all five caves (Pers. Comm., A. Parker). On that basis therefore, none of the five known roost sites will be physically damaged or lost. It is also considered unlikely that cave structural integrity or roosting site viability will be adversely impacted by blasting or other operational elements associated with the implementation of the LCIOP. Minimal vibration is expected from the waste rock landforms, diversion bund and access road, and disturbance is therefore expected to be unlikely. Therefore, the Project is expected to have minimal impact on Ghost Bat populations.

5.4.1 EPBC Act significant impact criteria assessment

Analysis of the Project against the EPBC Act significant impact criterion for Vulnerable species is presented in Table 5-7. The assessment has found none of the criteria are met, with the implementation of the Project and expected management measures. On that basis re-referral of the Project to DAWE is not expected to be required.

Table 5-7 EPBC Act: Significant Impact Criteria for Vulnerable Listed Species (DoE 2013)

Significant Impact Criterion	Ghost Bat	Comments
Lead to a long-term decrease in the size of an important population of a species	Unlikely	The Project will not result in the direct disturbance or loss of critical Ghost Bat caves. Further, given the size, lifespan and design of operations, the Project is unlikely to lead to a long-term decrease in the population of Ghost Bat.
Reduce the area of occupancy of an important population	Unlikely	The Project will not result in the direct disturbance or loss of critical Ghost Bat caves. The distance from known caves to proposed operational and infrastructure areas are provided above in Table 5-6. There are two caves present in proximity to the proposed blasting areas (categories 2, 3) and a cluster close to the haul road near its intersection with the Great Northern Highway (GNH) intersection (Category 2, 3). The closest distance from the proposed mine pit to a Ghost Bat cave is 729 m (Cave 1; Category 2). The same cave is located 350 m from a waste rock landform and diversion bund. The remaining caves in proximity to the operational area is greater than 1km away. Cave 4 and Cave 5 near the GNH intersection are located over 200 m from the access road. Cave 2 was initially surveyed when a southern haul road route option was under consideration (now dropped), and is at least 2 km from the currently proposed operations On that basis therefore, it is considered unlikely that any of the five known roost sites will be physically damaged or lost. It is also considered unlikely that cave structural integrity or roosting site viability will be adversely impacted by blasting or other operational elements at Lamb Creek. Therefore, the area of occupancy of the species will not be reduced.
Fragment an existing important population into two or more populations	Unlikely	Ghost bat have been recorded in low numbers within the Project area at two caves (Cave 1, Cave 3) located east of the development footprint. No direct disturbance or loss of caves is expected and thus it is considered unlikely the Project will fragment existing populations.
Adversely affect habitat critical to the survival of a species	Unlikely	All critical habitat (Cave 1, Cave 4, Cave 5) has a 100 m buffer implemented (Pers. Comm., A. Parker) to minimise disturbance to caves and preserve foraging habitat. Revegetation will occur after LCIOF operations. Given the distance from known caves to proposed operational blasting areas (Table 5-6), it is unlikely blasting will physically damage caves. Therefore, the Project is unlikely to adversely affect critical habitat.

**Ghost Bat Significance Assessment for the Lamb Creek Iron Ore Project
Prepared for Mineral Resources Limited**

Significant Impact Criterion	Ghost Bat	Comments
Disrupt the breeding cycle of an important population	Unlikely	Due to the low levels of cave usage recorded thus far (Rapallo 2012, 2022), it is considered unlikely that caves support breeding females. However, scat collection and hormone analysis has not been conducted at Category 2 caves with middens at the Project, therefore this cannot be confirmed. That being said, adverse impacts to Ghost Bat breeding are unlikely due to the distance of known roost sites to mining operations (Table 5-6) and if suitable management techniques are enforced (for example, restricting entry of all 'non-environmental' site personnel from the five caves identified within the vicinity of the Project).
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Unlikely	Ghost Bat foraging habitat occurs across all habitat types within the Project area (Rapallo 2022). Approximately 657 ha of Ghost Bat habitat will be disturbed for the development of the Project; however, Project design has incorporated a 100m buffer around each cave located within the Project and within the vicinity of the Project (Cave 1-5; Pers. Comm., A. Parker). Due to the short lifespan of mining and low number of Ghost Bat populations within the Project area, it is unlikely the Project will modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Unlikely	The Project is unlikely to introduce any new species to the area that would impact Ghost Bat.
Introduce disease that may cause the species to decline	Unlikely	There are no known diseases that may lead to Ghost Bat decline as a result of the Project. The Project is unlikely to increase species vulnerability to disease as a result of inbreeding.
Interfere substantially with the recovery of the species	Unlikely	Given the size, lifespan, and design of the Project, it is unlikely to interfere substantially with the recovery of the species.

5.4.2 Assessment of impacts against Key Threats

Key threats to the persistence of Ghost bat are identified by the Threatened Species Scientific Committee (TSSC 2016). Potential impacts arising from implementation of the Project and potential management techniques concerning Ghost bat are summarised in Table 5-8. The impact assessment has largely concluded that where impacts may occur, they are expected to be negligible–low. This is due to the distance of the pit to known roost sites and the fact that impact in the form of loss of foraging habitat will be rectified via rehabilitation immediately following the short mining duration proposed. Five threats are not considered applicable to this Proposal.

Table 5-8 Potential threats to Ghost Bat from implementation of the Project (TSSC 2016)

Threat factor	Consequence rating (TSSC 2016)	Expected impact	Impact details
Habitat loss (destruction of, or disturbance to, roost sites and nearby areas) due to mining	Severe	Negligible potential impact	<p>The distance from known caves to proposed operational and infrastructure areas are provided above in Table 5-6. There are two caves present in proximity to the proposed blasting areas (categories 2, 3) and a cluster close to the haul road near its intersection with the GNH intersection (Category 2, 3). The closest distance from the proposed mine pit to a Ghost Bat cave is 729 m (Cave 1; Category 2). The same cave is located 350 m from a waste rock landform and diversion bund. The remaining caves in proximity to the operational area is greater than 1km away. Cave 4 and Cave 5 are located 202 m and 237 m from the access road, respectively (Table 5-6). Cave 2 was initially surveyed when a southern haul road route option was under consideration (now dropped), and is at least 2 km from the currently proposed operations</p> <p>On that basis therefore, it is considered unlikely that any of the five known roost sites will be physically damaged or lost. It is also considered unlikely that cave structural integrity or roosting site viability will be adversely impacted by blasting or other operational elements at Lamb Creek.</p>
Disturbance of (human visitation at) breeding sites	Moderate-severe	Negligible potential impact	<p>Due to the low levels of cave usage recorded thus far (Rapallo 2012, 2022), it is considered unlikely that caves support breeding females. However, scat collection and hormone analysis has not been conducted at Category 2 caves with middens at the Project, therefore this cannot be confirmed.</p> <p>That being said, so long as personnel are restricted from approaching and entering roost sites at all times, there should be no impacts to these potential breeding sites. In addition, the remote and rugged location of the caves habitat further discourages human visitation.</p>

Threat factor	Consequence rating (TSSC 2016)	Expected impact	Impact details
Modification to foraging habitat	Moderate	Low potential impact	<p>It is expected that approximately 657 ha of vegetation will be cleared as a result of the Project. Rapallo (2022) concluded suitable foraging habitat occurs across all habitats of the survey area. It is considered likely that Ghost Bat use the Project area for foraging, particularly in drainage lines, rocky ridge and gorge habitat (Western Wildlife 2020).</p> <p>The accumulative effect of modifying foraging habitat in the Pilbara is a potential indirect impact to the persistence of Ghost Bat populations. Five active mine sites are located within 50 km of the Project (Figure 1-2) and have potential to cause habitat fragmentation and reduce foraging habitat extent. Little is known regarding the number of caves lost to mine sites within the vicinity of the Project, so the impact of foraging habitat destruction is difficult to assess.</p> <p>However, given the small disturbance footprint, short duration of the proposed Project and requirement to rehabilitate foraging habitat, impacts to foraging habitat are expected to be low, even when taking into consideration the cumulative impacts to such habitat from other mining operations locally.</p>
Collision with fences, especially those with barbed wire	Moderate	Unknown	Fencing will be minimal and no barbed wire fences will be constructed at the Project. That being said there is in fact no evidence that collision with fencing is a threat to the species in the Pilbara.
Collapse or reworking of old mine adits	Minor-moderate	No impact	N/A
Contamination by mine residue at roost sites	Moderate	No impact	Given the distance of roost caves to the proposed pit, it is considered unlikely blast residue or dust will affect the microclimate of Ghost Bat caves. No direct contamination is expected.
Disease	Unknown	No impact	N/A
Poisoning by cane toads	Severe	No impact	N/A
Competition for prey with foxes and feral cats	Unknown	No impact	N/A

5.5 DISCUSSION AND CONCLUSION

Ghost Bat are commonly recorded in the vicinity of the Project. Five Ghost Bat roost caves are present within relatively close proximity of the Project, at varying distances to proposed disturbance; However, significance assessment has revealed no Ghost Bat roost caves are proposed to be directly impacted or lost through its implementation. Indirect impact is also expected to be nil or negligible.

While the gap analysis has found that survey effort does not strictly comply with State and Federal requirements for three of the five caves this is not considered important as each was ultimately identified as a Ghost Bat roost cave. The objective of field surveys in the context of environmental impact assessment is to determine whether caves support significant species; to that end the surveys achieved their aim.

Analysis of the Project against the EPBC Act significant impact criterion for Vulnerable species has concluded that no criteria are met.

Further, analysis of the Project against each of the key threats to Ghost Bats identified by the Threatened Species Scientific Committee (TSSC 2016) reveals the Project represents negligible to low risk to the species. Therefore, on the basis of the historic survey effort achieved, and low risk the Project represents to the species, referral to DAWE under the EPBC Act is not considered necessary.

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Significance Assessment regarding Ghost bat presence at Lamb Creek.

Carl,

Mineral Resources Limited (MinRes) have requested a Subject Matter Expert Review from Bat Call WA on the existing Significance Assessment and Significant Fauna Management Plan of MNES bat presence, specifically Ghost Bat (*Macroderma gigas*) (PGb) but also Pilbara leaf-nosed bat (*Rhinonictoris aurantia*) (PLNb), at their Lamb Creek project. The review shall include aspects of presence and management (SOW (MinRes 2023a)).

The review relied on the following material that was provided:

- Lamb Creek Iron Ore Mine, Significant Fauna management Plan (MinRes 2021).
- Lamb Creek Iron Ore Project Supporting Document; Referral under section 38 Environmental Protection Act 1986., Significant Fauna management Plan (MinRes 2022a).
- Ghost bat significance assessment for the Lamb Creek Iron Ore Project. (Phoenix 2022)
- Targeted Ghost bat survey for the Lamb Creek Iron Ore Project. (Phoenix 2023)
- Shape files of Development Envelope and Indicative Footprint. (MinRes 2023b).
- Lamb Creek Proposed General Arrangement (MinRes 2022b).
- Lamb Creek Ghost Cave Review – Blasting Effect (Terra Firma 2023).

Having completed my review of the data set I can advise the following substantial conclusions:

1. There are two bat species listed as MNES under federal and state legislation potentially present at Lamb Creek. The Pilbara leaf-nosed bat and the Ghost bat. There are no records of the

PLNb at or nearby Lamb Creek and minimal non roosting records within 15 km in the project's various fauna surveys and in Bat Calls data base, the subject of the SOW is the PGB.

2. Phoenix (2022; 2023) have completed a comprehensive desk top review of earlier surveys completed by Rapallo between 2012 and 2021, a field survey campaign and post survey analysis using industry standard methods and techniques for bat identification that are in accordance with current national and state guidelines. The equipment used (Songmeter SM series detectors by Wildlife Acoustics, USA) is current and provides accurate bat call recordings. All echolocation-based surveys carried out were analysed and bat species identified by experienced bat specialists familiar with cryptic PGB calls. DNA from scats collected was analysed by the DBCA laboratory at Kensington WA. Internal cave dimensional characteristics were reported by Phoenix that together with echolocation and scat DNA results confirm cave categorisations.

3. A series of PGB presence records were identified by Phoenix from observational records, echolocation call analysis and DNA analysis from scats indicating that the bats were present across the Lamb Creek study area in small numbers and based on the desktop review, over multiple years. Caves where PGB presence was recorded were given usage classifications based on TSSC (2016) and Bat Call WA (2021), i.e., maternity, day and night and categories 2, 3 and 4 that confirm importance of usage.

4. Phoenix (2022; 2023) have identified four roost caves that are category 2 or 3 roosts within the study area. LC001 (isolated Cat. 3, also Rapallo cave 3), LC002 (isolated Cat. 2, also Rapallo cave 1), Rapallo cave 4 (Cat. 3) and Rapallo cave 5 (Cat.2). Rapallo caves 4 and 5 are in an apartment block complex within a steep gully. No PGB calls were reported for caves LC003 and LC005 and so insufficient information is presented to categorise caves LC003, LC004 and LC005. Of the four categorised caves, three are assessed as critical habitat after Bat Call (2021) being the isolated category 2 cave LC002 (Rapallo Cave 1) and the Rapallo caves 4 and 5. Cave LC001 is assessed as an isolated cat 3 cave and is therefore not critical habitat.

5. Phoenix (2022; 2023) does not address the caves at Lamb Creek in respect to the potential cumulative loss of PGB habitat. Potential mid-timeframe extirpation of PGB from the Hamersley Range east of Karijini NP is noted in TSSC (2016) and must therefore be considered.

6. Of the seven caves nominated in Phoenix (2023) all are proposed to be retained as viable roosts and it is expected that any caves within the Heritage Exclusion Zone (Phoenix 2023, figure

1-1) will also be retained. This is considered to be an acceptable outcome for the long-term protection of PGB presence at Lamb Creek post mining.

7. Several of the documents include a statement that damage to critical habitat and other caves due to the mining operations is “considered unlikely. This statement appears to be based on the planned distances of 280 m from the Development Envelope (DE) and 750 m from the current pit design.

8. A professional geotechnical assessment of the critical habitat cave 1 has been completed as a desk top study (Terra Firma 2023). This study is based on an in-ground vibration limit of 25 mm/sec PPV, a level that will ensure the cave remains a viable roost following completion of mining. The study is based on a pit design that is 750 m distant from the cave at its closest point. It concludes that a worst-case misfire of 10 holes instantaneously firing will not exceed the 25 mm/sec limit. The study also shows that blasting overpressures at Cave 1 will be high and may exceed 110 dB. The study does not address expected noise from the waste dump build north, 350 m north of Cave 1, but noise levels of a similar nature may be expected from heavy vehicles operations at that distance.

9. MinRes (2021,2022) are silent on whether mining is planned to be a 24/7 operation however this is expected normal mining practice therefore the caves and any bats within proximity to mining operations may be subject to impacts such as vehicle strike, in-ground vibration, sound, artificial light and airborne dust. These impacts are recognised and addressed. It is expected that these impacts will cause the temporary abandonment of some or all of the roosts within or immediately adjacent to the DE while operations are underway. Further, recent evidence has shown that PGB will recolonise roosts after mining operations cease as long as the caves remain in a viable condition. Temporary closure during the critical female breeding period of October to December may be required to ensure that no inadvertent loss of mothers and/or pups will occur in the event of mining activity (e.g., blasting, excavation, haulage, overburden stacking) in proximity to caves (see further discussion below).

10. MinRes correctly notes that all foraging habitat to be impacted is potentially used by Ghost bats. MinRes (2021, 2022) state that management mitigation strategies are planned to minimise this impact. These are considered adequate (see further discussion below).

11. Fencing is integral to good land and stock management in the pastoral, mining lands of the Pilbara, but it needs to be built in a manner compatible with wildlife, including Ghost bats.

Recognising that the project includes pastoral lands as well as ridge lines, it is recommended that three and four strand wire fencing in the Pilbara be built according to the perceived risk area that applies. PGb in particular are known to become entangled in barbed wire fencing during commuting and/or foraging. There are numerous records of fatalities resulting from entanglement (TSSC 2016; Bat Call 2021). Phoenix (2022) addresses this risk with a statement in Table 5.8 that is both naive and misleading. I have three records of PGb entanglement in barbed wire fencing within 50 km of the project. Further, no reference is made to any agreement with the managing pastoralist regarding the building of fencing without barbed wire, in particular along the haul road. I consider the areas along the perimeter the DE and the haul road to have high to moderate risk of entanglement, and therefore the potential for use of barbed wire in a limited manner, together with suitable bat deflectors, is acceptable. Phoenix (2021) should be corrected and MinRes 2021 and 2022 should be modified suitably to reflect this.

In addressing these points of discussion in the following paragraphs, my comments are based on the following hierarchy of objectives. Firstly, protect the caves considered to be critical habitat for the MNES species, in this case the PGb. Secondly, protect PGb that may be roosting in these caves. Thirdly understand the impact of the project on the PGb's foraging areas surrounding the caves in question and maintain adequate area for the future.

Item 1. General comments regarding buffers around PGb roosts at Lamb Creek.

Category 2 roosts such as the isolated cave 1 at Lamb Creek, ~270 m from the DE, are those with regular diurnal occupancy, typically between 25 and 75 % of days (Bat Call 2021, Sect 5.1). Category 3 such as the isolated Cave 3, ~520 m from the DE, are those with occasional diurnal occupancy. One apartment block including a Cat. 2 and a Cat. 3 cave has been identified at Lamb Creek ~150 m from the planned haul road. Note also that all Cat. 2 roosts and apartment blocks are designated as critical habitat (Bat Call 2021 Sect 5.1). There is no other critical roosting habitat identified.

Following numerous discussions on the subject with several proponents and based on field work at several unrelated projects acceptable buffers can be proposed around PGb critical habitat roosts that remain open during mining operations. These buffers are acceptable based on the following:

1. Category 2 and 3 caves are not permanently occupied therefore it has been proven that the PGB can easily relocate away if disturbed by the pre-mining or pit development operations.
2. Retention of roosting viability of the Cat. 2 and 3 caves can be shown by Geotech Engineering assessment and /or professional Blast Engineering planning before and during the occurrence of mining operations nearby.
3. Blast planning shall be based on maximum Peak Particle Velocity (PPV) limits that provide protection for any roosting bats, reproducing females in particular, that remain in open roosts when mining ops are nearby. The limiting PPV for critical habitat caves that remain open shall be 10 mm/sec from 1st October to 31st December to protect heavily pregnant females and newborn young. For critical habitat caves from 1st January to 30th September the limiting PPV shall be based on retaining the roost as viable. In accordance with these recommendations and the calculations in Terra Firma (2023) MinRes has advised that Cave 1 will be temporarily closed for Ghost bat access during nearby mining operations.
4. It is well documented that high or unusual levels of ambient noise have been shown to cause PGB to temporarily abandon diurnal roosts. Bat Call (2021, sect 6.2.2) recommends current best practice for sound levels at open Cat. 2 roost entrances of 70 dB(Z) during mining operations. This is based on Bullen and Creese (2014) supplemented by more recent unpublished author's observations. In accordance with the calculations in Terra Firma (2023) MinRes has advised that Cave 1 will be temporarily closed for Ghost bat access during nearby mining operations.
5. Current best practice for exclusion buffers at open critical habitat PGB caves is 200 m (Bat Call 2021) and 100 m for Cat 3 caves. At Lamb Creek Cave 1 and the Cave 4/5 apartment block, 150 m is considered adequate for mining activities and 100 m for other forms of ground disturbance, with added assurance given plans for the temporary closure of Cave 1..
6. As noted above, current field work (Bullen *et al.* 2023 and other personal observation sessions at PGB roost entrances) has shown that the species does not begin to forage from the ground immediately upon exiting the roost but departs the local area.

If during mine planning, limits for avoidance buffers, continuous ambient noise or in-ground vibration as defined above for open caves (default or specific) are not able to be met, an acceptable solution is to close off the entrances. PPV limits designed to retain the cave as a viable roost post

mining to allow recolonisation shall then be enforced. As noted above, it is expected that noise and vibration levels during the project may necessitate temporary closure at Cave 1. I recommend that while construction and mining operations are underway in proximity to this cave, and the displacement of bats is considered likely, the cave be closed to PGB occupation during the October to December breeding season as a minimum to avoid impacts to breeding PGB individuals while mining is carried out at the project. Caves 1 and 3 may also be closed year-round during mining operations to minimise impacts to PGB individuals. Cave closure is viable due to the proximity of Ghost bat habitat within 25 km to the east, south and west that will allow the bats to relocate away during the mining operations and return to the retained DE caves once mining is completed. MinRes' commitment to temporarily close Cave 1 is considered proactive given the combined modelling of PPV and noise levels expected (Terra Firma 2023).

Item 2. Impact of temporary closure of specific roost Cave 1.

This natural cave, together with the two caves 4 and 5 to the south, constitute the identified critical roosting habitat at and adjacent to the DE and haul road. With the possible closure of Cave 1 and the level of noise, dust and in-ground vibration during mining operations including mine closure possible, it is foreseen that the local population of PGB at Lamb Creek will relocate away from the DE and the colony at the project will contract to close to zero. Experience has shown at other iron ore projects with PGB colonies pre-mining, e.g., Poondanno project (Bullen and Creese 2014), 30 kilometres south-east of Port Hedland, that has been mined out for approximately seven years, that this level of abandonment is not permanent and the PGB return to roost in the viable caves that are retained (author's unpublished observations). Further numerous caves in mined out Pisolite mesas along the Robe River (Bat Call 2017), 50-year-old Hamersley Range adits in iron stone (author's unpublished data) and East Pilbara abandoned underground gold mines (Bat Call 2021) support healthy PGB colonies providing further evidence to the recolonisation ability of the PGB. It is also believed that the ranges that extend to the east, west and south of Lamb Creek contain additional Cat. 2 roost caves. Any long-term impact of the Lamb Creek project on the Hamersley Range PGB population east of Karijini is therefore foreseen to be minimal, limited only to the potential loss of foraging habitat within the DE.

Item 3. Comments regarding foraging habitat at and near Lamb Creek.

The DE at Lamb Creek is an area of 895 ha that is aligned east to west and 3.5 km long by 2.5 km wide. It is made up of high, moderate and low value PGB foraging habitat (MinRes 2022, table 8-3). These assessments are supported by recent field work results using VHF (e.g., Biologic, 2019) and/or GPS satellite tagged bats (Bullen *et al.*, 2023; authors unpublished recent data). These recent studies have shown that bats regularly forage up to 12 km from their diurnal roost caves and prefer more productive areas with scattered, patchy or more continuous woodland coverage. I consider that these results show that the concept of “critical foraging habitat” does not apply to PGB, rather foraging habitat up to 12 km from roost sites should be considered supporting habitat.

Maximum flight path distances flown in a night are typically in excess of 20 km and can be over 40. Of the area surrounding Lamb Creek within range of the project’s PGB roost caves, some 70,000 ha, I assess the majority, over 60,000 ha, as high value for PGB foraging. This is based on numerous past visits to the region supplemented by a review of available aerial imagery. The 895 ha therefore represents only ~1.5% of that available to PGB at Lamb Creek. Significantly, current field work involving numerous personal observation sessions at PGB roost entrances has shown that the species does not begin to forage from the ground immediately upon exiting the roost but departs the local area and begins to forage from the ground some distance away. This is supplemented by satellite tracking GPS tagged PGB (Bullen *et al.* 2023) and VHF and GPS data from Augusteyn *et al.* (2018, Figure 5). These studies show initial foraging from the ground very occasionally begins at distances of over 400 m and usually over 750 m from the roost. The PGB then remain at greater distances until returning to the roost. VHF data from Biologic (2019) also supports this. An additional comment can be made regarding foraging by PGB’s at cleared areas within the high value areas. Once cleared of trees and large shrubs the bats are only likely to use the periphery of the cleared area, however, observations during the clearing activities have sometimes shown that PGB can be temporarily attracted to forage, presumably due to the number of terrestrial prey disturbed by the clearing that become easy prey (author’s unpublished observations).

Item 4. Current understanding of habitat requirements for transiting to other roosts.

Currently there is limited data on the routes taken by PGB when transiting to other roosts. Recent Bullen *et al.* (2023) supported by data in Augusteyn (2018) indicate that long distance flights away

from an initial diurnal roost involve a number of foraging stops at high and medium quality sites. It can be inferred from this together with the nightly flight distances covered noted above, that there are no specific habitats required to support commuting long distances.

Item 5. Additional comments relevant to MinRes' proposed mitigation for Cat 2 caves.

- a. Subject to mine planning, Cave 1 may be retained with non-mining buffer of 150 m, however as noted above, this distance will be contingent on the closure of the cave to PGb for the duration of mining operations together with PPV limits consistent with retaining the cave's structure as a viable diurnal roost, see item 1 above.
- b. Blast monitoring, PGb usage monitoring and cave entry protocols are recommended to be applied to cave 1 if it is to remain open.

Best regards



R. Bullen

Managing Director / Principal Ecologist

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6 August 2024.

Review of queries re Ghost bats at Lamb Creek.

Carl,

Mineral Resources Limited (MinRes) have requested comment regarding responses received from DCCEEW regarding the submission on the proposed Lamb Creek project. The relevant responses relating specifically to Ghost bats at Lamb Creek are included Section 4 para. 12 of a document attached to MRL (2024). The request for comment includes one item of general nature followed by three specific queries. My professional opinion and advice to the four responses is as follows:

Para 12. I agree that there will be impact on the Ghost bat during the preliminary, construction, operation and rehabilitation phases of the project, however an assumption that this impact will be substantial is not well founded. My opinion is that MRL have proposed and intend to implement adequate mitigation measures including a cave closure and barbed wire management, to ensure that the presence of PGb nearby the project continues throughout and subsequent to the project completion. No PGb critical roosting habitat sites are to be removed and measures will be taken to protect reproducing female bats and their pups should they be present at the relevant sites nearby the project. In consideration of any cumulative impact on regional PGb populations, as no critical habitat is to be removed, the total foraging area supporting the species to be disturbed is under 700 ha and there will be no new unprotected barbed wire fencing installed, there will be minimal contribution to the very much larger impacts from the proposed and existing operations in the region.

Para 12a. Lamb Creek is bounded by the Marillana Creek plain to the north and by extensive ranges to the west, east and south. Immediately southwest is the Gaguna heritage exclusion zone and the ranges beyond to the south and west are BHP tenements that have been extensively surveyed over a number

of years. Rio Tinto and BHP also have extensive tenements to the east of Lamb Creek. Due to the presence of cave forming ironstone strata, additional surveys in the Gaguna area will almost certainly identify additional critical habitat for the PGb as has been the case at the adjacent BHP and RTIO tenements. However, my opinion is that there are an adequate number of known caves in my data base within 12 km and many within 20 km of Lamb Creek (relevant distances discussed in Bullen (2021) and Bullen et al. (2023)) that will support dispersal on a daily basis across the region. Additional surveys within Gaguna will only serve to increase the existing data base. My recommendation is to observe any limitations placed on the area by the traditional owners.

Regarding surveying for foraging habitat, it is known (Bullen 2021, Bullen et al. 2023, Trainer et al. 2024) that PGb use virtually all types of landscape for foraging and appear to prefer the flat plain areas. On the basis that the project will be carried out utilising current drill, blast and ore removal technologies and will not have a wind farm, the extensive Marillana Creek plains and the ranges do not require further survey effort for the presence of PGb to support the Lamb Creek project. On going monitoring of the identified roosting sites at the project will suffice.

Para 12b. I consider that the planned PGb mitigation measures at Lamb Creek are based on retaining the critical roost caves as viable habitat for the long term and minimising any direct impact to the bats as is reasonably practicable. They therefore comply with the intent of TSSC (2016).

Regarding the proposed closure of Cave 1 close to the proposed project impact area, this measure is intended to protect any PGb and in particular reproducing females and their pups from injury or death caused by disturbance from the mining operations. Being in close proximity, it is expected that noise and vibration levels from blasting and HV traffic will be at levels in excess of that shown to disturb diurnal PGb roosting. My experience has shown at two major projects and recently at a third operated by other proponents that closing the caves in an ethical manner as has been done at the other projects, and prohibiting PGb entry does not affect the bats in any detrimental way. In fact, I have data that has shown that PGb originating from other roost caves continue to forage outside the enclosures, presumably looking for preferred prey such as *Taphozous* and *Rhinonicteris* species that may continue to inhabit the “closed” cave and that exit and reenter through gaps too small for the PGb to pass.

Para 12c. MRL have commissioned an impact study of the noise generated by the planned movement of the proposed road train configuration ore trucks, i.e. 60m quads with payloads of between 120 to 140 tonnes (Lloyd 2024). That report predicts worst case noise levels at the entrance of caves 4 and 5, being the closest critical habitat roosts to the haul road, due to two passing trucks at a maximum speed of 80 kph to be approximately 72 dB(Z) (note however that actual speeds during mining operations may well be significantly less than 80 kph) which is on the current recommended level for minimal impact on roosting PGB (Bullen (2021) and 5 dB lower than that predicted by Lloyd for the passing iron ore bulk trains on the adjacent Yandicoogina mine railway. The railway has been in operation for a number of years and during that time there has been no recorded impact of the PGB roosting there. Regarding in-ground vibration, at the distances of over 250 m from the haul road, the rubber tyred trucks will produce no discernable in-ground vibration levels to add to any disturbance.

Best regards



R. Bullen

Managing Director / Principal Ecologist

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20 June 2023.

Ghost bat cave closure at Lamb Creek.

Carl,

Mineral Resources Limited (MinRes) have requested professional guidance regarding the potential impacts of temporary cave closure on fauna species other than roosting Ghost bats. I can provide the following based on my years of experience at several sites where caves and historical mine adits have been closed for differing periods. Unfortunately, I do not have photos that I can share at this time.

There are two possibilities regarding cave closure at Lamb Creek that MinRes may choose to apply.

1. Temporary closure over several months over the Pilbara's wet season corresponding to the females Ghost bat's primary reproductive time (October to December).
2. Longer term closure over several years covering the construction and operational life of the mine.

Option 1. Temporary closures over months have been successfully completed at several sites. My experience has shown that closure using bird netting that is UV stabilized and with a 5 or 10 mm aperture has been successful in eliminating bat and bird entrance to the cave. The netting should be stapled or otherwise attached to a lightweight timber frame that is shaped, fitted and secured in the cave entrance at a time when there is no larger terrestrial fauna within the cave. The gap remaining at the cave walls should be no larger than 50mm. Any edge gap larger than this with a length exceeding 300 mm would allow the passage of Ghost bats in my experience. My experience also precludes the use of "shade-cloth" that has been shown to occasionally tangle small birds, and

therefore probably small bats, leading to their death. With the netting in place there can be no entry into the cave by fauna larger than 1 – 2 g. An alternative to the netting is to use light weight wire netting or plastic garden trellis with <50mm apertures fixed to the frame. The type of wire netting would be as commonly used in bird aviaries.

Option 2. For multiyear closure, I would recommend a more substantial light weight steel frame fitted to the entrance. The netting in this case would be at least the bird avery steel netting or any heavier style with apertures not exceeding 100 mm. At this larger size, and with minimal edge openings as above, it is expected that Ghost bats would be excluded but smaller species up to 10g such as Pilbara leaf-nosed bats (*Rhinioncteris aurantia*) or Finlayson’s cave bat (*Vespadelus finlaysoni*) would be able to pass through unharmed. Other small fauna of a similar size including reptiles, frogs and snakes would also be able to access the cave.

With regard to larger fauna such as Quolls, Dingoes and/or Macropod species that will be excluded by the closures, Lamb Creek Cave 1 is situated in an area with numerous alternative deep overhangs and shallow caves that are suitable for their foraging and/or resting activities. Each of these species is known to travel significant distances on a daily basis.

Finally, I am not aware, with the exception of birds tangling in “shade cloth” types of materials, of any fauna mortalities caused by the types of cave closures described above

Best regards



R. Bullen

Managing Director / Principal Ecologist



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22nd September 2024

Mineral Resources Lamb Creek Iron Ore Project
Review of responses to requests for further information on MNES

M. Bamford

Background

Mineral Resources Ltd (MinRes) is proposing to develop the Lamb Creek Iron Ore Project, in the Pilbara region east of Karajini National Park, and is in the process of preparing responses to requests for further information (RFI) from the DCCEEW regarding MNES. These responses are being developed by MinRes and several specialist consultants, and BCE has been invited to address aspects of the RFI applying our extensive knowledge and experience of the fauna and the region, as well as commenting on some of the RFI responses of other consultants. BCE has also been requested to peer review and comment on the MNES significance assessment carried out for MinRes by its consultant Stantec.

Requests for further information

The RFI aspects BCE was requested to address were as follows:

6) Survey data justification

10) Northern Quoll

- Please provide clarification / evidence of why a targeted survey has not been conducted, given the presence and proposed clearance of critical habitat in the proposed action.
- Please also address the limitations that have been provided for the 2020 survey.
- Provide consideration of management measures, other than compensatory, that might support the management of impacts to an important Northern Quoll population i.e. potential for refuge habitat.

11) Night Parrot

- Provide justification as to why targeted surveys have not been conducted.

Comments on these are provided below.

6) Survey data justification

Based on our review of the site-specific MNES information collected by MinRes for the proposed Lamb Creek Project, the existing knowledge base of the local Pilbara region, and an understanding of the importance of a habitat suitability assessment approach for MNES, there is sufficient information available for assessing potential impacts to MNES and developing risk

mitigation measures. Accordingly, we see no justification for requiring ‘more recent’ surveys as queried in the RFI.

Multiple surveys have been undertaken for the project, and it lies in a region where many surveys have been undertaken to support environmental approvals of other projects. As a result, the vertebrate fauna, and species of conservation significance in particular, are well-documented in the region. The ongoing studies in the project area, including those targeting significant species, thus build upon a substantial base of existing knowledge. Furthermore, the ecology of the significant species is moderately well-understood due to decades of studies for the resource development sector. As such, there is abundant information on the location of bat roosts, the distribution and habitat preferences of the Northern Quoll and even, more recently, on the Night Parrot. It is important to view observations made in the project area in this context. It is also important to be aware that the Pilbara is a region of seasonal and annual weather extremes, and also one where fire plays an important ecological role. These factors mean that the abundance of species can vary enormously within and between years. As a result, the value of one-off surveys can be quite low, whereas the value of a long history of surveys is high. For example, in a monitoring study on Northern Quoll conducted by BCE for an iron ore project north of the Fortescue Marshes (Bonney Downs), the species was initially abundant, but disappeared following a regional fire and several years of poor rainfall and was only just detectable five years later. Throughout this period, the landscape in the area would have been considered as core habitat for the species and surveys showing its absence from the area could be viewed negatively, when in fact its absence is perfectly reasonable given the fire and low rainfall conditions.

The Lamb Creek project area is a good example of where a habitat suitability assessment approach, supplemented by an analysis of regional data and some targeted survey work, can very effectively demonstrate the importance of the landscape for species such as the Northern Quoll; in fact more effectively than relying on the results of just one or two surveys. Surveys should not be undertaken in the assumption that they are intended to confirm presence (or in some way indicate absence), but should be seen as a supplement to the interpretation of existing data and the landscape as has been done in the documents presented by MinRes.

10) Northern Quoll

The comments above apply very well to the Northern Quoll. It is clear that the project area lies in a region where the species is present in favoured landscapes, (typically rocky hills, breakaways and gorges), and the nature of its favoured landscapes is well-known. The species was confirmed to be present in 2012, and assessing the risk of the Lamb Creek project to the species should be based upon landscape interpretation, not on the outcome of recent surveys. The extent of recent fires probably means that the population has fallen in recent years (fire can be expected to reduce the carrying capacity of the landscape for the Northern Quoll as noted above in the study on Bonney Downs), but that makes it all the more important not to assume that recent or new surveys will somehow improve the understanding of the importance of the site, and of how the proposed action will impact upon the species. While the proposed action will remove what may be foraging habitat adjacent to the rocky hills (and notably, no actual denning habitat is proposed to be removed), the greatest threat to the Northern Quoll is likely to be further repeated fires. There may also be some risk from roadkill due to the placement of roads around the rocky hills and the increase in traffic generally.

While noting that the results of a single survey cannot be relied upon to confirm presence (and certainly not absence) of the Northern Quoll, DCCEEW did request some discussion on survey limitations identified by Rapallo (2020). Rapallo considered season of survey as a partial limitation, and noted that conditions were dry and rainfall had been low the previous two months; this limitation was made primarily with respect to bat species rather than the Northern Quoll. Fire is not mentioned as a factor that may have contributed to low population density. The season of survey is mentioned with respect to the Northern Quoll, but may not actually have been a limitation, as April is in the post-breeding period when juvenile Northern Quoll may be dispersing and thus more detectable. The post-breeding population abundance is also likely to be higher than at other times of the year due to the presence of juveniles. Rapallo (2020) notes that the Northern Quoll survey used only cameras which is not consistent with commonwealth guidance for a targeted survey for the species, but 50 baited cameras set for five nights is a high survey intensity and in our experience, cameras are more effective than cage traps for detecting the species.

11) Night Parrot

Based on the environmental descriptions provided for the proposed Lamb Creek Project, there is no foraging habitat and very limited possible roosting habitat for the Night Parrot. State Guidelines for Night Parrot surveys¹ provide a detailed description of preferred foraging and roosting habitat. Thus, there is no reason to survey for the species. This approach based on an assessment of habitat suitability is consistent with survey guidelines for Australia's threatened birds (DCCEEW 2010) which state that '*...a regional habitat analysis may be used to determine the importance of a site to the listed birds*'.

¹ Department of Biodiversity, Conservation and Attractions (2024). Guidelines for determining the likely presence and habitat usage of Night Parrot (*Pezoporus occidentalis*) in Western Australia

Review of the MNES significance assessments (Stantec).

This report was reviewed and comments provided in the body of the report. The report was comprehensive and detailed, but a few points need consideration.

- Grey Falcon. The section on this species needs to be revised. There is a statement that the project area is not within the species' commonly frequented range, but this is followed by a report of a record within 14km, and multiple records within 20km. It is also stated that the project area may provide breeding habitat, but this does not really align with descriptions of the area. The Grey Falcon occurs at low densities and is a rarely-seen species, so if there were multiple records within 20km, and there is possible breeding habitat on the site, then this may require further investigation. It may be that 'multiple records' is an inaccurate statement and that suitable breeding habitat does not exist, particularly as the reference is to 'gorges, gullies and rocky breakaways', whereas the Grey Falcon usually nests in tall trees along major rivers (which are not present in the Proposed Action Area).
- Ghost Bat. Refer to the review and advice of expert in Ghost Bat ecology retained by MinRes (Bob Bullen, Bat Call WA).
- Significance of impacts on Northern Quoll, Ghost Bat and Pilbara Olive Python. The Stantec report concludes significant impact on all three of these species could occur due to 'adverse impacts on critical habitat' and to 'reduced area of occupancy' (Northern Quoll only). The area of critical habitat has subsequently been reduced so that denning and shelter habitat for the Northern Quoll and the Pilbara Olive Python has been avoided. Therefore, only foraging/dispersal habitat is being affected, and as these are very extensive in the region, the designation of a 'significant impact' is very precautionary. Furthermore, the significant impact criteria can be challenging to interpret and two of these criteria are problematic with these three species.
 - Adversely affect habitat critical to the survival of a species.
 - Modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline (this criterion differs little from the first of the significant impact criteria, which refers to 'a long-term decrease' in population size, but it does provide a mechanism for decline through habitat loss and/or degradation).

They are problematic as the first of these is ambiguous. Does it mean that any area of habitat that supports even just an individual of a species for part of the time is critical, and thus the loss of even that small area of habitat is a significant impact? Or, and at the other extreme, does it mean only that the loss of a large area of habitat could threaten the survival of the species? The criterion does not give any scale of the impact. The second criterion is relevant as it can be interpreted as a qualifier for the first. For example, if habitat critical to the species is adversely affected (first criterion) to the point where there is population decline (second criterion), is that a significant impact? If this interpretation is valid, then none of these species may suffer significant impacts, as it is concluded that none will suffer population decline. For the Ghost Bat, the proposed action will remove 622.3ha of supporting (foraging and dispersal) habitat, but this is not expected to result in population decline because the impact is not on critical habitat. Supporting habitat is also very extensive in the region, which is presumably why the loss of 622.3ha of such habitat is not expected to result in a population decline, but on that basis it is difficult to conclude that the impact is going to be significant. The same argument can be used for the Northern Quoll and the Pilbara Olive Python where there is loss of only supporting habitat. However, mortality from roadkill is a threatening process that may be of more concern for these two species than small

proportional loss of supporting habitat. This is considered in the EPBC Preliminary Documentation.

- Whether or not the potential impacts on Northern Quoll, Ghost Bat and Pilbara Olive Python are considered significant, the project does occur in a region where the three species are present and therefore management of threatening processes will be needed. This could include fire management (to avoid single, extensive fires), avoiding denning habitat, minimising disturbance, restoration of disturbed areas where possible, signage and education to reduce risk of road kill, and monitoring (particularly of Ghost Bat roosts). This is clearly the intention of MinRes.

Project: Lamb Creek EPBC Preliminary document **Project No:** 304500955
To: Carl Paton **Date:** 12 August 2024
From: Peter Tapsell

RE: Lamb Creek Night Parrot Review

Stantec has reviewed the likelihood of the Night Parrot (*Pezoporus occidentalis*) being present within the vicinity of the Lamb Creek Proposal with the findings summarised below.

Habitat Requirements and Current State

The current Department of Biodiversity, Conservation and Attractions' (DBCA, 2024) Guidelines for determining the likely presence and habitat usage of the Night Parrot (*Pezoporus occidentalis*) in Western Australia states Night Parrots require two distinct habitats:

1. Dense vegetation patches for roosting.
2. Nearby floodplains or low-lying areas with diverse grasses and herbs for foraging.

Roosting Sites: These typically consist of long unburnt *Triodia* hummocks (often >50 years), and Night Parrots may fly up to 10 km from these sites for foraging

Foraging Areas: These include floodplains rich in forbs, grasses and chenopods (Department of Biodiversity Conservation and Attractions 2024).

Lamb Creek Analysis

Vegetation and Habitat Suitability

Figure 1 shows the fauna habitat mapping for the Lamb Creek Proposal and **Figure 2** shows the fire scars across the Project. These figure show:

- The Proposal Area contains some patches of mature *Triodia*, notably at site LCS03, which has not been affected by recent fires.
- Majority of the survey area has been frequently burnt, reducing the availability of long unburnt *Triodia* required for roosting.
- The survey area lacks the mosaic of samphire and chenopod shrublands typically associated with Night Parrot foraging habitats (Rapallo 2022).

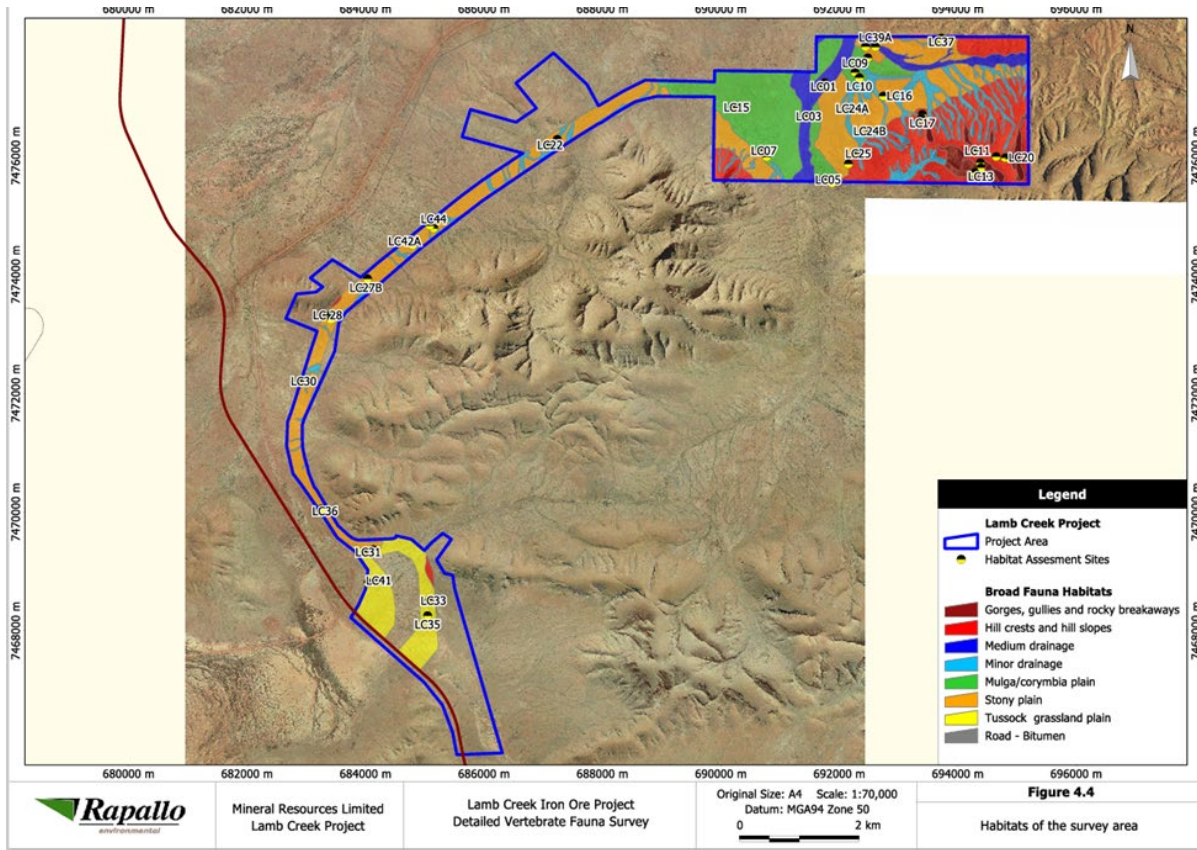


Figure 1: Fauna Habitat of the Lamb Creek Proposal

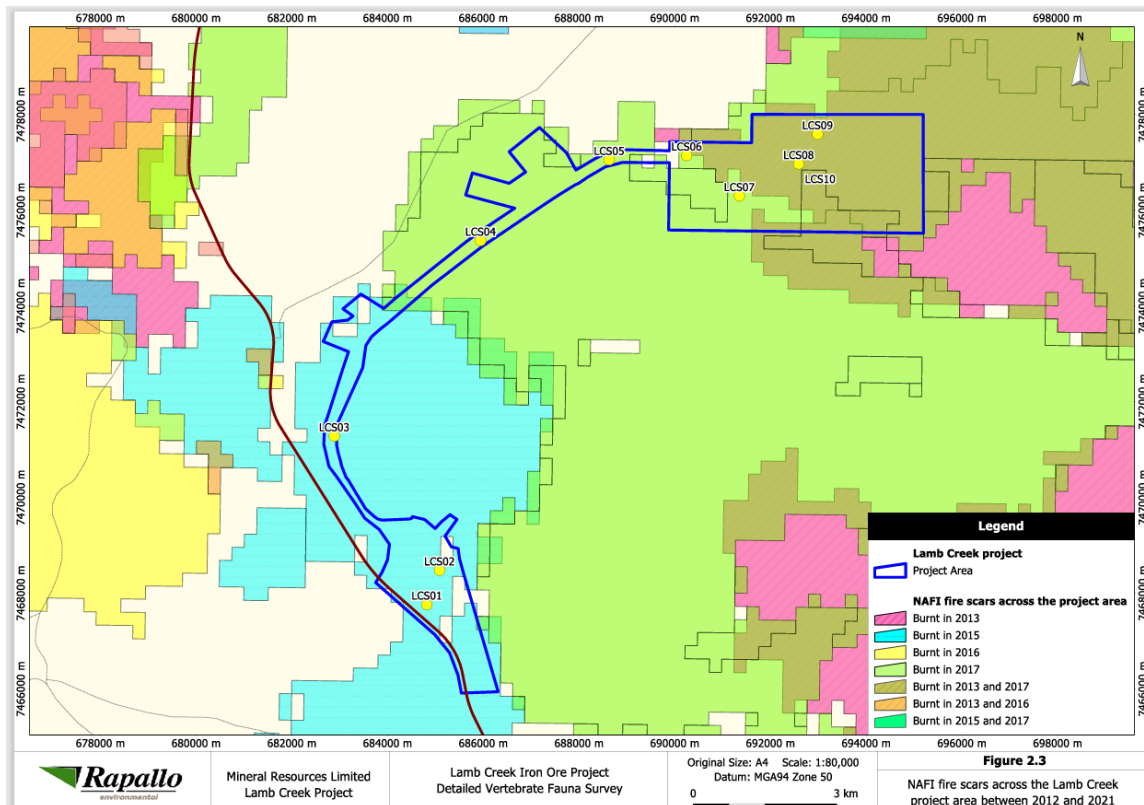


Figure 2: Fire Scars across the Lamb Creek Proposal

Aural Survey Findings

Despite the finding of the habitat assessment that the area has no foraging habitat and virtually no potential roosting habitat for the Night Parrot, an aural survey was undertaken. This survey was carried out in April 2020 and took place at three locations for a total of eight recording nights (Rapallo 2022). The aural surveys utilised one Wildlife Acoustics Song Meter SM4 Acoustic Recorder, with recordings analysed for Night Parrot calls. The recorders were deployed in open shrubland with patches of mature spinifex (**Figure 3**). Two of the sites (A3 and A-Haul) were placed within an area that was last burnt in 2015 and the third site by the mine (A-Footprint) was burnt in 2017 (**Figure 4**). While the *Triodia* was considered mature, there were no long unburnt patches available to survey. The aural survey concluded that Night Parrots were not detected during acoustic surveys in the Lamb Creek area in 2020.



Figure 3: Spinifex at the Lamb Creek Proposal

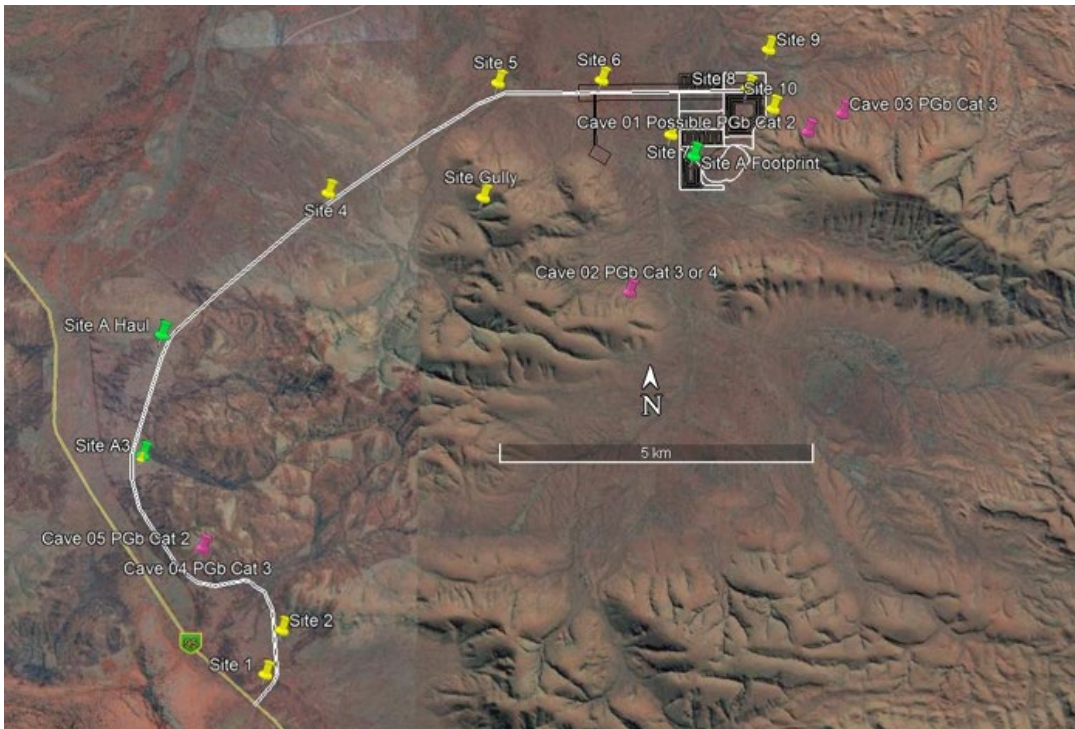


Figure 4: Locations for Night Parrot aural survey – Site A3, A-Haul Rd, A-Footprint

Assessment of Likelihood

Habitat Suitability

The survey area is characterised by stony plain habitats with low habitat complexity, minimal shading and significant fire impact. Habitat suitability is reduced due to:

- Presence of potential habitat, such as mature *Triodia* patches, is limited and fragmented.
- Areas within Lamb Creek do not include necessary foraging habitats such as those including mosaics with samphire and chenopod shrublands, salt lake margin or paleochannel.

Historical and Contemporary Records:

No recent records of Night Parrots exist in or adjacent to the Lamb Creek area according to DBCA database searches. The nearest contemporary record of Night Parrots is from areas near the Fortescue Marsh and south of Newman which are over 50km from the Proposal.

Conclusion

The Night Parrot is unlikely to occur in the Lamb Creek development area due to:

- Absence of detections in acoustic surveys.
- Lack of critical habitat elements and suitable, long unburnt *Triodia* patches.
- Historical and contemporary records indicating the species has not been recorded within, or adjacent to, the Proposal Area.

The detailed survey and habitat assessment suggest that, while the area falls within the broader distribution range, the specific conditions at Lamb Creek do not support the critical habitat requirements for the Night Parrot. The proposal area supports at best marginally suitable habitat, and/or severely degraded habitat (Rapallo 2022). Therefore, the likelihood of their occurrence in this area is very low.

Yours sincerely



Peter Tapsell
Team Lead / Senior Principal Environmental Scientist

Stantec Australia Pty Ltd

References

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- Rapallo. (2022). Detailed vertebrate fauna survey of the Lamb Creek project. Unpublished report prepared for Mineral Resources Limited.

To:	Mineral Resources	From:	Daniel Lloyd
Attention:	Carl Paton	Date:	2 August 2024
Email:	Carl.Paton@mrl.com.au	Pages:	7
Our Ref:	24079164-01B		
Re:	Project: Lamb Creek - Transportation Noise and Vibration Impact to Ghost Bat Caves		

1. INTRODUCTION

Lloyd George Acoustics has been commissioned to predict the noise and vibration levels resulting from road trains travelling along the Lamb Creek haul road to Ghost Bat habitats, as shown below in *Figure 1*. The assessment also considers potential noise from trains travelling on the Rio Tinto rail line. The Ghost Bat habitat is approximately 140 metres from the haul road and 320 metres from the Rio Tinto rail line.

From our conversation with Bob Bullen, we understand that Ghost Bats are susceptible to low frequency noise, and as such, all noise predictions are unweighted (Lz).

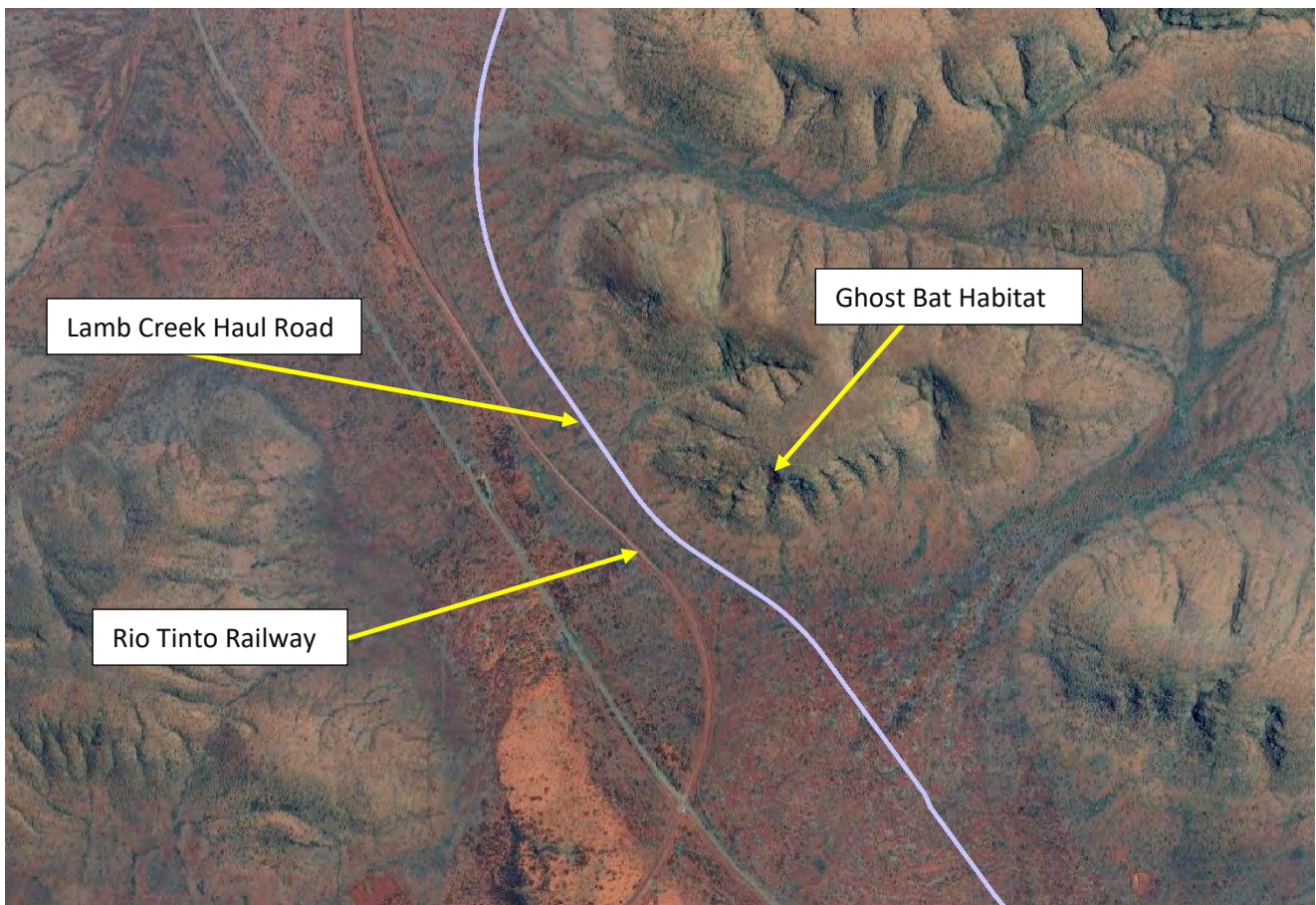


Figure 1 Location of Haul Road, Railway and Ghost Bat Habitat

2. HAUL ROAD ASSESSMENT

The predicted noise levels are based on measurements undertaken by Lloyd George Acoustics of similar 60m long quad road trains operating on the MRL Koolyanobbing mine site in December 2020 (ref *Environmental Noise Assessment Ashburton Project; Lloyd George Acoustics; ref 20115943-01; 20 Oct 2021*). Based on these measurements, the following sound power level has been used assuming the road train travelling at 80km/h along the haul road.

Table 1 Calculated Sound Power Levels from Road Train Movements, dB

Description	Octave Band Centre Frequency (Hz)								Overall dB
	63	125	250	500	1k	2k	4k	8k	
60m Quad Road Train at 80km/h	121	117	116	113	108	101	93	89	124

The noise levels have been predicted using the CONCAWE algorithms and assumes the wind is blowing from the source towards the caves, the ground effect is 40% (assuming 0% is water and 100% is grass), surveyed ground levels and a height above the ground at the cave entrance of 4.0m.

Based on the above, the predicted rise and fall of noise at the Ghost Bat habitat cave opening is shown below in *Figure 2*.

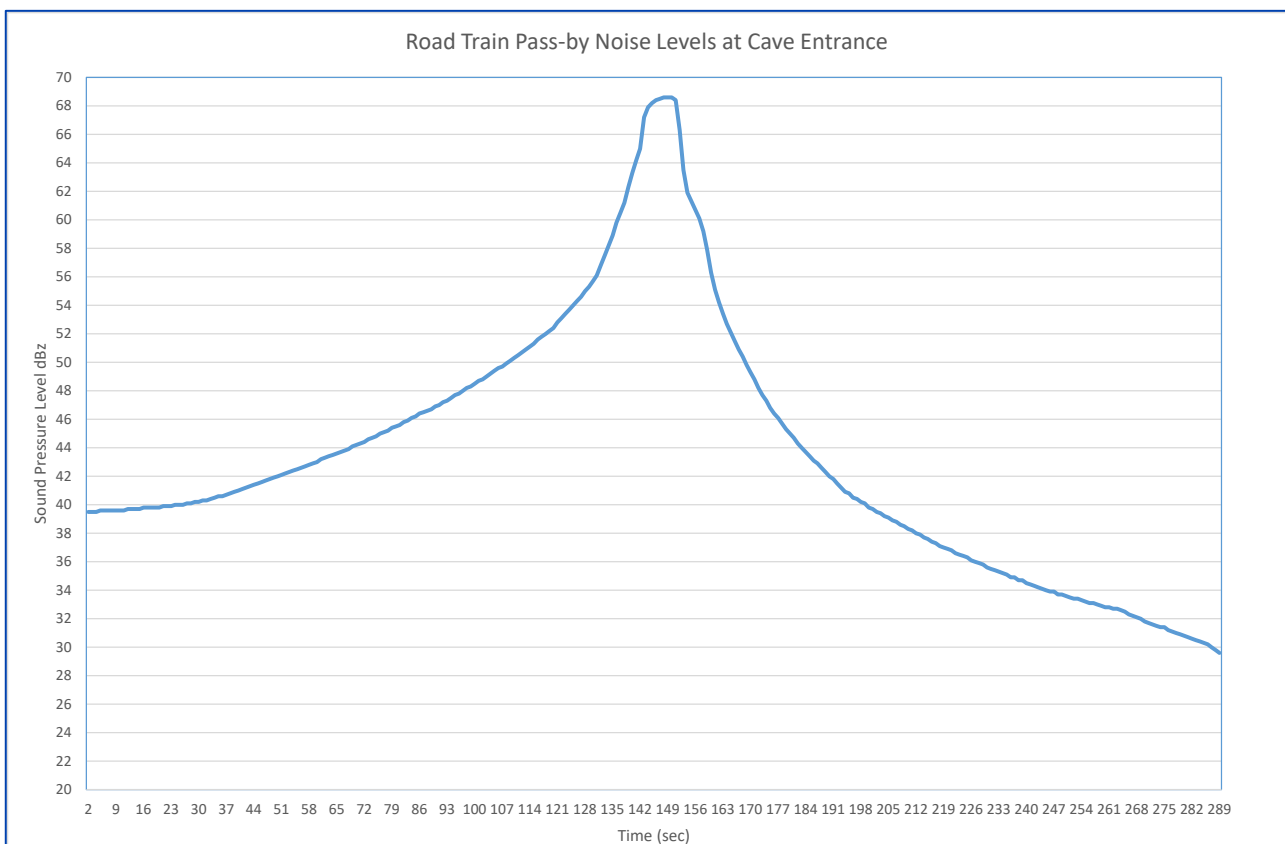
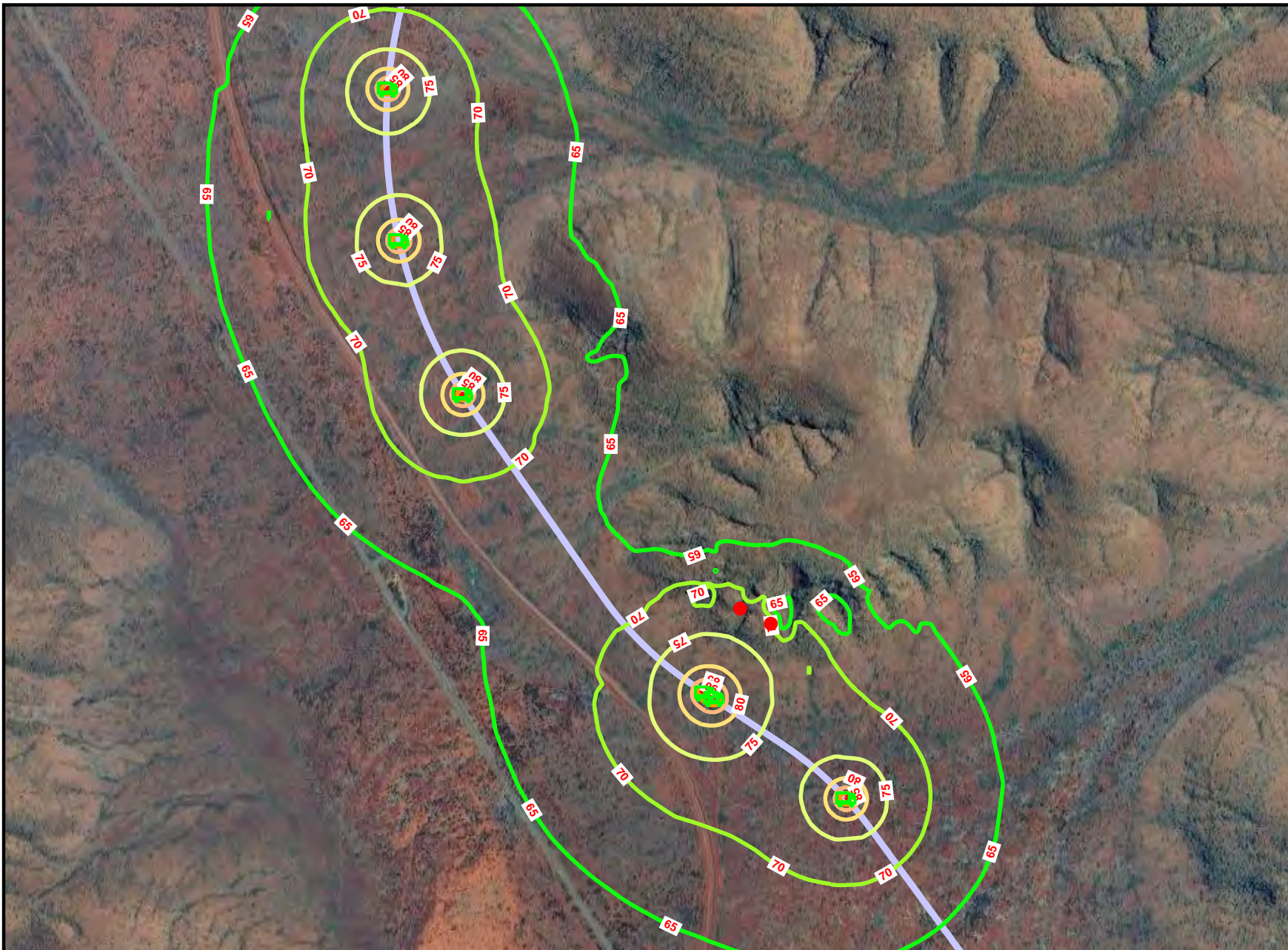





Figure 2 Predicted Noise from a Road Train Passing the Ghost Bat Habitat

The predicted maximum noise levels assuming a worst-case scenario of two road trains travelling past the Ghost Bat habitat at the same time, is presented in *Figure 3*.

Figure 3



Signs and symbols

-  Cave Location
-  Truck
-  Haul Road



Length Scale



Mineral Resources - Lamb Creek Iron Ore Mine
Predicted L_{Zmax} Noise Levels from Passing Road Trains
Wind from All Directions



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3. GROUND VIBRATION

The magnitude of any ground-borne vibration resulting from road trains operating on a road, is dependent upon the ground conditions between the source and the receiver. As this is unknown, we are unable to be predicted the vibration level with any accuracy. However, as the vibration energy transferred to the ground is very well attenuated by the road train's rubber tyres, it is our opinion that it would be extremely unlikely that any ground vibration would be perceivable at the Ghost Bat habitat.

4. FREIGHT TRAIN NOISE

Train consist on the Rio Tinto railway are reported as being 2400m long, powered by three banks of three locomotives and travelling at between 45 km/h and 75km/h.

Measurements undertaken by Lloyd George Acoustics of similar iron ore trains in the Pilbara region have been used to predict the likely noise from passing trains to the Ghost Bat habitat. A typical A-weighted pass-by noise level from a full iron train at 15m and 350m from the track is shown in *Figures 4 and 5* respectively.

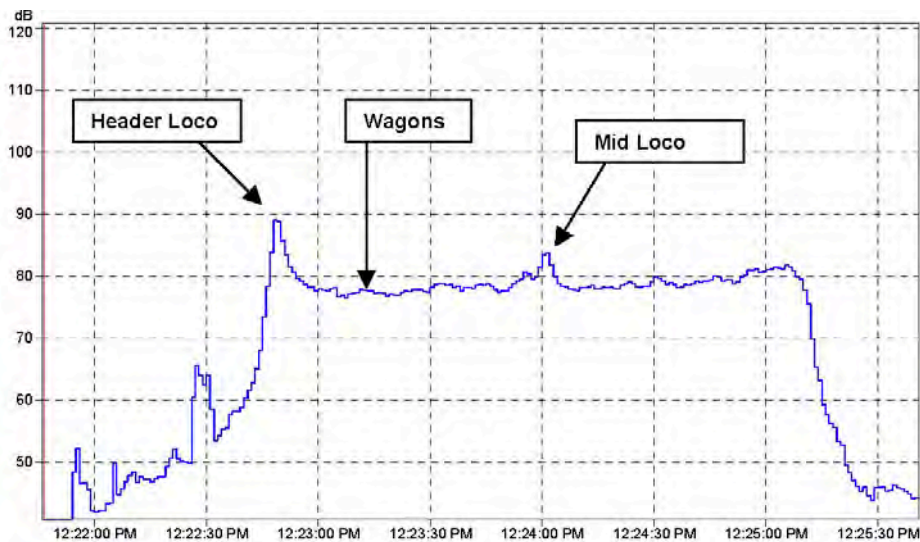


Figure 4 Measured Pass-by Noise Level of Iron Ore Train at 15m

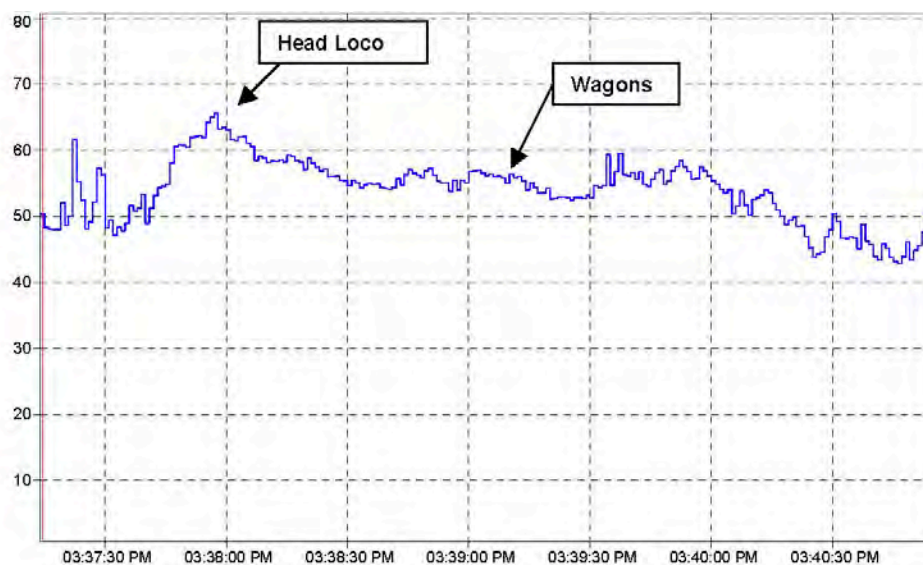


Figure 5 Measured Pass-by Noise Level of Iron Ore Train at 350m

To convert that above measurements to unweighted (Lz), a typical locomotive spectrum has been used, assuming a sound power level of 135 dBz. This is provided in *Table 2*.

Table 2 Sound Power Levels from Locomotive, dB

Description	Octave Band Centre Frequency (Hz)								Overall dB
	63	125	250	500	1k	2k	4k	8k	
Locomotive at Notch 8	131	127	123	123	120	120	122	120	135

It should be noted that the above sound power level, would result in a pass-by noise level of 103 dB(Z) or 96 dB(A) at 15m. From our in-house measurement data and other available literature, this is approximately 6 dB higher than the typical noise level at that distance.

Based on the above and using the noise modelling variables as for the road trains, the predicted noise level from a passing Rio Tinto iron ore train to the Ghost Bat habitat is shown in *Figure 6*.

For completeness, the scenario where two road trains and an iron ore train are passing the Ghost Bat habitat at the same time is shown in *Figure 7*. This scenario would add approximately 1 dB to the predicted noise levels assuming only the train is passing.

In summary, the predicted noise levels at the Ghost Bat habitat cave entrances, for each of the scenarios considered, are detailed in *Table 3*.

Table 3 Predicted Noise Levels to the Ghost Bat Habitat

Receiver	Coordinates	Predicted Noise Level dBz		
		Two Road Trains Passing	Iron Ore Train Passing	Road Train and Train Passing
Cave 1 (Main Cave)	-22.8697 , 118.7921	72	77	78
Cave 2	-22.8701 , 118.7930	70	74	75

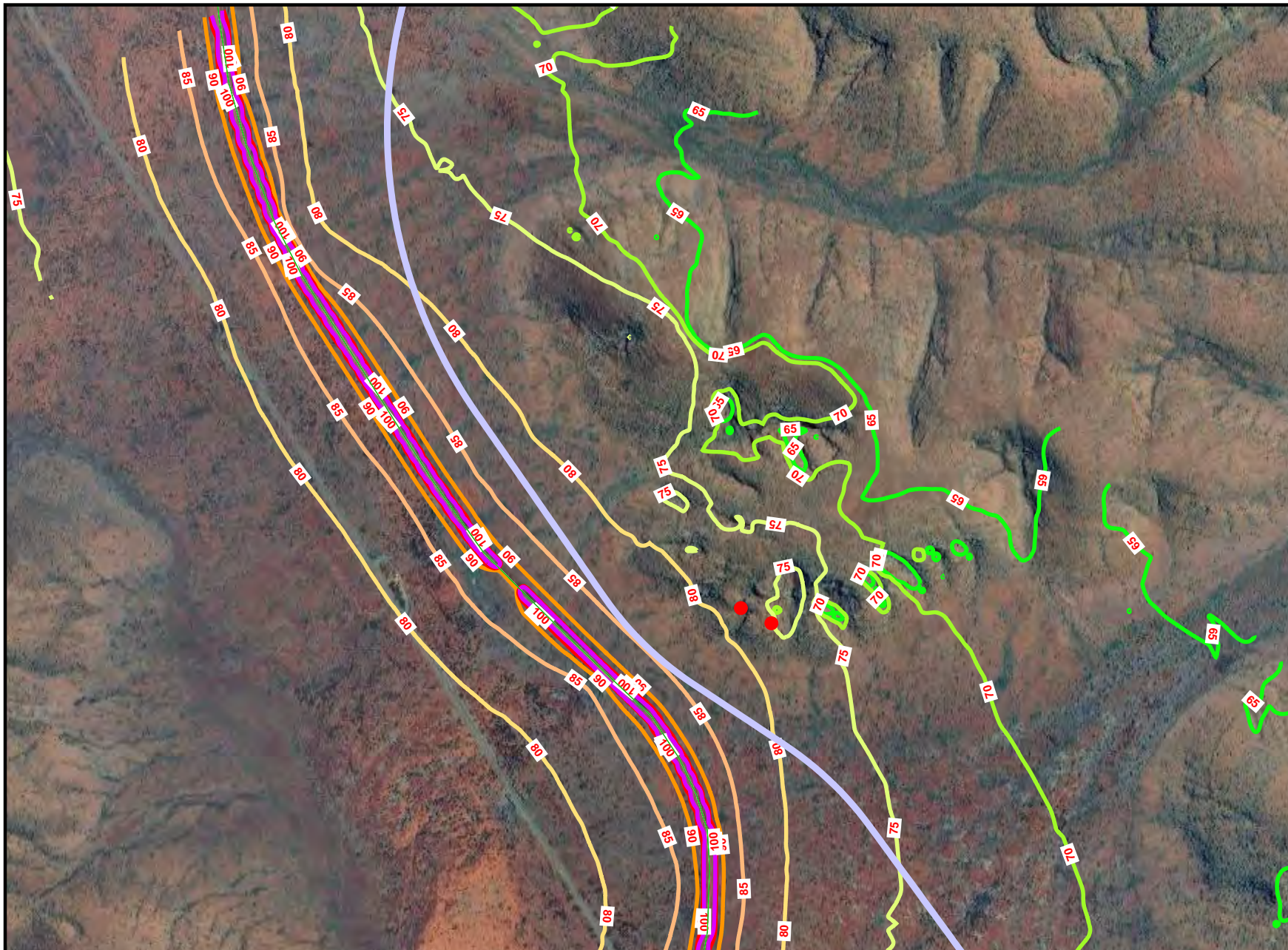
We trust the above is satisfactory. Should you require further information, please do not hesitate in contacting us.

Regards,



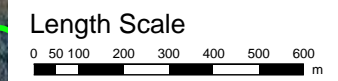
Daniel Lloyd

Figure 6



Signs and symbols

- Cave Location
- Haul Road
- Railway

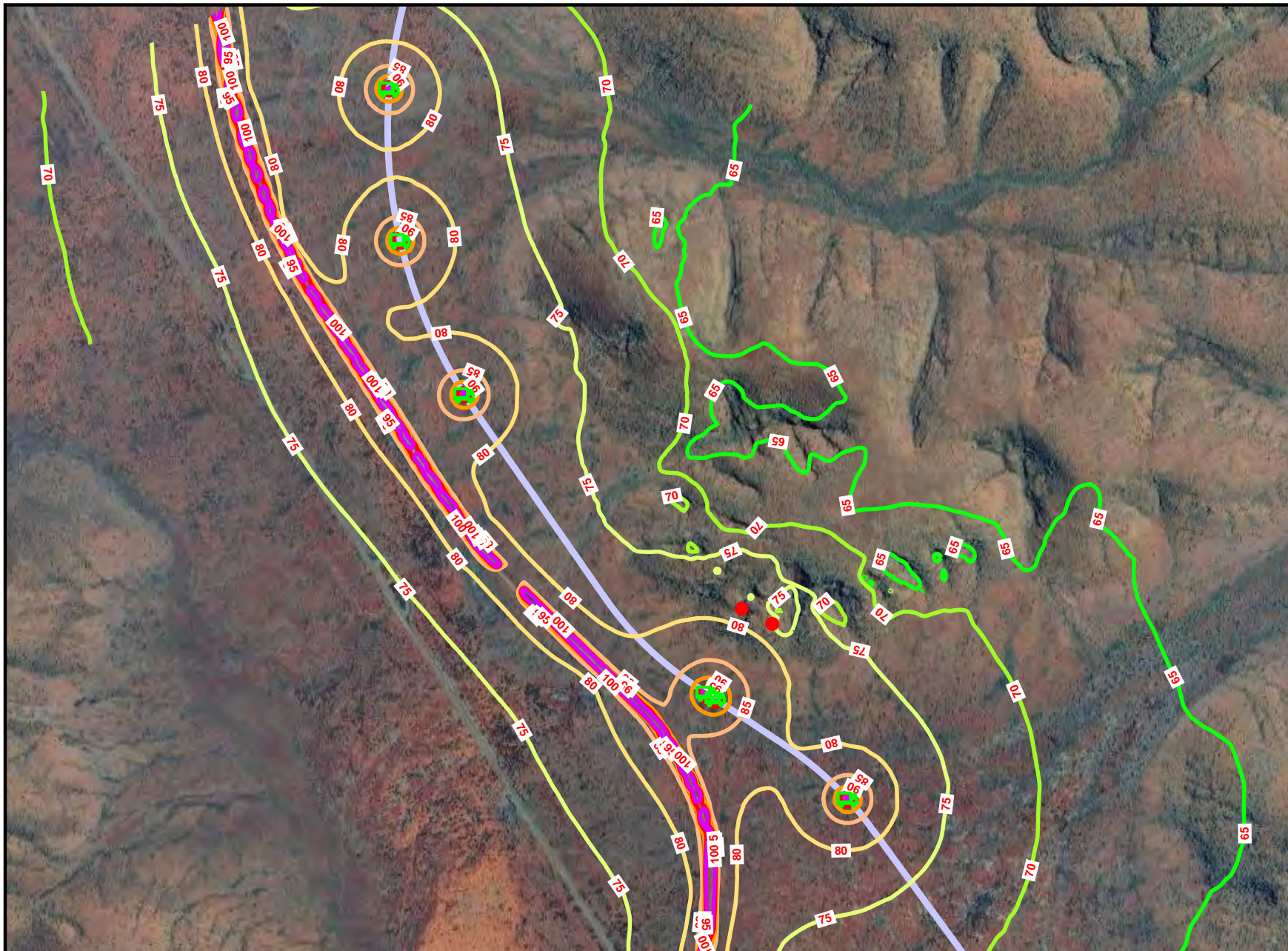


Mineral Resources - Lamb Creek Iron Ore Mine
Predicted L_{Zmax} Noise Levels from Passing Iron Ore Trains
Wind from All Directions



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Figure 7



Signs and symbols

- Cave Location
- 🚛 Truck
- Haul Road



Length Scale



Mineral Resources - Lamb Creek Iron Ore Mine
Predicted Combined L_{Zmax} Noise Levels from Passing Road Trains and Rio Tinto Train
Wind from All Directions



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Our Ref: TFA061-100M
Date: 4 May 2023

Mineral Resources Limited
20 Walters Drive
Osborne Park WA 6017

ATTENTION: MR HECTOR ROBLES (By email: hector.robles@mrl.com.au)

Dear Hector,

RE: LAMB CREEK GHOST CAVE REVIEW (CAVE 1) – BLASTING EFFECT

The MRL scope of work has sought to identify whether the structural integrity of naturally formed Caves (Cave 1) can be maintained when exposed to neighbouring blasting and peak particle velocities (PPV) of 25mm/s or less. Given a site visit and base-line capture of natural slope deterioration has not yet been approved, the specific blast vibration sensitivity and assessment has been requested via existing site photographs and ground conditions described within the 2021 geotechnical study - MP PER 20210830 MRL Lamb Creek Detailed Open Pit Geotechnical Study.

