Report No. J020348

Detailed vertebrate fauna survey of the Lamb Creek project

Prepared for: Mineral Resources Limited
Date: 24 January 2022

Rapallo Environmental is a Western Australian consultancy with a strong reputation for technical excellence, client-focus and innovation. We build long-term alliances through outstanding delivery on a range of services to the resource sector, government and associated industries.

ENVIRONMENTAL | ENGINEERING | CONSTRUCTION & OPERATIONS *NDT & Inspections* | MINING | RESOURCE MANAGEMENT

Report No. J020348
Detailed vertebrate fauna survey of the Lamb Creek project
Prepared for Mineral Resources Limited
24 January 2022

Revision	Date	Prepared	Reviewed	Approved
Internal Review	25/09/2020	Jon-Paul Emery	Marieke Weerheim	Marieke Weerheim
Draft Report – V1	19/11/2020	Marieke Weerheim	Kate George	Kate George
	04/02/2021		Sarah Osborne (MRL)	
Draft Report – V2	18/11/2021	Kate George	Marieke Weerheim Carl Paton (MRL)	Marieke Weerheim
Final	24/01/2022	Marieke Weerheim	Kate George Carl Paton (MRL)	Kate George

Rapallo Group
Perth Office
10 Elmsfield Road, Midvale WA 6056
Phone: (08) 6279 0900
Fax: (08) 6279 0934

Kalgoorlie Office
10 Broadwood Street, West Kalgoorlie 6430
Phone: (08) 9460 4300
Fax: (08) 9226 2388
PO Box 1123 Kalgoorlie

ABN: 31 726 506 590
ACN: 009 257 836
www.rapallo.com.au

This document has been prepared based on assumptions as reported throughout and upon information and data supplied by others.

While Rapallo Pty. Ltd. has taken all reasonable care to ensure the facts and opinions expressed in this document are accurate, it does not accept any legal responsibility to any person for any loss or damage suffered by him or her resulting from his or her use of this report however caused and whether by breach of contract, negligence or otherwise. The client has requested not to include impact assessment or survey recommendations in this report. Targeted surveys for conservation significant fauna including ghost bat and northern quoll were outside of the scope.

Table of Contents

Tables

Figures

Appendices

Executive summary

The Lamb Creek Iron Ore Project comprises a proposed mining area and an associated haul road, located approximately 130 kilometres north-west of Newman in the Pilbara region of Western Australia.

This report documents the findings of a desktop assessment and two field surveys (April 2020 and February 2021), that were conducted to identify the occurrence of vertebrate fauna species, and their supporting habitats, within the survey area.

Survey Area

The survey area was 1645 hectares (ha) in size. It comprised retention licence R47/19 the proposed haul road corridor within miscellaneous licence L47/736 and an alternative haul road section named 'intersection version B'.

An earlier survey of the Lamb Creek project was completed by Rapallo in 2012. That survey covered the same retention licence (R47/19), as well as two haul road options: a northern and a southern route. The 2012 northern route overlaps with 44% of the current haul road corridor. The 2012 southern route has been discounted as an option.

The Lamb Creek project area has been updated and expanded since the survey was completed. The current project area (as per December 2021) comprises retention licence R47/19 (pending conversion into mining lease M47/1592) and miscellaneous licences L47/736, L47/974, and L47/1008. Together these tenements cover an area of 2199 hectares. There is significant overlap between the tenements (Figure 1.1) hence this number is not cumulative. The fauna survey covered 1644 hectares (75%) of the current project area.

A proposed disturbance footprint (footprint V1) was provided by MRL prior to the survey in March 2020. This footprint formed the basis for site selection and survey planning. Footprint V1 has been superseded by footprint V3, which was provided by MRL in December 2021 after all fieldwork had been completed. Footprint V3 extends by 24 hectares (4% of footprint) outside of the survey area, most of which comprising the southern end of the proposed haul road.

Desktop

The region has had considerable survey effort over the last 20 years predominantly due to vertebrate fauna surveys completed within, or partly within, the boundary of the Mining Area C (MAC) Development Envelope. The MAC Development Envelope is approximately 10 kilometres south of the Lamb Creek retention licence (R4719). Mining Area C contains the same land systems as the Lamb Creek survey area and has similar habitats.

Lamb Creek was surveyed for vertebrate fauna in 2012, over a survey area that partially overlaps with the current project area. The detailed survey effort consisted of ten trap sites with a total trap effort of 2982 trap nights (pitfalls, Elliots and funnel traps). Cameras and cages were deployed for 182 camera nights and 300 cage trap nights respectively within gorges and the faces of rocky escapements. Other activities included spotlighting, habitat assessment, foraging , systematic bird survey and bat survey.

The desktop study identified 301 species of terrestrial vertebrate fauna recorded within 50 kilometres of the survey area. These included 157 birds, 46 mammals, 91 reptiles, and 7 amphibians. Not all species are likely to occur in the survey area due to the large search extent of the desktop assessment.

Additionally, many species tend to be patchily distributed even where appropriate habitats are present, and many species of birds can occur as regular migrants, occasional visitors or vagrants.

Discounting species listed as marine, the fauna desktop study identified 29 taxa of conservation significant fauna of which twelve were assessed as possible, likely, or confirmed to occur on the survey area. The remaining seventeen species identified by the desktop assessment were considered unlikely to highly unlikely occur in the survey area based on the absence of suitable habitat for the species and/or the survey area occurring well outside the known distribution of the species.

Field Survey

A detailed vertebrate fauna survey was completed by Rapallo over a period of 15 days from 16 to 28 April 2020, with supplementary field work occurring between 16 and 23 February 2021.

Survey work completed in 2020 included: ground truthing the 2012 broad fauna habitat mapping, systematic trapping, systematic bird surveys, foraging, opportunistic records, and deployment of SM4 recorders for night parrot and bats.

Survey effort consisted of 10 trap sites with a total trap effort of 3080 trap nights (pitfalls, Elliots and funnel traps). Cameras were deployed for 279 camera nights within the gorge, gully, breakaway habitat that occurs within the higher elevation areas of the retention licence and ranges adjacent to the proposed haul road corridor.

The survey area has experienced several fires over the past decade. Trap site locations were selected to cover the major (preliminary) habitats of the survey area and where possible trap sites were positioned in pockets of unburnt habitat within the burn mosaic.

Field survey activities for short range endemic invertebrates (SRE) included collection of invertebrate by-catch from pitfall traps, habitat assessment, foraging, and leaf litter sifting. SRE is reported in a standalone report (Rapallo 2022).

Supplementary survey work completed in 2021 included: fauna habitat assessment in order to update the 2012 habitat mapping, and a wet season deployment of SM4 recorders at caves in which ghost bat occurrence, or evidence of occurrence, was recorded in 2012 and 2020.

The field survey recorded 128 species of vertebrate fauna, including 63 bird species, 20 mammal species, 44 reptile species, and one frog. Combined with the 2012 fauna survey results, the total number of vertebrate fauna recorded from the Lamb Creek project area to date is 185 species.

Five species of vertebrate fauna listed as conservation significant under either the Western Australian *Biodiversity Conservation Act 2016* (BC Act) and/or the federal *Environment Protection and Biodiversity Conservation Act 1950* (EPBC Act) or ranked as a priority species by the Department of Biodiversity Conversation and Attractions (DBCA) have been recorded from or proximal to the Lamb Creek project area to date. These are listed below:

- Northern quoll (*Dasyurus hallucatus*) listed Endangered under both the EPBC Act and BC Act – Confirmed, recorded in 2012.
- Ghost bat (*Macroderma gigas*) listed Vulnerable under both the EPBC Act and the BC Act – Confirmed, recorded in 2012, 2020 and 2021.
- Western pebble-mound mouse (*Pseudomys chapmani*) DBCA Priority 4 – Confirmed, mounds recorded throughout the Lamb Creek survey area in 2012 and 2020.

- Fork-tailed Swift (*Apus pacificus*) listed migratory and marine under the EPBC Act – Confirmed, recorded in 2012.
- Pilbara olive python (*Liasis olivaceus barroni*) listed Vulnerable under both the EPBC Act and the BC Act – Confirmed, recorded in 2012.

A further three species of conservation significance were considered likely to occur within the survey area. These were peregrine falcon (*Falco peregrinus* – listed Other Specially Protected Fauna under the BC Act), Gane's blind snake (*Anilios ganei* –DBCA Priority 1), and Pilbara barking gecko (*Underwoodisaurus seorsus* – DBCA Priority 2).

Four species of conservation significance were regarded as possible to occur within the survey area. These were night parrot (*Pezoporus occidentalis* – listed Critically Endangered under the BC Act and Endangered under the EPBC Act), grey falcon (*Falco hypoleucos* – listed Vulnerable under both the EPBC Act and the BC Act), letter-winged kite (*Elanus scriptus* – DBCA Priority 1), and the short-tailed mouse (*Leggadina lakedownensis* – DBCA Priority 4).

Night parrot was not detected via acoustic recorder in 2020. Much of the spinifex across the survey area has been frequently burnt and habitats of the survey area do not include mosaics with samphire and chenopod shrublands, salt lake margin, or paleochannel.

The remaining seventeen species identified by the desktop assessment were considered unlikely to occur within the survey area.

Habitat

Habitat mapping was updated from the 2012 vertebrate fauna habitat assessments utilising aerial imagery, vegetation, topographical, land system and drainage mapping, and habitat data collected in February 2021. Seven broad fauna habitat types were identified within the survey area. These were, in decreasing order of extent; Stony plain, Hillcrest/hillslope, Mulga/corymbia plain, Minor drainage, Tussock grassland plain, Medium drainage and Gorge, gully and rocky breakaway. Additionally, a small portion of the survey area comprised cleared areas.

Within the survey area, the Gorge, gully, and rocky breakaway habitat was considered to be of high significance for vertebrate fauna as this habitat supports species of conservation significance (including nationally listed threatened species) or contains core habitats for such species. Five habitats were ranked as of moderate significance (Hillcrest/hillslope, Mulga/corymbia plain, Minor drainage, Tussock grassland plain, Medium drainage) and the remaining habitat (Stony plain) was ranked as low significance, as it is widespread in the surrounding region and species of conservation significance are exclusively dependent on this habitat.

Habitat Features

To date, no permanent or semi-permanent pools have been recorded from the Lamb Creek project area, despite extensive use of helicopters in 2012, 2020 and 2021 for baseline flora and fauna surveys.

There are five known caves on or proximal to the survey area in which ghost bat occurrence, or evidence of occurrence, has been recorded. These caves were surveyed as part of detailed fauna work, or sampled opportunistically during an SRE survey. To date, no targeted surveys or detailed cave/roost assessments have been completed at the Lamb Creek project.

Cave 1 is provisionally assigned as a Category 2 roost while Caves 2 and 3 are provisionally Category 3. Caves 4 and 5 are known Category 3 and 2 roosts, respectively, and occur nearby to a number of other

caves, shelters and overhangs identified in the desktop. Caves that are confirmed as Category 2 and groupings of caves that surround them are critical Ghost bat habitat.

Cave 1 and Cave 3 are located in the retention licence (R47/19) within respectively 325 meters and 600 meters from the proposed December 2021 disturbance footprint (footprint V3). Caves 4 and 5 are within approximately 200 meters of the disturbance footprint (haul road) in L47/713.

1 Introduction

1.1 Project overview

Mineral Resources Limited (MRL) is actively exploring the Pilbara region. The Lamb Creek project comprises a proposed mining and exploration area and an associated haul road alignment. The project is located approximately 130 kilometres north-west of Newman in the Pilbara region of Western Australia.

Rapallo Environmental (Rapallo) was commissioned by MRL to complete a single-phase detailed (Level 2) vertebrate fauna survey of the Lamb Creek project. The field survey was completed in April 2020, with supplementary data collected in February 2021. The size and extent of the survey area is outlined in section 1.3 below.

The project area as well as the proposed footprint have undergone several changes since the fauna survey was completed. The current Lamb Creek project area (as per December 2021) comprises retention licence R47/19 (pending conversion into mining lease M47/1592) and miscellaneous licences L47/736, L47/974, and L47/1008. Together these tenements cover an area of 2199 hectares. There is significant overlap between the tenements (Figure 1.1) hence this number is not cumulative.

1.2 Scope and objectives

The scope of the detailed vertebrate fauna survey was to:

- Complete a desktop study in order to understand the regional fauna assemblage and habitats, and to identify conservation significant vertebrate fauna which may occur in the survey area.
- Review previous 2012 survey results against the most recent desktop information, and verify current taxonomy and conservation status of relevant fauna and ecological communities.
- Complete a detailed (Level 2) fauna survey over the survey area to identify the fauna assemblage of the survey area.
- Refine previous 2012 fauna habitat mapping of the survey area and to extend fauna habitat mapping into the areas not covered by the 2012 fauna survey.

1.3 Survey area and project history

A detailed fauna survey was completed in April 2020, with supplementary data collected in April 2021. The survey area was 1645 hectares in size, comprising retention licence R47/19 (1200 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). The survey area is mapped in Figure 1.2.

An earlier detailed fauna survey was completed in March-April 2012 (Rapallo 2012a) over an area that partially overlaps with the current survey area. The 2012 survey area is also outlined in Figure 1.2. Two fires have burnt across the project area in 2015 and 2017 (NAFI 2021), which have altered vegetation composition and structure (Rapallo 2021a). One of the aims of the current fauna survey (section 1.2) was to ground-truth and refine the 2012 fauna habitat mapping.

The project area has changed since the survey was completed, with tenements L47/974, L47/1008 and M47/1592 added in December 2021, expanding the project area. Hence, the fauna survey covered 1220 hectares (75%) of the current project area, with 555 hectares (25%) unsurveyed (Figure 1.2).