This memo summarises the empirical findings presented 21 April 2023 at the MRL offices.

Location

Lamb Creek Cave 1 is located in the Pilbara region of Western Australia, approximately 100km northwest of Newman. Cave coordinates 693571mE, 7476273mN, 830mRL locate this feature on the northern flank of the Weeli Wollie North Anticline, within the Ophthalmia Fold Belt and appear largely hosted within Joffre, Whaleback Shale and Dales Gorge geological Members. Figure 1 presents the regional setting, large scale faulting and 1st /2nd order folds with interpreted hinge lines.

Natural weathering and hard-capping processes have developed thick (20-80m) indurated horizons, known locally as canga/scanga. Cave 1 is hosted within the banded iron formation (BIF) canga units, potentially between contacts of meso-beds (up to 150mm) and macro-beds (up to 500mm) in thickness.

Figure 2 (photograph provided by MRL), displays the Cave 1 development in the centre of image, directly above the erosional scree surface.

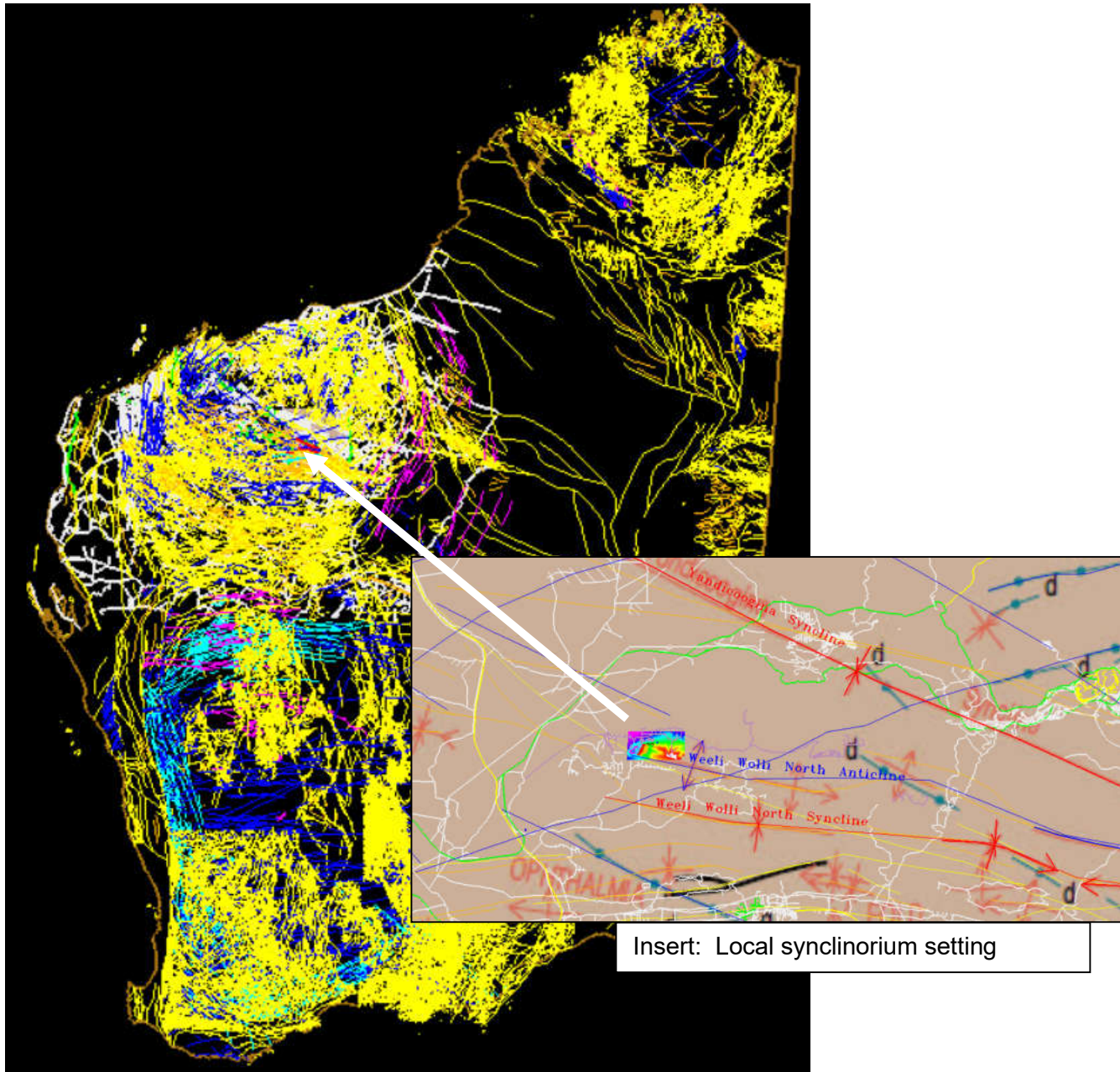


Figure 1: Regional location of Lamb Creek Cave 1

Condition

Despite a fully-developed hardcap profile in the area, there are structural defect sets that continue to control the topography and are likely to also control the shape and span of cave entrances in the Lamb Creek region.

Shallow near-surface defects were identified and described within MP PER 20210830 MRL Lamb Creek Detailed Open Pit Geotechnical Study. These can be ‘relatively’ confirmed via photo-interpretation of surrounding outcrop and Cave 1 entrance images. Figures 2, 3, 4 and 5 display structural observations/interpretations from these outcrop photographs, which appear to generally align with previous mapping records.



Figure 2: Cave setting within natural outcrop (looking east)

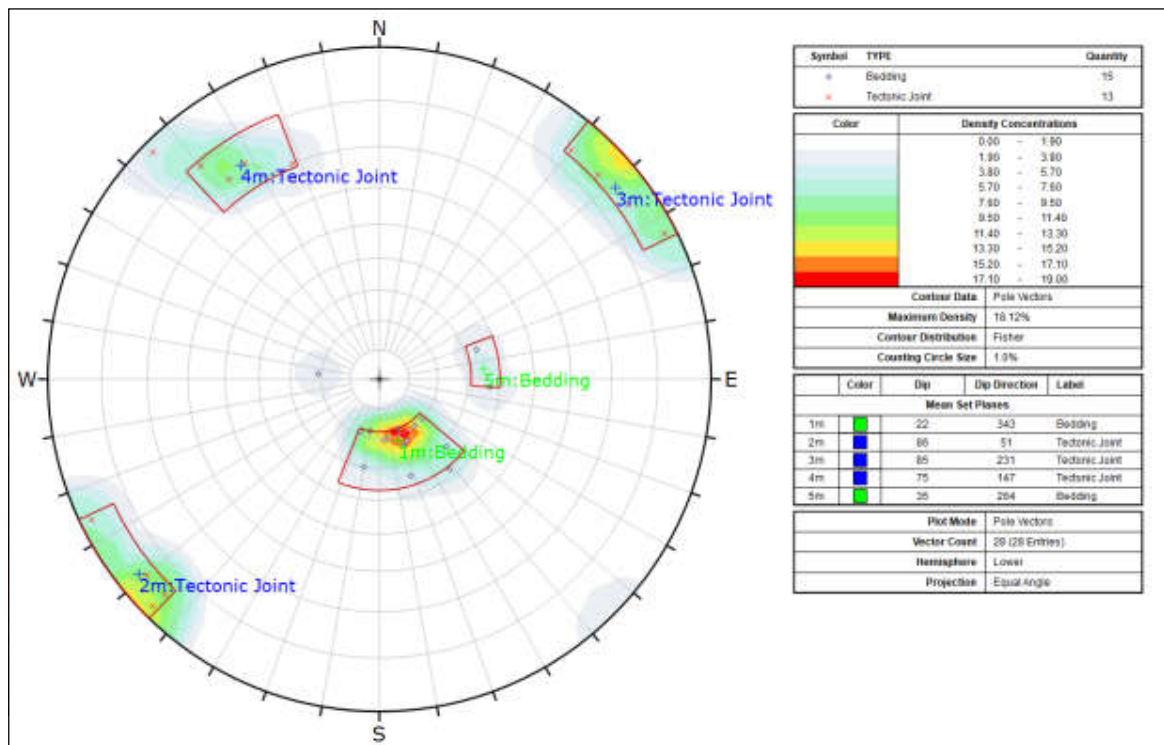


Figure 3: 2012 Site mapping
Detailed Open Pit Geotechnical Study

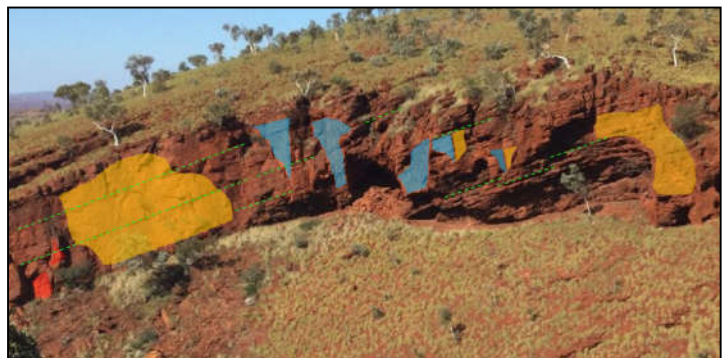


Figure 4: Visible structures



Figure 5: Cave 1 entrance; structural features visualised

Rockmass descriptions and condition ratings were also included in the 2021 MRL geotechnical report. In a generalised sense, the hard-capped banded iron formation and the moderate-high weathered rock, limonitic shale appear to make up the Cave 1 host material.

It is understood these rockmass descriptions have been derived exclusively from diamond drilling recovery at the Lamb Creek future operation (also known as the Boundary Project).

Geotechnical Domain	Unit Weight (kNm ³)	Weathering Classification	Hoek – Brown Rock Mass Parameters – Base Case			Hoek – Brown Rock Mass Parameters – Lower Case		
			Geological Strength Index range (GSI)	UCS Strength range (MPa)	m	Geological Strength Index (GSI)	Sensitivity Case UCS Strength (MPa)	m
Hard-capped Banded Iron Formation, mineralised, locally brecciated and / or mineralised, BIF (ore body)	33	Slightly	60 to 80 (Mean 75)	25 to 100 (Mean 50)	16	65	37.50	16
Moderately to highly weathered, mainly weak rock, un-mineralised BIF (with some localised breccia zones)	26	Moderately to highly	40 to 55 (Mean 53)	5 to 25 (Mean 15)	15	40	10	15
Highly weathered, extremely weak to very weak rock, partly mineralised, Shaley BIF	24	Highly	31 to 42 (Mean 39)	<1 to 5 (Mean 3)	12	31	2	12
Moderately weathered, weak rock, shale / limonitic shale	24	Moderately	35 to 59 (Mean 51)	5 to 10 (7.50)	6	35	5	6
Slightly weathered, very strong rock, BIF / chert / limonitic BIF	30	Slightly to fresh	60 to 75 (Mean 72)	100 to 200 (Mean 150)	15	60	100	15
Variably weathered (moderate to highly), variable strength (very weak to strong), Chert Breccia and BIF	28	Variably (moderate to highly)	50 to 65 (Mean 55)	25 to 100 (Mean 37.50)	15	50	25	15
Transported, weak rock, matrix-supported (red-brown partly to weakly / variably cemented), breccia conglomerate	25	Moderately / altered	40 to 50 (Mean 45)	5 to 25 (Mean 15)	8	40	5	8
Transported, medium strong rock, matrix-supported, hematite strongly cemented, breccia conglomerate (part desaturated)	31	Moderately / altered	45 to 65 (Mean 55)	25 to 50 (Mean 37.50)	8	45	25	8

Figure 6: Reported rockmass domains

Figure 7 presents a plan view of the proposed Lamb Creek open pit, complete with topographic overlay and projected distance measurement out to Cave 1. As highlighted, Cave 1 is located up to 750m away from future mining. This distance 'constant' is a repeated input within assessment calculations below.

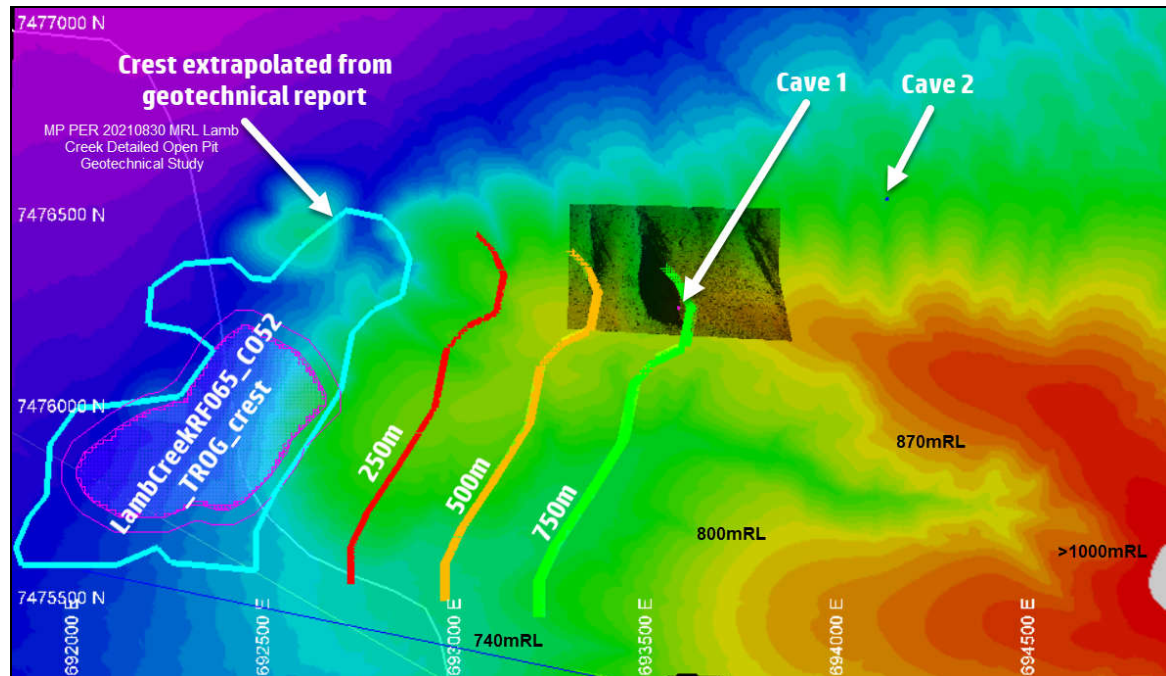


Figure 7: Plan view – relative distance of proposed open pit to Cave 1 location

It is understood there are no roosting bats “*no recent bat activity*” within the Cave 1 area - established from the monitoring period 13 September 2022 through to 18 October 2022 [Phoenix environmental science 2023 Draft (single page extract provided to TFA)]

No other features of note (natural or heritage) have been identified in or proximal to the cave and with that in mind, a 25mm/sec maximum PPV has been stipulated. As such, MRL are looking to maintain the current condition of Cave 1, that it could be used by roosting Ghost Bat colonies in the future.

Empirical Estimates

A useful first step in assessing potential blast sensitivity of a rock formation is to determine the maximum charge weight (CW) per delay. Although there is no site specific blast performance information available, the relative seismic sensitivity (RSS) of the host rock can be determined via GSI assessments (Mesec, 2005).

This is not a calibrated site-specific conversion however is a suitable first pass guide to confirm back analysis via other industry formulae.

(Mesec, 2005) $RSS = 28.8 e^{-0.054 GSI}$

[Relative Seismic Sensitivity]

Using reported upper and lower-end GSI estimates 60 and 32, the corresponding RSS (sensitivity) results 1.1 and 5.0 accordingly.

Charge weight to distance (CW:D) relationships are dependent on many site-based factors including local geology/structure, topography and blast geometry however guidance can be drawn from existing sedimentary literature (Mesec, 2018). Such literature indicates a Cave 1 distance at 750m may tolerate up to 5000kg of charge per delay.

Figure 8 presents an extrapolated plot ~ at 750m for the RSS 1.0 estimate.

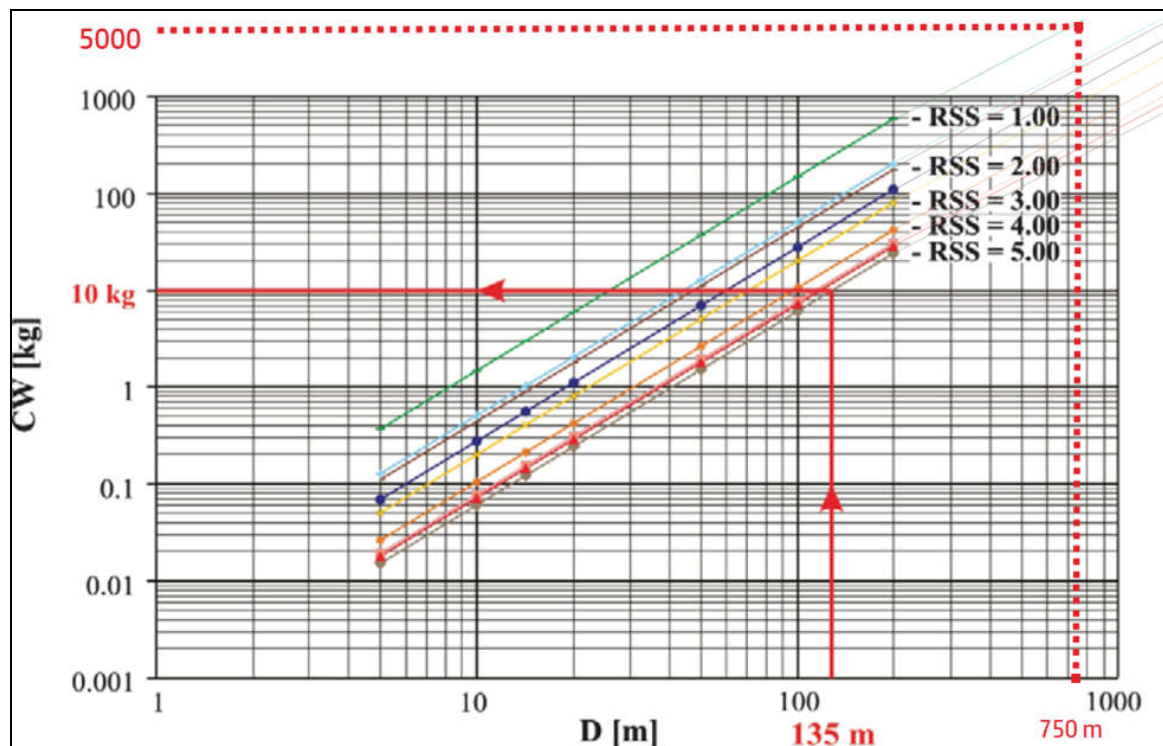


Figure 8: Indicative charge weight to distance plot – relative to RSS (GSI)

Closer to home, the Australian Standard AS2187.2 (2006) provides an equation to predict PPV (V), where:

$$V = K (R/Q^{1/2})^{-b}$$

- V = peak particle velocity (ppv) in mm/sec
- K & b = site constants (specific to attenuation character of the rock)
- R = range/distance to feature in meters
- Q = charge weight per delay in kg

The accurate prediction of ground vibration by calculation and extrapolation requires the use of site measurements to quantify possible site-based attenuation factors.

As stated within the Standard, where no data exists for a particular site project, a mean ppv may be calculated using $K = 1140$ and $b = -1.6$. This results in theoretical ppv values for planning purposes.

Pilbara-based variables have also been used $K = 800$ and $b = -1.6$ which are less conservative than generic values. These Pilbara constants may be more appropriate for the Lamb Creek Cave 1 project however site-based monitoring will ultimately be required to validate.

Table 1 below outlines the corresponding charge weight (Q) and distances (R), resulting in ppv values.

PPV		$V = K (R/Q^{1/2})^b$															
		1140													800		
		-1.6													-1.6		
AS2187.2 (2006)							Pilbara Standard										
(R) Distance meters	(Q) charge weight kilograms	(Q) charge weight	(Q) charge weight	(Q) charge weight	(Q) charge weight	MIS-FIRE UP TO 2t charge weight	(R) Distance meters	(Q) charge weight kilograms	(Q) charge weight	(Q) charge weight	(Q) charge weight	(Q) charge weight	MIS-FIRE UP TO 2t charge weight	(R) Distance meters	(Q) charge weight kilograms	(Q) charge weight	
250	100	200	500	1000			250	100	200	500	1000		250	100	200	500	
500	100	200					500	100	200				500	100	200		
750	100	200					750	100	200				750	100	200		
	(100kg)	(200kg)	(500kg)	(1000kg)				(100kg)	(200kg)	(500kg)	(1000kg)			(100kg)	(200kg)	(500kg)	(1000kg)
Distance (m)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)		Distance (m)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)		Distance (m)	PPV (mm/s)	PPV (mm/s)	PPV (mm/s)
25	263.1	458.2	953.6	1660.4	2890.8		25	184.7	321.5	669.2	1165.2	2028.7		25	184.7	321.5	669.2
50	86.8	151.1	314.6	547.7	953.6		50	60.9	106.1	220.8	384.4	669.2		50	60.9	106.1	220.8
75	45.4	79.0	164.4	286.3	498.5		75	31.8	55.4	115.4	200.9	349.8		75	31.8	55.4	115.4
100	28.6	49.9	103.8	180.7	314.6		100	20.1	35.0	72.8	126.8	220.8		100	20.1	35.0	72.8
125	20.0	34.9	72.6	126.4	220.1		125	14.1	24.5	51.0	88.7	154.5		125	14.1	24.5	51.0
150	15.0	26.1	54.2	94.4	164.4		150	10.5	18.3	38.1	66.3	115.4		150	10.5	18.3	38.1
175	11.7	20.4	42.4	73.8	128.5		175	8.2	14.3	29.7	51.8	90.2		175	8.2	14.3	29.7
200	9.4	16.4	34.2	59.6	103.8		200	6.6	11.5	24.0	41.8	72.8		200	6.6	11.5	24.0
250	6.6	11.5	24.0	41.7	72.6		250	4.6	8.1	16.8	29.3	51.0		250	4.6	8.1	16.8
275	5.7	9.9	20.6	35.8	62.3		275	4.0	6.9	14.4	25.1	43.8		275	4.0	6.9	14.4
300	4.9	8.6	17.9	31.2	54.2		300	3.5	6.0	12.6	21.9	38.1		300	3.5	6.0	12.6
325	4.3	7.6	15.7	27.4	47.7		325	3.0	5.3	11.0	19.2	33.5		325	3.0	5.3	11.0
350	3.9	6.7	14.0	24.3	42.4		350	2.7	4.7	9.8	17.1	29.7		350	2.7	4.7	9.8
375	3.5	6.0	12.5	21.8	38.0		375	2.4	4.2	8.8	15.3	26.6		375	2.4	4.2	8.8
400	3.1	5.4	11.3	19.7	34.2		400	2.2	3.8	7.9	13.8	24.0		400	2.2	3.8	7.9
425	2.8	4.9	10.2	17.8	31.1		425	2.0	3.5	7.2	12.5	21.8		425	2.0	3.5	7.2
450	2.6	4.5	9.4	16.3	28.4		450	1.8	3.2	6.6	11.4	19.9		450	1.8	3.2	6.6
475	2.4	4.1	8.6	14.9	26.0		475	1.7	2.9	6.0	10.5	18.2		475	1.7	2.9	6.0
500	2.2	3.8	7.9	13.8	24.0		500	1.5	2.7	5.5	9.7	16.8		500	1.5	2.7	5.5
525	2.0	3.5	7.3	12.7	22.2		525	1.4	2.5	5.1	8.9	15.5		525	1.4	2.5	5.1
550	1.9	3.3	6.8	11.8	20.6		550	1.3	2.3	4.8	8.3	14.4		550	1.3	2.3	4.8
575	1.7	3.0	6.3	11.0	19.2		575	1.2	2.1	4.4	7.7	13.4		575	1.2	2.1	4.4
600	1.6	2.8	5.9	10.3	17.9		600	1.1	2.0	4.1	7.2	12.6		600	1.1	2.0	4.1
625	1.5	2.7	5.5	9.6	16.8		625	1.1	1.9	3.9	6.8	11.8		625	1.1	1.9	3.9
650	1.4	2.5	5.2	9.0	15.7		650	1.0	1.8	3.6	6.3	11.0		650	1.0	1.8	3.6
675	1.3	2.3	4.9	8.5	14.8		675	0.9	1.6	3.4	6.0	10.4		675	0.9	1.6	3.4
700	1.3	2.2	4.6	8.0	14.0		700	0.9	1.6	3.2	5.6	9.8		700	0.9	1.6	3.2
725	1.2	2.1	4.4	7.6	13.2		725	0.8	1.5	3.1	5.3	9.3		725	0.8	1.5	3.1
750	1.1	2.0	4.1	7.2	12.5		750	0.8	1.4	2.9	5.0	8.8		750	0.8	1.4	2.9

What this essentially indicates is @ 750m, a nominal 200kg per delay charge would result in 2.0mm/sec vibration. A potential mis-fire, with up to 10 holes initiating at once, resulting in a maximum instantaneous charge of 2000kg, would result in a breach @ 500m (>25mm/sec) however **would not breach @ 750m** where only half the stipulated 25mm/sec maximum would be reached ~ 12.5mm/sec.

For interest sake, the Australian Standard constants would need to include a mis-fire approaching 5000kg, resulting in 26.1mm/sec @ 750m, as extrapolated within Table 2 below.

		Instantaneous Charge Weight														
		3000					4000		5000							
750	1.1	2.0	4.1	7.2	12.5	17.3	21.8	26.1	750	0.8	1.4	2.9	5.0	8.8		



Two graphical outcomes have resulted from the empirical calculations. Figure 9 presents Australian Standard AS2187.2 and less conservative Pilbara Standard results.

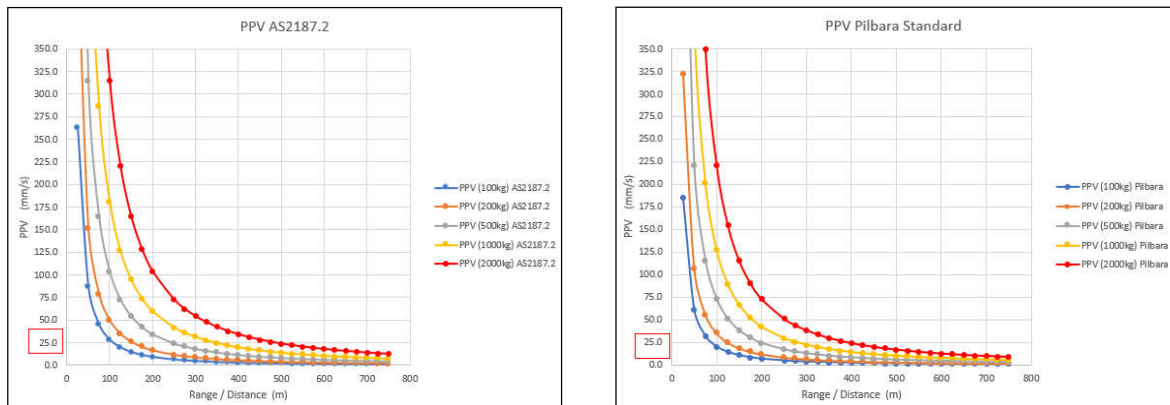


Figure 9: Equation derived PPV to Distance curves

As a matter of reference, this same 5000kg mis-fire charge weight was supported by the original seismic sensitivity ratio (SSR), based on distance/range and rockmass/GSI.

Airblast Overpressure

Given the varied topographical shape of the surrounding area, airblast overpressure may not be a controlling issue. Coupled with the fact that there are “no signs of recent use by Ghost Bats”, the cave itself may not be sensitive to sound disturbance.

Two cross sections from the proposed open pit to Cave 1 were assessed for potential acoustic travel. Figures 10 and 11 indicate any overpressure beyond 500m will likely pass overtop Cave 1.

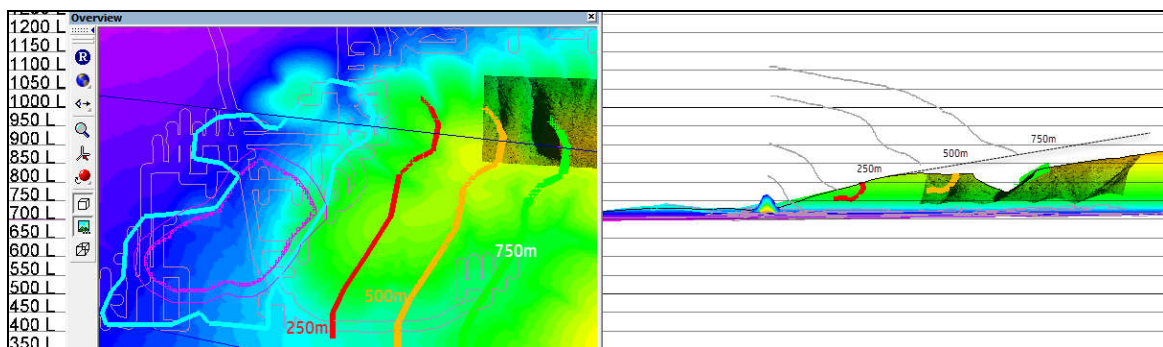


Figure 10: Plan and cross section view – Cave 1 at 750m

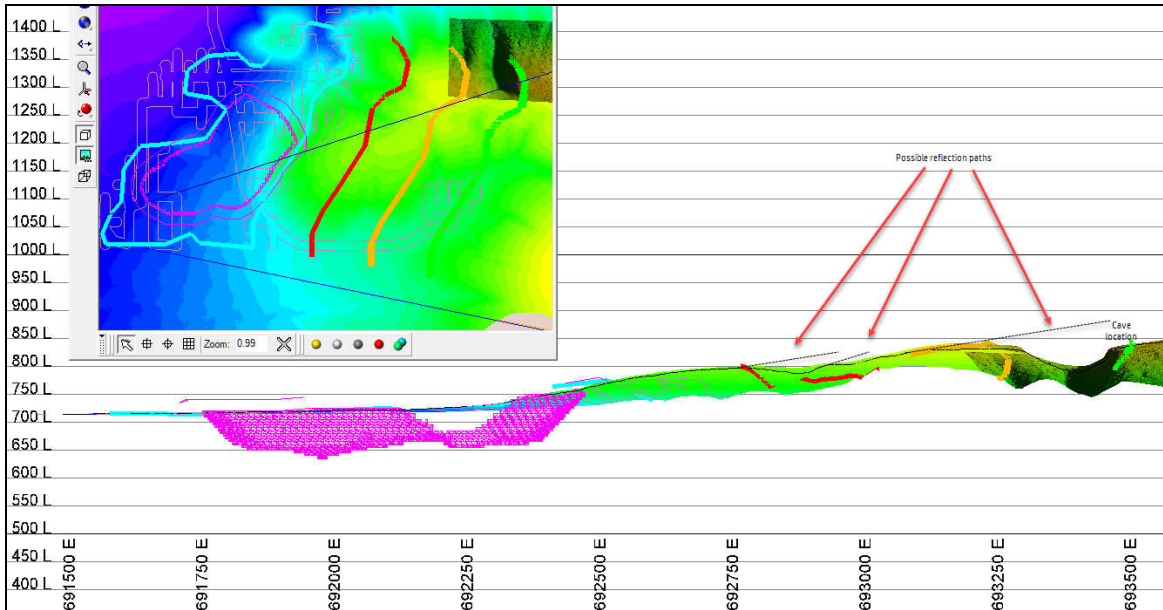


Figure 11: Plan and cross section view (2) – Cave 1 at 750m

The calculation for decibel/airblast pressure does not adequately account for topographical protection likely to be felt at the Cave 1 location. With this in mind, the academic calculations suggest @ 750m a decibel result of 111dB, 114dB, 117dB, 122dB and 125dB for 100kg, 200kg, 500kg, 2000kg and 5000kg charge weight per delay (Q) respectively.

Table 3 below, outlines the calculation process and results.

		kg		m										
		2000	5000	100	500									
		5000	750	750	19801									
Where:		$P = C (R/Q)^{1/3} \gamma^{-1.2}$												
P	pressure (kPa)													
C	constant (determined mainly by atmospheric conditions)	fully confined blasthole charges in average atmospheric conditions 3.3												
R	range distance to feature (m)	unconfined blasthole charges 185												
Q	charge mass per delay													
		confined blasthole charges				unconfined blasthole charges								
		Charge (kg)	2000	5000	2000	5000	2000	5000	2000	5000				
		Range (m)	100	100	500	500	750	750	1500	19801				
		P (kPa)	0.27474	0.39637	0.039825564	0.05746	0.02448	0.03532	15.4022	22.2208	2.23265	3.22104	1.37249	1.9801
$dB = 20 \log_{10}(P/2.0265 \times 10^{-8})$														
		Confined		C				Unconfined						
		100m	500m	750m	Charge (kg)	2000	5000	2000	5000	2000	5000	2000	5000	
					Charge (kg)	2000	5000	2000	5000	2000	5000	2000	5000	
					Range (m)	100	500	750	100	500	750	100	500	
					P (kPa)	0.157798162	0.02287	0.01406	0.10938	0.01585	0.00974658	0.08289	0.01202	
100kg		132.235	115.46	111										
200kg		134.644	117.868	114										
500kg		75.3378	66.9501	64.837										
2000kg		117.959	117.959	117										
5000kg		137.827	121.052	117										
100kg	dB	79.3378	70.9501	68.837										
200kg	dB	142.644	125.868	122										
500kg	dB	80.9295	72.5419	70.4288										
		145.827	129.052	125										

Acoustic monitoring at the 750m scale will be necessary to confirm the dampening effects of the Lamb Creek topography.

Fly Rock

With blasts patterns correctly designed, stemmed and fired up to 750m away, fly rock is not expected to exceed the site based Blast Exclusion Zone (BEZ).

Fume and Dust Mitigation

Given the prediction of post blast dust and fume is an imprecise process it is recommended that shots are fired when the prevailing winds are blowing away from sensitive areas.

Next Steps

A distance of 750m appears to preclude ground vibrations exceeding 25mm/sec.

In order to confirm site-specific ground attenuation characteristics, blast vibration monitoring is required at varying distances from future blasts.

It is recommended that a geotechnical site visit be completed to capture actual cave deterioration conditions and assess areas for future vibration monitoring. This visit will also allow actual rockmass (GSI) assessment of the cave and overlying material.

The AS2187.2 equation can be reapplied once Lamb Creek ground inputs are available.

We trust this letter meets your requirements at this time. Please do not hesitate to contact the undersigned with any queries you may have.

For and on behalf of
TERRA FIRMA AUSTRALIA



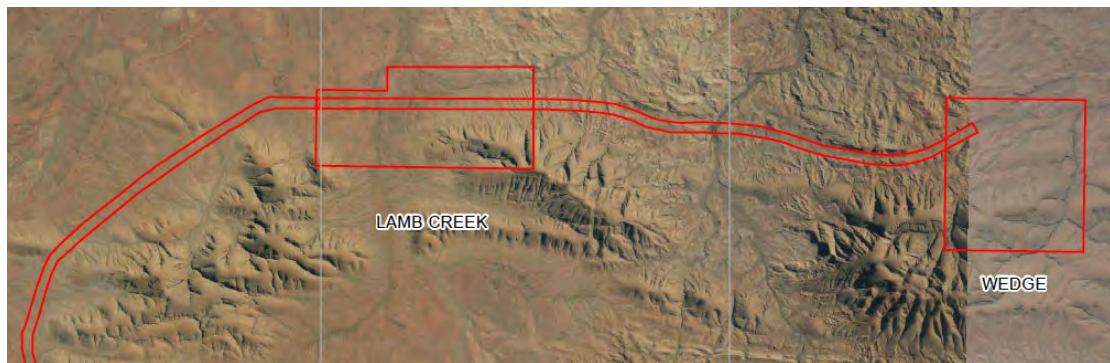
ADRIAN TROY

Mesec, J. (2005): Dependence of ground vibrations on engineering geological rock mass properties caused by blasting in sediment rock deposits, Doctoral dissertations, University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Zagreb.

Mesec, J.; Težak, D.; Jug, J. (2018): Reducing the adverse effects of blasting on the cave ecosystem near the future exploitation field Gradusa; The Mining-Geology-Petroleum Engineering Bulletin, 2018, pp. 45-54.

Lamb Creek and Wedge Project:

Vertebrate Fauna Desktop Assessment March 2020



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March 2020

Executive Summary

Introduction

Mineral Resources Limited (MRL) is proposing mineral exploration in the Lamb Creek and Wedge Study Area. Western Wildlife was commissioned by MRL to undertake a vertebrate fauna desktop assessment and use it to inform a risk assessment of the likelihood of the proposed exploration having an impact on the fauna of the Study Area. This report includes the results of the desktop fauna review and risk assessment as prepared in February – March 2020.

Methods

The desktop assessment was undertaken in accordance with the *Statement of environmental principles, factors and objectives* (Environmental Protection Authority (EPA) 2016a), *Environmental factor guideline – terrestrial fauna* (EPA 2016b), *Technical guidance – terrestrial fauna surveys* (EPA 2016c), the *Technical Guide: terrestrial vertebrate fauna surveys for environmental impact assessment* (EPA and DEC 2010) and relevant State and Federal Guidelines on conservation significant fauna.

No field survey was undertaken as part of this desktop assessment, but the Lamb Creek portion of the Study Area was subject to a single season Level 2 fauna survey in 2012 (Rapallo 2012).

The literature review involved collating fauna records collected during the 2012 fauna survey, results of previous fauna surveys within 35km of the Study Area, records on databases and in the general literature. Lists of all terrestrial vertebrate fauna potentially occurring in the Study Area were prepared and species of conservation significance identified.

Species of conservation significance were classified as: **Threatened** if listed as Extinct in the Wild, Critically Endangered, Endangered or Vulnerable under *The Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and/or *Biodiversity Conservation Act 2016* (BC Act); **Migratory** if listed as Migratory under the EPBC Act and/or BC Act, excluding those species also listed as threatened; **Specially Protected** if listed as Other Specially Protected Species or Conservation Dependent Fauna under the BC Act; **Priority** if listed as Priority by DBCA and **Locally Significant** if considered by the author to potentially be of local significance.

Once the faunal assemblage and conservation significant fauna were identified, a risk assessment was undertaken by identifying the potential impacts that could reasonably be expected to be associated with mineral exploration and assessing the risk of loss of individuals or population decline in the local area as low, moderate or high. Management actions to ameliorate the risk were compiled for each conservation significant species.

Results and Discussion

Fauna Habitats

At least six fauna habitats occur in the Study Area, but 54% of the Study Area is currently unmapped:

- Rocky Ridge and Gorge
- Rocky Hills and Plateaus
- Stony Plains
- Alluvial Plains
- Mulga Plains
- Drainage Line

Habitats of importance within the Study Area are the Rocky Ridge and Gorge (as it supports Threatened fauna and is limited in extent) and Drainage Lines (as they support diverse faunal assemblages, and may act as corridors for movement).

Faunal Assemblage

The faunal assemblage of the Study Area is likely to be diverse, particularly in reptiles. Although many of the species that occur are widely distributed through arid Australia, there is also a suite of species endemic to the rocky uplands of the Pilbara Bioregion. The predicted faunal assemblage includes up to nine frogs, 112 reptiles, 130 birds, 36 native mammals and nine introduced mammals. The 2012 fauna survey over the Lamb Creek portion of the Study Area resulted in an observed assemblage thus far of two frogs, 58 reptiles, 76 birds, 20 native mammals and two introduced mammals. Twenty conservation significant fauna have been recorded or potentially occur in the Study Area:

Threatened species

Seven threatened species potentially occur in the Study Area, of which three were recorded at Lamb Creek in 2012:

- Pilbara Olive Python (*Liasis olivaceous barroni*) - EPBC Act (Vulnerable), BC Act (Vulnerable) - **Recorded**
- Grey Falcon (*Falco hypoleucos*) - BC Act (Vulnerable)
- Night Parrot (*Pezoporus occidentalis*) - EPBC Act (Endangered), BC Act (Critically Endangered)
- Northern Quoll (*Dasyurus hallucatus*) - EPBC Act (Endangered), BC Act (Endangered) – **Recorded**
- Bilby (*Macrotis lagotis*) - EPBC Act (Vulnerable), BC Act (Vulnerable)
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) - EPBC Act (Vulnerable), BC Act (Vulnerable)
- Ghost Bat (*Macroderma gigas*) - EPBC Act (Vulnerable), BC Act (Vulnerable) – **Recorded**

The Pilbara Olive Python, Northern Quoll and Ghost Bat are all known to occur in or near the Study Area and the Pilbara Leaf-nosed Bat is likely to occur. The Study Area is likely to provide critical habitat to one or more of these species. These species are all reliant on the Rocky Ridge and Gorge habitat, with the bats requiring caves for roosting and breeding. It is currently unknown whether important caves are present. The Drainage Line habitat may also provide important habitat, particularly where waterholes are present in rocky areas, as sites for foraging pythons or bats.

Migratory species

Four Migratory species potentially occur in the Study Area:

- Oriental Plover (*Charadrius veredus*)
- Common Sandpiper (*Tringa hypoleucos*)
- Common Greenshank (*Tringa nebularia*)
- Fork-tailed Swift (*Apus pacificus*) – **Recorded**

The Study Area does not provide important habitat for migratory species, however, a few individuals may occur at times.

Specially Protected species

A single Specially Protected species potentially occurs in the Study Area:

- Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon potentially occurs as a breeding species or a foraging visitor. Although the Study Area provides habitat for this species, its population is large and secure.

Priority species

Eight Priority species potentially occur in the Study Area, of which one was recorded at Lamb Creek in 2012:

- Spotted Ctenotus (northeast) (*Ctenotus uber johnstonei*) – Priority 2
- Unpatterned Robust Slider (*Lerista macropisthopus remota*) – Priority 2
- Gane's Blind Snake (*Anilius ganei*) – Priority 1
- Pilbara Barking Gecko (*Underwoodisaurus seorsus*) – Priority 2
- Brush-tailed Mulgara (*Dasyercus blythi*) – Priority 4
- Long-tailed Dunnart (*Sminthopsis longicaudata*) – Priority 4
- Lakeland Downs Mouse (*Leggadina lakedownensis*) – Priority 4
- Western Pebble-mound Mouse (*Pseudomys chapmani*) – Priority 4 - **Recorded**

All four reptiles listed above are considered data deficient and are known from relatively few records across the Pilbara, consequently, it is difficult to determine their likely status in the Study Area. However, Gane's Blind Snake and the Pilbara Barking Gecko are known from several records in the surrounding area and are considered likely to occur in the Rocky Ridge and Gorge habitat.

Western Pebble-mound Mouse known from the Study Area and considered likely to be relatively common in suitable stony habitats both within Study Area and in the surrounding region. The Long-tailed Dunnart is moderately likely to occur in the Rocky Ridge and Gorge habitat and the Lakeland Downs Mouse is moderately likely to occur on the Alluvial Plains or Drainage Lines. The Brush-tailed Mulgara may occur on the Alluvial Plains, but the likelihood is low.

Potential Impacts

Potential impacts of the proposed mineral exploration on terrestrial fauna include, habitat loss, direct mortality, road mortalities, habitat degradation (e.g. through the spread of weeds, dust or altered fire regimes), increase in feral fauna and habitat disturbance (e.g. light, noise, vibration or human disturbance).

Risk Assessment

The risk of an impact causing the loss or long-term decline of a fauna population is 'low' for the majority of conservation significant fauna species.

The risk of an impact on the local populations of the Long-tailed Dunnart, Gane's Blind Snake and Pilbara Barking Gecko is considered to be 'moderate'. These are all Priority species and are also reliant on the Rocky Ridge and Gorge habitat.

The risk of an impact on the local populations of the Northern Quoll, Pilbara Olive Python, Ghost Bat and Pilbara Leaf-nosed Bat is considered to be 'high'. These species are all Threatened species listed as Matters of National Environmental Significance (MNES) under the EPBC Act, and are reliant on the Rocky Ridge and Gorge habitat.

Implementing the recommended management actions, particularly in regard to avoiding Rocky Ridge and Gorge habitat and Drainage Line habitats, is likely to result in a low residual risk for all species. However, if the management recommendations cannot be fully implemented, particularly where there is loss or disturbance of Rocky Ridge and Gorge habitat and Drainage Line habitats, a risk of an impact will remain.

Management Recommendations

The management actions focus reducing the impact on the terrestrial fauna assemblage and conservation significant fauna by protecting of important fauna habitats, avoiding direct mortality of fauna and minimising indirect impacts. It is recognised that some of these strategies are already in common use in the mining and resource sectors.

Implementing the recommended management actions, particularly in regard to avoiding Rocky Ridge and Gorge habitat and Drainage Line habitats, is likely to result in a low residual risk for all species. However, if the management recommendations cannot be fully implemented, particularly where there is loss or disturbance of Rocky Ridge and Gorge habitat and Drainage Line habitats, a risk of an impact will remain.

Table of Contents

Executive Summary	i
1. Introduction	7
1.1 Regional Context	7
1.2 Study Area	9
1.2.1 Current Study Area.....	9
1.2.2 Extent of Previous Fauna Survey	9
1.3 Climate and Weather	9
2. Methods	13
2.1 Overview	13
2.2 Guidance Documents	13
2.3 Personnel	13
2.4 Taxonomy and Nomenclature	13
2.5 Literature Review	14
2.5.1 Previous Fauna Surveys in the Region.....	14
2.5.2 Fauna Records on Databases and the General Literature.....	16
2.6 Habitat Mapping	17
2.7 Assessment of Conservation Significance	17
2.7.1 Legislative Protection for Fauna.....	17
2.7.2 Levels of Conservation Significance in this report.....	19
2.8 Likelihood of Occurrence	20
3. Survey Limitations	21
4. Fauna Habitats of the Study Area	22
5. Faunal Assemblage of the Study Area	25
5.1 Amphibians	28
5.1.1 Amphibians of Conservation Significance	28
5.2. Reptiles	28
5.2.1 Reptiles of Conservation Significance	28
5.3 Birds	30
5.3.1 Birds of Conservation Significance	30
5.4 Mammals	34
5.4.1 Mammals of Conservation Significance	34
6. Discussion	41
6.1 Faunal Assemblage	41
6.2 Conservation Significant Fauna	41
6.3 Important Habitats	45
7. Risk Assessment	46
7.1 Adequacy of Available Data	46
7.2 Approach	46
7.3 Potential Impacts on Vertebrate Fauna	47
7.4 Management Actions	48
7.5 Conclusions	50
8. References	58

Appendices. 62
Appendix 1. Amphibians potentially occurring in the Study Area. 62
Appendix 2. Reptiles potentially occurring in the Study Area..... 63
Appendix 3. Birds potentially occurring in the Study Area. 67
Appendix 4. Mammals potentially occurring in the Study Area..... 73
Appendix 5. EPBC Protected Matters Search Tool results. 75

Tables and Figures

Table 1. Fauna survey reports used in the preparation of this report. 14
Table 2. Databases used in the preparation of this report..... 17
Table 3. Fauna assessment limitations..... 21
Table 4. Fauna habitats in the Study Area..... 23
Table 5. Summary of vertebrate fauna potentially occurring in the Study Area..... 25
Table 6. Summary of Potentially Occurring Conservation Significant Fauna. 42
Table 7. Risk Assessment..... 51

Figure 1. Lamb Creek and Wedge Project – regional location..... 8
Figure 2. Lamb Creek and Wedge Project – study area..... 10
Figure 3. Lamb Creek and Wedge Project – extent of 2012 fauna survey. 11
Figure 4. Monthly Climate Statistics for Newman Airport (Bureau of Meteorology 2020).... 12
Figure 5. Lamb Creek and Wedge Project - fauna habitats. 24
Figure 6. Lamb Creek and Wedge Project - conservation significant fauna recorded in 2012.
..... 26
Figure 7. Lamb Creek and Wedge Project - DBCA Threatened and Priority Fauna Database
reptile records..... 27
Figure 8. Lamb Creek and Wedge Project - DBCA Threatened and Priority Fauna Database bird
records. 31
Figure 9. Lamb Creek and Wedge Project - DBCA Threatened and Priority Fauna Database
mammal records. 35
Figure 10. Lamb Creek and Wedge Project - Northern Quoll records and habitat. 37

1. Introduction

Mineral Resources Limited (MRL) is proposing mineral exploration in the Lamb Creek and Wedge Study Area. Western Wildlife was commissioned by MRL to undertake a vertebrate fauna desktop assessment and use it to inform a risk assessment of the likelihood of the proposed exploration having a significant impact on fauna of the Study Area. The key objectives of the desktop fauna review and risk assessment were to:

- Collate existing fauna data in and around the Study Area.
- Map Northern Quoll (*Dasyurus hallucatus*) shelter habitat (Rocky Ridge and Gorge habitat) across the Study Area.
- List the vertebrate fauna that were recorded in and/or have the potential to occur in the Study Area.
- Identify species of conservation significance, or habitats of particular importance for fauna, that have the potential to occur in the Study Area.
- Identify the potential impacts of mineral exploration on fauna and fauna habitats in the Study Area.
- Conduct a risk assessment to determine the likelihood of an impact on faunal assemblages and/or fauna of conservation significance
- Recommend management actions to reduce the risk of a significant impact on fauna and fauna habitats.

This report includes the results of the desktop fauna review and risk assessment as prepared in February – March 2020.

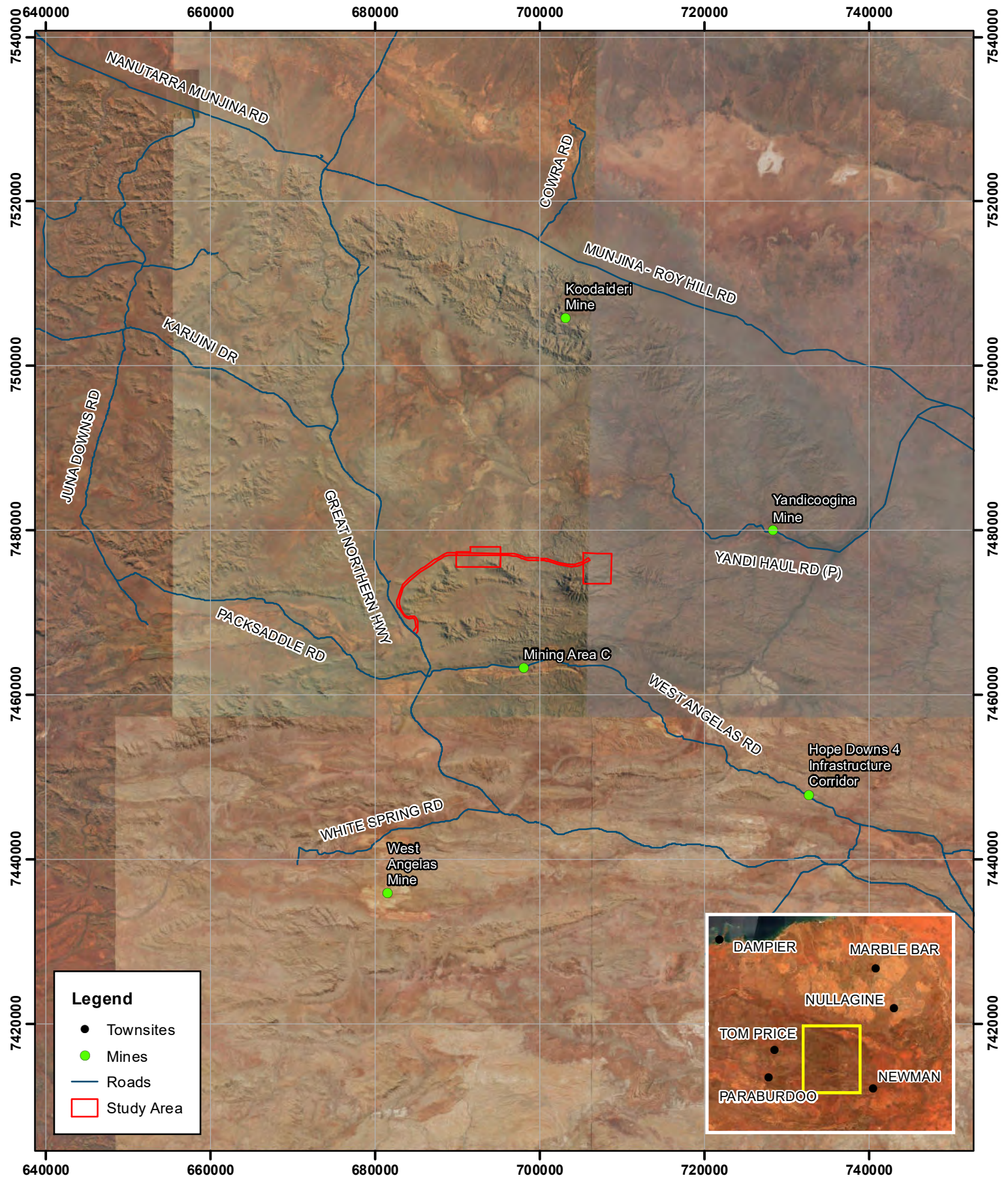
1.1 Regional Context



The Lamb Creek and Wedge Study Area is located 130km north of Newman in the Pilbara region of Western Australia (Figure 1).

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies Australia's landscapes into 89 Bioregions based on common climate, geology, landform, native vegetation and species information. These Bioregions are further subdivided into 419 subregions. The Study Area is situated in the Hamersley subregion of the Pilbara Bioregion (DEWHA 2004). It is described by Kendrick (2001) as comprising:

- Ranges and plateaus dissected with deep gorges, supporting Snappy Gum (*Eucalyptus leucophloia*) over Spinifex (*Triodia brizoides*) on skeletal soils.
- Valleys with fine-textured soils, supporting low Mulga woodlands over bunch grasses.

Refugia for vertebrate fauna in this subregion include the deep gorges of the Hamersley Range, where there is permanent water, humid conditions and protection from fire, as well as permanent springs (e.g. Weeli Wolli and Palm Spring) (Kendrick 2001).



Lamb Creek and Wedge Project Regional Location	Author: Jenny Wilcox	 Figure 1
	WEC Ref: MRL20-09-02	
 WESTERN WILDLIFE <small>This map should only be used in conjunction with WEC report MRL20-09-02.</small>	Filename: MRL20-09-02-f01.mxd	
	Scale: 1:600,000 (A4)	
	Projection: GDA 1994 MGA Zone 50	
	Revision: A - 10 March 2020	

1.2 Study Area

1.2.1 Current Study Area

The Study Area covered by this report is shown in Figure 2. It is about 3,110 ha and is comprised of two main areas; Lamb Creek in the west and Wedge in the east.

1.2.2 Extent of Previous Fauna Survey

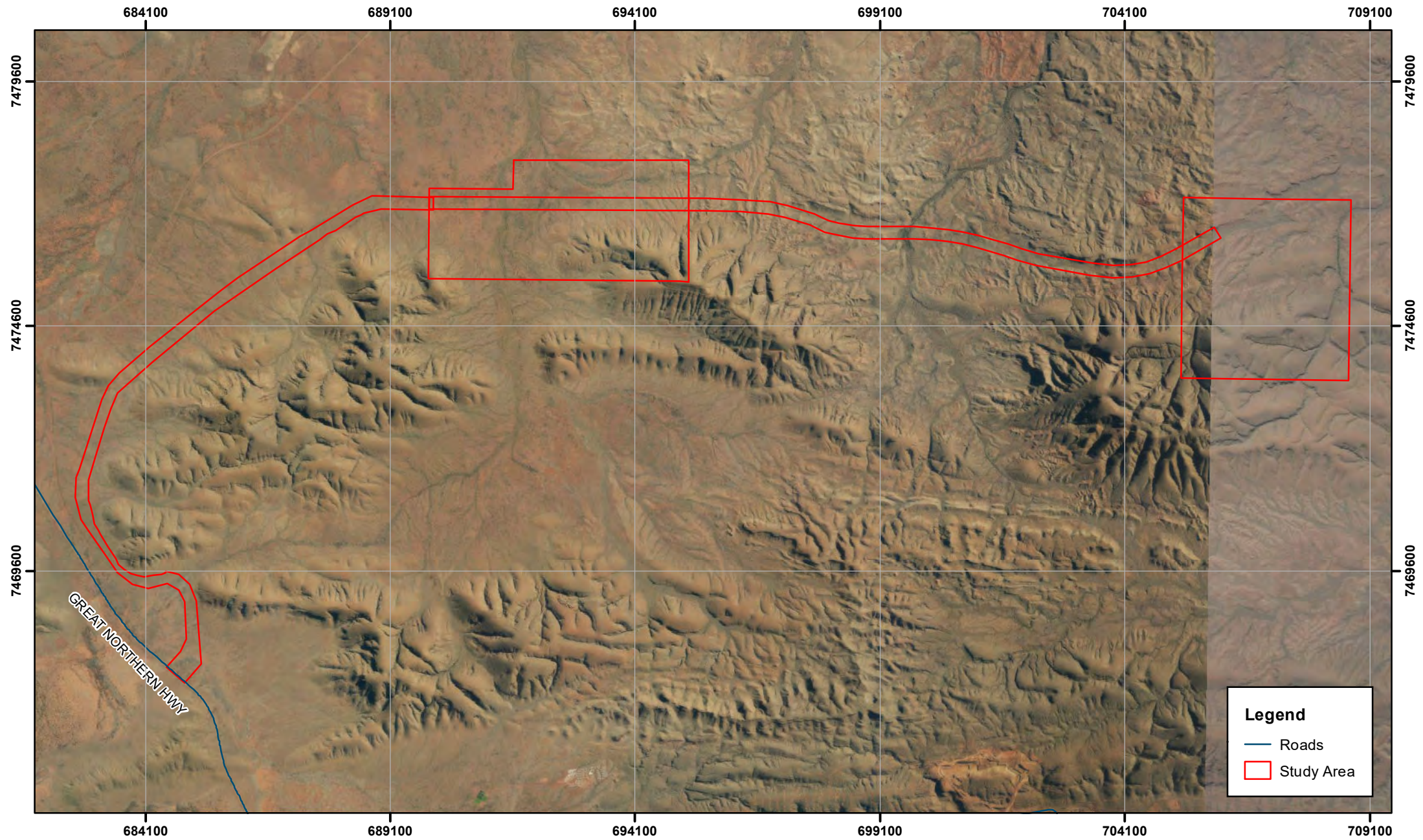
The Lamb Creek portion of the Study Area was surveyed with a single season Level 2 fauna survey and targeted Northern Quoll (*Dasyurus hallucatus*) survey in March/April 2012. The survey area and sampling site locations, where available, are shown in Figure 3. The vertebrate fauna component of the survey included:

- Trapping for ground-dwelling fauna (reptiles and small mammals) at ten sites, each with 12 pitfall traps (six buckets and six PVC pipes), ten funnel traps and 20 Elliott traps.
- Targeted cage trapping for Northern Quoll at six sites, each with 10 cage traps open for five nights.
- Camera trapping with baited camera traps at ten sites for two weeks and seven sites for six days.
- Bird surveys at trapping sites and opportunistic observations of birds.
- Bat survey using bat detectors at six sites and harp traps.
- Spotlighting by four people for 30 minutes in each habitat type.
- Hand foraging and habitat assessment transects (not shown on Figure 3, tracklogs unavailable).
- Keeping of opportunistic records of fauna.

The survey results have been included in the literature review.

1.3 Climate and Weather

The nearest weather station is Newman Airport (site number 007176), about 130 km southeast of the Study Area. The mean monthly maximum and minimum temperatures and rainfall for this weather station is presented in Figure 4. The data indicate that the highest rainfall and temperatures occur in the summer months, though some rain falls throughout the year. The average annual rainfall for Newman Airport between 1971 and 2020 is 324.3mm (Bureau of Meteorology 2020).



**WESTERN
WILDLIFE**



**Lamb Creek and Wedge Project
Study Area**

Author: Jenny Wilcox

Filename: MRL20-09-02-f02.mxd

WEC Ref: MRL20-09-02

Scale: 1:10,000 (A4)

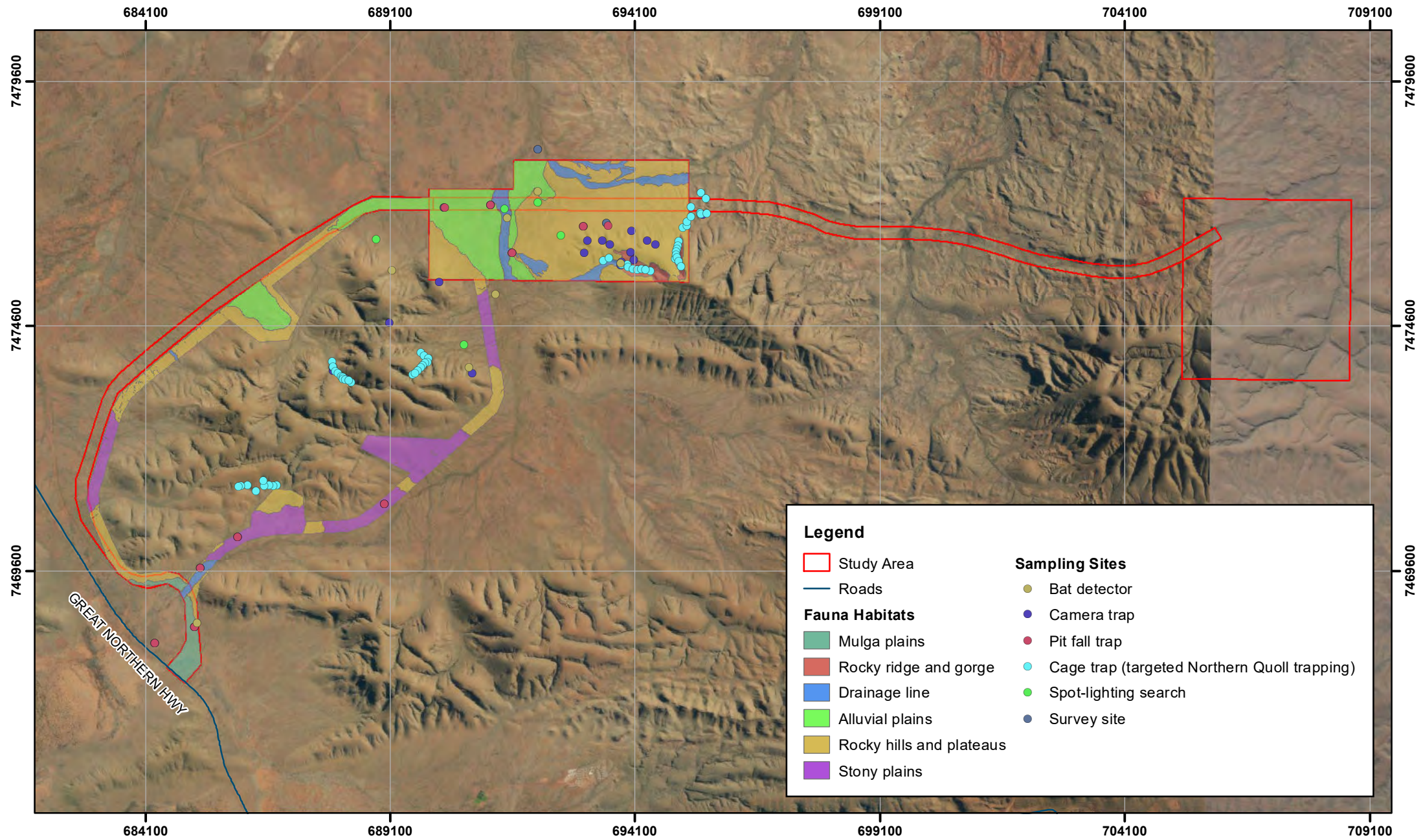
Projection: MGA Zone 50

Revision: A - 10 March 2020

Figure

2

This map should only be used in conjunction with WEC report MRL20-09-02.



**WESTERN
WILDLIFE**



**Lamb Creek and Wedge Project
Extent of 2012 Fauna Survey**

Author: Jenny Wilcox

Filename: MRL20-09-02-f03.mxd

WEC Ref: MRL20-09-02

Scale: 1:10,000 (A4)

Projection: MGA Zone 50

Revision: A - 10 March 2020

Figure

3

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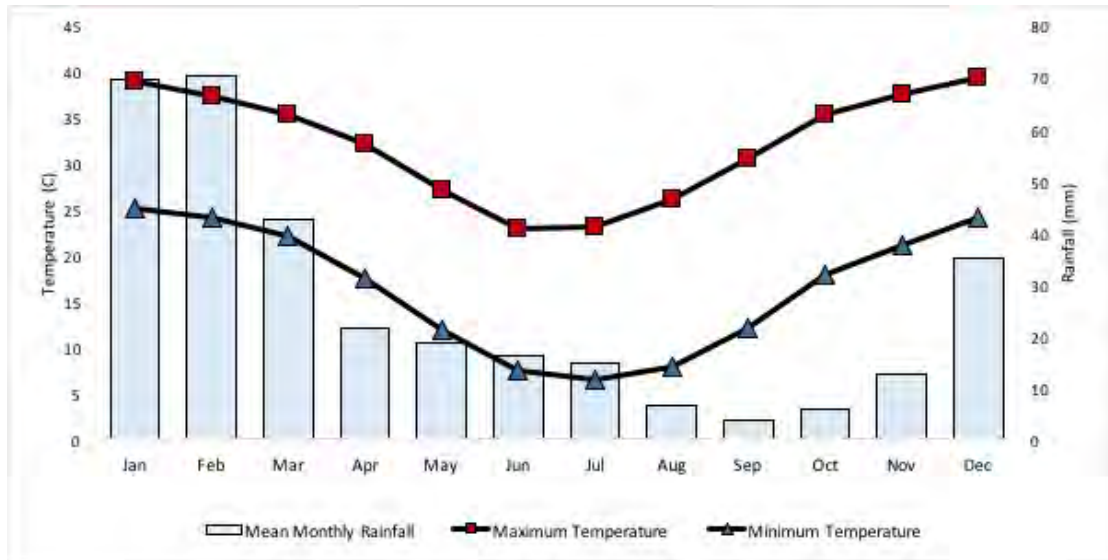


Figure 4. Monthly Climate Statistics for Newman Airport (Bureau of Meteorology 2020).

2. Methods

2.1 Overview

A desktop vertebrate fauna assessment was undertaken for the Study Area, as shown in Figure 2, in February and March 2020. No field survey was undertaken as part of this assessment, however, rocky ridge and gorge habitat was mapped across the Study Area and the results of the 2012 fauna survey (Rapallo 2012) are presented. The methods are further described in the sections below.

2.2 Guidance Documents

The desktop assessment was conducted with reference to the following documents:

- Environmental factor guideline: terrestrial fauna (EPA 2016a)
- Technical guidance: terrestrial fauna surveys (EPA 2016b)
- Technical guide: terrestrial vertebrate fauna surveys for environmental impact assessment (EPA and DEC 2010)
- Interim guideline for preliminary surveys of night parrot (*Pezoporus occidentalis*) in Western Australia (DPAW 2017)
- EPBC Act Referral Guideline for the Endangered Northern Quoll (DoE 2016)
- Survey Guidelines for Australia's Threatened Mammals (DSEWPaC 2011a)
- Survey Guidelines for Australia's Threatened Birds (DEWHA 2010b)
- Survey Guidelines for Australia's Threatened Reptiles (DSEWPaC 2011b)
- Survey Guidelines for Australia's Threatened Bats (DEWHA 2010a)

2.3 Personnel

This report was prepared by Ms. Jenny Wilcox (*BSc.Biol/Env.Sci., Hons.*). Jenny has 20 years' experience with fauna consulting, including fauna surveys in the Pilbara Bioregion.

2.4 Taxonomy and Nomenclature

Taxonomy and nomenclature for fauna species used in this report follow the Western Australian Museum checklists, updated September 2019. In the text, common names are used where appropriate, and all scientific names are given in species lists. Where a species lacks a common name, they are referred to by their scientific name. Where there have been taxonomic changes, mainly where a single species has been split into several species, effort has been made to assign older records to their current names.

2.5 Literature Review

2.5.1 Previous Fauna Surveys in the Region

The review of previous fauna surveys in the region was restricted to surveys within 35km of the Study Area, in the Hamersley subregion. They included one survey from within the Study Area and nine surveys within 35km of the Study Area (Table 1). Note that where the fauna records from these surveys have been submitted to DBCA, they will also occur on the NatureMap and/or DBCA Threatened and Priority Fauna databases (DBCA 2007-, DBCA 2020).

Table 1. Fauna survey reports used in the preparation of this report.

Survey	Key Findings	Reference
<p>Name: Level 2 Fauna Survey and Northern Quoll Survey of Lamb Creek</p> <p>Survey Dates: Single season Level 2 survey, March/April 2012</p> <p>Proximity: 0km (overlaps study area)</p>	<p>Observed vertebrate assemblage: 2 frogs, 58 reptiles, 76 birds, 20 native mammals, 2 introduced mammals.</p> <p>Conservation significant species recorded:</p> <ul style="list-style-type: none"> • Northern Quoll (<i>Dasyurus hallucatus</i>) - En • Ghost Bat (<i>Macroderma gigas</i>) - Vu • Pilbara Olive Python (<i>Liasis olivaceus barroni</i>) – Vu • Fork-tailed Swift (<i>Apus pacificus</i>) – Mi • Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4 	Rapallo (2012)
<p>Name: Proposed Mining Area C Development Envelope Vertebrate Fauna Desktop Assessment</p> <p>Survey Dates: review of multiple surveys between 1999 – 2013, including Level 1 and Level 2 surveys, targeted bat and targeted Northern Quoll surveys.</p> <p>Proximity: 12km south of the study area.</p>	<p>Observed vertebrate assemblage: 8 frogs, 86 reptiles, 108 birds, 30 native mammals, 8 introduced mammals.</p> <p>Conservation significant species recorded:</p> <ul style="list-style-type: none"> • Northern Quoll (<i>Dasyurus hallucatus</i>) - En • Ghost Bat (<i>Macroderma gigas</i>) - Vu • Pilbara Leaf-nosed Bat (<i>Rhinonictis aurantia</i>) - Vu • Pilbara Olive Python (<i>Liasis olivaceus barroni</i>) – Vu • Grey Falcon (<i>Falco hypoleucos</i>) - Vu • Fork-tailed Swift (<i>Apus pacificus</i>) – Mi • Peregrine Falcon (<i>Falco peregrinus</i>) - OS • Gane’s Blindsnake (<i>Anilius ganei</i>) – P1 • Pilbara Barking Gecko (<i>Underwoodisaurus seorsus</i>) – P2 • Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4 	Biologic (2017)
<p>Name: Yandicoogina Junction South West and Oxbow Fauna Survey</p> <p>Survey Dates: Single season Level 2 survey, July 2008</p> <p>Proximity: 20km east of the study area.</p>	<p>Observed vertebrate assemblage: 0 frogs, 14 reptiles, 46 birds, 10 native mammals, 2 introduced mammals.</p> <p>Conservation significant species recorded:</p> <ul style="list-style-type: none"> • Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4 	Biota (2010)

Table 1. (cont.)

Survey	Key Findings	Reference
<p>Name: Yandicoogina Expansion Billiard Deposit Fauna Survey</p> <p>Survey Dates: Single season Level 2 survey, July 2008</p> <p>Proximity: 25km east of the study area.</p>	<p>Observed vertebrate assemblage: 2 frogs, 8 reptiles, 44 birds, 7 native mammals, 1 introduced mammal.</p> <p>Conservation significant species recorded:</p> <ul style="list-style-type: none"> • Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4 	Biota (2011b)
<p>Name: Yandi Billiards Phase 1 Seasonal Fauna Survey</p> <p>Survey Dates: Single season Level 2 survey, March 2014</p> <p>Proximity: 25km east of the study area.</p>	<p>Observed vertebrate assemblage: 2 frogs, 54 reptiles, 78 birds, 19 native mammals, 2 introduced mammal.</p> <p>Conservation significant species recorded:</p> <ul style="list-style-type: none"> • Pilbara Olive Python (<i>Liasis olivaceus barroni</i>) – Vu • Fork-tailed Swift (<i>Apus pacificus</i>) – Mi • Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4 • Brush-tailed Mulgara (<i>Dasyercus blythi</i>) – P4 	Biota (2014)
<p>Name: Terrestrial Fauna of Koodaideri Phase 1</p> <p>Survey Dates: Single season Level 2 survey, August 2010.</p> <p>Proximity: 27km north of the study area.</p>	<p>Observed vertebrate assemblage: 2 frogs, 30 reptiles, 50 birds, 22 native mammals, 1 introduced mammal.</p> <p>Conservation significant species recorded:</p> <ul style="list-style-type: none"> • Northern Quoll (<i>Dasyurus hallucatus</i>) - En • Pilbara Leaf-nosed Bat (<i>Rhinonictis aurantia</i>) – Vu • Ghost Bat (<i>Macroderma gigas</i>) - Vu • Pilbara Olive Python (<i>Liasis olivaceus barroni</i>) – Vu • Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4 	Biota (2011a)
<p>Name: Koodaideri Project Targeted Fauna Survey</p> <p>Survey Dates: Single season targeted northern quoll and bat survey, July 2011.</p> <p>Proximity: 27km north of the study area.</p>	<p>Observed vertebrate assemblage: 0 frogs, 5 reptiles, 0 birds, 9 native mammals, 1 introduced mammal.</p> <p>Conservation significant species recorded:</p> <ul style="list-style-type: none"> • Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4 	Biota (2012)
<p>Name: Greater West Angelas Terrestrial Fauna Assessment</p> <p>Survey Dates: Two season Level 2 survey, Sept/Oct 2012, March 2013</p> <p>Proximity: 30km southwest of the study area.</p>	<p>Observed vertebrate assemblage: 0 frogs, 64 reptiles, 80 birds, 23 native mammals, 2 introduced mammal.</p> <p>Conservation significant species recorded:</p> <ul style="list-style-type: none"> • Pilbara Leaf-nosed Bat (<i>Rhinonictis aurantia</i>) - Vu • Fork-tailed Swift (<i>Apus pacificus</i>) – Mi • Pilbara Barking Gecko (<i>Underwoodisaurus seorsus</i>) – P2 • Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4 	Ecologia (2014)

Table 1. (cont.)

Survey	Key Findings	Reference
<p>Name: A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Option 6 Infrastructure Corridor</p> <p>Survey Dates: Two season Level 2 survey, Sept 2008 and May 2009.</p> <p>Proximity: 35km southeast of the study area.</p>	<p>Observed vertebrate assemblage: 1 frog, 42 reptiles, 62 birds, 16 native mammals, 0 introduced mammals.</p> <p>Conservation significant species recorded: Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4</p>	Ninox Wildlife Consulting (2009b)
<p>Name: A Vertebrate Fauna Survey of the Proposed Hope Downs 4 Infrastructure Corridor: Option 1</p> <p>Survey Dates: Single season Level 2 survey, May 2008</p> <p>Proximity: 35km southeast of the study area.</p>	<p>Observed vertebrate assemblage: 1 frog, 23 reptiles, 37 birds, 11 native mammals, 2 introduced mammals.</p> <p>Conservation significant species recorded:</p> <ul style="list-style-type: none"> • Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>) – P4 	Ninox Wildlife Consulting (2009a)

2.5.2 Fauna Records on Databases and the General Literature

The databases listed in Table 2 were searched for fauna records in and around the Study Area. In all cases the extent of the database search was larger than the extent of the Study Area in order to pick up records of species in the wider area that may also occur in the Study Area.

Where possible, coastal species, vagrants, species that favour habitats absent from the Study Area and erroneous records have been excluded from the list, unless some further discussion is warranted. The lists of fauna expected to occur in the Study Area were reviewed against a number of sources, including publications that provide information on general patterns of distribution of frogs (Tyler *et al.* 2000), reptiles (Wilson and Swan 2017, Storr *et al.* 1983, 1990, 1999 and 2002), birds (Barrett *et al.* 2003; Johnstone and Storr 1998 and 2004) and mammals (Churchill 2008, Menkhorst and Knight 2011; Van Dyck and Strahan 2008).

Table 2. Databases used in the preparation of this report.

Database	Type of records held	Area searched
NatureMap (DBCA 2007-) Note that the NatureMap database collates records from several other databases.	<ul style="list-style-type: none"> • WA Museum Specimen Databases for reptiles frogs, birds and mammals - records of specimens held in the Western Australian Museum. Includes historical records. • Fauna Survey Returns Database - records collected from fauna surveys carried out in Western Australia. Includes observational and trapping data. • Birds Australia Atlas Database - Records of bird observations in Australia, 1998-2009. • Birdata - records of bird observations in Australia, 2010-current. 	20km buffer around a central point (-22.803°S, 118.902°E). Extract obtained February 2020.
DBCA's Threatened and Priority Fauna Database (DBCA 2020)	Information and records on Threatened and Priority species in Western Australia.	50km buffer around a central point (50K 694100E, 7476500N). Extract obtained February 2020.
EPBC Act Protected Matters Search Tool	Information and modelled distributions for matters protected under the EPBC Act, including threatened species and ecological communities, migratory species and marine species.	20km buffer around a central point (-22.803°S, 118.902°E). Extract obtained February 2020.

2.6 Habitat Mapping

This report presents the habitat polygons mapped by Rapallo (2012) over the Lamb Creek portion of the Study Area. Each habitat was re-named on the basis of its key vegetation and/or landform features to simplify the discussion of habitat usage by fauna. No habitat mapping was available for the remaining portion of the Study Area, however, rocky ridge and gorge habitat was mapped for these areas using aerial photography. The rocky ridge and gorge habitat areas have not been ground-truthed for the presence of habitat features such as caves and crevices.

2.7 Assessment of Conservation Significance

2.7.1 Legislative Protection for Fauna

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) is the Commonwealth Government's primary piece of environmental legislation. Listed under Part 3 of the EPBC Act are 'Matters of National Environmental Significance' (MNES); these include threatened species, threatened ecological communities and migratory species. Threatened fauna species are assessed against categories based on International Union for Conservation of Nature (IUCN) criteria.

The migratory species listed under the EPBC Act are those recognised under international agreements. These agreements are the China-Australia Migratory Bird Agreement (CAMBA), the Japan-Australia Migratory Bird Agreement (JAMBA), the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA), or species listed under the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) for which Australia is a range state.

Matters of National Environmental Significance (MNES) include the following categories:

- **Extinct in the wild (EW):** Taxa known to survive only in captivity.
- **Critically Endangered (Cr):** Taxa facing an extremely high risk of extinction in the wild in the immediate future.
- **Endangered (En):** Taxa facing a very high risk of extinction in the wild in the near future.
- **Vulnerable (Vu):** Taxa facing a very high risk of extinction in the wild in the medium-term future.
- **Migratory (Mi):** Taxa listed under international agreements to which Australia is a party.

Reports on the conservation status of most vertebrate fauna species have been produced by the federal Department of Environment and Energy (DoEE) in the form of Action Plans. An Action Plan is a review of the conservation status of a taxonomic group against IUCN categories. Action Plans have been prepared for amphibians (Tyler 1998), reptiles (Cogger *et al.* 1993), birds (Garnett *et al.* 2011) and mammals (Woinarski *et al.* 2014). These publications also use categories similar to those used by the EPBC Act. The information presented in some of the earlier Action Plans may be out of date due to changes since publication.

The *Biodiversity Conservation Act 2016* (BC Act) is State legislation that aims to conserve and protect biodiversity and biodiversity components in Western Australia, including threatened fauna. It is administered by the Department of Biodiversity, Conservation and Attractions (DBCA). In addition to threatened fauna, the BC Act has scope to protect threatened ecological communities and important habitats.

Fauna species are listed under the BC Act as threatened species using IUCN categories, or as specially protected species, as described below.

Threatened Species:

- **Extinct in the wild (EW):** Taxa known to survive only in captivity.
- **Critically Endangered (Cr):** Taxa facing an extremely high risk of extinction in the wild in the immediate future.
- **Endangered (En):** Taxa facing a very high risk of extinction in the wild in the near future.
- **Vulnerable (Vu):** Taxa facing a very high risk of extinction in the wild in the medium-term future.

Specially Protected Species:

- **Migratory (Mi):** A subset of the migratory fauna that are known to visit Western Australia that are protected under the international agreements or treaties, excluding species that are listed as Threatened species.
- **Conservation dependent fauna (CD):** Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened
- **Other specially protected species (OS):** fauna in need of special protection to ensure their conservation.