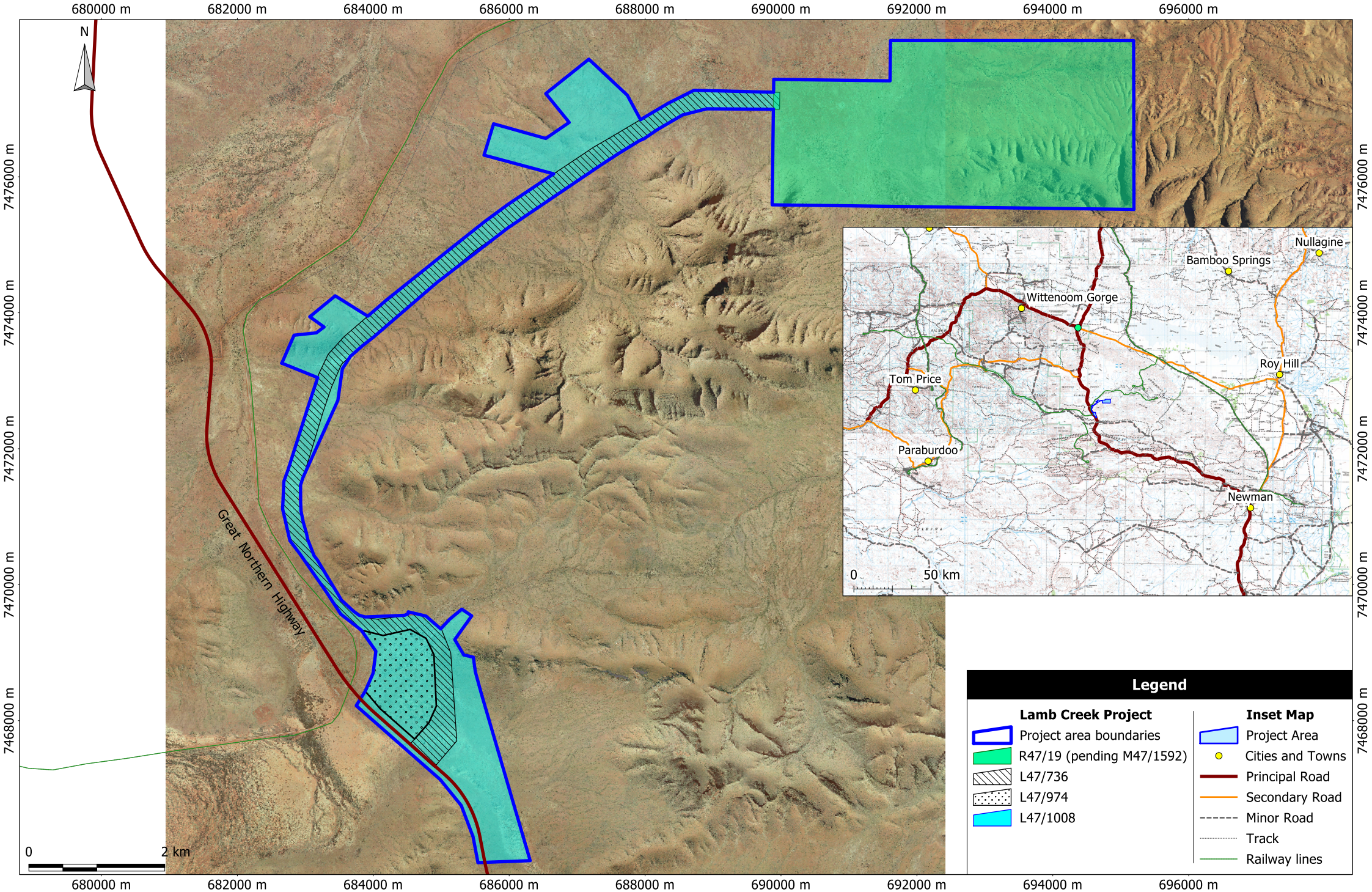
A proposed disturbance footprint (footprint V1) was provided by MRL in March 2020, and this footprint formed the basis for survey planning and site selection. Two new footprints were provided since the surveys were completed. The current footprint V3 (657 hectares) extends outside the survey area by 24 hectares (4% of total footprint), with most of the unsurveyed area comprising the southern section of the proposed haul road (Figure 1.2).

1.4 Definitions

To aid interpretation of this report and associated mapping, Table 1.1 provides explanation of the various components of the Lamb Creek project and associated survey areas, as mapped in Figure 1.1.

Table 1.1 Project and survey area definitions

Component	Description
Project area	Project area as per December 2021, comprising tenements R47/19 (pending M47/1592), L47/736, L47/974, and L47/1008. The project area has a total size of 2199 hectares. There is significant overlap between the tenements, so this number is not cumulative.
Survey area	Area covered by the detailed fauna survey in 2020, comprising R47/19, L47/736 and intersection version B, with a combined area of 1645 hectares.
Resource area	General description of R47/19 (pending M47/1592) in which the proposed mine pit and associated infrastructure will be located, as well as the northernmost section of the proposed haul road.
Haul road corridor	General description of the area in L47/736 in which most of the proposed haul road will be located.
Great Northern Highway intersection (GNHI)	General name given to the area where the proposed haul road intersects the Great Northern Highway.
Footprint V1	Proposed disturbance footprint provided by MRL in March 2020 which formed the basis for survey planning and site selection.
Footprint V2	Revised disturbance footprint provided by MRL in July 2021, which has now been superseded by footprint V3.
Footprint V3	Revised disturbance footprint provided by MRL in December 2021 and used to describe localities of recorded target species and potential impacts.
Adjacent to footprint V3	Within 100 metres of the December 2021 disturbance footprint (footprint V3).
Targeted survey	The combined surveys of April 2020 and May 2021.
Intersection version B	An alternative haul road section of 58 hectares, located adjacent to the Great Northern Highway. It currently falls within L47/974 which was not yet defined at the time of the survey.
Lamb Creek 2012 survey area	Area covered by the 2012 detailed (Level 2) fauna survey completed over the Lamb Creek project area as it was defined then. It incorporated the current R47/19 and two potential haul road corridors: a northern and a southern route. The southern route has since been discounted as an option, and the northern route has been partially realigned and overlaps with parts of the current haul road corridor in L47/736.



Rapallo environmental

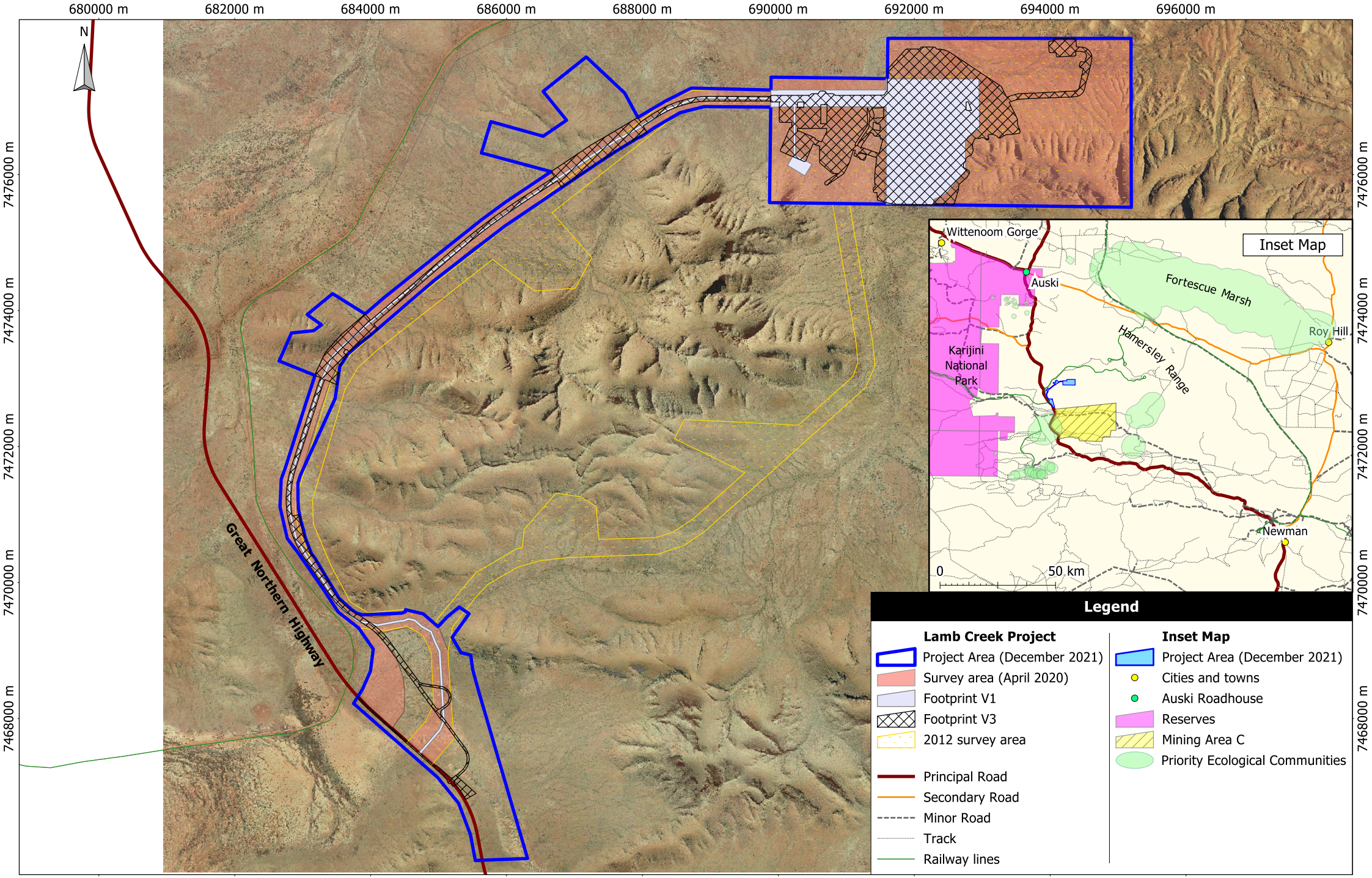
Mineral Resources Limited
Lamb Creek Project

Lamb Creek Iron Ore Project
Detailed Vertebrate Fauna Survey

Original Size: A4 Scale: 1:70,000
Datum: MGA94 Zone 50
0 2 km

Figure 1.1

Tenements of the Lamb Creek Iron Ore project area as per December 2021



Rapallo environmental

Mineral Resources Limited
Lamb Creek Project

Lamb Creek Iron Ore Project
Detailed Vertebrate Fauna Survey

Original Size: A4 Scale: 1:70,000
Datum: MGA94 Zone 50
0 2000 m

Figure 1.2

Location of the Lamb Creek project and delineation of the survey area

2 Regional context

2.1 Climate and weather

The Lamb Creek project is situated in the Hamersley subregion (PIL03) of the Pilbara IBRA region, which is part of the Eremaean province (Beard 1990). The climate of the Hamersley IBRA subregion (PIL03) is described as semi-desert tropical. The average rainfall is 300 millimetres per year, usually in summer cyclonic or thunderstorm events. Winter rain is not uncommon (Kendrick 2001). Cyclones develop off the north-west coast and often cross the coastline between Karratha and Port Hedland and move inland over the Fortescue Valley system towards Newman (Beard 1990).

The closest Bureau of Meteorology (BOM) weather station to the survey area is at Newman Airport (station number 007176), located 130 kilometres south-east of the survey area. This weather station has been recording rainfall data since 1971 and temperature data since 1996.

Data recorded at Newman Airport (Figure 2.1) shows a mean annual rainfall of 324.3 millimetres (mm). Mean monthly rainfall is highest in February at 70.2 mm, and lowest in September at 3.7 mm. The hottest month is December with a mean maximum temperature of 39.3°C and a mean minimum temperature of 24.1°C. The annual wind records from 9am and 3pm show a dominant easterly throughout the day, with the strongest winds recorded in the morning of up to 30 kilometres /hour (BOM 2021).

Evaporation rates are not recorded at the Newman Airport Weather Station. However, evaporation in the Central Pilbara Region is estimated to be between 2000 millimetres and 3500 millimetres per annum, which is approximately ten times greater than annual rainfall (Gardiner 2003). This disparity maintains a typically arid landscape, except for areas located in proximity to river systems and shallow groundwater resources.

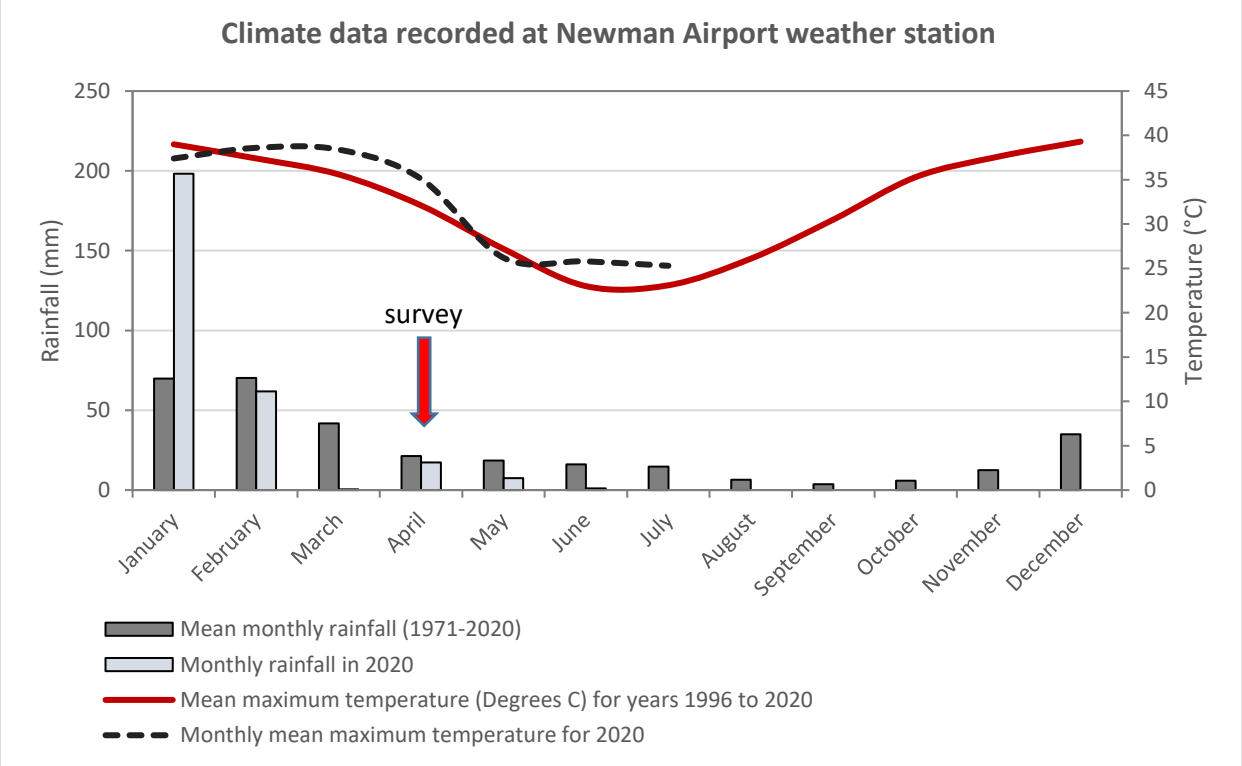


Figure 2.1 Long-term average monthly rainfall and maximum temperature, and 2019-2020 monthly rainfall and mean maximum temperature recorded at Newman Aero weather station (BOM 2020)

The fauna survey took place from 16 to 28 April 2020. Rainfall in the three months preceding the survey was higher than average for the region, with a total of 277.8 millimetres from January to March 2020 (BOM 2020). However, most of this rain fell in January, while rainfall for March was just below average and for February was well below average (see Figure 2.1).

During the survey in April 2020, the survey area was found the be very dry and there was no discernible moisture in the leaf litter, with the exception of the southernmost part of the survey area in the Wannamunna land system. Day-time temperatures in April 2020 were warm to hot, ranging from 33.9 °C to 39.7 °C, while night-time temperatures were mild, ranging from 22.9 °C to 26.6 °C (BOM 2021).

Additional data was collected during the wet season, between 16 and 25 February 2021, comprising supplementary habitat assessment work and deployment of bat recorders.

Table 2.1 Daily rainfall and temperatures recorded during the field survey (Newman Airport weather station)

Survey date	Rainfall (mm)	Maximum Temperature (°C)	Minimum Temperature (°C)
Primary field survey in April 2020			
15 April 2020	0	39.2	24.8
16 April 2020	0	37.8	25.2
17 April 2020	0	37.7	22.9
18 April 2020	0	38.6	23.2
19 April 2020	0	38	26.6
20 April 2020	0	36.2	24.5
21 April 2020	0	36.8	23.3
22 April 2020	0	37.5	24.9
23 April 2020	0	38.5	24.2
24 April 2020	0	39.7	25.6
25 April 2020	0	37.6	25.2
26 April 2020	0	33.8	24.3
27 April 2020	0	32.9	23.1
28 April 2020	0	34	20.7
29 April 2020	0	29.3	19.9
Supplementary data collection in February 2021			
16 February 2021	0	33.5	24.3
17 February 2021	0	37.7	26.5
18 February 2021	0	37.9	26.7
19 February 2021	34.6	32.8	22.3
20 February 2021	0.2	36.7	24.2
21 February 2021	0	38.1	26.3
22 February 2021	0	37.7	25.2
23 February 2021	0	37.6	25.5
24 February 2021	0	37.4	24.6

Survey date	Rainfall (mm)	Maximum Temperature (°C)	Minimum Temperature (°C)
25 February 2021	0	37.2	20.7

2.2 Biogeography

2.2.1 IBRA bioregions

The bioregions of Australia are described in the Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway & Cresswell 1995). Bioregions are large, geographically distinct areas of land with common characteristics such as geology, landform patterns, climate, ecological features and plant and animal communities. The latest version, IBRA7, classifies Australia's landscapes into 89 large geographically distinct bioregions and 419 subregions (DoE 2012).