The BC Act supersedes the *Western Australian Wildlife Conservation Act 1950* (WC Act).

Priority species are not listed under State or Commonwealth Acts. In Western Australia, DBCA maintains a list of Priority Fauna made up of species that are possibly Threatened but do not meet adequacy of survey requirements or are otherwise data deficient. There are four levels of Priority as defined by DBCA, as listed below.

- **Priority 1:** Poorly known species (on threatened lands)
- **Priority 2:** Poorly known species in few locations (some on conservation lands)
- **Priority 3:** Poorly known species in several locations (some on conservation lands)
- **Priority 4:** Rare, near threatened and other species in need of monitoring

2.7.2 Levels of Conservation Significance in this report

Five levels of conservation significance are used within this report to indicate the level of significance of fauna species, according to the following criteria:

- **Threatened (T):** Taxa listed as Extinct in the Wild, Critically Endangered, Endangered or Vulnerable under the EPBC Act and/or BC Act. These species are grouped as they are all species considered to be at risk of extinction, are often rare and are likely to be subject to on-going threatening processes.
- **Migratory (Mi):** Taxa listed as Migratory under the EPBC Act and/or BC Act, excluding those species also listed as threatened. These species are grouped as they are not necessarily rare, but may be dependent on specific habitats for a portion of their life-cycle. For these species, loss of important foraging, breeding or stop-over sites may have a disproportionately large impact on populations.
- **Specially Protected (SP):** Taxa listed as Other Specially Protected Species or Conservation Dependent Fauna under the BC Act. These species are not necessarily rare, but may be dependent on on-going conservation to ensure their protection.
- **Priority (P):** Taxa listed as Priority by DBCA. These species are grouped as they are either conservation dependent or data deficient and in need of further survey.

- **Locally Significant (LS):** Locally significant taxa are not listed under State or Commonwealth Acts or in publications on threatened fauna or as Priority species by DBCA, but are considered by the author to potentially be of local significance because they are at the limit of their distribution in the area, they have a very restricted range or they occur in breeding colonies (e.g. some waterbirds). This level of significance has no legislative recognition and is based on interpretation of information on the species patterns of distribution. For example, the Government of Western Australia (2000) used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Bush Forever. Recognition of such species is consistent with the aim of preserving regional biodiversity.

2.8 Likelihood of Occurrence

Fauna of conservation significance were assessed and ranked for their likelihood of occurrence in the study area, according to the following criteria:

- **Very Low:** The study area is outside the current known distribution of the species as presented in the literature; no suitable habitat was identified as being present during the field survey; for some species, individuals may occur occasionally as vagrants, especially if suitable habitat is located nearby, but the study area itself would not the species; includes species generally accepted as being locally extinct.
- **Low:** The study area is within or just outside the current known distribution of the species, as presented in the literature; any habitat present is of either limited in extent or marginal quality at best; no recent or nearby records of the species on databases; the species is generally known to be less common in the vicinity of the study area (e.g. for inland sites, where the species usually occurs on the coast).
- **Moderate:** The study area is within the current known distribution of the species, as presented in the literature; habitat of reasonable quality was identified as being present during the field survey; some recent and/or nearby records of the species of databases;
- **High:** The study area is well within the current known distribution of the species, as presented in the literature; habitat of good quality was identified as being present during the field survey; many recent and nearby records of the species on databases.
- **Known to Occur:** The species was positively identified in the study area during this field survey, or recorded as occurring in the study area on previous recent field surveys. Note that for a species 'known to occur', the habitat may still be marginal and therefore the population may be small or the species may visit the site irregularly.

3. Survey Limitations

Various factors can limit the effectiveness of a fauna survey. Pursuant to EPA Technical Guidance (EPA 2016b), these factors have been identified and their potential to impact on the effectiveness of the surveys has been assessed in Table 3 below. All fauna surveys have limitations, and not all fauna species present on the site are likely to be sampled during a survey. Fauna may not be recorded because they are rare, they are difficult to trap or observe, or because they are only present on the site for part of the year. The key limitation of this fauna assessment is the lack of fauna survey data for the eastern portion of the Study Area.

Table 3. Fauna assessment limitations.

Potential Limitation	Extent of limitation for the fauna survey	
Competency /experience of the team carrying out the survey	Not limiting	Supervising zoologist has over 20 years' experience with fauna surveys in Western Australia, including experience in Pilbara fauna.
Proportion of fauna identified, recorded and/or collected.	Not limiting	For reptiles, birds and mammals, at least half of the fauna expected to occur (based on literature review) were recorded during a survey at Lamb Creek (Rapallo 2012), covering about half of the Study Area.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data	Limitation	Only about half of the Study Area has been comprehensively surveyed. The remaining area has not been subject to baseline fauna surveys or targeted surveys for conservation significant fauna such as the Pilbara leaf-nosed Bat, Ghost Bat, Northern Quoll or Pilbara Olive Python.
Timing/weather/season/cycle	N/A	No field survey was undertaken as part of this assessment.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey	N/A	No field survey was undertaken as part of this assessment.
Intensity (in retrospect, was the intensity adequate)	N/A	No field survey was undertaken as part of this assessment.
Completeness (e.g. was relevant area fully surveyed)	Not limiting	The entire Survey Area was considered as part of the desktop assessment.
Resources (e.g. degree of expertise available in animal identification to taxon level)	N/A	No field survey was undertaken as part of this assessment.
Remoteness and/or access problems	N/A	No field survey was undertaken as part of this assessment.
Availability of contextual (e.g. biogeographic) information on the region	Not limiting	The Pilbara and in particular the Hamersley Ranges is a relatively well-studied region due to the prevalence of mining activities. The Pilbara Biological Survey also gives context to fauna studies in this region.

4. Fauna Habitats of the Study Area

Six fauna habitats were identified in the Lamb Creek Study Area by Rapallo (2012), primarily on the basis of the vegetation associations. These are summarised in Table 4 and shown in Figure 5. In this report, each habitat has been assigned a name on the basis of its key vegetation and/or landform features, as this aids understanding and simplifies the discussion in the following sections. Rapallo (2012) considered all the habitats identified to be typical of the Pilbara Bioregion.

The assemblage of terrestrial ground-dwelling fauna (i.e. reptiles and small mammals) in the Pilbara are strongly influenced by substrate, such as rocky, stony, clay, loam or sandy surfaces (Doughty *et al.* 2011, Gibson and McKenzie 2009). Therefore, any future field survey may be benefitted by reviewing the boundaries of the habitats identified by Rapallo (2012) and ensuring they are aligned to landform and soils rather than vegetation associations only.

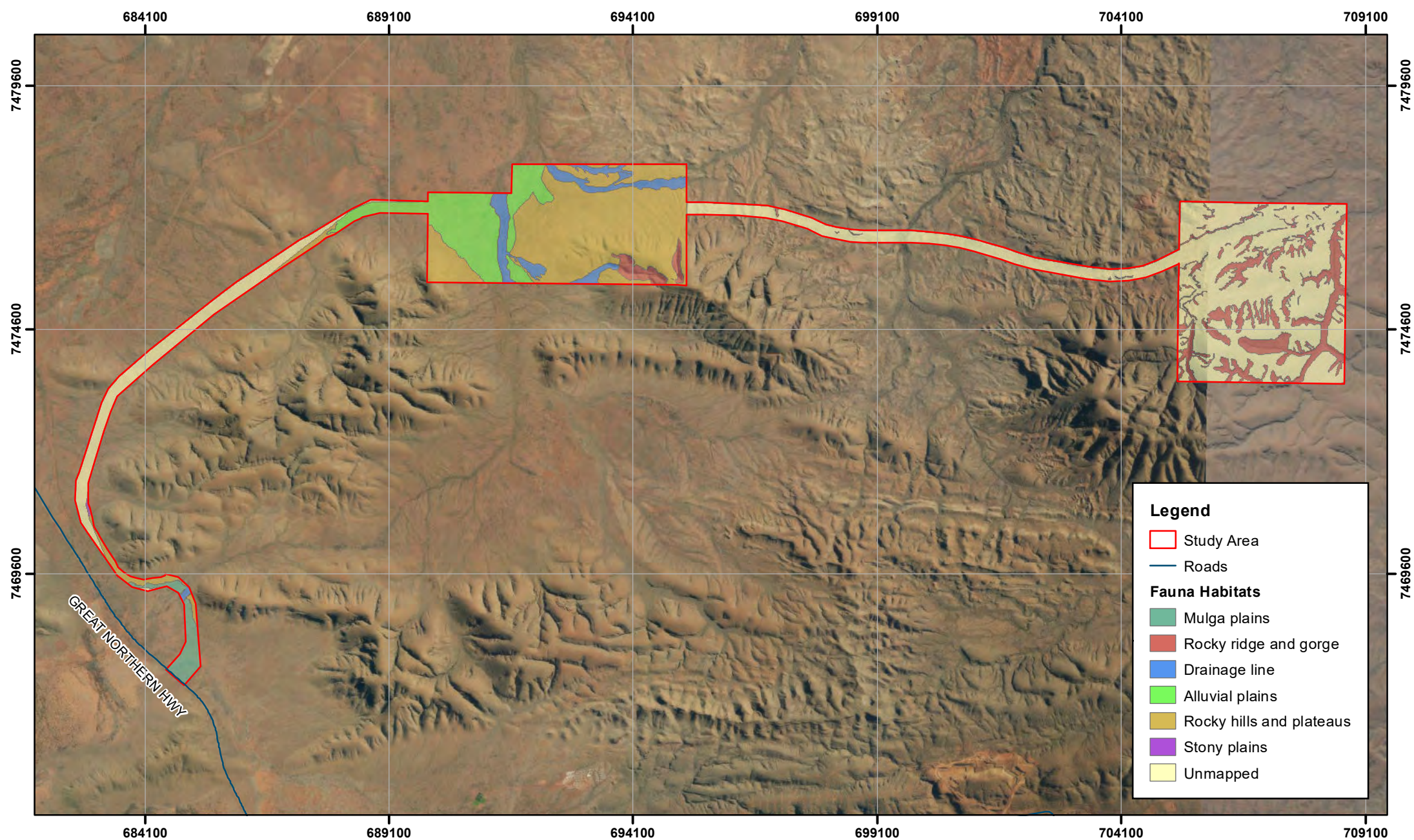
For this report, all rocky ridge and gorge habitat was mapped across the Wedge Study Area and associated haul road (Figure 5), as this habitat is important for Threatened fauna. This habitat type potentially contains cracks, crevices, caves, fallen boulders and rocky outcrops that provide shelter and breeding habitat to species such as the Northern Quoll. Although caves were identified by Rapallo (2012), the locations of these were not available. Caves are an important habitat element, as they may support important roosting and/or breeding habitat for Threatened bat species.

About 54% of the Study Area remains unmapped, but is likely to comprise of similar habitat types to the Lamb Creek Study Area. The unmapped portion of the Wedge Study Area is relatively rugged terrain, and is likely to comprise mostly rocky hills and plateaus.

Table 4. Fauna habitats in the Study Area.

Habitat	Key Habitat Elements	Area mapped (ha)*
Rocky ridge and gorge <ul style="list-style-type: none"> 'GORGE' in Rapallo (2012), described as open woodland with <i>Ficus sp.</i>, <i>Terminalia sp.</i>, <i>Brachychiton sp.</i> and <i>Eucalyptus leucophloia</i> over mixed <i>Gossypium robinsonii</i>, <i>Grevillea wickhamii</i>, <i>Cymbopogon ambiguus</i> and <i>Chrysopogon fallax</i> on steep-sided gorges excised into ironstone plateau. Note that the additional area of this habitat mapped in Wedge may include different vegetation types and rocky areas that are not enclosed in gorges. 	<ul style="list-style-type: none"> Outcropping rocky areas, fallen boulders, caves, overhangs and rock crevices. Likely to be critical habitat for Threatened fauna (Ghost Bat, Pilbara Leaf-nosed Bat, Northern Quoll and Pilbara Olive Python) 	348
Rocky hills and plateaus <ul style="list-style-type: none"> 'SHET' in Rapallo (2012), described as <i>Eucalyptus leucophloia</i> low open woodland over mixed scattered shrubs (typically <i>Gossypium robinsonii</i>, <i>Acacia hilliana</i>, <i>Grevillea wickhamii</i> and <i>Keraudrenia nephrosperma</i>) over <i>Triodia wiseana</i> hummock grassland on plateaus, scree slopes, breakaways and minor drainages with exposed rocky or stony soils. 	<ul style="list-style-type: none"> Occasional rocky outcrops. Small stones suitable for Priority fauna species, the Western Pebble-mound Mouse. 	811
Stony plains <ul style="list-style-type: none"> 'STABM' in Rapallo (2012), described as <i>Eucalyptus gamophylla</i> low open woodland over <i>Acacia aptaneura</i> or <i>Acacia hilliana</i> and <i>Senna glutinosa</i> open shrubland over <i>Triodia brizoides</i> and <i>Triodia wiseana</i> hummock grassland on scree slopes and stony plains with very shallow stony soils. 	<ul style="list-style-type: none"> Small stones suitable for Western Pebble-mound Mouse. 	17
Alluvial plains <ul style="list-style-type: none"> 'SATOM' in Rapallo (2012), described as <i>Acacia aptaneura</i> and/or <i>Corymbia deserticola</i> low woodland over <i>Acacia eleocharis</i> and mixed <i>Eremophila spp.</i> over <i>Triodia wiseana</i> very open hummock grassland on stony and loamy alluvial plains with occasional minor drainage channels. 	<ul style="list-style-type: none"> Dense vegetation in minor drainage lines (not mapped separately) provides shelter for fauna. Tree hollows in scattered eucalypts. 	328
Drainage line <ul style="list-style-type: none"> 'MEAT' in Rapallo (2012), described as <i>Corymbia hamersleyana</i> scattered low trees over <i>Gossypium robinsonii</i> and <i>Acacia elachantha</i> tall open shrubland over <i>Triodia wiseana</i> hummock grassland and <i>Eulalia aurea</i> and <i>Eragrostis eriopoda</i> very open tussock grassland on sandy or stony alluvial drainages. 	<ul style="list-style-type: none"> May function as a corridor for fauna movement. May contain seasonal waterholes. Tree hollows. Dense shrublands provide shelter for birds. Leaf litter accumulations. 	133
Mulga plains <ul style="list-style-type: none"> 'FLAGMA' in Rapallo (2012), described as <i>Acacia aptaneura</i> low woodland over <i>Themeda triandra</i>, <i>Cymbopogon ambiguus</i> and <i>Chrysopogon fallax</i> open tussock grassland on clay and loam floodplains. 	<ul style="list-style-type: none"> Mulga woodland provides bird foraging and nesting habitat. 	67
Unmapped <ul style="list-style-type: none"> Areas not covered by Rapallo (2012) or the mapping of rocky ridge and gorge habitat in this report. 		1,437
Total:		3,110

* Note that habitat areas do not add up to the total area due to overlaps in the spatial data provided.



Legend

- Study Area
- Roads

Fauna Habitats

- Mulga plains
- Rocky ridge and gorge
- Drainage line
- Alluvial plains
- Rocky hills and plateaus
- Stony plains
- Unmapped



**WESTERN
WILDLIFE**



**Lamb Creek and Wedge Project
Fauna Habitats**

Author: Jenny Wilcox

Filename: MRL20-09-02-f05.mxd

WEC Ref: MRL20-09-02

Scale: 1:10,000 (A4)

Projection: MGA Zone 50

Revision: A - 10 March 2020

Figure

5

This map should only be used in conjunction with WEC report MRL20-09-02.

5. Faunal Assemblage of the Study Area

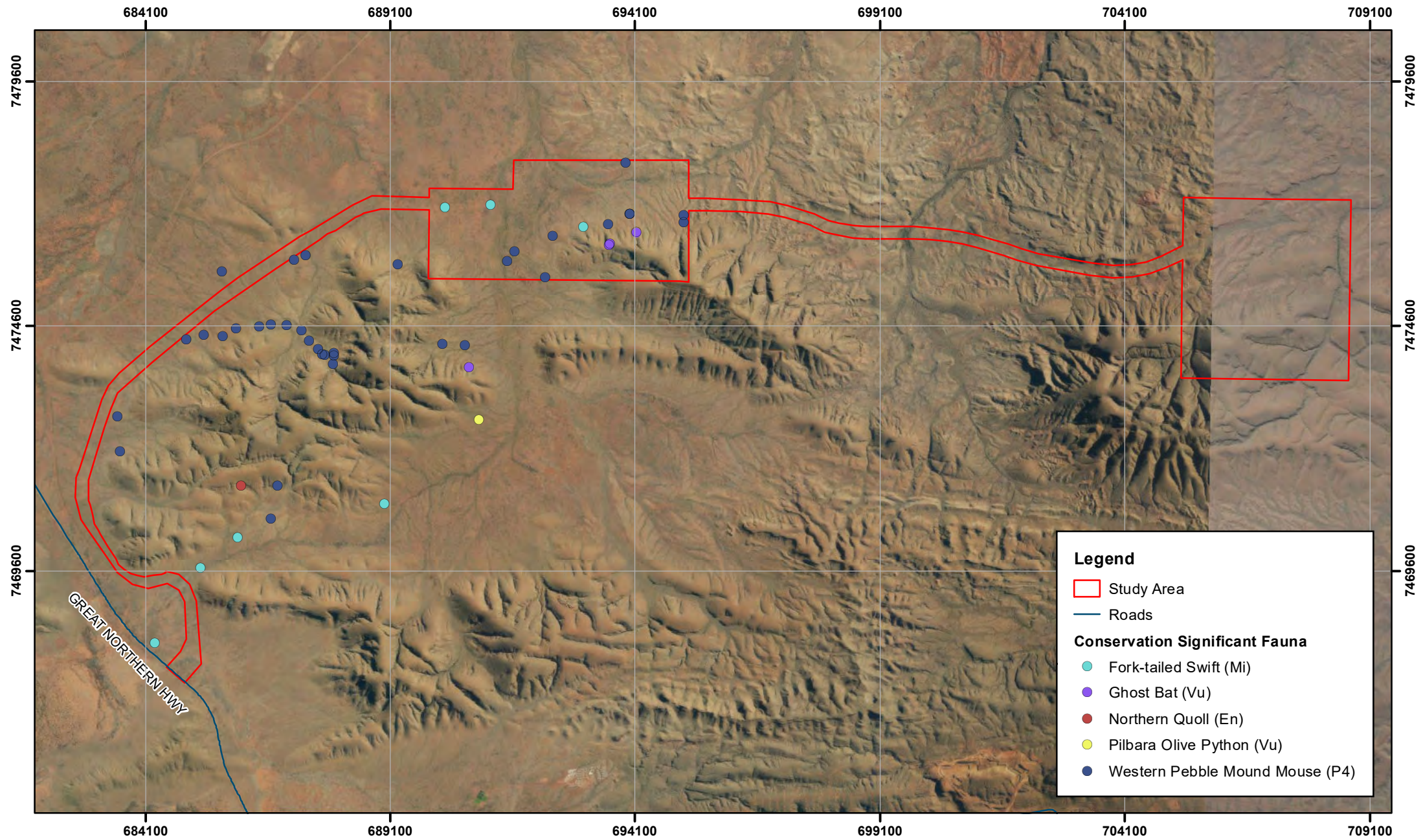
The results of the literature review and field survey were combined to create a list of all the terrestrial vertebrate fauna potentially occurring in the Study Area (Appendices 1 - 4). The potentially occurring faunal assemblage is summarised in Table 5. The faunal assemblage and conservation significant species likely to occur are further discussed in the sections below.

Table 5. Summary of vertebrate fauna potentially occurring in the Study Area.

Taxon	Total Species (predicted)	Introduced species	Conservation significant species				
			Threatened (T)	Migratory (Mi)	Specially Protected (SP)	DBCA Priority (P)	Locally significant (LS)
Amphibians	9	0	-	-	-	-	-
Reptiles	112	0	1	-	-	4	-
Birds	130	0	2	4	1	-	-
Mammals	45	9	4	-	-	4	-
Totals:	307	9	7	4	1	8	0

The overall vertebrate faunal assemblage is likely to be largely intact, with the exception of species that are extinct or greatly reduced in their distribution in the Bioregion.

The conservation significant fauna recorded in Lamb Creek portion of the Study Area by Rapallo (2012) are indicated in Figure 6, as unusually, these records have not been captured in the DBCA Threatened and Priority Fauna Database (DBCA 2020). The conservation significant reptiles, birds and mammals recorded within 50km of the Study Area on DBCA's Threatened and Priority Fauna Database are shown in Figures 7 – 9. The results of the EPBC Act Protected Matters search are given in Appendix 5. The significant fauna potentially occurring in the Study Area are discussed in the following sections and summarised in Table 6.



Legend

- Study Area
- Roads

Conservation Significant Fauna

- Fork-tailed Swift (Mi)
- Ghost Bat (Vu)
- Northern Quoll (En)
- Pilbara Olive Python (Vu)
- Western Pebble Mound Mouse (P4)



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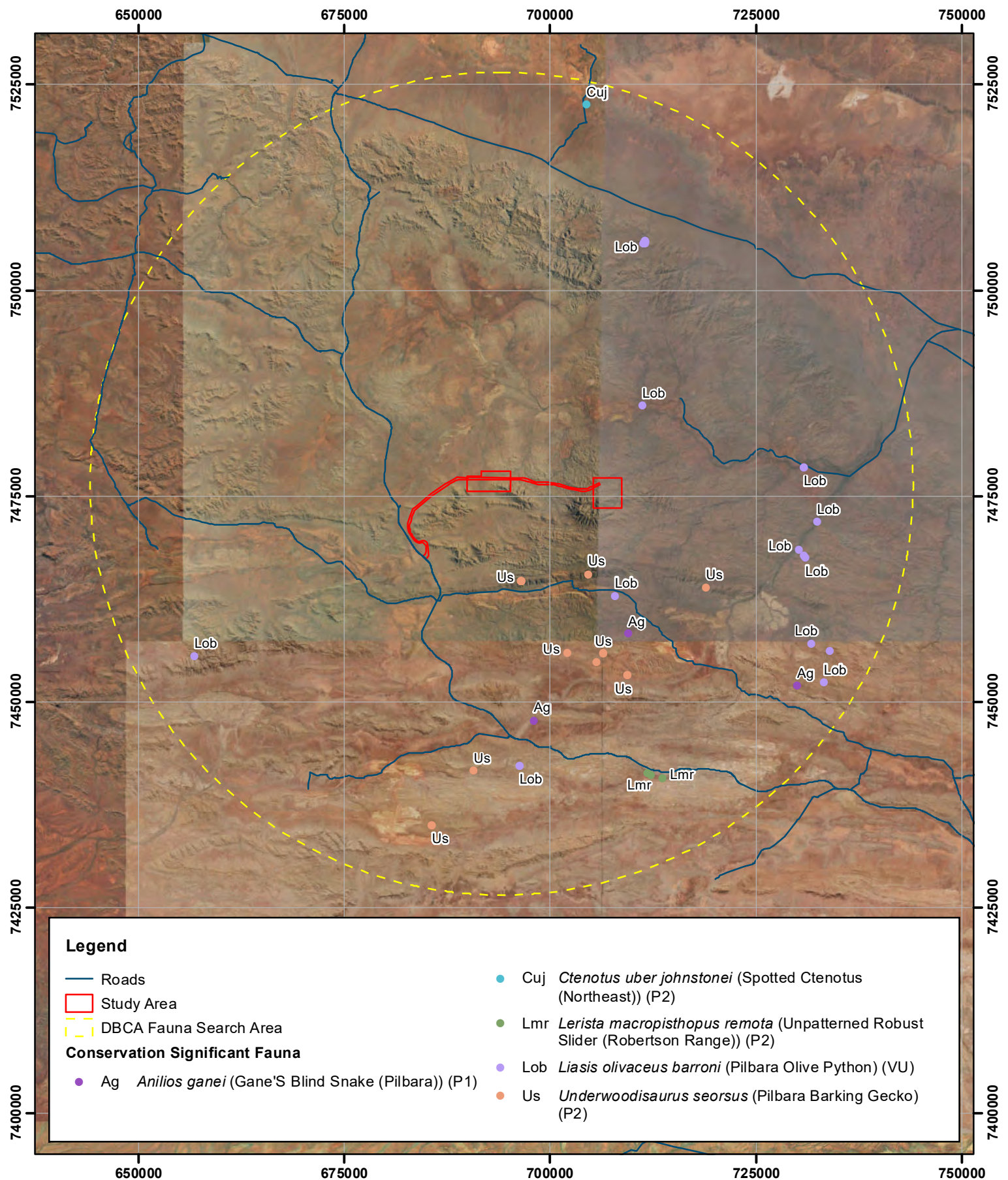




This map should only be used in conjunction with WEC report MRL20-09-02.

Lamb Creek and Wedge Project Conservation Significant Fauna Recorded in 2012	
Author: Jenny Wilcox	
Filename: MRL20-09-02-f06.mxd	

WEC Ref: MRL20-09-02
Scale: 1:10,000 (A4)
Projection: MGA Zone 50
Revision: A - 10 March 2020

Figure
6



 <p>WESTERN WILDLIFE</p> <p>This map should only be used in conjunction with WEC report MRL20-09-02.</p>	<p>Lamb Creek and Wedge Project DBCFA Threatened and Priority Fauna Database reptile records</p>	<p>Author: Jenny Wilcox</p>	 <p>Figure 7</p>
		<p>WEC Ref: MRL20-09-02</p>	
		<p>Filename: MRL20-09-02-f07.mxd</p>	
		<p>Scale: 1:600,000 (A4)</p>	
		<p>Projection: GDA 1994 MGA Zone 50</p>	
		<p>Revision: A - 10 March 2020</p>	

5.1 Amphibians

Nine species of frog potentially occur, of which two were recorded at Lamb Creek in 2012 (Appendix 1). The frog species that potentially occur in the Study Area are common and widely distributed in the semi-arid zone. Frogs are likely to occur throughout the Study Area, potentially breeding anywhere that holds relatively fresh water after rainfall, including man-made depressions. Burrowing species aestivate underground when conditions are dry, breeding opportunistically after rainfall. Many species develop from tadpoles into frogs very quickly, and can make use of ephemeral pools in minor drainages. Frogs are likely to breed in the drainage line habitat, however, they also forage in terrestrial habitats when conditions are suitable. The Gorge Toadlet (*Pseudophryne douglasi*) is endemic to rocky ranges in the Pilbara, and may occur if gorges with permanent water are present.

5.1.1 Amphibians of Conservation Significance

No frogs of conservation significance are likely to be present in the Study Area.

5.2. Reptiles

There are 112 species of reptile that have the potential to occur in the Study Area (Appendix 2). About half (58 species) were recorded on the Lamb Creek portion of the Study Area in 2012 (Rapallo 2012, Appendix 2). The reptile assemblage of the Pilbara Bioregion is very diverse, including a suite of endemic species associated with rocky surfaces (Doughty *et al.* 2011). As the reptile assemblage is generally informed by the ground surface (e.g. sandy, clayey or rocky surfaces) the Study Area is likely to support an assemblage dominated by species that occur on stony and rocky habitats. Species that favour sandy soil are only likely to occur in association with Drainage Lines.

5.2.1 Reptiles of Conservation Significance

There are five reptiles of conservation significance that potentially occur in the Study Area, as listed and discussed below.

Threatened Species

Pilbara Olive Python

This species is listed as Vulnerable under the EPBC Act and Vulnerable under the BC Act.

Liasis olivaceus barroni

The **Pilbara Olive Python** is restricted to ranges in the Pilbara and islands in the Dampier Archipelago and is known from relatively few localities. This very large python inhabits rock outcrops, usually close to waterholes, which it uses to hunt. The Pilbara Olive Python was recorded opportunistically in the Stony Plains habitat at Lamb Creek in 2012 (Figure 6). There are also several records of this species within 50km on DBCA's Threatened and Priority Fauna Database, including records to the north at Koodaideri Springs and east at Yandi (Figure 7). As suitable habitat is likely to be present in the Study Area, particularly in the Rocky Ridge and Gorge habitat, this species is considered likely to occur. If permanent or semi-permanent waterholes are present in the Study Area they are of particular importance to this species.

Priority Species	
<p>Spotted Ctenotus (northeast) This subspecies is listed as Priority 2 by DBCA</p>	<i>Lerista macropisthopus remota</i>
<p>Unpatterned Robust Slider This subspecies is listed as Priority 2 by DBCA</p>	<i>Lerista macropisthopus remota</i>
<p>Gane's Blind Snake This species is listed as Priority 1 by DBCA.</p>	<i>Anilios ganei</i>
<p>Pilbara Barking Gecko This species is listed as Priority 2 by DBCA.</p>	<i>Underwoodisaurus seorsus</i>

The **Spotted Ctenotus (northeast)** is known from the northeastern interior (Wilson and Swan 2017), but there are also scattered records in the Pilbara region. The requirements of this subspecies area not well known, but it usually occurs on hard reddish soils. There is a single record of this species on DBCA's Threatened and Priority Fauna Database (Figure 7), but it is 45km north of the Study Area and in a different IBRA subregion. The Spotted Ctenotus may occur in the Study Area, but the likelihood is low.

The **Unpatterned Robust Slider** has a small range and is endemic to the Pilbara region. It inhabits Acacia shrublands and woodlands, where it shelters at the base of shrubs in the loose soil under leaf litter (Wilson and Swan 2017). There are three records of this species from 2012 on DBCA's Threatened and Priority Fauna Database, about 33km south of the Study Area (Figure 7). This species potentially occurs in the Study Area and, if present, is likely to favour the Mulga Woodland habitat.

The habitat requirements for **Gane's Blind Snake** are poorly known, as this species is known from relatively few records and was only formally described in 1998. It is endemic to the Pilbara, occurring between Newman and Pannawonica. There are several nearby records of this species on DBCA's Threatened and Priority Fauna Database, the nearest 15km to the south of the Study Area (Figure 7). This species is tentatively associated with moist gorges and gullies, though some of the early specimens are from the Newman townsite and Mt Whaleback waste dump (Aplin 1998). The habitats of the Study Area, particularly the Rocky Ridge and Gorge, may be suitable for Gane's Blind Snake and it is likely that the Study Area falls within the range of this species. Therefore, this species is considered likely to occur in the Study Area.

The **Pilbara Barking Gecko** is endemic to the Hamersley Range in the Pilbara, occurring in rocky areas (Wilson and Swan 2016). It appears to be rare, as it has only been recorded from a handful of sites, despite extensive surveys in the region (Doughty and Oliver 2011). This species has been recorded in the vicinity of the Study Area, with the nearest records 8km south at Mining Area C (Figure 7, Appendix 2). This species is likely to occur in the Study Area, potentially occurring in rocky habitats such as Rocky Hills and Plateaus and Rocky Ridge and Gorge.

5.3 Birds

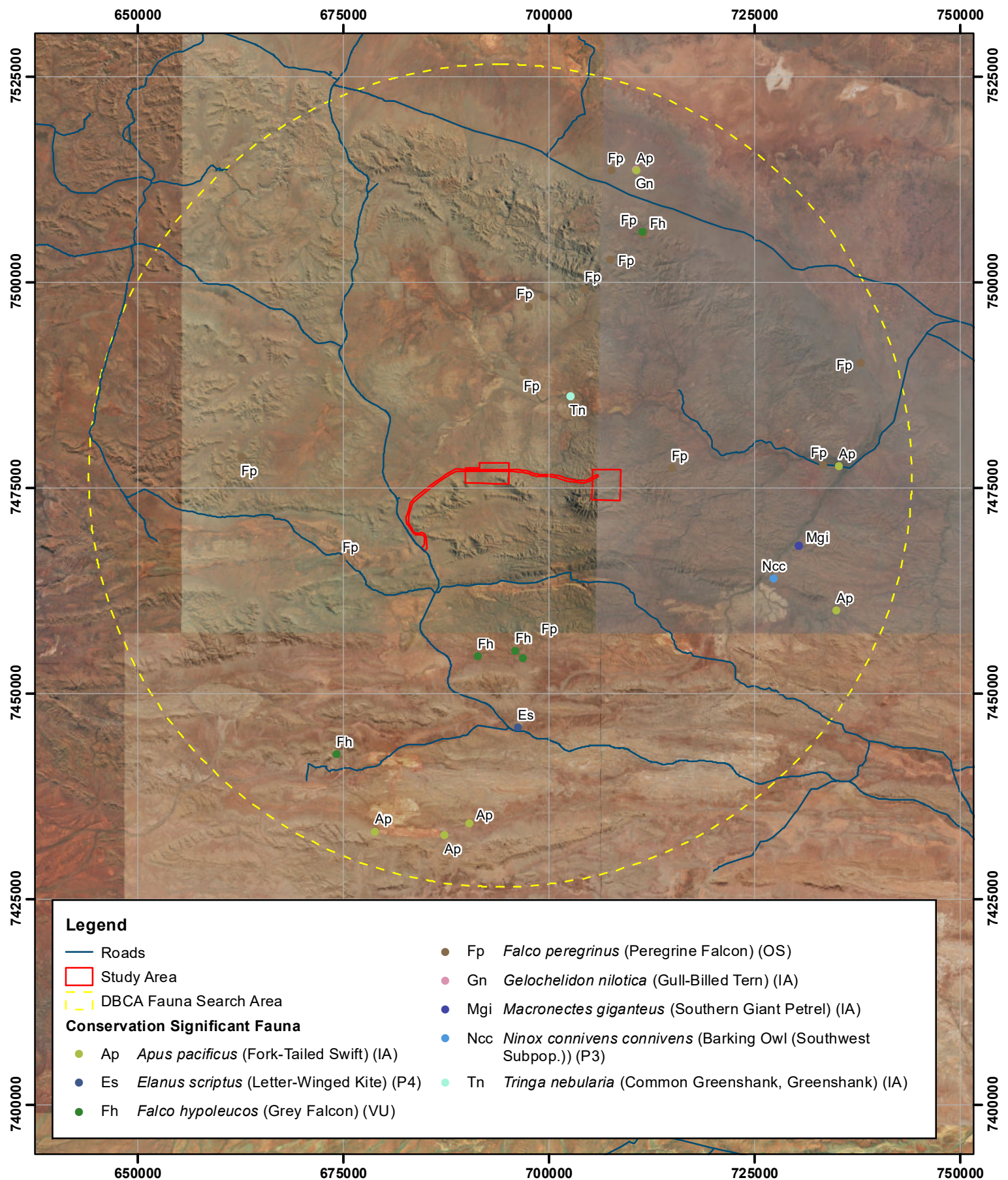
There are 130 species of bird that potentially occur in the Study Area (Appendix 3). More than half (76 species) were recorded on the Lamb Creek portion of the Study Area in 2012, with these records influenced by productive post-wet conditions (Rapallo 2012, Appendix 3). The terrestrial bird fauna of the Pilbara region is thought to be generally uniform, with a higher species richness where there is riparian vegetation such as tall *Eucalyptus* or *Melaleuca* trees (Burbidge *et al.* 2010). Many of the species present are likely to use a range of habitats across the Study Area, although the bird assemblage is likely to vary between more wooded habitats, such as Drainage Lines and open habitats, such as Rocky Hills and Plateaus.



The bird assemblage is likely to include a core suite of species that are resident in the Study Area, a second group that makes regular or nomadic movements into and through the Study Area and a third group of vagrants, that may occur in the Study Area on occasion. Resident species are present all year, though their populations may fluctuate in response to rainfall and fire. Birds that make regular seasonal movements include the Rainbow Bee-eater (*Merops ornatus*), cuckoos and some birds of prey. Honeyeaters are also likely to make seasonal or nomadic movements to take advantage of flowering events. Although not present all year, these species are likely to use the Study Area for foraging, breeding or shelter on a seasonal basis or when conditions are suitable.

Wetland dependent bird species, (e.g. ducks, swans, herons or ibis), are only likely to occur as visitors to the Study Area in very low numbers. Only species recorded in the surrounding area in the literature or on databases have been included in Appendix 3.

5.3.1 Birds of Conservation Significance

Several birds listed as Migratory were recorded on databases for the area (Appendix 5, Figure 8), but are considered unlikely to occur due to the lack of suitable wetland habitats in the Study Area. This includes the Barn Swallow (*Hirundo rustica*), Grey Wagtail (*Motacilla cinerea*), Yellow Wagtail (*Motacilla flava*), Curlew Sandpiper (*Calidris ferruginea*), Sharp-tailed Sandpiper (*Calidris acuminata*), Pectoral Sandpiper (*Calidris melanotos*), Australian Painted Snipe (*Rostratula australis*), Gull-billed Tern (*Gelochelidon nilotica*) and Southern Giant Petrel (*Macronectes giganteus*). The Letter-winged Kite (*Elanus scriptus*) is an irruptive species that is only likely to be an occasional vagrant and the record of the Barking Owl (*Ninox connivens*) is erroneously assigned to the southwest population.



 <p>WESTERN WILDLIFE</p> <p>This map should only be used in conjunction with WEC report MRL20-09-02.</p>	<p>Lamb Creek and Wedge Project DBCA Threatened and Priority Fauna Database bird records</p>	<p>Author: Jenny Wilcox</p>	 <p>Figure</p> <p>8</p>
		<p>WEC Ref: MRL20-09-02</p>	
		<p>Filename: MRL20-09-02-f08.mxd</p>	
		<p>Scale: 1:600,000 (A4)</p>	
		<p>Projection: GDA 1994 MGA Zone 50</p>	
		<p>Revision: A - 10 March 2020</p>	

These species are considered unlikely to occur except as occasional vagrants. They are not included in the list of potentially occurring birds in Appendix 3 and are not discussed further.

There are seven birds of conservation significance that have been recorded or potentially occur in the Study Area, two threatened species, one specially protected species and four Migratory species. Each species is listed in the boxes below, and discussed.

<u>Threatened Species</u>	
Night Parrot This species is listed as Endangered under the EPBC Act and as Critically Endangered fauna under the BC Act.	<i>Pezoporus occidentalis</i>
Grey Falcon This species is listed as Vulnerable under the BC Act.	<i>Falco hypoleucos</i>

Historically, the **Night Parrot** was recorded across a large range in the arid and semi-arid interior of Australia (Garnett *et al.* 2011). In recent times however, there are very few verified records of the species. Reliable records in recent times are from two main areas, one in western Queensland and one Western Australia (TSSC 2016b). Western Australia records are from Lake Gregory in the north, Lake Disappointment, a site near Wiluna and near the Fortescue Marsh in the Pilbara (NPRT 2019, Davis and Metcalf 2008). The key habitats for the Night Parrot are thought to be chenopod shrublands and Spinifex grasslands, with the chenopod shrublands a refuge during dry conditions (Garnett *et al.* 2011). Nesting sites are in mature Spinifex, often large ring-forming clumps (DPAW 2017). Foraging habitats are likely to vary across Australia, but include herbs, grasses, grass-like plants, *Sclerolaena spp.* and other chenopods (DPAW 2017). With the reasons for its decline unknown, potential threats to the species remain unconfirmed (TSSC 2016b). Possible threats include predation by feral cats or foxes, human-induced fire and degradation of soil around watering points (TSSC 2016b). Knowledge about the current distribution and habitat requirements of the Night Parrot in Western Australia is based on very few records, so there is considerable uncertainty when assessing the likelihood of occurrence of this species. The Study Area is close to the Fortescue Marsh sighting, and if there are large spinifex hummocks in the Alluvial Plains habitat they may possibly support Night Parrot roosting or breeding, although the likelihood is low as this parrot is very rare.

The **Grey Falcon** may number fewer than 1000 individuals, although it occurs across a large portion of arid and semi-arid Australia with its distribution centered on inland drainages (Garnett *et al.* 2011). It forages over timbered plains, including *Acacia* shrublands, also ranging out onto treeless plains. The Grey Falcon nests in tall trees on watercourses (Garnett *et al.* 2011) and occasionally on man-made structures such as transmission line towers (pers. obs.). Threats to this species are unknown, but may include habitat degradation due to overgrazing or clearing and provision of water in arid areas favouring the closely related Peregrine Falcon (Garnett *et al.* 2011). There are several records of this species in the vicinity of the Study Area on DBCA's Threatened and Priority Fauna Database (Figure 8), the nearest about 14km to the south. The Study Area appears to lack the large watercourses that provide breeding habitat for this species, although it potentially occurs as a foraging visitor.

Specially Protected Species

Peregrine Falcon

Falco peregrinus

This falcon is listed as Other Specially Protected Fauna under the BC Act.

The **Peregrine Falcon** is a widespread bird of prey that globally has a very large range and a very large population that appears to be secure (BirdLife International 2020). In Western Australia the population is secure, though this species may experience reductions at a local level due to human disturbance at nesting sites (Debus 1998). The Peregrine Falcon nests mainly on ledges on cliffs or rocky outcrops, and it may also use tall trees (Johnstone and Storr 1998). This species often takes advantage of man-made structures such as abandoned open pits or quarries. The species has been recorded nearby on DBCA’s Threatened and Priority Fauna Database (Figure 8). The Peregrine Falcon is considered likely to occur and may breed on the Rocky Ridge and Gorge habitat if suitable cliffs are present, or forage in the Study Area if breeding nearby.

Migratory Species

Oriental Plover

Charadrius veredus

This species is listed as migratory under the EPBC Act and migratory under the BC Act.

Common Sandpiper

Tringa hypoleucos

This species is listed as migratory under the EPBC Act and migratory under the BC Act.

Common Greenshank

Tringa nebularia

This species is listed as migratory under the EPBC Act and migratory under the BC Act.

Fork-tailed Swift

Apus pacificus

This species is listed as migratory under the EPBC Act and migratory under the BC Act.

The **Oriental Plover**, **Common Sandpiper** and **Common Greenshank** are migratory shorebirds that occur on inland waterbodies, as well as in coastal habitats. The Oriental Plover favours dry grasslands and open plains, including recently burnt areas (Geering *et al.* 2007). These species are non-breeding summer visitors to Australia, migrating from Siberia and east China through the East Asian-Australasian Flyway (Geering *et al.* 2007). The Study Area is only likely to be an internationally significant site for these species if it supports 20,000 birds or 1% or more of the flyway population of a species, or a nationally significant site if it supports 2,000 birds or 0.1% or more of the flyway population of a species (DoEE 2017). This equates to 230 Oriental Plover, 190 Common Sandpiper and 110 Common Greenshank to be nationally significant (Hansen *et al.* 2016). There is a single record of the Common Greenshank on DBCA’s Threatened and Priority Fauna Database, but no records of Common Sandpiper or Oriental Plover (Figure 8). The Study Area is only likely to support one or two birds on an irregular basis and is not considered important habitat for migratory shorebirds.

The **Fork-tailed Swift** is a non-breeding visitor to Australia between September and April (Boehm 1962, Johnstone and Storr 1998). The bird is primarily observed foraging for insects in proximity to cyclonic weather (Boehm 1962). Although a migratory species, the Fork-tailed Swift has a large range and a large population that appears to be stable (BirdLife International 2020). This species was recorded nearby on DBCA's Threatened and Priority Fauna Database (Figure 8), and is considered likely to occur in the Study Area, at least on occasion. The Fork-tailed Swift is a largely aerial species in Australia, so is unlikely to be affected by changes to the Study Area.

5.4 Mammals

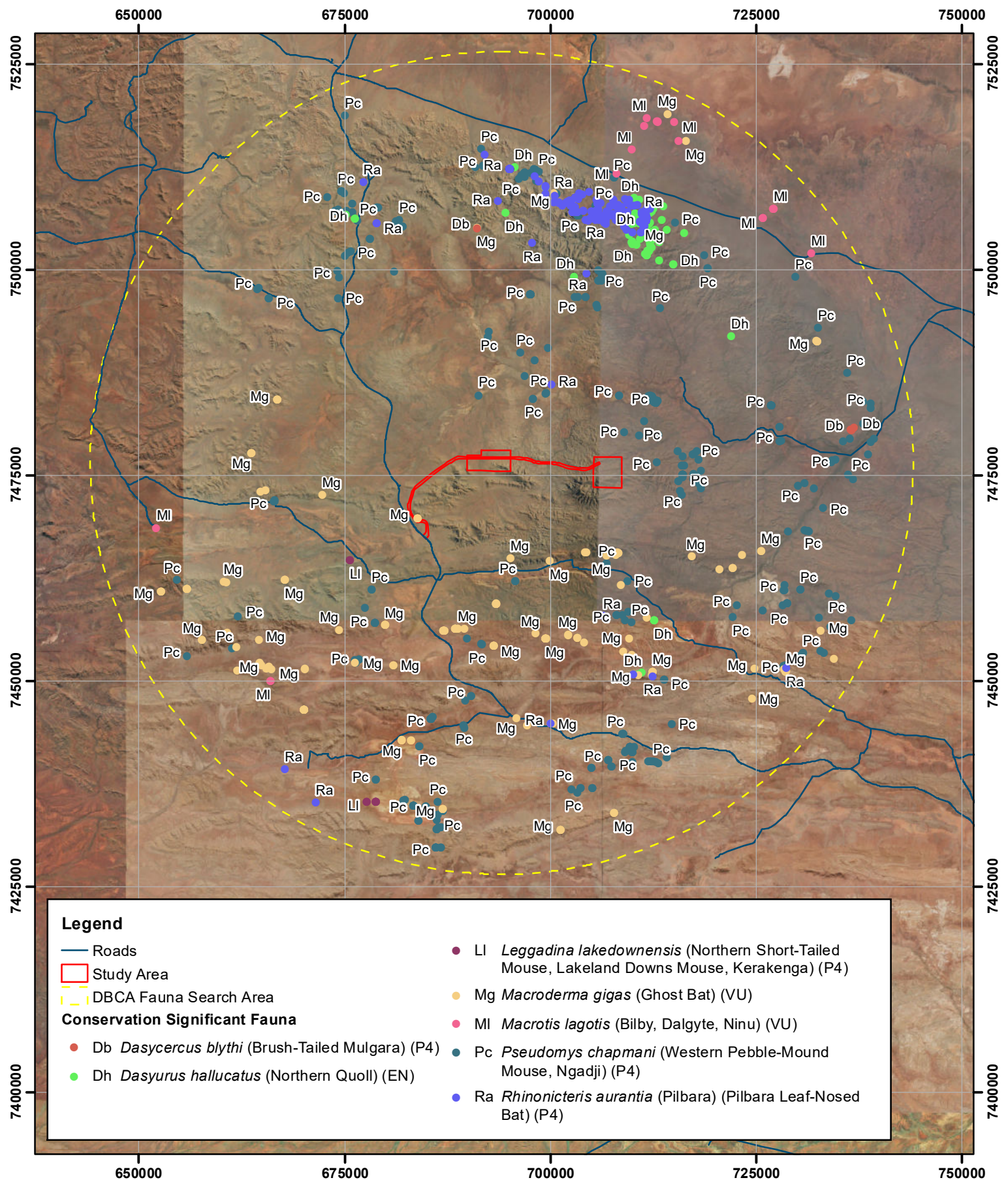
There are 45 species of mammal that have the potential to occur in the Study Area, of which 36 are native and nine introduced (Appendix 4). Half of these, (22 species) were recorded on the Lamb Creek portion of the Study Area in 2012, 20 of which were native mammals (Rapallo 2012, Appendix 4). The mammal assemblage is likely to be relatively intact, lacking only those species that are extinct in the Bioregion. Australia has a history of mammal extinctions since European settlement, most likely due to changed fire regimes and the impacts of feral Cats and Foxes (Woinarski *et al.* 2015). Of the mammals known from the Bioregion, 15% are now extinct (McKenzie *et al.* 2009).



The mammal assemblage includes a suite of species that favour rocky habitats, including Woolley's False Antechinus (*Pseudantechinus woolleyae*), Common Rock-rat (*Zyomys argurus*), Rothschild's Rock-wallaby (*Petrogale rothschildi*) and Northern Quoll (*Dasyurus hallucatus*). These species are strongly associated with rocky habitats in the Pilbara region, and the Rocky Ridge and Gorge habitat in the Study Area is likely to provide important habitat for these species. Many bats also roost in caves and rock crevices, also likely to be present in the Rocky Ridge and Gorge habitat, though they may forage more widely at night.

Although the mammal fauna of the Pilbara is relatively well-studied, there are still taxonomic issues to be resolved, for example there are several undescribed species of *Planigale* present (Westerman *et al.* 2016). This indicates that despite the many surveys that are undertaken in the region, there are still knowledge gaps.

5.4.1 Mammals of Conservation Significance

There are eight mammals of conservation significance that may occur in the Study Area. Each species is listed and discussed below.



 <p>WESTERN WILDLIFE</p> <p>This map should only be used in conjunction with WEC report MRL20-09-02.</p>	<p>Lamb Creek and Wedge Project DBCA Threatened and Priority Fauna Database mammal records</p>	<p>Author: Jenny Wilcox</p>	 <p>Figure</p> <p>9</p>
		<p>WEC Ref: MRL20-09-02</p>	
		<p>Filename: MRL20-09-02-f09.mxd</p>	
		<p>Scale: 1:600,000 (A4)</p>	
		<p>Projection: GDA 1994 MGA Zone 50</p>	
		<p>Revision: A - 10 March 2020</p>	

Threatened Species**Northern Quoll**

This species is listed as Endangered under the EPBC Act and the BC Act.

Dasyurus hallucatus

Bilby

This species is listed as Vulnerable under the EPBC Act and the BC Act.

Macrotis lagotis

Pilbara Leaf-nosed Bat

This species is listed as Vulnerable under the EPBC Act and the BC Act.

Rhinionictoris aurantia

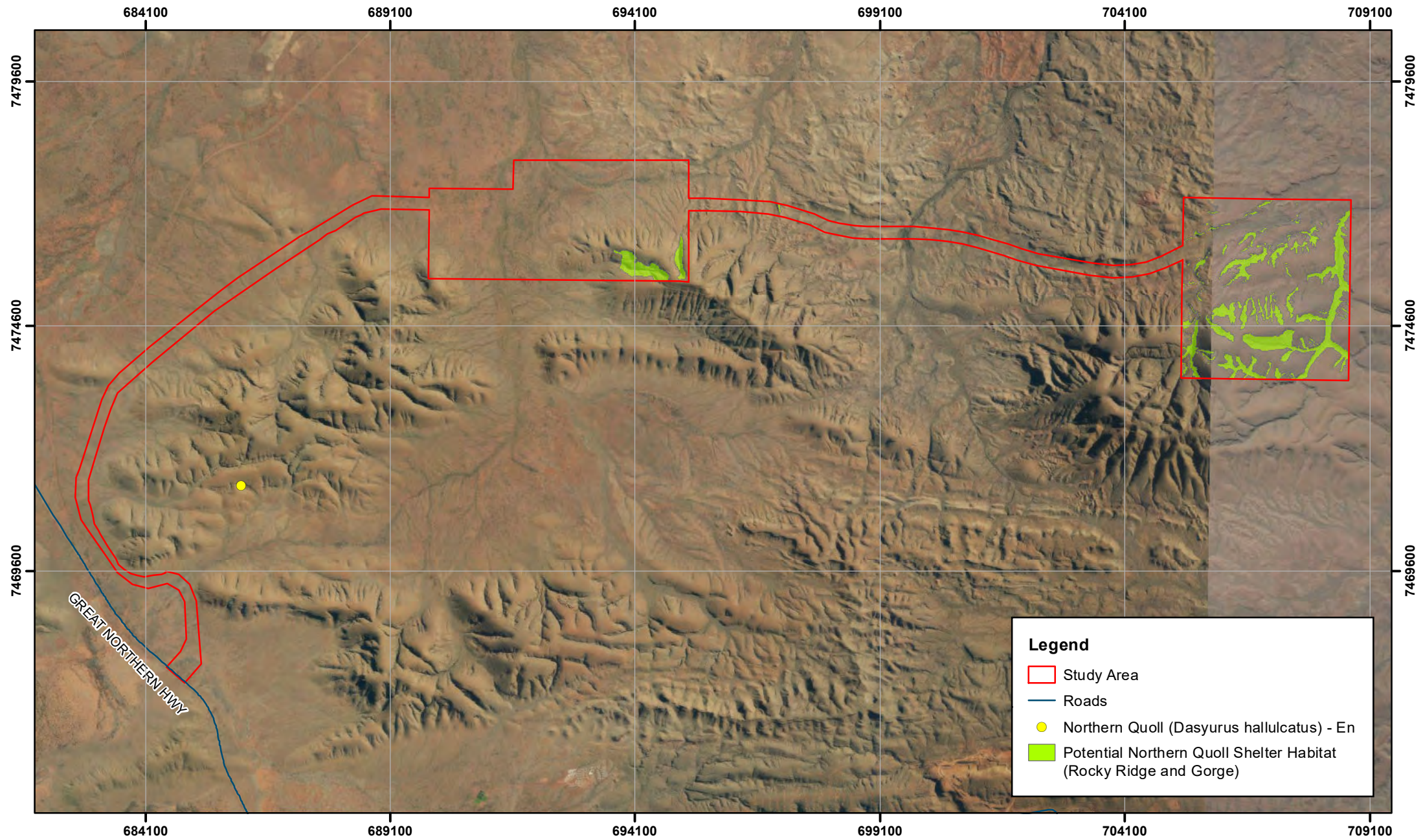
Ghost Bat

This species is listed as Vulnerable under the EPBC Act and the BC Act.

Macroderma gigas

The **Northern Quoll** occurs in a variety of habitats across its range, but in the Pilbara favours dissected rocky escarpments (Hill and Ward 2010, Van Dyck and Strahan 2008). Where shelter habitat occurs within the Northern Quolls predicted range, it is considered ‘habitat critical to the survival of the species’ (Commonwealth of Australia 2016). In the Pilbara, shelter and denning habitat consists of rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields and major drainage lines (Commonwealth of Australia 2016). In the Study Area, shelter habitat is primarily the Rocky Ridge and Gorge habitat (Figure 10). Little is known about Northern Quoll foraging and dispersal habitats, However, the EPBC Act referral guidelines recognise that all native vegetation within 1km of shelter habitat or Northern Quoll records may be considered foraging and dispersal habitat (Commonwealth of Australia 2016).

In the Study Area the Drainage Line habitat may also be important for foraging and dispersal, as it contains shelter such as tree hollows and is likely to be a higher productivity foraging environment. Despite the lack of data on usage of dispersal and foraging habitat, it is known that the Northern Quoll is highly mobile and capable of dispersing over long distances. For example, 2.5km in one day (Schmitt *et al.* 1989), 3.5km in seven days (King 1989), 2 – 3km at Poondano (Process Minerals International, unpublished data) and 2km at the Buckland Project (Phoenix Environmental Sciences 2012). A single Northern Quoll was recorded on a camera trap in the Lamb Creek portion of the Study Area in 2012 (Figures 6 and 10, Rapallo 2012), and there are several records in the surrounding area on DBCA’s Threatened and Priority Fauna Database (Figure 9), mainly from Koodaideri and surrounds.



**WESTERN
WILDLIFE**



**Lamb Creek and Wedge Project
Northern Quoll records and habitat**

Author: Jenny Wilcox

Filename: MRL20-09-02-10.mxd

WEC Ref: MRL20-09-02

Scale: 1:10,000 (A4)

Projection: MGA Zone 50

Revision: A - 10 March 2020

Figure

10

This map should only be used in conjunction with WEC report MRL20-09-02.

The range of the **Bilby** has declined considerably. The species currently occurs patchily across the Pilbara and inland northern Australia with the total population estimated at less than 10,000 individuals and in decline (Woinarski *et al.* 2014). The Bilby inhabits spinifex on plains and alluvial areas, mulga on ridges and rises and tussock grasslands on uplands and hills (Pavey 2006). Current threats to the Bilby in the northern part of its range include too-frequent fires and introduced herbivores and water-points (TSSC 2016b). Potential threats include predation by cats and foxes, land clearing and mining developments (TSSC 2016b). As the Bilby can move its home range in response to the changing availability of food (Van Dyck and Strahan 2008), they may not always be present despite suitable habitat being available. There are records of the Bilby within 50km of the study area on DBCA's Threatened and Priority Fauna Database (Figure 9), although the nearest records, 25km southwest and 30km west, are from 1984. The Alluvial Plain habitat may potentially support the Bilby, although the likelihood is low.

The **Pilbara Leaf-nosed Bat** requires warm, humid daytime roost sites and forages in gorges, along watercourses and over low Spinifex-covered hills (TSSC 2016d). The Pilbara Leaf-nosed Bat is likely to forage throughout the study areas, particularly along major creeklines. When foraging it typically flies very low to the ground, so it is vulnerable to road mortalities (Van Dyck and Strahan 2008). Shallow caves and simple vertical shafts are unlikely roost sites, as they are restricted to sites that maintain warm, humid conditions all year, usually deep within a mine or cave structure, and often over pools of water (Armstrong 2001). Critical roosting habitat includes permanent diurnal roosts (likely to be maternity roosts), non-permanent diurnal roosts that may support part of the breeding cycle and transitory diurnal roosts that are used outside of the breeding season. Pilbara Leaf-nosed Bats also use caves as nocturnal refuges for resting and feeding, but these are not used during the day for roosting and are not considered critical habitat (TSSC 2016d).

No Pilbara Leaf-nosed Bats were recorded in the Lamb Creek portion of the Study Area in 2012 (Rapallo 2012), however, there are records of Pilbara Leaf-nosed Bat in the surrounding area on DBCA's Threatened and Priority Fauna Database (Figure 9). The greatest concentration of records are around Koodaideri, about 29km north of the Study Area, and this site is thought to contain a potential roost site in an old mine adit. This species is likely to occur in the Study Area, at least as a foraging visitor, and roosting sites are potentially present in the Rocky Ridge and Gorge habitat.

The **Ghost Bat** is a large carnivorous bat that occurs across northern Australia. Though not recorded during the current survey, this species has been recorded across the Study Area on previous surveys (Figure 18). The Pilbara population has been estimated at up to 2000 individuals, with the Hamersley subpopulation (of which any colony in the Study Area is a part) comprising 350 individuals (TSSC 2016a), though this species also occurs across north and north-east Australia with the total population estimated at about 10,000 individuals (Woinarski *et al.* 2014, TSSC 2016a). Ghost Bats roost in both natural structures (such as caves), and old mine shafts. Intermittent roosts used by a few individuals, and may be relatively shallow caves, rock crevices or smaller mines (Armstrong and Anstee 2000, Woinarski *et al.* 2014). In the Hamersley Range, these colonies are usually small at less than 20 individuals (TSSC 2016a). Maternity roosts are situated in caves with a high relative humidity, often with a small entrance opening into a larger chamber. Deep mines are also known to be maternity roosts, including those at Bamboo Creek Mine in the Marble Bar shire (Armstrong and Anstee 2000). Ghost Bats are threatened by loss of roosting habitat (mostly in the Pilbara), disturbance at roost sites, degradation of foraging habitat, mortality on barbed wire fences near roost sites and poisoning by Cane Toads (Woinarski *et al.* 2014, TSSC 2016a).

The Ghost Bat was recorded in the Lamb Creek portion of the Study Area in 2012, with five bats observed in one cave and two in another (Figure 6, Rapallo 2012). It was also noted that there were other cave systems present that could not be searched for safety or access reasons (Rapallo 2012), and no search for caves has been undertaken in the eastern portion of the Study Area. The Rocky Ridge and Gorge habitat potentially contains caves that may be used by Ghost Bats. Any bats present are likely to move between caves both inside and outside the Study Area, according to prevailing weather conditions. There are many records of Ghost Bats in the surrounding area on DBCA's Threatened and Priority Fauna Database (Figure 9), particularly in the vicinity of the Area C Mine. The Study Area potentially provides critical roosting habitat and possibly breeding habitat for the Ghost Bat.

Priority Species	
<p>Brush-tailed Mulgara This species is listed as Priority 4 by DBCA.</p>	<i>Dasyercus blythi</i>
<p>Long-tailed Dunnart This species is listed as Priority 4 by DBCA.</p>	<i>Sminthopsis longicaudata</i>
<p>Lakeland Downs Mouse This species is listed as Priority 4 by DBCA.</p>	<i>Leggadina lakedownensis</i>
<p>Western Pebble-mound Mouse This species is listed as Priority 4 by DBCA.</p>	<i>Pseudomys chapmani</i>

The **Brush-tailed Mulgara** occurs across inland Australia, favouring Spinifex grasslands but also occurring in habitats adjacent to these (Woinarski *et al.* 2014). Although the taxonomic confusion between this species and the Crest-tailed Mulgara (*Dasycercus cristicauda*) has been resolved, there is a legacy of old records that cannot be reliably attributed to either species (Woinarski *et al.* 2014). However, it is currently considered that all records in the Pilbara Bioregion are of the Brush-tailed Mulgara. The population is considered to be large and at most slightly declining, and therefore is listed as of 'Least Concern' in the Action Plan for Australian Mammals 2012 (Woinarski *et al.* 2014). There are records of the Brush-tailed Mulgara 28km east and 27km north of the Study Area on DBCA's Threatened and Priority Fauna Database (Figure 9), from 2014 and 2017 respectively. The Alluvial Plain habitat may support this species.

The **Long-tailed Dunnart** inhabits rocky ranges, breakaways and scree in the Pilbara and adjacent arid inland areas (Van Dyck and Strahan 2008). It has also been recorded from open country with a stony surface (Van Dyck and Strahan 2008). Although there are no nearby records, the Study Area contains suitable habitat (Rocky Ridge and Gorge, Rocky Hills and Plateaus) and is within the known range of this species.

The **Lakeland Downs Mouse** favours cracking and gilgaied clays (Gibson and McKenzie 2009), but it also occurs in a range of other habitats, including spinifex grasslands and stony ranges (Van Dyck and Strahan 2008). Populations of this species can fluctuate dramatically (Van Dyck and Strahan 2008), so it may be common in one year and virtually absent in another. The Lakeland Downs Mouse has been recorded nearby on DBCA's Threatened and Priority Fauna Database, with the closest record 10km west of the Study Area (Figure 9). The Lakeland Downs Mouse potentially occurs in the Study Area where it is most likely to occur in the Drainage Line and Alluvial Plains habitats.

The **Western Pebble-Mound Mouse** occurs in the ranges of the central and southern Pilbara, and the smaller ranges of the Little Sandy Desert. It inhabits gentle stony slopes where it constructs its pebble mounds, often situating them near *Acacia*-lined minor drainages (Van Dyck and Strahan 2008). This species has disappeared from parts of its range along the Pilbara coast, Murchison and Gascoyne, possibly due to the fox and introduced herbivores (Van Dyck and Strahan 2008). Despite this, mining is not considered to be a threatening process for this species, as its habitat is relatively widespread (Woinarski *et al.* 2014). A total of 35 mounds of this species were found in the Lamb Creek portion of the Study Area in 2012, most of which were deemed to be active (Figure 6, Rapallo 2012). There are also many records of this species in the surrounding area on DBCA's Threatened and Priority Fauna Database (Figure 9). The Western Pebble-mound Mouse is likely to occur throughout the Stony Plain habitat and gently sloping parts of the Rocky Hills and Plateaus habitat in the Study Area.

6. Discussion

6.1 Faunal Assemblage

The faunal assemblage of the Study Area is likely to be diverse, particularly in reptiles. Although many of the species that occur are widely distributed through arid Australia, there is also a suite of species endemic to the rocky uplands of the Pilbara Bioregion. The predicted faunal assemblage includes up to nine frogs, 112 reptiles, 130 birds, 36 native mammals and nine introduced mammals. The 2012 fauna survey over the Lamb Creek portion of the Study Area resulted in an observed assemblage thus far of two frogs, 58 reptiles, 76 birds, 20 native mammals and two introduced mammals (Rapallo 2012).

6.2 Conservation Significant Fauna

Twenty conservation significant fauna have been recorded or potentially occur in the Study Area, as summarised in Table 6. The species have been grouped into their conservation significance categories and summarised below.

1. Threatened species.

Seven threatened species potentially occur in the Study Area, of which three were recorded at Lamb Creek in 2012 (Figure 6):

- Pilbara Olive Python (*Liasis olivaceus barroni*) – **Recorded at Lamb Creek**
- Grey Falcon (*Falco hypoleucos*)
- Night Parrot (*Pezoporus occidentalis*)
- Northern Quoll (*Dasyurus hallucatus*) – **Recorded at Lamb Creek**
- Bilby (*Macrotis lagotis*)
- Pilbara Leaf-nosed Bat (*Rhinioncteris aurantia*)
- Ghost Bat (*Macroderma gigas*) - **Recorded at Lamb Creek**

Threatened species are those that are considered in danger of extinction as their populations have declined and/or are still declining, and their total population size is small and/or fragmented or geographically restricted. Sites that support these species may be important for their long-term conservation, particularly if the site supports a resident breeding population.

The Pilbara Olive Python, Northern Quoll and Ghost Bat are all known to occur in or near the Study Area and the Pilbara Leaf-nosed Bat is likely to occur. The Study Area is likely to provide critical habitat to one or more of these species. These species are all reliant on the Rocky Ridge and Gorge habitat, with the bats requiring caves for roosting and breeding. It is currently unknown whether important caves are present. The Drainage Line habitat may also provide important habitat, particularly where waterholes are present in rocky areas, as sites for foraging pythons or bats.

Table 6. Summary of Potentially Occurring Conservation Significant Fauna.

Key to status: Cr = Critically Endangered, En = Endangered, Vu = Vulnerable, Mi = Migratory, Sp = Specially Protected, P1 – P4 = Priority 1 – 4, LS = Locally Significant.

Species or Assemblage	Conservation Status			Likelihood of Occurrence	Explanatory Notes
	EPBC Act	BC Act	DBCA Priority		
Threatened Species					
<i>Pezoporus occidentalis</i> Night Parrot	En	Cr		Low (?)	Little data are available on this elusive species. May occur if large spinifex clumps are present.
<i>Dasyurus hallucatus</i> Northern Quoll	En	En		Known to occur	Recorded at Lamb Creek (Rapallo 2012), see Figure 6.
<i>Macrotis lagotis</i> Bilby	Vu	Vu		Low	Few records in surrounding area but potentially suitable alluvial plains habitat is present.
<i>Rhinonictis aurantia</i> Pilbara Leaf-nosed Bat	Vu	Vu		High	Known from the surrounding area, potentially suitable habitat is present.
<i>Macroderma gigas</i> Ghost Bat	Vu	Vu		Known to occur	Recorded at Lamb Creek (Rapallo 2012), see Figure 6.
<i>Liasis olivaceus barroni</i> Pilbara Olive Python	Vu	Vu		Known to occur	Recorded at Lamb Creek (Rapallo 2012), see Figure 6.
<i>Falco hypoleucos</i> Grey Falcon		Vu		High	Only likely to occur as a foraging visitor, breeding habitat absent.
Migratory Species					
<i>Charadrius veredus</i> Oriental Plover	Mi	Mi		Moderate	Only likely to be a non-breeding visitor in very low numbers.
<i>Tringa nebularia</i> Common Greenshank	Mi	Mi		Moderate	Only likely to be a non-breeding visitor in very low numbers.
<i>Tringa hypoleucos</i> Common Sandpiper	Mi	Mi		Moderate	Only likely to be a non-breeding visitor in very low numbers.
<i>Apus pacificus</i> Fork-tailed Swift	Mi	Mi		Known to occur	Largely aerial in Australia. Recorded at Lamb Creek (Rapallo 2012), see Figure 6.
Specially Protected					
<i>Falco peregrinus</i> Peregrine Falcon		Sp		High	Common in surrounding area, potentially suitable rocky cliff habitat is present.
Priority Species					
<i>Anilius ganei</i> Gane's Blind Snake			P1	High	Known from the surrounding area and suitable rocky habitats are likely to occur.

Table 6. (cont.).

Species or Assemblage	Conservation Status			Likelihood of Occurrence	Explanatory Notes
	EPBC Act	BC Act	DBCA Priority		
<i>Ctenopus uber johnstonei</i> Spotted Ctenopus (northeast)			P2	Low	Few records in surrounding area, only scattered records in the Pilbara.
<i>Lerista macropisthopus remota</i> Unpatterned Robust Slider			P2	Moderate	Known from the surrounding area and suitable Mulga habitats are likely to occur.
<i>Underwoodisaurus seorsus</i> Pilbara Barking Gecko			P2	High	Common in surrounding area and suitable rocky habitats are likely to occur.
<i>Dasycercus blythi</i> Brush-tailed Mulgara			P4	Low	Few records in surrounding area but potentially suitable alluvial plains habitat is present.
<i>Sminthopsis longicaudata</i> Long-tailed Dunnart			P4	Moderate	Although there are no nearby records, the Study Area contains suitable rocky habitat and is within the known range of this species.
<i>Leggadina lakedownensis</i> Lakeland Downs Mouse			P4	Moderate	This species favours cracking clays, and it is unknown whether this habitat occurs in unmapped areas. It is known from the surrounding area and also uses other habitats.
<i>Pseudomys chapmani</i> Western Pebble-mound Mouse			P4	Known to occur	Recorded at Lamb Creek (Rapallo 2012), see Figure 6.

Although likely to occur, the Study Area is unlikely to provide important habitat for the Grey Falcon, as it forages over a large area and breeding habitat is absent. The Bilby has only a low likelihood of occurring, and even if present this species is mobile and wide-ranging. The likely status of the Night Parrot in the Study Area is difficult to assess, as this species is represented very few records in the region and very few records overall, so its pattern of distribution and abundance are not clear.

2. Migratory species.

Four Migratory species potentially occur in the Study Area, of which one was recorded at Lamb Creek in 2012 (Figure 6):

- Oriental Plover (*Charadrius veredus*)
- Common Sandpiper (*Tringa hypoleucos*)
- Common Greenshank (*Tringa nebularia*)
- Fork-tailed Swift (*Apus pacificus*) - **Recorded at Lamb Creek**

Migratory species are not always present at a site, but a particular site may have significance as a seasonal or ephemeral foraging, breeding or shelter area. Impacts to these sites may then impact the population both within the site and further afield. It is unlikely that the Study Area provides important habitat for migratory species, although low numbers of individuals may occur at times.

3. Specially Protected species.

A single Specially Protected species potentially occurs in the Study Area:

- Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is likely to occur and may breed in the Rocky Ridge and Gorge habitat. Although the Study Area provides habitat for this species, its overall population is large and secure.

4. Priority species

Eight Priority species potentially occur in the Study Area, of which one was recorded at Lamb Creek in 2012 (Figure 6):

- Spotted Ctenotus (northeast) (*Ctenotus uber johnstonei*)
- Unpatterned Robust Slider (*Lerista macropisthopus remota*)
- Gane's Blind Snake (*Anilius ganei*)
- Pilbara Barking Gecko (*Underwoodisaurus seorsus*)
- Brush-tailed Mulgara (*Dasycercus blythi*)
- Long-tailed Dunnart (*Sminthopsis longicaudata*)
- Lakeland Downs Mouse (*Leggadina lakedownensis*)
- Western Pebble-mound Mouse (*Pseudomys chapmani*) – **Recorded at Lamb Creek**

Priority species include those that may be Threatened, but are data deficient so their status cannot be determined (Priority 1, 2 and 3) and species that are adequately known but may be rare, near Threatened or recently downgraded from Threatened (Priority 4). Priority 1, 2 and 3 species are in need of further survey to provide data to determine their status and Priority 4 fauna are in need of monitoring.

All four reptiles listed above (Spotted Ctenotus, Unpatterned Robust Slider, Gane's Blind Snake and Pilbara Barking Gecko) are considered data deficient and are known from relatively few records across the Pilbara. Consequently, it is difficult to determine their likely status in the Study Area. However, Gane's Blind Snake and the Pilbara Barking Gecko are known from several records in the surrounding area (Figure 7) and are considered likely to occur in the Rocky Ridge and Gorge habitat in the Study Area. The remaining species may occur, but the likelihood is low for the Spotted Ctenotus and moderate for the Unpatterned Robust Slider.

All four mammals listed above are Priority 4, with the Western Pebble-mound Mouse known from the Study Area and considered likely to be relatively common in suitable stony habitats both within Study Area and in the surrounding region. The Long-tailed Dunnart is moderately likely to occur in the Rocky Ridge and Gorge habitat and the Lakeland Downs Mouse is moderately likely to occur on the Alluvial Plains or Drainage Lines. The Brush-tailed Mulgara may occur on the Alluvial Plains, but the likelihood is low.

5. Locally Significant Fauna

No locally significant fauna were identified in this assessment.

6.3 Important Habitats

All habitats have some importance in that they support native fauna, however, habitats may be of particular importance if they:

- support very diverse or unique faunal assemblages
- are restricted or rare in the region (and thus the faunal assemblages are restricted or rare)
- are refugia (e.g. from drought or fire)
- provide ecological linkage
- support conservation significant fauna

Of the habitats in the Study Area, the Rocky Ridge and Gorge habitat is considered the most important as it provides potential habitat for several Threatened and Priority fauna species and is limited in extent in the region compared with habitats such as stony plains. This habitat potentially provides caves, cracks and crevices for shelter, breeding and roosting sites for a range of native fauna.

The Drainage Line habitat is also important, as though it is widespread in the region, it is likely to support greater abundance and diversity of fauna than surrounding habitats and may provide a corridor for fauna movement. Permanent and semi-permanent waterpools are likely to provide water for fauna in an otherwise relatively dry landscape.

7. Risk Assessment

7.1 Adequacy of Available Data

This fauna risk assessment was performed entirely using data available in the literature, and no fieldwork was undertaken. The Study Area is in a relatively well-studied region, with many fauna surveys in the surrounding areas contributing to the fauna records available on databases. Within the Study Area itself, only the western Lamb Creek portion of the Study Area has been comprehensively surveyed. While assumptions on the likely fauna habitats and assemblages of the eastern Wedge portion of the Study Area can be made, there is a lack of data on the presence of key important habitat elements:

- Caves that may support roosting by the Pilbara Leaf-nosed Bat or Ghost Bat
- Permanent or semi-permanent waterholes that may support the Pilbara Olive Python
- Large/mature Spinifex hummocks that may support breeding or roosting by the Night Parrot

In addition, the presence of several Threatened species (Northern Quoll, Pilbara Leaf-nosed Bat, Ghost Bat, Pilbara Olive Python, Bilby and Night Parrot) have not yet been surveyed for in the Wedge portion of the Study Area. Surveys using the recommended methods for each species (e.g. as provided in DSEWPaC 2011b, DoE 2016, DPAW 2017 and DEWHA 2010a) will give a better understanding of the importance of the Study Area to each species and whether an important population is present. Such information is vital to an accurate risk assessment. In this case, the precautionary assumption was made; that populations of all Threatened species potentially present are actually present, and that all rocky areas potentially include caves and waterholes.

7.2 Approach

The risk assessment was necessarily high level as the area of impact within the Study Area has not been quantified, and baseline fauna surveys have not been completed across the entire Study Area. Therefore, the presence of fauna and fauna habitats has been inferred from the desktop review and the likely impacts have been inferred as those normally associated with mineral exploration.

The risk assessment process involved the following stages:

1. Identification of the faunal assemblage, conservation significant fauna species and their likelihood of occurrence. This was undertaken as part of the desktop assessment (see Table 6, section 6).
2. Identification of potential impacts on each conservation significant fauna species.

3. Identification of the risk of impact. The risk was categorized as:

- **Low** – species has only a low likelihood of occurring and/or the habitats present are not important for the species and/or the potential impacts are unlikely to result in the loss of individuals or decline in the local population of the species.
- **Moderate** – species moderately likely to occur and/or the habitats present are somewhat important for the species and/or the potential impacts may result in the loss of individuals or decline in the local population of the species.
- **High** – species highly likely or known to occur and/or the habitats present are important habitat (e.g. breeding habitat) for the species and/or the potential impacts are likely to result in the loss of individuals or decline in the local population of the species.

4. Identification of management actions.

7.3 Potential Impacts on Vertebrate Fauna

Potential impacts may be direct (e.g. habitat loss, accidental mortalities) or indirect (e.g. noise and vibration in adjacent habitat areas). As 'fauna' are a diverse group, the potential impact of mineral exploration is likely to vary between species. Potential impacts of the proposed mineral exploration on terrestrial fauna include:

- **Habitat loss**

Land clearing is recognised as a Key Threatening Process under the EPBC Act. Loss of habitat is likely to be the most significant direct impact on fauna in the Study Area. The loss of some habitat features may be permanent, when structures such as rocky outcrops or caves cannot be recreated through rehabilitation. For some species habitat loss may be temporary and these species may return to sites post-rehabilitation.

- **Direct mortality**

Some direct mortality is likely to occur while clearing, as although some species can move away, many are either too small or prefer to hide. Fauna may become trapped in bins, skips, artificial water sources, steep-sided trenches or un-capped drill-holes. Fauna may shelter in pipes or other construction materials and become trapped or killed. Barbed-wire fences may cause entanglement and mortalities of flying bats.

- **Road mortalities**

Loss of individual fauna to road mortalities. Many species have the potential to interact fatally with traffic, including nocturnal species crossing roads, low-flying bats, reptiles crossing/basking on tracks and kangaroos crossing tracks.

- **Habitat degradation**

Degradation of surrounding habitats may occur through the potential introduction of weeds, dust, trampling or crushing of vegetation with vehicles, altered fire regimes or altered hydrological regimes. Where it impacts surrounding habitats, (e.g. roadsides), dust may reduce the potential of that habitat to supply food and shelter to fauna. Dust in waterbodies, such as water pools on drainage lines, may impact water quality and reduce the potential of these to support fauna, including species such as the Pilbara Olive Python. Habitats modified by weeds potentially support fewer fauna species. Weeds may prevent regeneration of fauna habitats after fire or rehabilitation. Although fire is a natural part of the ecosystem, fires that are too frequent, too intense or very widespread can impact fauna by removing shelter (such as old-growth spinifex) and reducing productivity. While fauna populations can recover after fire as habitats re-generate, frequent fires may prevent this, causing local extinction. Altered surface water flows or run-off containing sediment may impact important habitats in drainage lines. Changes to underground water levels may impact the humidity of important bat roost caves.

- **Increase in feral fauna**

Feral fauna such as cats and foxes may increase in abundance through provision of water that collects in sumps, food scraps or increased access along tracks. Introduced predators prey on a variety of native fauna. Predation by feral cats is identified as a threatening process for significant fauna species, including the Northern Quoll and Pilbara Olive Python (particularly juveniles).

- **Disturbance**

Disturbance to surrounding habitats may be from light, noise, or vibration (e.g. from drilling). Exposure to artificial light sources has the potential to impact fauna behaviour, including foraging and breeding behaviours. It may lead to fauna being attracted to light sources (where they may then be impacted by other processes) or preventing fauna from accessing otherwise suitable habitats. At its lowest level, noise and vibration (e.g. from vehicle movements and generators) may cause fauna to avoid areas of otherwise suitable habitat. This may occur both within the project footprint and in adjacent habitats, though the overall effect on populations is not likely to be large. Drilling and blasting may also result in larger impacts such as the collapse or abandonment of bat roosts and abandonment of nests and/or eggs, burrows and/or young.

The potential impacts of mineral exploration on each conservation significant fauna species are given in Table 7.

7.4 Management Actions

Where relevant, management actions for each conservation significant fauna species are given in Table 7. The following broad management recommendations focus reducing the impact on the terrestrial fauna assemblage, by protecting of important fauna habitats, avoiding direct mortality of fauna and minimising indirect impacts. It is recognised that some of these strategies are already in common use in the mining and resource sectors.

- **Minimise habitat loss**
 - Minimise overall clearing footprint.
 - Avoid clearing Rocky Ridge and Gorge habitat.
 - Avoid clearing and/or downstream impacts on Drainage Line habitats.
 - Avoid clearing long-unburnt spinifex with large spinifex hummocks (most likely to occur on the Alluvial Plains habitat).
 - Progressively rehabilitate tracks and other cleared areas when no longer required.

- **Minimise direct mortality of fauna**
 - Where possible, avoid clearing during peaks of breeding activity (i.e. immediately after the wet season).
 - Undertake land clearing progressively to allow fauna to escape away from the direction of clearing.
 - Ensure all drill-holes are capped.
 - Avoid the creation of steep-sided holes (e.g. sumps), or ensure they are fitted with egress matting or another method of escape to avoid fauna entrapment.
 - Avoid the use of barbed wire fencing.
 - Ensure that staff trained in fauna handling are on-site in order to remove fauna that may become trapped.

- **Minimise habitat degradation**
 - Prohibit driving over uncleared habitat areas.
 - Prepare and implement a strategy to reduce the risk of fire in long-unburnt spinifex habitats.
 - Prepare and implement a strategy to prevent the introduction of new weeds and spread of existing weeds.
 - Employ dust suppression measures where necessary to prevent excess dust settling on adjacent habitat areas.

- **Minimise road mortalities**
 - Avoid driving between dusk and dawn.
 - Maintain low speed limits on access tracks.

- **Minimise increase in feral predators such as cats or foxes**
 - Responsibly dispose of all food waste so it cannot be accessed by fauna.
 - Avoid providing artificial water sources.
 - Educate all personnel that feeding of fauna is prohibited.
 - Targeted control (e.g. shooting or trapping) where increased presence of feral fauna is recorded.