The Lamb Creek project is located in the Hamersley (PIL3) subregion of the Pilbara bioregion. The Hamersley subregion comprises the southern section of the Pilbara Craton. It is a mountainous area of Proterozoic sedimentary ranges and plateaux, dissected by gorges (basalt, shale and dolerite). Geographically it is synonymous with the Hamersley vegetation system as described by Beard (1990). The dominant vegetation is mulga low woodland over bunch grasses on fine textured soils in valley floors, and Eucalyptus leucophloia (snappy gum) over *Triodia brizoides* on skeletal soils of the ranges. Regional vegetation is further described in section 2.3 Drainage runs into either the Fortescue River to the north, the Ashburton river to the south, or the Robe river to the west (Kendrick 2001).

2.2.2 Land systems

The Lamb Creek survey area traverses five land systems, as mapped by the Western Australian Land Information Authority (2018) and described by Van Vreeswyk *et al*. (2004). These are listed and summarised in Table 2.2.

The majority of the survey area occurs within the Boolgeeda land system, comprising stony slopes, plains, hills, and drainage floors with spinifex. This land system underlies the majority of the retention licence and the proposed haul road corridor.

The Newman land system, comprising rugged mountains, ridges, and plateaux, was the second dominant, intersecting the haul road in two places and covering the south-west and south-eastern corners of the retention licence.

The McKay and Platform Land Systems occurred in the north-eastern part of the retention licence only, while the Wannamunna land system only appeared in the southernmost part of the haul road corridor where it intersects the highway. Intersection version B fell entirely within the Boolgeeda land system.

The vegetation in all but the Wannamunna land system is typified by spinifex grasslands. Wannamunna is characterised by hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands (and occasionally eucalypt woodlands). Floristically, the survey area fell within the Hamersley 18 and Hamersley 82 vegetation system-associations as defined by Beard (2018) as described further in section 2.3.2. Vegetation system mapping and land system mapping overlapped quite well for the Lamb Creek survey area, with Hammersley 82 roughly following the Newman land system, while Hamersley 18 roughly followed the other four land systems including Wannamunna.

Table 2.2 Land systems of the Lamb Creek detailed fauna survey area

Name	Land type	Description	Extent in survey area
Boolgeeda Land System	Stony plains with spinifex grasslands	Stony lower slopes, stony plains below hills, and narrow sub-parallel drainage floors. Supports hard and soft spinifex grasslands or mulga shrublands. Often occurs below hill systems such as Newman and Rocklea	1036 ha
McKay Land System	Hills and ranges with spinifex grasslands	Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands. Relief up to 100 m	44 ha
Newman Land System	Hills and ranges with spinifex grasslands	Rugged high mountains, ridges and plateaux with near vertical escarpments of jaspilite, chert and shale, supporting hard spinifex grasslands. Relief up to 400 m.	340 ha
Platform Land System	Stony plains with spinifex grasslands	Stony upper plains, dissected slopes and drainage floors, supporting hard spinifex grasslands. Erosional surfaces formed by partial dissection of the old tertiary surface. The gently inclined upper plains have extensive marginal dissection zones with gently inclined to steep slopes. Floors incised up to 30 m with steep stable marginal slopes becoming wider downslope.	198 ha
Wannamunna Land System	Wash plains on hardpan with mulga shrublands	Hardpan plains and internal drainage tracts supporting mulga shrubland and woodlands, and occasionally eucalypt woodlands. Depositional surfaces, level hardpan wash plains subject to overland sheet flow. Broad internal drainage flats receiving run-on from adjacent hardpan surfaces; rare, channelled tracts but mostly not organised through drainage. Relief up to 5 m.	27 ha

2.2.3 Geology

The survey area is located in the south-west corner of the Roy Hill 1:250,000 Geological Survey Sheet (SF50-12: Thorne & Tyler 1997). The geology of the survey area is generally defined by the assemblage of 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.

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). The survey area overlies the following geological units (Thorne & Tyler 1997).

- Brockman Iron Formation (PLHB): banded iron-formation, chert, and pelite;
- Quaternary Alluvium (Qa): unconsolidated silt, sand, and gravel; in drainage channels and on adjacent floodplains;
- Quaternary Alluvium and Colluvium (Qw): red-brown sandy and clayey soil; on low slopes and sheetwash areas; and
- Cainozoic Colluvium (Czc): partly consolidated quartz and rock fragments in silt and sand matrix; old valley-fill deposits.

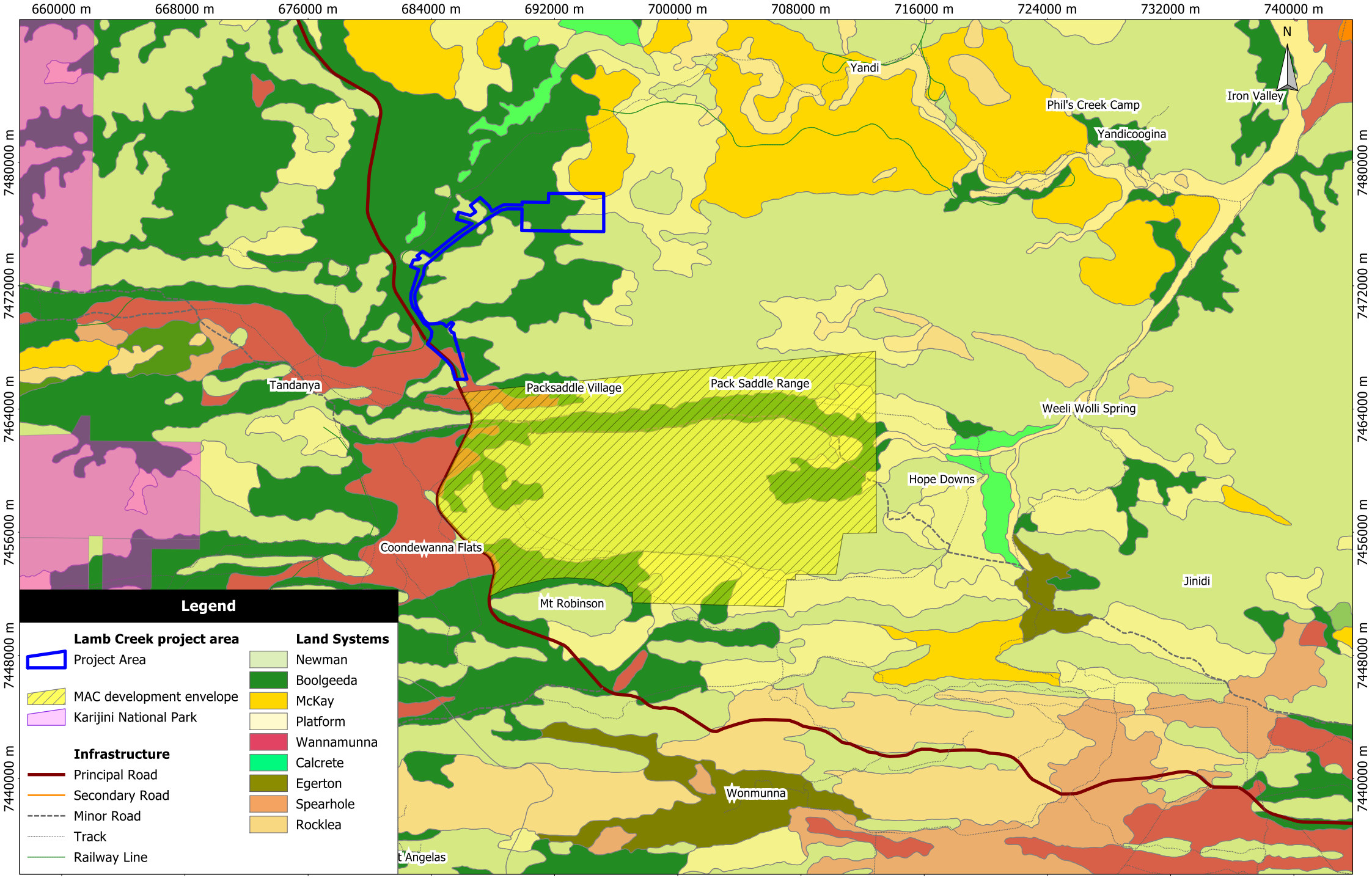
2.2.4 Soils

The survey area is located within the Fortescue botanical district of the Pilbara region (Beard 1990). This region is mountainous, with soils ranging from shallow, stony sandy loams along slopes, to cracking clays, stripped hardpans and calcareous loams along active waterways (Beard 1990).

The landforms of the survey area are typical of the eastern Pilbara with rocky hills, small gorges, mostly seasonal watercourses, and gravelly loam valleys. The soils are typified by hard red alkaline soils on plains, pediments and alluvial areas, while shallow, skeletal soils are common on ranges that rise to 1,250 m (Beard 1990). The southern part of eastern Pilbara region is characterised by earthy loams underlain by red-brown hardpan (Beard 1975, 1990).

The survey area has two distinct soil and landform assemblages. The majority of the haul road corridor (L47/736) and the edges of the mine tenement (R47/19) are characterised as soil unit Fa13. The central part of the mine tenement and small portion of the potential haul road alignment is characterised as soil unit Fb3. These are defined as follows (CSIRO Australia 2018):

- 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 (Um5.51) along with some (Uc5.11) soils on the steeper slopes. Associated are (Dr2.33, Dr2.32) soils on the limited areas of dissected pediments, while (Um5.52) and (Uf6.71) 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 (Um5.52) along with small areas of (Gn2.12) soils.



Rapallo environmental

Mineral Resources Limited
Lamb Creek Project

Lamb Creek Iron Ore Project
Detailed Vertebrate Fauna Survey

Original Size: A4 Scale: 1:300,000
Datum: MGA94 Zone 50
0 10 km

Figure 2.2

Land System Mapping and Regional localities

2.3 Regional vegetation

2.3.1 Botanical district

The survey area is located in the Fortescue botanical district of the Pilbara region (Beard 1990), which forms part of the Eremaean Botanical Province. The Pilbara region receives a slightly higher than average rainfall than most of the Eremaean Province, due to the prevalence of cyclones off the coast, but this is not enough to modify the essentially desert appearance of the plant cover (Beard 1990).

The Fortescue botanical district consists predominantly of tree and shrub steppe communities with *Eucalyptus* trees, Acacia shrubs and spinifex grasses including *Triodia pungens* and *T. wiseana* (Beard 1975). Mulga (species of the *Acacia aneura* complex) occurs in valleys, and short-grass plains may be present on alluvial soils (Beard 1990).

2.3.2 Vegetation system-associations

Digital maps (shapefiles) of pre-European vegetation communities, based on state-wide mapping by J.S. Beard at 1:250,000 scale, are published by the Department of Primary Industries and Regional Development (Beard 2018).

Vegetation of the Hamersley (PIL3) IBRA subregion is generally low Mulga woodland over bunch grasses on fine textured soils in the valleys with snappy gums (*Eucalyptus leucophloia*) over *Triodia brizoides* on skeletal soils of the ranges (Kendrick 2001). The mountain tops and gorges of the Hamersley subregion provide refugia for humidophile and/or fire intolerant flora, and support a diversity of range-restricted species (Kendrick 2001).

The survey area falls within two Beard (2018) vegetation system-associations: Hamersley 18: Low woodland of *Acacia aneura*, and Hamersley 82: Hummock-grass (*Triodia wiseana*) steppe with irregularly scattered *Eucalyptus brevifolia* trees (Table 2.3). Cameras were deployed within the gorge, gully, breakaway habitat adjacent to the proposed haul road corridor located primarily within Hamersley 82.

Table 2.3 Beard vegetation system-associations within the survey area

Beard Vegetation System and Association	Extent in survey area	Extent in Western Australia (ha) [1)]	Pre-European extent remaining (%) [1)]
Hamersley 18	982 ha	575 852 ha	99.2%
Hamersley 82	663 ha	2 157 841 ha	99.4%

Footnotes:
1) Numbers from 2018 Statewide Vegetation Statistics (DBCA 2019)

Vegetation that is not a Threatened or Priority Ecological Community may still be considered significant if it has a restricted distribution, or has experienced a degree of historical impact from threatening processes (EPA 2016a). Vegetation types retaining less than 30% of their pre-European extent generally experience accelerated species loss at an ecosystem level (EPA 2000) and are regarded as being 'vulnerable', while vegetation types retaining less than 10% of their original extent are regarded as being 'endangered' (EPA 2000, Shepherd *et al.* 2002, DER 2014, 2016a).

As described above, the Hamersley 18 and Hamersley 82 vegetation system-associations intersected by the survey area still have close to 100% of their original extent remaining, and would be considered 'least concern' (DER 2014).

2.4 Reserves and Environmentally Sensitive Areas

2.4.1 Environmentally Sensitive Areas

Environmentally sensitive areas (ESAs) are protected under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and are selected for their environmental values at state or national levels. The survey area does not occur within an ESA, nor are there any ESAs within five kilometres of the survey area, as shown by the Department of Water and Environment Regulation (DWER) Clearing Permit System and Map Viewer (DWER 2020).

Karijini National Park is located to the west of the survey area, approximately 18 kilometres west of the intersection of the proposed haul road and the Great Northern Highway. Mungaroona Range Nature Reserve is approximately 100 kilometres northwest of the survey area. The nearest Nationally Important Wetland is the Fortescue Marsh located 52 km north of the survey area (AWE 2021).

2.4.2 Threatened and Priority Ecological Communities

The survey area is not located within a known Threatened or Priority Ecological Community (TEC-PEC) (Rapallo 2012b, 2021b). The nearest known PEC is subtype 2 of the Coolibah-Lignum Flats vegetation community, with the edge of the buffer zone located less than five kilometres south of the survey area (DBCA 2021b) as shown in Figure 1.2.

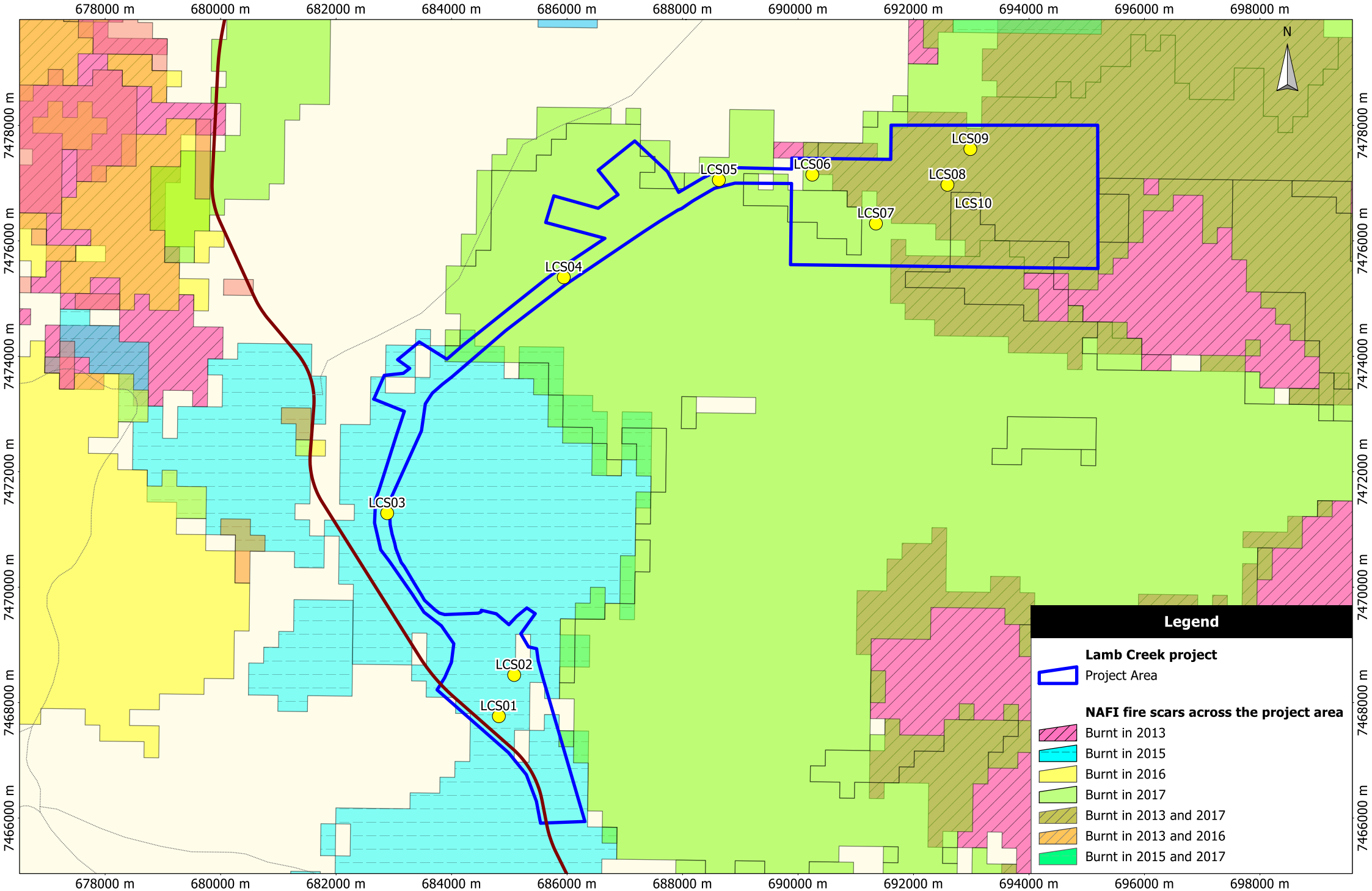
The Coolibah-Lignum Flats vegetation complex is described as: Woodland or forest of *Eucalyptus victrix* (coolibah) over thicket of *Duma florulenta* (lignum) on red clays in run-on zones. Associated species include *Eriachne benthamii*, *Themeda triandra*, *Aristida latifolia*, *Eulalia aurea* and *Acacia aneura* (DBCA 2021d). The Coolibah-Lignum Flats PEC is unlikely to occur within the fauna survey area, as discussed in Rapallo (2012b) and Rapallo (2021b). It must be noted that the flora surveys did not cover the entirety of the current project area.

2.5 Fire history

Fire mapping for Australia is available from the Northern Australia and Rangelands Fire Information (NAFI 2021) website, with fire scar data available from 2000 to present. The NAFI service displays maps of fire activity based on information from satellites, such as hotspots (locations of recently burning fires) and fire scars (maps of recently burnt country).

The majority of the Lamb Creek project area has been burnt since the 2012 fauna survey (Rapallo 2012a), with three partially overlapping fire scars resulting in a mosaic of different fire ages. Fire mapping over the project area between 2012 and 2021 (NAFI 2021) is shown in Figure 2.3.

It must be noted that NAFI data is very broad-scale and does not show the fine-scale mosaic within the project area, nor does the mapping indicate fire intensity. For example, trap site LCS03 (see section 3.3.1) was positioned in one of the few unburnt areas, but the NAFI data does not provide enough detail to show this (Figure 2.3).



Rapallo environmental

Mineral Resources Limited
Lamb Creek Project

Lamb Creek Iron Ore Project
Detailed Vertebrate Fauna Survey

Original Size: A4 Scale: 1:80,000
Datum: MGA94 Zone 50
0 3 km

Figure 2.3

NAFI fire scars across the Lamb Creek project area between 2012 and 2021

3 Methods

3.1 Desktop

The fauna desktop study comprised a search of paid and free databases as listed in Table 3.1, and a review of available literature relevant to the survey area as listed in Table 3.2. The fauna desktop served to place the fauna assemblage of the survey area in a regional context and to compile a list of vertebrate fauna species with the potential to occur within the survey area. This list was then filtered for conservation significant fauna species and likelihood to occur within the survey area was assessed using the fauna decision matrix located in Appendix I.

Table 3.1 Database search parameters

Source of information	Zone	Easting (mE)	Northing (mS)	Search area type
DBCA (2020a)Threatened and Priority Fauna Database (TPFA)	50K	688039	7473704	50 km radius circle centred on point
DBCA (2021a) Threatened and Priority Ecological Communities (TEC-PEC) database	50K	688039	7473704	50 km radius circle centred on point
DBCA (2020b) NatureMap online database	50K	688039	7473704	40 km radius circle centred on point
AWE (2020) Protected Matters search tool	50K	688039	7473704	50 km radius circle centred on point
Birdlife Australia (2020) Birdata online database	50K	688039	7473704	100 x 100 km box centred on point

The surveys used as part of the literature review are listed in Table 3.2 and generally occurred within 50 kilometres of the Lamb Creek project area.

Table 3.2 Fauna surveys completed within 50 km of Lamb Creek

Report title	Distance to Lamb Creek
Rapallo (2012a) Level 2 Fauna Survey and Targeted Northern Quoll Survey of the Lamb Creek Project area	0 km
Biologic (2011) Area C and surrounds fauna survey	3-25 km to the south
Biologic (2012) Southern Flank vertebrate fauna survey	3-25 km to the south
Biologic (2013) Mudlark vertebrate fauna survey	3-25 km to the south
Biologic (2016a) South Flank targeted fauna survey	3-25 km to the south
Ecologia (2004a) Packsaddle Range biological survey	3-25 km to the south
Ecologia (2004b) Area C: Deposits D, E, F biological survey	3-25 km to the south
Ecologia (2005) Pilbara Leaf-nosed Bat and Ghost Bat monitoring survey at Nimingarra and Cattle Gorge.	3-25 km to the south
Ecologia (1998) Mining area C biological survey	3-25 km to the south
ENV (2007) Area C: R deposit fauna assessment	3-25 km to the south
ENV (2008) Area C southern flank deposit fauna assessment	3-25 km to the south

Report title	Distance to Lamb Creek
Halpern Glick Maunsell (1999) Mining Area C western access corridor biological assessment	3-25 km to the south
Outback Ecology (2008) Area C Mining Operation Environmental Management Plan	3-25 km to the south
Specialised Zoological (2008) Area C bat survey	3-25 m to the south

3.1.1 Conservation status and naming

Names for bird species follow Birdlife Australia (2019), names for mammals, reptiles and amphibians follow the Western Australian Museum (2019) with common names supplemented from Wilson and Swan (2017). Further information was gained from Johnstone and Storr (1998, 2004) for birds, Van Dyck and Strahan (2008) for mammals, and Cogger (Cogger 2018) and Tyler and Doughty (2009) for reptiles and amphibians, as well as the Frog Watch website (WAM 2018).

Distribution maps and recent records of vertebrate fauna species were verified using the Atlas of Living Australia (ALA 2021), and Birdata online databases, the Species Profile and Threats Database (SPRAT) (AWE 2021), NatureMap (DBCA 2020b), as well as maps published in Van Dyck and Strahan (2008), Johnstone and Storr (1998, 2004), Wilson and Swan (2017), Cogger (2018), and other relevant publications as cited within this report.

Conservation codes cited in this report are as per Appendix II.

3.2 Personnel and licensing

The personnel involved in the field survey, data entry and analysis, and the preparation of this report are listed in Table 3.3. The field survey was conducted under Fauna Taking (Biological Assessment) Licence BA27000239 issued under Regulation 17 of the *Biodiversity Conservation Regulations 2018*. As part of the license conditions, a list of fauna species recorded in the survey will be forwarded to the DBCA.

Table 3.3 Personnel involved in the project

Name	Position	Field survey	Reporting
Kate George	Principal Environmental Scientist	X	X
Marieke Weerheim	Senior Environmental Scientist	X	X
Jon-Paul Emery	Ecologist	X	X
Jari Cornelis	Ecologist	X	
Heidi Nore	Ecologist	X	
Kady Grosser	Ecologist	X	
Molly George	Ecologist	X	

3.3 Field survey

The detailed vertebrate fauna survey was completed over the period of 16 to 28 April 2020 with supplementary habitat assessment and bat recording occurring during the wet season between the 17 and 25 February 2021.

3.3.1 Systematic trapping

Ten systematic trap sites were established across the survey area, as mapped in Figure 3.1. Trap site locations were selected to cover the major habitats of the survey area and where possible trap sites were positioned in pockets of unburnt habitat within the burn mosaic. Coordinates of trap sites are presented in Appendix III and habitat assessment data presented in Appendix IX.

Trap sites were established in a staggered manner over a four-day period, with sites kept open from the day they were established for a period of seven nights. Trap site closure also occurred in a staggered manner over a four-day period.

Trap site design aligned with recommendations in EPA (2016b). Each systematic trap site comprised six 20-litre buckets, six pipes, and twelve funnel traps, which were distributed equally along two 50-metre drift fences running parallel, approximately 50 metres apart. The two trap lines were surrounded by a grid of 20 aluminium box traps. One camera was positioned at each trap site for a period of 7 days.

Trap effort is summarised in Table 3.4.

All traps were cleared between first light and 10 am. The majority of vertebrate fauna captured in traps were identified in the field and released. Reptiles and mammals that could not immediately be identified at the trap site were taken back to a central location within the project area with shelter (referred to as the 'day camp') for identification using the appropriate keys in Cogger (2018), Wilson and Swan (2017), Van Dyck *et al.* (2013), and Menkhorst and Knight (2010).

Terrestrial invertebrate fauna from orders known to support short range endemic invertebrates (SRE) were collected, stored and labelled according to Western Australian Museum guidelines (WAM 2012). Potential SRE specimens were taken back to Perth and submitted to taxonomic experts for identification. Invertebrate fauna captured during the 2020 vertebrate fauna survey are included in Rapallo (2022).

3.3.2 Bird surveys

Bird surveys were completed at the ten trap sites, with each site surveyed at least once. All systematic bird surveys were completed in the morning before 10 am when bird activity was high and cryptic species were most detectable. The survey method involved 50-minute surveys surrounding each individual trap site. The survey area for each survey was unbounded, but restricted to one single habitat which was representative for each trap site.

3.3.3 SM4 recorders for bats and night parrot

The bat assemblage of the survey area was assessed using two ultrasonic echolocation recorders that were moved to systematically sample all the potential fauna habitats across the survey area. The model of recorder used was a Wildlife Acoustics SM4BAT-FS ultrasonic recorder, hereafter referred to as simply SM4 bat recorders.

Bat survey consisted of completing a total of thirty-three overnight ultrasonic bat sound recordings, beginning at twilight, at sixteen locations within and proximal to the survey area.

SM4 bat recorders were deployed for a minimum of one night at each trap site, as well as at caves 1 and 3 located on the retention licence where ghost bat had been recorded in 2012 (Rapallo 2012a). Additional caves (caves 2, 4 and 5) outside the defined survey area, but proximal to the project area, were sampled opportunistically. Cave 2 was sampled in April 2020, and was located approximately two kilometres to the south of the retention licence. Caves 4 and 5 were sampled in February 2021, and were located in the hills proximal to the Great Northern Highway intersection. Cave 2 was sampled two nights in April 2020, while caves 4 and 5 were sampled for 2 nights in February 2021 (Appendix III).

The survey area was sampled for potential night parrot calls using one Wildlife Acoustics Song Meter SM4 Acoustic Recorder, hereafter referred to as the SM4 night parrot recorder. Acoustic recorders were deployed at areas within the survey area that contained patches of mature spinifex as potential habitat, and a location on the 2020 disturbance footprint. The night parrot recorder was deployed at each site for a minimum of two consecutive nights, with a total of eight acoustic survey nights (Appendix III).

Recordings were "continuous" made using ultrasonic SM4BAT-FS and acoustic SM4A SongMeter (both by Wildlife Acoustics Inc., USA) detectors. The audio settings used followed the manufacturer's recommendations contained in the user manuals (Bat Call WA 2021).

Recordings were sent to Bat Call WA for analysis and identification. For the ultrasonic (bat) recordings, call analysis details are provided in Bat Call WA (2021) (Appendix VIII) as recommended by the Australasian Bat Society (Australasian Bat Society 2006). Reference data for the species identified are available in (Bullen & McKenzie 2002, McKenzie & Bullen 2003, 2009). For the acoustic recordings (night parrot), Bat Call reviewed recordings both manually and using an automatic scan technique for Night parrot calls. Candidate calls were compared to Bat Call's confirmed reference calls.

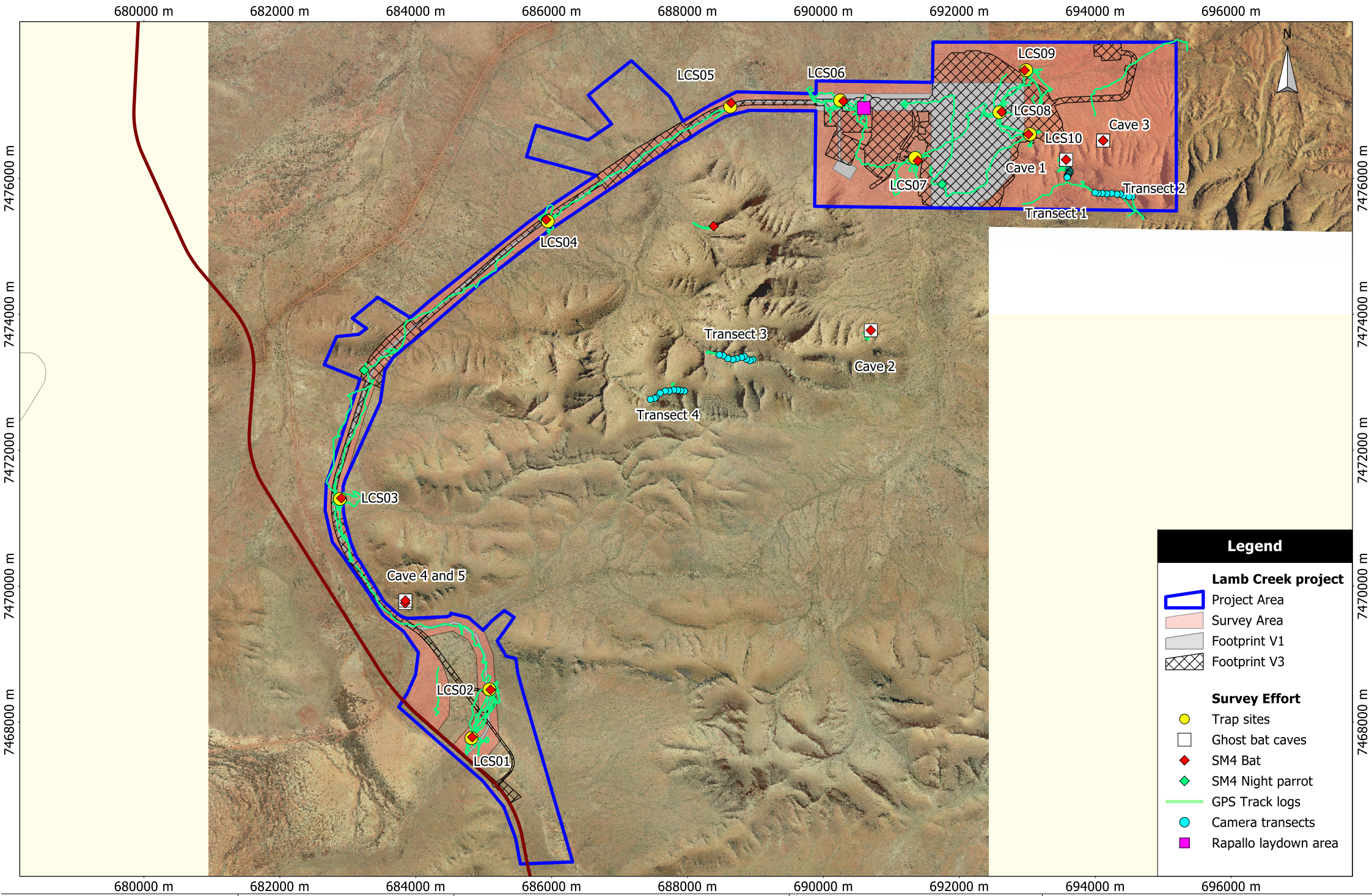
See Figure 3.1 and Appendix III for SM4 deployment locations and duration.