- **Minimise disturbance to adjacent uncleared habitat areas.**
 - Minimise the use of artificial lighting, or when required for safety, avoid light spill onto important habitats such as water pools or rocky outcrops.
 - Avoid drilling close to Rocky Ridge and Gorge habitat areas when Northern Quoll have large young in the den (April to September).
 - Prohibit entry to caves.

7.5 Conclusions

Conducting mineral exploration in the Lamb Creek and Wedge Study Area will result in direct mortality of fauna through land clearing, loss of habitat and indirect impacts such as habitat disturbance or increase in feral predators.

The risk of an impact causing the loss or long-term decline of a fauna population is 'low' for the majority of conservation significant fauna species.

The risk of an impact on the local populations of the Long-tailed Dunnart, Gane's Blind Snake and Pilbara Barking Gecko is considered to be 'moderate'. These are all Priority species and are also reliant on the Rocky Ridge and Gorge habitat.

The risk of an impact on the local populations of the Northern Quoll, Pilbara Olive Python, Ghost Bat and Pilbara Leaf-nosed Bat is considered to be 'high'. These species are all Threatened species listed as Matters of National Environmental Significance (MNES) under the EPBC Act, and are reliant on the Rocky Ridge and Gorge habitat.

Implementing the recommended management actions, particularly in regard to avoiding Rocky Ridge and Gorge habitat and Drainage Line habitats, is likely to result in a low residual risk for all species. However, if the management recommendations cannot be fully implemented, particularly where there is loss or disturbance of Rocky Ridge and Gorge habitat and Drainage Line habitats, a risk of an impact will remain.

Note that as the Study Area has not yet been fully surveyed for terrestrial fauna to the standards required by EPA (2016a) and EPA and DEC (2010), the status of conservation significant species in the Study Area has yet to be fully investigated. As these surveys are completed, the additional data on the presence and extent of fauna populations and their habitats may result in changes to the predicted risk of impact.

Table 7. Risk Assessment.

Key to status: Cr = Critically Endangered, En = Endangered, Vu = Vulnerable, Mi = Migratory, Sp = Specially Protected, P1 – P4 = Priority 1 – 4,

Species	Conservation Status			Likelihood of Occurrence	Potential Impacts	Risk of impact on local population	Management actions
	EPBC Act	BC Act	DBCA Priority				
Threatened Species							
<i>Pezoporus occidentalis</i> Night Parrot	En	Cr		Low (?)	<p>Habitat loss – loss of large Spinifex clumps in the Alluvial Plain habitat that may be roosting/breeding habitat.</p> <p>Habitat degradation – accidental fires may destroy areas of old-growth spinifex.</p> <p>Increased feral predators – cats or foxes may prey on this species.</p>	<p>Low</p> <p>Species is extremely uncommon and has a low likelihood of occurring anywhere. The habitats present are likely to be widespread in the Pilbara region.</p>	<p>Avoid clearing areas of old-growth Spinifex (large spinifex hummocks) on Alluvial Plains.</p> <p>Implement strategies to reduce the risk of fire in long-unburnt spinifex habitats.</p>
<i>Dasyurus hallucatus</i> Northern Quoll	En	En		Known to occur	<p>Habitat loss – loss of critical shelter habitat (Rocky Ridge and Gorge).</p> <p>Disturbance – dust, noise and movement when drilling or clearing near Rocky shelter habitat.</p> <p>Direct mortality – death of individuals when clearing rocky shelter habitat.</p> <p>Road mortality – death of individuals on roads at night.</p> <p>Increased feral predators – cats or foxes may prey on this species.</p>	<p>High</p> <p>Species is known to occur and critically important rocky shelter habitat is potentially present. Any loss of rocky ridge and gorge habitat is likely to result in a decline in the local population.</p>	<p>Avoid clearing Rocky Ridge and Gorge habitat.</p> <p>Avoid disturbance adjacent to Rocky Ridge and Gorge habitat when there may be young in dens (April – September).</p> <p>Limit driving between dusk and dawn.</p> <p>Maintain low speed limits on access tracks.</p> <p>Implement controls on the increase of feral predators.</p>

Table 7 (cont.)

Species	Conservation Status			Likelihood of Occurrence	Potential Impacts	Risk of impact on local population	Management actions
	EPBC Act	BC Act	DBCA Priority				
<i>Macrotis lagotis</i> Bilby	Vu	Vu		Low	Habitat loss – loss of Alluvial Plains and Drainage Line habitats. Road mortality – death of individuals on roads at night.	Low This species has a low likelihood of occurring, and although some habitat may be lost, this wide-ranging species is very mobile, each individual covering a large area. Any impacts are unlikely to be long-lasting.	Minimise the clearing footprint. Limit driving between dusk and dawn Maintain low speed limits on access tracks.
<i>Rhinonictes aurantia</i> Pilbara Leaf-nosed Bat	Vu	Vu		Moderate	Habitat loss – loss of critical roosting and/or breeding habitat in caves. Disturbance – Pilbara Leaf-nosed Bats are highly susceptible to disturbance in caves which may lead to abandonment of young. Light spill may change the behaviour of bats. Road mortality – death of individuals on roads at night.	High Species is known to occur in the region and critical roosting habitat is potentially present. Loss of an important roosting site is likely to result in a decline in the local population.	Avoid clearing Rocky Ridge and Gorge habitat. Prohibit entry to caves. Minimise light spill onto adjacent habitat areas.
<i>Macroderma gigas</i> Ghost Bat	Vu	Vu		Known to occur	Habitat loss – loss of critical roosting and/or breeding habitat in caves. Disturbance - Ghost Bats are highly susceptible to disturbance in caves which may lead to abandonment of young. Direct mortality – entanglement in barbed wire or fencing.	High Species known to occur and roosting has been observed in caves in the Study Area. Likely to be roosting habitat present in unrecorded caves. Loss of an important roosting site is likely to result in a decline in the local population.	Avoid clearing Rocky Ridge and Gorge habitat. Prohibit entry to caves. Avoid use of barbed wire.

Table 7. (cont.)

Species	Conservation Status			Likelihood of Occurrence	Potential Impacts	Risk of impact on local population	Management actions
	EPBC Act	BC Act	DBCA Priority				
<i>Liasis olivaceus barroni</i> Pilbara Olive Python	Vu	Vu		Known to occur	<p>Habitat loss – loss of critical foraging habitat (permanent and semi-permanent waterholes, Rocky Ridge and Gorge habitat, particularly where adjacent to water).</p> <p>Direct mortality – death of individuals when clearing rocky shelter habitat.</p> <p>Road mortality – death of individuals on roads at night.</p> <p>Increased feral predators – cats or foxes may prey on this species, particularly on juveniles.</p>	<p>High</p> <p>Species is known to occur in the area and critical habitat is likely to be present. Loss of critical rocky shelter and foraging (waterhole) habitat is likely to result in a decline in the local population.</p>	<p>Avoid clearing Rocky Ridge and Gorge habitat.</p> <p>Avoid altering hydrology of drainage lines, and/or downstream impacts such as sediment run-off.</p> <p>Limit driving between dusk and dawn</p> <p>Maintain low speed limits on access tracks.</p> <p>Implement controls on the increase of feral predators.</p>
<i>Falco hypoleucos</i> Grey Falcon		Vu		High	<p>Habitat loss – loss of foraging habitat on Stony Plains or Alluvial Plains.</p>	<p>Low</p> <p>Although this species is known from the region, the Study Area is unlikely to provide important habitat. Any foraging habitat present is likely to be part of a much larger foraging range for very few birds, and no breeding habitat is likely to occur.</p>	None required.

Table 7. (cont.)

Species	Conservation Status			Likelihood of Occurrence	Potential Impacts	Risk of impact on local population	Management actions
	EPBC Act	BC Act	DBCA Priority				
Migratory Species							
<i>Charadrius veredus</i> Oriental Plover	Mi	Mi		Moderate	None likely.	Low The habitats of the Study Area are unlikely to be of importance to this species, and only a few individuals are likely to occur on occasion.	None required.
<i>Tringa nebularia</i> Common Greenshank	Mi	Mi		Moderate	Habitat loss – loss of permanent and semi-permanent waterholes in the Drainage Line habitat.	Low The habitats of the Study Area are unlikely to be of importance to this species, and only a few individuals are likely to occur on occasion.	Avoid altering hydrology of drainage lines, and/or downstream impacts such as sediment run-off.
<i>Tringa hypoleucos</i> Common Sandpiper	Mi	Mi		Moderate	Habitat loss – loss of permanent and semi-permanent waterholes in the Drainage Line habitat.	Low The habitats of the Study Area are unlikely to be of importance to this species, and only a few individuals are likely to occur on occasion.	Avoid altering hydrology of drainage lines, and/or downstream impacts such as sediment run-off.
<i>Apus pacificus</i> Fork-tailed Swift	Mi	Mi		Known to occur	None likely.	Low This species is thought to be entirely aerial in Australia and is not dependent on habitats in the Study Area.	None required.

Table 7. (cont.)

Species	Conservation Status			Likelihood of Occurrence	Potential Impacts	Risk of impact on local population	Management actions
	EPBC Act	BC Act	DBCA Priority				
Specially Protected							
<i>Falco peregrinus</i> Peregrine Falcon		Sp		High	Habitat loss – loss of potentially nesting habitat in the Rocky Ridge and Gorge habitat.	Low Although likely to occur, this species has a population that is large and secure, and the Study Area is unlikely to support more than a few individuals.	Avoid clearing Rocky Ridge and Gorge habitat.
Priority Species							
<i>Ctenotus uber johnstonei</i> Spotted Ctenotus (northeast)			P2	Low	Habitat loss – loss of habitat, but the habitat requirements of this species are not well known. Direct mortality – during land clearing.	Low This species has a low likelihood of occurring, and as it is not associated with rocky areas or drainage, its habitat is unlikely to be restricted.	Minimise the clearing footprint.
<i>Lerista macropisthopus remota</i> Unpatterned Robust Slider			P2	Moderate	Habitat loss – loss of Mulga woodland habitat. Direct mortality – during land clearing.	Low Although this species may occur, its Mulga Plains habitat is not likely to be widespread in the Study Area, occurring only on the western edge.	Minimise the clearing footprint.

Table 7. (cont.)

Species	Conservation Status			Likelihood of Occurrence	Potential Impacts	Risk of impact on local population	Management actions
	EPBC Act	BC Act	DBCA Priority				
<i>Anilius ganei</i> Gane's Blind Snake			P1	Moderate	Habitat loss – loss of Rocky Ridge and Gorge habitat. Direct mortality – during land clearing.	Moderate This species is known to occur in the surrounding area, has a small overall range and is reliant on rocky habitats in the Hamersley Ranges.	Avoid clearing Rocky Ridge and Gorge habitat.
<i>Underwoodisaurus seorsus</i> Pilbara Barking Gecko			P2	High	Habitat loss – loss of Rocky Ridge and Gorge habitat. Direct mortality – during land clearing. Increased feral predators – cats or foxes may prey on this species.	Moderate This species is known to occur in the surrounding area, has a small overall range and is reliant on rocky habitats in the Hamersley Ranges.	Avoid clearing Rocky Ridge and Gorge habitat. Implement controls on the increase of feral predators.
<i>Dasycercus blythi</i> Brush-tailed Mulgara			P4	Low	Habitat loss – loss of Alluvial Plains habitat. Increased feral predators – cats or foxes may prey on this species.	Low This species has been rarely recorded in the region, has a low likelihood of occurring and its Alluvial Plains habitat is likely to be limited in extent inside the Study Area.	Minimise the clearing footprint. Implement controls on the increase of feral predators.

Table 7. (cont.)

Species	Conservation Status			Likelihood of Occurrence	Potential Impacts	Risk of impact on local population	Management actions
	EPBC Act	BC Act	DBCA Priority				
<i>Sminthopsis longicaudata</i> Long-tailed Dunnart			P4	Moderate	<p>Habitat loss – loss of Rocky Ridge and Gorge habitat.</p> <p>Direct mortality – during land clearing of rocky shelter habitat.</p> <p>Increased feral predators – cats or foxes may prey on this species.</p>	<p>Moderate</p> <p>Although not recorded in the surrounding area, the Study Area is likely to contain suitable rocky habitats for this species.</p>	<p>Avoid clearing Rocky Ridge and Gorge habitat.</p> <p>Implement controls on the increase of feral predators.</p>
<i>Leggadina lakedownensis</i> Lakeland Downs Mouse			P4	Moderate	<p>Habitat loss – loss of Alluvial Plains or Drainage Line habitat.</p> <p>Direct mortality – during land clearing.</p> <p>Increased feral predators – cats or foxes may prey on this species.</p>	<p>Low</p> <p>This species has not been commonly recorded in the region, its favoured habitat type (cracking clays) is unlikely to be present and as an irruptive species, any impacts are unlikely to long-lasting.</p>	<p>Minimise the clearing footprint.</p> <p>Implement controls on the increase of feral predators.</p>
<i>Pseudomys chapmani</i> Western Pebble-mound Mouse			P4	Known to occur	<p>Habitat loss – loss of Stony Plains habitat.</p> <p>Direct mortality – clearing of active pebble-mounds.</p> <p>Increased feral predators – cats or foxes may prey on this species.</p>	<p>Low</p> <p>Although this species is known to occur and habitat and individuals are likely to be impacted within the Study Area, this species is common within its habitat type and likely to be common in adjoining stony plain areas.</p>	<p>Minimise the clearing footprint.</p> <p>Avoid clearing active pebble mound mouse mounds.</p> <p>Implement controls on the increase of feral predators.</p>

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Appendices.

Appendix 1. Amphibians potentially occurring in the Study Area.

Key to records:

Lamb Creek = recorded in or near the study area in 2012 (Rapallo 2012).

Mining Area C = species recorded approx. 12km south at Mining Area C, 1999 – 2016 (Biologic 2017).

Yandicoogina = species recorded approx. 20km east at Yandicoogina 2008 – 2014 (Biota 2010, 2011b, 2014).

Koodaideri = species recorded approx. 27km north at Koodaideri, August 2010 or July 2011 (Biota 2011a, 2012).

West Angelas = species recorded approx. 30km southwest at West Angelas, 2012 – 2013 (Ecologia 2014).

Hope Downs = species recorded approx. 30km southeast on Hope Downs Infrastructure Options 1 or 6 (Ninox Wildlife Consulting 2009a, 2009b).

EPBC = modelled occurrence of species or species habitat in the area on the EPBC Protected Matters Search Tool.

DBCA = species recorded in the area on DBCA’s Threatened and Priority Fauna Database (DBCA 2020).

NatureMap = species recorded within 40km on NatureMap (DBCA 2007-).

Species	Conservation Status	Records								
		Other surveys						Databases		
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap
Pelodryadidae (tree frogs and water-holding frogs)										
Main’s Frog	<i>Cyclorana maini</i>	+	+	+			+			+
Western Water-holding Frog	<i>Cyclorana occidentalis</i>			+						+
Desert Tree Frog	<i>Litoria rubella</i>	+	+	+	+					+
Limnodynastidae (burrowing frogs)										
Centralian Burrowing Frog	<i>Platyplectrum spenceri</i>		+							
Northern Burrowing Frog	<i>Neobatrachus aquilonius</i>									
Shoemaker Frog	<i>Neobatrachus sutor</i>		+							
Desert Spadefoot	<i>Notaden nichollsi</i>									
Myobatrachidae (ground frogs)										
Pilbara Toadlet	<i>Uperoleia saxatilis</i>		+		+					
Gorge Toadlet	<i>Pseudophryne douglasi</i>		+							
# frog species expected:		9								

Appendix 2. Reptiles potentially occurring in the Study Area.

Key to records:

Lamb Creek = recorded in or near the study area in 2012 (Rapallo 2012).

Mining Area C = species recorded approx. 12km south at Mining Area C, 1999 – 2016 (Biologic 2017).

Yandicoogina = species recorded approx. 20km east at Yandicoogina 2008 – 2014 (Biota 2010, 2011b, 2014).

Koodaideri = species recorded approx. 27km north at Koodaideri, August 2010 or July 2011 (Biota 2011a, 2012).

West Angelas = species recorded approx. 30km southwest at West Angelas, 2012 – 2013 (Ecologia 2014).

Hope Downs = species recorded approx. 30km southeast on Hope Downs Infrastructure Options 1 or 6 (Ninox Wildlife Consulting 2009a, 2009b).

EPBC = modelled occurrence of species or species habitat in the area on the EPBC Protected Matters Search Tool.

DBCA = species recorded in the area on DBCA's Threatened and Priority Fauna Database (DBCA 2020).

NatureMap = species recorded within 40km on NatureMap (DBCA 2007-).

Species	Conservation Status	Records							
		Other surveys					Database		
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA
Cheloniidae Flat-shelled Turtle <i>Chelodina steindachneri</i>									
Carpodactylidae (knob-tailed geckoes) Smooth Knob-tailed Gecko <i>Nephurus levis</i> <i>Nephurus wheeleri</i> Pilbara Barking Gecko <i>Underwoodisaurus seorsus</i>									
	P	+	+			+			+
Diplodactylidae (ground geckoes) Clawless Gecko <i>Crenadactylus pilbarensis</i> Western Fat-tailed Gecko <i>Diplodactylus bilybara</i> Desert Fat-tailed Gecko <i>Diplodactylus laevis</i> Southern Pilbara Beak-faced Gecko <i>Diplodactylus savagei</i> <i>Diplodactylus pulcher</i> <i>Lucasium stenodactylum</i> <i>Lucasium wombeyi</i> Western Marbled Velvet Gecko <i>Oedura fimbria</i> Beaked Gecko <i>Rhynchoedura ornata</i> Jewelled Gecko <i>Strophurus elderi</i> Southern Phasmid Gecko <i>Strophurus jeanae</i> <i>Strophurus wellingtonae</i>									
		+							+
		?			?				?
		+	+			+	+		+
		+	+			+	+		+
		+	+	+	+	+	+		+
		+	+		+	+	+		+
		+	+		+	+	+		+
		+	+		+	+	+		+
Gekkonidae (geckoes) Medium Pilbara Spotted Rock Gehyra <i>Gehyra fenestrula</i> Small Pilbara Spotted Rock Gehyra <i>Gehyra micra</i> Pilbara Dtella <i>Gehyra pilbara</i> Spotted Dtella <i>Gehyra punctata</i> Variegated Dtella <i>Gehyra variegata</i> Bynoe's Gecko <i>Heteronotia binoei</i> Pilbara Cave Gecko <i>Heteronotia spelea</i>									
			+						+
		?	?	?		?	?		?
		+	+			+	+		+
		+	+		+	+	+		+
		+	+		+	+	+		+

Appendix 2. (cont.)

Species	Conservation Status	Records									
		Other surveys					Database				
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap	
Pygopodidae (legless lizards)											
	<i>Delma butleri</i>		+		+						
	<i>Delma elegans</i>	+	+			+					+
	<i>Delma nasuta</i>	+	+	+		+	+				+
	<i>Delma pax</i>		+	+	+	+	+				+
	<i>Delma tincta</i>	+	+			+	+				+
Burton's Legless Lizard	<i>Lialis burtonis</i>	+	+			+	+				+
Hooded Scaly-foot	<i>Pygopus nigriceps</i>	+	+			+					+
Agamidae (dragon lizards)											
Western Ring-tailed Dragon	<i>Ctenophorus caudicinctus</i>	+	+	+	+	+	+				+
Military Dragon	<i>Ctenophorus isolepis</i>	+	+	+	+						+
Central Netted Dragon	<i>Ctenophorus nuchalis</i>		+								+
Western Netted Dragon	<i>Ctenophorus reticulatus</i>		+				+				+
Mulga Dragon	<i>Diporiphora amphiboluroides</i>	+	+				+				+
Southern Pilbara Tree Dragon	<i>Diporiphora valens</i>	+	+			+					+
Long-nosed Dragon	<i>Gowidon longirostris</i>	+	+	+		+	+				+
Bearded Dragon	<i>Pogona minor</i>	+	+		+	+	+				+
Pebble Dragon	<i>Tympanocryptis cephalus</i>		+			+					
Scincidae (skink lizards)											
	<i>Carlia munda</i>	+	+	+	+	+	+				+
	<i>Carlia triacantha</i>		+			+	+				+
	<i>Cryptoblepharus buchananii</i>		+				+				
	<i>Cryptoblepharus ustulatus</i>	+	+		+	+	+				+
	<i>Ctenotus duricola</i>		+	+	+	+	+				+
	<i>Ctenotus grandis</i>										+
	<i>Ctenotus hanloni</i>		+	+							
	<i>Ctenotus helenae</i>	+	+			+	+				+
	<i>Ctenotus leonhardii</i>		+	+							
	<i>Ctenotus pallasotus</i>										
	<i>Ctenotus pantherinus</i>	+	+	+	+	+	+				+
	<i>Ctenotus piankai</i>		+								
	<i>Ctenotus rubicundus</i>	+	+	+	+						+
	<i>Ctenotus rutilans</i>	+	+			+	+				+
Rock Ctenotus	<i>Ctenotus saxatilis</i>	+	+		+	+	+				+
	<i>Ctenotus schomburgkii</i>	+	+			+	+				+
	<i>Ctenotus serventyi</i>		+								+

Appendix 2. (cont.)

Species	Conservation Status	Records								
		Other surveys					Database			
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap
Scincidae (cont.)										
Spotted Ctenotus	<i>Ctenotus uber</i>		+				+			+
Spotted Ctenotus (northeast)	<i>Ctenotus uber jonstonei</i>	P							+	
Slender Blue-tongue	<i>Cyclodomorphus melanops</i>		+	+	+	+	+			+
Western Pilbara Spiny-tailed Skink	<i>Egernia cygnitos</i>			+		+				+
	<i>Egernia formosa</i>		+	+		+				+
Pilbara Skink	<i>Egernia pilbarensis</i>									
Western Narrow-banded Skink	<i>Eremiascincus pallidus</i>			+						+
Broad-banded Sand Swimmer	<i>Eremiascincus richardsonii</i>			+						+
	<i>Lerista bipes</i>				+					
	<i>Lerista flammicauda</i>			+						
	<i>Lerista jacksoni</i>				+					
Unpattered Robust Slider	<i>Lerista macropisthopus remota</i>	P							+	
	<i>Lerista muelleri</i>		+	+	+	+	+			+
	<i>Lerista neander</i>			+		+	+			+
	<i>Lerista timida</i>					+				
	<i>Lerista verhmens</i>					+				
Pilbara Blue-tailed Slider	<i>Lerista zietzi</i>		+	+	+	+				+
Night Skink	<i>Liopholis striata</i>									
Dwarf Skink	<i>Menetia greyii</i>		+	+	+	+	+			+
	<i>Menetia surda</i>			+			+			+
	<i>Morethia ruficauda</i>		+	+	+	+				+
	<i>Notoscincus ornatus</i>									
	<i>Proablepharus reginae</i>									+
Central Blue-tongue	<i>Tiliqua multifasciata</i>		+	+		+	+			+
Varanidae (goanna or monitor lizards)										
Spiny-tailed Goanna	<i>Varanus acanthurus</i>		+	+	+	+	+			+
Short-tailed Pygmy Goanna	<i>Varanus brevicauda</i>		+	+	+	+	+			+
Pilbara Pymy Mulga Goanna	<i>Varanus bushi</i>		+	+		+				+
	<i>Varanus caudolineatus</i>									+
Pygmy Desert Goanna	<i>Varanus eremius</i>									
Perentie	<i>Varanus giganteus</i>		+	+		+				+
Sand Goanna	<i>Varanus gouldii</i>			+						+
Yellow-spotted Monitor	<i>Varanus panoptes</i>		+	+		+	+			+
Northern Pilbara Rock Monitor	<i>Varanus pilbarensis</i>		+	+	+					+
Black-tailed Monitor	<i>Varanus tristis</i>		+	+		+	+			+

Appendix 2. (cont.)

Species	Conservation Status	Records								
		Other surveys						Database		
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap
Typhlopidae (blind snakes)										
<i>Anilius ammodytes</i>			+		+					+
Gane's Blind Snake <i>Anilius ganei</i>	P		+						+	+
Beaked Blind Snake <i>Anilius grypus</i>			+		+		+			+
<i>Anilius hamatus</i>			+				+			+
Pilbara Blind Snake <i>Anilius pilbarensis</i>							+			+
<i>Anilius waitii</i>							+			+
Boidae (pythons)										
Pygmy Python <i>Antaresia perthensis</i>		+	+			+				+
Stimson's Python <i>Antaresia stimsoni</i>			+							+
Black-headed Python <i>Aspidites melanocephalus</i>			+							+
Pilbara Olive Python <i>Liasis olivaceus barroni</i>	T	+	+	+	+			+	+	+
Elapidae (front-fanged snakes)										
Pilbara Death Adder <i>Acanthophis wellsii</i>			+			+	+			+
Northwest'n Shovel-nosed Snake <i>Brachyuropsis approximans</i>			+			+				+
Yellow-faced Whipsnake <i>Demansia psammophis</i>		+	+	+		+	+			+
Rufous Whipsnake <i>Demansia rufescens</i>			+			+				+
Moon Snake <i>Furina ornata</i>			+		+	+				+
Monk Snake <i>Parasuta monarchus</i>		+	+	+		+	+			+
Mulga Snake <i>Pseudechis australis</i>		+	+			+	+			+
Ringed Brown Snake <i>Pseudonaja modesta</i>		+	+		+	+				+
Gwardar <i>Pseudonaja mengdeni</i>		+	+			+				+
Rosen's Snake <i>Suta fasciata</i>		+	+			+	+			+
Spotted Snake <i>Suta punctata</i>										+
Pilbara Bandy-bandy <i>Vermicella snelli</i>		+	+			+				+
# reptile species expected:		112								

Appendix 3. Birds potentially occurring in the Study Area.

Key to records:

Lamb Creek = recorded in or near the study area in 2012 (Rapallo 2012).

Mining Area C = species recorded approx. 12km south at Mining Area C, 1999 – 2016 (Biologic 2017).

Yandicoogina = species recorded approx. 20km east at Yandicoogina 2008 – 2014 (Biota 2010, 2011b, 2014).

Koodaideri = species recorded approx. 27km north at Koodaideri, August 2010 or July 2011 (Biota 2011a, 2012).

West Angelas = species recorded approx. 30km southwest at West Angelas, 2012 – 2013 (Ecologia 2014).

Hope Downs = species recorded approx. 30km southeast on Hope Downs Infrastructure Options 1 or 6 (Ninox Wildlife Consulting 2009a, 2009b).

EPBC = modelled occurrence of species or species habitat in the area on the EPBC Protected Matters Search Tool.

DBCA = species recorded in the area on DBCA's Threatened and Priority Fauna Database (DBCA 2020).

NatureMap = species recorded within 40km on NatureMap (DBCA 2007-).

Species	Conservation Status	Records									
		Other surveys						Database			
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap	
Dromaiidae (emus) Emu <i>Dromaius novaehollandiae</i>			+		+						+
Anatidae (ducks & swans) Grey Teal <i>Anas gracilis</i> Pacific Black Duck <i>Anas superciliosus</i>				+							+
Phasianidae (quails) Stubble Quail <i>Coturnix pectoralis</i> Brown Quail <i>Coturnix ypsilophora</i>			+	+		+					
Pelecanidae (pelicans) Australian Pelican <i>Pelecanus conspicillatus</i>											+
Threskiornithidae (ibis & spoonbills) Straw-necked Ibis <i>Threskiornis spinicollis</i>						+					
Ardeidae (herons, egrets, bitterns & night-herons) White-faced Heron <i>Ardea novaehollandiae</i> Rufous Night-heron <i>Nycticorax caledonicus</i>		+	+	+			+				+
Phalacrocoracidae (cormorants) Little Pied Cormorant <i>Phalacrocorax melanoleucos</i> Pied Cormorant <i>Phalacrocorax varius</i>				+							+
Anhingidae (darter) Australasian Darter <i>Anhinga novaehollandiae</i>											+

Appendix 3. (cont.)

Species	Conservation Status	Records								
		Other surveys						Database		
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap
Accipitridae (osprey, hawks, eagles & harriers)										
Black-shouldered Kite	<i>Elanus caeruleus</i>	+	+			+				+
Square-tailed Kite	<i>Hamirostra isura</i>						+			
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>	+	+	+			+			+
Black Kite	<i>Milvus migrans</i>	+	+							+
Whistling Kite	<i>Haliastur sphenurus</i>	+	+	+		+	+			+
Brown Goshawk	<i>Accipiter fasciatus</i>	+	+			+				+
Collared Sparrowhawk	<i>Accipiter cirrocephalus</i>	+	+		+	+				+
Little Eagle	<i>Hieraetus morphnoides</i>	+	+	+		+				+
Wedge-tailed Eagle	<i>Aquila audax</i>	+	+		+	+	+			+
Spotted Harrier	<i>Circus assimilis</i>	+	+			+				+
Otididae (bustard)										
Australian Bustard	<i>Ardeotis australis</i>	+	+		+	+	+			+
Turnicidae (button-quails)										
Little Button-Quail	<i>Turnix velox</i>	+	+			+				+
Burhinidae (stone-curlews)										
Bush Stone-Curlew	<i>Burhinus grallarius</i>					+				
Recurvirostridae (stilts & avocets)										
Black-winged Stilt	<i>Himantopus himantopus</i>		+							
Charadriidae (plovers, dotterels & lapwings)										
Oriental Plover	<i>Charadrius veredus</i>	Mi					+			
Black-fronted Dotterel	<i>Euseyonis melanops</i>		+	+						+
Scolopacidae (sandpipers, tattlers, godwits & allies)										
Common Sandpiper	<i>Tringa hypoleucos</i>	Mi					+			
Common Greenshank	<i>Tringa nebularia</i>	Mi						+	+	+
Glareolidae (pratincoles)										
Australian Pratincole	<i>Stiltia isabella</i>									
Columbidae (pigeons and doves)										
Common Bronzewing	<i>Phaps chalcoptera</i>	+	+		+	+	+			+
Crested Pigeon	<i>Ocyphaps lophotes</i>	+	+	+	+	+	+			+
Spinifex Pigeon	<i>Geophaps plumifera</i>	+	+	+	+	+	+			+
Diamond Dove	<i>Geopelia cuneata</i>	+	+	+	+	+	+			+
Peaceful Dove	<i>Geopelia striata</i>		+	+	+					+
Cuculidae (cuckoos)										
Pheasant Coucal	<i>Centropus phasianus</i>			+						
Pallid Cuckoo	<i>Cacomantis pallidus</i>	+	+	+	+		+			+
Black-eared Cuckoo	<i>Chrysococcyx osculans</i>		+							
Horsfield's Bronze-Cuckoo	<i>Chrysococcyx basalus</i>	+	+	+	+	+	+			+

Appendix 3. (cont.)

Species	Conservation Status	Records								
		Other surveys						Database		
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap
Tytonidae (barn owls)										
Barn Owl <i>Tyto alba</i>			+			+				
Strigidae (hawk owls)										
Barking Owl <i>Ninox connivens</i>							+			+
Southern Boobook <i>Ninox boobook</i>		+	+			+				+
Podargidae (frogmouths)										
Tawny Frogmouth <i>Podargus strigoides</i>		+	+			+				+
Caprimulgidae (nightjars)										
Spotted Nightjar <i>Eurostopodus argus</i>		+	+		+	+	+			+
Aegothelidae (owlet-nightjars)										
Australian Owlet-Nightjar <i>Aegotheles cristatus</i>		+	+			+	+			+
Apodidae (swifts)										
Fork-tailed Swift <i>Apus pacificus</i>	Mi	+	+	+		+		+	+	
Alcedinidae (kingfishers)										
Blue-winged Kookaburra <i>Dacelo leachii</i>			+	+	+					+
Red-backed Kingfisher <i>Todiramphus pyrrhopygius</i>		+	+	+		+	+			+
Sacred Kingfisher <i>Todiramphus sanctus</i>			+				+			+
Meropidae (bee-eaters)										
Rainbow Bee-eater <i>Merops ornatus</i>		+	+	+	+					+
Falconidae (falcons)										
Brown Falcon <i>Falco berigora</i>		+	+	+	+	+	+			+
Australian Kestrel <i>Falco cenchroides</i>		+	+	+	+	+	+			+
Australian Hobby <i>Falco longipennis</i>		+	+		+	+	+			+
Grey Falcon <i>Falco hypoleucos</i>	T		+						+	
Peregrine Falcon <i>Falco peregrinus</i>	OS		+						+	+
Black Falcon <i>Falco subniger</i>										
Cacatuidae (cockatoos)										
Galah <i>Cacatua roseicapilla</i>		+	+			+	+			+
Little Corella <i>Cacatua sanguinea</i>			+	+			+			+
Cockatiel <i>Nymphicus hollandicus</i>		+				+				+
Psittacidae (parrots, lorikeets and rosellas)										
Australian Ringneck <i>Platycercus zonarius</i>		+	+	+	+	+	+			+
Budgerigar <i>Melopsittacus undulatus</i>		+	+			+	+			+
Bourke's Parrot <i>Neopsephotus bourkii</i>			+							
Night Parrot <i>Pezoporus occidentalis</i>	T						+			
Mulga Parrot <i>Psephotus varius</i>			+			+				
Ptilonorhynchidae (bowerbirds)										
Western Bowerbird <i>Ptilonorhynchus maculatus guttatus</i>		+	+		+	+	+			+

Appendix 3. (cont.)

Species	Conservation Status	Records									
		Other surveys					Database				
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap	
Climacteridae (treecreepers)											
Black-tailed Treecreeper	<i>Climacteris melanurus</i>		+								
Maluridae (fairy-wrens, grasswrens and emu-wrens)											
Striated Grasswren	<i>Amytornis striatus</i>		+				+				+
Variiegated Fairy-wren	<i>Malurus lamberti</i>	+	+	+	+	+	+				+
White-winged Fairy-wren	<i>Malurus leucopterus</i>		+		+	+	+				+
Splendid Fairy-wren	<i>Malurus splendens</i>		+			+					+
Rufous-crowned Emu-wren	<i>Stipiturus ruficeps</i>		+		+	+	+				+
Meliphagidae (honeyeaters and chats)											
Brown Honeyeater	<i>Lichmera indistincta</i>	+	+	+	+	+					+
Black Honeyeater	<i>Sugomel niger</i>	+									+
Pied Honeyeater	<i>Certhionyx variegatus</i>	+	+								+
Singing Honeyeater	<i>Gavicalis virescens</i>	+	+	+	+	+	+				+
Grey Honeyeater	<i>Lacustroica whitei</i>	+	+			+					+
Grey-headed Honeyeater	<i>Ptilotula keartlandi</i>	+	+	+	+	+	+				+
White-plumed Honeyeater	<i>Ptilotula penicillata</i>	+	+	+	+		+				+
Black-chinned Honeyeater	<i>Melithreptus gularis</i>	+	+			+					+
White-fronted Honeyeater	<i>Purnella albifrons</i>	+	+		+	+					+
Yellow-throated Miner	<i>Manorina flavigula</i>	+	+	+	+	+	+				+
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>	+	+	+		+	+				+
Crimson Chat	<i>Epthianura tricolor</i>	+	+			+					+
Pardalotidae (pardalotes)											
Red-browed Pardalote	<i>Pardalotus rubricatus</i>	+	+	+	+	+					+
Striated Pardalote	<i>Pardalotus striatus</i>		+		+	+	+				+
Acanthizidae (thornbills, gerygones & allies)											
Inland Thornbill	<i>Acanthiza apicalis</i>	+	+			+	+				+
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>		+								+
Slaty-backed Thornbill	<i>Acanthiza robustirostris</i>		+								+
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>	+	+		+	+	+				+
Redthroat	<i>Pyrrholaemus brunnea</i>		+								+
Weebill	<i>Smicrornis brevirostris</i>	+	+	+	+	+	+				+
Western Gerygone	<i>Gerygone fusca</i>	+	+	+	+	+	+				+
Pomatostomidae (babblers)											
White-browed Babbler	<i>Pomatostomus superciliosus</i>		+			+					+
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>	+	+	+		+	+				+
Psophodidae (quail-thrushes)											
Western Quail-thrush	<i>Cinclosoma marginatum</i>		+								

Appendix 3. (cont.)

Species	Conservation Status	Records								
		Other surveys					Database			
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap
Neosittidae (sittellas)										
Varied Sittella <i>Daphoenositta chrysoptera</i>			+							
Artamidae (woodswallows)										
Masked Woodswallow <i>Artamus personatus</i>		+	+	+	+	+				+
Black-faced Woodswallow <i>Artamus cinereus</i>		+	+	+	+	+				+
Little Woodswallow <i>Artamus minor</i>		+	+	+	+	+				+
Cracticidae (butcherbirds & magpie)										
Grey Butcherbird <i>Cracticus torquatus</i>		+	+	+		+				+
Pied Butcherbird <i>Cracticus nigrogularis</i>		+	+	+	+	+				+
Australian Magpie <i>Cracticus tibicen</i>		+	+	+	+	+				+
Campephagidae (cuckoo-shrikes and trillers)										
Ground Cuckoo-shrike <i>Coracina maxima</i>		+	+							+
Black-faced Cuckoo-Shrike <i>Coracina novaehollandiae</i>		+	+	+	+	+				+
White-winged Triller <i>Lalage tricolor</i>		+	+			+				+
Oreoicidae (bellbirds)										
Crested Bellbird <i>Oreoica gutturalis</i>		+	+	+	+	+				+
Pachycephalidae (shrike-tits, whistlers and allies)										
Rufous Whistler <i>Pachycephala rufiventris</i>		+	+	+	+	+				+
Grey Shrike-thrush <i>Colluricincla harmonica</i>		+	+	+	+	+				+
Rhipiduridae (fantails)										
Grey Fantail <i>Rhipidura albiscapa</i>			+	+		+				+
Willie Wagtail <i>Rhipidura leucophrys</i>		+	+	+	+	+				+
Monarchidae (flycatchers, monarchs and magpie-lark)										
Magpie-Lark <i>Grallina cyanoleuca</i>		+	+	+	+	+				+
Corvidae (ravens and crows)										
Torresian Crow <i>Corvus orru</i>		+	+	+	+	+				+
Little Crow <i>Corvus bennetti</i>		+	+	+		+				+
Petroicidae (robins)										
Red-capped Robin <i>Petroica goodenovii</i>			+	+		+				+
Hooded Robin <i>Melanodryas cucullata</i>		+	+	+	+	+				+
Alaudidae (larks)										
Horsfield's Bushlark <i>Mirafrja javanica</i>			+			+				
Hirundinidae (swallows and martins)										
White-backed Swallow <i>Cheramoeca leucosterna</i>										
Welcome Swallow <i>Hirundo neoxena</i>			+							
Tree Martin <i>Petrochelidon nigricans</i>			+	+			+			+
Fairy Martin <i>Petrochelidon ariel</i>			+							+

Appendix 3. (cont.)

Species	Conservation Status	Records								
		Other surveys						Database		
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap
Acrocephalidae (reed warblers)										
Australian Reed Warbler <i>Acrocephalus australis</i>										+
Locustellidae (warblers, songlarks and grassbirds)										
Spinifexbird <i>Eremiornis carteri</i>		+	+		+	+	+			+
Rufous Songlark <i>Megalurus mathewsi</i>		+	+	+		+				+
Brown Songlark <i>Megalurus cruralis</i>		+				+				+
Dicaeidae (flowerpeckers)										
Mistletoebird <i>Dicaeum hirundinaceum</i>		+	+	+		+	+			+
Estrildidae (grassfinches, sparrows and allies)										
Zebra Finch <i>Taeniopygia guttata</i>		+	+	+	+	+	+			+
Star Finch <i>Neochmia ruficauda</i>			+	+	+					
Painted Finch <i>Emblema pictum</i>		+	+	+	+	+	+			+
Motacillidae (pipits and wagtails)										
Australian Pipit <i>Anthus australis</i>			+			+	+			+
# bird species expected:		130								

Appendix 4. Mammals potentially occurring in the Study Area.

Key to records:

Lamb Creek = recorded in or near the study area in 2012 (Rapallo 2012).

Mining Area C = species recorded approx. 12km south at Mining Area C, 1999 – 2016 (Biologic 2017).

Yandicoogina = species recorded approx. 20km east at Yandicoogina 2008 – 2014 (Biota 2010, 2011b, 2014).

Koodaideri = species recorded approx. 27km north at Koodaideri, August 2010 or July 2011 (Biota 2011a, 2012).

West Angelas = species recorded approx. 30km southwest at West Angelas, 2012 – 2013 (Ecologia 2014).

Hope Downs = species recorded approx. 30km southeast on Hope Downs Infrastructure Options 1 or 6 (Ninox Wildlife Consulting 2009a, 2009b).

EPBC = modelled occurrence of species or species habitat in the area on the EPBC Protected Matters Search Tool.

DBCA = species recorded in the area on DBCA's Threatened and Priority Fauna Database (DBCA 2020).

NatureMap = species recorded within 40km on NatureMap (DBCA 2007-).

Species	Conservation Status	Records								
		Other surveys						Database		
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap
Tachyglossidae (echidnas)										
Echidna	<i>Tachyglossus aculeatus</i>	+	+		+					
Dasyuridae (dasyurid marsupials)										
Brush-tailed Mulgara	<i>Dasyurus blythi</i>	P			+				+	
Little Red Kaluta	<i>Dasykaluta rosamondae</i>		+	+	+	+	+			+
Northern Quoll	<i>Dasyurus hallucatus</i>	T	+	+				+	+	
Woolley's Pseudantechinus	<i>Pseudantechinus woolleyae</i>						+			+
Pilbara Ningui	<i>Ningui timealeyi</i>		+	+	+	+	+			+
Pilbara Planigale	<i>Planigale sp 1</i>		+	+	+	+	+			+
Long-tailed Dunnart	<i>Sminthopsis longicaudata</i>	P								
Striped-faced Dunnart	<i>Sminthopsis macroura</i>		+	+		+				+
Ooldea Dunnart	<i>Sminthopsis ooldea</i>			+		+				+
Lesser Hairy-footed Dunnart	<i>Sminthopsis youngsoni</i>			+	+					+
Thylacomyidae (bilbies)										
Bilby	<i>Macrotis lagotis</i>	T						+	+	
Macropodidae (kangaroos and wallabies)										
Euro	<i>Osphranter robustus</i>		+	+	+	+				+
Red Kangaroo	<i>Osphranter rufus</i>			+	+	+	+			+
Rothschild's Rock-Wallaby	<i>Petrogale rothschildi</i>		+	+		+				+
Muridae (rats and mice)										
Lakeland Downs Mouse	<i>Leggadina lakedownensis</i>	P							+	
House Mouse	<i>Mus musculus</i>	Int.	+	+		+				+
Spinifex Hopping Mouse	<i>Notomys alexis</i>									
Western Pebble-mound Mouse	<i>Pseudomys chapmani</i>	P	+	+	+	+	+		+	+
Delicate Mouse	<i>Pseudomys delicatulus</i>					+	+			
Desert Mouse	<i>Pseudomys desertor</i>		+	+		+	+			+
Sandy Inland Mouse	<i>Pseudomys hermannsburgensis</i>		+	+	+	+	+			+
Common Rock-Rat	<i>Zyomys argurus</i>		+	+	+	+	+			+

Appendix 4. (cont.)

Species	Conservation Status	Records								
		Other surveys						Database		
		Lamb Creek	Mining Area C	Yandicoogina	Koodaideri	West Angelas	Hope Downs	EPBC	DBCA	NatureMap
Leporidae (rabbits)										
Rabbit <i>Oryctolagus cuniculus</i>	Int.		+			+				
Rhinonictoridae (leaf-nosed bats)										
Pilbara Leaf-nosed Bat <i>Rhinonictoris aurantia</i>	T		+		+	+		+	+	+
Megadermatidae (ghost bat)										
Ghost Bat <i>Macroderma gigas</i>	T	+	+		+			+	+	+
Emballonuridae (sheathtail bats)										
Yellow-bellied Sheathtail Bat <i>Saccolaimus flaviventris</i>		+	+	+	+	+				+
Common Sheathtail Bat <i>Taphozous georgianus</i>		+	+	+	+	+				+
Hill's Sheathtail Bat <i>Taphozous hilli</i>			+		+					+
Molossidae (freetail bats)										
Greater Northern Freetail Bat <i>Chaerephon jobensis</i>		+	+		+					+
Northern Freetail Bat <i>Ozimops lumsdenae</i>			+		+					+
White-striped Freetail Bat <i>Austronomus australis</i>			+	+	+		+			+
Vespertilionidae (ordinary bats)										
Gould's Wattled Bat <i>Chalinolobus gouldii</i>		+	+	+	+		+			+
Chocolate Wattled Bat <i>Chalinolobus morio</i>										+
Lesser Long-eared Bat <i>Nyctophilus geoffroyi</i>			+		+					+
Inland Broad-nosed Bat <i>Scotorepens balstoni</i>			+							+
Little Broad-nosed Bat <i>Scotorepens greyii</i>		+	+	+	+		+			+
Finlayson's Cave Bat <i>Vespadelus finlaysoni</i>		+	+	+	+		+			+
Canidae (dogs and foxes)										
Dog / Dingo <i>Canis familiaris</i>	Int.	+	+		+	+	+			+
Fox <i>Vulpes vulpes</i>	Int.		+							
Felidae (cats)										
Feral / House Cat <i>Felis catus</i>	Int.		+		+					+
Equidae (horses)										
Donkey <i>Equus asinus</i>	Int.		+	+						
Horse <i>Equus caballus</i>	Int.									+
Camelidae (camels)										
Camel <i>Camelus dromedarius</i>	Int.		+							
Bovidae (horned ruminants)										
Cow <i>Bos taurus</i>	Int.	+	+	+						+
Number of species expected:		45 (36 native, 9 introduced)								

Appendix 5. EPBC Protected Matters Search Tool results.

Fauna species listed for the area 20km in radius from 22.803°S, 118.902°E on the EPBC Act Protected Matters Search Tool.



Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about [Environment Assessments](#) and the EPBC Act including significance guidelines, forms and application process details.

Report created: 06/03/20 20:00:29

[Summary](#)

[Details](#)

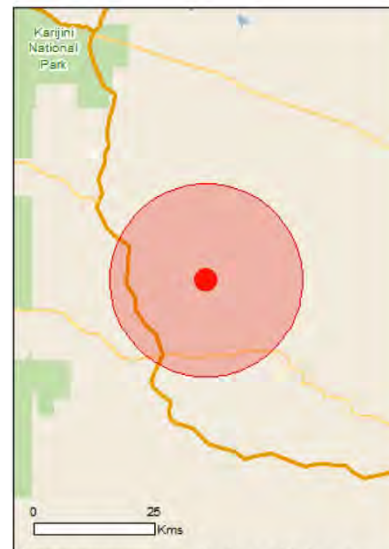
[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

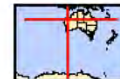
[Acknowledgements](#)



This map may contain data which are
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[Coordinates](#)

Buffer: 20.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	8
Listed Migratory Species:	9

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at <http://www.environment.gov.au/heritage>

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	14
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	9
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat likely to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat likely to occur within area
Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Invasive Species

[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resources Audit, 2001.

Name	Status	Type of Presence
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		



LEVEL 2 FAUNA SURVEY
AND
TARGETED NORTHERN QUOLL SURVEY
OF THE
LAMB CREEK
FOR
PROCESS MINERALS INTERNATIONAL PTY LTD
OCTOBER 2012

Rev	Date	Revision Description	Prepared by	Reviewed By	Approved by
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Table of Contents

1. Executive Summary	7
2. Introduction	10
2.1. Background.....	10
2.2. Scope and Aims	10
2.3. Existing Environment	14
2.3.1. Climate	14
2.3.2. Drainage	15
2.3.3. Geology	15
2.3.4. Soil and Landform.....	16
2.3.5. IBRA Zone	16
2.3.6. Land systems	17
2.3.7. Regional Vegetation	19
2.3.8. Land Use.....	19
2.3.9. Reserves and Environmentally Sensitive Areas	19
2.4. Legislation and Survey Guidance	19
2.4.1. Environmental Protection and Biodiversity Act (EPBC Act) 1999	20
2.4.2. Wildlife Conservation Act 1950.....	20
2.4.3. DEC Priority Listings	20
2.4.4. EPA Guidance Statements.....	21
2.4.5. Short Range Endemism	21
2.4.6. Northern Quoll Survey Guidelines	22
3. Methods	24
3.1. Scientific Licence	24
3.2. Vouchering.....	24
3.3. Personnel.....	24
3.4. Desktop Survey.....	25
3.5. Reconnaissance Survey.....	26
3.6. Vertebrate Fauna Survey.....	26
3.6.1. Systematic trapping	26
3.6.2. Bird Surveys	30
3.6.3. Bat Surveys.....	30
3.6.4. Spotlighting	30
3.6.5. Hand Foraging And Habitat Assessment Transects	30
3.6.6. Motion Detecting Cameras	31

3.6.7.	Opportunistic records	31
3.7.	SRE Survey.....	31
3.7.1.	Leaf litter collection.....	32
3.7.2.	Categories of short-range endemism	32
3.7.3.	Taxonomic Identification	32
3.8.	Targeted Northern Quoll Survey	33
3.9.	Biodiversity Assessment and Species Richness	33
3.9.1.	Species accumulation curve.....	33
3.9.2.	Species Richness	34
3.10.	Survey Limitations and Constraints.....	34
3.11.	Sources Of Information	35
4.	Results.....	36
4.1.	Desktop Survey Results	36
4.2.	Habitats	36
4.3.	Vertebrate Fauna Survey Summary	42
4.4.	Mammals	42
4.4.1.	Assemblage.....	42
4.4.2.	Species Accumulation Curve and Species Richness Estimates.....	45
4.5.	Reptiles and Amphibians	47
4.5.1.	Assemblage.....	47
4.5.2.	Species Accumulation Curve and Species Richness Estimates.....	52
4.6.	Birds.....	53
4.6.1.	Assemblage.....	53
4.6.2.	Species Accumulation Curve and Species Richness Estimates.....	58
4.7.	Short Range Endemics.....	59
4.8.	Targeted Northern Quoll Survey	60
5.	Discussion	62
5.1.	Habitats	62
5.2.	Mammals	62
5.2.1.	Family Dasyuridae (Carnivorous Marsupials).....	63
5.2.2.	Family Macropodidae.....	63
5.2.3.	Family Muridae (Rodents).....	64
5.2.4.	Family Canidae.....	64
5.2.5.	Family Megadermatidae	64
5.2.6.	Family Emballonuridae	65
5.2.7.	Family Molossidae	65

5.2.8.	Family Vespertilionidae	65
5.3.	Reptiles	65
5.3.1.	Families Gekkonidae and Pygopodidae (Geckos and Legless Lizards)	65
5.3.2.	Family Scincidae (Skinks).....	67
5.3.3.	Family Agamidae (Dragons)	67
5.3.4.	Family Elapidae (Front Fanged Land Snakes)	68
5.3.5.	Family Typhlopidae (Blind Snakes).....	69
5.3.6.	Family Pythonidae (Pythons)	69
5.3.7.	Family Varanidae (Goannas/Monitors)	70
5.4.	Amphibians.....	70
5.5.	Avifauna.....	71
5.6.	Invertebrates.....	72
5.6.1.	Araneae – Mygalomorphae (Trapdoor Spiders)	72
5.6.2.	Pseudoscorpiones (False Scorpions of Pseudoscorpions)	73
5.6.3.	Chilopoda (Centipedes)	73
5.6.4.	Diplopoda (Millipedes).....	74
5.6.5.	Isopoda (Slaters).....	75
5.6.6.	Scorpiones	75
5.6.7.	Habitat Association	76
6.	Species of Conservation Significance.....	77
6.1.	Night Parrot – <i>Pezoporus occidentalis</i>	77
6.2.	Northern Quoll – <i>Dasyurus hallucatus</i>	77
6.3.	Orange Leaf-nosed Bat – <i>Rhinonicteris aurantia</i>	78
6.4.	Pilbara Olive Python – <i>Liasis olivaceus</i> subsp. <i>barroni</i>	79
6.5.	Peregrine Falcon - <i>Falco peregrinus</i>	79
6.6.	<i>Ramphotyphlops ganei</i>	79
6.7.	Western Pebble-mound Mouse – <i>Pseudomys chapmani</i>	80
6.8.	Ghost Bat – <i>Macroderma gigas</i>	80
6.9.	Australian Bustard – <i>Ardeotis australis</i>	81
6.10.	Bush Stone-curlew – <i>Burhinus grallarius</i>	81
6.11.	Grey Falcon - <i>Falco hypoleucos</i>	82
6.12.	Rainbow Bee-eater – <i>Merops ornatus</i>	82
6.13.	Eastern Great Egret – <i>Ardea modesta</i>	82
6.14.	Cattle Egret - <i>Ardea ibis</i>	83
6.15.	Oriental Plover – <i>Charadrius veredus</i>	83
6.16.	Fork-tailed Swift – <i>Apus pacificus</i>	83

7. Management and Mitigation	84
7.1. Sensitive Habitat Areas.....	84
7.2. Sensitive Habitat Features.....	84
7.3. Management and Mitigation Recommendations	84
7.4. Ground disturbance and rehabilitation management	85
7.5. Avoidance and Minimisation of Impacts to SREs	85
7.6. Noise, Vibration and Light Management.....	85
7.7. Environmental Awareness and Education Program.....	86
7.8. Invasive Species Management Program	86
8. References	87
APPENDICES	95

List of Tables

Table 1	Tenements of the Lamb Creek Project	10
Table 2:	Land systems on the project area.....	17
Table 3	Personnel involved in this survey	24
Table 4	Database Searches undertaken for the Lamb Creek project area.....	25
Table 5	Regional literature sources	26
Table 6	Trap night summary by habitat and trap type for the Lamb Creek L2 Fauna Survey	27
Table 7	Summary of limitations experienced during the Survey	34
Table 8	List of Species of Conservation Significance that have been recorded within 50 kilometres of the Project Area	37
Table 9	Habitats found on the project area	39
Table 10	Mammal records from the Lamb Creek project area.....	43
Table 11	Acoustic Analysis of bat calls from the Lamb Creek Project area	45
Table 12	Observed and estimated non-volant mammal species richness	46
Table 13	Reptiles recorded from the Lamb Creek project area.	48
Table 14	Amphibian records from the Lamb Creek project area.	51
Table 15	Observed and estimated reptile species richness	52
Table 16	Avifauna records from the Lambs Creek project area.....	54
Table 17	Observed and estimated avifauna species richness	58
Table 18	Summary of the SRE status of taxa collected in the survey and submitted for identification.....	59

List of Figures

Figure 1	Location Plan.....	12
Figure 2	Lamb Creek Tenements.....	13
Figure 3	Mean annual rainfall at Newman Airport BoM Station (007176) over years 1971 to 2012.....	14
Figure 4	Mean monthly temperatures at Newman Airport BoM Station (007176).....	15
Figure 5	Lamb Creek Land Systems.....	18
Figure 6	Lamb Creek Survey Sites and Equipment.....	28
Figure 7	Trap layout.....	29
Figure 8	Lamb Creek Species of Conservation Significance and Habitats.....	41
Figure 9	Individual based rarefaction curve for mammal species surveyed using systematic techniques.....	45
Figure 10	Individual based rarefaction curve (species accumulation curve) for reptile species surveyed using systematic techniques.....	52
Figure 11	Individual based rarefaction curve (species accumulation curve) for bird species surveyed using utilising two hectare bird surveys.....	58
Figure 12	Lamb Creek SRE Sample Sites.....	61

Appendices

Appendix I:	State and Federal Conservation Codes
Appendix II:	Scientific License
Appendix III:	Threatened Fauna Database Search Results
Appendix IV:	DEC Threatened Ecological Communities Search Results
Appendix V:	SEWPaC Environmental Reporting Tool Search Results
Appendix VI:	NatureMap Search Results
Appendix VII:	Birdlife Australia Birdata Search Results
Appendix VIII:	Western Australian Museum Short Range Endemic Search Results
Appendix IX:	Regional Comparison of Species
Appendix X:	Raw Habitat Data
Appendix XI:	Specialised Zoological Anabat Data Report
Appendix XII:	WAM SRE Reports

1. EXECUTIVE SUMMARY

Rapallo Environmental was commissioned by Process Minerals International Pty Ltd (PMI) to conduct a Level 2 fauna survey of the proposed Lamb Creek iron ore mine, two alternative haul road routes and three alternative accommodation village sites. The Lamb Creek project is located approximately 130km north of Newman off the Great Northern Highway in the East Pilbara Region of Western Australia.

The core aims of the survey were to search published literature and databases for data on fauna found in the region; collect baseline data on vertebrate faunal assemblages of the project area and surrounding areas (collectively referred to as 'survey area'); survey for evidence of the presence of species of conservation significance; survey for introduced species; map the habitats of the project area; and identify habitat that could support species of conservation significance.

The Survey was divided into four projects

- 1) Reconnaissance Survey
- 2) Level 2 Vertebrate Fauna Survey
- 3) Level 2 SRE survey
- 4) Targeted Northern Quoll Survey

Surveys were conducted between the 19-20th March and 26 March – 12 April 2012. Prior to the surveys, database searches were completed to identify if species of conservation significance could potentially use habitats found along the haul road alignment. GIS data and aerial photography was used to demark the survey area, project area and land systems and to identify potential areas of interest.

Five habitat types were identified on the project area with each area being systematically trapped twice for a total of 10 trap sites on the project area. Vertebrate fauna was identified and released each morning as the trap lines were cleared. If specimens could not be immediately identified they were placed in a calico bag and identified at the field camp. After identification the specimens were released near the site of capture when conditions permitted (i.e. nocturnal fauna were not released during midday heat).

A Songbird SM2+ bat recording device was used to survey bat species in the survey area. The device was placed at a suitable location within each habitat for one night during the survey period. Suitable locations included areas with caves, water or mature woodlands with hollow bearing trees.

Bird assemblages were assessed and compiled using a combination of trap site specific surveys and opportunistic observations. Two hectare bird surveys, following Birds Australia guidelines, were completed each day between 6am and 9am when bird activity was peak and cryptic species were most detectable. Records from each site were supplemented with opportunistic records.

Spotlight surveys were undertaken on each night that the trap grids were open. Spotlight surveys were run over 30 minutes and were undertaken by a team of four ecologists.

A targeted Northern Quoll survey was conducted on the survey area consisting of 6 trap lines each containing ten cage traps. Each trap line was open for 5 consecutive nights and was checked each morning. Each cage was baited using a mammal bait mixture of honey, oats, peanut butter and sardines. In addition to targeted cage trapping, motion detecting cameras were deployed across the survey area in habitats that had the potential to support Northern Quolls. The targeted Northern Quoll survey was conducted in accordance with guidelines supplied by The Department of Sustainability, Environment Water, Populations and Communities (SEWPaC).

Habitats were assessed by ground truthing areas of interest identified on aerial photographs and from land system mapping. To assess habitats, transects were walked across large areas of the survey area. Data was recorded at each point along the transect where the habitat changed.

Individual based rarefaction curves (species accumulation curves) were used to investigate the survey success and to calculate species richness values for the survey area. They were produced for each vertebrate fauna group. They were derived from data collected at systematic trap sites only.

Database searches and literature reviews indicated 16 species listed under the *Wildlife Conservation Act 1950*, the *Environmental Protection and Biodiversity (EPBC) Act 1999* and by the Department of Conservation (DEC) could potentially occur on the survey area. Evidence of four species listed under the *EPBC Act* and *Wildlife Conservation Act 1950* were recorded during the survey. Evidence of three species listed as Priority by the DEC were also recorded during the survey.

A total of 8087 vertebrate records were made during the survey at Lamb Creek representing 152 species.

Species listed under the *EPBC Act* and *Wildlife Conservation Act 1950* that were recorded during the survey were the Northern Quoll, the Pilbara Olive Python (*Liasis olivaceus barroni*), the Rainbow Bee-eater (*Merops ornatus*) and the Fork-tailed Swift (*Apus pacificus*). Species recorded during the survey that are listed as Priority by the DEC were the Ghost Bat (*Macroderma gigas*), the Australian Bustard (*Ardeotis australis*) and the Western Pebble-mound Mouse (*Pseudomys chapmani*).

In order to minimise the project's impacts on vertebrate and SRE invertebrate fauna, a series of general recommendations are given below.

- speed limits along haul roads that intersect habitats likely to support species of conservation significance;
- sensitive habitats and habitat features to be marked out to reduce risk of accidental damage;
- man-made water bodies (i.e. turkey nests) to be located away from vehicle traffic areas (as such features often attract the Pilbara Olive Python).
- avoid unnecessary clearing of vegetation, i.e. beyond that strictly required;
- avoid clearing or disturbing habitats that support populations of significant fauna;
- avoid excessive disturbance and clearing around creeks or minor drainage channels;
- rapidly rehabilitate cleared areas such as laydown sites, access tracks and grid lines where these are no longer required;

- avoid direct impacts (clearing and grading) to active nests and large trees, particularly those associated with watercourses as a variety of birds use these habitats;
- wind-rows of topsoil, log debris and leaf litter formed during clearing should be retained, as they create extremely good micro-habitat for a range of fauna, particularly reptiles;
- encourage a culture of environmental consciousness on site by increasing the awareness of the environmental commitments of the project;
- display appropriate signage on site e.g. litter management, speed restrictions, species of conservation significance, important habitat;
- set site and targeted habitat speed limits on site especially in areas where species of conservation significance are regularly reported;
- implement weed control program;
- rubbish disposal procedures should be applied, especially for food refuse, in order to discourage scavenging by crows, foxes and feral cats. Large numbers of these animals can have an adverse impact on other fauna;
- feral animal control program;
- fencing off vulnerable habitats; and
- implementing fire management plans to reduce the risk of large high intensity wildfires.

2. INTRODUCTION

2.1. BACKGROUND

Process Minerals International Pty Ltd (PMI) intends to construct and operate an iron ore mining operation at Lamb Creek, approximately 130 km north-west of Newman the East Pilbara Region of Western Australia (Figure 1). The project includes a proposed mine site, haul routes and an accommodation village. Iron ore will be hauled by road-trains from the site via a dedicated haul road to link in with the Great Northern Highway.

PMI purchased the Lamb's Creek project from Iron Ore Holdings (IOH) in October 2011. No previous fauna studies have been conducted by IOH in the area of the proposed mine. Table 1 and Figure 2 outline the tenements of the Lamb Creek project area.

Table 1 Tenements of the Lamb Creek Project

Tenement	Status	Purpose	Tenement Area
L47/635	Pending	A bore field, a mine site accommodation facility, a pipeline, a power line, taking water.	82 ha
L47/636	Pending	A bore field, a mine site accommodation facility, a pipeline, a power line, taking water.	64
L47/637	Pending	A bore field a pipeline, a power line, a road, taking water.	149 ha
L47/638	Pending	A bore field, a pipeline, a power line, a road, taking water.	30 ha
L47/639	Pending	A bore field, a pipeline, a power line, a road, taking water.	276 ha
L47/640	Pending	A bore field, a pipeline, a power line, a road, taking water.	156 ha
L47/641	Pending	A bore field, a pipeline, a power line, a road, a truck parking bay, taking water.	42 ha
E47/1238/ Pending M47/1468	Live/Pending	Mine site and associated infrastructure	44 blocks/ 1201 ha.

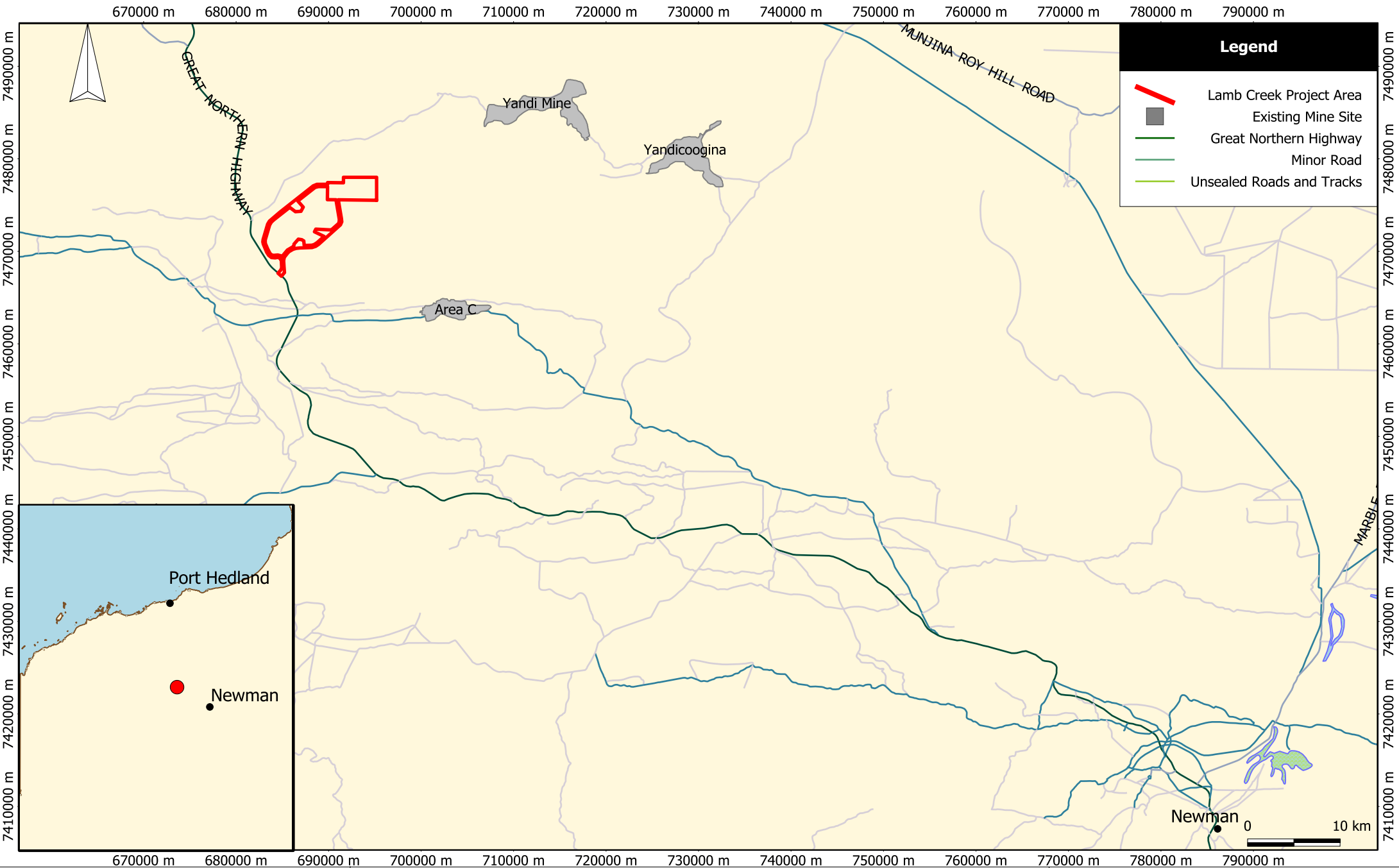
2.2. SCOPE AND AIMS

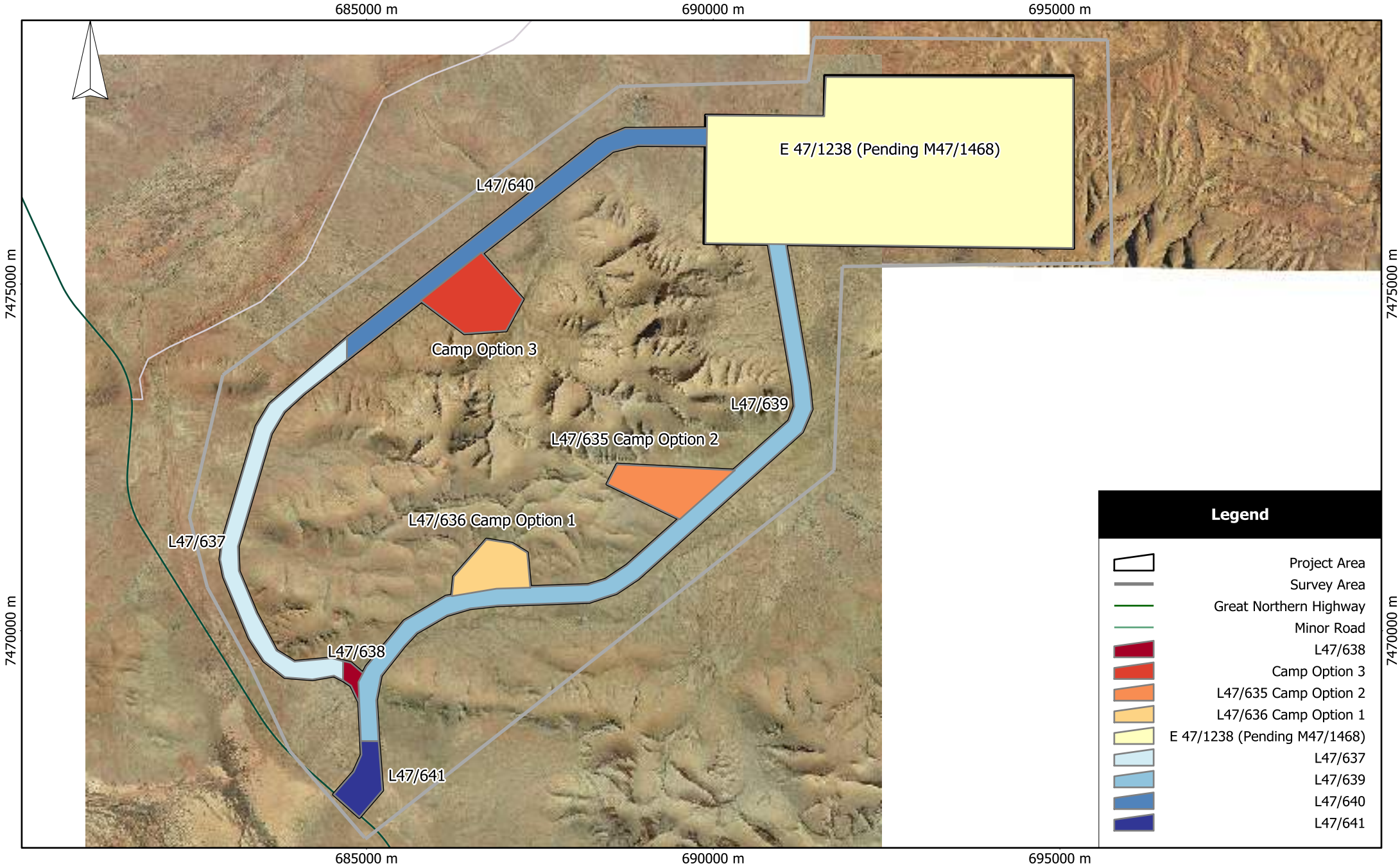
Rapallo Environmental was commissioned by PMI to conduct a Level 2 fauna survey (herein referred to as the 'fauna survey') of the proposed Lamb Creek iron ore project area (herein referred to as the

‘project area’) and adjacent areas of similar habitat. The project area and adjacent habitats that were investigated during the fauna survey combined are referred to as the ‘survey area’(Figure 2). In addition, Rapallo Environmental was commissioned to conduct a targeted Northern Quoll survey of the survey area.

The core aims of the survey were to:

- characterise vertebrate fauna assemblages of the survey area;
- characterise habitats of the project area and investigate their linkages to regional habitats;
- collect data on species of conservation significance that occur within and adjacent to the project area (if any);
- identify habitats that may support species of conservation significance on the project area;
- identify habitats that may support species of conservation significance off the project area but within PMI’s tenement holding;
- identify, map and survey habitats with potential to support Northern Quolls;
- identify Short-range Endemic (SRE) invertebrates occurring or likely to occur in the survey area;
- describe SRE habitat in the project area; and
- understand survey findings in a regional context to evaluate potential risks to SRE populations.





Original Size: A4 Scale: 1:70,000
Datum: MGA94



Process Minerals International

Figure 2

Lamb Creek Survey Sites and Equipment

2.3. EXISTING ENVIRONMENT

2.3.1. CLIMATE

Climate in the Pilbara region of Western Australia is characterised as an arid tropical climate with most rain falling during the hot summers between January and March (Beard 1990). Climatic conditions are influenced by tropical cyclones predominately through these months.

The nearest Bureau of Meteorology (BoM) weather station to the survey area is at Newman Airport (station number 007176), approximately 130 km southeast of Lamb Creek. Mean annual rainfall recorded at this station over the period of 1971 to 2012, is 322 mm (Bureau of Meteorology 2012). February has the highest mean monthly rainfall of 77.3 mm and September has the lowest mean monthly rainfall of 4.5mm (Figure 3).

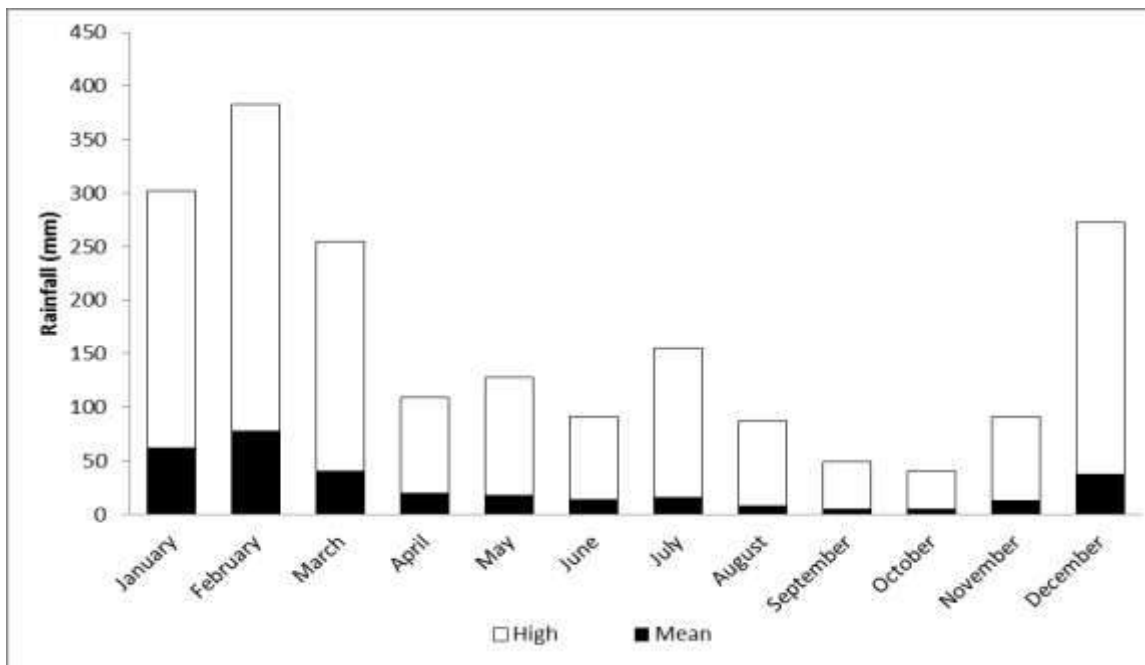


Figure 3 Mean annual rainfall at Newman Airport BoM Station (007176) over years 1971 to 2012

Evaporation rates are not recorded at the Newman Airport BoM Station. However, evaporation in the Central Pilbara Region is estimated to be between 2000 mm and 3500 mm, and is 10 times higher than rainfall (Gardiner 2003). This disparity maintains a typically arid landscape, with the exception of areas located in proximity to river systems and shallow groundwater resources.

The hottest month recorded at the Newman Airport Station is January with a mean maximum temperature of 39.2 °C and a mean minimum temperature of 24.9 °C (Figure 4).

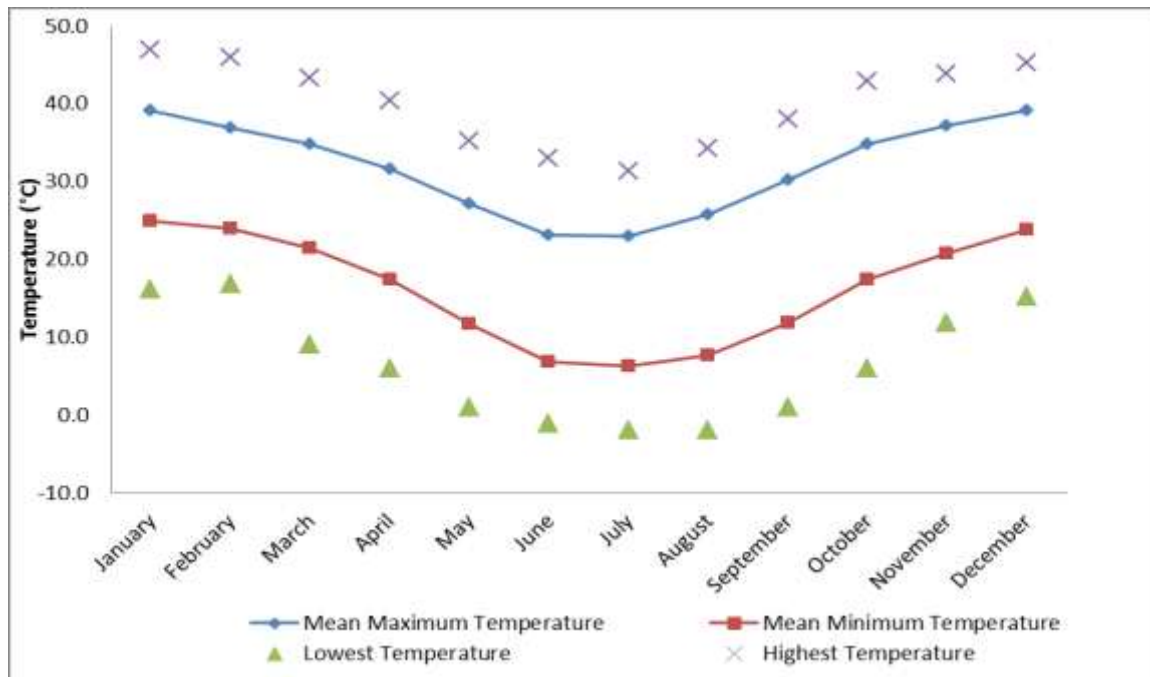


Figure 4 Mean monthly temperatures at Newman Airport BoM Station (007176)

2.3.2. DRAINAGE

Regional stream flow in the Pilbara is ephemeral, related to intense rainfall from with cyclonic activity or localised thunderstorms. Stream flow decays rapidly once rainfall has ceased. The drainage system upstream of the Fortescue Marsh has negligible base flow with stream flow and water table recharge following rainfall events (Van Vreeswyk *et al.* 2004).

The proposed mining area (tenement M47/1468) contains four minor non-perennial (type 2) water courses. The southern proposed haul route option (L47/638, L47/639, L47/641) and two prospective accommodation areas (L47/635, L47/636) are crossed by eight minor non-perennial water courses. Seven non-perennial water courses cross the northern proposed haul road option (L47/637, L47/640) and the northern prospective accommodation area (E47/1329). No major or perennial drainage lines occur within or directly adjacent to the survey area Geoscience Australia.

2.3.3. GEOLOGY

The project area is located in the south-west corner of the Roy Hill 1:250,000 Geological Survey Sheet (Thorne & Tyler 1997). The geology of the project area is generally defined by the assemblage prehnite-pumpellyite-epidote-actinolite. Basement rocks comprise the early Proterozoic Brockman Iron Formation and Weeli Wolli Formation. The Brockman Iron Formation consists of banded iron formation (BIF) and shale, while the Weeli Wolli formation consists of BIF separated by shale and siltstone bands, with younger dolerite sills that intersect the sedimentary sequence (Thorne & Tyler 1997).

Regionally, the fresh basement rocks are typically overlain by weathered basement rocks which occur as lateritic and basal gravel and/or conglomerate deposits. These weathered deposits underlie early Tertiary Channel Iron Deposits (CID), which are the dominant economic-grade iron deposits in the

region. The CID is typically overlain by younger alluvial and colluvial gravels and sediments (Thorne & Tyler 1997).

2.3.4. SOIL AND LANDFORM

The project area is typical of the Eastern Pilbara with rocky hills, small gorges, mostly seasonal watercourses and gravelly loam valleys. The project area is located in the Fortescue Valley Zone of the Fortescue Province which is described by Tillie (2006) as alluvial plains, hardpan wash plains and sandplains (with stony plains, floodplains and some salt lakes) on alluvial deposits over sedimentary rocks of the Hamersley Basin. Soils are generally red deep sands, red loamy earths and red/brown non-cracking clays with some red shallow loams and hard cracking clays. Vegetation is generally mulga shrublands and spinifex grasslands, with some tussock grasslands and halophytic shrublands. This region is located in the Pilbara along the Fortescue River between Millstream National Park and Ethel Creek Station.

The project area has two distinct soil and landform assemblages. The majority of the potential haul road alignment and the edges of the mine tenement are characterised as Fa13. The central part of the mine tenement and small portion of the potential haul road alignment is characterised as Fb3. These are defined in Australian Soils Resource Information System (CSIRO Australia 2012) as follows:

- **Fa13:** Ranges of banded jaspilite and chert along with shales, dolomites, and iron ore formations with some areas of ferruginous duricrust as well as occasional narrow winding valley plains and steeply dissected pediments. This unit is largely associated with the Hamersley and Ophthalmia Ranges. The soils are frequently stony and shallow and there are extensive areas without soil cover: chief soils are shallow stony earthy loams along with some soils on the steeper slopes. Associated are soils on the limited areas of dissected pediments, while and soils occur on the valley plains; and
- **Fb3:** High-level valley plains set in extensive areas of unit Fa13. There are extensive areas of pisolitic limonite deposits: principal soils are deep earthy loams along with small areas of soils.

2.3.5. IBRA ZONE

The project is within the Hamersley subregion (Pilbara 3) under the Interim Biogeographic Regionalisation of Australia (IBRA) system, which covers the southern section of the Pilbara Craton. The Hamersley subregion is a mountainous area of Proterozoic sedimentary ranges and plateaux, dissected by gorges of basalt, shale and dolerite. Vegetation is generally low Mulga woodland over bunch grasses on fine textured soils in the valleys with snappy gums (*Eucalyptus leucophloeia*) over *Triodia* species on skeletal soils of the ranges (Kendrick 2002).

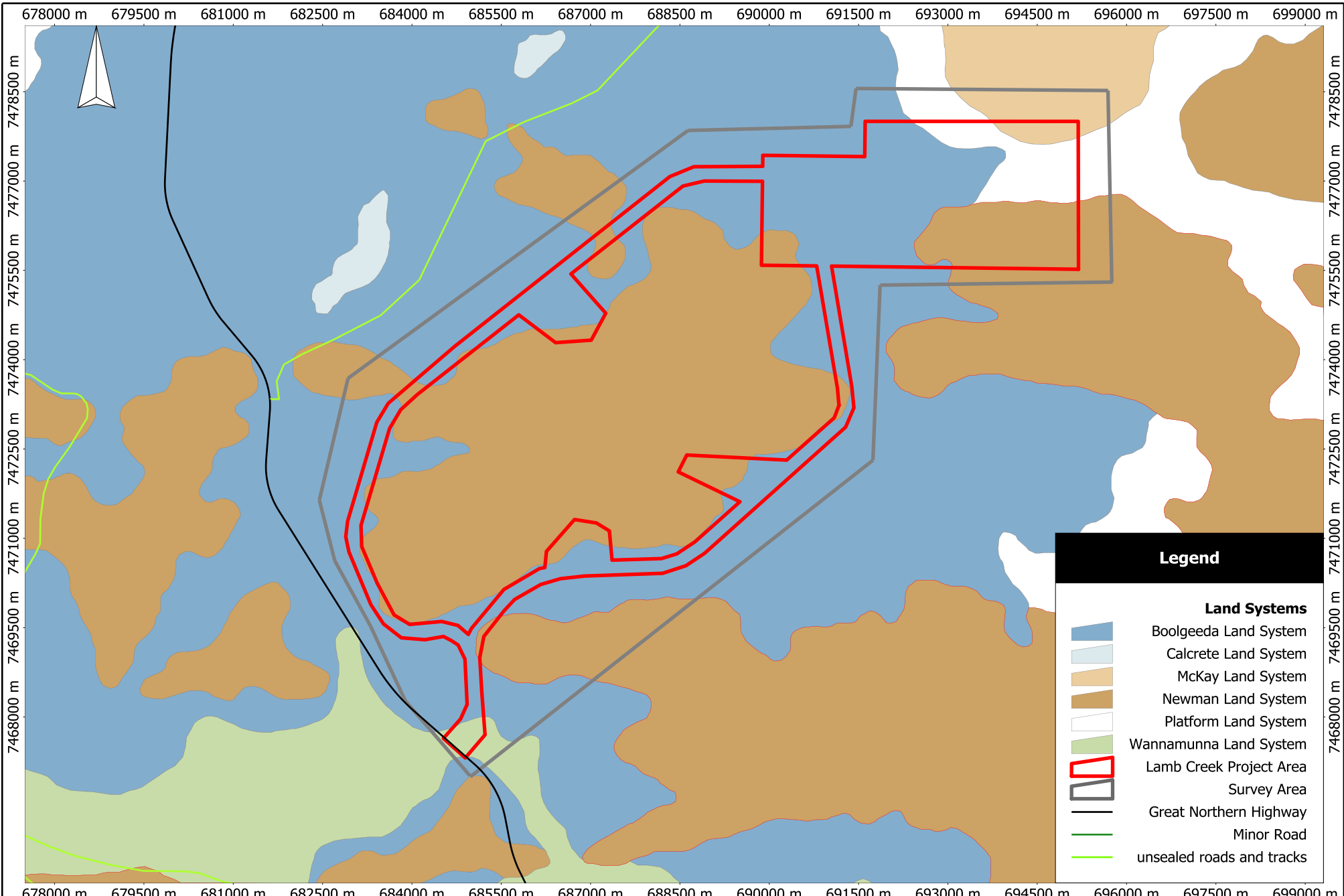
The Hamersley subregion contains calcrete deposits that are refugia and centres of endemism for troglofauna; however the current knowledge of troglofaunal diversity and endemism is preliminary. Several features in the Hamersley subregion serve as refugia. Gorges in the Hamersley Ranges that have permanent water and are protected from fire harbour humidophiles and fire intolerant species. Mountain tops in the Hamersley Ranges provide refuge from fire and support a diversity of restricted flora (Kendrick 2002).

2.3.6. LAND SYSTEMS

The project area covers several land systems within the Hamersley subregion (Figure 5, Table 2), as described by Van Vreeswyk et al. (2004). The approximate area size of each land system located on the project area can be found in Table 2.

Table 2: Land systems on the project area

Land System	Vegetation Description (Van Vreeswyk <i>et al.</i> 2004)	Area in the Pilbara (km ²)	Area on Project Area (km ²)	Precent of the land system that occurs within project area
Boolgeeda	Stony lower slopes, level stony plains and narrow sub-parallel drainage floors, relief up to 20 m. A common system in shallow valleys below hill systems such as Newman and Rocklea	7,748	11.584	0.149%
McKay	Hills, ridges, plateaux remnants and minor breakaways of sedimentary and meta sedimentary rocks supporting hard spinifex grasslands, relief up to 100 m	4,202	0.440	0.01%
Newman	Rugged high mountains, ridges and plateaux with near vertical escarpments of jaspilite, chert and shale	14,580	2.77	0.018%
Platform	Erosional surfaces formed by partial dissection of the old tertiary surface; gently inclined upper plains with extensive marginal dissection zones with gently inclined to steep slopes. Floors incised up to 30m with steep stable marginal slopes becoming wider downslope	1,570	1.98	0.12%
Wannamunna	Depositional surfaces, level hardpan washplains subject to overland sheet flow. Broad internal drainage flats receiving run-on from adjacent hardpan surfaces; rare channelled tracts but moistly no organised through drainage. Relief up to 5m	577	0.27	0.04%



Legend

Land Systems

- Boolgeeda Land System
- Calcrete Land System
- McKay Land System
- Newman Land System
- Platform Land System
- Wannamunna Land System
- Lamb Creek Project Area
- Survey Area
- Great Northern Highway
- Minor Road
- unsealed roads and tracks



Original size: A4 Scale: 1:85,000
Datum MGA94(50)

Process Minerals International

Figure 5
Lamb Creek Land Systems

2.3.7. REGIONAL VEGETATION

The vegetation within the study area is governed by geological, topographical, and edaphic influences of the Fortescue Botanical District (Beard 1990). This district consists predominantly of tree and shrub steppe communities with *Eucalyptus* trees, *Acacia* shrubs and grasses including *Triodia pungens* and *T. wiseana* (Beard 1975). Mulga (*Acacia aneura* and related taxa) occurs in valleys and short-grass plains may be present on alluvial soils (Beard 1990). Communities of *Eucalyptus leucophloia* over *Triodia* species occur on the skeletal soils of the ranges (Kendrick 2002). The other major influence on the flora and vegetation in the Pilbara Region is the heavy rains that occur during and immediately following cyclonic events. Cyclones develop off the north-west coast and often cross the coastline between Karratha and Port Headland and then travel inland over the Fortescue Valley system towards Newman. Vegetation was mapped by Rapallo (2012) in a Level 2 flora and vegetation survey.

2.3.8. LAND USE

Dominant land use within the Hamersley subregion is grazing. Land is classified (in order of spatial dominance) as unallocated crown land and crown reserves, native pastures, conservation, mining and urban (Kendrick 2002). The project area is located in the East Pilbara Region which has a total population of 10,500 people. The major industries in the East Pilbara Region are mining, pastoral and tourism (URS Australia Pty Ltd 2011). The Shire of East Pilbara contains numerous Aboriginal communities; the largest are Jigalong, Punmu and Parngurr. Aboriginal communities are also located in Nullagine (Irrungadji Community) and Marble Bar (Pipunya and Goodabinya Communities).

2.3.9. RESERVES AND ENVIRONMENTALLY SENSITIVE AREAS

Environmentally sensitive areas (ESAs) are protected under the *Environmental Protection (Clearing of Native Vegetation) Regulation 2004* and are selected for their environmental values at state or national levels.

The project area does not overlay any ESAs as described by the *Environmental Protection (Clearing of Native Vegetation) Regulation 2004* or Priority Ecological Communities (PECs) as defined by DEC. According to the DEC's Native Vegetation Map Viewer, there are no ESAs within five kilometers of the project area. The nearest PEC buffer is located over 6 km south-west of where the proposed haul road will intersect with the Great Northern Highway. That PEC is described as 'Coolibah – Lignum Flats'.

Karijini National Park is located to the west of the project area, approximately 18 km west of the intersection of the proposed haul road and the Great Northern Highway. Mungaroo Range Nature Reserve is approximately 100 km northwest of the project area.

2.4. LEGISLATION AND SURVEY GUIDANCE

The conservation status of flora and fauna species is assessed under Commonwealth and State Acts; the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the Western Australian *Wildlife Conservation Act 1950*. In Western Australia the Department of Environment and Conservation (DEC) can also list fauna species under a Priority listing.

In addition to the conservation status of fauna the Environment Protection Authority (EPA) has produced a series of guidance statements to aid in assessing the environmental impacts of developments in Western Australia.

2.4.1. ENVIRONMENTAL PROTECTION AND BIODIVERSITY ACT (EPBC ACT) 1999

At a Federal level the *EPBC Act* contains a list of fauna species that are considered Critically Endangered, Endangered, Vulnerable, Conservation Dependent, Extinct or Extinct in the Wild (Appendix I). The conservation categories and EPBC listed species follow the recommendations of the International Union for the Conservation of Nature and Natural Resources (IUCN, 2008).

The *EPBC Act* also has lists of migratory species that are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The list of migratory species under the *EPBC Act* has been revised to include listed species only, thus excluding family listings.

2.4.2. WILDLIFE CONSERVATION ACT 1950

In Western Australia, all native fauna is protected under the *Wildlife Conservation Act 1950* and cannot be collected, kept or culled without the appropriate permits. The *Wildlife Conservation Act 1950* uses a set of Schedules to classify the level of protection given to fauna species.

Fauna species included under conservation acts and/or agreements are formally recognised as of conservation significance under state or federal legislation. Those species listed in JAMBA are also protected under Schedule 3 of the Western Australian *Wildlife Conservation Act 1950*.

The DEC regularly reviews and revises the schedule of threatened fauna listings in Western Australia.

2.4.3. DEC PRIORITY LISTINGS

In Western Australia, the DEC has produced a supplementary list of Priority fauna (Appendix I). These are species that are not considered Threatened under the Western Australian *Wildlife Conservation Act 1950*, but for which the DEC feels there is cause for concern. Thus these species are recognised as having conservation significance and are given consideration when developments are proposed within their distributions and known habitats.

At the State level the recommendations of listed species by the IUCN are not stringently adhered to. Hence a species may be listed as a Priority by the DEC and not listed by the IUCN and vice versa.

In addition to the Priority listings the DEC will recognise the conservation significance of species included in publications such as such as Garnett and Crowley (2000) and Cogger *et al.*, (1993) and through interpretation of distribution information. In the latter a species may be considered significant, although this level of significance has no legislative or published recognition, if;

- the species is occurring at the limit of their distribution;
- the species that have a very restricted range e.g. Short Range Endemics; or,

- the species occurs as a breeding colony e.g. some waterbirds.

2.4.4. EPA GUIDANCE STATEMENTS

The Environmental Protection Authority (EPA) Guidance Statement; *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australian No 56* (2004) and EPA Position Statement 3; *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (2002) outlines the minimal expectations of the EPA in regards to terrestrial fauna considerations in an environmental impact assessment. The guidance statement provides a number of general recommendations for consideration before a survey:

- level of survey required;
- design and intensity factors;
- survey limitations; and,
- reporting of data.

For the Pilbara IBRA region – Group 2, the guidance statement states that any proposed project with footprint greater than 50 hectares is considered to generate a high scale impact and requires a Level 2 Fauna Survey to adequately assess potential impacts (EPA, 2004). The EPA's Technical Guide; *Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (Environmental Protection Authority 2004) provides the standards and protocols for undertaking fauna surveys (Level 1 and Level 2) with techniques and methods specific to the different bio-regions of Western Australia.

The following statements outline the minimal expectations of the EPA in regards to consideration of SRE fauna in an environmental impact assessment.

- EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002).
- EPA Guidance Statement No. 20: *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009).

Guidance Statement No. 20 addresses the general standards required for SRE surveys and to develop a common framework by which they should be carried out. It also sets out the expectations in respect of the quality and quantity of data collected during SRE surveys, and how this data should be analysed and reported.

Importantly, the Guidance Statement recognises and discusses limitations on current knowledge in respect to SRE fauna. In particular, the limitations encountered after recording rare and cryptic taxa are discussed and the low probability of further survey success acknowledged. If such specimens are restricted to impact zones, risk based analysis based using habitat as a surrogate for distribution will be considered (EPA 2009).

2.4.5. SHORT RANGE ENDEMISM

Harvey (2002) reviewed the occurrence of short range endemism in Australian invertebrate fauna. The main criterion nominated for inclusion as a SRE species was that the species had a naturally small range of less than 10,000 square kilometres. He identified a series of major groups of

invertebrates as having a very high proportion of species that satisfied characterisation as SRE's. Harvey (2002) found that those species possessed a series of ecological and life-history traits including:

- Poor powers of dispersal.
- Confinement to discontinuous habitats.
- Usually highly seasonal; only active during cooler, wetter periods.
- Low levels of fecundity.

Based on these traits and after reviewing the literature in Australia, Harvey (2002) listed a series of invertebrate groups that either showed high levels of short range endemism or were likely to possess SRE species after further taxonomic studies. The list of groups includes:

- Mygalomorph Spiders
- Scorpions
- Pseudoscorpions
- Millipedes
- Snails

These taxa are of particular risk of possessing SRE species and survey methodologies should include specific systems that aim to record members of each taxon.

The EPA Guidance Statement No. 20 (EPA 2009) indicates that the optimal time for conducting surveys in the Pilbara is in the cyclone season (November to April), when there is sufficient rainfall to stimulate enhanced activity in otherwise cryptic groups such as *Quistrachia* (land snails) and male mygalomorph spiders. The SRE survey of the survey area was completed at the end of this period, with good rainfall preceding the survey.

2.4.6. NORTHERN QUOLL SURVEY GUIDELINES

The Department of Sustainability, Environment Water, Populations and Communities (SEWPaC,) has released survey and referral guidelines for Northern Quoll (*Dasyurus hallucatus*) (Department of Sustainability, Environment, Water, Population and Communities 2011). The guidelines include maps of known and potential distribution, survey methods, and guidelines for determining whether projects in potential Northern Quoll habitat should be referred to SEWPaC under the *Environment Biodiversity and Conservation Act 1999*.

For the purposes of assessment under the *EPBC Act*, SEWPaC (2011) recommends that surveys for Northern Quoll involve an initial reconnaissance survey which aims to identify the need for further investigations through a targeted survey. These should be conducted by a suitably qualified person with demonstrated skill in mammal surveys, maximise the chance of detecting the species, and account for uncertainty and error (such as false presences and absences).

A reconnaissance survey can be conducted at any time of the year but should be undertaken in the early planning stages of the project. The reconnaissance survey should assess the suitability of habitat for northern quolls, both for denning / shelter and dispersal and foraging purposes. Suitable habitat should be mapped during this survey and habitat areas calculated. Data collected should describe the

habitat quality including information on vegetation, microhabitat, fire history, presence of introduced predators, grazing history and landscape condition. A reconnaissance survey may investigate the presence or potential presence of the northern quoll by using non-invasive techniques such as active searching for scats and latrine sites, motion sensitive cameras, hair tubes or spotlighting where appropriate.

A targeted survey is recommended for any proposal occurring within the modelled distribution of the species and where the reconnaissance survey identifies the presence of quolls and / or habitat critical to the survival of northern quoll. The objective of the targeted survey is to determine the relative abundance and distribution of Northern Quolls likely to be impacted by the proposed development. The survey protocol should be designed so that the total population of Northern Quolls in the impact area can be calculated. A targeted survey should be undertaken before development and during the months of May, June, July or August (primarily to avoid any disturbance during the reproductive period) and include proposed impact areas as well as adjacent suitable habitat.

Records of the species exist within 50 kilometres of the project area. In addition, potential suitable habitat for the species exists on the project area. As a result, PMI has proceeded with undertaking a targeted Northern Quoll survey in conjunction with its Level 2 Fauna Survey.

3. METHODS

The survey was divided into four sections:

- a Reconnaissance Survey (Section 3.5);
- a systematic surveys for vertebrate fauna (Section 3.6):
- a systematic surveys for SRE's (Section 3.7) ; and,
- a targeted survey for Northern Quolls (Section 3.8).

3.1. SCIENTIFIC LICENCE

This survey was licensed under the Western Australian Wildlife Conservation Act 1950 Regulation 17 "Licence to Take Fauna for Scientific Purposes" licence number: SF008562 (Appendix II).

3.2. VOUCHERING

Rapallo will voucher specimens if:

- it can't be identified in the field (typically difficult species such as *Ramphotyphlops*);
- it is a species of taxonomic confusion/interest; or
- it is possibly an un-described species.

Rapallo sought advice from the Western Australian Museum (WAM) prior to the field survey in regards of fauna that may be required for vouchering. WAM advised Rapallo that they were not currently in need of vouchered specimens from the survey region.

3.3. PERSONNEL

Table 3 outlines the personnel that were involved in the field survey and the preparation of this report.

Table 3 Personnel involved in this survey

Name	Position	Trap Installation	Field Survey	Reporting
Chris Jackson	Senior Ecologist	•	•	•
Henry Cook	Ecologist	•	•	
Cara McGary	Environmental Scientist		•	•
Chris Cooper	Graduate Ecologist	•	•	•
Magnus Peterson	Field Ecologist		•	
Dejan Stojanovic	Field Ecologist	•	•	
Bruce Cripps	Laborer	•		
Shaun Stevens	Laborer	•		

3.4. DESKTOP SURVEY

Prior to the field survey, database searches were completed to determine if species of conservation significance had either been recorded within the survey area or had the potential to occur within habitats found on the project area. Table 4 describes which databases were used for information regarding species of conservation significance. Results of the database searches are presented in Appendices 4-8. An in-depth description of all potential conservation significant species found on the survey area can be found in section 6.

Table 4 Database Searches undertaken for the Lamb Creek survey area.

Search	Latitude	Longitude	Buffer (kilometres)	Comments
DEC Threatened Fauna Database (2012a)	22°50' 18" S	118°50' 17" E	50	Point Search
DEC Threatened Ecological Communities Database (2012b)	22°50' 18" S	118°50' 17" E	50	Point Search
SEWPaC Environmental Reporting Tool (2012)	22°46'01"S 22°53'52"S 22°53'56"S 22°45'57"S	118°42'17.89"E 118°42'17.89"E 118°56'4.52"E 118°55'55.96"E	10	Area Search
NatureMap(2012c)	22°26' 29" S	118°18' 53" E	40	Point Search
Birds Australia BirdData (Birdlife Australia 2012)	22°50'19"S	118°50'16"E	40	Point Search
WAM Mollusc Database (2012a)	22°50' 18" S	118°50' 17" E	50	Point Search
WAM Terrestrial SRE Database (2012b)	22°50' 18" S	118°50' 17" E	50	Point Search

In addition to the above database sources, data from previous fauna surveys in the region were reviewed. Table 5 details which reports were used for the regional literature review.

Table 5 Regional literature sources

Report	Author	Distance from Lamb Creek (km)
Fauna survey of the proposed Hope Downs 4 mining area.	Ninox Wildlife Consulting, (2009)	30km SE of Lamb Creek
Yandicoogina Junction South West and Oxbow Fauna Survey.	Biota Environmental Sciences, (2010)	41km NE of Lamb Creek.
Fauna survey of proposed Iron Ore Mine, Cloud Break.	Bamford Consulting Ecologists, (2005)	80km NE of Lamb Creek
Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas.	Biota Environmental Sciences, (2005)	Mindy Mindy approximately 80km E of Lamb Creek.

3.5. RECONNAISSANCE SURVEY

Prior to the deployment of field teams to the survey area, aerial photographs and land system shape files were analysed to identify areas of interest across the survey area.

A two-day reconnaissance survey, via helicopter, of the survey area was conducted on the 19-20 March 2012 by staff from Rapallo Environmental. The aims of this survey were to identify habitat types, assess the road access to the survey area and ground truth areas of interest identified from GIS maps and aerial photography. A total of 5 unique habitat types were identified during the reconnaissance survey as being capable of supporting different assemblages of vertebrate fauna.

The reconnaissance survey team also deployed motion detecting cameras which were placed in caves and under rock overhangs at the bases of mesas and banded iron stone (BIF) outcrops. A total of 10 motion detecting cameras were deployed during the reconnaissance survey in the locations shown in Figure 6. These cameras were retrieved after approximately two weeks. Videos were downloaded and examined for fauna recordings.

3.6. VERTEBRATE FAUNA SURVEY

3.6.1. SYSTEMATIC TRAPPING

Rapallo Environmental used a nested pitfall trap grid to survey the terrestrial fauna of the survey area. Each site consisted of:

- twenty Elliot traps;
- ten funnel traps;
- six regular bucket pitfall traps; and
- six bucket pitfall traps with narrowed entrances.

The trap configuration is illustrated in Figure 7.

Ten trap sites were deployed, two sites for each major habitat.

Each pitfall trap had a white polystyrene tray to provide shelter, and a moist sponge to prevent desiccation for any captures.

Funnel traps were covered with a sheet of foil insulation to shelter any captives from extreme daytime temperatures.

Table 6 shows the total number of trap nights by habitat type in the survey area fauna survey. Habitat codes are described in Section 4.2.

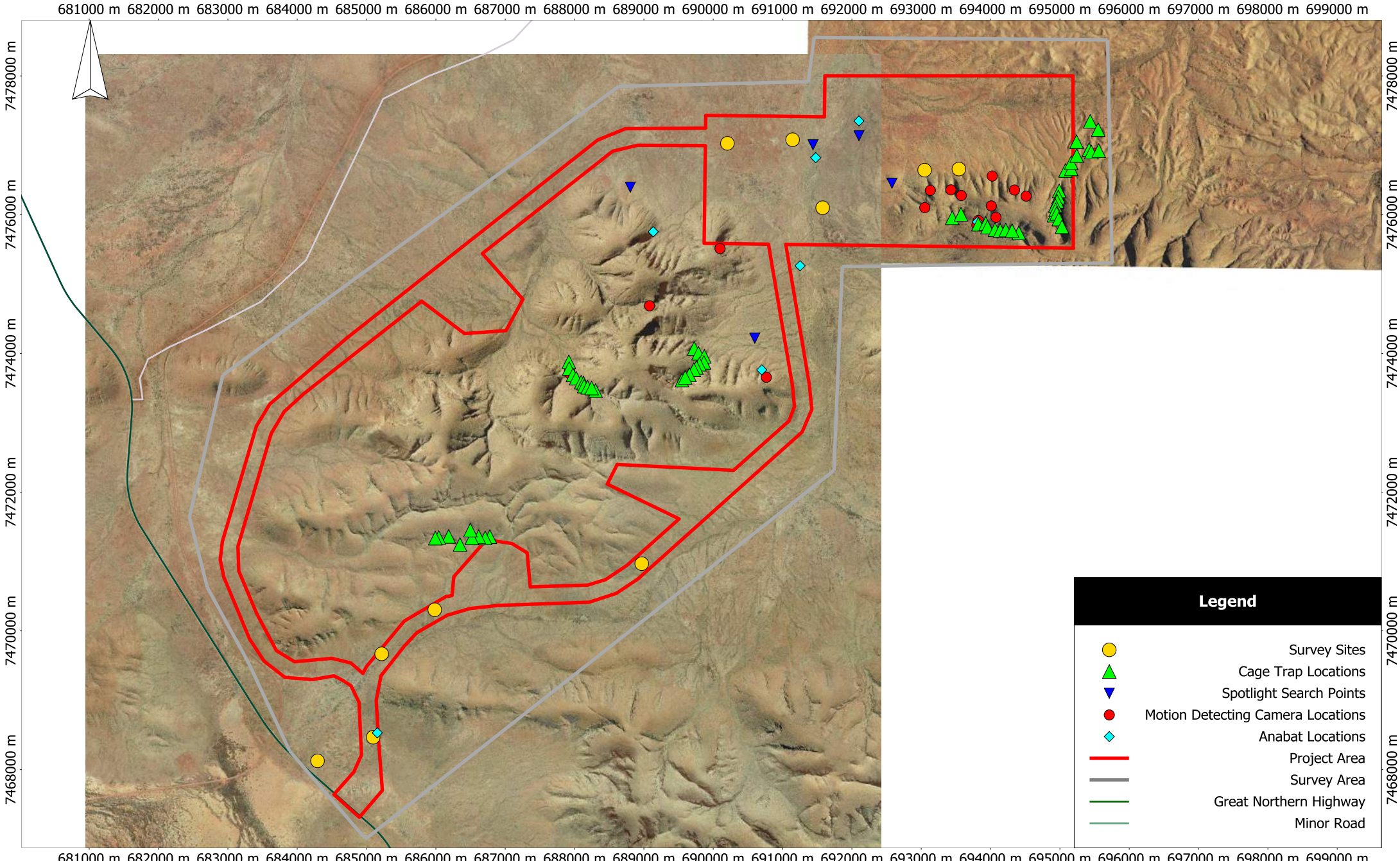
Table 6 Trap night summary by habitat and trap type for the Lamb Creek L2 Fauna Survey










Habitat Code	Pitfall Traps	Elliot Traps	Funnel Traps	Total Nights
SHET	168	280	140	588
MEAT	168	280	140	588
STABM	168	280	140	588
FLAGMA	180	300	150	630
SATOM	168	280	140	588
Total	852	1420	710	2982

Vertebrate fauna was identified and released each morning as the trap lines were cleared. If specimens could not be immediately identified they were placed in a calico bag and identified at the field camp. After identification the specimens were released near the site of capture when conditions permitted (i.e. nocturnal fauna were not released during midday heat).

The following data were recorded for each capture:


- trap site and trap number;
- species;
- number of animals;
- sex and reproductive condition; and
- age class (juvenile/adult).



Legend	
	Survey Sites
	Cage Trap Locations
	Spotlight Search Points
	Motion Detecting Camera Locations
	Anabat Locations
	Project Area
	Survey Area
	Great Northern Highway
	Minor Road

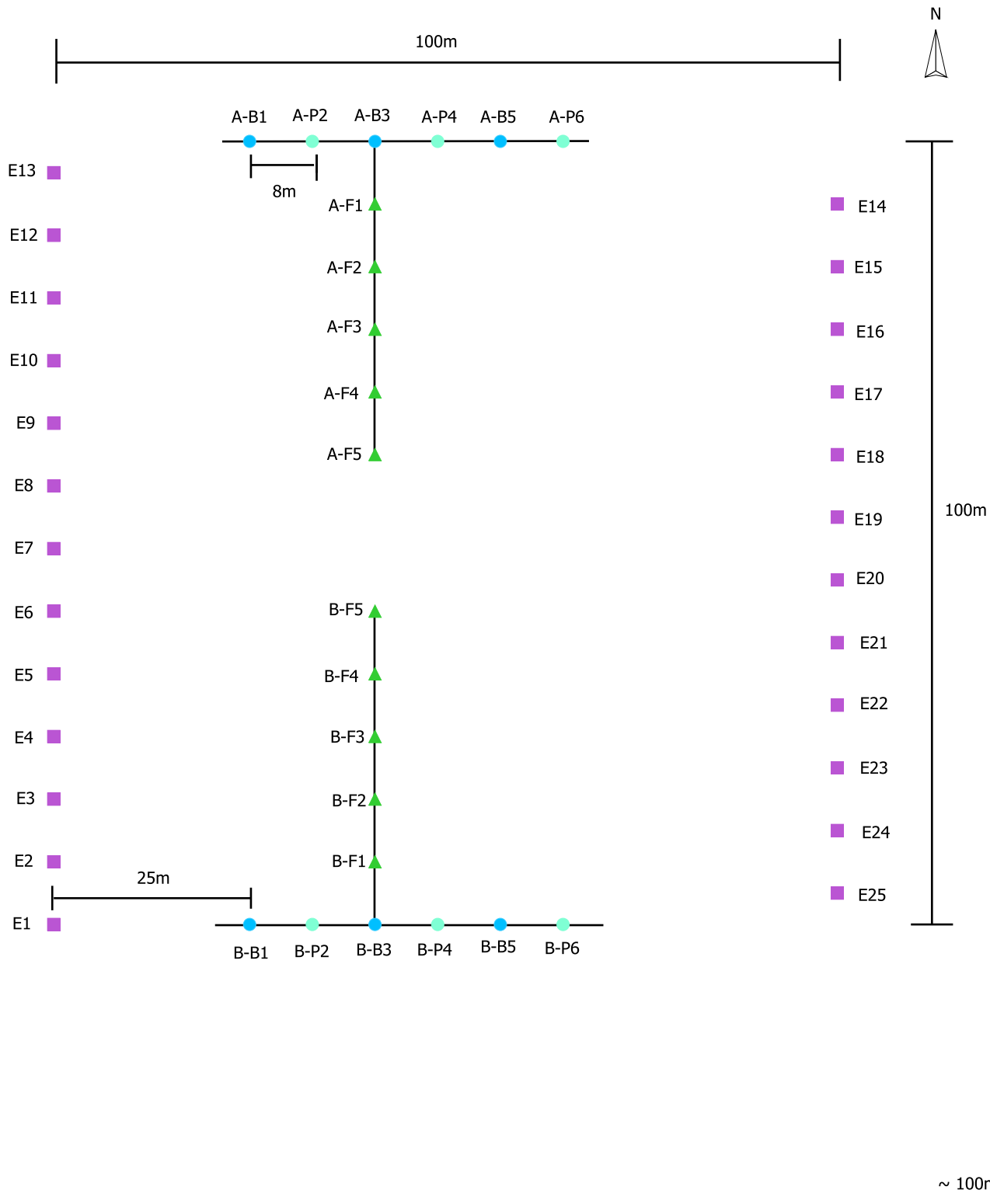
681000 m 682000 m 683000 m 684000 m 685000 m 686000 m 687000 m 688000 m 689000 m 690000 m 691000 m 692000 m 693000 m 694000 m 695000 m 696000 m 697000 m 698000 m 699000 m



Original Size: A4 Scale: 1:70,000
 Datum: MGA94
 0 1 km


Process Minerals International

Figure 6
 Lamb Creek Survey Sites and Equipment



Legend

- Buckets
- Elliotts
- ▲ Funnels
- ◆ Invertebrate
- Pipes
- Motion Detecting Camera



Original Size: A4
 Scale: 1:750
 0 20 m

Process Minerals International

Figure 7
 Lamb Creek Trap Layout

3.6.2. BIRD SURVEYS

Bird assemblages were assessed and compiled using a combination of trap site specific surveys and opportunistic observations.

Two hectare bird surveys, following Birds Australia guidelines, were completed each day between 6am and 9am when bird activity was peak and cryptic species were most detectable.

Records from each site were supplemented with opportunistic records. These records were collected at trap sites, during travel between trap sites and during day time forage surveys. Birds were identified by direct observation or by auditory survey. Road kill was examined whenever possible and species recorded where possible.

3.6.3. BAT SURVEYS

Bat surveys were conducted on the survey area using SM2BAT+ and ANABAT SD1 ultrasonic recorders. Both devices were placed in suitable locations on the survey area. Suitable locations included areas with caves, water or mature woodlands with hollow bearing trees.

Data collected on the ANABAT device was analysed by Dr. Kyle Armstrong of Specialised Zoological.

In addition, Rapallo deployed Harp Traps along potential fly-ways and next to water bodies. Traps were set prior to sun set and checked at the conclusion of spotlight activities each night. Harp traps were closed after being checked.

3.6.4. SPOTLIGHTING

Spotlight surveys were undertaken in each of the habitat types recorded on the survey area. In order to not disturb nocturnal fauna, spotlight surveys were not conducted at the systematic trap sites. Spotlight surveys were run over 30 minutes and were undertaken by a team of four ecologists.

Any terrestrial fauna or potential SRE's recorded during the searches were recorded using GPS locations. Habitat and time were noted if species of conservation significance were recorded during the survey.

3.6.5. HAND FORAGING AND HABITAT ASSESSMENT TRANSECTS

Transects were walked across the survey area to supplement data collected during other survey activities and to characterise and demarcate habitats. Additionally, they were used to survey habitats considered suitable for potential SREs.

Transects were plotted using data collected during the Reconnaissance Survey. They were designed to intercept several habitats at a time.

Each transect was walked by two ecologists. Each time the habitat type noticeably changed, the following data were collected to characterise the new habitat:

- GPS reading;
- soil type and characteristics;

- geology;
- landform;
- litter depth;
- evidence of disturbance (i.e. fire, grazing);
- understorey vegetation density and composition; midstorey vegetation density; canopy density and composition; and
- suitability for species of conservation significance.

During each transect, Rapallo staff would undertake foraging activities including lifting bark and old tin, rolling old logs and raking through sand and leaf litter.

The following data would be collected each time vertebrate fauna or potential SREs were encountered:

- GPS reading;
- species, sex, maturity; and
- habitat type.

If potential SREs were encountered, they were vouchered following guidelines released by the WAM (WAM 2008). Evidence of species of conservation significance was photographed if encountered.

3.6.6. MOTION DETECTING CAMERAS

Motion detecting cameras (MDCs) were deployed across the survey area in habitats with potential to support Northern Quolls. A total of 10 MDCs were deployed during the reconnaissance survey, these cameras were left for a period of two weeks before being collected and redeployed at an additional seven sites on the survey area for 6 days. Scoutguard motion detecting cameras were used for this survey. Each camera was programmed to record for 30 seconds at one minute intervals with detection sensitivity set to high.

Each camera was securely fastened at each location and focused onto a bait station. The bait used consisted of tinned cat food with high sardine content.

Data recorded from the MDCs has been included in the overall species list for the survey.

3.6.7. OPPORTUNISTIC RECORDS

While traversing the survey area, records were taken of all potential SRE invertebrates and their burrows. A brief habitat description was recorded, as well as GPS coordinates and site photos.

3.7. SRE SURVEY

Surveys for potential SRE specimens were in conjunction with sections 3.3.1, 3.6.2 and 3.6.5. Additional survey techniques, designed specifically for the detection of SRE's are described in section 3.7.1.

A total of 14 sites were foraged for SRE taxa (Figure 12). Litter samples were collected for later processing. At each forage site, SRE taxa were searched for by turning rocks, raking litter, raking under hummocks of *Triodia*, lifting bark and turning old logs. Clumps of vinous *Fiscus* sp. were targeted, when present, for potential SRE gastropods.

3.7.1. LEAF LITTER COLLECTION

Leaf litter was collected from 14 sites (Figure 12). The species of tree or shrub from under which leaf litter was collected was recorded. These sites were divided into the following landform types:

- south facing slopes/hillsides;
- creek lines;
- outcrops; and
- plains.

Leaf litter was collected in a twenty litre bucket and sifted using 1.5 millimetre sieves. The final mixture of organic matter was taken back to the Rapallo Environmental laboratory and run through either Tullgren Funnels or Winkler traps. Sifted samples were run for approximately 48 hours.

Specimens collected from the Tullgren Funnels and Winkler traps were sorted under a microscope at the Rapallo Environmental laboratory. Potential SRE taxa were separated from the bulk samples and vouchered for taxonomic identification according to WAM (2011) guidelines.

3.7.2. CATEGORIES OF SHORT-RANGE ENDEMISM

Currently, there is no accepted system to determine the likelihood that a species is an SRE. For the purposes of this report we have adopted the three-tier SRE likelihood system developed by (Phoenix Environmental Sciences 2012, Appendix 10), wherein species are categorised based on the different probabilities of short-range endemism: ‘confirmed’, ‘likely’ or ‘potential’ SRE (Table 2-1). These categories are dynamic and can change as knowledge of SRE status is updated.

Although the different categories of SRE-likelihood may help to set conservation priorities, SRE taxa of all categories should be assessed on their merit, in order to determine appropriate conservation measures that adhere to the Precautionary Principle within environmental impact assessments. That is, “where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation” (Environmental Protection Authority 2002).

3.7.3. TAXONOMIC IDENTIFICATION

All potential SRE taxa were sent off to taxonomic experts for identification before being vouchered in the WAM collection. The following taxonomists were involved with specimen identification:

- | | |
|------------------------------------|--|
| • Dr Volker Framenau (Phoenix) | Millipedes, centipedes, pseudoscorpions, spiders |
| • Dr Simon Judd (Phoenix) | Slaters |
| • Dr Corey Whisson (WAM) | Land snails |
| • Dr Erich Volschenk (Scorpion ID) | Scorpions |

3.8. TARGETED NORTHERN QUOLL SURVEY

A targeted survey for the Northern Quoll was conducted simultaneously with the fauna survey. The targeted Northern Quoll survey was designed following methods described in Northern Quoll Survey Guidelines (SEWPaC 2011). Potential trap sites were identified during the Reconnaissance Survey.

Six sites were selected for the targeted Northern Quoll survey. These sites consisted of deeply dissected gorges and along the face of rocky escarpments. Each trap site consisted of 10 cage traps deployed approximately 100 m apart. The distance between traps was extended slightly where suitable habitat was not continuous. Locations were recorded using a GPS for each cage trap.

Traps were set in locations that provided shade and were covered with a sheet of foil insulation or a hessian sack to shelter any captive animals from weather such as wind, rain and sunlight. Traps were baited using a mixture of peanut butter, rolled oats, honey and tinned sardines and were rebaited every second day.

Traps were set out for five nights on each line. Traps were cleared before 9 am each day. Each bait ball was replaced after two nights if no captures were recorded in a trap. Traps were moved if ants were active in the trapping area.

The following data was recorded if a capture occurred:

- date, trap number
- sex
- weight
- foot length
- head length and width

The reproductive status of each quoll was determined using diagnostics outlined in Oakwood (2000).

Following measurement all quolls were individually marked with a micro-chip inserted subcutaneously between the shoulder blades. This enabled swift identification of recaptured individuals without the need of handling them a second time.

A small (2 mm²) piece of ear tissue was removed and stored in 100% ethanol for DNA analysis.

3.9. BIODIVERSITY ASSESSMENT AND SPECIES RICHNESS

3.9.1. SPECIES ACCUMULATION CURVE

Individual based rarefaction curves (species accumulation curves) were produced for each vertebrate fauna group. They were derived from data collected at systematic trap sites only.

Rarefaction curves enable evaluation of the sampling effort and can be used to predict the potential number of species found on a survey (Colwell 2000). EstimateS V8.02 was used to generate the species accumulation curves.

Curves were constructed by plotting individuals caught along the x-axis against Coleman rarefaction estimates along the y-axis. The data was sampled 10,000 times.

3.9.2. SPECIES RICHNESS

Data collected during systematic and standardised fauna surveys can be analysed by a series of models to determine site specific species richness. Such calculations are useful for determining the biodiversity of a survey area and the expected number of species (species richness). Inference derived from biodiversity calculations is constrained if there are limited regional calculations to compare the results to.

Species richness estimators are often influenced by sampling issues such as low sample size, small number of species dominating data sets or a high number of species recorded only once or twice. These issues are most easily overcome by using a combination of appropriate non-parametric species richness models and comparing the outputs against the Cole-rarefaction used as the estimator of species richness in this report.

The following species richness estimators were used to assess the biodiversity of the Lamb Creek survey area:

- ACE Mean;
- ICE Mean;
- Chao Mean;
- Jackknife Mean.

Species richness estimators were calculated for each major vertebrate fauna group.

3.10. SURVEY LIMITATIONS AND CONSTRAINTS

An assessment of the limitation of the survey has been displayed in Table 7 in accordance with Guidance Statement No. 56 (Environmental Protection Authority 2004).

Table 7 Summary of limitations experienced during the Survey

Aspect	Constraint	Comment
Experience of Consultants	No	All members of the survey team have experience in undertaking fauna surveys. At least one member of any field team group was extremely experienced with surveying for and identifying Pilbara fauna.
Scope	No	Scope and intensity of survey were suitable to achieve the survey aims.
Proportion of fauna identified, recorded and/or collected	No	High fauna abundance and diversity was recorded during the survey.
Information sources e.g. previously available information (whether historic or recent) vs. new data.	No	Extensive surveying has been undertaken in the Pilbara region including several surveys within 50 kilometers of the survey area within the previous five years.

Aspect	Constraint	Comment
Proportion of task achieved and further work may be required	No	All habitat areas were well surveyed and the timing was optimal for presence of most native species.
Timing, weather, seasons. Cycle	No	Only a single season of surveying was undertaken. This survey was completed at the end of the wet season. Warm days and availability of water would have positively affected the activity of most species.
Disturbances that affected the survey	Yes, Partial	Isolated storms during the survey period may have affected trap numbers on several nights.
Survey Intensity	No	Survey intensity was appropriate for the survey areas size and proportion of habitats.
Completeness of Survey	No	All landsystems and habitats in the survey area were adequately surveyed.
Resources	No	The survey was adequately resourced.
Access Problems and Remoteness	No	All areas were accessible by 4WD or quad bike.
Availability of contextual information within the region	No	There are numerous studies, completed within the last five years, on habitats found within the survey area.

3.11. SOURCES OF INFORMATION

The following literature sources have been used to determine nomenclature, taxonomy and fauna distribution patterns used in this report:

- **Mammals:** Van Dyck and Strahan (2008), Menkhorst and Knight (2011);
- **Bats:** Churchill (2008);
- **Reptiles:** Cogger (2000); Storr et al.(2002); Storr et al.(1999); Wilson and Swan (2008);
- **Amphibians:** Tyler et al. (2000), Tyler and Doughty (2009);
- **Birds:** Christidis and Boles (2008); Barrett (2003); Johnstone and Storr (1998 and 2004); Benshemesh (2000); Marchant and Higgins (1993); Garnett and Crowley (2000); Higgins (1999).

Nomenclature for herpetofauna and mammals follows that of the Western Australian Museum Reptile and Frog Checklist and Mammal Checklist (Western Australian Museum 2012c) except where indicated otherwise. Nomenclature for birds follow Christidis and Boles (2008), except where indicated otherwise.

4. RESULTS

4.1. DESKTOP SURVEY RESULTS

Desktop searches of the DEC Threatened and Priority Fauna database, SEWPac's Protected Matters database, NatureMap, Birddata and the Western Australian Museum are detailed in Appendices 4-8. Table 8 details the results of these database searches.

A search of the WAM databases identified 18 SRE taxa that have the potential to occur in the survey area.

Data from regional literature sources has been collated and presented in Appendix IX.

A total of 16 species of conservation significance have been recorded within 50 kilometres of the survey area. Based on an analysis of regional literature sources and data collected on habitats from this survey, Rapallo anticipates that 11 of these species could occur on the project area.

4.2. HABITATS

Six habitats were identified on the project area as potentially being able to support varying faunal assemblages (Table 9). All habitats generally conformed to the vegetation communities described by Beard (1990) and land systems described by Van Vreeswyk *et al* (2004).

Table 8 List of Species of Conservation Significance that have been recorded within 50 kilometres of the Project Area

Species	Common Name	Conservation Category		Section	Likelihood of Occurrence
		State	Federal		
<i>Pezoporus occidentalis</i>	Night Parrot	Schedule 1 - Species rare or likely to become extinct	Critically Endangered	6.1	LOW - Lack of suitable habitat on the project area
<i>Dasyurus hallucatus</i>	Northern Quoll	Schedule 1 - Species rare or likely to become extinct	Endangered	6.2	HIGH – Suitable habitat occurs on the project area, one individual recorded in the survey area (Figure 8).
<i>Rhinonicteris aurantius</i>	Orange Leaf-nosed Bat (Pilbara Population)	Schedule 1 - Species rare or likely to become extinct	Vulnerable	6.3	MEDIUM – Suitable habitat near ore body and records from Rio Tinto Area C
<i>Liasis olivaceus barroni</i>	Pilbara Olive Python	Schedule 1 - Species rare or likely to become extinct	Vulnerable	6.4	HIGH – Suitable habitat occurs on the project area, one individual recorded in the project area (Figure 8).
<i>Falco peregrinus</i>	Peregrine Falcon	Schedule 4 - Other specially protected fauna	Not Listed	6.5	HIGH – Suitable habitat occurs in the north-east section project area
<i>Ramphotyphlops ganei</i>	Blind Snake	Priority 1 – Poorly known taxa	Not Listed	6.6	MEDIUM – May occur in moist gullies on the project area.
<i>Psuedomys chapmani</i>	Western Pebble-mound Mouse	Priority 4 - Taxa in need of monitoring	Not Listed	6.7	HIGH - Suitable habitat, several active Pebble-mounds recorded during survey (Figure 8).
<i>Macroderma gigas</i>	Ghost Bat	Priority 4 - Taxa in need of monitoring	Not Listed	6.8	HIGH – Suitable habitat present on project area and species was recorded during the survey (Figure 8).
<i>Ardeotis australis</i>	Australian Bustard	Priority 4 - Taxa in need of monitoring	Not Listed	6.9	HIGH - Suitable habitat occurs on the project area, species recorded during the survey

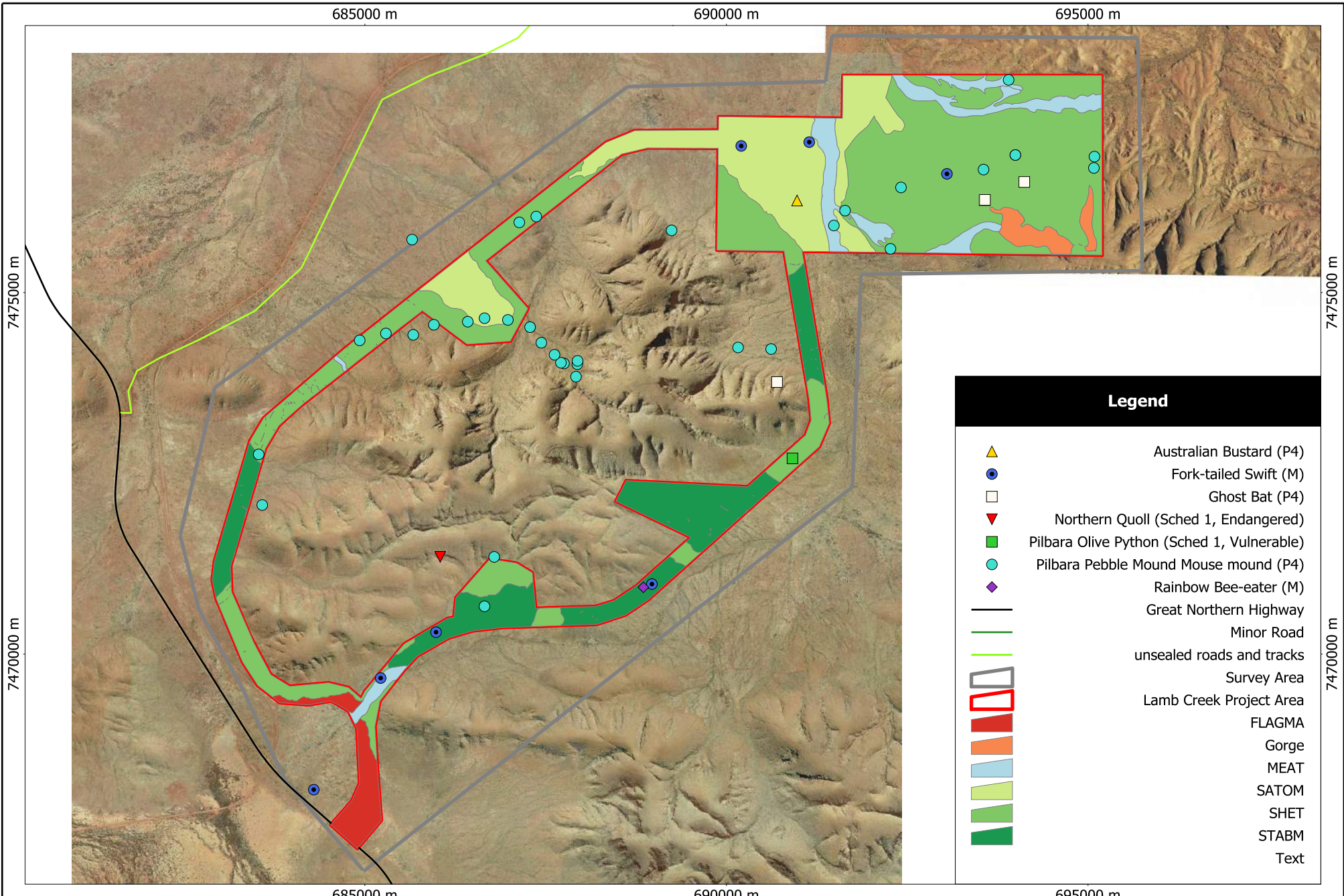


Species	Common Name	Conservation Category		Section	Likelihood of Occurrence
		State	Federal		
					(Figure 8).
<i>Burhinus grallarius</i>	Bush Stone-curlew	Priority 4 - Taxa in need of monitoring	Not Listed	6.10	MEDIUM - Suitable habitat occurs on the project area.
<i>Falco hypoleucos</i>	Grey Falcon	Priority 4 - Taxa in need of monitoring	Not Listed	6.11	LOW - Potential occasional visitor during irruptive events
<i>Merops ornatus</i>	Rainbow Bee-eater	Not Listed	Migratory - listed overfly/marine area	6.12	HIGH - Suitable habitat on the project area – recorded in one location on the project area during survey (Figure 8).
<i>Ardea modesta</i>	Eastern Great Egret	Not Listed	Migratory - wetland species	6.13	LOW - Lack of suitable habitat on the project area
<i>Ardea ibis</i>	Cattle Egret	Not Listed	Migratory - wetland species	6.14	LOW - Lack of suitable habitat on the project area
<i>Charadrius veredus</i>	Oriental Plover	Not Listed	Migratory - wetland species	6.15	LOW - Lack of suitable habitat on the project area
<i>Apus pacificus</i>	Fork-tailed Swift	Not Listed	Migratory - listed overfly/marine area	6.16	HIGH – Recorded at several locations during the survey (Figure 8).

Table 9 Habitats found on the project area

Habitat Name	Habitat Code	Land System	Habitat Description	Species of Conservation Significance that could use habitat
<i>Acacia aptaneura</i> over hummock grassland	SATOM	Boolgeeda, Newman	Vegetation: <i>Acacia aptaneura</i> and/or <i>Corymbia deserticola</i> low woodland over <i>Acacia eleocharis</i> and mixed <i>Eremophila</i> species over <i>Triodia wiseana</i> very open hummock grassland Geology, Soil, Landform: Stony and loamy alluvial plains with occasional, very minor drainage channels	Australian Bustard, Bush Stone-curlew, Fork-tailed Swift, Rainbow Bee-eater,
Minor drainage with <i>Corymbia</i> , <i>Acacia</i> , <i>Gossypium</i> over <i>Triodia</i> hummock grassland	MEAT	Boolgeeda, Platform	Vegetation: <i>Corymbia hamersleyana</i> scattered low trees over <i>Gossypium robinsonii</i> , <i>Acacia elachantha</i> tall open shrubland over <i>Triodia wiseana</i> hummock grassland and <i>Eulalia aurea</i> , <i>Eragrostis eriopoda</i> very open tussock grassland. Geology, Soil, Landform: Sandy/stony alluvial drainage, well defined	Rainbow Bee-eater, Australian Bustard, Bush Stone-curlew, Fork-tailed Swift.
<i>Eucalyptus leucophloia</i> woodland over mixed shrubs over <i>Triodia wiseana</i> grassland	SHET	Newman, Platform, McKay, Platform	Vegetation: <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> , low open woodland over mixed species (typically <i>Gossypium robinsonii</i> , <i>Acacia hilliana</i> , <i>Grevillea wickhamii</i> , <i>Keraudrenia nephrosperma</i>) scattered shrubs over <i>Triodia wiseana</i> hummock grassland. Geology, Soil, Landform: Plateaus, scree slopes, breakaways and minor drainage lines with exposed rock or stony soils	Western Pebble-mound Mouse, Ghost Bat, Pilbara Olive Python, Fork-tailed Swift, Rainbow Bee-eater.
<i>Eucalyptus gamophylla</i> woodland over hummock	STABM	Boolgeeda, Newman,	Vegetation: <i>Eucalyptus gamophylla</i> low open woodland over <i>Acacia elachantha</i> or <i>Acacia hilliana</i> , <i>Senna glutinosa</i> subsp. <i>pruinosa</i> open shrubland over <i>Triodia brizoides</i> ,	Western Pebble-mound Mouse, Rainbow Bee-eater, Pilbara Olive Python, Fork-tailed Swift,

Habitat Name	Habitat Code	Land System	Habitat Description	Species of Conservation Significance that could use habitat
grassland			<i>Triodia wiseana</i> hummock grassland. Geology, Soil, Landform: Scree slopes and stony plains, adjacent to plateaus, with shallow stony soils and occasional, very minor drainage channels	Australian Bustard, Bush Stone-curlew.
Mulga groves	FLAGMA	Boolgeeda, Wannamunna	Vegetation: <i>Acacia aptaneura</i> low woodland over <i>Themeda triandra</i> , <i>Cymbopogon ambiguus</i> , <i>Chrysopogon fallax</i> open tussock grassland. Geology, Soil, Landform: Clay and loam floodplains	Australian Bustard, Rainbow Bee-eater, Bush Stone-curlew, Fork-tailed Swift.
Gorges	GORGE	Newman	Vegetation: Open woodland with <i>Ficus</i> sp., <i>Terminalia</i> , <i>Brachychiton</i> sp <i>Cymbopogon ambiguus</i> , <i>Eucalyptus leucophloia</i> subsp. <i>leucophloia</i> over mixed <i>Gossypium robinsonii</i> , <i>Grevillea wickhamii</i> and <i>Chrysopogon fallax</i> . Geology, Soil, Landform: Steep sided gorge incised into ironstone plateau	Pilbara Olive Python, Northern Quoll



Legend

	Australian Bustard (P4)
	Fork-tailed Swift (M)
	Ghost Bat (P4)
	Northern Quoll (Sched 1, Endangered)
	Pilbara Olive Python (Sched 1, Vulnerable)
	Pilbara Pebble Mound Mouse mound (P4)
	Rainbow Bee-eater (M)
	Great Northern Highway
	Minor Road
	unsealed roads and tracks
	Survey Area
	Lamb Creek Project Area
	FLAGMA
	Gorge
	MEAT
	SATOM
	SHET
	STABM
	Text



Original size: A4 Scale: 1:70,000
 Datum MGA94(50)

0 2 km

Process Minerals International

Figure 8

Lamb Creek Species of Conservation Significance

4.3. VERTEBRATE FAUNA SURVEY SUMMARY

A total of 8087 fauna records were made during the fauna survey of the Lamb Creek survey area representing 152 species.

4.4. MAMMALS

4.4.1. ASSEMBLAGE

Mammalian fauna was underrepresented for the Lamb Creek survey area with 164 individuals representing 22 species being recorded in total. Of these captures, seven bat species were recorded. Regionally, 42 species have been recorded within a 100km radius of the Lamb Creek project area including six species of conservation significance.

Systematic captures of small mammals were dominated by small Dasyurids which accounted for 64% of all systematic captures on the survey area. The most common species of mammal recorded during the survey was the Stripe-faced Dunnart (*Sminthopsis macroura*) with 35 individuals recorded during systematic trapping and one record from spotlighting surveys. This species was recorded across all habitat types surveyed on the project area.

Mammalian diversity and abundance were highest in the FLAGMA habitat type with six species being recorded while mammal diversity and abundance were lowest in the MEAT habitat type.

A single record of the Northern Quoll was made from a motion detecting camera during the survey. It was recorded on a camera located in a gorge off the project area but within the survey area, encircled by the proposed haul roads. The Northern Quoll is listed as Endangered under the *EPBC Act* and as Schedule 1 - Species that are rare or likely to become extinct under the *WCA Act*. A single Northern Quoll scat was also found underneath a rocky overhang (Figure 8). Further information on the species is provided in section 6.2.

Several Ghost Bats (*Macroderma gigas*) were also recorded in the survey, including two sightings on the project area (Figure 8). This species is listed by DEC as Priority 4 - Taxa in need of monitoring. Seven individuals were recorded from two caves including one cave situated within the proposed impact area and one in the survey area. Further information on this species is presented in section 6.8.

Evidence of the Western Pebble-mound Mouse, listed by DEC as Priority 4 - Taxa in need of monitoring, was also recorded in the survey area. Numerous pebble mounds were recorded across the project area (Figure 8). Further information on this species is presented in section 6.6.

Acoustic analysis of bat calls was conducted by Dr Kyle Armstrong of Specialised Zoological, the results are listed below in Table 11.

Three introduced mammal species were recorded during the survey; domesticated cattle, house mice, and wild dogs/dingoes. The abundance of introduced mammal species was low. The house mice were recorded on the FLAGMA floodplains while Cattle observations were confined to drainage related habitats. Only secondary signs of wild dogs/dingoes (tracks) were recorded.

Table 10 Mammal records from the Lamb Creek survey area

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	QUOLL TRAPS	OPP	FORAGE/ SPOTLIGHTING /MDC	TOTAL
Echidna	<i>Tachyglossus aculeatus</i>								*	*
Northern Quoll	<i>Dasyurus hallucatus</i>								1,*	1
Little Red Kaluta	<i>Dasykaluta rosamondae</i>	15	1		1	3				20
Long-tailed Planigale	<i>Planigale ingrami</i>			4	2				1	7
Pilbara Ningau	<i>Ningau timealeyi</i>			6		5				11
Stripe-faced Dunnart	<i>Sminthopsis macroura</i>	4	4	2	14	11			1	36
Euro	<i>Macropus robustus</i>								10	10
Rothschild's Rock-wallaby	<i>Petrogale rothschildi</i>						2	(2)	1	3(2)
Ghost Bat	<i>Macroderma gigas</i>								7	7
Common Sheath-tailed Bat	<i>Taphozous georgianus</i>								20	20
Finlayson's Cave Bat	<i>Vespadelus finlaysoni</i>								4	4
Western Pebble-mound Mouse	<i>Pseudomys chapmani</i>								35*	35*
Desert Mouse	<i>Pseudomys desertor</i>	2	1		2	1				6



Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	QUOLL TRAPS	OPP	FORAGE/ SPOTLIGHTING /MDC	TOTAL
Sandy Inland Mouse	<i>Pseudomys hermannsburgensis</i>	7	3	1	8	7				26
Common Rock Rat	<i>Zyzomys argurus</i>						1			1
House Mouse – Intr.	<i>Mus musculus</i>				2					2
Dingo/Dog	<i>Canis lupis dingo/familiaris</i>								*	*
Cattle – Intr.	<i>Bos taurus</i>							10		10
TOTAL NUMBERS		28	9	13	29	27	3	10(2)	44	164(2)

*Secondary signs – no individual animals trapped or observed in survey area

Table 11 Acoustic Analysis of bat calls from the Lamb Creek Survey area

Species	s,p ¹	Duration (msec)	Max Frequency (kHz)	Char frequency (kHz)
Gould's wattled bat <i>Chalinolobus gouldii</i>	1,10	6.0 ± 1.3 4.2 – 7.6	39.6 ± 3.5 34.6 – 44.9	30.7 ± 0.7 29.9 – 31.9
Northern free-tailed bat <i>Chaerephon jobensis</i>	1,5	7.1 ± 1.7 4.9 – 8.9	31.7 ± 3.4 28.0 – 35.9	20.9 ± 2.1 18.5 – 23.8
Yellow-bellied sheath-tailed bat <i>Saccolaimus flaviventris</i>	1,4	15.8 ± 2.6 12.4 – 17.9	20.9 ± 0.6 20.1 – 21.3	17.5 ± 0.2 17.2 – 17.6
Little broad-nosed bat <i>Scotorepens greyii</i>	1,11	5.9 ± 0.8 4.1 – 7.2	50.4 ± 5.8 41.2 – 59.3	36.1 ± 0.6 34.6 – 36.9
Common sheath-tailed bat <i>Taphozous georgianus</i>	1,14	8.9 ± 1.5 6.6 – 10.5	27.4 ± 0.5 26.9 – 28.7	24.7 ± 0.3 24.2 – 25.2
Finlayson's cave bat <i>Vespadelus finlaysoni</i>	3,35	4.1 ± 1.0 3.0 – 7.9	72.5 ± 10.0 58.6 – 90.9	57.5 ± 1.3 55.4 – 59.9

(Mean ± SD; range; ¹ s,p: number of sequences measured, combined total number of pulses measured).

4.4.2. SPECIES ACCUMULATION CURVE AND SPECIES RICHNESS ESTIMATES

The species accumulation curve in Figure 9 indicates a flattening as it approaches the theoretical asymptote of 6.98 species. The geometry of the curve indicates few, if any trappable mammal species remain undetected in the habitat types surveyed in the survey area.

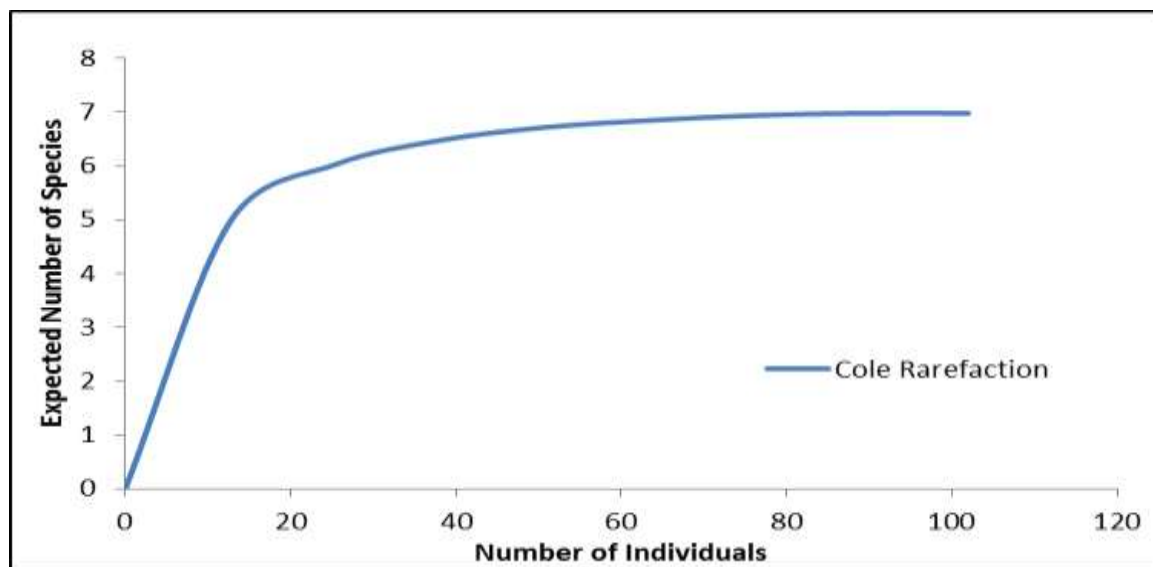


Figure 9 Individual based rarefaction curve for mammal species surveyed using systematic techniques

Based on the data collected during the survey and non-parametric analysis of species richness, between six and seven species could occur in the habitats in the survey area (Table 12).

Table 12 Observed and estimated non-volant mammal species richness

Type	Species Richness
Trapped Non-volant Mammal Species	7
ACE Mean	7
Jackknife1 Mean	7
ICE Mean	7
Chao1 Mean	7

4.5. REPTILES AND AMPHIBIANS

4.5.1. ASSEMBLAGE

Analysis of regional reports and databases indicate that 98 reptile species and five frog species could potentially occur within the project area at Lamb Creek.

Reptile records were high during the survey period with a total of 58 species observed from 782 records. The reptile assemblage comprised 13 species of Gecko, five species of Pygopods, 18 species of Skinks, six species of Agamids, seven Elapid species, seven Varanid species and two species of Pythons. Table 13 details the reptile species recorded by habitat during the survey.

The most common species recorded were *Ctenophorus caudicinctus* (n=108), with the majority of records coming from foraging and opportunistic recordings followed by *Lucasium stenodactylum* (n=107) which was predominantly found from systematic records. These species were recorded across all five habitat types that were systematically surveyed and foraged.

The majority of species records were from systematic surveys (n=449) with the remainder being found opportunistically (n=146) or while foraging/spotlighting (n=186).

Species richness for reptiles was generally consistent across the five habitat types surveyed. Reptile species richness was found to be highest in the MEAT (n=25) habitat type while reptile abundance was found to be highest across the SATOM habitat type (n=182). Reptile species richness was lowest on the STABM habitat type (n=21) with reptile abundance being lowest on the FLAGMA habitat type.

One reptile species of conservation significance was recorded during the survey. The Pilbara Olive Python is listed by DEC under the *Wildlife Conservation Act 1950* as Schedule 1 – Species that are rare or likely to become extinct. The species is also listed under the *EPBC Act* as Vulnerable. One opportunistic record of this species was made along the southern haul road option in the STABM habitat type. Further information on this species can be found in section 6.4.

Amphibian diversity was low across the whole survey area with only two species recorded during the survey. Of those two species only one, *Cyclorana maini*, was found to be abundant with over 800 individuals recorded during systematic surveys. Of these records, 706 were recorded from the FLAGMA habitat type. The second species recorded on the survey area, *Litoria rubella*, was found in much lower numbers during systematic surveys (n=2).

Table 14 details the amphibians recorded by habitat during the survey.

Table 13 Reptiles recorded from the Lamb Creek survey area.

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	OPP	FORAGE/ SPOTLIGHTING	TOTAL
Clawless Gecko	<i>Crenadactylus ocellatus</i>		1						1
Fat-tailed Gecko	<i>Diplodactylus conspicillatus</i>			1					1
	<i>Diplodactylus pulcher</i>		1		1		1		3
	<i>Diplodactylus savagei</i>			2				1	3
	<i>Gehyra punctata</i>						(1)	60	60(1)
Tree Dtella	<i>Gehyra variegata</i>	17	2	5	2	2		2	30
Bynoe's Gecko	<i>Heteronotia binoei</i>	4	1	6	2	5			18
Sand-plain Gecko	<i>Lucasium stenodactylum</i>	46	20	2	5	9	25		107
	<i>Lucasium wombeyi</i>	7				1			8
Banded Knob-tailed Gecko	<i>Nephrurus wheeleri</i>							2	2
Marbled Velvet Gecko	<i>Oedura marmorata</i>						(1)	20	20(1)
Beaked Gecko	<i>Rhynchoedura ornata</i>	24	5	2	8	2	25		66
	<i>Strophurus wellingtonae</i>				1	1	2		4
	<i>Delma elegans</i>		1		1		1		3
	<i>Delma nasuta</i>			1	1				2
Excitable Delma	<i>Delma tinctoria</i>				1				1
Burtons Legless Lizard	<i>Lialis burtonis</i>	1	1	1					3
Western Hooded Scaly-	<i>Pygopus nigriceps</i>	1			1				2

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	OPP	FORAGE/ SPOTLIGHTING	TOTAL
foot									
	<i>Carlia munda</i>	4	1		5	1			11
	<i>Cryptoblepharus ustulatus</i>						45		45
	<i>Ctenotus duricola</i>	1	2	6		1			10
Clay-soil Ctenotus	<i>Ctenotus helenae</i>	16	5		8	5			34
Leopard Ctenotus	<i>Ctenotus pantherinus</i>	24	4	3	3	3			37
	<i>Ctenotus rubicundus</i>		1	4		1			6
	<i>Ctenotus rutilans</i>			3		1			4
Rock Ctenotus	<i>Ctenotus saxatilis</i>	3	2	11	1	10			27
	<i>Ctenotus schomburgkii</i>	1	3						4
	<i>Ctenotus uber</i>					1			1
Spinifex Slender Bluetongue	<i>Cyclodomorphus melanops</i>	3			3				6
	<i>Egernia cygnitos</i>						1		1
	<i>Egernia formosa</i>						2	3	5
	<i>Lerista muelleri</i>	3				1			4
	<i>Lerista zietzi</i>							2	2
	<i>Menetia greyii</i>							2	2
	<i>Morethia ruficauda</i> subsp. <i>exquisita</i>			1			(1)	1	2(1)
Centralian Blue-tongue	<i>Tiliqua multifasciata</i>	1	1		3				5

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	OPP	FORAGE/ SPOTLIGHTING	TOTAL
Long-nosed Dragon	<i>Amphibolurus longirostris</i>	1	4						5
Mulga Dragon	<i>Caimanops amphiboluroides</i>				1		1		2
	<i>Diporiphora valens</i>				2				2
Ring-tailed Dragon	<i>Ctenophorus caudicinctus</i>	8	2	8	3	17	20	50	108
Military Dragon	<i>Ctenophorus isolepis</i>	14	2		3	2	15	40	76
Dwarf Bearded Dragon	<i>Pogona minor</i>		1			1		1	3
Spiny-tailed Monitor	<i>Varanus acanthurus</i>		3	11					14
Short-tailed Pygmy Monitor	<i>Varanus brevicauda</i>	3	3			3			9
Bush's Pygmy Monitor	<i>Varanus bushi</i>	1					1		2
Perentie	<i>Varanus giganteus</i>						2	1	3
Yellow-spotted Monitor	<i>Varanus panoptes</i>						1		1
Pilbara Rock Monitor	<i>Varanus pilbarensis</i>						3		3
Black-headed Monitor	<i>Varanus tristis</i>		3	1			(1)		4(1)
Pygmy Python	<i>Antaresia perthensis</i>							1	1
Pilbara Olive Python	<i>Liasis olivaceus</i>						1		1
Yellow-faced Whipsnake	<i>Demansia psammophis</i>	1	1			1			3
Monk Snake	<i>Parasuta monachus</i>			2					2
Mulga Snake	<i>Pseudechis australis</i>		1	1	1				3
Mengden's Brown Snake	<i>Pseudonaja mengdeni</i>						(1)		(1)

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	OPP	FORAGE/ SPOTLIGHTING	TOTAL
Ringed Brown Snake	<i>Pseudonaja modesta</i>					1			1
Rosen's Snake	<i>Suta fasciata</i>	1		1					2
Pilbara Bandy Bandy	<i>Vermicella snelli</i>			1					1
TOTAL		182	70	73	56	69	146(5)	186	782(5)

*Species records in parentheses were recorded during the reconnaissance survey.

Table 14 Amphibian records from the Lamb Creek survey area.

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	OPP	FORAGE/ SPOTLIGHTING	TOTAL
Sheep Frog	<i>Cyclorana maini</i>	7	81	3	706	7			804
Desert Tree Frog	<i>Litoria rubella</i>		2				2		4
TOTAL		7	83	3	706	7	2		808

4.5.2. SPECIES ACCUMULATION CURVE AND SPECIES RICHNESS ESTIMATES

The reptile species accumulation curve shown in Figure 10 appears to be increasing as it approaches the theoretical asymptote. This indicates that several species may have remained undetected during the survey. The results of the asymptote calculation have potentially been influenced by a large number of species recorded either once or twice during the survey.

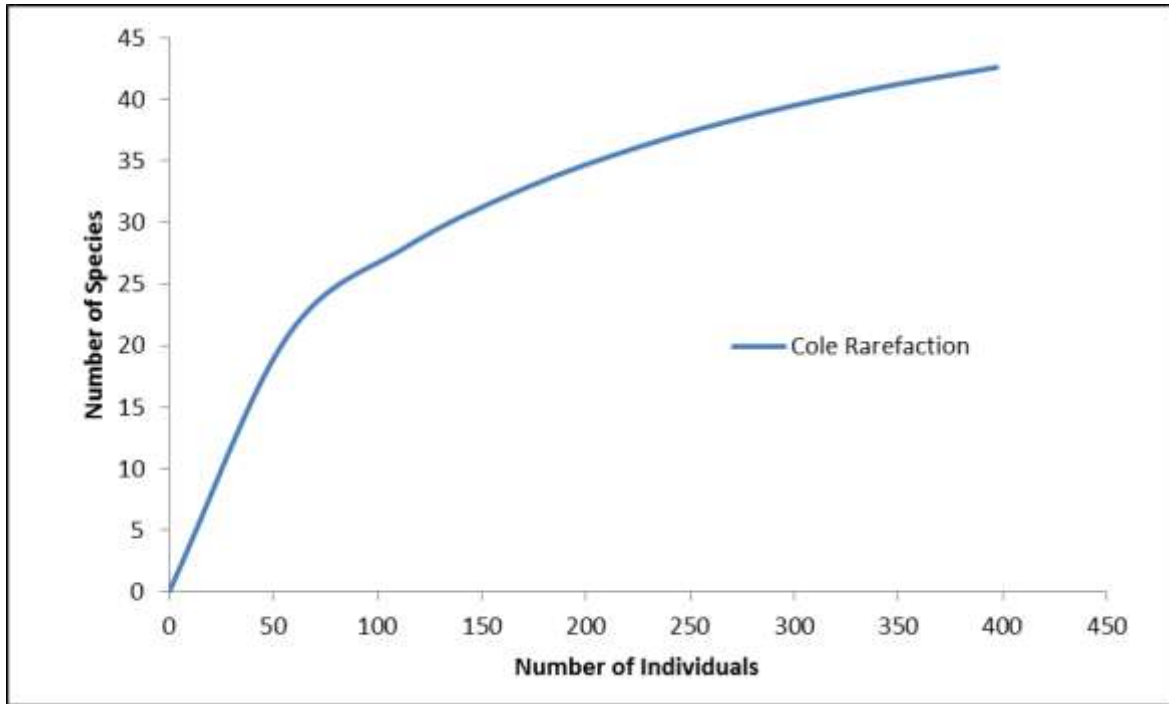


Figure 10 Individual based rarefaction curve (species accumulation curve) for reptile species surveyed using systematic techniques.

Based on observed data and non-parametric estimators, between 49.63 and 57.06 species could occur in habitats on the survey area (Table 15).

Table 15 Observed and estimated reptile species richness

Type	Species Richness
Trapped reptile Species	44
ACE Mean	56.14
Jackknife1 Mean	53.63
ICE Mean	57.06
Chao1 Mean	49.63

4.6. BIRDS

4.6.1. ASSEMBLAGE

Avifauna was the most commonly observed fauna group during the survey with a total of 76 species recorded from 7145 records (Table 16). The majority of species were recorded during systematic surveys (n=67) while the remaining six species were recorded opportunistically or during spotlight surveys. Bird diversity was lower than expected as 148 species have been recorded within the region. However, suitable habitat for many of those species, namely waders and other aquatic birds, is lacking on the project area

The highest bird diversity (n=47) was recorded in the STABM habitat type while the bird abundance was highest in the FLAGMA habitat type. Avifauna abundance was highest in the FLAGMA habitat type due to several large flocks of irruptive species such as Budgerigars and Zebra Finches at the site. The lowest abundance and diversity was recorded in the SHET habitat type, probably reflecting this habitats low botanical diversity.

The most commonly recorded species during the survey were irruptive species such as the Budgerigar, Zebra Finch and Diamond Dove with flocks in excess of 100 regularly recorded. Generalist honeyeaters also dominated the bird assemblage (Table 16).

Three bird species of conservation significance were recorded during the survey. The Australian Bustard is listed by DEC as Priority 4 – Taxa in need of monitoring. Three records were made during the survey; an adult and chick were recorded at dusk within the impact area while the chick was recorded again the following day. It is likely that these were the same individuals that were recorded several nights later along an access road bordering the impact area.

The Fork-tailed Swift is listed under the *EPBC Act* as Migratory. This species was recorded at seven sites during systematic surveys and opportunistically across the survey area (Figure 8).

The Rainbow Bee-eater is listed under the *EPBC Act* as Migratory. One individual of this species was recorded during systematic surveys on the project area in the STABM habitat type (Figure 8).

Further information on the ecology and conservation significance of these species can be found in section 6.

Table 16 Avifauna records from the Lambs Creek survey area.

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	FORAGE/ SPOTLIGHT	OPP	TOTAL
Common Bronzewing	<i>Phaps chalcoptera</i>		3	1		2			6
Crested Pigeon	<i>Ocyphaps lophotes</i>	13	5	2	3	21			44
Diamond Dove	<i>Geopelia cuneata</i>	40	200	12	169	27			448
Spinifex Pigeon	<i>Geophaps plumifera</i>							6	6
Tawny Frogmouth	<i>Podargus strigoides</i>						2		2
Spotted Nightjar	<i>Eurostopodus argus</i>							2	2
Australian Owlet-nightjar	<i>Aegotheles cristatus</i>							4	4
Fork-tailed Swift	<i>Apus pacificus</i>	25	5	2	100	10			142
White-faced Heron	<i>Ardea novaehollandiae</i>				1				1
Black-shouldered kite	<i>Elanus axillaris</i>		4			2			6
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>							1	1
Whistling Kite	<i>Haliastur sphenurus</i>				2				2
Black Kite	<i>Milvus migrans</i>				3				3
Brown Goshawk	<i>Accipiter fasciatus</i>	1	1		1				3
Collared Sparrowhawk	<i>Accipiter cirrocephalus</i>				1				1
Spotted Harrier	<i>Circus assimilis</i>							4	4
Wedge-tailed Eagle	<i>Aquila audax</i>							2	2
Little Eagle	<i>Aquila morphnoides</i>	1							1
Australian Hobby	<i>Falco longipennis</i>							1	1

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	FORAGE/ SPOTLIGHT	OPP	TOTAL
Brown Falcon	<i>Falco berigora</i>	4	1	5	3				13
Nankeen Kestrel	<i>Falco cenchroides</i>					1			1
Australian Bustard	<i>Ardeotis australis</i>							4	4
Little Button Quail	<i>Turnix velox</i>	9	26	4	7	4			50
Galah	<i>Cacatua roseicapilla</i>				1	6			7
Cockatiel	<i>Nymphicus hollandicus</i>	29	27	4	11				71
Australian Ringneck	<i>Platycercus zonarius</i>	2	2	2		6			12
Budgerigar	<i>Melopsittacus undulatus</i>	570	545	462	1106	460			3143
Horsfield's Bronze-cuckoo	<i>Chrysococcyx basalus</i>	1	1			2			4
Pallid Cuckoo	<i>Cuculus pallidus</i>	1	5	1	1	2			10
Boobook Owl	<i>Ninox novaeseelandiae</i>						1		1
Red-backed Kingfisher	<i>Todiramphus pyrrhopygius</i>	1		1	3	1			6
Rainbow Bee-eater	<i>Merops ornatus</i>					1			1
Western Bowerbird	<i>Ptilonorhynchus guttatus</i>					3			3
Variegated Fairy Wren	<i>Malurus lamberti</i>		1		8				9
Weebill	<i>Smicrornis brevirostris</i>	8	43	13	11	18			93
Western Gerygone	<i>Gerygone fusca</i>		3		5				8
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>				4				4
Inland Thornbill	<i>Acanthiza apicalis</i>		2		2				4
Red-browed Pardalote	<i>Pardalotus rubricatus</i>	1	2	2					5

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	FORAGE/ SPOTLIGHT	OPP	TOTAL
Pied Honeyeater	<i>Certhionyx variegatus</i>	3						3	6
Singing Honeyeater	<i>Lichenostomus virescens</i>	19	19	5	19	13			75
Grey-headed Honeyeater	<i>Lichenostomus keartlandi</i>	21	20	12	2	25			80
White-plumed Honeyeater	<i>Lichenostomus ornatus</i>	5	16	1		1			23
White-fronted Honeyeater	<i>Prunella albifrons</i>	15	17	1		7			40
Yellow-throated Miner	<i>Manorina flavigula</i>	1	16	9		29			55
Spiny Cheeked Honeyeater	<i>Acanthagenys rufogularis</i>	15	14		22	5			56
Grey Honeyeater	<i>Conopophila whitei</i>	1			3				4
Crimson Chat	<i>Epthianura tricolor</i>	45	3	36	27	54			165
Black Honeyeater	<i>Certhionyx niger</i>	28	4	60	3	26			121
Brown Honeyeater	<i>Lichmera indistincta</i>		73	22		24			119
Black-chinned Honeyeater	<i>Melithreptus gularis</i>		6	2	2	9			19
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>	5	3		19	6			33
Ground Cuckoo-shrike	<i>Coracina maxima</i>				2			2	4
Black-faced Cuckoo Shrike	<i>Coracina novaehollandiae</i>	2	9	2	11	5			29
White-winged Triller	<i>Lalage tricolor</i>	31	20	11	35	10			107
Rufous Whistler	<i>Pachycephala rufiventris</i>	4	13	3	14	6			40
Grey Shrike-thrush	<i>Colluricincla harmonica</i>					1			1
Crested Bellbird	<i>Oreoica gutturalis</i>	15	8	4	11	17			55
Masked Woodswallow	<i>Artamus personatus</i>	71	1	171	153	12			408
Black-faced Woodswallow	<i>Artamus cinereus</i>	6		1	33	3			43

Common Name	Scientific Name	SATOM	MEAT	SHET	FLAGMA	STABM	FORAGE/ SPOTLIGHT	OPP	TOTAL
Little Woodswallow	<i>Artamus minor</i>			1					1
Grey Butcherbird	<i>Cracticus torquatus</i>	1	1		2	1			5
Pied Butcherbird	<i>Cracticus nigrogularis</i>	4	1	1	2	4			12
Australian Magpie	<i>Cracticus tibicen</i>		2			5			7
Willie Wagtail	<i>Rhipidura leucophrys</i>	5	10	1	12	10			38
Australian Raven	<i>Corvus coronoides</i>	1							1
Little Crow	<i>Corvus bennetti</i>	1			1	2			4
Torresian Crow	<i>Corvus orru</i>	10	4		2	3			19
Magpie Lark	<i>Grallina cyanoleuca</i>	2							2
Hooded Robin	<i>Petroica cucullata</i>	1			7	10			18
Brown Songlark	<i>Cincloramphus cruralis</i>		1	1	2	1			5
Rufous Songlark	<i>Cincloramphus mathewsi</i>	6	1		12	2			21
Spinifexbird	<i>Eremiornis carteri</i>	12		4	6	3			25
Mistletoebird	<i>Dicaeum hirundinaceum</i>					2			2
Zebra Finch	<i>Taeniopygia guttata</i>	235	301	276	381	136			1329
Painted Finch	<i>Emblema pictum</i>		2	38	2	3			45
TOTAL		1271(43)	1441(43)	1173(35)	2227(47)	1001(47)	3	29(6)	7145

4.6.2. SPECIES ACCUMULATION CURVE AND SPECIES RICHNESS ESTIMATES

The species accumulation curve in Figure 11 shows that the curve fails to flatten as it reaches the theoretical asymptote. The geometry of the curve indicates that it is likely that further bird species remain undetected in the habitat types surveyed utilising 2 hectare bird surveys.