3.3.4 Foraging and leaf litter Searching

Foraging (active searching) targeting both vertebrate and invertebrate fauna was conducted at all trap sites, for a minimum of 1.5 person hours per site. Foraging methods included turning rocks, logs, peeling bark, raking leaf litter, litter sieving and searching under vegetation. Northern quoll camera sites (see section 3.3.6) were searched for a minimum of 0.5 person hours, plus time spent traversing between camera locations.

3.3.5 Opportunistic observations

Opportunistic records of mammals, birds, reptiles, amphibians and potential SRE invertebrates were collected throughout the survey area. Opportunistic records included direct sightings and calls, as well as secondary signs of presence such as tracks, scats, diggings, burrows, mounds, feathers, bones, and sloughed reptile skins. All records were accompanied by a GPS waypoint and/or fauna habitat notes, to link species records to fauna habitats.



Rapallo environmental

Mineral Resources Limited
Lamb Creek Project

Lamb Creek Iron Ore Project
Detailed Vertebrate Fauna Survey

Original Size: A4 Scale: 1:70,000
Datum: MGA94 Zone 50
0 2 km

Figure 3.1

Survey Effort

3.3.6 Camera transects

Forty Swift Enduro motion-detecting camera traps were deployed along four transects in the gorge, gully, breakaway landscapes that occur within the higher elevation areas of the retention licence and ranges adjacent to the proposed haul road corridor. The four transect sites were selected based on aerial photography with consideration of safety and logistics.

Camera transects were placed in four selected areas of gorge / gully habitat, with two transects deployed within the defined survey aera, and two in the elevated areas to the south of the project area. Cameras were positioned between 15 and 50 meters apart, depending on the length of the gorge / gully. This method broadly aligned with an initial reconnaissance survey under (DotEE 2016).

Cameras were deployed for a minimum of 5 consecutive nights (some longer due to the logistics of retrieval) and baited with cat food that contained a high sardine content. Bait was enclosed in non-reward food tubes, to allow for longer deployment time.

Each camera on the transects was programmed to record video for 30 seconds upon being triggered, with detection sensitivity set to medium. See Table 3.4, Figure 3.1 and Appendix III for trap effort and location of camera transects.

A single ScoutGuard 550V camera was deployed at each of the 10 trap sites for a minimum of five days. Cameras were positioned about 30 centimetres off the ground and angled towards the ground. Cameras at trap sites were baited daily for a period of five nights with a mix of dried oats, peanut butter, and olive oil. Bait was not replenished after the fifth night to minimise impacts on normal animal behaviour.

3.3.7 Species richness estimators

Species accumulation curves for birds and trappable ground-dwelling fauna were generated via EstimateS software Version 9.1.0 (Copyright R. K. Colwell). Predicted species richness was calculated by taking the average of the estimators ACE, Chao 1, Jackknife 1 and Bootstrap (Colwell 2013).

Since models can only be generated from data collected through systematic methods, the species accumulation curve and predicted species richness were calculated from systematic trapping data, and from systematic bird surveys. Separate analyses were conducted for these two methods.

Predicted species richness of trappable ground-dwelling vertebrate fauna was calculated using the combined trapping data for mammals and reptiles from all ten trap sites for the single-season fauna survey, with statistics calculated over abundance data (total number of captures per species at that site).

Predicted species richness of birds was calculated using data from systematic birds surveys only, with data entered as total abundance for each species per site. Analyses for both trappable ground-dwelling fauna and birds were run using the default settings with the following exceptions:

- Accumulations (runs) were randomised 10,000 times without replacement.
- Upper abundance limit for rare or infrequent species was set to 3.

3.3.8 Habitat mapping

Broad fauna habitat mapping was completed in 2012 over an area that partially overlaps with the current 2020 survey area. The broad fauna habitat mapping from 2012 was selectively ground-truthed during the 2020 survey and further refined with habitat assessment data collected during a short-range endemic

fauna survey completed in February 2021 (Rapallo 2022). Habitat data included notes on land form, soil, rock cover, and broad description of vegetation.

Fauna habitats were assessed for the likelihood that they may support fauna of conservation significance. All major fauna habitats present within the survey area were scored for significance (High, Moderate or Low) according to the criteria in Appendix IV.

Table 3.4 Summary of survey effort

Name	Effort
Pit fall trap nights	840
Funnel trap nights	840
Box (Elliot) trap nights	1400
Ultrasonic (bat) detector nights	33
Acoustic (night parrot) detector nights	8
Camera nights (transects)	279
Camera nights (trap sites)	73
Systematic bird census (minutes)	500
Trap Site Foraging (minutes)	900
Camera transect site foraging (minutes)	1410

4 Results and Discussion

4.1 Desktop results vertebrate fauna

A portion of the current Lamb Creek project area was surveyed for vertebrate fauna in 2012 by means of a single-season detailed (Level 2) fauna survey. The 2012 survey area overlapped in part with the 2020 survey area, as outlined in section 1 (Figure 1.2). Survey effort consisted of ten trap sites open for five consecutive nights: a trap effort of 852 pitfall traps, 1420 Elliot traps and 710 funnel traps. Bat recorders were deployed for 13 nights. Cameras and cages were deployed for 182 camera nights and 300 cage trap nights within gorges and the faces of rocky escapements. Other activities included spotlighting, habitat assessment, foraging and systematic bird survey (Rapallo 2012).

4.1.1 Regional survey effort

The region has had considerable survey effort over the last 20 years predominantly due to vertebrate fauna surveys completed within, or partly within, the boundary of the Mining Area C (MAC) Development Envelope. The MAC Development Envelope is approximately 10 kilometres south of R47/19 as showed in Figure 1.1.

Twenty-one vertebrate fauna surveys have been conducted wholly or partially in the MAC Envelope between 1997 and 2016; these comprised seven Level 2 surveys (one or two seasons), five Level 1 surveys and nine targeted surveys (for conservation significant fauna) (Biologic 2017).

Mining Area C contains the same land systems as the Lamb Creek survey area and has similar habitats.

4.1.2 Regional fauna assemblage

The fauna desktop study identified 301 species of terrestrial vertebrate fauna recorded within 50 kilometres of the survey area. These included 157 birds, 46 mammals, 91 reptiles, and 7 amphibians. Not all species are likely to occur in the survey area due to the large search extent of the desktop assessment. Additionally, many species tend to be patchily distributed even where appropriate habitats are present, and many species of birds can occur as regular migrants, occasional visitors or vagrants. The desktop results are presented in Appendix V.

4.1.3 Introduced fauna (Pests)

The desktop study identified ten introduced taxa (Pests) recorded within 50 kilometres of the survey area, as presented in Table 4.1. Three of these introduced fauna species are currently listed on the Western Australian Organism List (WAOL) as Permitted - s11 (Department of Agriculture and Food, Western Australia 2021), while the other seven were listed as Declared Pest – s22(2).

Based on distribution maps, database records, and habitat preferences, seven species were considered possible to likely to occur in the survey area. These were cattle (*Bos taurus*), camel (*Camelus dromedarius*), domestic dog (*Canis lupus*), cat (*Felix catus*), house mouse (*Mus musculus*), rabbit (*Oryctolagus cuniculus),* and the red fox (*Vulpes vulpes*). The cat and house mouse were recorded during the survey, while either dingo or dog was also recorded.

Table 4.1 Desktop results: Introduced (feral) fauna recorded within 50 kilometres of the survey area

Scientific name	Common name	Pest Status (WAOL)	Likelihood
Columba livia	Rock Dove	Permitted - s11	Unlikely
Bos taurus	European Cattle	Declared pest - s22(2)	Confirmed
Camelus dromedarius	Dromedary, Camel	Declared pest - s22(2)	Likely
Canis familiaris familiaris	Dog	Declared pest - s22(2)	Likely
Vulpes vulpes	Red Fox	Declared pest - s22(2)	Likely
Equus asinus	Donkey	Declared pest - s22(2)	Unlikely
Equus caballus	Horse	Declared pest - s22(2)	Unlikely
Felis catus	Cat	Permitted - s11	Possible
Oryctolagus cuniculus	Rabbit	Declared pest- s22(2)	Likely
Mus musculus	House Mouse	Permitted - s11	Possible

4.1.4 Conservation significant fauna

The fauna desktop study identified 50 taxa of conservation significant fauna recorded previously within 50 kilometres of the survey area. These are listed in Appendix VI.

Twenty-one of these species were conservation significant only because they are listed Marine under the EPBC Act. These all comprised common and widespread species, including cuckoos, raptors, egrets, rainbow bee-eater, magpie-lark and welcome swallow. Marine species are listed in Appendix VI but are not discussed further in this document.

For the remaining 29 species, likelihood to occur in the survey area was assessed using location and date of previous records, and currently known range and habitat requirements relative to the fauna habitats recorded in the survey area (section 4.5). The risk matrix used to assess likelihood is presented in Appendix I, and likelihood scores are shown in Appendix VI.

Based on the likelihood assessment outlined above, seventeen conservation significant species were considered unlikely to highly unlikely to occur in the survey area due to absence of suitable habitat (such as sand dunes for bilbies and mulgaras, and rivers, dams, wetlands for wader species). Species were also considered unlikely if they were rare vagrants, or where recent distribution maps showed that the survey area was located well outside their known range (these database records may have been incorrect).

The Pilbara Leaf-nosed bat (*Rhinonicteris aurantia* – Pilbara population) was considered unlikely to occur in the survey area, based on extensive survey efforts completed in the adjacent Mining Area C. Despite many years of surveying including cave assessments and acoustic surveys, the species was only detected twice as a foraging visitor (Biologic 2017). Bob Bullen (*pers. comm*. 2020) confirmed that, based on the survey results for Mining Area C, it is highly unlikely that roost caves for the Pilbara Leaf-nosed Bat occur in the survey area.

The remaining twelve species of conservation significant fauna were assessed as possible, likely or confirmed to occur in the survey area. These are listed in Table 4.2 below.

Table 4.2 Desktop results: Fauna species confirmed to possible to occur in the survey area

Name	Status[1)]		Likelihood	Details
	BCA	EPBC		
Fork-tailed swift (*Apus pacificus)*		MI, MA	Confirmed	Recorded at Lamb Creek in 2012, from all habitats surveyed (Rapallo 2012a) and there are also multiple records from Mining Area C (Biologic 2017).
Peregrine falcon (*Falco peregrinus)*	OS		Likely	Recorded from Mining Area C (Biologic 2017). Prefers areas with cliffs and rocky escarpments for nesting. The survey area contains some potentially suitable breeding habitat within the gorge, gully , breakaway habitat that occurs within the higher elevation areas of the retention licence, with more extensive suitable habitat in the ranges adjacent to the proposed haul road corridor. Water ecotones and tree covered areas provide productive habitat for Peregrine falcon prey species. However, Peregrine Falcons are an open country hunter (Ratcliffe 1993, Jenkins 2000) and some level of open country is essential for them to access prey (Jenkins & Hockey 2001). Peregrine falcon is likely to forage broadly across all habitats within the survey area especially on drainage ecotones during wetter seasons, but lack of permanent and semi-permanent water in the region will limit prey availability.
Night parrot (*Pezoporus occidentalis*)	CR	EN	Possible	Based on accepted records, Night parrot habitat comprises long-unburnt mature Triodia grasslands forming mosaics with samphire and chenopod shrublands (Jackett et al. 2017, McDougall et al. 2009, Murphy et al. 2017) including genera such as Atriplex, Bassia and Maireana, on floodplains and claypans, and on the margins of salt lakes, creeks or other sources of water (McGilp 1931, Wilson 1937). Contemporary Western Australian Pilbara/Murchison records include records north east of Wiluna (Hamilton et al. 2017, Jackett et al. 2017), Lake Disappointment (Great Sandy Desert) (Harewood 2018), Great Sandy Desert (Caccetta 2018) , south of Newman (Ison 2017), salt lake systems on Martu County (Michelmore & Birch 2020) and near the Fortescue Marsh (Davis & Metcalf 2008). The current interim guidelines for preliminary surveys of Night parrot in Western Australia suggest the species requires large, dense Triodia hummocks primarily old-growth (often more than 50 years unburnt) for roosting and nesting (DPaW 2017), although little is known about foraging sites hence the precautionary score of possible. Foraging habitat is typically located nearby to roosting habitat (Jackett et al. 2017), though individuals have been recorded 9.4 km from roosting sites in a single night and recorded to have travelled over 40 km in a single night (Murphy et al. 2017). Local records of the Night parrot are scarce, with the nearest contemporary record of the species observed at Minga Well, a station bore and livestock watering point with large pools of water near Fortescue Marsh (Davis & Metcalf 2008) and a record from near Newman (Ison 2017) . At Lamb Creek, mature triodia at site LCS03 (which has not been affected by recent fires) could be utilised by Night parrot; however, most of the survey area has been recently burnt in 2013, 2015 and 2017 (NAFI 2021). There is unburnt Triodia on the surrounding hill slopes, but the majority were small clumps that would not provide extensive cover, with larger clumps occurring on outwash slopes. Small patches of mature triodia occurred in creek lines and low points of stony plain but were often small patches. Night parrot was not detected via acoustic recorder and habitats of the survey area do not include mosaics with samphire and chenopod shrublands, salt lake margin, or paleochannel.

Name	Status[1)]		Likelihood	Details
	BCA	EPBC		
Grey falcon (*Falco hypoleucos)*	VU	VU	Possible	Grey falcon commonly nests in timbered areas, particularly tall trees along watercourses, and forages in open or more sparsely vegetated habitats (Garnett et al. 2011). Medium Drainage habitats are likely to provide suitable nesting habitat for the species. Grey falcon is likely to forage broadly across all habitats within the survey area particularly Stony Plain. Highly nomadic with multiple records within 20 km of the survey area, including from Mining Area C where none of the records were breeding records (Biologic 2017).
Letter-winged Kite (*Elanus scriptus*)	P4		Possible	The Letter-winged Kite is a bird of open country and grasslands in arid and semi-arid Australia, where there are tree-lined streams or water courses. When food is plentiful, the species irrupts and birds may disperse to higher rainfall coastal regions (Birdlife 2020b). This kite roosts by day in the high canopy of leafy trees and is the only member of its family that hunts at night. Highly nomadic several records within 10 km of the survey area (DBCA 2020b). Probable infrequent visitor during irruptive events.
Ghost bat (*Macroderma gigas*)	VU	VU	Confirmed	Recorded by Rapallo in 2012, 2020 and 2021 in the retention licence (cave 1 and 3) and adjacent (cave 2). A regional review completed in November 2016 mapped all known ghost bat caves in the vicinity of Mining Area C (Biologic 2016b). A cluster of roost caves are located just east of the Lamb Creek haul road alignment. Bat Call WA confirmed that these caves comprise a category 2 roost cave surrounded by category 3 caves in an "apartment block" configuration (Bob Bullen pers. comm. 2020). These caves (cave 4 and 5 in Figure 3.1) are located 200-250 m east of the haul road corridor.
Short-tailed mouse (*Leggadina lakedownensis*)	P4		Possible	This species has a broad distribution across much of northern Australia, but is irregularly distributed with scattered populations (Van Dyck & Strahan 2008). In habits areas of open tussock and hummock grassland, Acacia scrubland, and savanna woodland, on alluvial clay or sandy soils (Lee 1995) and also cracking clay in the Pilbara (Gibson & McKenzie 2009) The DBCA threatened fauna database has two records from the same locality approximately 9 km SW of the survey area (GNHI), recorded in 1997 from the Boolgeeda land system DBCA 2020b). There are no records from Mining Area C despite extensive survey effort (Biologic 2017). The Short-tailed mouse could occur within the tussock grassland habitat of the survey area.
Northern quoll (*Dasyurus hallucatus*)	EN	EN	Confirmed	Recorded at Lamb Creek during the 2012 surveys (flora and fauna) from scats and camera (Rapallo 2012a). No records from Mining Area C despite extensive survey effort . Scats recorded approximately 5 km northwest of Mining Area C and a male quoll observed 5 km east of Mining Area C (Biologic 2017). Regionally there is a concentration of records 40 km to the north east from 2018 (DBCA 2020b). At Lamb Creek, potential habitat occurs within the gorge, gully , breakaway landscapes that occur within the higher elevation areas of the retention licence and ranges adjacent to the proposed haul road corridor. Northern quoll may forage/disperse through surrounding habitats such as hill crest/hillslope and drainage habitats.

Name	Status[1)]		Likelihood	Details
	BCA	EPBC		
Western pebble-mound mouse (*Pseudomys chapmani*)	P4	LC	Confirmed	The Western pebble-mound mouse occurs on the gentler slopes of rocky ranges where the ground is covered with a stony mantle and vegetated by hard spinifex, often with a sparse overstorey of eucalypts and scattered shrubs (Anstee & Armstrong 2001). Recorded in the survey area during the 2012 and 2020 survey from stony plain and hillcrest/hilltop habitat. Multiple records from Mining Area C (Biologic 2017) and other localities (DBCA 2020b).
Pilbara olive python (*Liasis olivaceus barroni*)	VU	VU	Confirmed	Within inland Pilbara the species is most often encountered near permanent waterholes in rocky ranges or among riverine vegetation (Pearson 1993). Recorded at Lamb Creek during the 2012 survey crossing stony plain between the Hamersley massive (hillcrest /hilltop habitat) and the Lamb Creek (medium drainage) within the now discounted southern haul road option (Rapallo 2012a). Five records from Mining Area C (Biologic 2017). At Lamb Creek, potential habitat occurs within the gorge, gully , breakaway landscapes that occur within the higher elevation areas of the retention licence and ranges adjacent to the proposed haul road corridor. The species may forage/disperse through drainage habitats.
Pilbara barking gecko (*Underwoodisaurus seorsus*)	P2		Likely	Pilbara barking gecko is a rock inhabiting, restricted-range species encountered at mid elevations in the Hamersley Ranges, widely separated from the closest populations of the related barking gecko *Underwoodisaurus milii* in the northern Goldfields and Shark Bay in Western Australia (Doughty & Oliver 2011) . The species has been recorded from several locations at Mining Area C and surrounds from gorge gully habitats (Biologic 2017). The species is known to be distributed over a wider area, having been recorded 120 km to the north-west and approximately 40 km to the south-west (DBCA 2020b). It is unknown whether its distribution is continuous between these areas, or if it occurs as a series of isolated populations. At Lamb Creek, potential habitat occurs within the gorge, gully , breakaway landscapes that occur within the higher elevation areas of the retention licence and ranges adjacent to the proposed haul road corridor.
Gane's blind snake (*Anilios ganei*)	P1		Likely	Endemic to the Pilbara, Gane's blind snake was originally listed because it was known from just a few scattered records, this species has now been more recently recorded from nine records in the region (DBCA 2020b). Gane's blind snake has been recorded from five locations within the Mining Area C Development Envelope, including an open drainage line (ENV Australia 2007) , rocky slope below the vertical wall of a gully, and mulga woodland habitat (Biologic 2011). Gane's blind snake was not recorded in this survey or the 2012 Lamb creek fauna survey but potential habitat occurs within the gorge, gully, breakaway, medium drainage, tussock grassland and mulga/corymbia plain habitats.

Footnotes:
1) Status: BCA = Western Australian Biodiversity Conversation Act 2016. EPBC = Commonwealth Environment Protection and Biodiversity Conservation Act 1999. See Appendix II for conservation codes.

4.2 Vertebrate fauna assemblage

During the 2020 detailed fauna survey of Lamb Creek, 128 species of vertebrate fauna were recorded, including 63 bird species, 20 mammal species, 44 reptile species, and one frog.

Combined with the 2012 fauna survey results, the total number of vertebrate fauna recorded from the Lamb Creek project area to date is 185 species. Results are presented in Appendix VII, summarised in Table 4.3 below and discussed in the text below.

Table 4.3 Summary of the total number of vertebrate fauna species recorded from Lamb Creek to date

Species group	2012 fauna survey	2020 fauna survey	Total recorded from Lamb Creek to date
Birds	76	63	87
Mammals	22	20	28
Reptiles	58	44	68
Amphibians	2	1	2
Totals	**158**	**128**	**185**

4.2.1 Birds

Birds were the most frequently observed fauna group, with 947 records representing 63 bird species. Of these species, 51 (81%) were recorded during systematic bird surveys, eleven species were recorded opportunistically, and one species, the little button-quail, was captured in a fauna trap.

Bird diversity was lower than predicted from the desktop study, which listed 159 bird species recorded from the region (section 4.1.2). However, the survey area did not contain suitable habitat for every one of these regional species. For example, there was no habitat for waders or waterbirds, while some species on the desktop list are migratory or respond to rainfall.

The habitat with the highest bird diversity recorded was medium drainage lines, dominated by *Corymbia*, *Acacia* and *Gossypium* over spinifex) with 34 bird species recorded, whereas the habitat with the lowest number of birds recorded was the hill crests and hill slopes habitat with only nine species recorded. The low diversity in this habitat likely reflects the low botanical diversity and structurally simplistic habitat.

The most frequently recorded bird species during the systematic surveys were the white-breasted woodswallow (n=103), Singing honeyeater (n=84), and budgerigars (n=76).

One conservation significant bird species has been recorded in the Lamb Creek project to date. This is the fork-tailed swift (*Apus pacificus*) which is listed EPBC Migratory and Marine. The fork-tailed swift is an extremely aerial species that is highly unlikely to land in the survey area and would not be affected by developments on the ground.

A comparison with data from the 2012 survey (Rapallo 2012a) indicated that the bird diversity in 2020 was lower than in that earlier survey, when 76 bird species were recorded (Table 4.3). The 2012 survey, however, covered a larger area as a southern haul road option was included, and in 2012 the survey area had not experienced recent fires. Over both survey years combined (see Appendix V) a total of 87 bird species have been recorded from the Lamb Creek project to date. Of these species, 52 were recorded in both survey years, 24 were only recorded in 2012, and four were only recorded in 2020. This difference

reflects the variability in bird assemblages between seasons and between years, and underlines that no single season survey would capture the complete avifauna of an area.

No conservation significant bird species were recorded in 2020. However, in 2012 the Fork-tailed swift (listed EPBC Migratory and Marine) was recorded from several locations (section 4.1.4).

4.2.2 Mammals

Twenty species of mammal were recorded during the 2020 survey. Bats were the most abundant group, with seven species recorded including the conservation significant ghost bat (listed Vulnerable). The majority of mammal species were recorded from systematic trap sites.

Mammal diversity was lower than predicted from the desktop study, which lists 46 mammal species recorded previously within 50 kilometres of the survey area (Appendix V), of which 43 species recorded from the adjacent Mining Area C. However, the Lamb Creek survey area did not contain suitable habitat for some of these regional species (for example no sand plains for Bilbies), and the survey comprised a single season only. In comparison, 21 surveys have been completed over the adjacent Mining Area C with data spanning many years and seasons, and over a much larger area containing habitats that do not occur in the Lamb Creek survey area (Biologic 2017).

To date, 28 mammal species have been recorded from Lamb Creek over both 2012 and 2020 surveys combined (Table 4.3). The number of mammal species recorded in 2020 was 19 compared to 22 recorded in 2012. The majority of species were recorded in both surveys. The northern quoll, listed Endangered, was only recorded in 2012, as discussed further below.

Systematic captures of small mammals were dominated by small dasyurids and rodents. The most abundant species were the Ooldea dunnart (*Sminthopsis ooldea*), Pilbara ningaui (*Ningaui timealeyi*) and the sandy inland mouse (*Pseudomys hermannsburgensis*) each with five captures. One additional species, the common rock rat (*Zyzomys argurus*) was recorded from a camera trap. The only conservation significant trappable mammal species recorded in 2020 was the western pebble-mound mouse (*Pseudomys chapmani*) which was recorded in the form of numerous mounds across the survey area. Nearly all pebble-mounds were recorded in the habitats of hill crest and hill slopes (section 4.5.2) and stony plain (section 4.5.1).

The 2020 survey recorded two conservation significant mammal species: the ghost bat (Vulnerable) and the western pebble-mound mouse (Priority 4). These same species were also recorded in 2012, as well as the northern quoll and the Pilbara olive python. These are discussed further in section 4.3.

Four introduced (feral) mammal species were recorded in 2020. These were the dromedary camel (*Camelus dromedarius*) and dog/dingo (*Canis lupus* sp.) which are listed declared pests s22(2), and the feral cat (*Felis catus*) and house mouse (*Mus musculus*) which are listed permitted s11 on the Western Australian Organism List (DAFWA 2021). One additional species of introduced fauna, the cow (*Bos taurus*) was recorded in 2012 (Rapallo 2012a).

4.2.3 Reptiles

During the 2020 survey 44 species of reptile and one species of amphibian were recorded from the Lamb Creek survey area. The desktop study indicated a total of 91 reptile species and seven amphibian species have been recorded within 50 kilometres of the survey area. However, the survey area does not contain suitable habitat for every one of these species.

To date, 68 reptile species and two frog species have been recorded from the 2012 and 2020 Lamb Creek survey areas (Table 4.3). In 2012 58 reptile species and two frog species were recorded, which is clearly higher than the number of species recorded in 2020. The lower numbers in 2020 were most likely because spotlighting was not permitted in 2020 due to logistics and client safety restrictions, and also because the survey area was recovering after several fires which burnt the majority of the survey area.

Overall, reptile records were still quite high during the 2020 survey. The reptile assemblage comprised sixteen skink species, five varanid species, five pygopod species, six agamid species and eight gecko species and four species of elapid for a total of 44 reptile species. The most commonly recorded reptile species were the rock ctenotus (*Ctenotus saxatilis*) with 86 records followed by the leopard ctenotus (*Ctenotus pantherinus*) with 61 records. The two most common geckos were the Pilbara ground gecko (*Lucasium wombeyi*) and western beaked gecko (*Rhynchoedura ornata*) with 37 and 36 records, respectively. The majority of reptile records came from systematic trapping.

Reptile species richness was generally consistent across all sites. The highest species richness was recorded at sites S06 and S09 with 15 species recorded at each.

No reptile species of conservation significance were recorded in 2020. However, in 2012 the Pilbara olive python (*Liasis olivaceus barroni*), listed Vulnerable under both the *Biodiversity Conservation Act 2016* and the EPBC Act, was recorded from a single location (section 4.3).

4.2.4 Amphibians

Amphibian diversity was low across the survey area, with only one species, *Cyclorana maini,* recorded. This is not a conservation listed taxon. One individual was detected opportunistically at trap site S02 within the Tussock grassland plain habitat. The lack of diversity and abundance of amphibian records likely reflects the low rainfall in the month prior to the survey.

4.2.5 Species richness estimators

To provide an indication of survey completeness, the software program EstimateS (Version 9.1.0) (Colwell 2013) was used to generate species accumulation curves and to calculate predicted species richness. Species accumulation curves represent a theoretical model of the relationship between survey effort and species accumulation: as the number of individuals recorded during the survey increases, the accumulation of fauna species decreases until the curve reaches an asymptote (Gotelli & Colwell 2011).

Since models can only be generated from data collected through systematic methods, the species accumulation curve and predicted species richness were calculated from systematic trapping data, and from systematic bird surveys. Separate analyses were conducted for these two methods.

4.2.5.1 Species accumulation curve for trapping data

The species accumulation curve for trapping data is presented in Figure 4.1, plotting the number of fauna species recorded (y-axis) against the number of individual animals captured in traps (x-axis). Observed species richness is presented as a sample-based rarefaction curve, computing the mean number of fauna species (S(est)) over all possible combinations of 1, 2, and up to 402 individuals captured (Colwell *et al.* 2012).

Systematic trapping recorded 43 species. The predicted species richness for trappable ground-dwelling fauna was 71 species, which indicates that 61% of the (estimated) trappable fauna had been captured

during the survey. This is reflected in the species accumulation curve, which after 402 individuals captured has not started to approach an asymptote (Figure 4.1).

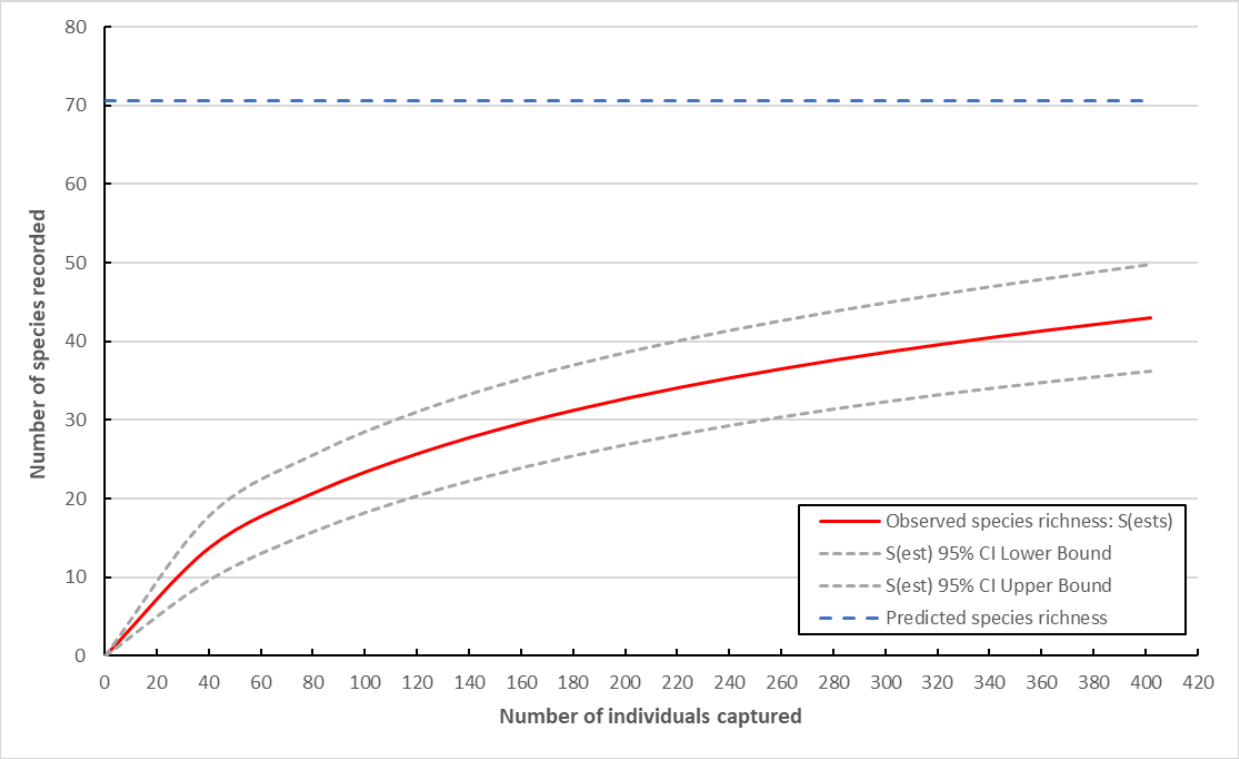


Figure 4.1 Species accumulation curve for trappable vertebrate fauna

The primary reason for the large difference between predicted and recorded species richness was the Chao 1 estimator which is very sensitive to the presence of species represented only by singletons (rare species) relative to species captured more than once. The theory behind the Chao 1 estimator is that if rare species (singletons) are still being discovered by the end of the survey, there are likely to still be more species present in the survey area that have not yet been recorded (Vavrek 2011). During the 2020 survey of Lamb Creek, sixteen species out of a total of 43 were trapped only once, hence 37% of the species were represented by singletons. This suggests that more species are likely present in the survey area than recorded during the current survey.