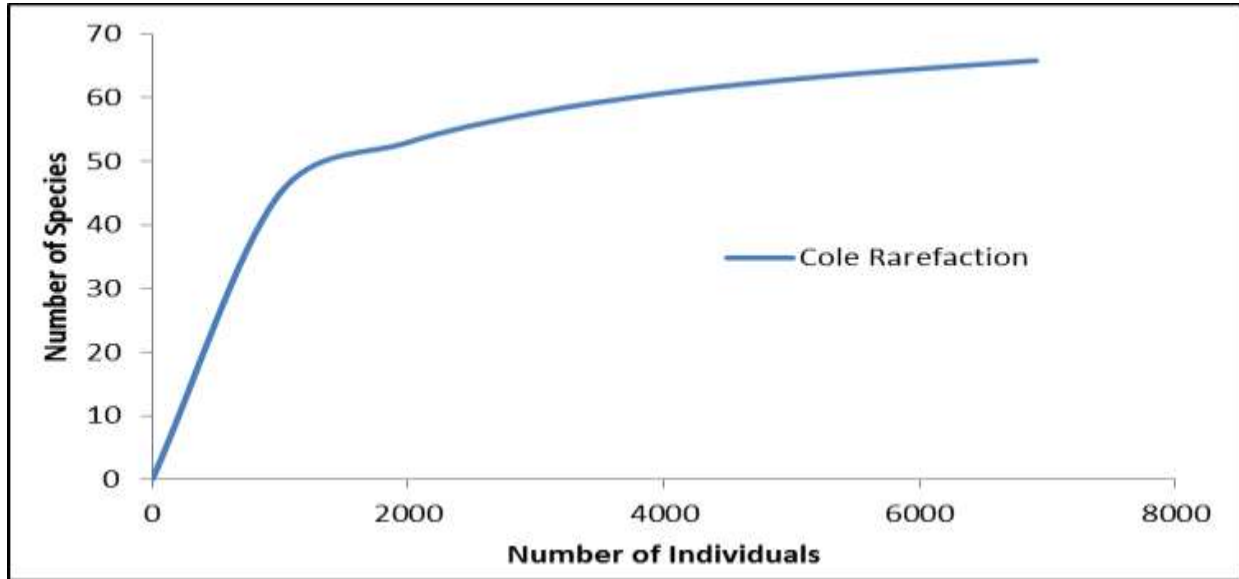


Figure 11 Individual based rarefaction curve (species accumulation curve) for bird species surveyed using utilising two hectare bird surveys.

The discrepancy between the number of species recorded during the two hectare bird surveys and the theoretical asymptote can be accounted for by the addition of opportunistic bird records. The total avian assemblage recorded during the survey of 76 species suggests that the combined datasets are close to the actual number of avian species utilising the survey area during the season.

Estimates of species richness for avifauna are prone to errors. The major cause of the error is the highly mobile or migratory nature of bird species. Thus, species richness calculations can only be used to deduce the survey effort at a seasonal time scale rather than an annual time scale.

Based on observed data and non-parametric estimators, between 77.5 and 99.37 species could occur in habitats on the project area, (Table 17).

Table 17 Observed and estimated avifauna species richness

Type	Species Richness
Recorded Avian Species	67
ACE Mean	81.63
Jackknife1 Mean	77.5
ICE Mean	79.55
Chao1 Mean	99.37

4.7. SHORT RANGE ENDEMICS

A total of 37 specimens were submitted for identification and assessment of SRE status with taxonomists of the WAM, Phoenix and Scorpion ID.

Nine mollusc specimens were submitted for identification. Taxonomic identifications suggest that the samples represented three species but none were found to be potential SRE taxa (Appendix 10).

The other 28 specimens comprised three spider species, including two mygalomorphs; four pseudoscorpion species; one centipede species, one millipede species, two slater species and 3 scorpion species.

Of the 14 taxa identified, 6 were identified as potential SRE and one was identified as a likely SRE (Appendix XII). Results of taxonomic identifications are summarised in Table 18 and discussed in detail in section .

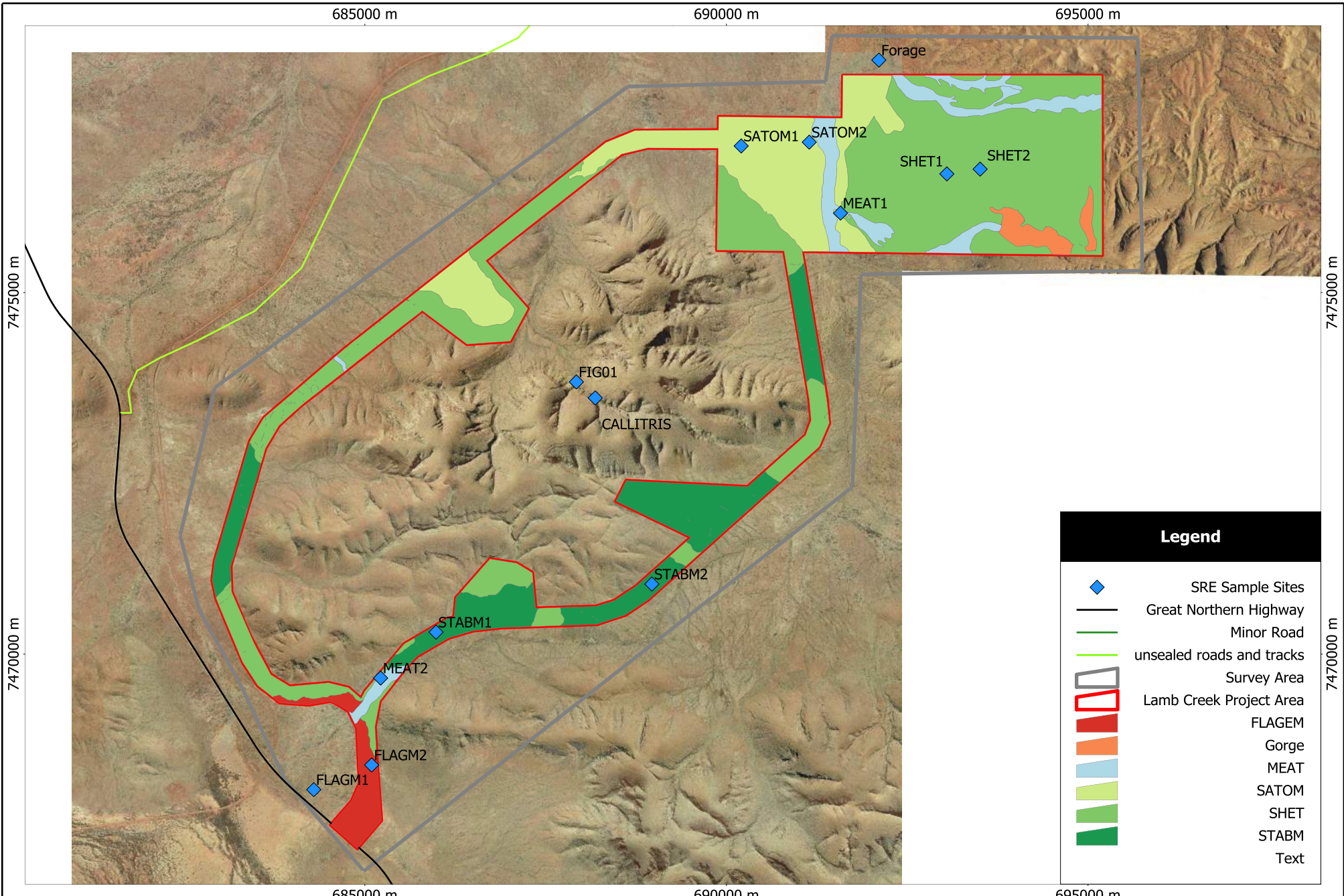
Table 18 Summary of the SRE status of taxa collected in the survey and submitted for identification

Higher taxon	Family	Species	SRE status	Remarks	Record Site
Mollusca	Bulimulidae	<i>Bothriembryon</i> sp. nov.	Not SRE	Undescribed widespread species	Gorge
	Pupillidae	<i>Pupoides beltianus</i>	Not SRE	Widespread species	STABM 2, Forage
		<i>Gastrocopta</i> cf. <i>mussoni</i>	Not SRE	Widespread species	Ficus, MEAT2
Araneomorphae (modern spiders)	Zodariidae	<i>Zodariidae</i> sp. indet.	Not SRE	Not SRE target group	SHET 2
Mygalomorphae (trapdoor spiders)	Barychelidae	<i>Aurecocrypta</i> 'MYG057'	Not SRE	Widespread in Pilbara	STABM1
		<i>Synothele</i> 'MYG255'	Potential	First record of species	STABM2
Pseudoscorpiones (pseudoscorpions)	Atemnidae	<i>Oratemnus</i> sp. indet.	Not SRE	Commonly collected in Pilbara, not considered SRE	FLAGMA2
	Cheiridiidae	<i>Cheiridiidae</i> sp. indet.	Not SRE	Commonly collected in Pilbara, not considered SRE	SHET2
	Chthoniidae	<i>Austrochthonius</i> 'pilbara'	Potential	Possibly representing species complex, under revision at WAM	STABM2
	Olpiidae	<i>Beierolpium</i> '8/2' <i>Beierolpium</i> sp. indet.	Not SRE	Commonly collected in Pilbara, not considered SRE	SHET1 & 2, STABM2

Chilopoda - Geophilomorpha (soil centipedes)	indet.	<i>Geophilomorpha</i> sp. indet.	Potential	Taxonomically poorly resolved	STABM2
Diplopoda - Spirobolida (millipedes)	Triguniulidae	<i>Austrostrophus</i> sp. indet.	Potential	May represent <i>Austrostrophus</i> 'DIP018', currently considered potential SRE	STABM2
Isopoda	Armadillidae	<i>Buddelundia</i> '13'	Potential	Possibly also found at Wonmunna mining lease	FLAGMA2
		<i>Spherillo</i> sp. indet.	Likely	Rarely found in the Pilbara	STABM2
Scorpiones (Scorpions)	Buthidae	<i>Lychas</i> 'harveyi'	Not SRE	Widespread in Pilbara	SHET, STABM1
		<i>Lychas</i> 'pilbara1'	Not SRE	Widespread in Pilbara	SHET, STABM1
	Urodacidae	<i>Urodacus</i> sp. indet	Potential SRE	Habitat may support SRE species.	FLAGMA 2

4.8. TARGETED NORTHERN QUOLL SURVEY

Three hundred cage trap nights were sampled during the Target Northern Quoll Survey, representing six sites of ten cages left open for 5 nights. No Northern Quolls were captured.



Legend	
	SRE Sample Sites
	Great Northern Highway
	Minor Road
	unsealed roads and tracks
	Survey Area
	Lamb Creek Project Area
	FLAGEM
	Gorge
	MEAT
	SATOM
	SHET
	STABM
	Text



Original size: A4 Scale: 1:70,000
 Datum MGA94(50)
 0 2 km

Process Minerals International

Figure 12
 Lamb Creek SRE Sample Sites

5. DISCUSSION

5.1. HABITATS

Flora surveys of the Lamb Creek project area conducted by Rapallo (2012) identified six vegetation associations. The vegetation associations roughly match the habitats identified in this survey, with some small variations. In total, six habitats were identified (Table 9). All habitats generally conformed to the habitats described by Beard (1990) and Van Vreeswyk et al. (2004).

The habitats of the project area were all typical of the Pilbara bio-region, especially its expression in the south eastern areas of the Pilbara and on the south eastern edge of the Hamersley Range. No Priority Ecological Communities (PEC) or Threatened Ecological Communities (TEC) occur within 50 km of the project area (DEC 2012b).

Low plains and alluvial deposits dominated the majority of the project area with *Eucalyptus* woodland over hummock grassland covering 46% of the project area (SATOM). The habitat type is considered to be wide spread throughout the Pilbara.

The south-western section of the haul road alignment consists of a broad shallow drainage valley that supports *Acacia aptaneura* low woodland over *Themeda triandra*, *Cymbopogon ambiguus*, *Chrysopogon fallax* open tussock grassland (FLAGMA). Several SRE specimens were collected from this habitat type. This habitat type occurs on approximately 3% of the Lamb Creek project area.

At the fringes of the valley, steep sided gullies and gorges associated with rocky breakaways and outcrops with *Eucalyptus leucophloia* subsp. *leucophloia* woodland over mixed shrubs over *Triodia wiseana* grassland becoming the dominant habitat type (GORGE, STABM and SHET). This habitat occurs on 25% of the project area. The remaining sections of the haul road are flat plains with alluvial deposits and dominant vegetation types include *Triodia* grassland, mixed acacia shrublands and mulga woodlands over perennial grasslands. Several SRE specimens, Western Pebble-mound Mouse mounds and a record of the Pilbara Olive Python were collected from these habitat types.

Defined, ephemeral drainage systems dissect the valley and plains along the haul road alignment (MEAT). Larger drainage systems support tall *Corymbia* trees (>10 meters) and thick *Acacia* shrublands. Some drainage systems, particularly the north-eastern portions of the project area have been heavily degraded by cattle grazing and weeds are present. Buffel grass (*Cenchrus ciliaris*), an introduced grass species, was present in much of the degraded areas and sparsely in some of the less impacted habitat areas.

5.2. MAMMALS

The mammal species recorded during the survey are typical of mammalian fauna assemblages in the Pilbara region.

A discussion of the regional mammal records and records collected during the survey are presented below. Appendix XI contains the data recorded using ANABAT software to record ultrasonic calls.

5.2.1. **FAMILY DASYURIDAE (CARNIVOROUS MARSUPIALS)**

Five species of the family Dasyuridae were recorded during the survey of the Lamb Creek project area. The family Dasyuridae comprised 64% of the total mammal captures on the survey area.

The Little Red Kaluta (*Dasykaluta rosamondae*) was recorded 20 times during the survey. This species is endemic to the Pilbara region and typically occurs amongst spinifex-hummock grasslands on sandy, stony or clay plains. This species has also been recorded in stony-hill country (Van Dyck & Strahan 2008; Menkhorst & Knight 2011)

The Long-tailed Planigale (*Planigale ingrami*) was recorded six times during the survey in the SHET and FLAGMA habitat types. The distribution of the species in the Pilbara is highly isolated from other northern populations (Van Dyck & Strahan 2008).

The Stripe-faced Dunnart (*Sminthopsis macroura*) was the most common species of mammal recorded during the survey with 36 individuals. This species is most commonly found on sandy substrates but is often found on cracking clay and stony plains with associated hummock and tussock grassland and arid shrublands (Menkhorst & Knight 2011).

The Northern Quoll (*Dasyurus hallucatus*) is listed as Endangered under the *EPBC Act*. In the Pilbara, Northern Quolls typically use a variety of rocky formations for denning and foraging (Van Dyck & Strahan 2008; Rapallo Environmental 2010). The Northern Quoll was not recorded in cage traps during the survey however an individual was recorded on a motion detecting camera during the survey. A Northern Quoll scat was also found underneath a rocky overhang. Subsequent trapping at this site did not reveal any further evidence of Northern Quolls. Further information on the ecology and conservation significance of this species can be found in Section 6.1.

5.2.2. **FAMILY MACROPODIDAE**

One species of kangaroo and one species of wallaby were recorded during the survey.

The Euro (*Macropus robustus*) was recorded several times during the survey, from direct opportunistic sightings and on a motion detecting cameras. This species is found throughout the Pilbara, with a wider distribution across almost all of Western Australia, excluding the Nullarbor and South-West regions (Van Dyck & Strahan 2008; Menkhorst & Knight 2011). The Euro typically shows preferences for rocky regions and outcrops but can occur in most habitat types. They are distinguished from other large kangaroo species by their shaggy coat; shorter, stockier proportions and bare rhinarium. Records of this species are common within 40 km of the project area (DEC 2012c).

Rothschild's Rock Wallaby (*Petrogale rothschildsi*) was recorded two times during the Targeted Northern Quoll Survey. Additional records were made of individuals on motion detecting cameras and while spotlighting. This species is a Pilbara endemic utilising rocky ridges of the Hamersley and Chichester ranges. Throughout Australia, rock wallabies have declined in abundance and distribution. Current data suggests this species has not suffered similar extensive declines (Van Dyck & Strahan 2008; Menkhorst & Knight 2011).

5.2.3. FAMILY MURIDAE (RODENTS)

Five species from the family Muridae were recorded during the survey. Four species were recorded during systematic trapping while evidence of a single species was recorded during foraging transects.

The Desert Mouse (*Pseudomys desertor*) is widely distributed across arid Australia and is locally common where it does occur. Like the Sandy Inland Mouse, populations are known to respond to large rainfall events, after which they can become extremely common (Dickman *et al.* 1999). This species is often recorded and there are several records within 40 km of the project area (DEC 2012c).

The Sandy Inland Mouse (*Pseudomys hermannsburgensis*) is a widely distributed rodent species that is characteristic of the arid interior. It is an irruptive species with populations responding to increased levels of seed produced after large rainfall events (Van Dyck & Strahan 2008). The species can become extremely common during such irruptive seasons (Dickman *et al.* 1999). In the Pilbara, The Sandy Inland Mouse is common and frequently recorded. It is well represented in regional records, being recorded several times within 40km of the project area (DEC 2012c).

The Common Rock Rat (*Zygomys argurus*) is a wide ranging species that occurs in disjunct populations through northern Australia. This species is frequently recorded throughout the Pilbara and is well represented regionally, being recorded within 40 km of the project area (DEC 2012c). Although primarily found on rocky outcrops and in areas of complex rock formations, this species is reported to use extensive rocky plains and slopes between outcrops as either foraging habitat or during dispersal (Van Dyck & Strahan 2008). A single individual was recorded during the survey.

The Western Pebble Mound Mouse (*Pseudomys chapmani*) is listed by DEC as Priority 4- taxa in need of monitoring. This species builds large prominent mounds that were recorded at 35 locations during the survey, typically in the low sloping, stony foothills. Occupation of the mounds can be determined by the structure of the entrances. Most mounds located during the survey were deemed to be active. Further information on the ecology and conservation significance of this species is provided in Section 6.2.5.

The introduced House Mouse (*Mus musculus*) was recorded twice during the survey. Although typically found close to human habitation they are known to utilise most habitat types within Australia and are often found in remote locations.

5.2.4. FAMILY CANIDAE

Two species of Canid could potentially occur on the project area. The Red Fox (*Vulpes vulpes*) and the Dingo/Feral Dog (*Canis lupus dingo/familiaris*) are both found in the Pilbara and have been recorded within 40km of the project area however no individuals of either species were recorded during the survey.

5.2.5. FAMILY MEGADERMATIDAE

This family is represented in Australia by the Ghost Bat (*Macroderma gigas*). This species is currently listed as P4 – Taxa in need of monitoring under the *Wildlife Conservation Act, 1950*. It is the largest species of microbat in Australia and is highly predatory, taking a variety of vertebrate species including birds, reptiles, rodents and other bats (Churchill 2008). Five Ghost Bats were recorded on the project area from two roost caves, and one additional cave occupied by Ghost Bats was recorded in the central survey

area (Figure 8). There was no evidence of middens within either cave suggesting other roosts are located in the surrounding area.

5.2.6. FAMILY EMBALLONURIDAE

Twenty individuals of Common Sheath-tailed Bats (*Tapozous georgianus*) were recorded roosting in caves within the survey area. This widely distributed species does not hang when roosting like other bat species, but clings to the wall, propped up by its forearms. Consequently it is the only species to utilise fissures, vertical crevices and mine shafts (Van Dyck & Strahan 2008). This species is common and has been recorded within 40kms of the project area. As well as being frequently encountered on foraging transects, this species was recorded at four locations by the SM2+ bat recorder.

The Yellow-bellied Sheath-tailed Bat (*Saccolaimus flaviventris*) was recorded at four locations on the survey area. This species is widespread across tropical Australia with its range extending into southern temperate Australia during summer (Churchill 2008). This species was recorded at four locations during the survey by the SM2+ bat recorder.

5.2.7. FAMILY MOLOSSIDAE

The Northern Free-tailed Bat is a widespread species that utilises most habitats across northern Australia. This species is commonly recorded roosting in hollow tree spouts, often in large colonies. This species is one of the few Australia microbats that have an audible call. This species was recorded at one location during the survey by the SM2+ bat recorder.

5.2.8. FAMILY VESPERTILIONIDAE

Four individuals of the Inland Cave Bat (*Vespadelus finlaysoni*) were recorded roosting inside a cave on the project area. This species is widely distributed in arid and semi-arid Australia and are usually associated with rocky areas (Churchill 2008). Records of this species have been made within 40km of the project area. This species was also recorded at all locations sampled by the SM2+ bat recorder.

The Gould's Wattled Bat (*Chalinolobus gouldii*) was recorded in five locations on the survey area, this species is widespread and common across Australia occupying virtually habitats from tropical rainforest, alpine regions, deserts, woodlands and urban areas (Churchill 2008). This species was also recorded at one location sampled by the SM2+ bat recorder.

The Little Broad-nosed Bat (*Scotorepens greyii*) was recorded at four locations on the survey area. This species is found across northern Australia, through central Australia and into southern New South Wales (Churchill 2008). This species typically roosts in tree hollows and under bark but is also frequently found in abandoned dwellings (Van Dyck & Strahan 2008). This species was recorded at four locations during the survey by the SM2+ bat recorder.

5.3. REPTILES

5.3.1. FAMILIES GEKKONIDAE AND PYGOPODIDAE (GECKOS AND LEGLESS LIZARDS)

A total of 18 species of geckos and legless lizards from 334 records were made during the Lamb Creek survey. The total number of species captured represents 69% of the 26 species found within the region.

Three species of the genus *Diplodactylus* were recorded during the survey. *Diplodactylus conspicillatus* and *Diplodactylus savagei* were both recorded from the SHET habitat type with capture numbers of one and two respectively. *Diplodactylus pulcher* was recorded twice during the survey with one record coming from both the MEAT and FLAGMA habitat types.

The genus *Lucasium* was represented twice during the survey with large numbers (n=107) of *Lucasium stenodactylum* being recorded across all five habitat types found on the project area. *Lucasium wombeyi* was found to be less common on the project area (n=8) with records from the SATOM and STABM habitat types.

Two species of *Gehyra* were recorded during the survey; *Gehyra punctata* and *Gehyra variegata*. *Gehyra punctata* was the most abundant species recorded during spotlight surveys (n=60) with all records of this species coming from rocky outcrops and gorges during spotlight surveys rather than through systematic trapping. Conversely *G. variegata* was predominantly recorded during systematic surveys (n=30) with only two of those records coming from foraging surveys.

Several genera of gecko were represented by a single species during the survey; *Crenadactylus ocellatus*, *Heteronotia binoei*, *Rhynchoedura ornata*, *Nephrurus wheeleri*, *Oedura marmorata* and *Strophurus wellingtonae*.

Three of these species; *H. binoei* (n=18), *O. marmorata* (n=20) and *R. ornata* (n=66) can be considered common in the Pilbara region with numerous records of these species occurring within 40 km of the project area (DEC 2012c). *Oedura marmorata* is commonly found within rocky gorges, rocky outcrops, scree slopes and woodlands while *H. binoei* and *R. ornata* are commonly found within arid and semi-arid regions of Australia. Within the project area these species were found to be locally abundant within their preferred habitat types.

Strophurus wellingtonae was recorded four times during the survey with two systematic records and two spotlighting records. These records are a good example of a common species that is infrequently encountered in traps. This species was recorded in areas of Mulga/spinifex associations on heavy red soils, the habitat type it is known to favour (Wilson & Swan 2008). This species has been recorded within 40 km of the project area (DEC 2012c).

Nephrurus wheeleri was recorded once during spotlighting surveys from a deep narrow rock crevice in a creek bed with *Corymbia* and *Triodia* associations. Two individuals were found sheltering inside the narrow entrance. This species has two distinct populations with the Pilbara population preferring rocky ranges and outcrops with spinifex associations (Wilson & Swan 2008). This species has been recorded several times within 40 km of the project area.

A single record of *Crenadactylus ocellatus* was made during the survey from the MEAT habitat types. This monotypic genus is secretive and rarely found far from cover. It is a terrestrial generalist dwelling under rocks and surface litter (DEC 2012c). Records of this species have been made within 40 km of the project area (DEC 2012c).

The most commonly recorded Pygopod species during the survey were *Delma elegans* and *Lialis burtonis*. *Lialis burtonis* is a common species and is Australia's most widespread reptile species occurring in all habitat types except for high altitudes, cooler regions of the southern Australian mainland and Tasmania (Wilson & Swan 2008). During systematic surveys this species was recorded three times, once in each of the SATOM, MEAT and SHET habitat types.

Delma elegans was also recorded three times during the survey. Once from under woody debris around the campsite and twice during systematic surveys from the MEAT and FLAGMA habitat types. This species is restricted to the Pilbara region and is known to shelter in spinifex associations in rocky areas of the Hamersley Ranges and adjacent lowlands (Wilson & Swan 2008).

Delma nasuta and *Delma tincta* were recorded twice and once respectively during systematic surveys of the project area. *Delma nasuta* was recorded from the SHET and FLAGMA habitat types while *D. tincta* was recorded from the FLAGMA habitat type. Both these species are widespread across several habitat types in Western Australia (Wilson & Swan 2008). Both of these species have been previously recorded within 40 km of the project area (DEC 2012c).

A single species of the genus *Pygopus* was found during the survey, two records of *Pygopus nigriceps* were recorded from the SATOM and FLAGMA habitat types. This common species is widespread across Western Australia (Wilson & Swan 2008). Records of this species have been made previously within 40 km of the project area (DEC 2012c).

Delma pax was notably absent from the species record. This species is restricted to the Pilbara and is common in the region with several records within 40 km of the project area. This species is expected to occur on the project area as suitable habitat occurs within the boundaries of the tenement.

5.3.2. FAMILY SCINCIDAE (SKINKS)

A total of 208 skinks comprising 18 species were recorded during the survey of the Lamb Creek survey area.

The skink fauna of Lamb Creek was dominated by the ubiquitous *Ctenotus* skinks. This widespread radiation of skinks has colonised all arid and semi-arid habitats and most tropical and temperate habitats on mainland Australia (Wilson & Swan 2008). Records from this genus comprised 58% of all skink records found on the survey area.

The most abundant skink species recorded during the survey was *Cryptoblepharus ustulatus* (n=45). Opportunistic sightings of this species were commonly made during the checking of Northern Quoll cage traps. This species is exclusively found among rocky habitats in the Pilbara region.

Several species were notably absent from the species record for the Lamb Creek survey area. No members of the genus *Eremiascincus* were recorded during the survey. The Broad-banded Sandswimmer (*Eremiascincus richardsonii*) is typically found in areas with hard soils with some populations in the Pilbara inhabiting caves and gorges. The Narrow-banded Sandswimmer (*Eremiascincus fasciolatus*) is more typically found in areas of sandy soil dominated by spinifex (Cogger 2000). Suitable habitat for these species occurs on the project area and both species have been recorded within a 40 km radius of the project area (DEC 2012c).

5.3.3. FAMILY AGAMIDAE (DRAGONS)

Six out of the ten regionally recorded species of dragons were recorded during the survey from a total of 195 records.

The Ring-tailed Dragon (*Ctenophorus caudicinctus*) was the most ubiquitous species during the survey being recorded 108 times. This widespread and common species was mostly found on stony loam plains and stony hills. The Military Dragon (*Ctenophorus isolepis*), another widespread and common species

was also found in high numbers (n=76) on the survey area utilising similar habitats to *C. caudicinctus* however records show a preference to stony loam plains with no individuals being recorded on the SHET habitat type.

The Long-nosed Dragon (*Amphibolurus longirostris*) is a common and wide spread species ranging from western and central Western Australia through to central Northern Territory. Five records were made of this species on the survey area, predominantly from minor drainage lines in the MEAT habitat type. Records of this species occur within 40 km of the project area, it is usually found along gorges and *Eucalypt* lined watercourses (Wilson & Swan 2008).

Two species were recorded twice on the survey area; *Caimanops amphiboluroides*, *Diporiphora valens* and *Pogona minor*. *Caimanops amphiboluroides* was recorded from a systematic record from the FLAGMA habitat type and an opportunistic record of the species from the basecamp site located within the SATOM habitat type. A cryptic species, it is infrequently encountered in systematic surveys and if disturbed slides slowly from view making opportunistic records difficult to obtain. This species has been recorded within 40 km of the project area and is found in Mulga woodlands and shrublands on heavy stony soils (Wilson & Swan 2008). *Diporiphora valens* is a Pilbara endemic restricted to the arid interior of the Pilbara, the species is known to occur in shrublands and low woodlands over spinifex. Two records were made of this species from the FLAGMA habitat type, fitting the typical habitat preference detailed in Wilson and Swan (2008). This species has been recorded within 40 km of the project area (DEC 2012c).

Three records were made on the survey area of the Dwarf Bearded Dragon (*Pogona minor*). Two of these records were systematic records with a single individual being recorded in both the MEAT and STABM habitat types along with a single opportunistic record of the species. *Pogona minor* occurs across a large area of the Australian mainland from central South Australia and southern Northern Territory across to coastal Western Australia and north into the Pilbara region. It is found in woodland and shrubland habitats and records have been made within 40 km of the project area.

5.3.4. FAMILY ELAPIDAE (FRONT FANGED LAND SNAKES)

A total of seven species of Elapid snake were encountered during surveys of the Lamb Creek survey area. The most common species recorded were the Mulga Snake (*Pseudechis australis*) and the Yellow-faced Whipsnake (*Demansia psammophis* subsp. *cupreiceps*) with three records for each species. All records of these species were made during systematic surveys. Records of *P. australis* were made from the MEAT, SHET and FLAGMA habitat types while the records of *D. psammophis cupreiceps* records were made from the SATOM, MEAT and STABM habitat types. *Pseudechis australis* is a large elapid snake capable of causing human fatalities and is a common and widespread species across a wide range of semi-arid and arid Australia while the *cupreiceps* subspecies of *D. psammophis* is found from the arid interior of Western Australia to the north-west coast of the state. Numerous records for both species have been found within 40 km of the project area.

Two capture records were recorded for both *Parasuta monachus* and *Suta fasciata*. *Parasuta monachus* has a narrow range within the Pilbara region and is usually found on hard red soils with *Acacia* woodland associations. The records for *P. monachus* were made from the SHET habitat type. *Suta fasciata* is found on stony soils supporting woodlands in the Pilbara region (Wilson & Swan 2008). The *S. fasciata* individuals were recorded from the SHET and SATOM habitat types. Records of *P. monachus* exist

within 40km of the project area however no records of *S. fasciata* have been made within 100km of the project area.

Mengden's Brown Snake (*Pseudonaja mengdeni*) was recorded once during the reconnaissance survey while placing a motion detecting camera in a rocky gorge. This individual had evidence of attempted predation around the tail. This species was not recorded during systematic surveys of the Lamb Creek survey area however records exist of this species being recorded within 40 km of the project area (DEC 2012c)

The Ringed Brown Snake (*Pseudonaja modesta*) was recorded once during systematic surveys from the STABM habitat type. This species is widespread across Australia being found from semi-arid to central arid regions. *P. modesta* records have been made within 40 km of the project area and suitable habitat exists within the tenement.

One record of the Pilbara Bandy-Bandy was made during systematic surveys. This species was recorded from the SHET habitat type. *V. snelli* is a cryptic species and is rarely encountered. *V. snelli* individuals feed exclusively on blind snakes of the genus Typhlopidae. This species is restricted to the Pilbara region of Western Australia. Records of this species have been made within 40 km of the project area (DEC 2012c).

5.3.5. FAMILY TYPHLOPIDAE (BLIND SNAKES)

No species of Typhlopidae blind snakes were recorded during the survey however four species have been regionally recorded including the Priority 4 species; *Ramphotyphlops ganei*. Three species are Pilbara restricted; *Ramphotyphlops ammodytes*, *Ramphotyphlops grypus* and *Ramphotyphlops hammatus*. Suitable habitat occurs on the project area for all of these species to potentially occur.

5.3.6. FAMILY PYTHONIDAE (PYTHONS)

Two python species were recorded from single individuals encountered on the survey area. One record of *Antaresia perthensis* was made during spotlight surveys of a rocky gorge. This species, the world's smallest python; is restricted to the Pilbara region and inhabits rocky outcrops and woodlands. It is often associated with termite mounds (Wilson & Swan 2008). Records of this species exist within 40km of the project area.

The Pilbara Olive Python (*Liasis olivaceus* subsp. *barroni*) was opportunistically recorded once on the project area during the survey. An individual was found on the southern haul road option early in the morning. This individual was approximately three metres long and was found to be in good condition. The individual moved off in the direction of a nearby rocky escarpment. This species is state listed as Schedule 1 – Species that are rare or likely to become extinct under the *Wildlife Conservation Act, 1950* and federally listed as Vulnerable under the *EPBC Act*. Habitat capable of supporting populations of *L. olivaceus* subsp. *barroni* occurs on the project area and records of this species have been recently made within 40 km of the project area.

Notable absentees from the species record include the Black-headed Python (*Aspidites melanocephalus*) and the Stimson's Python (*Antaresia stimsoni*). These species are commonly encountered in the Pilbara region. As suitable habitat for these species is located in the region, these two species are expected to occur on the project area.

5.3.7. FAMILY VARANIDAE (GOANNAS/MONITORS)

The genus *Varanus* was represented by 36 individuals comprising seven species on the Lamb Creek survey area. The most commonly recorded species was *Varanus acanthurus* with a total of 14 captures from the MEAT (n=3) and SHET (n=11) habitat types. This species is widespread across northern Australia commonly occurring in rocky ranges and on heavy to stony soils (Wilson & Swan 2008). This species has been recorded within a 40 km radius of the project area (DEC 2012c)

Varanus brevicauda, the worlds' smallest monitor, was recorded nine times during systematic surveys. This species is a very secretive and generally stays close to spinifex cover. *V. brevicauda* was recorded in three different habitat types with three individuals being recorded in each habitat type. *V. brevicauda* is a widespread species occurring across central and northern Western Australia and the southern half of the Northern Territory. Regional data shows that this species has been recorded within 40 km of the project area.

Varanus tristis was recorded four times during systematic surveys and once during the reconnaissance survey. The systematic records were from the MEAT (n=3) and SHET (n=1) habitat types while a single opportunistic record was made in a weathered conglomerate drainage system. *V. tristis* is widespread across Australia occurring in many different habitat types including the semi-arid and arid zones. This species has been recorded within 40 km of the project area.

Four species were recorded in low numbers on the survey area. *Varanus bushi*, *Varanus giganteus*, *Varanus panoptes* and *Varanus pilbarensis* were recorded two, three, one and three times respectively. *V. bushi* was systematically trapped once in the SATOM habitat type and opportunistically caught once in the MEAT habitat type. This species is a Pilbara endemic with a limited distribution, it is usually found in Mulga and *Eucalyptus* woodlands (Wilson & Swan 2008). Records of this species have been found within 40 km of the project area.

The Perentie (*Varanus giganteus*) was opportunistically recorded twice during the survey and also recorded once during spotlight surveys of the SHET habitat type. This species is Australia's largest goanna. The distribution of *V. giganteus* ranges from the Pilbara region through central Australia to central Queensland encompassing semi-arid and arid zones (Wilson & Swan 2008). This species has been regionally recorded within 40 km of the project area.

A single *Varanus panoptes* individual was recorded from the side of the southern haul road option in the STABM habitat type. This species has two disjunct populations, one in the Pilbara region and the other across most of Queensland and the northern half of the Northern Territory. In the Pilbara region it is found on riverine flats, woodlands and grasslands. The species has been recorded in the region within 40 km of the project area.

Varanus pilbarensis was opportunistically recorded three times during the survey. *V. pilbarensis* was exclusively encountered in rocky regions such as gorges, rocky outcrops and scree fields. This species is a Pilbara endemic and its distribution is limited by the above habitats. Regional data indicates this species has been recorded within 40 km of the project area.

5.4. AMPHIBIANS

Only two of the five amphibian species that are known to occur regionally were captured during the survey. The Sheep Frog (*Cyclorana maini*) being by far the most common with over 800 records.

Records of this species increased dramatically after several thunderstorms that occurred during the survey. *C. maini* was recorded across all the habitat types surveyed with the majority of records (n=706) coming from the FLAGMA habitat type. This species is common and widespread across Western Australia from the Pilbara region east through central Western Australia and into the Northern Territory. It is commonly found on flood plains and near ephemeral stream beds (Tyler & Doughty 2009). Records of this species have been made within 40 km of the project area (DEC 2012c).

The Desert Tree Frog (*Litoria rubella*) was recorded four times during the survey, twice in the MEAT habitat type during systematic surveys and twice around the basecamp site in the SATOM habitat type. This species was only found after several thunderstorms that occurred during the survey. In Western Australia this species is found in the semi-arid and arid zones from the Pilbara north into the Kimberley (Tyler & Doughty 2009). This species is commonly found around areas of human habitation and has been recorded within 40 km of the project area.

The low diversity of amphibian fauna in the species records for Lamb Creek can possibly be attributed to climatic conditions during the survey as well as inappropriate habitats on the project area for several species. While several thunderstorms did occur it is possible that insufficient water was available to stimulate burrowing frog species in the Myobatrachidae family.

5.5. AVIFAUNA

Species diversity and abundance on the Lamb Creek survey area was affected by heavy wet season rains as well as cyclonic activity. Extra rainfall has led to a flow on effect, with high levels of seed, invertebrates and flowering trees and shrubs. This provides excellent breeding conditions for many species resulting in the abundance of several irruptive species during the survey. Irruptive species such as the Budgerigar (n=3143) and the Zebra Finch (n=1329) were the most common species recorded during the survey. Higher than normal numbers of uncommon nomadic and irruptive species were recorded during the survey, in particular honeyeater species that are infrequently recorded away from mass flowering events. White-fronted Honeyeater, Pied Honeyeater, Black-chinned Honeyeater and Grey Honeyeater were all recorded multiple times during the survey with many feeding in the flowering *Corymbia* sp. along drainage lines. Ground Cuckoo-shrike is another infrequently recorded nomadic species that was sighted several times during the survey.

Raptor species were common across the survey area with 11 species being recorded. The high diversity seen in raptors could be the result of increased prey abundance on the survey area brought on by good breeding conditions for many of the prey species.

The largest group of birds absent from the species record for the Lamb Creek survey area are the birds associated with wetlands and/or riparian habitats. Thirty wetland species have been recorded regionally, probably in ephemeral drainage systems located near the project area that become inundated in times of heavy rain. One wetland species, the White-faced Heron, was recorded flying over the southernmost end of the survey area, bordering the Great Northern Highway.

Three species of conservation significant birds were recorded during the survey. The Australian Bustard, listed by DEC as Priority 4 – Taxa in need of monitoring, displayed a preference for the SATOM habitat type of *Acacia aptaneura* and/or *Corymbia deserticola* low woodland over *Acacia elachantha* and mixed *Eremophila* species over *Triodia wiseana* very open hummock grassland.

The Fork-tailed Swift is listed under the *EPBC Act* as Migratory, this species was recorded flying over all the identified habitat types on the project area with the highest abundance (n=100) occurring over the FLAGMA habitat type of *Acacia aptaneura* low woodland over *Themeda triandra*, *Cymbopogon ambiguus*, *Chrysopogon fallax* open tussock grassland.

The Rainbow Bee-eater is listed under the *EPBC Act* as Migratory, one individual was recorded in the STABM habitat type of *Eucalyptus gamophylla* low open woodland over *Acacia elachantha* or *Acacia hilliana*, *Senna glutinosa* subsp. *pruinosa* open shrubland over *Triodia brizoides*, *Triodia wiseana* hummock grassland.

Regionally, a further eight species of conservation significance have been recorded however suitable habitat for these species does not occur on the project area making their presence at Lamb Creek unlikely.

5.6. INVERTEBRATES

5.6.1. ARANEAE – MYGALOMORPHAE (TRAPDOOR SPIDERS)

The Western Australian mygalomorph fauna is vast and many families and genera remain taxonomically poorly known (Phoenix Environmental Sciences 2012). A recent molecular study of Pilbara Mygalomorphae (Helix 2012) provided a new benchmark for diversity estimates in the Pilbara which by far exceeds the species richness of the region documented in during the DEC Pilbara Biological Survey (Durrant *et al.* 2010). Many of these genetic lineages are known from very restricted ranges only (Helix 2012; Phoenix 2012).

During the SRE survey, two mygalomorph spiders from STABM 1 and 2 were collected.

Both mygalomorph spiders collected during the survey belong to the family Barychelidae. Barychelid spiders vary in size and are distinguished by well-developed claw tufts and short terminal segment of the posterior lateral spinnerets (Raven 1994). They are a cryptic group with deep burrows (to 60cm) and well camouflaged and lack the thick trapdoor commonly associated with trapdoor spiders or the extensive webbing around the entrance associated with other mygalomorphs species.

The DEC Pilbara survey recovered four species of Barychelid trapdoor spiders in three genera, of which *Synothele* was with four species most diverse (Durrant *et al.* 2010). Molecular data suggests 20 different molecular lineages within the family indicate a much higher diversity in the region. As many of the known species have restricted ranges (Helix 2012) there is high potential for this genus to contain SRE species/morphospecies.

The mygalomorph specimens collected in the STABM2 pitfall traps during the survey was identified as *Aureocrypta* 'MYG057'. This species is not uncommon throughout the Pilbara region of Western Australia (WAM 2012b)(WA Museum database). It is not an SRE.

The other mygalomorph specimen, collected at STABM1, was identified as *Synothele* 'MYG255'; a fairly large species within the genus. It is the first representative of this new morphospecies in the WA Museum reference collection. As this genus typically has restricted ranges in the Pilbara, this specimen is considered a potential SRE.

While there is no way to determine whether the species is an SRE from this single survey, the STABM habitat in which it was collected is widespread and continuous on and off the project area. Additionally, only small amounts of the habitat type will be impacted by the proposed project. If the species is an SRE, Rapallo believes there is a low risk of it being impacted by the proposed project.

5.6.2. PSEUDOSCORPIONES (FALSE SCORPIONS OF PSEUDOSCORPIONS)

Pseudoscorpiones superficially resemble scorpions but lack the tail or a sting of scorpions. Most species most species are less than 1 cm long. Pseudoscorpions can be found inhabiting a wide variety of habitats including leaf litter, soil, under the bark of trees, under stones, and in rock crevices (Harvey, Milledge, & Yen 1989). In Western Australia, 17 families of pseudoscorpions have been recorded to date (Harvey 2011). The group contains several SRE species.

Database results from WAM indicate that one SRE pseudoscorpion species has been recorded at Area C, within 15 km of the survey area. Eleven pseudoscorpion specimens were collected during the survey. They belong to four different families (Artemnidae, Chthoniidae and Oplidae). Only one species, *Austrochthonius* ‘pilbara’, is considered a potential SRE.

The taxonomy of the group Artemnidae is unclear although current evidence suggests that most species are widespread. Similarly, specimens collected from the group Cheiridiidae are at present poorly known but initially data suggests that most species from this group are widespread. It is highly unlikely that species from this group would be SREs.

The Oplidae group contains some of the most frequently recorded species in xeric habitats in the Pilbara. Species from the genus *Beierolpiu*, such as those found at Lamb Creek, are generally considered widespread and thus not SRE species. Some genera and species in the Oplidae group however, may be considered range restricted, particularly subterranean species.

One species in the family Chthoniidae was collected during the survey. *Austrochthonius* ‘pilbara’, was collected in a litter sample from below a blue mallee at STABM2. The species is currently poorly defined and may consist of a group of species. It is currently considered a potential SRE. While the distribution of this species is unknown, the habitat in which it was found is widespread and continuous on and off the project area.

Other species of *Austrochthonius* occur in leaf litter and soil environments throughout much of southwestern Australia, as well as subterranean ecosystems in Cape Range and near Busselton (Harvey 1991; Harvey & Mould 2006). The taxonomy of the Western Australian species is not resolved. The deep genetic divergences within the genus demonstrated in recent molecular analyses are, unfortunately, not reflected in their morphology and thus species identification is extremely difficult. The genus *Austrochthonius* is currently under revision at the Western Australian Museum (M. Harvey personal communication).

5.6.3. CHILOPODA (CENTIPEDES)

The centipedes represent a diverse group of predatory arthropods ranging from about 4 to 300mm long. Each pair of legs is attached to a separate body segment which distinguishes this class from the millipedes (Diplopoda; two pairs of legs per segment) (Colloff *et al.* 2012).

All five orders of centipedes can be found in Australia of which two orders and one family are associated with relictual habitats and therefore potential SRE. Geophilomorpha, Lithobiomorpha and the Cryptopidae (within the Scolopendromorpha) are associated with relictual habitats such as moist and deep leaf litter. Geophilomorpha and Cryptopidae have also been found in subterranean environments in the Pilbara where they are limited to very small ranges (e.g. Edgecombe 2005).

No SRE centipedes have been recorded within 40 km of the project area according to the WAM database search. However, one centipede specimen was collected from a litter sample at STABM2 during the survey and submitted for identification. It was identified as belonging to the order Geophilomorpha and is considered a potential SRE.

The taxonomy of the Geophilomorpha is poorly resolved and it is currently impossible to identify the specimen beyond order level. Based on their high diversity in combination for the preference for moist, deep litter habitats, all undescribed representatives of the Geophilomorpha are here considered potential SREs. While the distribution of this species is unknown, the habitat in which it was found is widespread and continuous on and off the project area.

5.6.4. DIPLOPODA (MILLIPEDES)

Particular orders of Millipedes are one of the main target groups of SRE surveys, with SRE species frequently occurring in some groups. Within Western Australia SREs are particularly expected within the orders Sphaerotheriida (rolling millipedes) and Polydesmida, (Harvey 2002; Environmental Protection Authority 2009). A recent review of Australian *Atelomastix* (order Spirostreptida) found all of 29 species treated were SREs (Edward & Harvey 2010).

No SRE millipede species were reported in the WAM database searches. However, one millipede specimen was collected in the STABM2 blue mallee leaf litter sample during the survey. It has been identified as *Austrostrophus* sp. indet., a member of the Triguniulidae family and a potential SRE.

The millipede family Triguniulidae represents a conspicuous element of the Southeast Asian and Indonesian faunas where 21 genera are recognised (Hoffman 2003). In Australia, however, the group has few representatives, including two monotypic genera from WA, *Austrostrophus* and *Speleostrophus* (Hoffman 1994, 2003). *Speleostrophus nesiotus*, endemic to caves on Barrow Island is the only Australian native millipede on a State endangered list (Mesibov 2006).

The genus *Austrostrophus* was described only fairly recently and includes a single species, *A. stictopygus* (Hoffman 2003). At the time of its description, *A. stictopygus* was thought to have a very narrow distribution and was only known from the Burrup Peninsula. Recent surveys as part of resource developments in the Pilbara have shown that the species is widespread throughout the region (Harvey *et al.* 2011).

The specimen submitted for identification was a juvenile and could not be identified to species level. It is possible that it represents a second undescribed species known in addition to *A. stictopygus*, namely *Austrostrophus* ‘DIP018’ collected from two localities in the southeastern Pilbara and currently considered a potential SRE. Consequently, *Austrostrophus* sp. indet. from Lamb Creek is considered a potential SRE. While the distribution of this species is unknown, the habitat in which it was found is widespread and continuous on and off the project area.

5.6.5. **ISOPODA (SLATERS)**

Due to their reduced dispersal ability and narrow habitat preferences, slaters are one of the target groups of SRE surveys (Harvey 2002). The WAM database search recorded no slaters within 40 km of the project area. Two slater specimens were collected in litter samples at FLAGMA2 and STABM2 (Figure 12). These have been identified as two different species. One is a potential SRE and the other is a likely SRE.

The specimen collected in a litter sample from below a strap-leaved *Acacia* sp. at FLAGMA2 (Figure 12) was identified as *Buddelundia* '13', a member of the Armadillidae. The genus is currently under taxonomic revision by S. Judd. Species of *Buddelundia* often have a very wide distribution and are not expected to have many SRE species (S. Judd personal communication in Phoenix Environmental 2012).

However, *Buddelundia* '13' represents a small species-complex that is restricted to the Pilbara. This species was previously collected at the Wonmunna mining lease 80 km west of Newman (Phoenix Environmental Sciences 2011). However, the single specimen collected here is not fully mature so a determination is tentative. It is considered a potential SRE (S. Judd personal communication in Phoenix Environmental 2012). While the taxonomic resolution and distribution of this species is unknown, the habitat in which it was found is widespread and continuous on and off the project area.

The second isopod specimen was collected in the blue mallee sample at STABM2. The specimen is only tentatively associated with the genus *Spherillo*. It almost certainly belongs to a different, unnamed genus (S. Judd personal communication in Phoenix Environmental 2012). There have been very few specimens of this genus collected in the Pilbara, but species diversity appears high. This genus was also collected at Wonmunna (Phoenix Environmental Sciences 2011) but both clearly represent different species. It is extremely rare to find these armadillids among the epigeal isopods of the Pilbara and they are therefore considered likely SREs (S. Judd personal communication in Phoenix Environmental 2012). This specimen was collected in a habitat that is widely distributed and continuous on and off the project area.

5.6.6. **SCORPIONES**

Thirteen scorpion samples were collected during the Lamb Creek fauna survey. The bulk of the samples were from the family Buthidae in the genus *Lychas*. This genus is widespread across the Australian mainland and is also distributed throughout Africa, eastern Asia and India. Two morpho-species were identified from the collected samples. *Lychas* 'harveyi' is a widespread species, particularly in the Pilbara where it is one of the most common scorpion species (Phoenix Environmental 2012). The nine specimens were identified as belonging to this morpho-species and were collected from all habitat types surveyed. *Lychas* 'pilbara1' is a widespread species that was recorded in the SATOM, SHET and MEAT habitat types. Although widely distributed throughout the Pilbara this species is not common and seldom collected. Neither *Lychas* species is regarded as an SRE species.

A single specimen of the genus *Urodacus* was collected from the FLAGMA2 site. *Urodacus* is an endemic genus that is highly diverse. The 23 species that are currently described may represent as little as 20% of the actual diversity within the genus. The Pilbara Biological Surveys recorded one formally described species and 9 undescribed species. Unfortunately certain identification of scorpions from this genus can only be made from adult male individuals. Consequently the specimen recorded from Lamb creek can only be recorded as *Urodacus* sp. indet owing to the immature life-stage of the sample collected. Further specimens are necessary to determine identification and SRE status of this species.

Given the relictual nature of the Wannamunna land system where this specimen was collected it is possible that this species may represent a SRE species.

5.6.7. HABITAT ASSOCIATION

Four potential and one likely SRE species have been recorded in the STABM habitat type, which is described as *Eucalyptus gamophylla* low open woodland over *Acacia elachantha* or *Acacia hilliana*, *Senna glutinosa* subsp. *pruinosa* open shrubland over *Triodia brizoides*, *Triodia wiseana* hummock grassland. It is located on the Boolgeeda land system which covers a very large area of the Pilbara (approximately 7,748 km²). This vegetation type is distributed over approximately 46% of the project area and is continuous with similar habitat in adjacent off footprint areas.

The other potential SRE species was collected at FLAGMA2. Despite being in flat, relatively open areas, both of these sites were noticeably wetter than the other foraging sites with traplines becoming inundated during rain, particularly STABM2.

The FLAGM2 trapping/litter site is located in the Wannamunna land system which comprises only a small portion (approximately 3%) of the project area near the intersection of the proposed haul road and the Great Northern Highway. The Wannamunna land system is a relatively uncommon land system with high conservation and pastoral value that supports the majority of the priority flora species recorded in Rapallo's flora survey (Rapallo Environmental 2012) and 'at risk' ecological communities 'Grove/inter-grove mulga, eastern Hamersley Range' and 'Valley floor mulga' mentioned in Kendrick (2002). Presence of a potential SRE species further supports the ecological value of this land system.

Recommendations regarding the management of habitats for SREs are presented in Section 7.

6. SPECIES OF CONSERVATION SIGNIFICANCE

Database searches for the area surrounding the haul road alignment indicate that 16 fauna species of conservation significance have been recorded in the region. Seven of these species were recorded within the habitats of the project area during surveys. Their locations are mapped in Figure 8. Based on an analysis of habitats recorded during the survey, an additional three species may occasionally use habitats of the project area (Table 9).

6.1. NIGHT PARROT – *PEZOPORUS OCCIDENTALIS*

The Night Parrot is listed under the *Wildlife Conservation Act 1950* as Schedule 1 – Fauna that are rare or likely to become extinct and under the *EPBC Act* as Critically Endangered and Migratory.

This enigmatic species was once relatively common throughout the arid zone but has declined in the last 80 years with the increase in pastoral activities in arid and semi-arid Australia. Although previously wide-ranging this species is known now from a few recent sightings and specimens. Sightings are centred on the Boulia region in western Queensland and the Fortescue Marsh in the Pilbara (Johnstone & Storr 1998).

Practically nothing is known about the biology of this species, although it is known to be highly nomadic. Recent records have corresponded with rainfall events and abundant food resources (Johnstone & Storr 1998).

There is one record of a Night Parrot located approximately 60 km northeast of the project area, at Mingawirriewirrie (Minga) Well. Pastoral activities across the region have decreased within the previous 20 years. As such there are potentially suitable areas of habitat for this species to use on the project area. While it is considered unlikely that the species is found on the project area, the possibility cannot be completely discounted; however it is acknowledged that sightings of this species are extremely rare.

6.2. NORTHERN QUOLL – *DASYURUS HALLUCATUS*

The Northern Quoll is listed under the *Wildlife Conservation Act 1950* as Schedule 1 – Fauna that are rare or likely to become extinct and under the *EPBC Act* as Endangered.

The Northern Quoll is a large omnivorous marsupial that was historically distributed throughout the northern areas of Australia (Van Dyke and Strahan, 2008). It has suffered wide-spread and drastic population reductions, a trend linked to altered fire regimes, habitat degradation, predation and competition from feral animals and poisoning resulting from consumption of cane toads (Braithwaite & Griffiths 1994; Oakwood 2000). Today the species distribution is confined to several isolated pockets of northern Queensland, the plateaus of Arnhem Land, the eastern Kimberley, offshore islands and the Pilbara (Van Dyke and Strahan, 2008). The Pilbara and offshore islands may represent the last populations free of cane toads.

There is limited data on the species ecology, especially the Pilbara populations. Most of the data from the Pilbara has been collected in relation to mineral development. Based on this data, it appears that the species is less likely to use riparian habitats containing hollows, as has been observed in other populations. The Pilbara populations seem closely tied to rocky habitats that contain caves and crevices. Rapallo (2010) reported extremely high densities associated with rocky mesas 20 kilometres to the east

of Port Hedland. This population appeared to avoid the surrounding hummock grassland plains and only occasionally use riparian habitats.

The project area and surrounds contain features such as gorges, rocky outcroppings, caves and overhangs as well as fig trees that appear to be suitable habitat to support Northern Quolls. However, the survey area appears to be only sparsely populated by Northern Quolls and there are very few records within 50 kilometres of the project area. Two observations were also recorded at Phil's Creek, 40 km west of Lamb Creek in habitats similar to those of the project area (Rapallo Environmental 2012)

A single record of the Northern Quoll was made during the survey from a motion detecting camera (Table 4). This camera was located in the central survey area but outside of the project footprint, along a gorge that is ringed by the proposed haul road. An old scat was also located within the same area ringed by the haul road.

Given the survey effort used to detect the presence of the species (182 MDC Camera nights and 300 cage trap nights), it would appear that there are no large populations of the species on the project area. Rapallo has deployed MDCs in similar habitats 300 kilometres to the WNW of the project area (Rapallo 2011). MDCs at these sites had a success rate of 59% and an average detection length of 2.8 days before Northern Quolls were detected. This survey had a detection rate of 0.5% on the MDCs.

Based on the survey effort used, Rapallo believes it is unlikely that an extensive population of Northern Quolls populates the project area, or habitats adjacent to it. It is more likely that the individual recorded during the survey is a dispersing individual. If there are permanent populations, they appear to be very sedentary based on the results of the camera and cage trap surveys.

Further recommendations relating to the Northern Quoll, including management and mitigation measures, are presented in section 7.

6.3. ORANGE LEAF-NOSED BAT – *RHINONICTERIS AURANTIA*

The Pilbara population of the Orange Leaf-nosed Bat is listed under the *Wildlife Conservation Act 1950* as Schedule 1 – Fauna that are rare or likely to become extinct and under the *EPBC Act* as Vulnerable.

The Orange Leaf-nosed Bat is an endemic species distributed across the top end of the Northern Territory and the Kimberley (Kulzer *et al.* 1970), with relict populations in the Pilbara region (Churchill 2008). They are considered to be the only remaining representatives of a diverse group that was present in the Miocene, and the species itself is thought to be old following the discovery of three – five million year old fossil material in the Riversleigh World Heritage Area (Archer, Hand, & Godthelp 1991).

The Orange Leaf-nosed Bat is unable to enter torpor (daily hibernation) to conserve heat. This species is susceptible to suffering exhaustion and hypothermia when exposed to cool roost temperatures (Kulzer *et al.* 1970). Orange Leaf-nosed Bats have one of the highest rates of pulmocutaneous water loss recorded for a mammal when exposed to low humidity (Baudinette *et al.* 2000). Consequently, during the dry season, they are restricted to relatively deep subterranean roosts that are able to provide a stable, warm and humid environment (Churchill, Helman, & Hall 1988; Armstrong 2007; Churchill 2008). These suitable roosts are uncommon in the landscape although some underground mine workings in the Pilbara provide additional habitat (Armstrong, 2007).

As the Orange Leaf-nosed Bat has been recorded in close proximity to Lamb Creek (at mine site Area C), it is possible that this species may occur in or near the project area. Although no evidence of Pilbara Leaf-nosed Bats was detected during the survey it is possible that the deep clefts in the cliffs in the north-east of the project area may lead to sufficiently deep caves. These clefts were not explored due to unstable geology. Although no permanent water sources are in the immediate area, the surrounding region has not been surveyed and a bore dam within a few kilometres would provide adequate permanent water for Pilbara Leaf-nosed Bats.

6.4. PILBARA OLIVE PYTHON – *LIASIS OLIVACEUS* SUBSP. *BARRONI*

The Pilbara Olive Python is listed under the *Wildlife Conservation Act 1950* as Schedule 1 – Fauna that are rare or likely to become extinct and under the *EPBC Act* as Vulnerable. It is a subspecies of the Olive Python that is found only in the Pilbara region of Western Australia. It can grow up to five meters in length and will use rocky hills and gorges associated with creek-lines as habitat. Records of the species are generally associated with permanent water sources.

Some evidence suggests that it is more common than was once thought in the Pilbara, though it remains listed. Development of mines and associated infrastructure and a decline in some target prey species may be having a negative impact on the species abundance and distribution. Cats and foxes may also have a negative impact upon the species, predated upon hatchlings and juveniles.

One Pilbara Olive Python was observed during the survey (Figure 8). It was recorded crossing stony plains between the Hamersley massive and Lamb Creek. The rocky hills, gorges and drainages of the project area are highly suitable for the species. There are likely to be other individuals on the project area.

The proposed project is likely to have an impact on local populations of the species. Further recommendations regarding the species are presented in Section 7.

6.5. PEREGRINE FALCON - *FALCO PEREGRINUS*

The Peregrine Falcon is listed as Schedule 4 - Other Specially Protected Fauna The species was not listed in the DEC Threatened Fauna search undertaken for the area. The Peregrine Falcon experienced a large population decline as a result of reduced breeding success caused by herbicide and pesticide use. Since the banning of such chemicals the population has stabilised and expanded. In Western Australia, populations are stable in areas with granite outcrops and cliffs (Johnstone & Storr 1998). In the absence of such habitats, the species has been known to use nests of species from the family Corvidae and occasionally hollows for nesting (Marchant & Higgins 1993).

The species may occasionally hunt over the project area. The presence of rocky outcrops means that there is potential for the species to nest in or near the project area, but no nests were observed. The project is unlikely to have a significant impact on the species through removal of foraging habitat as it is contiguous with vast areas of similarly habitat.

6.6. *RAMPHOTYPHLOPS GANEI*

Ramphotyphlops ganei is classified as Priority 1 – Poorly known taxa. It is a relatively large and robust blind snake, growing to approximately 33cm long and 1.5cm thick. They can be distinguished by other Pilbara blind snakes by their large and robust size, scalation (mid-body scales 24 rows), snout shape

(rounded from above and in profile) and length of nasal cleft in the 2nd upper labial scale (extends vertically to top of head) (Plate 9) (Wilson & Swan 2008).

This species was first collected in 1985 and first described in 1998. Very little is known about its ecology. Only 28 records of the species have been made in the Pilbara (DEC 2012c). This species appears to be restricted to the Pilbara, recorded from Pannawonica, throughout the Hamersley Ranges through to Newman, and north to the edge of the Chichester Range, south of Port Hedland. Wilson and Swan (2008), report that this species may be associated with moist gorges and gullies but recent records from areas of snake-wood and acacia scrub indicate that this may not be the case.

There are two records of this species within 20 km of the project area listed on NatureMap (DEC 2012c). This species is usually recorded through pit fall trapping, of which there were 10 arrays of 20 pit falls across five suitable habitat types. No *R. ganei* were recorded during the survey but, habitat of moderate suitability, such as drainages and outcroppings, are present in the project area. Thus the habitat has moderate potential to support *R. ganei*.

6.7. WESTERN PEBBLE-MOUND MOUSE – *PSEUDOMYS CHAPMANI*

The Western Pebble-mound Mouse is listed as Priority 4 - Taxa in need of monitoring by the DEC. It is endemic to Western Australia and is noted for the large mounds of pebbles constructs around burrow systems. Dormant and extinct mounds displaying these characteristics suggest the species was once distributed south into the Murchison. Its current distribution is limited to the Pilbara and northern Gascoyne regions of Western Australia (Van Dyck & Strahan 2008).

The species is communal with up to ten individuals living in an active burrow system at any one time. The pebble mounds around the burrows are roughly similar throughout their distribution with pebbles ranging between 0.5 and 3.5 centimetres in width. The mound area generally varies with mound age but mounds 4m in diameter have been reported.

Numerous mounds attributed to the species were recorded during the survey. The majority of mounds were active (Figure 8). This species is likely to be impacted by the project due to the abundance of active mounds throughout the project area. It will be difficult to avoid all active mounds.

6.8. GHOST BAT – *MACRODERMA GIGAS*

The Ghost Bat is classified by DEC as Priority 4 - taxa in need of monitoring. The Ghost Bat is the largest Australian microbat species. Weighing an average 105 grams they are almost twice the weight of the next largest microbat (Churchill 2008). They are the only strictly carnivorous bat in Australia, feeding on frogs, birds, reptiles, mammals (including other bats) and large insects. Prey is caught and carried to an established feeding site (rock overhang or small cave). These sites are easily recognised by the accumulation of prey remains on the floor. Searching for these sites is one way of determining the presence of Ghost Bats. They can also be detected by searching large caves, mines and deep rock fissures for day roosting sites (Churchill 2008). As this species does not use echolocation to hunt for prey like other microbats, consequently they are difficult to detect using ANABAT.

Ghost Bats have a widespread but patchy distribution across a diverse range of habitats (Van Dyck & Strahan 2008). The exact reason for their decline is unknown, although this species is sensitive to disturbance. Genetic studies have shown that this species is highly reliant on a few maternity sites and thus highly susceptible to swift decline if these sites are compromised.

There are several small cave systems within the survey area that are likely to be used as roosts by Ghost Bats. Ghost bats were observed roosting in two caves in the project area (Figure 8) and one in the survey area. Five Ghost Bats were observed in one cave and two in the other. Ghost Bats may also forage in other habitats in the project area. Several potential caves were observed on the project area but were not searched due to inaccessibility or safety issues (unstable rocks). One roost cave containing two Ghost Bats is located on the proposed impact area, inside the proposed ore body. The other is adjacent in the area of hills ringed by haul road. Fencing can adversely affect bats when it is initially erected. Any fencing of the project area to limit stock movements through the area may cause direct mortalities through striking of the fence line. Noise and vehicle movements would also impact caves as constant disturbance through noise or vibration can cause bat species to abandon caves. It is highly likely mining operations in the area would impact the local Ghost Bat population in the short term, resulting in the abandonment of those caves whilst mining operations occur. Measures to mitigate the impact of such activities are discussed in Section 7.

6.9. AUSTRALIAN BUSTARD – *ARDEOTIS AUSTRALIS*

The Australian Bustard is classified as Priority 4 – Taxa in need of monitoring by DEC. Garnett and Crowley (2000) list the species as near threatened.

The species is widely distributed but has suffered massive historical population declines. It is particularly vulnerable to intensive agricultural practices and fox predation (Garnett & Crowley 2000). The species uses a wide variety of grass habitats; including tussock grasslands, *Triodia* and grassy woodlands. They can also use chenopod flats and have been reported in modified habitats such as golf courses. The species feeds on a variety of insects (particularly stick insects) and fruit (Johnstone & Storr 1998).

The project area contains suitable habitats for the species. Two Australian Bustards were recorded on two separate evenings during the survey (Figure 8). The species is highly mobile and there is a low risk of long term detrimental impacts to the Pilbara population as a result of the proposed project.

6.10. BUSH STONE-CURLEW – *BURHINUS GRALLARIUS*

The Bush Stone-curlew is listed as Priority 4 – taxa in need of monitoring by DEC. Garnett and Crowley (2000) list the species as near threatened. The species is associated with lightly wooded areas where there is an abundance of fallen logs and leaf litter. Once distributed in all but the most arid areas of Australia, the species has suffered large range contractions and population declines. It is particularly vulnerable to feral animal predation but has also suffered from land clearing and altered fire regimes (Johnstone & Storr 1998).

Whilst not common, the species is still moderately abundant throughout the Pilbara. It uses tussock grassland plains and shrub lands of *Acacia* as well as ephemeral drainage systems.

This species was not recorded during the survey. However, the habitats of the project area are potentially suitable for the species. The species is highly mobile and there are large areas of suitable habitat throughout the Pilbara. While the project may have a localised impact on the species, it is unlikely to have a long term impact on the regional population of the species.

6.11. GREY FALCON - *FALCO HYPOLEUCOS*

The Grey Falcon is listed by the DEC as Priority 4 - Taxa in need of monitoring. The Grey Falcon's total population estimated at fewer than 5,000 individuals and 1,000 pairs (Garnett & Crowley 2000). Garnett and Crowley (2000) list it as Near Threatened and if any decline is detected the species will need to be reclassified as Vulnerable. The species is generally found north of 26°S (Gascoyne, Lake Carnegie and Warburton) (Johnstone & Storr 1998), but have been infrequently sighted from the Murchison northward (Birddata, 2012). There are an estimated 50 pairs in South Australia and consistently few sightings across the country (Garnett & Crowley 2000). However, it continues to be seen throughout its range (Reid & Fleming 1992), and evidence for general decline across arid zone is lacking (Garnett & Crowley 2000).

The distribution of the Grey Falcon is centred on inland drainage systems where there is an average annual rainfall of less than 500 mm. There it frequents timbered lowland plains, particularly *Acacia* shrublands that are crossed by tree-lined watercourses. It also hunts far out into treeless areas and frequents tussock grassland and open woodland, especially in winter (Olsen & Olsen 1986).

The nearest records for the species are within 20 km from the project area. The project is inside the species' core distribution and contains habitats that are suitable for its use, including areas with large eucalypts near dry watercourses. The Grey Falcon may occur in the project area; however, it is unlikely to nest there due to limited availability of water. The project may impact the species if large eucalypts are removed or if significant watercourse alterations are undertaken.

6.12. RAINBOW BEE-EATER – *MEROPS ORNATUS*

The Rainbow Bee-eater *Merops ornatus* is listed as a Migratory Terrestrial Species under the *EPBC Act*. The Rainbow Bee-eater prefers open or lightly timbered areas, often near water. This species has been recorded in dry open sclerophyll forest, open woodlands and shrublands, including mallee, spinifex tussock grassland with scattered trees, chenopod shrubland with scattered trees and riparian or littoral assemblages. It is often seen around disturbed areas such as quarries, road cuttings and mines where exposed bare soil provides suitable breeding sites (Marchant & Higgins 1993). The Rainbow Bee-eater is a migratory bird and moves north from the southern areas of Australia during winter (Johnstone & Storr 1998).

One individual was recorded during the survey. There is suitable habitat across the project area. The species is highly mobile and there is a low risk of long term detrimental impacts to the Pilbara population as a result of the proposed project.

6.13. EASTERN GREAT EGRET – *ARDEA MODESTA*

The Eastern Great Egret can be found throughout Australia, with the exception of the arid regions. It is listed under the *EPBC Act* as both a Migratory Marine and Migratory Wetland species. The Eastern Great Egret inhabits terrestrial wetlands, estuarine, littoral habitats and grasslands. It prefers permanent water bodies on floodplains and the shallows of deep permanent lakes (Marchant & Higgins 1993), though it can be seen on any watered area including damp grasslands (Johnstone & Storr 1998). The species may be recorded on the project area after wide-spread flooding, but it is unlikely to use the area regularly. It was not recorded during the fauna survey.

6.14. CATTLE EGRET - *ARDEA IBIS*

The Cattle Egret is listed as a Migratory Wetland species under the *EPBC Act*. In Western Australia the Cattle Egret is common in areas of medium to high rainfall. The Cattle Egret uses grasslands, woodlands and wetlands, and is not common in arid areas (Johnstone & Storr 1998). The species may be recorded on the project area after wide-spread flooding, but it is unlikely to use the area regularly. It was not recorded during the fauna survey.

6.15. ORIENTAL PLOVER – *CHARADRIUS VEREDUS*

The Oriental Plover is listed as a Migratory Wetland species under the *EPBC Act*. It moves south from breeding grounds in Mongolia and China to spend winters (southern summer) in Indonesia, Australia and sometimes New Zealand. It is found inland, generally in open grassland in arid or semi-arid climates and may be found in estuarine or littoral environments. The Oriental Plover prefers flat inland plains sparsely vegetated with short grass and hard bare ground such as claypans, playing fields, lawns and cattle camps (Marchant & Higgins 1993). The species was not recorded during the fauna survey.

6.16. FORK-TAILED SWIFT – *APUS PACIFICUS*

The Fork-tailed Swift is listed under the *EPBC Act* as a Migratory Marine species. It breeds in north-east and mid-east Asia and winters in Australia and southern New Guinea. It is a visitor to most parts of Western Australia, arriving in the Kimberley in late September, in the Pilbara and Eucla by November and in the south-west land division by mid-December. The species generally returns to its breeding grounds by April. It ranges from common in the Kimberley; uncommon to moderately common in the north-west, west and south-eastern coasts and rare or scarce elsewhere (Johnstone & Storr 1998).

Fork-tailed Swifts were recorded across all five habitat types in the project area. Flocks of approximately 100 individuals were recorded at one location. This irruptive species is likely to be a transient user of the habitats in the project area following the significant rainfall that occurred in the project area in the months preceding the survey.

7. MANAGEMENT AND MITIGATION

While most birds, larger mammals and reptiles will be able to avoid the impact of clearing for the project, smaller mammals, reptiles and burrowing frogs will be unavoidably killed by the large machinery used for vegetation removal and ground preparation, or by exposure to predators. All fauna are at risk of impacts from habitat impacts, disturbance, introduction of non-native predators, and vehicle impacts.

In order to minimise the project's impacts on vertebrate and SRE invertebrate fauna, a series of general recommendations are given below.

7.1. SENSITIVE HABITAT AREAS

Two habitats have been identified as supporting a disproportionate high number of species of conservation significance, the FLAGMA habitat type which falls within the Wannamunna land system and the STABM habitat type which falls within the Boolgeeda land system.

The Boolgeeda land system is relatively extensive throughout the Pilbara. Species of conservation significance that are found within the STABM habitat type are likely to be found elsewhere in the same habitats of the local area. Rapallo recommends that, where possible, these habitats should be avoided. Mine site planning should recognise the value of this habitat in the local area and where possible, infrastructure should be placed away from the habitat type.

Rapallo recommends avoiding disturbance in FLAGMA habitat type of the Wannamunna land system. If disturbance cannot be avoided, Rapallo recommends consulting the DEC to determine the most effective mitigation measures.

7.2. SENSITIVE HABITAT FEATURES

Direct records of species of conservation significance were collected from several habitat features. Such features include caves and gorges. These features should be avoided to ensure long term persistence of these species during and after the operation of the mine.

If sensitive caves or habitat features cannot be avoided, Rapallo recommends consulting the DEC to determine the most effective mitigation measures.

Data on these features are provided in Appendix X.

7.3. MANAGEMENT AND MITIGATION RECOMMENDATIONS

Specific management measures should be developed as further mine site planning is undertaken. However the following, broad measures are recommended to reduce impact on species of conservation significance, specifically the Northern Quoll and Pilbara Olive Python:

- speed limits along haul roads that intersect habitats likely to support species of conservation significance;
- signage delineating zones of conservation significant species and/or their habitat;
- sensitive habitats and habitat features to be marked out to reduce risk of accidental damage;

- man-made water bodies (i.e. turkey nests) to be located away from high traffic areas (as such features often attract the Pilbara Olive Python);
- provide trained fauna handling personnel to supervise clearing works so that slow moving fauna such as the Pilbara Olive Python can be captured and relocated.

7.4. GROUND DISTURBANCE AND REHABILITATION MANAGEMENT

Before any large-scale clearing is undertaken, the following measures should be implemented:

- avoid unnecessary clearing of vegetation, i.e. beyond that strictly required;
- avoid clearing or disturbing habitats that support populations of significant fauna;
- avoid excessive disturbance and clearing around creeks or minor drainage channels;
- progressively rehabilitate cleared areas such as laydown sites, access tracks and grid lines where these are no longer required;
- avoid direct impacts (clearing and grading) to active nests and large trees, particularly those associated with watercourses as a variety of birds use these habitats; and
- wind-rows of topsoil, log debris and leaf litter formed during clearing should be retained to provide for rehabilitation, and they create extremely good micro-habitat for a range of fauna, particularly reptiles.

Most habitats found within the proposed project area are also found outside the project area. The level of impact caused by the project could be reduced by increasing the health of other similar habitats. This could be done by:

- undertaking weed control projects;
- fencing off vulnerable habitats; and
- implementing fire management plans to reduce the risk of large high intensity wildfires.

7.5. AVOIDANCE AND MINIMISATION OF IMPACTS TO SRES

Distribution of possible SRE taxa suggests that they are associated with sheet flow and minor drainage areas on plains. Impacts to SRE taxa could be avoided and minimised through the following measures:

- protect creek line habitats and minimise clearing near creek lines, drainage lines and sheet flows;
- limit the number of access tracks across creek lines and drainage;
- manage and exclude impacts from areas where potential SRE's have been found wherever possible; and
- fire management to ensure long term viability of habitats that are recognised to support potential SRE's on the project area.

7.6. NOISE, VIBRATION AND LIGHT MANAGEMENT

Noise, vibration and altered light regimes can impact the behaviour of conservation significant species and SRE taxa. Equipment and infrastructure (i.e. processing plants) should be located in areas/habitats

deemed as low risk for species of conservation significance and possible SRE's (i.e. not adjacent to creek lines, drainage, and very moist habitats)

7.7. ENVIRONMENTAL AWARENESS AND EDUCATION PROGRAM

Environmental awareness and education programs for on-site personnel should be designed to achieve the following:

- encourage a culture of environmental consciousness on site by increasing the awareness of the environmental commitments of the project;
- display appropriate signage on site e.g. litter management, speed restrictions, species of conservation significance; and
- set site and targeted habitat speed limits on site especially in areas where species of conservation significance are regularly reported.

7.8. INVASIVE SPECIES MANAGEMENT PROGRAM

As the project falls within an active cattle station, the project area is susceptible to carrying a heavy weed load and supporting non-native predators. Such species have negative impacts on the Northern Quoll and other species of conservation significance. Rapallo recommends implementing an invasive species management program. Such a program may offset the localised impacts of the proposed mining project. An invasive species management program could include:

- weed control program;
- rubbish disposal procedures should be applied, especially for food refuse, in order to discourage scavenging by crows, dogs, foxes and feral cats. Large numbers of these animals can have an adverse impact on other fauna, humans and infrastructure; and
- feral animal control program.

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APPENDICES

Appendix I: State and Federal Conservation Codes

Western Australian Wildlife Conservation Act 1950 - Fauna

- Priority 1 Taxa with few, poorly known populations on threatened lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
- Priority 2 Taxa with few, poorly known populations on conservation lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
- Priority 3 Taxa with several, poorly known populations, some on conservation lands. Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
- Priority 4: Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation land.

Western Australian Wildlife Conservation Act 1950-Flora

- Declared Rare Flora R Taxa, which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.
- Declared Rare Flora X Taxa which have not been collected or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
- Priority 1 Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, eg road verges, urban areas, farmland, active mining leases etc, or the plants are under threat, eg from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
- Priority 2 Taxa which are known from one or a few (generally <5) populations at least some of which are not believed to be under immediate threat) i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need for further study.
- Priority 3 Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the

number of known populations (generally > 5), or known populations being large and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further study.

Priority 4 Taxa which are considered to have been adequately surveyed and which, whilst being rare, are not commonly threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Extinct A native species is eligible to be included in the *extinct* category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.

Endangered A native species is eligible to be included in the *endangered* category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.