Opportunistic and spotlighting records of trappable fauna (excluding microbats and species too large to be captured in the traps deployed) yielded an additional nine species of small to medium-sized ground dwelling vertebrate fauna that could have been captured in traps. Hence, the actual number of trappable fauna recorded during the survey was 52, which represents 73% of the predicted total.

A comparison with data from the 2012 survey (Rapallo 2012a) yielded a total of 26 mammals (of which 19 trappable), 68 reptiles, and two frogs recorded from the Lamb Creek project area over both surveys combined (see Appendix V). Out of the combined total of 96 species of mammals, reptiles, and frogs recorded from Lamb Creek to date, 49 were recorded in both surveys, 33 were recorded only in 2012, and fourteen were recorded only in 2020.

The desktop study identified 46 mammals, 91 reptiles, and seven frog species within 50 kilometres of the survey area (section 4.1.2). Of these, 24 mammals were not considered trappable as they were either too big for the traps deployed, or were bats. Hence, the total number of potential trappable fauna identified in the desktop is 113 species. This number exceeds the predicted species richness, which is not unexpected, as not all species occur everywhere within their range, and not all habitats that appear

potentially suitable may meet the exact specifications that a particular species needs. The Pilbara region is well surveyed, and this indicates that the desktop list provides a good representation of all potential species within 50 kilometres of the survey area. Further trapping efforts in the survey area are likely to yield additional species for the Lamb Creek project.

Based on current desktop results, differences between the two survey years, as well as the shape of the species accumulation curve, it is expected that additional surveys would improve the known species richness of the Lamb Creek survey area. However, without considerable trapping effort, further surveys are unlikely to yield additional trappable conservation significant vertebrate fauna. The habitat suitable for those species not yet recorded in the survey area (see desktop section 4.1.4) are primarily within the areas to the south of the haul road, which is outside of the survey area.

4.2.5.2 Species accumulation curve for systematic bird survey data

The species accumulation curve for systematic bird survey data is presented in Figure 4.2, plotting the number of bird species recorded (y-axis) against the total number of detections for all species combined (x-axis). Observed species richness is presented as a sample-based rarefaction curve, computing the mean number bird species (S(est)) over all possible combinations of 1, 2, and up to 335 detections (Colwell *et al.* 2012). Predicted species richness was calculated by taking the average of the estimators ACE, Chao 1, Jackknife 1, and Bootstrap, as appropriate for abundance data (Colwell 2013).

Systematic bird surveys recorded 51 bird species. The predicted bird species richness was 67 species, which indicates that 76% of the (estimated) bird species present in the survey area had been detected through systematic surveys. This is reflected in the species accumulation curve, which after 335 detections is not yet approaching an asymptote (Figure 4.2).

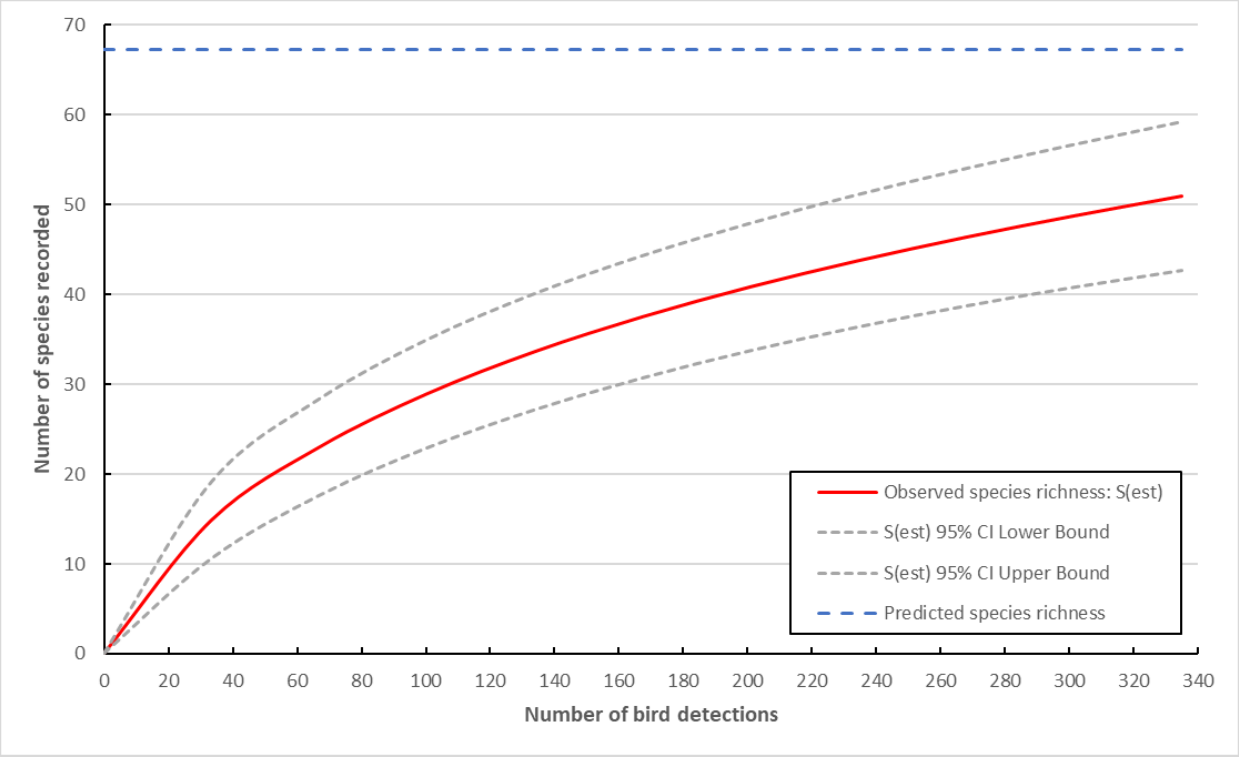


Figure 4.2 Species accumulation curve for systematic bird surveys

Similar to the trapping data, the Chao 1 estimator for the systematic bird data was very high compared to the other estimators, which is reflected by the fact that out of the total 51 species, 15 were

represented by singletons (29%). A high Chao 1 is a strong indication that further rare species occur in the survey area that have not yet been detected during the survey.

Opportunistic bird records collected during the survey (plus three Little button-quails captured in traps) yielded an additional twelve species. Hence the actual number of bird species recorded during the survey was 63, which represent 94% of the predicted total.

Bird assemblages of a given area often show variability between seasons and between years. A comparison with data from the 2012 survey (Rapallo 2012a) yielded a total of 86 bird species recorded from the Lamb Creek project area over both surveys combined (see Appendix V). Of these species, 47 were recorded in both survey years, 29 were only recorded in 2012, and 10 were only recorded in 2020. The total number of 86 bird species exceeds the predicted species richness of 67 bird species. However, since predicted species richness was calculated on data from the 2020 survey, it can only estimate total bird species richness at the time of the survey, and not across seasons or years.

The desktop study identified 157 bird species recorded within 50 kilometres of the survey area. The survey area contains potentially suitable habitat for 131 of these species (excluding ducks, waders, and other waterbirds).

Based on the desktop results, seasonal variability in bird assemblages, and the shape of the species accumulation curve, it is expected that additional surveys would further improve the known bird species richness of the Lamb Creek survey area. However, further surveys are unlikely to yield additional conservation significant bird species for the survey area.

4.4 Conservation significant vertebrate fauna

Five species of vertebrate fauna listed as conservation significant under either the Western Australian *Biodiversity Conservation Act 2016* (BC Act) or the federal *Environment Protection and Biodiversity Conservation Act 1950* (EPBC Act)[1] or listed as priority species by the department of Biodiversity Conversation and Attractions (DBCA) have been recorded from or proximal to the current Lamb Creek survey area to date, as listed below.

- Northern quoll (*Dasyurus hallucatus*) listed Endangered under both the EPBC Act and BC Act – Confirmed, recorded in 2012.
- Ghost bat (*Macroderma gigas*) listed Vulnerable under both the EPBC Act and the Biodiversity Conservation Act 2016 (BD Act) listed Confirmed, recorded in 2012 and 2020.
- Western pebble-mound mouse (*Pseudomys chapmani*) listed DBCA Priority 4 – Confirmed, recorded throughout the project area in 2012 and 2020.
- Fork-tailed Swift (*Apus pacificus*) listed Migratory and Marine under the EPBC Act – Confirmed, recorded in 2012.
- Pilbara olive python (*Liasis olivaceus barroni*) listed Vulnerable under both the EPBC Act and the BC Act – Confirmed, recorded in 2012.

4.4.1 Northern quoll

The Northern quoll is listed as Endangered under the EPBC act and the BC Act. The species, once widely distributed across northern Australia, is now restricted to three isolated populations; the Pilbara, the Kimberley and Northern Territory, and Queensland, in addition to a number of islands along the north coast (DoE 2016). Such declines are primarily due to the western expansion of the cane toad which is highly toxic to predators when consumed (Woinarski *et al.* 2008). Other threats include predation from feral predators such as foxes and cats, inappropriate fire regimes, disease, habitat degradation through grazing as well as habitat destruction through mining and agriculture (Woinarski *et al.* 2011).

The Northern quoll is both arboreal and terrestrial, inhabiting ironstone and sandstone ridges, scree slopes, granite boulders and outcrops, drainage lines and riverine habitats (Braithwaite & Griffiths 1994, Oakwood 2002). Rocky habitats tend to support higher densities, as they offer protection from predators and are generally more productive in terms of availability of resources (Braithwaite & Griffiths 1994, Oakwood 2002). Other microhabitat features important to the species include: rock cover; proximity to permanent water and time-since last fire (Woinarski *et al.* 2008). Dens occur in a wide range of situations including: rock overhangs, tree hollows, hollow logs, termite mounds, goanna burrows and human dwellings/infrastructure, where individuals usually den alone (Oakwood 2002, Woinarski *et al.* 2008). Northern quoll populations go through boom-bust cycles with population crashes recorded in years of drought (Hernandez-Santin, et al. 2019, Moore et al. 2021).

The Northern quoll is moderately common through part of the Pilbara (within 150 kilometres of the coast) and therefore usually present where suitable rocky habitat is present. Northern quoll occur in the hard rocky habitats of the Pilbara that provide denning habitat and safety from predators and fire (Hill & Ward 2010, Turpin & Bamford 2014).

Habitat critical to the survival of the northern quoll is defined as rocky habitats such as ranges, escarpments, mesas, gorges, breakaways, boulder fields, major drainage lines, or treed creek lines (DotEE

[1] Note that all species listed under the EPBC Act as Threatened (see Appendix II) are considered Matters of National Environmental Significance (MNES).

2016). The gorge, gully, breakaway habitat within the higher elevation areas of the retention licence and ranges adjacent to the proposed haul road corridor fit the definition of critical northern quoll habitat, defined by large areas of condensed, complex rocky habitat, with intact vegetation occurring within and in the areas surrounding habitat (DotEE 2016, Moore et al. 2021). Habitat complexity within-patch scale (Moore *et al.* 2021) is present for denning via the deep cracks and crevices of the extensive outcropping. Suitable denning habitat for this species occurs within the gorge, gully, breakaway habitat within the higher elevation areas of the retention licence and the ranges adjacent to the proposed haul road corridor. Northern quoll may forage/disperse through surrounding habitats such as hill crest/hillslope and drainage habitats.

No evidence of Northern quoll was detected during the 2020 survey, despite significant effort including searching on foot for scats, footprints and other signs, and placement of 40 camera traps (279 camera nights) (Figure 3.1). The 2012 trap effort of 182 camera nights and 300 cage trap nights yielded one individual recorded via camera and a scat from gorge, gully, breakaway habitat located in the ranges adjacent to the current haul road corridor (Rapallo 2012a). In addition, a scat was recorded during April 2012 flora surveying from a rock overhang in the gorge, gully, rocky breakaways habitat of the eastern part of the retention licence (M. Weerheim *pers. comm*.) (Figure 4.3). The 2012 survey coincided with the recruitment season for northern quoll (Hernandez-Santin, et al. 2019).

Northern quoll was recorded very infrequently from the adjacent Mining Area C, despite significant survey effort over many years, and all records were scats only (Biologic 2017).

Based on desktop evidence and records from 2012 and 2020, it appears that northern quoll are locally present at low density. It is unlikely that an extensive population of northern quoll inhabits the survey area, or habitats adjacent to it, bearing in mind that the current 2020 survey was completed at reconnaissance level, and survey work to date (2012 and 2020) and did not cover all areas of potential gorge / gully habitat within the project area.

4.4.2 Ghost bat

The Ghost bat (*Macroderma gigas*) is listed It is listed as Vulnerable under both the Western Australian *Biodiversity Conservation Act 2016* and under the Commonwealth EPBC Act. The species has declined significantly over the last 200 years and currently has a patchy and widespread distribution across northern Australia (Van Dyck & Strahan 2008). The availability of suitable roost caves is critical for the species' persistence and survival (Armstrong & Anstee 2000).

Rapallo recorded ghost bat at Lamb Creek during a detailed fauna survey in 2012. At that time, the ghost bat was Priority 4 and not considered an MNES species. Hence, (DEWHA 2010) did not apply to the ghost bat at the time. Furthermore, ultrasonic recordings in 2012 failed to detect ghost bat calls as, at the time, the consensus was that their echolocation and social calls were difficult to distinguish from other signals based on their structure (Armstrong 2010). All ghost bat records from Rapallo (2012) were through direct sightings on the few select caves that could be visited by the team on foot as access via helicopter was not provided.

Bat survey work completed in 2020-2021 was a component of the detailed survey in order to assess general bat populations of the survey area. Caves 1, 2 and 3, where ghost bats had been detected visually in 2012 were re-visited in April 2020. Caves 4 and 5 were identified after the 2020 field survey when additional regional information became available. Because they were very close to the survey area (approximately 200 meters) caves 4 and 5 were visited opportunistically in February 2021 during SRE field

work, with some additional recordings also made at caves 1 and 2. The purpose of this was to make use of the opportunity to accumulate more survey data, as a helicopter was available.

Calls at times consistent with foraging visits were detected at Caves 2 and 3 in April 2020 and at Caves 3 and 4 in February 2021. At least four diurnally roosting ghost bats were confirmed at Cave 1 in 2020. This was confirmed by the temporal pattern of their recorded calls on three nights. Both social and ultrasonic calls were recorded before dawn followed by similar numbers of calls soon after dusk that day.

In 2021 calls consistent with diurnally roosting ghost bats were detected at Cave 5. These records are consistent with the Ghost bat being present in the region (Bat Call WA 2021) including the adjacent Mining Area C (Biologic 2017, 2016b).

Cave 1 is provisionally assigned as a Category 2 roost while Caves 2, and 3 are provisionally Category 3. Caves 4 and 5 are known Category 3 and 2 respectively (Bat Call unpublished data) and occur nearby to a number of other caves, shelters and overhangs identified in Biologic (2016b).