Vulnerable A native species is eligible to be included in the *vulnerable* category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

Appendix II: Scientific License



DEPARTMENT OF ENVIRONMENT AND CONSERVATION

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PAGE 2
NO. SF008562
PERSON NO. 159889

DATE OF ISSUE 03/04/2012
VALID FROM 03/04/2012
DATE OF EXPIRY 19/08/2012


LICENSING OFFICER

LICENSEE: MR CJ JACKSON
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RAPALLO
PO BOX 8190
SUBIACO EAST WA 6008

(CHRIS JAMES)

WILDLIFE CONSERVATION REGULATIONS 1970

Regulation 17:- Licence to Take Fauna for Scientific Purposes

FURTHER CONDITIONS (OF LICENCE NUMBER SFO08562)

1. The licensee shall take fauna only in the manner stated on the endorsed Regulation 17 licence application form and endorsed related correspondence.
2. Except in the case of approved lethal traps, the licensee shall ensure that measures are taken in the capture and handling of fauna to prevent injury or mortality resulting from that capture or handling. Where traps or other mechanical means or devices are used to capture fauna these shall be deployed so as to prevent exposure of trapped animals to ants and debilitating weather conditions and inspected at regular intervals throughout each day of their use. At the conclusion of research all markers etc and signs erected by the licensee and all traps shall be removed, all pitfalls shall be refilled or capped and the study area returned to the condition it was in prior to the research/capture program. During any break in research, cage traps should be removed and pitfalls either removed, capped or filled with sand.
3. No collecting is to be undertaken in areas where it would impinge on pre-existing scientific research programs.
4. Any form of colour marking of birds or bats shall only be undertaken in accordance with the requirements of the Australian Bird and Bat Banding Scheme.
5. Any inadvertently captured specimen of fauna which is declared as likely to become extinct, rare or otherwise in need of special protection is to be released immediately at the point of capture. Where such a specimen is injured or deceased, the licensee shall contact Department of Environment and Conservation licensing staff at Kensington (08 9423 2434) for advice on disposal. Records are to be kept of any fauna so captured and details included in the report required under further condition 6 below.
6. Within one month of the expiration of this licence, the holder shall submit an electronic return detailing the locality, site, geocode, date and number of each species captured, sighted or vouchered during the currency of the licence, into the Department of Environment and Conservation Fauna Survey Database (DECFSDB). A copy of any paper, report or thesis resulting from the research shall on completion be lodged with the Director General. If a renewal of this licence is required, the licensee shall submit a written progress report for activities undertaken during this licence period prior to the expiry of this licence.
7. Not more than ten specimens of any one protected species shall be taken and removed from any location less than 20km apart. Where exceptional circumstances make it necessary to take large series in order to obtain adequate statistical data the collector will proceed with circumspection and justify their actions to the Director General in advance.
8. All holotypes and syntypes and a half share of paratypes of species or subspecies permitted to be permanently taken under this licence shall be donated to the Western Australian Museum. Duplicates (one pair in each case) of any species collected which represents a significant extension of geographic range shall be donated on request to the Western Australian Museum.
9. To prevent any unnecessary collecting in this State, all specimens and material collected under the authority of this license shall, on request, be loaned to the Western Australian Museum. Also, the unused portion or portions of any specimen collected under the authority of this license shall be offered for donation to the Western Australian Museum or made available to other scientific workers if so required.

Appendix III: Threatened Fauna Database Search Results

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	AUTHOR	VERNALCULAR	KINGDOM	CONSERVATIONCLASS	DAY	MONTH	YEAR	LOCALITY_NAM	SITE_NAME	
Dasyurus hallucatus	FAUNASURVEY	213076	24093	Dasyuridae	Dasyurus	hallucatus	Gould	Northern Quoll	Animalia	T	MAMMAL	11	08	2010	JUNA DOWNS	KD006
Dasyurus hallucatus	FAUNASURVEY	160003	24093	Dasyuridae	Dasyurus	hallucatus	Gould	Northern Quoll	Animalia	T	MAMMAL	25	06	2010	NEWMAN	HDN05
Dasyurus hallucatus	FAUNASURVEY	160001	24093	Dasyuridae	Dasyurus	hallucatus	Gould	Northern Quoll	Animalia	T	MAMMAL	23	06	2010	NEWMAN	HDN05
Dasyurus hallucatus	FAUNASURVEY	160002	24093	Dasyuridae	Dasyurus	hallucatus	Gould	Northern Quoll	Animalia	T	MAMMAL	24	06	2010	NEWMAN	HDN05
Rhinonictis aurantius	FAUNASURVEY	213488	24179	Hipposideridae	Rhinonictis	aurantius	Gray	Orange Leafnosed-bat	Animalia	T	MAMMAL	10	08	2010	JUNA DOWNS	KDDBAT01
Rhinonictis aurantius	FAUNASURVEY	213492	24179	Hipposideridae	Rhinonictis	aurantius	Gray	Orange Leafnosed-bat	Animalia	T	MAMMAL	10	08	2010	JUNA DOWNS	KDDBAT01
Rhinonictis aurantius	FAUNASURVEY	213487	24179	Hipposideridae	Rhinonictis	aurantius	Gray	Orange Leafnosed-bat	Animalia	T	MAMMAL	10	08	2010	JUNA DOWNS	KDDBAT01
Rhinonictis aurantius	FAUNASURVEY	213486	24179	Hipposideridae	Rhinonictis	aurantius	Gray	Orange Leafnosed-bat	Animalia	T	MAMMAL	10	08	2010	JUNA DOWNS	KDDBAT01
Rhinonictis aurantius	FAUNASURVEY	213491	24179	Hipposideridae	Rhinonictis	aurantius	Gray	Orange Leafnosed-bat	Animalia	T	MAMMAL	10	08	2010	JUNA DOWNS	KDDBAT01
Rhinonictis aurantius	FAUNASURVEY	213490	24179	Hipposideridae	Rhinonictis	aurantius	Gray	Orange Leafnosed-bat	Animalia	T	MAMMAL	10	08	2010	JUNA DOWNS	KDDBAT01
Rhinonictis aurantius	FAUNASURVEY	213489	24179	Hipposideridae	Rhinonictis	aurantius	Gray	Orange Leafnosed-bat	Animalia	T	MAMMAL	10	08	2010	JUNA DOWNS	KDDBAT01
Rhinonictis aurantius	TFAUNA	16475	24179	Hipposideridae	Rhinonictis	aurantius	Gray	Orange Leafnosed-bat	Animalia	T	MAMMAL	22	11	2006	NEWMAN	The R-Deposit project area is north west of Newman at the Area C mine site
Rhinonictis aurantius	TFAUNA	16397	24179	Hipposideridae	Rhinonictis	aurantius	Gray	Orange Leafnosed-bat	Animalia	T	MAMMAL	05	03	2008	NEWMAN	Jinanyi mining lease
Leggadina lakedowensis	WAMSPICEMENS	M47912	24217	Muridae	Leggadina	lakedowensis	Watts	Short-tailed Mouse	Animalia	F	MAMMAL	27	09	1997	NEWMAN	JUNA DOWNS
Leggadina lakedowensis	WAMSPICEMENS	M47771	24217	Muridae	Leggadina	lakedowensis	Watts	Short-tailed Mouse	Animalia	F	MAMMAL	14	06	1997	NEWMAN	WEST ANGELES
Leggadina lakedowensis	WAMSPICEMENS	M47672	24217	Muridae	Leggadina	lakedowensis	Watts	Short-tailed Mouse	Animalia	F	MAMMAL	14	06	1997	NEWMAN	WEST ANGELES
Leggadina lakedowensis	WAMSPICEMENS	M47673	24217	Muridae	Leggadina	lakedowensis	Watts	Short-tailed Mouse	Animalia	F	MAMMAL	13	06	1997	NEWMAN	WEST ANGELES
Macroderma gigas	TFAUNA	16396	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	05	03	2008	NEWMAN	Jinanyi mining lease
Macroderma gigas	FAUNASURVEY	299488	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	09	04	2011	NEWMAN	Site x
Macroderma gigas	WAMSPICEMENS	M48195	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	01	01	2001	NEWMAN	
Macroderma gigas	WAMSPICEMENS	M49657	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	01	01	2001	NEWMAN	NEAR WEST ANGELAS HILL
Macroderma gigas	TFAUNA	15843	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	05	11	2007	NEWMAN	south east of Minaq well, Mulga Downs Station, Cloudbreak Project Area
Macroderma gigas	FAUNASURVEY	299490	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	09	04	2011	NEWMAN	Site x
Macroderma gigas	TFAUNA	3001	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	02	09	1998	NEWMAN	West Angela Hill, Cave AA1.
Macroderma gigas	TFAUNA	16395	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	05	03	2008	NEWMAN	Jinanyi mining lease
Macroderma gigas	TFAUNA	16394	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	05	03	2008	NEWMAN	Jinanyi mining lease
Macroderma gigas	WAMSPICEMENS	M48754	24180	Megadermatidae	Macroderma	gigas	(Dobson)	Ghost Bat	Animalia	F	MAMMAL	01	01	2001	NEWMAN	Jinanyi mining lease
Pseudomys chapmani	TFAUNA	5318	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	01	01	1994	KARIJINI	Mt Meharry
Pseudomys chapmani	TFAUNA	5327	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	01	01	1994	KARIJINI	Munjina Gorge
Pseudomys chapmani	TFAUNA	5255	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	29	07	1991	JUNA DOWNS	Road near Mt Windell (Karijini Dr?)
Pseudomys chapmani	FAUNASURVEY	210857	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	28	03	2011	JUNA DOWNS	KDD14
Pseudomys chapmani	WAMSPICEMENS	M18741	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	09	03	2008	NEWMAN	
Pseudomys chapmani	TFAUNA	5266	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	01	01	1994	JUNA DOWNS	S of Munjina Gorge
Pseudomys chapmani	FAUNASURVEY	213452	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	19	08	2010	JUNA DOWNS	KDD14
Pseudomys chapmani	WAMSPICEMENS	M18346	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	18	09	1979	NEWMAN	
Pseudomys chapmani	TFAUNA	5329	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	01	01	1994	NEWMAN	
Pseudomys chapmani	FAUNASURVEY	299503	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	18	03	2011	NEWMAN	Site x
Pseudomys chapmani	FAUNASURVEY	40813	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	22	08	2011	NEWMAN	Site x
Pseudomys chapmani	TFAUNA	5280	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	07	03	1992	NEWMAN	Packsaddle Plots 1/1 & 1/2
Pseudomys chapmani	WAMSPICEMENS	M16827	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	13	12	1979	NEWMAN	
Pseudomys chapmani	WAMSPICEMENS	M55090	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	07	05	2004	NEWMAN	WEST ANGELES
Pseudomys chapmani	TFAUNA	5319	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	01	01	1994	NEWMAN	
Pseudomys chapmani	TFAUNA	5412	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	05	03	1996	NEWMAN	Area C South Flank Deposit
Pseudomys chapmani	FAUNASURVEY	299497	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	15	03	2011	NEWMAN	Site x
Pseudomys chapmani	FAUNASURVEY	210858	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	28	03	2011	NEWMAN	KDD19
Pseudomys chapmani	TFAUNA	11793	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	12	05	2006	NEWMAN	Mariliana PMN15
Pseudomys chapmani	FAUNASURVEY	303083	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	27	05	2011	NEWMAN	KDCC1
Pseudomys chapmani	WAMSPICEMENS	M52486	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	29	05	1998	NEWMAN	Area C South Flank Deposit
Pseudomys chapmani	TFAUNA	5443	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	01	03	1996	NEWMAN	
Pseudomys chapmani	WAMSPICEMENS	M47173	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	WAMSPICEMENS	M55289	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	31	05	2004	NEWMAN	PACKSADDLE RANGE
Pseudomys chapmani	WAMSPICEMENS	M47171	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	WAMSPICEMENS	M47640	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	12	06	1997	NEWMAN	WEST ANGELES
Pseudomys chapmani	FAUNASURVEY	344487	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	12	04	2011	NEWMAN	SFJ07P
Pseudomys chapmani	FAUNASURVEY	344488	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	06	11	2011	NEWMAN	KDDBE33
Pseudomys chapmani	WAMSPICEMENS	M52598	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	13	05	1996	NEWMAN	
Pseudomys chapmani	WAMSPICEMENS	M47159	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	FAUNASURVEY	210859	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	30	03	2011	NEWMAN	KDDBE33
Pseudomys chapmani	TFAUNA	5908	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	01	05	2001	NEWMAN	Hammersley Range on sandy alluvial plain. Proposed Hope Downs rail corridor (HAE3)
Pseudomys chapmani	TFAUNA	11795	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	18	05	2006	NEWMAN	Mariliana PMN16
Pseudomys chapmani	WAMSPICEMENS	M47168	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	17	03	1996	NEWMAN	
Pseudomys chapmani	WAMSPICEMENS	M52577	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	09	05	1996	NEWMAN	
Pseudomys chapmani	WAMSPICEMENS	M47153	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	22	03	1996	NEWMAN	MINING LEASE
Pseudomys chapmani	WAMSPICEMENS	M47155	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	20	03	1996	NEWMAN	MINING LEASE
Pseudomys chapmani	WAMSPICEMENS	M47152	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	22	03	1996	NEWMAN	Site x
Pseudomys chapmani	TFAUNA	16480	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	27	11	2006	NEWMAN	The R-Deposit project area is north west of Newman at the Area C mine site
Pseudomys chapmani	TFAUNA	11798	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	13	05	2006	NEWMAN	Mariliana PMN21
Pseudomys chapmani	WAMSPICEMENS	M47166	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	WAMSPICEMENS	M47174	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	FAUNASURVEY	344489	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	08	11	2011	NEWMAN	SFJ07P
Pseudomys chapmani	FAUNASURVEY	299504	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	05	03	2011	NEWMAN	Site x
Pseudomys chapmani	WAMSPICEMENS	M16833	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	07	12	1979	NEWMAN	
Pseudomys chapmani	WAMSPICEMENS	M50582	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	05	03	1998	NEWMAN	HAMERSLEY IRON'S YANDI
Pseudomys chapmani	WAMSPICEMENS	M50681	24233	Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	F	MAMMAL	05	03	1998	NEWMAN	HAMERSLEY IRON'S YANDI
Pseudomys chapmani	FAUNASURVEY	210861	24233													

Pseudomys chapmani	WAMSPSPECIMENS	M47918 24233 01/10/1997	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	01	10	1997	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M47158 24233 00/03/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	FAUNASURVEY	299508	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	19	03	2011	NEWMAN	Site x
Pseudomys chapmani	TFAUNA	16414	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	05	02	2008	NEWMAN	Area C South Flank Deposit
Pseudomys chapmani	TFAUNA	11797	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	12	05	2006	NEWMAN	Marilana PMN119
Pseudomys chapmani	FAUNASURVEY	344490	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	09	11	2011	NEWMAN	SFJ07P
Pseudomys chapmani	FAUNASURVEY	299505	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	19	03	2011	NEWMAN	Site x
Pseudomys chapmani	WAMSPSPECIMENS	M47157 24233 00/03/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M47664 24233 19/06/1997	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	19	06	1997	NEWMAN	WEST ANGELES
Pseudomys chapmani	WAMSPSPECIMENS	M18293 24233 12/12/1979	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	12	12	1979	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M47167 24233 00/03/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M52578 24233 09/05/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	09	05	1996	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M18251 24233 15/06/1979	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	15	06	1979	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M55086 24233 05/05/2004	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	05	05	2004	NEWMAN	WEST ANGELES
Pseudomys chapmani	WAMSPSPECIMENS	M47165 24233 00/03/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	TFAUNA	11792	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	12	05	2006	NEWMAN	Marilana PMN18
Pseudomys chapmani	WAMSPSPECIMENS	M52544 24233 13/05/1992	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	13	05	1992	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M52501 24233 13/05/1992	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	13	05	1992	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M50916 24233 13/06/1997	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	13	06	1997	NEWMAN	WEST ANGELES
Pseudomys chapmani	WAMSPSPECIMENS	M46335 24233 24/05/1995	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	24	05	1995	NEWMAN	
Pseudomys chapmani	TFAUNA	16479	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	15	12	1979	NEWMAN	West Angelas (Mt Meharry) - Iron Mine
Pseudomys chapmani	WAMSPSPECIMENS	M18345 24233 17/09/1979	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	17	09	1979	NEWMAN	
Pseudomys chapmani	TFAUNA	16481	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	22	11	2006	NEWMAN	The R-Deposit project area is north west of Newman at the Area C mine site
Pseudomys chapmani	WAMSPSPECIMENS	M47163 24233 00/03/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M50680 24233 05/03/1998	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	05	03	1998	NEWMAN	HAMERSLEY IRON S YANDI
Pseudomys chapmani	TFAUNA	16479	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	22	11	2006	NEWMAN	The R-Deposit project area is north west of Newman at the Area C mine site
Pseudomys chapmani	WAMSPSPECIMENS	M47164 24233 00/03/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	FAUNASURVEY	299509	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	07	04	2011	NEWMAN	Site x
Pseudomys chapmani	TFAUNA	16478	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	22	11	2006	NEWMAN	The R-Deposit project area is north west of Newman at the Area C mine site
Pseudomys chapmani	WAMSPSPECIMENS	M52542 24233 13/05/1992	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	13	05	1992	NEWMAN	
Pseudomys chapmani	TFAUNA	5281	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	10	02	1993	NEWMAN	The Governor, plots 1/3 & 1/4
Pseudomys chapmani	FAUNASURVEY	303084	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	13	09	2011	NEWMAN	KDC01P
Pseudomys chapmani	WAMSPSPECIMENS	M18077 24233 10/12/1980	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	10	12	1980	NEWMAN	YANDICOGGINA CREEK
Pseudomys chapmani	TFAUNA	5250	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	10	12	1980	NEWMAN	Yandicoggin, Marilana Stn
Pseudomys chapmani	WAMSPSPECIMENS	M52496 24233 16/09/1991	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	16	09	1991	NEWMAN	
Pseudomys chapmani	FAUNASURVEY	340824	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	22	08	2011	NEWMAN	Site x
Pseudomys chapmani	FAUNASURVEY	299501	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	17	03	2011	NEWMAN	Site x
Pseudomys chapmani	TFAUNA	11796	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	12	05	2006	NEWMAN	Marilana PMN18
Pseudomys chapmani	WAMSPSPECIMENS	M47154 24233 20/03/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	20	03	1996	NEWMAN	MINING LEASE
Pseudomys chapmani	FAUNASURVEY	299500	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	16	03	2011	NEWMAN	Site x
Pseudomys chapmani	FAUNASURVEY	299498	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	16	03	2011	NEWMAN	Site x
Pseudomys chapmani	WAMSPSPECIMENS	M18250 24233 15/06/1979	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	15	06	1979	NEWMAN	
Pseudomys chapmani	WAMSPSPECIMENS	M47172 24233 00/03/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	FAUNASURVEY	344492	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	03	11	2011	NEWMAN	SFJ07P
Pseudomys chapmani	WAMSPSPECIMENS	M47160 24233 00/03/1996	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	03	03	1996	NEWMAN	
Pseudomys chapmani	FAUNASURVEY	299506	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	19	03	2011	NEWMAN	Site x
Pseudomys chapmani	WAMSPSPECIMENS	M52498 24233 19/09/1991	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	19	09	1991	NEWMAN	
Pseudomys chapmani	TFAUNA	16483	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	22	11	2006	NEWMAN	The R-Deposit project area is north west of Newman at the Area C mine site
Pseudomys chapmani	TFAUNA	11800	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	11	05	2006	NEWMAN	Marilana PMN11
Pseudomys chapmani	WAMSPSPECIMENS	M55092 24233 07/05/2004	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	07	05	2004	NEWMAN	WEST ANGELES
Pseudomys chapmani	TFAUNA	11791	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	12	05	2006	NEWMAN	Marilana
Pseudomys chapmani	WAMSPSPECIMENS	M52543 24233 13/05/1992	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	13	05	1992	NEWMAN	
Pseudomys chapmani	TFAUNA	16482	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	22	11	2006	NEWMAN	The R-Deposit project area is north west of Newman at the Area C mine site
Pseudomys chapmani	FAUNASURVEY	344486	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	10	11	2011	NEWMAN	SFJ07P
Pseudomys chapmani	TFAUNA	5246	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	13	12	1979	NEWMAN	West Angelas (Mt Meharry) - Iron Mine
Pseudomys chapmani	WAMSPSPECIMENS	M55097 24233 07/05/2004	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	07	05	2004	NEWMAN	WEST ANGELES
Pseudomys chapmani	TFAUNA	16427	24233 Muridae	Pseudomys	chapmani	Kitchener	Western Pebble-mound Mouse	Animalia	4	MAMMAL	17	03	2008	NEWMAN	Area C mine

Appendix IV: DEC Threatened Ecological Communities Search
Results



DEPARTMENT OF ENVIRONMENT AND CONSERVATION

THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES INFORMATION

CONDITIONS IN RESPECT OF SUPPLY OF INFORMATION

1. All requests for data are to be made in writing to the Director General, Department of Environment and Conservation Attention: Species and Communities Branch
2. The data supplied may not be supplied to other organisations, nor be used for any purpose other than for the project for which they have been provided, without the prior written consent of the data custodian (Val English), Species and Communities Branch.
3. Specific locality information for threatened and priority ecological communities (TECs/PECs) is regarded as confidential, and should be treated as such by receiving organisations. Specific locality information for TECs/PECs may not be used in public reports without the written permission of the Director General, Department of Environment and Conservation. Publicly available reports may only show generalised locations (ie buffer locations). The TEC database manager is to be contacted for guidance on the presentation of TEC/PEC information.
4. Note that the Department of Environment and Conservation respects the privacy of private landowners who may have threatened and priority ecological communities on their property. Locations of TECs/PECs identified in the data as being on private property should be treated in confidence, and contact with property owners made through the Department of Environment and Conservation.
5. Receiving organisations should note that while every effort has been made to prevent errors and omissions in the data provided, they may be present. The Department of Environment and Conservation accepts no responsibility for this.
6. Receiving organisations must also recognise that the Threatened Ecological Communities database is subject to continual updating and amendment, and such considerations should be taken into account by the user.
7. It should be noted that the supplied data do not necessarily represent a comprehensive listing of the threatened and priority ecological communities of the area in question. Its comprehensiveness is dependant on the amount of survey carried out within the specified area. Private property has been relatively little surveyed. The receiving organisation should employ a consultant, if there is any likelihood of the presence of any threatened or priority ecological community, to undertake a survey of the area under consideration.
8. Acknowledgment of the Department of Environment and Conservation as source of the data is to be made in any published material. Copies of all such publications are to be forwarded to the Department of Environment and Conservation, Attention: Manager, Species and Communities Branch.

Threatened and Priority Ecological Community buffers in WA

UNDER NO CIRCUMSTANCES IS THIS DATA TO BE PROVIDED TO ANY THIRD PARTIES, for more details see conditions for the supply of this information.

Citation

Title: **Threatened and Priority Ecological Community buffers in WA**
Custodian: **Department of Environment & Conservation**

Description

Abstract: **Ecological communities throughout WA that are "Presumed Totally Destroyed", "Critically Endangered", "Endangered", "Vulnerable", "Priority 1-5", "Lower Risk" and "Not evaluated". Communities are based on various life-forms including plants, invertebrates and micro-organisms.**

Geographical Bounding Box

North: **-14.788854**
South: **-35.005719**
East: **128.870214**
West: **113.765525**

Data Currency and Status

Beginning Date: **1/1/94**
Ending Date: **current**
Maintenance/Update: **As requested**

Access

Stored Data **ESRI shapefile**
Format:
Coordinate **GCS_GDA_1994**
System:

Access Constraints: Digital data is only available with written permission of the custodian. In addition, some occurrence data eg. location of sites on private land, is password restricted.

Data Quality

Positional Accuracy: Point location data within occurrences usually from GPS fix, usually within 100 metres. Some digitized from hard copy.

Attribute Accuracy: Not documented.

Logical Consistency: Not documented.

Completeness: Information on specific communities was obtained from regional, subregional or specific habitat surveys of floristic communities, invertebrate communities, wetland assemblages and communities of micro-organisms.

Attributes List:

<u>Name</u>	<u>Description</u>
BDY_ID	Associated boundary polygon unique identifier
OCC_UNIQUE	Unique occurrence identifier
COM_ID	Shortened community name identifier
COM_NAME	Community name
CT_DESC	State listed Category of Threat
S_ID_COUNT	Number of Site IDs within a buffer
FIRST_S_ID	First site identifier
LAST_S_ID	Last site identifier
BUFFER	Buffer radius from site ID or boundary in metres

General Information:

Priority Ecological Communities

- There are 284 known PECs and subtypes , 271 (~95%) of these on the TEC/PEC database
- The location of priority communities is good, but not complete across the state
- There is a formal list of PECs at <http://www.dec.wa.gov.au/content/view/849/2017/>
- Many PECs are awaiting endorsement as TECs

buffers

- The buffer radius around each occurrence of a TEC or PEC is included to help ensure that developments with potential to impact groundwater or surface water are picked up.
- For wetland TEC or PECs we seek to include an area within the buffer zone that is intended to help protect groundwater and surface water. The area required to protect different types of wetlands from a variety of hydrological impacts will, of course, differ.

- For upland TEC or PECs that are believed not to be groundwater dependent, the buffer area radius encompasses the TEC or PEC site location recorded in the TEC database, and extends at least to the furthest point in the occurrence. This is to ensure that the 'buffer' area encompasses at least the entire TEC or PEC. This means that some linear occurrences may need a larger buffer radius to encompass the entire occurrence.
- Occurrences with a buffer distance of 0 are no longer extant.

Contact Information

Contact Organisation: Department of Environment & Conservation
Contact Position: TEC Database Administrator - Species and Communities Branch
Mail Address: Locked Bag 104, Bentley Delivery Centre
Suburb/Locality: Kensington
Country/State: WA
Postcode: 6983
Telephone: (08) 9334 0116
Fax: (08) 9334 0300
Email: communities.data@dec.wa.gov.au

Metadata Information

Metadata Date: current

Appendix V: SEWPaC Environmental Reporting Tool Search
Results



EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at <http://www.environment.gov.au/epbc/assessmentsapprovals/index.html>

Report created: 12/04/12 12:31:56

[Summary](#)

[Details](#)

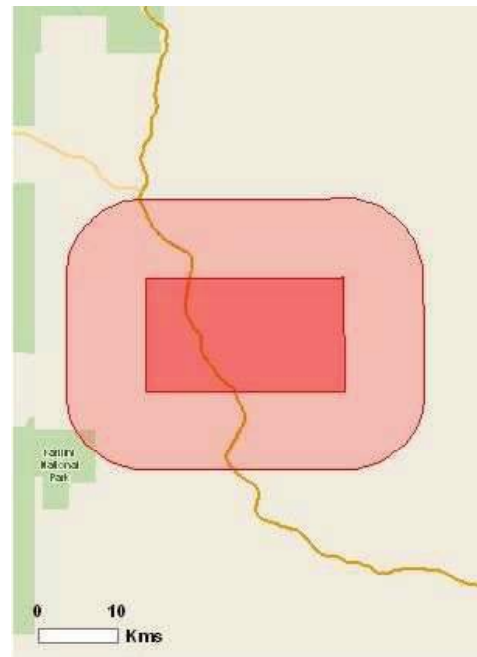
[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

[Acknowledgements](#)



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

[Coordinates](#)

Buffer: 10.0Km



Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see <http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html>

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communities:	None
Threatened Species:	6
Migratory Species:	8

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at <http://www.environment.gov.au/heritage/index.html>

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at <http://www.environment.gov>.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	5
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

Place on the RNE:	None
State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	4
Nationally Important Wetlands:	None

Details

Matters of National Environmental Significance

Threatened Species		[Resource Information]
Name	Status	Type of Presence
BIRDS		
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area

Name	Status	Type of Presence
MAMMALS		
Dasyurus hallucatus Northern Quoll [331]	Endangered	Species or species habitat likely to occur within area
Rhinonictoris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat likely to occur within area
PLANTS		
Lepidium catapycnon Hamersley Lepidium, Hamersley Catapycnon [9397]	Vulnerable	Species or species habitat likely to occur within area
Thryptomene wittweri Mountain Thryptomene [16645]	Vulnerable	Species or species habitat likely to occur within area
REPTILES		
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat may occur within area

Migratory Species [\[Resource Information \]](#)

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
------	------------	------------------

Migratory Marine Birds

Apus pacificus Fork-tailed Swift [678]		Species or species habitat may occur within area
---	--	--

Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
--	--	--

Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
--	--	--

Migratory Terrestrial Species

Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
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Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area
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Migratory Wetlands Species

Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
--	--	--

Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
--	--	--

Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
--	--	--

Other Matters Protected by the EPBC Act

Listed Marine Species [\[Resource Information \]](#)

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [\[Resource Information \]](#)

Name	State
Karijini	WA

Invasive Species [\[Resource Information \]](#)

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resources Audit,

Name	Status	Type of Presence
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Mammals

Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus		
Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area

Plants

Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area

Coordinates

-22.76596 118.93221,-22.89802 118.93459,-22.89802 118.70497,-22.76715 118.70497,
-22.76715 118.92983,-22.76596 118.92983,-22.76596 118.93221

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [Department of Environment, Climate Change and Water, New South Wales](#)
- [Department of Sustainability and Environment, Victoria](#)
- [Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [Department of Environment and Natural Resources, South Australia](#)
- [Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts](#)
- [Environmental and Resource Management, Queensland](#)
- [Department of Environment and Conservation, Western Australia](#)
- [Department of the Environment, Climate Change, Energy and Water](#)
- [Birds Australia](#)
- [Australian Bird and Bat Banding Scheme](#)
- [Australian National Wildlife Collection](#)
- Natural history museums of Australia
- [Museum Victoria](#)
- [Australian Museum](#)
- [SA Museum](#)
- [Queensland Museum](#)
- [Online Zoological Collections of Australian Museums](#)
- [Queensland Herbarium](#)
- [National Herbarium of NSW](#)
- [Royal Botanic Gardens and National Herbarium of Victoria](#)
- [Tasmanian Herbarium](#)
- [State Herbarium of South Australia](#)
- [Northern Territory Herbarium](#)
- [Western Australian Herbarium](#)
- [Australian National Herbarium, Atherton and Canberra](#)

- [University of New England](#)
- [Ocean Biogeographic Information System](#)
- [Australian Government, Department of Defence](#)
- [State Forests of NSW](#)
- Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

[Please feel free to provide feedback via the Contact Us page.](#)

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Appendix VI: NatureMap Search Results

Lamb Creek Fauna

Created By Guest user on 30/04/2012

Kingdom Animalia
Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 118°18' 52" E, 22°26' 29" S
Buffer 40km
Group By Species Group

Species Group	Species	Records
Amphibian	5	173
Bird	156	2881
Mammal	25	279
Reptile	91	917
TOTAL	277	4250

	Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
Amphibian					
1.	25375	<i>Cyclorana maini</i> (Sheep Frog)			
2.	25392	<i>Litoria rubella</i> (Little Red Tree Frog)			
3.	25422	<i>Neobatrachus aquilonius</i> (Northern Burrowing Frog)			
4.	25432	<i>Pseudophryne douglasi</i> (Gorge Toadlet)			
5.	25445	<i>Uperoleia russelli</i> (Northwest Toadlet)			
Bird					
6.	24559	<i>Acanthagenys rufogularis</i> (Spiny-cheeked Honeyeater)			
7.	24260	<i>Acanthiza apicalis</i> (Broad-tailed Thornbill)			
8.	24261	<i>Acanthiza chrysorrhoa</i> (Yellow-rumped Thornbill)			
9.	24264	<i>Acanthiza robustirostris</i> (Slaty-backed Thornbill)			
10.	24265	<i>Acanthiza uropygialis</i> (Chestnut-rumped Thornbill)			
11.	25535	<i>Accipiter cirrocephalus</i> (Collared Sparrowhawk)			
12.	25536	<i>Accipiter fasciatus</i> (Brown Goshawk)			
13.	25755	<i>Acrocephalus australis</i> (Australian Reed Warbler)			
14.	25544	<i>Aegotheles cristatus</i> (Australian Owllet-nightjar)			
15.	24301	<i>Aegotheles cristatus</i> subsp. <i>cristatus</i>			
16.	25647	<i>Amytomis striatus</i> (Striated Grasswren)			
17.	24539	<i>Amytomis striatus</i> subsp. <i>striatus</i>		P4	
18.	24540	<i>Amytomis striatus</i> subsp. <i>whitei</i>			
19.	24312	<i>Anas gracilis</i> (Grey Teal)			
20.	24316	<i>Anas superciliosa</i> (Pacific Black Duck)			
21.	24599	<i>Anthus australis</i> subsp. <i>australis</i>			
22.	24285	<i>Aquila audax</i> (Wedge-tailed Eagle)			
23.	24341	<i>Ardea pacifica</i> (White-necked Heron)			
24.	24610	<i>Ardeotis australis</i> (Australian Bustard)		P4	
25.	25566	<i>Artamus cinereus</i> (Black-faced Woodswallow)			
26.	24352	<i>Artamus cinereus</i> subsp. <i>melanops</i>			
27.	24355	<i>Artamus minor</i> (Little Woodswallow)			
28.	24356	<i>Artamus personatus</i> (Masked Woodswallow)			
29.	24318	<i>Aythya australis</i> (Hardhead)			
30.	24359	<i>Burhinus grallarius</i> (Bush Stone-curlew)		P4	
31.	25715	<i>Cacatua roseicapilla</i> (Galah)			
32.	24726	<i>Cacatua roseicapilla</i> subsp. <i>roseicapilla</i>			
33.	25716	<i>Cacatua sanguinea</i> (Little Corella)			
34.	25600	<i>Centropus phasianinus</i> (Pheasant Coucal)			
35.	24563	<i>Certhionyx niger</i> (Black Honeyeater)			
36.	24564	<i>Certhionyx variegatus</i> (Pied Honeyeater)			
37.	24377	<i>Charadrius ruficapillus</i> (Red-capped Plover)			
38.	24321	<i>Chenonetta jubata</i> (Australian Wood Duck)			
39.	24431	<i>Chrysococcyx basalis</i> (Horsfield's Bronze Cuckoo)			
40.	24434	<i>Chrysococcyx osculans</i> (Black-eared Cuckoo)			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
41.	24833 <i>Cincloramphus cruralis</i> (Brown Songlark)			
42.	24834 <i>Cincloramphus mathewsi</i> (Rufous Songlark)			
43.	24288 <i>Circus approximans</i> (Swamp Harrier)			
44.	24289 <i>Circus assimilis</i> (Spotted Harrier)			
45.	25582 <i>Climacteris melanura</i> (Black-tailed Treecreeper)			
46.	24395 <i>Climacteris melanura</i> subsp. <i>wellsi</i>			
47.	25675 <i>Colluricincla harmonica</i> (Grey Shrike-thrush)			
48.	24613 <i>Colluricincla harmonica</i> subsp. <i>rufiventris</i>			
49.	24361 <i>Coracina maxima</i> (Ground Cuckoo-shrike)			
50.	25568 <i>Coracina novaehollandiae</i> (Black-faced Cuckoo-shrike)			
51.	24363 <i>Coracina novaehollandiae</i> subsp. <i>subpallida</i>			
52.	24416 <i>Corvus bennetti</i> (Little Crow)			
53.	25593 <i>Corvus orru</i> (Torresian Crow)			
54.	24418 <i>Corvus orru</i> subsp. <i>ceciliae</i> (Western Crow)			
55.	24671 <i>Coturnix pectoralis</i> (Stubble Quail)			
56.	25701 <i>Coturnix ypsilophora</i> (Brown Quail)			
57.	24420 <i>Cracticus nigrogularis</i> (Pied Butcherbird)			
58.	25595 <i>Cracticus tibicen</i> (Australian Magpie)			
59.	25596 <i>Cracticus torquatus</i> (Grey Butcherbird)			
60.	24424 <i>Cracticus torquatus</i> subsp. <i>torquatus</i>			
61.	24435 <i>Cuculus pallidus</i> (Pallid Cuckoo)			
62.	24322 <i>Cygnus atratus</i> (Black Swan)			
63.	25547 <i>Dacelo leachii</i> (Blue-winged Kookaburra)			
64.	25673 <i>Daphoenositta chrysoptera</i> (Varied Sittella)			
65.	24606 <i>Daphoenositta chrysoptera</i> subsp. <i>pileata</i> (Varied Sittella)			
66.	24325 <i>Dendrocygna eytoni</i> (Plumed Whistling Duck)			
67.	25607 <i>Dicaeum hirundinaceum</i> (Mistletoebird)			
68.	24470 <i>Dromaius novaehollandiae</i> (Emu)			
69.	24631 <i>Emblema pictum</i> (Painted Finch)			
70.	25578 <i>Ephippiorhynchus asiaticus</i> (Black-necked Stork)			
71.	24570 <i>Epthianura tricolor</i> (Crimson Chat)			
72.	24837 <i>Eremiomis carteri</i> (Spinifex-bird)			
73.	24379 <i>Erythrogonys cinctus</i> (Red-kneed Dotterel)			
74.	24368 <i>Eurostopodus argus</i> (Spotted Nightjar)			
75.	25621 <i>Falco bengora</i> (Brown Falcon)			
76.	25622 <i>Falco cenchroides</i> (Australian Kestrel)			
77.	25623 <i>Falco longipennis</i> (Australian Hobby)			
78.	25624 <i>Falco peregrinus</i> (Peregrine Falcon)			S
79.	25727 <i>Fulica atra</i> (Eurasian Coot)			
80.	25730 <i>Gallirallus philippensis</i> (Buff-banded Rail)			
81.	24401 <i>Geopelia cuneata</i> (Diamond Dove)			
82.	25585 <i>Geopelia striata</i> (Peaceful Dove)			
83.	24403 <i>Geopelia striata</i> subsp. <i>placida</i>			
84.	24404 <i>Geophaps plumifera</i> (Spinifex Pigeon)			
85.	25530 <i>Gerygone fusca</i> (Western Gerygone)			
86.	24271 <i>Gerygone fusca</i> subsp. <i>fusca</i>			
87.	24443 <i>Grallina cyanoleuca</i> (Magpie-lark)			
88.	24293 <i>Haliaeetus leucogaster</i> (White-bellied Sea-Eagle)			
89.	24295 <i>Haliastur sphenurus</i> (Whistling Kite)			
90.	24297 <i>Hamirostra melanostemon</i> (Black-breasted Buzzard)			
91.	25734 <i>Himantopus himantopus</i> (Black-winged Stilt)			
92.	24491 <i>Hirundo neoxena</i> (Welcome Swallow)			
93.	25562 <i>Ixobrychus flavicollis</i> (Black Bittern)			
94.	24572 <i>Lacustroica whitei</i> (Grey Honeyeater)			
95.	24367 <i>Lalage tricolor</i> (White-winged Triller)			
96.	24575 <i>Lichenostomus keartlandi</i> (Grey-headed Honeyeater)			
97.	24578 <i>Lichenostomus penicillatus</i> (White-plumed Honeyeater)			
98.	24581 <i>Lichenostomus virescens</i> (Singing Honeyeater)			
99.	25661 <i>Lichmera indistincta</i> (Brown Honeyeater)			
100.	24582 <i>Lichmera indistincta</i> subsp. <i>indistincta</i>			
101.	24326 <i>Malacorhynchus membranaceus</i> (Pink-eared Duck)			
102.	25651 <i>Malurus lamberti</i> (Variegated Fairy-wren)			
103.	24544 <i>Malurus lamberti</i> subsp. <i>assimilis</i>			
104.	25652 <i>Malurus leucopterus</i> (White-winged Fairy-wren)			
105.	24548 <i>Malurus leucopterus</i> subsp. <i>leucopterus</i>			T
106.	25654 <i>Malurus splendens</i> (Splendid Fairy-wren)			
107.	24583 <i>Manorina flavigula</i> (Yellow-throated Miner)			
108.	25665 <i>Melithreptus gularis</i> (Black-chinned Honeyeater)			
109.	24736 <i>Melopsittacus undulatus</i> (Budgerigar)			
110.	24598 <i>Merops ornatus</i> (Rainbow Bee-eater)			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
111.	24654 <i>Microeca fascinans subsp. assimilis</i>			
112.	25542 <i>Milvus migrans (Black Kite)</i>			
113.	25545 <i>Mirafra javanica (Horsfield's Bushlark)</i>			
114.	24737 <i>Neophema bourkii (Bourke's Parrot)</i>			
115.	24819 <i>Ninox connivens subsp. connivens (Barking Owl)</i>			
116.	25748 <i>Ninox novaeseelandiae (Boobook Owl)</i>			
117.	25564 <i>Nycticorax caledonicus (Rufous Night Heron)</i>			
118.	24742 <i>Nymphicus hollandicus (Cockatiel)</i>			
119.	24407 <i>Ocyphaps lophotes (Crested Pigeon)</i>			
120.	25680 <i>Pachycephala rufiventris (Rufous Whistler)</i>			
121.	24624 <i>Pachycephala rufiventris subsp. rufiventris</i>			
122.	24627 <i>Pardalotus rubricatus (Red-browed Pardalote)</i>			
123.	25682 <i>Pardalotus striatus (Striated Pardalote)</i>			
124.	24628 <i>Pardalotus striatus subsp. munchisoni</i>			
125.	24648 <i>Pelecanus conspicillatus (Australian Pelican)</i>			
126.	24658 <i>Petroica cucullata (Hooded Robin)</i>			
127.	24659 <i>Petroica goodenovii (Red-capped Robin)</i>			
128.	24667 <i>Phalacrocorax sulcirostris (Little Black Cormorant)</i>			
129.	25699 <i>Phalacrocorax varius (Pied Cormorant)</i>			
130.	24409 <i>Phaps chalcoptera (Common Bronzewing)</i>			
131.	24593 <i>Phylidonyris albifrons (White-fronted Honeyeater)</i>			
132.	24841 <i>Platalea flavipes (Yellow-billed Spoonbill)</i>			
133.	24842 <i>Platalea regia (Royal Spoonbill)</i>			
134.	24751 <i>Platycercus zonarius subsp. zonarius</i>			
135.	24843 <i>Plegadis falcinellus (Glossy Ibis)</i>			
136.	25703 <i>Podargus strigoides (Tawny Frogmouth)</i>			
137.	24683 <i>Pomatostomus superciliosus (White-browed Babbler)</i>			
138.	25706 <i>Pomatostomus temporalis (Grey-crowned Babbler)</i>			
139.	24684 <i>Pomatostomus temporalis subsp. rubeculus</i>			
140.	24771 <i>Porzana tabuensis (Spotless Crane)</i>			
141.	24390 <i>Psophodes occidentalis (Western Wedgebill)</i>			
142.	24757 <i>Ptilonorhynchus maculatus subsp. guttatus (Western Bowerbird)</i>			
143.	24278 <i>Pyrrholaemus brunneus (Redthroat)</i>			
144.	24451 <i>Rhipidura fuliginosa subsp. alisteri</i>			
145.	25614 <i>Rhipidura leucophrys (Willie Wagtail)</i>			
146.	24454 <i>Rhipidura leucophrys subsp. leucophrys</i>			
147.	30948 <i>Smicromis brevirostris (Weebill)</i>			
148.	24522 <i>Sterna bergii (Crested Tern)</i>			
149.	24529 <i>Sterna leucoptera (White-winged Black Tern)</i>			
150.	24329 <i>Stictonetta naevosa (Freckled Duck)</i>			
151.	25656 <i>Stipiturus ruficeps (Rufous-crowned Emu-wren)</i>			
152.	25705 <i>Tachybaptus novaehollandiae (Australasian Grebe)</i>			
153.	24331 <i>Tadorna tadornoides (Australian Shelduck)</i>			
154.	30870 <i>Taeniopygia guttata (Zebra Finch)</i>			
155.	30871 <i>Taeniopygia guttata subsp. castanotis</i>			
156.	24844 <i>Threskiornis molucca (Australian White Ibis)</i>			
157.	24845 <i>Threskiornis spinicollis (Straw-necked Ibis)</i>			
158.	24308 <i>Todiramphus pyrrhopygia (Red-backed Kingfisher)</i>			
159.	25549 <i>Todiramphus sanctus (Sacred Kingfisher)</i>			
160.	24851 <i>Tumix velox (Little Button-quail)</i>			
161.	25577 <i>Vanellus miles (Masked Lapwing)</i>			

Mammal

162.	25454 <i>Canis lupus</i>			
163.	24181 <i>Chaerephon jobensis (Northern Freetail-bat)</i>			
164.	24186 <i>Chalinolobus gouldii (Gould's Wattled Bat)</i>			
165.	24091 <i>Dasykaluta rosamondae (Little Red Kaluta)</i>			
166.	24093 <i>Dasyurus hallucatus (Northern Quoll)</i>			T
167.	24135 <i>Macropus robustus subsp. erubescens (Euro)</i>			
168.	24136 <i>Macropus rufus (Red Kangaroo)</i>			
169.	24182 <i>Mormopterus beccarii (Beccari's Freetail-bat)</i>			
170.	24223 <i>Mus musculus (House Mouse)</i>			
171.	24095 <i>Ningau timealeyi (Pilbara Ningau)</i>			
172.	24194 <i>Nyctophilus geoffroyi (Lesser Long-eared Bat)</i>			
173.	24144 <i>Petrogale rothschildi (Rothschild's Rock-wallaby)</i>			
174.	24101 <i>Planigale ingrami (Long-tailed Planigale)</i>			
175.	24233 <i>Pseudomys chapmani (Western Pebble-mound Mouse)</i>			P4
176.	24237 <i>Pseudomys hermannsburgensis (Sandy Inland Mouse)</i>			
177.	24173 <i>Pteropus scapulatus (Little Red Flying-fox)</i>			
178.	24174 <i>Saccolaimus flaviventris (Yellow-bellied Sheathtail-bat)</i>			
179.	24200 <i>Scotorepens greyii (Little Broad-nosed Bat)</i>			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
180.	24116 <i>Sminthopsis macroura</i> (Stripe-faced Dunnart)			
181.	24117 <i>Sminthopsis ooldea</i> (Ooldea Dunnart)			
182.	24175 <i>Taphozous georgianus</i> (Common Sheathtail-bat)			
183.	24176 <i>Taphozous hillii</i> (Hill's Sheathtail-bat)			
184.	24157 <i>Trichosurus vulpecula</i> subsp. <i>arnhemensis</i> (Northern Brushtail Possum)			
185.	24205 <i>Vespadelus finlaysoni</i> (Finlayson's Cave Bat)			
186.	24248 <i>Zyomys argurus</i> (Common Rock-rat)			
Reptile				
187.	25332 <i>Acanthopis wellsi</i> (Pilbara Death Adder)			
188.	30833 <i>Amphibolurus longirostris</i>			
189.	25318 <i>Antaresia perthensis</i> (Pygmy Python)			
190.	25241 <i>Antaresia stimsoni</i> subsp. <i>stimsoni</i>			
191.	25331 <i>Brachyuropis approximans</i>			
192.	25015 <i>Carlia munda</i>			
193.	25017 <i>Carlia triacantha</i>			
194.	24919 <i>Crenadactylus ocellatus</i> subsp. <i>homi</i>			
195.	30893 <i>Cryptoblepharus buechananii</i>			
196.	30892 <i>Cryptoblepharus ustulatus</i>			
197.	24865 <i>Ctenophorus caudicinctus</i> subsp. <i>caudicinctus</i>			
198.	24876 <i>Ctenophorus isolepis</i> subsp. <i>isolepis</i>			
199.	24882 <i>Ctenophorus nuchalis</i> (Central Netted Dragon)			
200.	24886 <i>Ctenophorus reticulatus</i> (Western Netted Dragon)			
201.	25036 <i>Ctenotus duricola</i>			
202.	25041 <i>Ctenotus grandis</i> subsp. <i>grandis</i>			
203.	25043 <i>Ctenotus grandis</i> subsp. <i>titan</i>			
204.	25044 <i>Ctenotus hanloni</i>			
205.	25045 <i>Ctenotus helenae</i>			
206.	25060 <i>Ctenotus pantherinus</i> subsp. <i>acripes</i>			
207.	25064 <i>Ctenotus pantherinus</i> subsp. <i>ocellifer</i>			
208.	25065 <i>Ctenotus pantherinus</i> subsp. <i>pantherinus</i>			
209.	25072 <i>Ctenotus rubicundus</i>			
210.	25071 <i>Ctenotus rutilans</i>			
211.	25073 <i>Ctenotus saxatilis</i> (Rock Ctenotus)			
212.	25074 <i>Ctenotus schomburgkii</i>			
213.	25089 <i>Cyclodomorphus melanops</i> subsp. <i>elongatus</i>			
214.	25090 <i>Cyclodomorphus melanops</i> subsp. <i>melanops</i>			
215.	24997 <i>Delma butleri</i>			
216.	24998 <i>Delma elegans</i>			
217.	25000 <i>Delma haroldi</i>			
218.	25001 <i>Delma nasuta</i>			
219.	25002 <i>Delma pax</i>			
220.	25004 <i>Delma tincta</i>			
221.	25295 <i>Demansia psammophis</i> subsp. <i>cupreiceps</i>			
222.	25297 <i>Demansia rufescens</i> (Rufous Whipsnake)			
223.	24926 <i>Diplodactylus conspicillatus</i> (Fat-tailed Gecko)			
224.	24940 <i>Diplodactylus pulcher</i>			
225.	24944 <i>Diplodactylus savagei</i>			
226.	24899 <i>Diporiphora valens</i>			
227.	25092 <i>Egernia depressa</i> (Pygmy Spiny-tailed Skink)			
228.	25094 <i>Egernia formosa</i>			
229.	25109 <i>Eremiascincus richardsonii</i> (Broad-banded Sand Swimmer)			
230.	25301 <i>Furina omata</i> (Moon Snake)			
231.	24956 <i>Gehyra pilbara</i>			
232.	24958 <i>Gehyra punctata</i>			
233.	24959 <i>Gehyra variegata</i>			
234.	24961 <i>Heteronotia binoei</i> (Bynoe's Gecko)			
235.	24962 <i>Heteronotia spelea</i> (Desert Cave Gecko)			
236.	25135 <i>Leista flammicauda</i>			
237.	30929 <i>Leista jacksoni</i>			
238.	25155 <i>Leista muelleri</i>			
239.	25183 <i>Leista zietzi</i>			
240.	25005 <i>Lialis burtonis</i>			
241.	25238 <i>Liasis olivaceus</i> subsp. <i>barroni</i>		T	
242.	30933 <i>Lucasium stenodactylum</i>			
243.	30934 <i>Lucasium wombeyi</i>			
244.	25184 <i>Menetia greyii</i>			
245.	25187 <i>Menetia surda</i> subsp. <i>surda</i>			
246.	25193 <i>Morethia ruficauda</i> subsp. <i>exquisita</i>			
247.	24972 <i>Nephurus wheeleri</i> subsp. <i>cinctus</i>			
248.	24976 <i>Oedura marmorata</i> (Marbled Velvet Gecko)			

Name ID	Species Name	Naturalised	Conservation Code	¹ Endemic To Query Area
249.	25254 <i>Parasuta monachus</i>			
250.	24907 <i>Pogona minor subsp. minor</i>			
251.	25199 <i>Proablepharus reginae</i>			
252.	25261 <i>Pseudechis australis (Mulga Snake)</i>			
253.	25263 <i>Pseudonaja modesta (Ringed Brown Snake)</i>			
254.	25264 <i>Pseudonaja nuchalis (Gwardar)</i>			
255.	25009 <i>Pygopus nigriceps</i>			
256.	25270 <i>Ramphotyphlops ammodytes</i>			
257.	25277 <i>Ramphotyphlops grypus</i>			
258.	25279 <i>Ramphotyphlops hamatus</i>			
259.	25288 <i>Ramphotyphlops waitii</i>			
260.	24982 <i>Rhynchoedura omata (Beaked Gecko)</i>			
261.	24927 <i>Strophurus elderi</i>			
262.	24932 <i>Strophurus jeanae</i>			
263.	24949 <i>Strophurus wellingtonae</i>			
264.	25269 <i>Suta fasciata (Rosen's Snake)</i>			
265.	25202 <i>Tiliqua multifasciata (Central Blue-tongue)</i>			
266.	25209 <i>Varanus acanthurus (Spiny-tailed Monitor)</i>			
267.	25210 <i>Varanus brevicauda (Short-tailed Pygmy Monitor)</i>			
268.	30825 <i>Varanus bushi (Pilbara Mulga Monitor)</i>			
269.	25211 <i>Varanus caudolineatus</i>			
270.	25212 <i>Varanus eremius (Pygmy Desert Monitor)</i>			
271.	25215 <i>Varanus gilleni (Pygmy Mulga Monitor)</i>			
272.	25218 <i>Varanus gouldii (Bungarra or Sand Monitor)</i>			
273.	25222 <i>Varanus panoptes subsp. panoptes</i>			
274.	25223 <i>Varanus panoptes subsp. rubidus</i>			
275.	25224 <i>Varanus pilbarensis (Pilbara Rock Monitor)</i>			
276.	25227 <i>Varanus tristis subsp. tristis (Racehorse Monitor)</i>			
277.	25311 <i>Vermicella snelli</i>			

Conservation Codes

- T - Rare or likely to become extinct
- X - Presumed extinct
- IA - Protected under international agreement
- S - Other specially protected fauna
- 1 - Priority 1
- 2 - Priority 2
- 3 - Priority 3
- 4 - Priority 4
- 5 - Priority 5

¹ For NatureMap's purposes, species flagged as endemic are those whose records are wholly contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

Appendix VII: Birdlife Australia Birdata Search Results

**Bird list for one degree square containing the point
118.83503, -22.82911**

Common Name	Scientific Name
Emu	<i>Dromaius novaehollandiae</i>
Stubble Quail	<i>Coturnix pectoralis</i>
Brown Quail	<i>Coturnix ypsilophora</i>
Plumed Whistling-Duck	<i>Dendrocygna eytoni</i>
Freckled Duck	<i>Stictonetta naevosa</i>
Black Swan	<i>Cygnus atratus</i>
Australian Wood Duck	<i>Chenonetta jubata</i>
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>
Grey Teal	<i>Anas gracilis</i>
Pacific Black Duck	<i>Anas superciliosa</i>
Hardhead	<i>Aythya australis</i>
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>
Common Bronzewing	<i>Phaps chalcoptera</i>
Crested Pigeon	<i>Ocyphaps lophotes</i>
Spinifex Pigeon	<i>Geophaps plumifera</i>
Diamond Dove	<i>Geopelia cuneata</i>
Peaceful Dove	<i>Geopelia striata</i>
Tawny Frogmouth	<i>Podargus strigoides</i>
Spotted Nightjar	<i>Eurostopodus argus</i>
Australian Owlet-nightjar	<i>Aegotheles cristatus</i>
Australasian Darter	<i>Anhinga novaehollandiae</i>
Little Pied Cormorant	<i>Microcarbo melanoleucos</i>
Great Cormorant	<i>Phalacrocorax carbo</i>
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>
Pied Cormorant	<i>Phalacrocorax varius</i>
Australian Pelican	<i>Pelecanus conspicillatus</i>
Black-necked Stork	<i>Ephippiorhynchus asiaticus</i>
Black Bittern	<i>Ixobrychus flavicollis</i>
White-necked Heron	<i>Ardea pacifica</i>
Eastern Great Egret	<i>Ardea modesta</i>
White-faced Heron	<i>Egretta novaehollandiae</i>
Little Egret	<i>Egretta garzetta</i>
Nankeen Night-Heron	<i>Nycticorax caledonicus</i>
Glossy Ibis	<i>Plegadis falcinellus</i>
Australian White Ibis	<i>Threskiornis molucca</i>
Straw-necked Ibis	<i>Threskiornis spinicollis</i>
Royal Spoonbill	<i>Platalea regia</i>
Yellow-billed Spoonbill	<i>Platalea flavipes</i>
Black-shouldered Kite	<i>Elanus axillaris</i>
Letter-winged Kite	<i>Elanus scriptus</i>
Square-tailed Kite	<i>Lophoictinia isura</i>
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>
Whistling Kite	<i>Haliastur sphenurus</i>
Black Kite	<i>Milvus migrans</i>

Brown Goshawk	<i>Accipiter fasciatus</i>
Collared Sparrowhawk	<i>Accipiter cirrocephalus</i>
Spotted Harrier	<i>Circus assimilis</i>
Swamp Harrier	<i>Circus approximans</i>
Wedge-tailed Eagle	<i>Aquila audax</i>
Little Eagle	<i>Hieraaetus morphnoides</i>
Nankeen Kestrel	<i>Falco cenchroides</i>
Brown Falcon	<i>Falco berigora</i>
Australian Hobby	<i>Falco longipennis</i>
Peregrine Falcon	<i>Falco peregrinus</i>
Buff-banded Rail	<i>Gallirallus philippensis</i>
Spotless Crane	<i>Porzana tabuensis</i>
Eurasian Coot	<i>Fulica atra</i>
Australian Bustard	<i>Ardeotis australis</i>
Bush Stone-curlew	<i>Burhinus grallarius</i>
Black-winged Stilt	<i>Himantopus himantopus</i>
Black-fronted Dotterel	<i>Eiseyornis melanops</i>
Red-kneed Dotterel	<i>Erythrogonys cinctus</i>
Little Button-quail	<i>Turnix velox</i>
Gull-billed Tern	<i>Gelocheidon nilotica</i>
Galah	<i>Eolophus roseicapillus</i>
Little Corella	<i>Cacatua sanguinea</i>
Cockatiel	<i>Nymphicus hollandicus</i>
Australian Ringneck	<i>Barnardius zonarius</i>
Budgerigar	<i>Melopsittacus undulatus</i>
Bourke's Parrot	<i>Neopsephotus bourkii</i>
Pheasant Coucal	<i>Centropus phasianinus</i>
Horsfield's Bronze-Cuckoo	<i>Chalcites basalis</i>
Pallid Cuckoo	<i>Cacomantis pallidus</i>
Southern Boobook	<i>Ninox novaeseelandiae</i>
Eastern Barn Owl	<i>Tyto javanica</i>
Blue-winged Kookaburra	<i>Dacelo leachii</i>
Red-backed Kingfisher	<i>Todiramphus pyrrhopygius</i>
Sacred Kingfisher	<i>Todiramphus sanctus</i>
Rainbow Bee-eater	<i>Merops ornatus</i>
Black-tailed Treecreeper	<i>Climacteris melanura</i>
Spotted Bowerbird	<i>Ptilonorhynchus maculatus</i>
Western Bowerbird	<i>Ptilonorhynchus guttatus</i>
Splendid Fairy-wren	<i>Malurus splendens</i>
White-winged Fairy-wren	<i>Malurus leucopterus</i>
Variegated Fairy-wren	<i>Malurus lamberti</i>
Rufous-crowned Emu-wren	<i>Stipiturus ruficeps</i>
Striated Grasswren	<i>Amytornis striatus</i>
Redthroat	<i>Pyrrholaemus brunneus</i>
Weebill	<i>Smicrornis brevirostris</i>
Western Gerygone	<i>Gerygone fusca</i>
Slaty-backed Thornbill	<i>Acanthiza robustirostris</i>
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>
Inland Thornbill	<i>Acanthiza apicalis</i>

Red-browed Pardalote	<i>Pardalotus rubricatus</i>
Striated Pardalote	<i>Pardalotus striatus</i>
Pied Honeyeater	<i>Certhionyx variegatus</i>
Singing Honeyeater	<i>Lichenostomus virescens</i>
Grey-headed Honeyeater	<i>Lichenostomus keartlandi</i>
Grey-fronted Honeyeater	<i>Lichenostomus plumulus</i>
White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>
Yellow-throated Miner	<i>Manorina flavigula</i>
Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>
Grey Honeyeater	<i>Conopophila whitei</i>
Crimson Chat	<i>Epthianura tricolor</i>
Black Honeyeater	<i>Sugomel niger</i>
Brown Honeyeater	<i>Lichmera indistincta</i>
Black-chinned Honeyeater	<i>Melithreptus gularis</i>
Grey-crowned Babbler	<i>Pomatostomus temporalis</i>
White-browed Babbler	<i>Pomatostomus superciliosus</i>
Chiming Wedgebill	<i>Psophodes occidentalis</i>
Varied Sittella	<i>Daphoenositta chrysoptera</i>
Ground Cuckoo-shrike	<i>Coracina maxima</i>
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>
White-winged Triller	<i>Lalage sueurii</i>
Rufous Whistler	<i>Pachycephala rufiventris</i>
Grey Shrike-thrush	<i>Colluricincla harmonica</i>
Crested Bellbird	<i>Oreoica gutturalis</i>
Masked Woodswallow	<i>Artamus personatus</i>
Black-faced Woodswallow	<i>Artamus cinereus</i>
Little Woodswallow	<i>Artamus minor</i>
Grey Butcherbird	<i>Cracticus torquatus</i>
Pied Butcherbird	<i>Cracticus nigrogularis</i>
Australian Magpie	<i>Cracticus tibicen</i>
Grey Fantail	<i>Rhipidura albiscapa</i>
Willie Wagtail	<i>Rhipidura leucophrys</i>
Little Crow	<i>Corvus bennetti</i>
Torresian Crow	<i>Corvus orru</i>
Magpie-lark	<i>Grallina cyanoleuca</i>
Red-capped Robin	<i>Petroica goodenovii</i>
Hooded Robin	<i>Melanodryas cucullata</i>
Horsfield's Bushlark	<i>Mirafrja javanica</i>
Australian Reed-Warbler	<i>Acrocephalus australis</i>
Rufous Songlark	<i>Cincloramphus mathewsi</i>
Brown Songlark	<i>Cincloramphus cruralis</i>
Spinifexbird	<i>Eremiornis carteri</i>
Welcome Swallow	<i>Hirundo neoxena</i>
Fairy Martin	<i>Petrochelidon ariel</i>
Tree Martin	<i>Petrochelidon nigricans</i>
Mistletoebird	<i>Dicaeum hirundinaceum</i>
Zebra Finch	<i>Taeniopygia guttata</i>
Star Finch	<i>Neochmia ruficauda</i>
Painted Finch	<i>Emblema pictum</i>
Australasian Pipit	<i>Anthus novaeseelandiae</i>

Crow & Raven species

Appendix VIII: Western Australian Museum Short Range Endemic
Search Results

PHYLUM	CLASS	ORDER	INFRAORDER	FAMILY	GENUS	SPECIES	AUTHORITY	COUNTRY	SITE	LATITUDE	LONGITUDE	LATDEC	LONGDEC
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas	'pilbara'		Australia	Hammersley Range	22°07'56.82"S	117°55'08.68"E	-22.1325	117.919
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas	'pilbara'		Australia	Area C, 83.6 km NW. of Newman	22°59'30"S	118°57'33"E	-22.9917	118.959
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas	'pilbara'		Australia	Area C, 74.1 km NW. of Newman	22°55'04"S	119°11'21"E	-22.9178	119.189
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas	'pilbara'		Australia	Area C, 85.8 km NW. of Newman	22°53'47"S	119°03'43"E	-22.8964	119.062
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas	'pilbara'		Australia	Area C, 85.8 km NW. of Newman	22°53'47"S	119°03'43"E	-22.8964	119.062
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas	'pilbara'		Australia	Area C, 90.6 km NW. of Newman	22°53'56"S	119°00'07"E	-22.8989	119.002
Arthropoda	Arachnida	Scorpiones		Buthidae	Lychas	'pilbara'		Australia	Area C, 89.5 km NW. of Newman	22°58'41"S	118°57'49"E	-22.9781	118.964
Arthropoda	Diplopoda	Polydesmida		Paradoxosomatidae	Antichiropus	'Area C'		Australia	Area C, ca. 120 km NNW. Newman, site 12-12N	22°55'00.5"S	118°54'37.7"E	-22.9168	118.911
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	API Hardey, 78.5 km WNW of Paraburdoo	22°51'10"S	116°59'52"E	-22.8528	116.998
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 83.1 km NW. of Newman	22°58'30"S	119°02'16"E	-22.975	119.038
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 82.7 km NW. of Newman	22°53'57"S	119°05'58"E	-22.8992	119.099
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 74.1 km NW. of Newman	22°55'04"S	119°11'21"E	-22.9178	119.189
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 89.6 km NW. of Newman	23°00'04"S	118°56'52"E	-23.0011	118.948
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 83.9 km NW. of Newman	22°59'35"S	119°00'57"E	-22.9931	119.016
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 87.2 km NW. of Newman	22°59'21"S	118°58'56"E	-22.9892	118.982
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 84.7 km NW. of Newman	22°54'21"S	119°01'44"E	-22.9058	119.029
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 74.1 km NW. of Newman	22°55'04"S	119°11'21"E	-22.9178	119.189
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 85.2 km NW. of Newman	23°00'13"S	118°59'39"E	-23.0036	118.994
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 89 km NW. of Newman	22°57'23"S	118°59'00"E	-22.9564	118.983
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 74.1 km NW. of Newman	22°55'04"S	119°11'21"E	-22.9178	119.189
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 93.1 km NW. of Newman	23°00'00"S	118°54'47"E	-23	118.913
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 82.7 km NW. of Newman	22°59'30"S	118°57'33"E	-22.9917	118.959
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 75.8 km NW. of Newman	22°54'21"S	119°10'48"E	-22.9058	119.18
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 75.8 km NW. of Newman	22°54'34"S	119°10'33"E	-22.9094	119.176
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 82.7 km NW. of Newman	22°57'49"S	119°02'50"E	-22.9636	119.047
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 74.1 km NW. of Newman	22°55'04"S	119°11'21"E	-22.9178	119.189
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Area C, 93.7 km NW. of Newman	22°59'55"S	118°54'27"E	-22.9986	118.908
Arthropoda	Arachnida	Scorpiones		Urodacidae	Urodacus	'firetail'		Australia	Hammersley Range	22°06'55.54"S	117°52'36.92"E	-22.1154	117.877
Arthropoda	Arachnida	Araneae	Araneomorphae	Hersiliidae	Tamopsis	gracilis	Baehr & Baehr, 1993	Australia	gorge SW. of Mt Robinson	23°08'S	118°54'E	-23.1333	118.9
Arthropoda	Arachnida	Araneae	Araneomorphae	Hersiliidae	Tamopsis	gracilis	Baehr & Baehr, 1993	Australia	Mt Elvire Station, site ME 8	29°26'55"S	119°34'56"E	-29.4486	119.582
Arthropoda	Arachnida	Araneae	Araneomorphae	Zodariidae	Spinasteron	waldockae	Baehr, 2003	Australia	Angelas [- West Angelas]	23°11'S	118°47'E	-23.1833	118.783
Arthropoda	Arachnida	Araneae	Araneomorphae	Zodariidae	Spinasteron	waldockae	Baehr, 2003	Australia	Roy Hill Station, Fortescue River, Ponderumba	22°37'19"S	119°57'27"E	-22.6219	119.957
Arthropoda	Arachnida	Araneae	Araneomorphae	Zodariidae	Spinasteron	waldockae	Baehr, 2003	Australia	Hope Downs Station	23°01'48"S	119°01'16"E	-23.03	119.021
Arthropoda	Arachnida	Araneae	Araneomorphae	Zodariidae	Spinasteron	waldockae	Baehr, 2003	Australia	gorge SW. of Mt Robinson	23°08'S	118°54'E	-23.1333	118.9
Arthropoda	Arachnida	Opiliones		Laniatores	Assamiidae	Dampetrus	'near isolatus'	Australia	Area C, ca. 80 km NW. of Newman	22°55'36"S	118°58'22"E	-22.9267	118.973
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena	'MYG044'		Australia	Hammersley Range, Weeli Wolli Creek region, Ar	22°55'33.0"S	119°02'16.4"E	-22.9258	119.038
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena	'MYG044'		Australia	Hammersley Range, Weeli Wolli Creek region, Ar	22°55'52.9"S	119°02'49.2"E	-22.9314	119.047
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena	'MYG044'		Australia	Hammersley Range, Weeli Wolli Creek region, Ar	22°55'52.9"S	119°02'50.0"E	-22.9314	119.047
Arthropoda	Arachnida	Araneae	Mygalomorphae	Actinopodidae	Missulena	'MYG044'		Australia	Hammersley Range, Weeli Wolli Creek region, Ar	22°55'53.8"S	119°02'50.4"E	-22.9316	119.047
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Aureocrypta	'chichester? (female)'		Australia	Koodaideri, 105.7 km NW. of Newman	22°34'34"S	119°08'23"E	-22.5761	119.114
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele	'MYG055'		Australia	Southern Flank, 72 km NW. of Newman	23°00'10"S	119°08'20"E	-23.0028	119.139
Arthropoda	Arachnida	Araneae	Mygalomorphae	Barychelidae	Synothele	'MYG055'		Australia	Southern Flank, 72 km NW. of Newman	23°00'10"S	119°08'22"E	-23.0028	119.139
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe	'MYG083'		Australia	Hammersley Range, Weeli Wolli Creek region, Ar	22°55'30.9"S	119°02'15.7"E	-22.9252	119.038
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe	'MYG083'		Australia	Hammersley Range, Weeli Wolli Creek region, Ar	22°55'30.9"S	119°02'15.7"E	-22.9252	119.038
Arthropoda	Arachnida	Araneae	Mygalomorphae	Idiopidae	Aganippe	'MYG083'		Australia	5.5 km NE. of Giles Point, Pilbara survey sit	23°12'48.8"S	119°12'08.5"E	-23.2136	119.202
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 92.1 km NW. of Newman	23°00'39"S	118°55'05"E	-23.0108	118.918
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 88.4 km NW. of Newman	22°53'56"S	119°01'50"E	-22.8989	119.031
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 103.4 km NW. of Newman	22°59'29"S	118°48'24"E	-22.9914	118.807
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 103.6 km NW. of Newman	22°59'04"S	118°48'28"E	-22.9844	118.808
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 103.6 km NW. of Newman	22°59'05"S	118°48'30"E	-22.9847	118.808
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Mt Webber	21°31'37.92"S	119°18'50.00"E	-21.5272	119.314
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 87.3 km NW. of Newman	23°00'40"S	118°58'15"E	-23.0111	118.971
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 87.3 km NW. of Newman	23°00'39"S	118°58'14"E	-23.0108	118.971
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 87.3 km NW. of Newman	23°00'38"S	118°58'15"E	-23.0106	118.971
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 96 km NW. of Newman	23°00'48"S	118°52'31"E	-23.0133	118.875
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG001 group female'		Australia	Area C, 92.1 km NW. of Newman	23°00'38"S	118°55'07"E	-23.0106	118.919
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG104'		Australia	Mariliana Station, site RNHW03	22°27'59.5"S	119°01'21.3"E	-22.4665	119.023
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG104'		Australia	Area C, 82.7 km NW. of Newman	22°57'49"S	119°02'50"E	-22.9636	119.047
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 86.2 km NW. of Newman	23°00'05"S	118°58'54"E	-23.0014	118.982
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 88.4 km NW. of Newman	22°53'56"S	119°01'50"E	-22.8989	119.031
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 87.3 km NW. of Newman	22°53'43"S	119°02'42"E	-22.8953	119.045
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 83.9 km NW. of Newman	22°59'35"S	119°00'57"E	-22.9931	119.016
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 89.6 km NW. of Newman	22°55'22"S	119°09'46"E	-22.9228	119.163
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 78.2 km NW. of Newman	22°55'04"S	119°08'02"E	-22.9178	119.134
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 78.2 km NW. of Newman	22°55'04"S	119°08'02"E	-22.9178	119.134
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 88.4 km NW. of Newman	22°53'56"S	119°01'50"E	-22.8989	119.031
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 89.4 km NW. of Newman	22°58'49"S	118°57'44"E	-22.9803	118.962
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 82.7 km NW. of Newman	22°53'57"S	119°05'58"E	-22.8992	119.099
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 91.3 km NW. of Newman	22°54'02"S	118°59'36"E	-22.9006	118.993
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 78.2 km NW. of Newman	22°55'04"S	119°08'02"E	-22.9178	119.134
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesiidae	Aname	'MYG195'		Australia	Area C, 93.1 km NW. of Newman	23°00'00"S	118°54'47"E	-23	118.913

Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 89.4 km NW. of Newman	22°58'49"S	118°57'44"E	-22.9803	118.962
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 86.2 km NW. of Newman	23°00'05"S	118°58'54"E	-23.0014	118.982
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 90.6 km NW. of Newman	22°59'52"S	119°01'47"E	-22.9978	119.03
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 82.7 km NW. of Newman	22°53'57"S	119°05'58"E	-22.8992	119.099
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 82.7 km NW. of Newman	22°53'57"S	119°05'58"E	-22.8992	119.099
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 83.9 km NW. of Newman	22°59'35"S	119°00'57"E	-22.9931	119.016
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 81.6 km NW. of Newman	22°54'25"S	119°07'27"E	-22.9069	119.124
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 89.6 km NW. of Newman	23°00'04"S	118°56'52"E	-23.0011	118.948
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 89.3 km NW. of Newman	22°54'23"S	119°00'45"E	-22.9064	119.012
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 82.7 km NW. of Newman	22°53'57"S	119°05'58"E	-22.8992	119.099
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 86.2 km NW. of Newman	23°00'05"S	118°58'54"E	-23.0014	118.982
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 86.2 km NW. of Newman	23°00'05"S	118°58'54"E	-23.0014	118.982
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 89.3 km NW. of Newman	22°54'23"S	119°00'45"E	-22.9064	119.012
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 82.7 km NW. of Newman	22°53'57"S	119°05'58"E	-22.8992	119.099
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 89.3 km NW. of Newman	22°54'23"S	119°00'45"E	-22.9064	119.012
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 82.7 km NW. of Newman	23°00'18"S	119°01'26"E	-23.005	119.024
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 82.7 km NW. of Newman	22°53'57"S	119°05'58"E	-22.8992	119.099
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 82.7 km NW. of Newman	22°53'57"S	119°05'58"E	-22.8992	119.099
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 84.7 km NW. of Newman	22°54'21"S	119°01'44"E	-22.9058	119.029
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 93.1 km NW. of Newman	23°00'00"S	118°54'47"E	-23	118.913
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 89.3 km NW. of Newman	22°54'23"S	119°00'45"E	-22.9064	119.012
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 84.7 km NW. of Newman	22°54'21"S	119°01'44"E	-22.9058	119.029
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 88.4 km NW. of Newman	22°53'56"S	119°01'50"E	-22.8989	119.031
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 88.4 km NW. of Newman	22°53'56"S	119°01'50"E	-22.8989	119.031
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Aname	'MYG195'		Australia	Area C, 93.1 km NW. of Newman	23°00'00"S	118°54'47"E	-23	118.913
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Chenistonia	'MYG088 female'		Australia	BHP Billiton Area C, ca. 95 km NW. of Newman	22°54'38.1"S	118°58'14.8"E	-22.9105	118.971
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Chenistonia	'MYG088'		Australia	BHP Billiton Area C, ca. 95 km NW. of Newman	22°54'38.0"S	118°58'00.2"E	-22.9105	118.967
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Teyl	'MYG027'		Australia	Hammersley Range, Weeli Wollie Creek region, Ar	22°55'30.9"S	119°02'15.7"E	-22.9252	119.038
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Yilgarnia	'MYG197'		Australia	Area C, 81.4 km NW. of Newman	22°57'29"S	119°04'09"E	-22.9581	119.069
Arthropoda	Arachnida	Araneae	Mygalomorphae	Nemesidae	Yilgarnia	'MYG197'		Australia	Area C, 83.9 km NW. of Newman	22°59'35"S	119°00'57"E	-22.9931	119.016
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus	'PSE014 long hand 2'		Australia	Area C, 87.3 km NW. of Newman	22°53'43"S	119°02'42"E	-22.8953	119.045
Arthropoda	Arachnida	Pseudoscorpiones	Panctenata	Garypidae	Synsphyronus	'PSE014 long hand 2'		Australia	Area C, 74.1 km NW. of Newman	22°55'04"S	119°11'21"E	-22.9178	119.189

Appendix IX: Regional Comparison of Species

Mammals										
Scientific Name	Common Name	Database Searches					Fauna Survey of the proposed Hope Downs 4 mining area. (Ninox Wildlife Consulting, 2009)	Yandicoogina Junction South West and Oxbow Fauna Survey. (Biota Environmental Sciences, 2010)	Fauna survey of proposed Iron Ore Mine, Cloud Break. (Bamford Consulting Ecologists, 2005)	Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas. (Biota Environmental Sciences, 2005)
		Lamb Creek Level 2 Fauna Survey	Conservation Significance	EPBC Search (10 km buffer)	DEC Search	Naturemap Records (40 km radius)				
Tachyglossidae										
<i>Tachyglossus aculeatus</i>	Echidna								▼	
Dasyuridae										
<i>Dasykaluta rosamondae</i>	Kaluta	▼				▼	▼		▼	
<i>Dasyurus hallucatus</i>	Northern Quoll		EPBC - E,	▼	▼	▼				
<i>Ningauai timealeyi</i>	Pilbara Ningauai	▼				▼	▼	▼	▼	
<i>Planigale aff. ingrami</i>		▼				▼			▼	
<i>Planigale aff. maculata</i>							▼			
<i>Pseudantechinus woolleyae</i>	Wolley's False Antechinus		IUCN- LC							
<i>Sminthopsis macroura</i>	Stripe- faced Dunnart	▼				▼			▼	
<i>Sminthopsis ooldea</i>	Ooldea Dunnart					▼	▼			
<i>Sminthopsis youngsoni</i>	Lesser Hairy-footed Dunnart									▼
Phalangeridae										
<i>Trichosurus vulpecula</i>	Northern Brush-tail Possum					▼				
Thylacomyidae (Bilbies)										
<i>Macrotis lagotis</i>	Bilby		EPBC - V DEC - S1	V					▼	
Macropodidae										
<i>Macropus robustus</i>	Euro					▼	▼		▼	▼
<i>Macropus rufus</i>	Red Kangaroo					▼	▼		▼	
<i>Petrogale rothschildi</i>	Rothschild's Rock-wallaby					▼				▼
Pteropodidae										
<i>Pteropus scapulatus</i>	Little Red Flying-fox					▼				
Megadermatidae										
<i>Macroderma gigas</i>	Ghost bat	▼	p4			▼				
Hipposideridae										
<i>Rhinonicteris aurantius</i>	Pilbara Leaf-nosed Bat		EPBC - V, DEC - S1	▼	▼					
Emballonuridae										
<i>Taphozous georgianus</i>		▼				▼	▼	▼	▼	
<i>Taphozous hilli</i>						▼				
<i>Saccolaimus flaviventris</i>	Yeollow-bellied Sheath-tail bat					▼	▼	▼	▼	
Vespertilionidae										
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat					▼	▼	▼	▼	
<i>Chalinolobus morio</i>	Chocolate Wattled Bat						▼			

Scientific Name	Common Name	Database Searches					Fauna Survey of the proposed Hope Downs 4 mining area. (Ninox Wildlife Consulting, 2009)	Yandicoogina Junction South West and Oxbow Fauna Survey. (Biota Environmental Sciences, 2010)	Fauna survey of proposed Iron Ore Mine, Cloud Break. (Bamford Consulting Ecologists, 2005)	Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas. (Biota Environmental Sciences, 2005)
		Lamb Creek Level 2 Fauna Survey	Conservation Significance	EPBC Search (10 km buffer)	DEC Search	Naturemap Records (40 km radius)				
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat					▼		▼		
<i>Scotorepens greyii</i>	Western Broad Nosed Bat					▼	▼	▼		
<i>Vespadelus finlaysoni</i>	Inland Cave Bat	▼				▼	▼	▼		
Molossidae										
<i>Chaerephon jobensis</i>	Northern Freetail Bat					▼	▼	▼		
<i>Mormopterus beccarii</i>	Beccari's Freetail Bat					▼				
<i>Tadarida australis</i>	White-Striped Freetail Bat						▼	▼		
Muridae										
<i>Leggadina lakedownensis</i>	Tropical Short-tailed Mouse		P4		▼					
<i>Mus musculus</i>	House Mouse	▼				▼		▼	▼	
<i>Pseudomys chapmani</i>	Pebble Mound Mouse	▼	P4		▼	▼	▼	▼	▼	
<i>Pseudomys desertor</i>	Desert Mouse	▼						▼	▼	
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse	▼				▼	▼		▼	
<i>Zyzomys argurus</i>	Common Rock Rat	▼				▼	▼	▼		
Leporidae										
<i>Oryctolagus cuniculus</i>	Rabbit			▼						
Canidae										
<i>Canis lupus dingo</i>	Dingo					▼	▼	▼	▼	
<i>Vulpes vulpes</i>	Fox			▼						
Felidae										
<i>Felis catus</i>	Feral Cat			▼				▼	▼	
Equidae										
<i>Equus asinus</i>							▼	▼		
<i>Equus caballus</i>								▼		
Camelidae										
<i>Camelus dromedarius</i>	Camel							▼		
Bovidae										
<i>Bos taurus</i>	Cow	▼					▼			
Taxonomy follows Western Australian Museum Mammals Checklist, Last modified: 12 August 2008 except where indicated otherwise.										
■ Recorded on Threatened and Priority Fauna Database Search for the area (DEC) as schedule 1 or 4										
■ Recorded on Protected Matters Database Search for the area - EPBC Act 1999 (DEH) as endangered (e), vulnerable (v) or migratory (m)										
■ Priority listed by DEC										
IUCN (2009) - VU = Vulnerable, EN = Endangered, NT - Near Threatened, LC = Least Concern, DD = Data Deficient										

Reptiles and Amphibians

Scientific Name	family	Common Name	Lamb Creek Level 2 Fauna Survey	Conservation Significance	DEC Search	EPBC Search	Naturemap Records	Fauna Survey of the proposed Hope Downs 4 mining area. (Ninox Wildlife Consulting, 2009)	Yandicoogina Junction South West and Oxbow Fauna Survey. (Biota Environmental Sciences, 2010)	Fauna survey of proposed Iron Ore Mine, Cloud Break. (Bamford Consulting Ecologists, 2005)	Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas. (Biota Environmental Sciences, 2005)
Amphibians											
<i>Cyclorana mainii</i>	Hylidae	Sheep Frog	▼				▼				▼
<i>Cyclorana platycephala</i>	Hylidae										
<i>Litoria rubella</i>	Hylidae		▼				▼			▼	
<i>Neobatrachus aquilonius</i>	Myobatrachidae	Northern Burrowing Frog					▼				
<i>Pseudophryne douglasi</i>	Myobatrachidae						▼				
<i>Uperoleia russeii</i>	Myobatrachidae						▼				
Reptiles											
Chelidae (Turtles)											
<i>Chelodina steindachneri</i>	Chelidae	Flat-shelled Turtle								▼	
Agamidae (dragons)											
<i>Amphibolurus longirostris</i>	Agamidae	Long nosed Dragon	▼				▼	▼	▼	▼	
<i>Caimanops amphiboluroides</i>	Agamidae	Mulga Dragon	▼					▼			
<i>Ctenophorus caudicinctus</i>	Agamidae	Ring-tailed Dragon	▼				▼	▼	▼	▼	▼
<i>Ctenophorus isolepis</i>	Agamidae	Central Military Dragon	▼				▼		▼		▼
<i>Ctenophorus nuchalis</i>	Agamidae	Central Netted Dragon					▼			▼	
<i>Ctenophorus reticulatus</i>	Agamidae	Western Netted Dragon					▼			▼	
<i>Ctenophorus scutulatus</i>	Agamidae	Lozenge-marked Dragon					▼				
<i>Diporiphora valens</i>	Agamidae		▼				▼				
<i>Diporiphora winneckeii</i>	Agamidae	Cane-grass Dragon									
<i>Pogona minor</i>	Agamidae	Dwarf Bearded Dragon	▼		▼		▼	▼			
<i>Tympanocryptis cephalus</i>	Agamidae	Pebble Mimicking Dragon					▼				
Boidae (Pythons)											
<i>Antaresia perthensis</i>	Boidae	Pygmy Python	▼				▼				
<i>Antaresia stimsoni</i>	Boidae	Stimson's Python					▼				
<i>Aspidites melanocephala</i>	Boidae	Black-headed Python					▼	▼		▼	
<i>Liasis olivaceus subsp. barroni</i>	Boidae	Pilbara Olive Python	▼	DEC - S1, EPBC - V	▼	▼	▼	▼	▼	▼	▼
Elapidae (Front-fanged Land snakes)											
<i>Acanthophis wellsi</i>	Elapidae	Pilbara Death Adder					▼	▼			
<i>Brachyuropsis approximans</i>	Elapidae						▼				
<i>Demansia psammophis subsp. cupreiceps</i>	Elapidae	Yellow-faced Whipsnake	▼				▼		▼		
<i>Demansia rufescens</i>	Elapidae	Rusty Whipsnake					▼				
<i>Furina ornata</i>	Elapidae	Moon Snake					▼				
<i>Parasuta monachus</i>	Elapidae	Monk Snake	▼				▼				
<i>Pseudechis australis</i>	Elapidae	King Brown	▼				▼				
<i>Pseudonaja mengdeni</i>	Elapidae	Gwardar	▼				▼				
<i>Pseudonaja modesta</i>	Elapidae	Ringed Brown Snake	▼				▼				
<i>Pseudonaja nuchalis</i>	Elapidae	Western Brown Snake					▼				
<i>Suta fasciata</i>	Elapidae	Rosen's Snake	▼								
<i>Suta punctata</i>	Elapidae	Little Spotted Snake					▼				
<i>Vermicella snelli</i>	Elapidae	Pilbara Bandy Bandy	▼				▼	▼			

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Gekkonidae (Geckos)											
<i>Crendactylus ocellatus</i>	Gekkonidae	Clawless Gecko	▼				▼				
<i>Diplodactylus conspicillatus</i>	Gekkonidae	Fat-tailed Gecko	▼				▼			▼	▼
<i>Diplodactylus granariensis rex</i>	Gekkonidae										
<i>Diplodactylus pulcher</i>	Gekkonidae		▼				▼				
<i>Diplodactylus savagei</i>	Gekkonidae		▼				▼	▼			
<i>Gehyra pilbara</i>	Gekkonidae						▼				
<i>Gehyra punctata</i>	Gekkonidae		▼				▼		▼		
<i>Gehyra purpurascens</i>	Gekkonidae						▼				
<i>Gehyra variegata</i>	Gekkonidae		▼				▼	▼		▼	
<i>Heteronotia spelea</i>	Gekkonidae	Prickly Cave Gecko					▼			▼	
<i>Heteronotia binoei</i>	Gekkonidae	Bynoe's Gecko	▼				▼			▼	
<i>Lucasium stenodactylum</i>	Gekkonidae		▼				▼	▼	▼		▼
<i>Lucasium wombeyi</i>	Gekkonidae						▼				
<i>Nephrurus levis subsp. pilbarensis</i>	Gekkonidae	Knob-tailed Gecko					▼				
<i>Nephrurus wheeleri subsp. cinctus</i>	Gekkonidae	Banded Knob-tail Gecko	▼				▼	▼			
<i>Oedura marmorata</i>	Gekkonidae	Marbled Velvet Gecko	▼				▼		▼		
<i>Rhynchoedura ornata</i>	Gekkonidae	Beaked Gecko	▼				▼				
<i>Strophurus elderi</i>	Gekkonidae	Jewelled Gecko					▼				
<i>Strophurus jeanae</i>	Gekkonidae										
<i>Strophurus strophurus</i>	Gekkonidae	Spiny-tailed Gecko									
<i>Strophurus wellingtonae</i>	Gekkonidae		▼				▼	▼			
<i>Underwoodisaurus milli</i>	Gekkonidae	Thick-tailed Gecko					▼				
<i>Underwoodisaurus seorsus</i>	Gekkonidae	Pilbara Thick-tailed Gecko		Proposed Priority species							
Pygopodidae (legless lizards)											
<i>Delma elegans</i>	Pygopodidae		▼				▼				
<i>Delma butleri</i>	Pygopodidae										
<i>Delma haroldi</i>	Pygopodidae						▼	▼			
<i>Delma pax</i>	Pygopodidae						▼				
<i>Delma nasuta</i>	Pygopodidae		▼				▼		▼		
<i>Delma tincta</i>	Pygopodidae	Excitable Delma	▼				▼	▼			
<i>Lialis burtonis</i>	Pygopodidae	Burton's Legless Lizard	▼				▼	▼		▼	
<i>Pygopus nigriceps</i>	Pygopodidae	Hooded Scaly-foot	▼				▼	▼			
Scincidae (Skinks)											
<i>Carlia munda</i>	Scincidae		▼				▼	▼	▼	▼	▼
<i>Carlia tricantha</i>	Scincidae						▼	▼			
<i>Cryptoblepharus buchananii</i>	Scincidae						▼				
<i>Cryptoblepharus plagioccephalus</i>	Scincidae									▼	
<i>Cryptoblepharus ustulatus</i>	Scincidae		▼				▼				
<i>Ctenotus ariadnae</i>	Scincidae										▼
<i>Ctenotus duricola</i>	Scincidae						▼	▼			▼
<i>Ctenotus grandis</i>	Scincidae						▼				
<i>Ctenotus harlani</i>	Scincidae						▼		▼		

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<i>Ctenotus helena</i>	Scincidae		▼				▼	▼			▼
<i>Ctenotus leonhardii</i>	Scincidae										
<i>Ctenotus pantherinus</i>	Scincidae	Panther Skink	▼				▼	▼	▼	▼	
<i>Ctenotus rubicundus</i>	Scincidae		▼				▼		▼	▼	
<i>Ctenotus rufescens</i>	Scincidae						▼				
<i>Ctenotus rutilans</i>	Scincidae		▼				▼	▼			
<i>Ctenotus saxatilis</i>	Scincidae		▼				▼	▼		▼	▼
<i>Ctenotus schomburgkii</i>	Scincidae	Barred Wedge Snout Ctenotus	▼				▼	▼			
<i>Ctenotus serventyi</i>	Scincidae						▼				▼
<i>Cyclodomorphus melanops</i>	Scincidae	Spinifex Slendered Bluetongue	▼				▼	▼	▼	▼	
<i>Egernia cygnitos</i>	Scincidae	Western Pilbara Spiny-tailed Skink					▼				
<i>Egernia formosa</i>	Scincidae		▼				▼				
<i>Eremiascincus richardsonii</i>	Scincidae	Broad-banded Sand-swimmer					▼				
<i>Eremiascincus fasciolatus</i>	Scincidae	Narrow-banded Sand-swimmer					▼				
<i>Lerista flammicauda</i>	Scincidae	Fire-tailed Slider									
<i>Lerista jacksoni</i>	Scincidae						▼				
<i>Lerista muelleri</i>	Scincidae		▼				▼	▼		▼	
<i>Lerista neander</i>	Scincidae						▼				
<i>Lerista vehmens</i>	Scincidae						▼				
<i>Lerista zietzi</i>	Scincidae		▼				▼	▼			
<i>Menetia greyii</i>	Scincidae		▼				▼			▼	▼
<i>Menetia surda</i>	Scincidae						▼				
<i>Morethia ruficauda exquisita</i>	Scincidae	Fire-tailed Skink	▼				▼			▼	
<i>Notoscincus butleri</i>	Scincidae			DEC- P4							
<i>Proablepharus reginae</i>	Scincidae										
<i>Tiliqua multifasciata</i>	Scincidae	Central Bluetongue	▼				▼	▼		▼	
Typhlopidae (Blind Snakes)											
<i>Ramphotyphlops ammodytes</i>	Typhlopidae						▼			▼	
<i>Ramphotyphlops ganei</i>	Typhlopidae			DEC- P4	▼		▼				
<i>Ramphotyphlops grypus</i>	Typhlopidae						▼			▼	
<i>Ramphotyphlops hamatus</i>	Typhlopidae						▼				
<i>Ramphotyphlops pilbarensis</i>	Typhlopidae										
<i>Ramphotyphlops waitii</i>	Typhlopidae										
Varanidae (Monitors/Goannas)											
<i>Varanus acanthurus</i>	Varanidae	Ridge-tailed Monitor	▼				▼	▼		▼	
<i>Varanus brevicauda</i>	Varanidae	Short-tailed Pygmy Monitor	▼				▼			▼	
<i>Varanus bushi</i>	Varanidae	Pilbara Pygmy Mulga Monitor	▼				▼	▼			
<i>Varanus caudolineatus</i>	Varanidae	Stripe-tailed Monitor								▼	
<i>Varanus eremius</i>	Varanidae	Rusty Desert Monitor									
<i>Varanus giganteus</i>	Varanidae	Perentie	▼				▼				

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Casuariidae											
<i>Dromaius novaehollandiae</i>	Emu	LC		▼		▼				▼	▼
Phasianidae											
<i>Coturnix ypsilophora</i>	Brown Quail			▼		▼				▼	
<i>Coturnix pectoralis</i>	Stubble Quail			▼					▼		
Anartidae											
<i>Anas gracilis</i>	Grey Teal			▼					▼	▼	
<i>Anas superciliosa</i>	Pacific Black Duck			▼		▼				▼	
<i>Chenonetta jubata</i>	Australian Wood Duck			▼							
<i>Cygnus atratus</i>	Black Swan			▼						▼	
<i>Dendrocygna eytoni</i>	Plumed Whistling-Duck			▼		▼					
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck			▼						▼	
<i>Tadorna tadornoides</i>	Australian Shelduck									▼	
<i>Aythya australis</i>	Hardhead			▼							
Procellariidae											
<i>Macronectes giganteus</i>	Southern Giant Petrel	DEC - T (IUCN - LC)			▼						
Podicipedidae											
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe			▼							
Columbidae											
<i>Geopelia cuneata</i>	Diamond Dove		▼	▼		▼		▼	▼	▼	▼
<i>Geopelia striata</i>	Peaceful Dove			▼		▼			▼		
<i>Geophaps plumifera</i>	Spinifex Pigeon		▼	▼		▼		▼	▼		▼
<i>Ocyphaps lophotes</i>	Crested Pigeon		▼	▼		▼		▼	▼	▼	
<i>Phaps chalcoptera</i>	Common Bronzewing		▼	▼		▼		▼	▼	▼	
Podargidae											
<i>Podargus strigoides</i>	Tawny Frogmouth		▼	▼		▼				▼	
Caprimulgidae											
<i>Eurostopodos argus</i>	Spotted Nightjar		▼	▼		▼		▼		▼	
Aegothelidae											
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar		▼	▼		▼		▼		▼	▼
Anhingidae											
<i>Anhinga novaehollandiae</i>	Australasian Darter			▼		▼					
Phalacrocoracidae											
<i>Microcarbo melanoleucos</i>	Little Pied Cormorant			▼					▼		

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<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant			▼							
<i>Phalacrocorax varius</i>	Pied Cormorant					▼					
Pelecanidae											
<i>Pelecanus conspicillatus</i>	Australian Pelican			▼		▼					
Ardeidae											
<i>Ardea ibis</i>	Cattle Egret	EPBC - M, IUCN-LC					▼				
<i>Ardea pacifica</i>	White-necked Heron			▼				▼		▼	
<i>Ardea modesta</i>	Eastern Great Egret	EPBC - M,		▼			▼				
<i>Egretta novaehollandiae</i>	White-faced Heron			▼		▼				▼	
<i>Nycticorax caledonicus</i>	Nankeen Night-Heron			▼		▼					
Threskiornithidae											
<i>Threskiornis spinicollis</i>	Straw-necked Ibis			▼		▼				▼	
<i>Plegadis falcinellus</i>	Glossy Ibis			▼							
Apodidae											
<i>Apus pacificus</i>	Fork-tailed Swift	EPBC - M, IUCN-LC	▼				▼			▼	
Accipitridae											
<i>Accipiter fasciatus</i>	Brown Goshawk			▼		▼					
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk			▼		▼			▼		
<i>Aquila audax</i>	Wedge-tailed Eagle		▼	▼		▼		▼		▼	
<i>Elanus axillaris</i>	Black-shouldered Kite		▼	▼							
<i>Circus approximans</i>	Swamp Harrier			▼							
<i>Circus assimilis</i>	Spotted Harrier		▼	▼		▼			▼	▼	
<i>Haliaeetus leucogaster</i>	White-bellied Sea Eagle	EPBC - V		▼							
<i>Haliaeetus spheurnus</i>	Whistling Kite		▼	▼		▼		▼	▼		
<i>Hamirostra isura</i>	Square-tailed Kite					▼					
<i>Hamirostra melanosternon</i>	Black-breasted Buzzard		▼					▼			
<i>Hieraaetus morphnoides</i>	Little Eagle			▼				▼	▼	▼	
<i>Milvus migrans</i>	Black Kite		▼	▼		▼			▼		
Falconidae											
<i>Falco longipennis</i>	Australian Hobby		▼	▼		▼			▼		
<i>Falco cenchroides</i>	Nankeen Kestrel		▼	▼		▼		▼	▼		
<i>Falco hypoleucos</i>	Grey Falcon	DEC - P4			▼	▼			▼		
<i>Falco peregrinus</i>	Peregrine Falcon ^{S4}	DEC - S4 (IUCN-LC)						▼	▼		

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<i>Falco berigora</i>	Brown Falcon		▼	▼		▼		▼		▼	▼
Railidae											
<i>Gallirallus philippensis</i>	Buff-banded Rail			▼							
<i>Fulica atra</i>	Eurasian Coot			▼							
<i>Porzana tabuensis</i>	Spotless Crane			▼							
<i>Tribonyx ventralis</i>	Black-tailed Native-hen									▼	
Otididae											
<i>Ardeotis australis</i> ^{P4, (IUCN - NT)}	Australian Bustard	DEC - P4		▼	▼	▼		▼		▼	
Burhinidae											
<i>Burhinus grallarius</i>	Bush-stone curlew	DEC - P4		▼	▼	▼					
Recurvirostridae											
<i>Himantopus himantopus</i>	Black-winged Stilt			▼		▼					
Charadriidae											
<i>Charadrius veredus</i>	Oriental Plover	EPBC - M, IUCN-LC					▼				
<i>Euseyonis melanops</i>	Black-fronted Dotterel			▼		▼				▼	
<i>Erythronyx cinctus</i>	Red-kneed Dotterel									▼	
Scolopacidae											
<i>Tringa nebularia</i>	Common Greenshank					▼					
Turnicidae											
<i>Turnix velox</i>	Little Button-quail		▼	▼		▼		▼		▼	▼
Cacatuidae											
<i>Eolophus roseicapillus</i>	Galah		▼	▼		▼		▼		▼	▼
<i>Cacatua sanguinea</i>	Little Corella			▼		▼			▼	▼	
<i>Nymphicus hollandicus</i>	Cockateil		▼	▼		▼				▼	
Psittacidae											
<i>Barnardius zonarius</i>	Australian Ringneck		▼	▼		▼		▼	▼	▼	▼
<i>Melopsittacus undulatus</i>	Budgerigar		▼	▼		▼		▼		▼	▼
<i>Pezoporus occidentalis</i>	Night Parrot	EPBC - E, M (IUCN - CR)					▼			▼	
<i>Polytelis alexandrae</i>	Princess Parrot	DEC - P4									
<i>Neopsephotus bourkii</i>	Bourke's Parrot			▼						▼	
Cuculidae											
<i>Cacomantis pallidus</i>	Pallid Cuckoo		▼	▼		▼		▼		▼	▼
<i>Centropus phasianinus</i>	Pheasant Coucal			▼					▼		

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<i>Chalcites basalis</i>	Horsfield's Bronze-Cuckoo			▼		▼		▼	▼	▼	▼
Strigidae											
<i>Ninox connivens</i>	Barking Owl					▼					
<i>Ninox novaeseelandiae</i>	Southern Boobook		▼	▼		▼		▼		▼	
Tytonidae											
<i>Tyto javanica</i>	Eastern Barn Owl			▼		▼				▼	
Halcyonidae											
<i>Dacelo leachii</i>	Blue-winged Kookaburra			▼		▼		▼	▼	▼	
<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher		▼	▼		▼			▼	▼	
<i>Todirhamphus sanctus</i>	Sacred Kingfisher			▼		▼		▼			
Meropidae											
<i>Merops ornatus</i>	Rainbow Bee-eater	EPBC - M, IUCN-LC	▼	▼		▼	▼	▼	▼	▼	▼
Climacteridae											
<i>Climacteris melanura subsp. wellsi</i>	Black-tailed Treecreeper			▼							
Ptilonorhynchidae											
<i>Ptilonorhynchus guttatus</i>	Western Bowerbird		▼	▼		▼					
<i>Ptilonorhynchus maculatus</i>	Spotted Bowerbird			▼							
Maluridae											
<i>Amytornis striatus</i>	Striated Grasswren		▼	▼		▼		▼			▼
<i>Malurus lamberti</i>	Variegated Fairy-wren		▼	▼		▼		▼	▼	▼	▼
<i>Malurus leucopterus</i>	White-winged Fairy-wren			▼		▼		▼		▼	▼
<i>Malurus splendens</i>	Splendid Fairy-wren					▼		▼			
<i>Stipiturus ruficeps</i>	Rufous-crowned Emu-wren			▼		▼		▼		▼	
Acanthizidae											
<i>Acanthiza apicalis</i>	Inland Thornbill			▼		▼		▼			
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill			▼		▼			▼		
<i>Acanthiza robustirostris</i>	Slaty-backed Thornbill			▼		▼					
<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill			▼		▼		▼		▼	
<i>Aphelocephala leucopsis</i>	Southern Whiteface								▼		
<i>Gerygone fusca</i>	Western Gerygone		▼	▼		▼		▼	▼	▼	
<i>Pyrrholaemus brunneus</i>	Redthroat	IUCN - LC		▼		▼		▼	▼	▼	

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<i>Smicronis brevirostris</i>	Weebill		▼	▼		▼		▼	▼	▼	▼
Pardalotidae											
<i>Pardalotus striatus</i>	Striated Pardalote		▼	▼		▼		▼	▼	▼	▼
<i>Pardalotus rubricatus</i>	Red-browed Pardalote		▼	▼		▼		▼	▼	▼	▼
Meliphagidae											
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater		▼	▼		▼		▼	▼	▼	
<i>Certhionyx variegatus</i>	Pied Honeyeater		▼								▼
<i>Conopophila whitei</i>	Grey Honeyeater	Not listed - scarce species with little known about its habitats	▼	▼		▼					
<i>Epthianura aurifrons</i>	Orange Chat								▼		
<i>Epthianura tricolor</i>	Crimson Chat		▼	▼		▼					▼
<i>Lichenostomus keartlandi</i>	Grey-headed Honeyeater		▼	▼		▼		▼	▼	▼	▼
<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater		▼	▼		▼		▼	▼	▼	
<i>Lichenostomus plumulus</i>	Grey-fronted Honeyeater					▼		▼	▼	▼	
<i>Lichenostomus virescens</i>	Singing Honeyeater		▼	▼		▼		▼	▼	▼	▼
<i>Lichmera indistincta</i>	Brown Honeyeater		▼	▼		▼		▼	▼	▼	▼
<i>Manorina flavigula</i>	Yellow-throated Miner		▼	▼		▼		▼	▼	▼	▼
<i>Melithreptus gularis</i>	Black-chinned Honeyeater		▼	▼		▼		▼	▼	▼	▼
<i>Purnella albifrons</i>	White-fronted Honeyeater					▼					
<i>Sugomel niger</i>	Black Honeyeater		▼	▼		▼					▼
Pomatostomidae											
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler		▼	▼		▼		▼	▼	▼	
<i>Pomatostomus superciliosus</i>	White-browed Babbler			▼		▼		▼	▼	▼	
Neosittidae											
<i>Daphoenositta chrysoptera</i>	Varied Sittella			▼		▼			▼		
Campephagidae											
<i>Coracina maxima</i>	Ground Cuckoo-shrike		▼	▼		▼			▼	▼	
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike		▼	▼		▼		▼	▼	▼	▼
<i>Lalage sueurii</i>	White-winged Triller		▼	▼		▼		▼	▼	▼	▼

Database Searches								Fauna Survey of the proposed Hope Downs 4 mining area. (Ninox Wildlife Consulting, 2009)	Yandicoogina Junction South West and Oxbow Fauna Survey. (Biota Environmental Sciences, 2010)	Fauna survey of proposed Iron Ore Mine, Cloud Break. (Bamford Consulting Ecologists, 2005)	Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas. (Biota Environmental Sciences, 2005)
Scientific Name	Common Name	Conservation Significance	Lamb Creek Level 2 Fauna Survey	Birds Australia Birddata Search	DEC Search	Naturemap Records	EPBC Search				
Pachycephalidae											
<i>Colluricincla harmonica</i>	Grey Shrike-thrush			▼		▼		▼	▼	▼	▼
<i>Oreoica gutturalis</i>	Crested Bellbird		▼	▼				▼	▼	▼	▼
<i>Pachycephala rufiventris</i>	Rufous Whistler		▼	▼		▼		▼	▼	▼	▼
Artamidae											
<i>Artamus cinereus</i>	Black-faced Woodswallow		▼	▼		▼		▼	▼	▼	▼
<i>Artamus minor</i>	Little Woodswallow		▼	▼		▼		▼	▼		
<i>Artamus personatus</i>	Masked Woodswallow		▼	▼		▼		▼	▼		
<i>Cracticus nigrogularis</i>	Pied Butcherbird			▼		▼		▼		▼	▼
<i>Cracticus tibicen</i>	Australian Magpie		▼	▼		▼			▼	▼	▼
<i>Cracticus torquatus</i>	Grey Butcherbird			▼		▼		▼	▼	▼	▼
Rhipiduridae											
<i>Rhipidura albiscapa</i>	Grey Fantail			▼		▼		▼		▼	
<i>Rhipidura leucophrys</i>	Willie Wagtail		▼	▼		▼		▼	▼	▼	▼
Corvidae											
<i>Corvus bennetti</i>	Little Crow			▼		▼			▼	▼	
<i>Corvus coronoides</i>	Australian Raven					▼					
<i>Corvus orru</i>	Torresian Crow			▼		▼		▼	▼	▼	▼
Monarchidae											
<i>Grallina cyanoleuca</i>	Magpie-lark		▼	▼		▼			▼	▼	
Petroicidae											
<i>Melanodryas cucullata</i>	Hooded Robin		▼	▼		▼		▼	▼	▼	
<i>Petroica goodenovii</i>	Red-capped Robin			▼		▼		▼		▼	
Alaudidae											
<i>Mirafra javanica</i>	Horsfield's Bushlark			▼		▼				▼	
Acrocephalidae											
<i>Acrocephalus australis</i>	Australian Reed-Warbler			▼		▼					
Megaluridae											
<i>Cincloramphus cruralis</i>	Brown Songlark			▼		▼				▼	
<i>Cincloramphus mathewsi</i>	Rufous Songlark		▼	▼		▼			▼		▼
<i>Eremiornis carteri</i>	Spinifexbird		▼	▼		▼		▼	▼	▼	▼

Database Searches								Fauna Survey of the proposed Hope Downs 4 mining area. (Ninox Wildlife Consulting, 2009)	Yandicoogina Junction South West and Oxbow Fauna Survey. (Biota Environmental Sciences, 2010)	Fauna survey of proposed Iron Ore Mine, Cloud Break. (Bamford Consulting Ecologists, 2005)	Fauna Habitats and Fauna Assemblage of the Proposed FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas Mine Areas. (Biota Environmental Sciences, 2005)
Scientific Name	Common Name	Conservation Significance	Lamb Creek Level 2 Fauna Survey	Birds Australia Birddata Search	DEC Search	Naturemap Records	EPBC Search				
Hirundinidae											
<i>Petrochelidon ariel</i>	Fairy Martin			▼		▼				▼	
<i>Petrochelidon nigricans</i>	Tree Martin			▼		▼			▼		▼
Nectariniidae											
<i>Dicaeum hirundinaceum</i>	Mistletoebird		▼	▼		▼		▼		▼	
Estrildidae											
<i>Emblema pictum</i>	Painted Finch		▼	▼		▼			▼	▼	▼
<i>Neochmia ruficauda</i> subsp. <i>subclarescens</i>	Star Finch			▼	▼				▼	▼	
<i>Taeniopygia guttata</i>	Zebra Finch		▼	▼		▼		▼	▼	▼	▼
Motacillidae											
<i>Anthus novaeseelandiae</i>	Australasian Pipit			▼		▼				▼	
Taxonomy follows Christidis and Boles (2008)* except where indicated otherwise such as . Great Egret (<i>Ardea alba</i>) is a WAM listing - Western Australian Museum Birds Checklist, Last modified: 6 October 2008. Both names are presented because EPBC Act 1999 lists Great Egret (<i>A. alba</i>) Christidis and Boles (2008) lists <i>Adea modesta</i> (Eastern Great Egret). Reference to subspecies such as "western ssp" comes from DEC listings.											
Taxonomy follows Western Australian Museum Bird Checklist, Last modified: 6 October 2008 except where indicated otherwise.							WAM				
■ Recorded on Threatened and Priority Fauna Database Search for the area (DEC) as schedule 1 or 4							DEC				
■ Recorded on Protected Matters Database Search for the area - EPBC Act 1999 (DEH) as endangered (e), vulnerable (v) or migratory (m)							EPBC				
■ Priority listed by DEC							BA				
IUCN (2009) - VU = Vulnerable, EN = Endangered, NT - Near Threatened, LC = Least Concern, DD = Data Deficient											

Appendix X: Raw Habitat Data

Date	Recorder	Zone	Easting	Northing	Site ID	Survey type	Habitat Type	Habitat Description	Landform	Soil	Geology	Litter	Fire	Disturbance	Potential Species of Sig	Recorded species of Cons Sig	Photo numbers
3/04/2012	CC MP	50k	692354	7477632	022-mags	transect	Boolgeeda land system	Corymbia upper storey, mid storey acacia thicket over T. basedowi	plain	Ironstone		<20% 5mm	> 5years				3275-3279 WNEWG-CC
3/04/2012	CC MP	50k	692198	7477587	023-mags	transect	Boolgeeda land system	mulga floodplain. Dominant mulga upper storey with occasional corymbia over triodia and ptilotus.	plain	alluvial clay loam		patchy <20% cover, <5mm depth	no signs of recent fire	grazing and weeds			3280-3284 NESWG-CC
3/04/2012	CC MP	50k	691875	7477656	024-mags	transect	Boolgeeda land system	Corymbia upper storey with diverse acacia shrubland over themeda australis and triodia pungens. Scattered mulga patches.	Floodplain	alluvial clay loam		40% cover, 5mm depth	>5 years				3285-3289 NESWG-CC
3/04/2012	CC MP	50k	691702	7477830	025-mags	transect	Boolgeeda land system	mulga floodplain with acacia understorey over triodia pungens, themeda australis and ptilotus.	Floodplain	clay loam with iron stone pebbles		<5%, 1-5mm depth	no signs of recent fire	high impact grazing, weeds.			3291-3295 NESWG-CC
3/04/2012	CC MP	50k	691723	7477964	026-mags	transect	Boolgeeda land system	Acacia spiky leaf with hibiscus and senna shrubs over ephemeral grasses (themeda and triodia) with occasional associated corymbia.	floodplain drainage line	deep loam		<10% cover, 1-5mm depth	no signs of recent fire	grazing and weeds			3296-3300 NESWG-CC
3/04/2012	CC MP	50k	691930	7478235	027-mags	transect	Boolgeeda land system	Scattered corymbia over ephemeral grassland with occasional acacia shrubs. Understorey primarily themeda and triodia.	floodplain drainage line	deep alluvial clay loam		<10% cover, 1-5mm depth	no signs of recent fire	grazing			3303-3307 NESWG-CC
5/04/2012	CC DS	50k	684008	7468874	009-CJ	transect	wannamunna land system	Corymbia and snappy gum with acacia aneura over themeda and aristida understorey with associated triodia.	grassy open woodland	stony loam		20% cover, 1cm depth	fire >10 years	minor disturbance			3480-3484 NESWG-CC
5/04/2012	CC DS	50k	684029	7469108	010-CJ	transect	wannamunna land system	blue mallee over acacia shrubs with triodia pungens understorey	spinifex open woodland	stony loam		<5% cover <5mm depth	old fire scars				3485-3489 NESWG-CC
6/05/2012	CC CJ	50k	687368	7476225	084-CJ	transect	Newman land system	Corymbia and snappy gum upperstorey with acacia, regen blue mallee and malvaceae sp mid storey. Silver senna, blue grey senna, eremophila, solanaceae sp, goodenia sp, trichadesma, bush celery, triodia pungens and basedowi, ptilotus and other perennial grasses.	Stony loam floodplain	stony loam		patchy under trees, 0-2mm depth	patchy fire, 5-10years old		potential pmm habitat		3630-3634 NESWG-CC
6/05/2012	CC CJ	50k	686573	7475916	085-CJ	transect	Boolgeeda land system	Snappy Gum, Blue malle, hakea, corymbia hamersleyana and corymba sp Upperstorey. Regen blue malle, jakea, acacia minirichi, grevillea wickhamii midstorey. Triodia basedowi and pungens, ptilotus, grey senna, indigophora sp, fishbone senna.	minor drainage and associated floodplain	stony loam		none	fire < 5 years old	grazing			3635-3639 NESWG-CC
6/05/2012	CC CJ	50k	685238	7475564	086-CJ	transect	Boolgeeda land system	Snappy Gum, Blue malle, hakea, corymbia hamersleyana and corymba sp Upperstorey. Regen blue malle, jakea, acacia minirichi, grevillea wickhamii midstorey. Triodia basedowi and pungens, ptilotus, grey senna, indigophora sp, fishbone senna. same as site 05-CJ	minor drainage and associated floodplain	stony loam		none	fire < 5 years old	grazing			same as above
3/04/2012	CM CJ	50k	693702	7477900	001-CJ	transect		stony creek lined with Eucalyptus, Acacia, themeda and triodia.	MEAT drainage	stony pebbles, red brown loam.		<10%		drill lines, roads			302-305-CM
5/04/2012	CM MP	50k	687918	74738784	004-HC	transect	Newman land system	Brachychiton, Eucalyptus camaldulensis, callitris and ficus upperstorey. Acacia, ptilotus, solanum, eremophila, ficus, malvaceae, astrotricha midstorey. Ephemeral grasses	Steep rocky BIF gorge	coarse stony sand with		patchy 3-5CM depth	long time since fire				
6/04/2012	CM MP	50k	691578	7476099	MEAT1-HC	transect	Boolgeeda land system	Sparse Eucalyptus leucophloia and corymbia with mixed acacia, mulga and hakea upperstorey. Blue mallee with three acacia species midstorey. T. basedowi, t. pungens, indigophora, ptilotus, senna, solanum and malvaceae understorey.	Plain with creekline drainage	red brown clay loam with high coverage of BIF pebbles.		<5% cover 0-1cm depth	5-10 years since fire				39-43 - CM

Appendix XI: Specialised Zoological Anabat Data Report



Bat call identification from Lamb Creek, WA

Type: Acoustic analysis

Prepared for: Rapallo Pty Ltd

Date: 4 June 2012

Job No.: SZ273

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SUMMARY

Bat identifications from acoustic recordings are provided from Lamb Creek, c. 120 km WNW of Newman, in the Pilbara region of Western Australia. Six species of bat were identified as being present (Table 1). Details supporting the identifications are provided, as recommended by the Australasian Bat Society (ABS 2006). A summary of pulse parameters is provided in Table 2, and representative call sequences are illustrated in Figure 1. Further data is available should verification be required.

COMMENTS ON IDENTIFICATIONS

The yellow-bellied sheath-tailed bat *Saccolaimus flaviventris* was distinguished from the northern free-tailed bat *Chaerephon jobensis* by the pattern of harmonics (*S. flaviventris*: harmonics c. 10 kHz apart with most energy in h2 at c. 20 kHz; *C. jobensis*: harmonics c. 20 kHz apart with most energy in h1 at c. 20 kHz; Figure 1).

No unambiguous calls of bats of conservation significance (ghost bat *Macroderma gigas*; Pilbara leaf-nosed bat *Rhinonictis aurantia*) were present. All short duration multi-harmonic signals were allocated to the common sheath-tailed bat *Taphozous georgianus* based on pulse structure and energy distribution; and all signals with a characteristic frequency above 100 kHz were from Finlayson's cave bat *Vespadelus finlaysoni* (Figure 1).

METHODS

Data recorded with a Wildlife Acoustics Song Meter SM2BAT were supplied as WAV format files on three 4 GB SD cards (recording settings were not available from the submitted data); plus one DAT format file as downloaded from a Titley Scientific AnaBat SD1 bat detector. Each WAV file was opened and inspected in Cool Edit 2000. Species were identified based on information in McKenzie and Muir (2000) and McKenzie and Bullen (2009), and nomenclature follows Armstrong and Reardon (2006). Signals recorded with the AnaBat SD1 detector were reinterpreted from the DAT file in CFC Read 4.3s software and examined in AnalookW 3.8s software. The frequency division ratio was set to a factor of 8. Three call variables were measured on good quality search phase pulses in representative call sequences: pulse duration (milliseconds), maximum frequency (kHz) and characteristic frequency (kHz). To double-check whether any signals of *R. aurantia* were present, a continuous representation of the AnaBat recordings in ZCA and MAP files was examined.

REFERENCES

- ABS (2006). Recommendations of the Australasian Bat Society Inc for reporting standards for insectivorous bat surveys using bat detectors. *The Australasian Bat Society Newsletter* 27: 6–9. [ISSN 1448-5877]
- Armstrong, K. and Reardon, T. (2006). Standardising common names of bats in Australia. *The Australasian Bat Society Newsletter* 26: 37–42.
- McKenzie, N.L. and Muir, W.P. (2000). Bats of the southern Carnarvon Basin, Western Australia. *Records of the Western Australian Museum Supplement* 61: 465–477.
- McKenzie, N.L. and Bullen, R.D. (2009). The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Records of the Western Australian Museum Supplement* 78: 123–155.

TABLE 1. Species identifications, with the degree of confidence indicated by a code. Date and serial/unit correlates with site; see Table 2 for full species names.

	<i>C. gouldii</i>	<i>C. jobensis</i>	<i>S. flaviventris</i>	<i>S. greyii</i>	<i>T. georgianus</i>	<i>V. finlaysoni</i>
Date						
SM2BAT						
3/04/2012	◆	—	◆	◆	◆	◆
4/04/2012	◆	—	◆	—	—	◆
5/04/2012	—	—	—	—	◆	◆
6/04/2012	—	—	—	—	◆	◆
7/04/2012	◆	—	—	◆	—	◆
8/04/2012	◆	—	◆	◆	—	◆
9/04/2012	◆	◆	◆	◆	◆	◆
AnaBat serial 3775						
4/04/2012	◆	—	◆	—	—	◆
5/04/2012	—	—	—	—	◆	◆
7/04/2012	◆	—	—	◆	—	◆
8/04/2012	—	—	◆	◆	—	◆
9/04/2012	◆	◆	—	◆	◆	◆

Definition of confidence level codes:

— Not detected.

◆ Unambiguous identification of the species at the site based on measured call characteristics and comparison with available reference material. Greater confidence in this ID would come only after capture and supported by morphological measurements or a DNA sequence.

NC Needs Confirmation. Either call quality was poor, or the species cannot be distinguished reliably from another that makes similar calls. Alternative identifications are indicated in the *Comments on identifications* section of this report. If this is a species of conservation significance, further survey work might be required to confirm the record.

TABLE 2. Summary of variables from representative call sequences (Mean \pm SD; range; ¹ s,p: number of sequences measured, combined total number of pulses measured).

Species	s,p ¹	Duration (msec)	Max Frequency (kHz)	Char frequency (kHz)
Gould's wattled bat <i>Chalinolobus gouldii</i>	1,10	6.0 \pm 1.3 4.2 – 7.6	39.6 \pm 3.5 34.6 – 44.9	30.7 \pm 0.7 29.9 – 31.9
Northern free-tailed bat <i>Chaerephon jobensis</i>	1,5	7.1 \pm 1.7 4.9 – 8.9	31.7 \pm 3.4 28.0 – 35.9	20.9 \pm 2.1 18.5 – 23.8
Yellow-bellied sheath-tailed bat <i>Saccolaimus flaviventris</i>	1,4	15.8 \pm 2.6 12.4 – 17.9	20.9 \pm 0.6 20.1 – 21.3	17.5 \pm 0.2 17.2 – 17.6
Little broad-nosed bat <i>Scotorepens greyii</i>	1,11	5.9 \pm 0.8 4.1 – 7.2	50.4 \pm 5.8 41.2 – 59.3	36.1 \pm 0.6 34.6 – 36.9
Common sheath-tailed bat <i>Taphozous georgianus</i>	1,14	8.9 \pm 1.5 6.6 – 10.5	27.4 \pm 0.5 26.9 – 28.7	24.7 \pm 0.3 24.2 – 25.2
Finlayson's cave bat <i>Vespadelus finlaysoni</i>	3,35	4.1 \pm 1.0 3.0 – 7.9	72.5 \pm 10.0 58.6 – 90.9	57.5 \pm 1.3 55.4 – 59.9

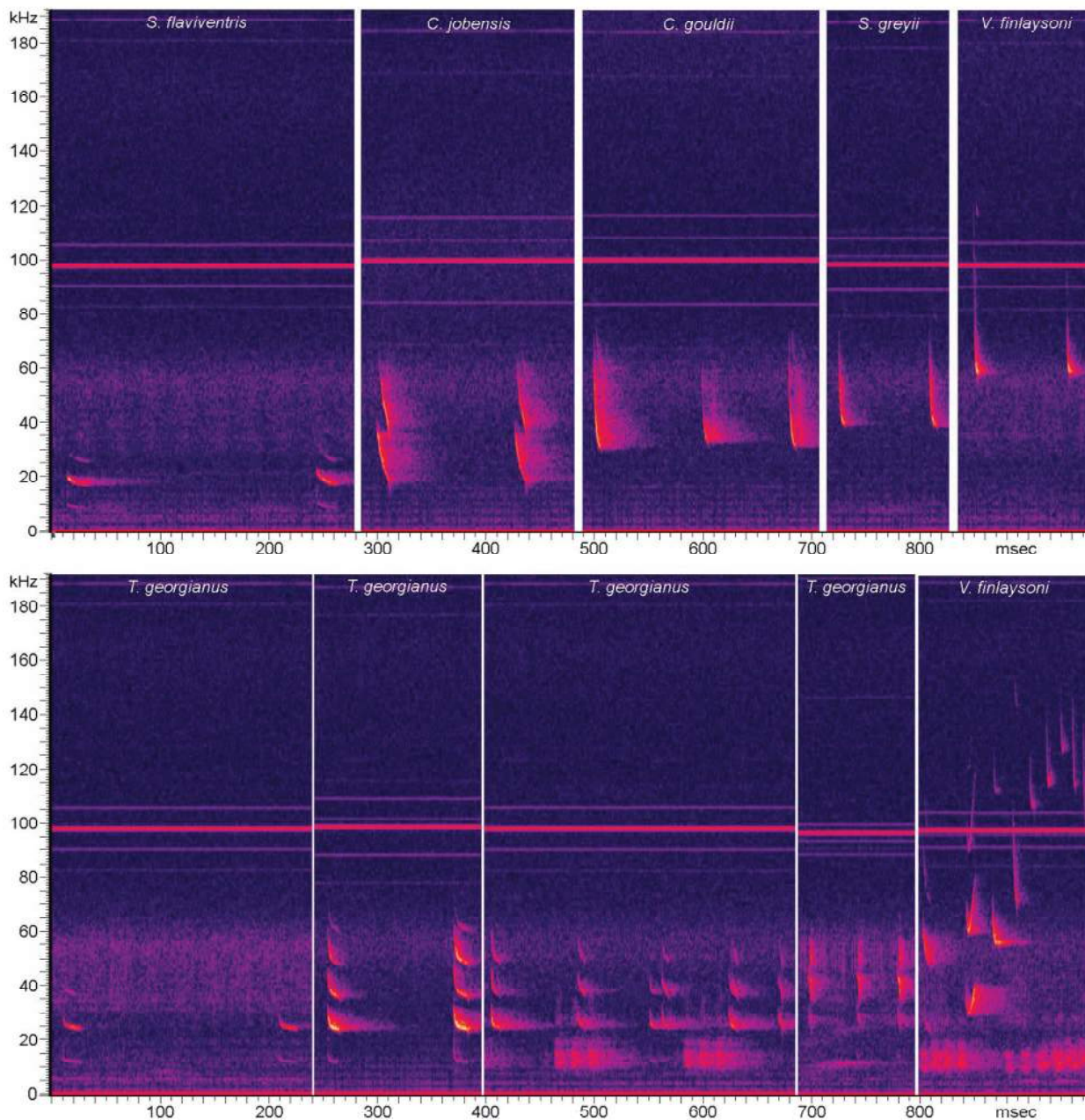


FIGURE 1. Representative call sequence portions of the species identified.

Appendix XII: WAM SRE Reports

Land snails from Lamb Creek, ca. 120km NW of Newman (Western Australia)

Brief Report to *Rapallo Environmental*

15 June 2012

Corey S. Whisson

Department of Aquatic Zoology, Western Australian Museum,
Locked Bag 49, Welshpool DC, Western Australia 6986, Australia



Although identifications in this report were consistent with the best available information and current scientific thinking at the time of identification the use of this report is at the risk of the user. Any liability to users of this report for loss of any kind arising out of the use of this report or the information and identifications it contains is expressly disclaimed.

SUMMARY

The samples from Lamb Creek, approximately 120km NW of Newman, submitted to the Western Australian Museum on the 22nd May 2010, contained three single species of land snails belonging to the families Bulimulidae and Pupillidae. None are considered short-range endemic species. Some pupillid specimens were juvenile and could not be identified past family level.

METHODS

8 samples of land snail specimens were collected by the environmental consultancy *Rapallo Environmental* during a faunal survey of the Lamb Creek area, approximately 120km north-west of Newman, Western Australia in April 2012. These specimens were presented to the Mollusc Section of the Western Australian Museum for identification and comment on the 22nd of May 2012 (WAMTS-057).

Specimen data, giving the site numbers and co-ordinates, habitat information and the collecting methods employed were provided with the specimens.

Land snail specimens were examined under a *Leica* MZ95 dissecting microscope. They were compared with dry and preserved specimens in the Molluscan Collections of the Western Australian Museum and with descriptions and figures in relevant publications. As we have limited material from the project areas, most of the survey specimens have been registered and deposited into the Western Australian Museum's Mollusc Collection.

RESULTS

The land snails collected during this survey belong to the terrestrial pulmonate families Bulimulidae and Pupillidae (Appendix A). The three species identified from this survey are considered to form part of the indigenous Western Australian fauna.

Bulimulidae

***Bothriembryon* sp. nov.**

Undescribed widespread species.

Family Pupillidae

Subfamily Gastrocoptinae

***Gastrocopta* cf. *mussoni* Pilsbry, 1917**

Probably conspecific with *G.mussoni* which is a widespread species

Subfamily Pupillinae***Pupoides beltianus* (Tate, 1894)**

Widespread species

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Pilsbry, H.A., (1917), in Tyron, G.W. & Pilsbry, H.A. *Manual of Conchology*. Philadelphia :
Conchology Department, Academy of Natural Sciences Ser. 2, **24**

Tate, R. (1894). Brief diagnoses of Mollusca from Central Australia. *Trans. R. Soc. S. Aust.* **18**:
191-194.

Appendix A: Land snails from Lamb Creek.

Site	Family	Genus	Species	Reg. No. (WAM S)	No. Specimens
PMI Lamb 24 mollusc	Bulimulidae	<i>Bothriembryon</i>	sp. nov.	83524	1 dead-taken
PMI Lamb 25 mollusc	Bulimulidae	<i>Bothriembryon</i>	sp. nov.	83523	1 dead-taken
PMI Lamb 26 mollusc	Pupillidae	Juv.		Not kept	1 dead-taken
PMI Lamb 27 mollusc	Pupillidae	Juv.		Not kept	1 live-taken
PMI Lamb 28 mollusc	Pupillidae	<i>Pupoides</i>	<i>beltianus</i>	83525	1 dead-taken
PMI Lamb 29 mollusc	Pupillidae	Juv.		Not kept	1 dead-taken
PMI Lamb 35 mollusc	Pupillidae	<i>Gastrocopta</i>	cf. <i>mussoni</i>	83527	1 dead-taken
PMI Lamb 36 mollusc	Pupillidae	<i>Gastrocopta</i>	cf. <i>mussoni</i>	83526	1 dead-taken, 2 live-taken
PMI Lamb 37 mollusc		Not	Submitted		



PHOENIX

ENVIRONMENTAL SCIENCES

Terrestrial invertebrates from Lamb Creek, Western Australia

Prepared for Rapallo

June 2012

Taxonomic Report



Terrestrial invertebrates from Lamb Creek, Western Australia

Prepared for Rapallo

Taxonomic Report

Author: Volker W. Framenau

Date: 18 June 2012

Submitted to: Cara McGary, Chris Jackson

Chain of authorship and review			
Name	Task	Version	Date
Volker Framenau	Interim for client comments	0.1	15 June 2012
Volker Framenau	Final submitted to client	1.0	18 June 2012
	Choose an item.		
	Choose an item.		
	Choose an item.		
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Contents

CONTENTS.....	I
LIST OF TABLES.....	I
LIST OF APPENDICES	I
EXECUTIVE SUMMARY	II
1 SCOPE OF WORKS	3
2 BACKGROUND.....	3
2.1.1 Short-range endemic invertebrates.....	3
2.1.2 Categories of short-range endemism	4
2.2 Identification and personnel.....	5
2.3 Taxonomy and nomenclature	6
2.4 Specimen depository	6
3 RESULTS	7
3.1 Summary	7
3.2 Araneae – Araneomorphae (modern spiders).....	8
3.3 Araneae – Mygalomorphae (trapdoor spiders)	8
3.3.1 Barychelidae (Brush-footed Trapdoor Spiders)	8
3.4 Pseudoscorpiones (False scorpions or Pseudoscorpions)	9
3.4.1 Atemnidae.....	9
3.4.2 Cheiridiidae	9
3.4.3 Family Chthoniidae	9
3.5 Chilopoda (Centipedes).....	10
3.5.1 Geophilomorpha (Soil Centipedes).....	10
3.6 Diplopoda (Millipedes).....	11
3.6.1 Spirobolida - Triguniulidae	11
3.7 Isopoda (Slaters)	11
3.7.1 Armadillidae	12
4 REFERENCES.....	12

List of Tables

Table 2-1 Phoenix SRE categories reflecting survey, taxonomic and identification uncertainties.....	5
Table 2-2 Phoenix and external personnel involved in identification	5
Table 2-3 Nomenclatural references, morphospecies designations and reference collections for the invertebrates of Lamb Creek	6
Table 3-1 Status of SRE target invertebrate from Lamb Creek.....	7

List of Appendices

Appendix 1 Short-range Endemic invertebrates identified from Lamb Creek	
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EXECUTIVE SUMMARY

In May 2012, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Rapallo to identify pseudoscorpions, centipedes, millipedes, isopods and spiders collected at Lamb Creek, Western Australia. A total of 18 samples were identified and screened for short-range endemic (SRE) invertebrate taxa. The scorpions delivered to Phoenix will be reported on separately through ScorpionID (E. Volschenk).

There are uncertainties in determining the range-restrictions of many invertebrates in Western Australia due to lack of surveys, lack of taxonomic resolutions within target taxa and problems in identifying certain life stages. To account for these uncertainties Phoenix uses a three-tier categorisation for short-range endemism: confirmed SRE, likely SRE and potential SRE.

The identification material included 11 morphospecies in 11 genera from nine families. These include one likely SRE:

- a slater, *Spherillo* sp. indet. (Armadillidae) – rarely collected in the Pilbara with some troglomorphic features.

The material also included five potential SREs:

- a trapdoor spider, *Synothele* 'MYG255' (family Barychelidae) – currently only known from a single male collected at Lamb Creek; it is recommended to conduct a molecular analysis to compare the COI sequence with the database at the WA Museum
- a pseudoscorpion, *Austrochthonius* 'pilbara' (family Chthoniidae) – this species possibly represents a species complex which may include SREs; currently under revision at the WA Museum (M.S. Harvey)
- a soil centipede, *Geophilomorpha* sp. indet. – taxonomically poorly resolved centipede order; due to high diversity and cryptic lifestyle in moist and deep leaf litter considered potential SREs
- a millipede, *Austrostrophus* sp. indet. (Trigoniulidae) – unidentifiable juvenile; two species are currently known in the genus from the Pilbara one of which is widespread (*A. stictopygus*), the other is a potential SRE (*Austrostrophus* 'DIP018')
- a slater, *Buddelundia* '13' (Armadillidae) – possibly conspecific to specimens collected 80 km west of Newman.

1 SCOPE OF WORKS

In May 2012, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Rapallo to identify spiders, pseudoscorpions, centipede, millipedes and slaters collected at Lamb Creek, Western Australia (project PMI Lamb Creek 13726). A total of 18 samples were identified and screened for short-range endemic (SRE) invertebrate taxa.

2 BACKGROUND

2.1.1 Short-range endemic invertebrates

Short-range endemic fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km², that may also be disjunct and highly localised (Harvey 2002; Ponder & Colgan 2002). The most appropriate analogy is that of an island, where the movement of fauna is restricted by the surrounding marine waters, therefore isolating the fauna from other terrestrial populations. Isolating mechanisms and features such as roads, urban infrastructure, large creek lines and ridges can act to prevent the dispersal and gene flow of the less mobile invertebrate species.

Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 2002):

- **Relictual short-range endemism:** relictual SREs are thought to have had wider distributions during more mesic geological periods. Australia's aridification over the last 60 million years resulted in a contraction of the ranges of these species into relatively small habitat pockets where moist conditions persist (relictual Gondwanan habitats). Evolutionary processes over long periods of isolation typically resulted in each population developing into a distinctive species. Millipedes and slaters are typical relictual SREs and they are generally found in deep gullies often on the south-facing slopes of mountains, hills and ridges. Relictual SREs often inhabit areas with: high rainfall, areas where topography induces fog, areas with permanent water (swamps, creek lines and river systems) or deep litter beds. Sometimes habitats have various combinations of these features.
- **Habitat specialisation:** habitat specialist SREs may have settled in particular isolated habitat types by means of dispersal or phoresy (transport of one organism by another) and evolved in isolation into distinct species. Such habitat islands include rocky outcrops (pseudoscorpions in the genus *Synsphyronus* or spiders in the family Selenopidae are typical examples) or salt lakes (e.g. wolf spiders of the genus *Tetrallycosa*). Unlike relictual SREs in mesic habitats, habitat specialist SREs are restricted by environmental parameters other than humidity and are often found in arid environments such as the Pilbara.

Invertebrate groups that contain SRE taxa are generally well distributed across the Australian landscape and well adapted to semi-arid environments due to a variety of behavioural and morphological features that have developed to avoid desiccation and predation. They generally possess (Harvey 2002):

- poor powers of dispersal
- confinement to discontinuous habitats
- seasonality, i.e. only active in cooler or wetter months
- slow growth
- low levels of fecundity.

2.1.2 Categories of short-range endemism

Currently, there is no accepted system to determine the likelihood that a species is an SRE. The uncertainty in categorising a specimen as SRE originates in a number of factors including:

- **Poor regional survey density** (sometimes taxon-specific): A regional fauna is simply not known well enough to assess the distribution of species. This factor also considers the fact that, simply because a species has not been found regionally, does not mean it is really absent; this confirmation ('negative proof') is almost impossible to obtain ('absence of proof is not proof of absence').
- **Lack of taxonomic resolution:** many potential SRE taxa (based on habitat constraints, SRE status of closely related species, or morphological peculiarities such as troglomorphy) have never been taxonomically treated and identification to species level is very difficult or impossible as species-specific character systems have not been defined. Good taxonomic resolution does not necessarily require a published revision, but generally requires a taxonomist to be actively working on this group or a well-established, preferably publicly available, reference collection (i.e. museum collection).
- **Problems of identification:** SRE surveys often recover life stages of potential SRE taxa that cannot be confidently identified based on morphological characters, even if revisions exist. These include, for example, juvenile or female millipedes, mygalomorph spiders and scorpions. Molecular techniques are increasingly being employed to overcome these identification problems.

Considering these factors of uncertainty, Phoenix currently employs a simple three-tier system to categorise the different probabilities of short-range endemism: confirmed, likely or potential SRE (Table 2-1). These categories are dynamic and can change with every single survey as knowledge of SRE status is updated. For example, the millipede *Austrostrophus stictopygus* Hoffman, 2003 (order Spirobolida) has been shown widespread in the Pilbara based on material collected as part of environmental assessment studies following its initial description from few localities (Harvey *et al.* 2011; Hoffman 2003).

Life stages of species that cannot be identified at the species level, e.g. some females and juveniles, are assessed based on the knowledge of the higher taxon they belong to, i.e. family or genus. For example, all juvenile or female *Antichiropus* millipedes would be classified as 'confirmed SRE' as all but two of the 120+ known species in this genus are currently considered SREs (Wojcieszek *et al.* 2011).

Although the different categories of 'SRE-likelihood' may help to set conservation priorities, SRE taxa of all categories should be assessed on their merit, in order to determine appropriate conservation measures that adhere to the Precautionary Principle within environmental impact assessments. That

is, “where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation” (EPA 2002).

Table 2-1 Phoenix SRE categories reflecting survey, taxonomic and identification uncertainties

SRE category	Criteria	Typical representative
(Confirmed) SRE	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group well represented in collections, in particular from the region in question; high levels of endemism in documented species; inference is often possible from immature specimens	<i>Antichiropus</i> millipedes and araneomorph spiders in the genus <i>Karaops</i> (Selenopidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (i.e. some form of troglomorphism); often singleton in survey and few, if any, regional records	Opiliones, some pseudoscorpions and slaters, many mygalomorph spiders
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners often widespread	Cryptopidae, Geophilida

2.2 IDENTIFICATION AND PERSONNEL

All taxa were examined in 70% or 100% ethanol under a Leica M205A stereomicroscope.

The method of identification for each taxon, i.e. by taxonomic literature or comparison with type or other reference material, is indicated in the taxonomic part of this report. Phoenix personnel involved in the identification are listed in Table 2-2.

Table 2-2 Phoenix and external personnel involved in identification

Name	Qualifications
Dr Volker W. Framenau	M.Sc. (Cons. Biol.), Ph.D. (Zool.)
Dr Erich Volschenk	Ph.D. (Zool.)
Dr Simon Judd	Ph.D. (Zool.) – independent Isopoda taxonomist

2.3 TAXONOMY AND NOMENCLATURE

The taxonomic nomenclature of invertebrates follows the references detailed in Table 2-3.

Morphospecies designations of undescribed species are generally adopted from the systems of the scientist(s) working on the group. For mygalomorph spiders, the Western Australian Museum has established a morphological reference collection of males that aids in the identification of spiders. Morphospecies are numbered consecutively with the prefix “MYG”, e.g. *Aname* ‘MYG001’ (Nemesiidae).

Table 2-3 Nomenclatural references, morphospecies designations and reference collections for the invertebrates of Lamb Creek

Taxonomic group	Taxonomic reference for described species and higher taxa	Morphospecies designation and reference collection
Araneae (Mygalomorphae)	Platnick (2012)	“MYG”-numbering system developed by V.W. Framenau (WAM, Phoenix), reference collection at WAM
Araneae (Araneomorphae: Selenopidae)	Platnick (2012)	Morphospecies designations developed by M. Harvey (WAM) and V.W. Framenau (WAM, Phoenix), reference collection at WAM
Pseudoscorpiones	Harvey (2011a)	“PSE”-morphospecies designations developed by M. Harvey (WAM), reference collection at WAM
Diplopoda (Polydesmida: <i>Antichiropus</i>)	Mesibov (2006)	“DIP”-morphospecies designations developed by C. Car and M. Harvey (WAM), reference collection at WAM
Chilopoda (Geophilomorpha, Cryptopidae only)	Colloff <i>et al.</i> (2005)	Taxonomically poorly studied groups, no reference collection available
Isopoda	Schotte <i>et al.</i> (2008)	Morphospecies designations developed by S. Judd, reference material at WAM

2.4 SPECIMEN DEPOSITORY

The EPA guidance statement No. 20 (*‘Sampling of short-range invertebrate fauna for environmental impact assessment in Western Australia’*) (EPA 2009) recommends that all specimens representing SRE target groups are lodged with the WAM to enhance the knowledge of the distribution of putatively rare species. Phoenix adheres to this recommendation and all of the survey specimens will be lodged with the WA Museum.

3 RESULTS

3.1 SUMMARY

The identification material included 11 morphospecies in 11 genera from nine families (Table 3-1; Appendix 1). These include one likely and five potential SREs.

Table 3-1 Status of SRE target invertebrate from Lamb Creek

Higher taxon	Family	Species	SRE status	Remarks
Araneomorphae (modern spiders)	Zodariidae	Zodariidae sp. indet.	Not SRE	Not SRE target group
Mygalomorphae (trapdoor spiders)	Barychelidae	<i>Aureocrypta</i> 'MYG057'	Not SRE	Widespread in Pilbara
		<i>Synothele</i> 'MYG255'	Potential	Currently only record of species
Pseudoscorpiones (pseudoscorpions)	Atemnidae	<i>Oratemnus</i> sp. indet.	Not SRE	Commonly collected in Pilbara, not considered SRE
	Cheiridiidae	Cheiridiidae sp. indet.	Not SRE	Commonly collected in Pilbara, not considered SRE
	Chthoniidae	<i>Austrochthonius</i> 'pilbara'	Potential	Possibly representing species complex, under revision at WAM
	Olpidae	<i>Beierolpium</i> '8/2' <i>Beierolpium</i> sp. indet.	Not SRE	Commonly collected in Pilbara, not considered SRE
Chilopoda - Geophilomorpha (soil centipedes)	indet.	Geophilomorpha sp. indet.	Potential	Taxonomically poorly resolved
Diplopoda - Spirobolida (millipedes)	Triguniulidae	<i>Austrostrophus</i> sp. indet.	Potential	May represent <i>Austrostrophus</i> 'DIP018', currently considered potential SRE
Isopoda (slaters)	Armadillidae	<i>Buddelundia</i> '13'	Potential	Possibly also found at Wonmunna mining lease
		<i>Spherillo</i> sp. indet.	Likely	Rarely found in the Pilbara

3.2 ARANEAE – ARANEOMORPHAE (MODERN SPIDERS)

With the exception of the Selenopidae (Flat Rock Spiders), modern spiders do not belong to the target groups for SRE surveys and therefore the single male zodariid spider from Lamb Creek (Appendix 1 was not identified beyond family level and is here not commented on).

3.3 ARANEAE – MYGALOMORPHAE (TRAPDOOR SPIDERS)

Trapdoor spiders represent one of the focal groups in surveys of SRE taxa (Harvey 2002). A number of mygalomorph spiders, e.g. *Idiosoma nigrum* Main, 1952, *Kwonkan eboracum* Main, 1983 and *Moggridgea tingle* Main, 1991 are listed on Schedule 1 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2012* (Western Australian Government 2012). The Western Australian mygalomorph fauna is vast and many families and genera remain taxonomically poorly known (e.g. Barychelidae: *Idiommata*; Idiopidae: *Aganippe*; Nemesiidae: *Aname*, *Chenistonia*, *Kwonkan*). A recent molecular study of Pilbara Mygalomorphae based COI sequence data (Helix 2012) provided a new benchmark for diversity estimates in the Pilbara which by far exceeds the species richness of the region documented in during the DEC Pilbara Biological Survey (Durrant *et al.* 2010). Many of these genetic lineages are known from very restricted ranges only (Helix 2012).

3.3.1 Barychelidae (Brush-footed Trapdoor Spiders)

Barychelid spiders, commonly called Brush-footed Trapdoor Spiders, are small to fairly large in size with well-developed claw tufts and short terminal segment of the posterior lateral spinnerets (Raven 1994). Of all trapdoor spiders, few are as cryptic as the Barychelidae. Their burrows tend to be less than 60 cm deep and often lack the firm thick door of the Ctenizidae or the extensive webs of Dipluridae.

In Western Australia, the genera *Aureocrypta*, *Idiommata*, *Mandjelia* and *Synothele* are known to occur from the Southwest region into the Pilbara region and *Moruga* has been found in the Kimberleys (Raven 1994). The DEC Pilbara survey recovered four species of Brush-footed Trapdoor Spiders in three genera, of which *Synothele* was with four species most diverse (Durrant *et al.* 2010). However, a recent molecular study on Pilbara Barychelidae uncovered a 20 different molecular lineages (putative species) within the family suggesting a much higher diversity in the region; many of these species appear to have restricted ranges (Helix 2012).

3.3.1.1 Genus *Aureocrypta*

Aureocrypta males are very similar to those in the genus *Synothele* but differ in the uniformly dark colour of the abdomen (mottled in *Synothele*) and some details of the male pedipalp. Two species are currently described, both only known from Western Australia, *A. katersi* and *A. lugubris* (Raven 1994).

***Aureocrypta* 'MYG057'**

Aureocrypta 'MYG057' is not uncommon throughout the Pilbara region of Western Australia (WA Museum database). It is not an SRE.

3.3.1.2 Genus *Synothele*

The genus *Synothele* can be identified by the low number of maxillary cuspules in combination with the lack of lyra (specialised clubbed setae) on the maxillae, and the often mottled abdomen

(uniformly dark in the similar *Aureocrypta*). The genus is widespread throughout Western Australia (21 species) and South Australia (3 species) with most species known only from very limited ranges (Raven 1994).

***Synothele* 'MYG255'**

Synothele 'MYG255' is a fairly large species within the genus. It is the first representative of this new morphospecies in the WA Museum reference collection. Based on the distribution patterns of the genus in the Pilbara, it is considered a potential SRE. It is recommended to conduct molecular identification against the mygalomorph COI sequence database of the WA Museum to expand the knowledge of the distribution of this species.

3.4 PSEUDOSCORPIONES (FALSE SCORPIONS OR PSEUDOSCORPIONS)

Pseudoscorpiones resemble scorpions in that they possess a pair of long pedipalps with pincers which are directed forward; however, they do not possess the tail or a sting of scorpions. Most species are small to very small in size (most species are less than 1 cm long) (Harvey & Yen 1989). Pseudoscorpions can be found inhabiting a wide variety of habitats including leaf litter, soil, under the bark of trees, under stones, and in rock crevices (Harvey & Yen 1989; Main 1985). In Western Australia, 17 families of pseudoscorpions have been recorded to date (Harvey 2011a). The group contains several SRE species, for example species in the genus *Synsphyronus* (family Garypidae) are often habitat specific SREs on rocky outcrops (Harvey 2011b).

3.4.1 Atemnidae

Atemnids are frequently found under bark of trees in Western Australia, but the systematics of the group, particularly of the genus *Oratemnus*, is uncertain and the taxonomy of individual species unclear (M Harvey personal communication). However, based upon current evidence, it seems that most species will eventually be found to be widely distributed. For this reason, the specimen collected at Lamb Creek is not considered an SRE.

3.4.2 Cheiridiidae

The systematic status of the many populations of Cheiridiidae is currently unknown but it is very unlikely that any represent short-range endemic species (M Harvey personal communication).

3.4.3 Family Chthoniidae

Members of the Chthoniidae are small pseudoscorpions with comparatively large chelicerae. Five indigenous genera have been reported from Australia, and each is widespread (Edward & Harvey 2008). Chthoniidae are especially common in leaf litter and under rocks in high rainfall areas of eastern and south-western Australia.

3.4.3.1 Genus *Austrochthonius*

Species of *Austrochthonius* occur in leaf litter and soil environments throughout much of southwestern Australia, as well as subterranean ecosystems in Cape Range and near Busselton (Harvey 1991; Harvey & Mould 2006). The taxonomy of the Western Australian species is not resolved but there are clearly several species represented in the collections of the WA Museum. Recent molecular analyses showed deep genetic divergences within the genus, but this is not reflected in their morphology and species identification is extremely difficult. The genus

Austrochthonius is currently under revision at the Western Australian Museum (M. Harvey personal communication).

***Austrochthonius* 'pilbara'**

Austrochthonius 'pilbara' is currently poorly defined and may consist of a group of species. It is currently considered a potential SRE.

3.4.3.2 Olpiidae

Systematically, the Olpiidae are poorly defined and lack any uniting characters (Harvey 1992; Murienne *et al.* 2008). In Australia, six genera in the family are listed with valid species, *Austrohorus*, *Beierolpium*, *Euryolpium*, *Linnaeolpium*, *Olpium* and *Xenolpium* (Harvey 2011a). Olpiids are mostly found in xeric habitats, under stones, bark and in leaf litter and frequently belong to the most commonly collected pseudoscorpions in surveys for SRE in these habitats in Western Australia. Most species, as those from the genus *Beierolpium* found at Lamb Creek (Appendix 1) are generally widespread and not considered SREs, although some genera or species may be range-restricted, in particular in subterranean habitats (Harvey & Leng 2008).

3.5 CHILOPODA (CENTIPEDES)

The centipedes represent a diverse group of predatory arthropods. Each pair of legs is attached to a separate body segment which distinguishes this class from the millipedes (Diplopoda; two pairs of legs per segment) (Colloff *et al.* 2005). Adult body length ranges from 4 to 300 mm, with most species measuring 10 to 100 mm long. In most cases, they feed on small live arthropods and other invertebrates, although large scolopendromorphans can take vertebrate prey (Edgecombe & Giribet 2007).

All five orders of centipedes can be found in Australia, of which one, the Craterostigmomorpha, only occurs in Tasmania and New Zealand (Colloff *et al.* 2005). Scolopendromorpha and Scutigermomorpha (house centipedes) are the most commonly encountered centipedes in WA. Most species are very fast runners and are highly mobile and therefore, widespread (e. g. Edgecombe & Barrow 2007; Edgecombe & Giribet 2009; Koch 1982, 1983a, b, c; Waldox & Edgecombe 2012). Therefore, they are not considered target groups for SRE surveys. In contrast, Geophilomorpha, Lithobiomorpha and the Cryptopidae (within the Scolopendromorpha) may include Gondwanan refugial SREs based on the habitat preference for moist and deep leaf litter. Geophilomorpha and Cryptopidae have also been found in subterranean environments in the Pilbara where they are limited to very small ranges (e. g. Edgecombe 2005).

3.5.1 Geophilomorpha (Soil Centipedes)

With more than 1,200 described species world-wide, the Geophilomorpha are the most diverse centipede order (Bonato 2011). Their body is conspicuously narrow and elongate, with at least 33 segments (27 to 191 pairs of legs). Thirteen families are known world-wide, of which six are known to occur in Australia, Ballophilidae, Chilenophilidae, Geophilidae, Mecistocephalidae, Oryidae and Schendylidae (Colloff *et al.* 2005). Most recent taxonomic additions to the WA fauna included the description of the genus *Australoschendyla* (family Schendylidae) (Jones 1996) and a new species in the genus *Tuoba* (family Geophilidae) ((Jones 1998).

The taxonomy of the Geophilomorpha is poorly resolved and it is currently impossible to identify the specimen beyond order level. Based on their high diversity in combination for the preference for

moist, deep litter habitats, all undescribed representatives of the Geophilomorpha are here considered potential SREs.

3.6 DIPLOPODA (MILLIPEDES)

The Australian millipedes are poorly studied and biogeographic patterns remain largely unresolved (Black 1997; Shelley & Golovatch 2011). At least eight orders of millipedes are native to Australia; all species in the order Julida are introduced (Mesibov 2006). Millipedes belong to one of the main target groups of SRE surveys. SREs are particularly expected within the orders Sphaerotheriida (rolling millipedes), Polydesmida, and Chordeumatida (not known from WA) (EPA 2009; Harvey 2002). A recent review of Australian *Atelomastix* (order Spirostreptida) found all of 29 species treated were SREs (Edward & Harvey 2010).

3.6.1 Spirobolida - Triguniulidae

The millipede family Triguniulidae represents a conspicuous element of the Southeast Asian and Indonesian faunas where 21 genera are recognised (Hoffman 2003). In Australia, however, the group has few representatives, including two monotypic genera from WA, *Austrostrophus* and *Speleostrophus* (Hoffman 1994, 2003). *Speleostrophus nesiotus*, endemic to caves on Barrow Island, was gazetted on 11 April 2003 under the WA *Wildlife Conservation Act 1950* as a Schedule 1 species. It is the only Australian native millipede on a State endangered list (Mesibov 2006).

3.6.1.1 Genus *Austrostrophus*

The genus *Austrostrophus* was described only fairly recently and includes a single species, *A. stictopygus* (Hoffman 2003). This millipede has been described as a “curious and disjunct spiroboloid” (Hoffman 2003), based on unusual morphological features such as structure of the male gonopods, punctuate paraprocts (anal segments) and fringed edge on the metazonum (posterior unit of segments). Punctuate paraprocts are otherwise only present in the eastern state genus *Ainigmabolus* (Hoffman 2003)

At the time of its description, *A. stictopygus* was thought to have a very narrow distribution and was only known from the Burrup Peninsula. Recent surveys as part of resource developments in the Pilbara have shown that the species is widespread throughout the region (Harvey *et al.* 2011).

***Austrostrophus* sp. indet.**

The specimen submitted for identification was a juvenile and could not be identified to species level. It is possible that it represents a second undescribed species known in addition to *A. stictopygus*, namely *Austrostrophus* ‘DIP018’ collected from two localities in the southeastern Pilbara and currently considered a potential SRE. Consequently, *Austrostrophus* sp. indet. from Lamb Creek is here also considered a potential SRE.

3.7 ISOPODA (SLATERS)

Almost 200 described species of Oniscidea, a suborder of the Isopoda containing the supralittoral, terrestrial and secondarily aquatic slaters (or woodlice), have been recorded from Australia (DSEWPC 2010). The WA fauna is comparatively poorly known with many undescribed species (Judd & Horwitz 2003). Slaters are an ideal biological model for faunistic and biogeographical studies, due to their reduced dispersal ability and narrow habitat preferences (e.g. Taiti & Argano 2009). Consequently, they belong to one of the target groups of SRE surveys (EPA 2009; Harvey 2002).

3.7.1 Armadillidae

Armadillidae typically have a convex dorsal surface and the animal can roll up into a ball. The family is diverse in Australia, currently 24 genera are described; many species live in litter or under wood and stones in forest or woodland or near the coast (Green *et al.* 2010).

3.7.1.1 Genus *Buddelundia*

Members of the genus *Buddelundia* belong to the most common terrestrial isopods in WA and the genus was well represented in the Rail Corridor. The genus is currently under taxonomic revision by S. Judd. Species of *Buddelundia* often have a very wide distribution and are not expected to have many SRE species (S. Judd personal communication).

***Buddelundia* '13'**

Buddelundia '13' represents a small species-complex of highly convex habit that is restricted to the Pilbara. This species was previously collected at the Wonmunna mining lease 80 km west of Newman (Phoenix 2011). However, the single specimen collected here is not fully mature so a determination is tentative. It is considered a potential SRE (S. Judd personal communication).

3.7.1.2 Genus *Spherillo*

***Spherillo* sp. indet.**

Isopods of the type here collected are only tentatively associated with the genus *Spherillo*. They almost certainly belong to a different, unnamed genus (S. Judd personal communication). There have been very few specimens of this genus collected in the Pilbara, but species diversity appears high. They have some troglobitic characteristics (e.g. reduced eyes and lack of pigment). This genus was also collected at Wonmunna (Phoenix 2011) but both clearly represent different species. It is extremely rare to find these armadillids among the epigeal isopods of the Pilbara and they are therefore considered likely SREs (S. Judd personal communication).

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Appendix 1 Short-range Endemic invertebrates identified from Lamb Creek

Field No.	Order	Family	Genus and species	♂♂	♀♀	Juv.	total
XREF PMI Lamb 06	Araneae	Zodariidae	Zodariidae sp. indet.	1			1
XREF PMI Lamb 05		Barychelidae	<i>Aureocrypta</i> 'MYG057'	1			1
XREF PMI Lamb 02		Barychelidae	<i>Synothele</i> 'MYG255'	1			1
XREF PMI Lamb 19	Pseudoscorpiones	Atemnidae	<i>Oratemnus</i> sp. indet.		1		1
XREF PMI Lamb 33		Cheiridiidae	Cheiridiidae sp. indet.		1		1
XREF PMI Lamb 39		Chthoniidae	<i>Austrochthonius</i> 'pilbara'			1	1
XREF PMI Lamb 20		Olpiidae	<i>Beierolpium</i> '8/2'			1	1
XREF PMI Lamb 21		Olpiidae	<i>Beierolpium</i> '8/2'		1		1
XREF PMI Lamb 17		Olpiidae	<i>Beierolpium</i> '8/3'		1		1
XREF PMI Lamb 30		Olpiidae	<i>Beierolpium</i> sp. indet.			1	1
XREF PMI Lamb 32		Olpiidae	<i>Beierolpium</i> sp. indet.			1	1
XREF PMI Lamb 22		Olpiidae	<i>Beierolpium</i> sp. indet.			1	1
XREF PMI Lamb 31		Olpiidae	<i>Beierolpium</i> sp. indet.			1	1
XREF PMI Lamb 38		Geophilomorpha		Geophilomorpha sp. indet.			
XREF PMI Lamb 37	Spirobolida	Triguniulidae	<i>Austrostrophus</i> sp. indet.			1	1
FLAGM2	Isopoda	Armadillidae	<i>Buddelundia</i> '31'			1	1
STABM2		Armadillidae	<i>Spherillo</i> sp. indet.	1			1



Lamb Creek Scorpion Identification Report

Report ID: RA.LC.2012.05

Prepared for: Rapallo

By Dr Erich S. Volschenk

Saturday, 30 June 2012

Rapallo is undertaking a short-range endemic survey at Lamb Creek, and has requested:

- Taxonomic identifications of scorpion from the survey;
- SRE assessment of the species represented in the collection, and;
- Lodgement of these specimens in the Western Australian Museum Arachnology Collection

The collection is comprised of 13 samples.

FAMILY: Buthidae CL Koch, 1837

The family Buthidae is the most diverse and wide spread of all scorpion families (Fet & Lowe 2000). In Australia, Buthidae is represented by the genera *Australobuthus* Locket; *Isometrus* Ehrenberg; *Isometroides* Keyserling, *Lychas* C.L. Koch, and *Hemilychas* Hirst. In Western Australia, only the genera *Isometrus*, *Isometroides* and *Lychas*, have been recorded. The taxonomy of the constituent species of *Isometrus*, *Isometroides* and *Lychas* is very problematic and each genus contains numerous undescribed species, most notably in the genus *Lychas* (Volschenk unpublished data). Most Authors refer to LE Koch (1977) for keys and identification. That revision represents an important study of the Australian scorpions; however, several taxonomic decisions made by Koch (1977) have been rejected by subsequent authors and the taxonomy in that publication is not up to date. Most Australian buthid species appear to have wide distributions; however, a few taxa have confirmed SRE distributions (Volschenk unpublished data).

GENUS: *Lychas* CL Koch, 1845

The genus *Lychas* is widespread across the Australian mainland. The taxonomy of this genus is problematic, with numerous undescribed species known in Australia (Volschenk *et al.* 2010). The situation is further complicated with the genus being also represented in Africa, India and eastern Asia (Fet & Lowe 2000). All of the Australian species are endemic and are currently under revision by ES Volschenk. Most species of *Lychas* appear to have wide distributions; however, a small number of undescribed species are known to be SRE's.

Species: *Lychas* 'harveyi' Morphospecies

SRE STATUS

Lychas 'harveyi' is not an SRE.

TAXONOMIC RESOLUTION

Lychas 'harveyi' is a well-defined and clearly recognised morphospecies.

DISTRIBUTION

Lychas 'harveyi' is a widespread species. Records are known from the Midwest and Pilbara regions of Western Australia where it is one of the most common scorpion species.

RECOMENDATIONS

Lychas 'harveyi' is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
T114305	S13	2	0	0	Newman, ca. 120 km NW	
T114315	S16	0	1	0	Newman, ca. 120 km NW	
T114317	S14	1	0	0	Newman, ca. 120 km NW	
T114316	S12	0	1	0	Newman, ca. 120 km NW	
T114307	S11	1	0	0	Newman, ca. 120 km NW	
T114308	S10	1	0	0	Newman, ca. 120 km NW	
T114314	S08	0	1	0	Newman, ca. 120 km NW	
T114310	S07				Newman, ca. 120 km NW	
T114311	S01	0	1	0	Newman, ca. 120 km NW	

Number of samples: 9

Species: *Lychas* 'pilbara1' Morphospecies

SRE STATUS

Lychas 'pilbara1' is not an SRE.

TAXONOMIC RESOLUTION

Lychas 'pilbara1' is a well-defined and clearly recognised morphospecies.

DISTRIBUTION

Lychas 'pilbara1' has been recorded throughout the Pilbara region of Western Australia. Despite being widespread, it appears to have a very patchy distribution and is never common.

RECOMENDATIONS

Lychas 'pilbara1' is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
T114312	S15	2	0	0	Newman, ca. 120 km NW	
T114306	S13	0	0	0	Newman, ca. 120 km NW	
T114313	S09	1	0	0	Newman, ca. 120 km NW	

Number of samples: 3

FAMILY: Urodacidae Pocock

The family Urodacidae is endemic to Australia (Fet 2000; Prendini 2000; Prendini 2003; Volschenk *et al.* 2000) where it is represented by the genera *Urodacus* Peters, 1861 and *Aops* Volschenk and Prendini, 2008.

GENUS: *Urodacus* Peters, 1861

Urodacus has been considered a member of the family Scorpionoidea for many years, but in a revision of the superfamily Scorpionoidea Latreille, Prendini (Prendini 2000) placed *Urodacus* in its own family. Unlike the species designations for Buthidae, LE Koch's (Koch 1977) species' of *Urodacus* have been mostly supported by subsequent authors (Harvey & Volschenk 2002; Volschenk & Prendini 2008; Volschenk *et al.* 2000). The biggest issue confronting *Urodacus* taxonomy is the number of undescribed species being uncovered through current revisionary work (Volschenk unpublished data). Currently 23 species of *Urodacus* are described; however, this may represent as little as 20% of the real diversity of this genus in Australia. *Urodacus* appears to be most diverse in Western Australia and few species are recorded east of the Great Dividing Range in eastern Australia. *Urodacus* contains both widespread and SRE species. During a large-scale survey of the Pilbara fauna, Volschenk, et. al. (Volschenk *et al.*) recorded nine undescribed species and only one formerly describes species were reported in that study.

Species: *Urodacus* sp. indet.

SRE STATUS

Urodacus sp. indet. undetermined SRE status.

TAXONOMIC RESOLUTION

Urodacus sp. indet. specimen/s could not be identified owing to incorrect sex and/or life history stage.

DISTRIBUTION

Urodacus sp. indet. cannot be defined as this is not a clear species. See comments for the genus.

RECOMENDATIONS

Urodacus sp. indet. management is impossible since it is not clear which species this is.

WAM Rego.	Client Rego.	♂	♀	Juv.	Location	Notes
T114309	S10	0	0	1	Newman, ca. 120 km NW	

Number of samples: 1

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