Caves that are confirmed as Category 2 and groupings of caves that surround them are critical Ghost bat habitat (Bat Call WA 2021). Based on this, caves 4 and 5 are confirmed critical habitat, and cave 1 is potential critical habitat pending confirmation. Caves are initially given a provisional categorisation based on the first visit. In order for this status to become confirmed, permanent monitoring is required to confirm pattern of usage over a two-year period (B. Bullen *pers. comm*. January 2022).The roost categories are detailed in (Appendix VIII).

Ghost bat will often forage more broadly across habitats, often utilising drainage lines and other habitats where prey species are likely to be most abundant (Richards *et al.* 2008, Tidemann *et al.* 1985). Therefore, until habitat requirements for Ghost bat in the Pilbara are refined it is assumed that suitable foraging habitat exists across all habitats of the survey area.

Cave 1 and cave 3 are located in the retention licence (R47/19), within respectively 325 metres and 600 meters from footprint V3, while cave 4 and 5 are located adjacent to the project area within 200 meters of the haul road footprint in L47/713 (Figure 4.3).

In summary, ghost bat was confirmed in the areas surveyed at Lamb Creek in 2012, 2020 and 2021. To date no targeted work on ghost bats as per DEWHA (2010) or detailed cave/roost assessments have been completed in the Lamb Creek project area, and some areas have never been visited as they were added after the surveys were completed. The work completed on ghost bats in 2012, 2020 and 2021 was either a component of a detailed survey or opportunistic records.

4.4.3 Pilbara olive python

The Pilbara olive python (*Liasis olivaceus barroni*) is listed Vulnerable under both the *Biodiversity Conservation Act 2016* and the EPBC Act. This species was not recorded in 2020, but in 2012 it was recorded crossing stony plain habitat between the Hamersley massive (hillcrest/hilltop habitat) and the Lamb Creek (medium drainage) within the now discounted southern haul road option (Rapallo 2012a), (Figure 4.3). The species has been recorded from the adjacent Mining Area C (Biologic 2017) and from four DBCA records in the vicinity (Appendix VI).The Pilbara olive python favours areas with permanent water holes in rocky rangers or along rivers (Pearson 1993).

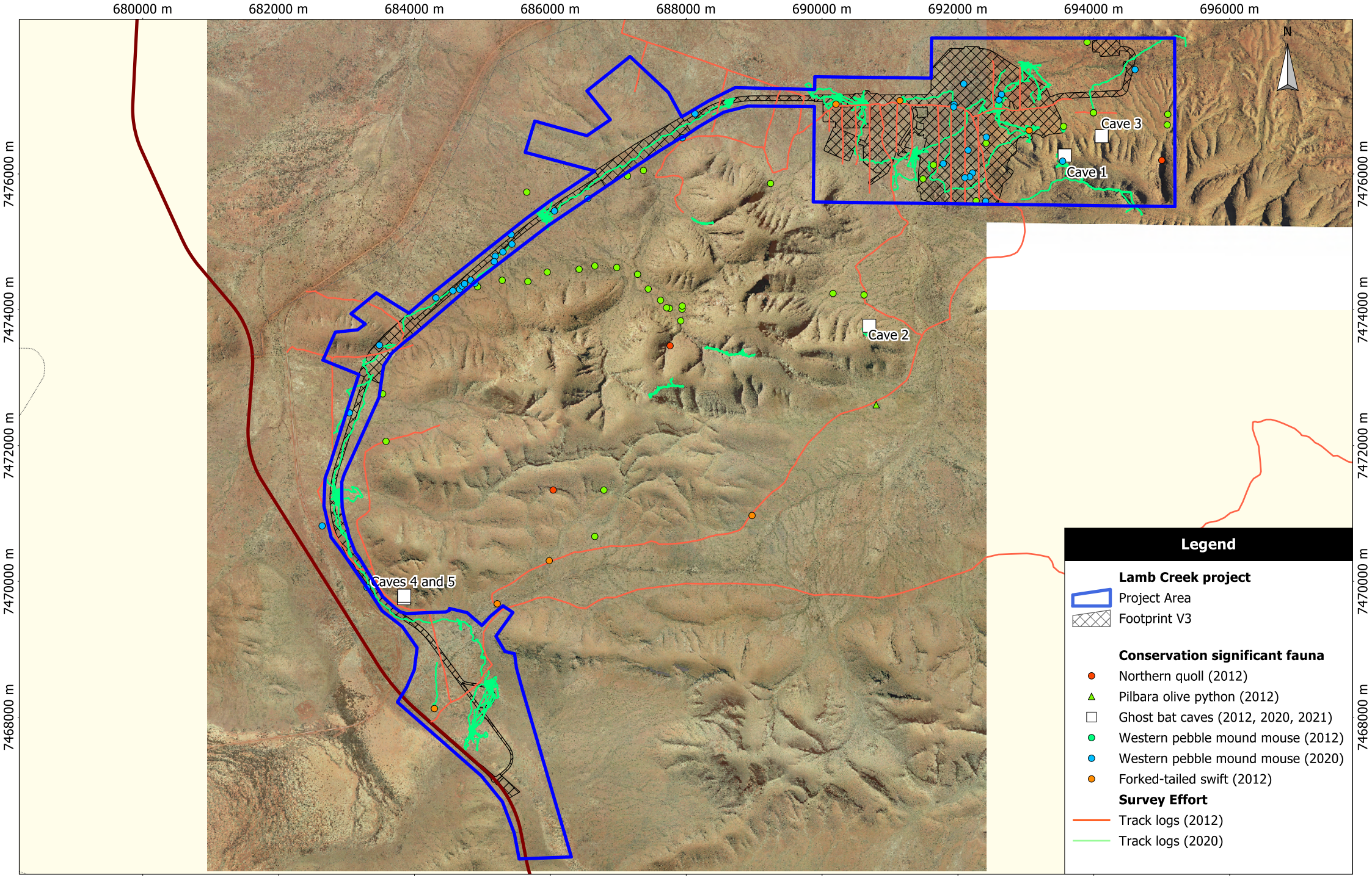
This species is likely to be found within the gorges and gullies of the ranges adjacent to the proposed haul road corridor and may forage/disperse through surrounding habitats such as stony plain and drainage habitats.

4.4.4 Western pebble-mound mouse

The Western pebble-mound mouse (*Pseudomys chapmani*) is listed by the DBCA as Priority 4 which is defined as taxa in need of monitoring. The species has experienced a significant decline in their range from the Gascoyne and Murchison (Van Dyck & Strahan 2008). Pebble mounds were recorded in both 2012 and 2020 from the hill crest/hill slopes and stony plain habitats (Figure 4.3). The Western pebble-mound mouse was also recorded throughout similar habitat in the adjacent Mining Area C project area (Biologic 2017) and appears to be locally common.

4.4.5 Fork-tailed swift

The Fork-tailed swift (*Apus pacificus*) is listed Migratory and Marine under the EPBC Act. It was not recorded in 2020, but in 2012 it was recorded from all habitats of the survey area (Rapallo 2012a) . This species is migratory, and would forage above the Lamb Creek project area during summer (Johnstone & Storr 1998). The species is entirely aerial and would not land in the survey area. Hence, project activities on the ground are unlikely to impact this species.



Rapallo environmental

Mineral Resources Limited
Lamb Creek Project

Lamb Creek Iron Ore Project
Detailed Vertebrate Fauna Survey

Original Size: A4 Scale: 1:70,000
Datum: MGA94 Zone 50
0 2 km

Figure 4.3

Conservation significant vertebrate fauna records 2012 and 2020 surveys

4.5 Broad fauna habitats

Seven broad fauna habitats were identified in the survey area, as mapped in Figure 4.4. Habitats are summarised in Table 4.4 and Table 4.5 with habitat assessment data presented in Appendix IX.

Table 4.4 Broad Fauna Habitats

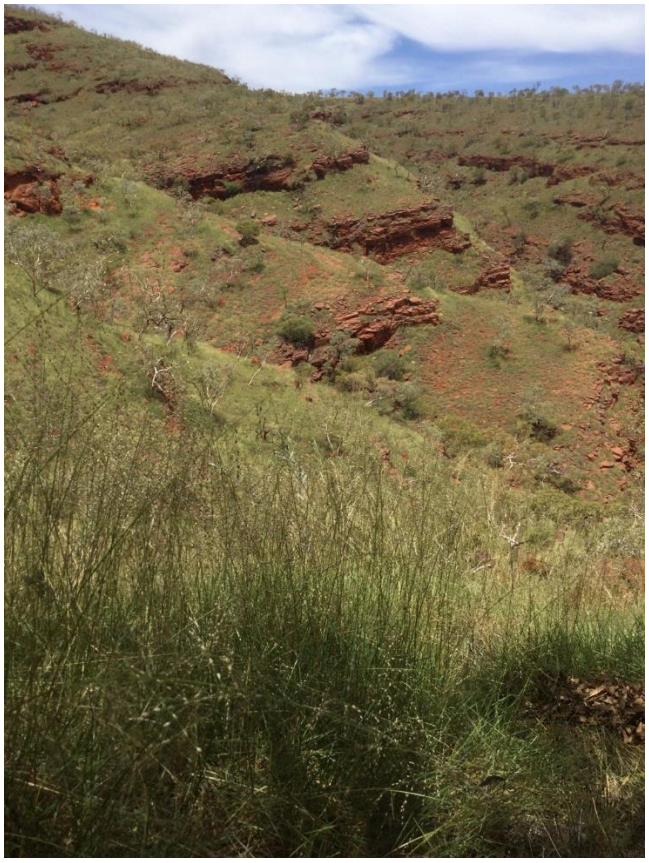
Broad fauna habitat	Area (ha)
Stony plain	518
Hillcrests/hillslope	319
Mulga/corymbia plain	292
Minor drainage	211
Tussock grassland plain	137
Medium drainage	113
Gorge, gully and rocky breakaway	55
Road – Bitumen (not a habitat)	1
	1645

Table 4.5 Fauna habitat descriptions

Habitat	Representative Photo
Stony plain Plains and lower slopes of spinifex hummock grasslands (or in small patches, tussock grass) on red sandy clay loam to loam soil. Typically, with a mantle of gravel (less so on the valley floor adjacent to drainage, where soils are loamier). Little to no overstory aside from scattered trees or patches of mixed shrubs often regenerating from fire. Generally, *Eucalyptus leucophloia* occurs on the slopes, *Eucalyptus gamophylla* on lower slopes and *Corymbia hamersleyana* is typically associated with drainage). Potential conservation significant species: ▪ Night parrot (possible foraging/ dispersal in small area of unburnt mature Triodia near LCS03) ▪ Ghost bat (foraging/ dispersal) ▪ Grey falcon (foraging/ dispersal ▪ Western pebble-mound mouse (breeding/ shelter, foraging/ dispersal) ▪ Pilbara olive python (foraging/dispersal) Sites: LC16, LC22, LC24B, LC24A, LC27B, LC28, LC29A, LC30, LC37A, LC40, LCS08, LCS03 LCS04 Area: 518 hectares Significance: Low	

Habitat	Representative Photo
Hillcrest/hill slopes Slopes and hill crests of the higher elevation areas. Spinifex hummock grassland dominated with scattered Eucalyptus leucophloia trees and mallee, and acacia and grevillea shrubs on rocky, red skeletal soils (loams to clay/loam). Potential conservation significant species: ▪ Ghost bat (foraging/ dispersal) ▪ Western pebble-mound mouse (breeding/ shelter, foraging/ dispersal) ▪ Northern quoll (foraging/ dispersal) Area : 319 hectares Sites: LC11, LC19, LC17, LC38, LC26, LCS10 Significance: Moderate	
Mulga/corymbia plain Open mulga shrubland patches over spinifex or tussock grassland on loams to sandy clay loam occurring in areas of sheet flow drainage. The mulga patches are surrounded by run-off zones of stonier plain of open spinifex/tussock grassland under very open mulga/ *Corymbia deserticola (*shrubland). Potential conservation significant species: ▪ Ghost bat (foraging/ dispersal) ▪ Grey falcon (foraging/ dispersal ▪ Gane's blind snake Area: 291 hectares Sites: LC04, LC05, LC06, LC07, LC08, LC09, LC10, LC15, LCS05 and LCS06 Significance: Moderate	

Habitat	Representative Photo
Minor drainage The smaller narrow drainage channels and shallow gullies that bisect the stony plain habitat and hill slopes, forming flow zones on the valley floor. Mixed open shrubland to shrubland often over tussock grass and herbs with occasional fringing trees (scattered *Eucalyptus leucophloia, Corymbia or Eucalyptus gamophylla)* Potential conservation significance species: ▪ Ghost bat (foraging/ dispersal) ▪ Grey falcon (foraging/ dispersal) ▪ Peregrine falcon (foraging/ dispersal) ▪ Pilbara olive python (foraging/ dispersal) ▪ Northern quoll (foraging/ dispersal) Area : 210.6 hectares Sites: LC18, LC23, LC25, LC27A, LC36, LC37, LC42A, LC44, LC43, LC45, LC29B Significance: Moderate	
Tussock grassland plain Tussock grass (Aristida i*naequiglumis*, *A. contorta*, *Themeda triandr*a) dominated largely undefined drainage plain. Contains occasional open mulga woodland stands or scattered mulga individuals on brown sandy clay loam to loams. Contains patches of spinifex. Potential conservation significant species: ▪ Ghost bat (foraging/ dispersal) ▪ Grey falcon (foraging/ dispersal ▪ Peregrine falcon (foraging/ dispersal) ▪ Gane's blind snake ▪ Short-tailed mouse Area : 137 hectares Sites: LC31, LC32, LC33, LC34, LC35, LC41, LC42, LCS01, LCS02 Significance: Moderate	

Habitat	Representative Photo
Medium drainage Wide loamy drainage channels to undefined drainage (gravelly) containing occasional emergent *Corymbia hamersleyana* over patches of low mixed shrubs over buffel grass and tussock grass dominated understory on low relief. Contains very occasional mulga stands in loamier soils. Potential conservation significant species: ▪ Ghost bat (foraging/ dispersal) ▪ Grey falcon (breeding/ nesting, foraging, dispersal) ▪ Pilbara olive python (foraging/dispersal) ▪ Northern quoll (foraging/ dispersal) ▪ Peregrine falcon (foraging/ dispersal) ▪ Gane's blind snake Area : 113 hectares Sites: LC01, LC02, LC03, LC39, LC39A, LCS07, LCS09 Significance: Moderate	
Gorge, gully and rocky breakaway The wide rocky gullies and gorges that bisect the hillcrest/hillslopes of the higher elevation areas containing caves, deep cracks, and crevices. Breakaways occur as the rugged edges of hillslopes. Spinifex hummock grassland with mixed shrubland patches or occasional ficus occurring in shaded locations or occasional *Eucalyptus leucophloia.* otential conservation significant species: ▪ Pilbara olive python (breeding/ shelter, foraging/ dispersal) ▪ Northern quoll (breeding/ shelter, foraging/ dispersal) ▪ Ghost bat (roosting/foraging/ dispersal) ▪ Peregrine falcon (breeding/foraging/ dispersal) ▪ Pilbara barking gecko ▪ Gane's blind snake Area : 54.7 hectares Sites: LC13, LC21, LC12, LC14, LC20, LC12, LC14, LC20 Significance: High	

4.5.1 Stony plain

A habitat of the lower slopes, undulating and level plains, the stony plain habitat often occurs in shallow valleys below hill systems. This habitat typically has a low habitat complexity due to low diversity of microhabitat and minimum shading from vegetation and landform dependent on surrounding topography and outcropping.

The stony plain habitat is the most extensive habitat on the survey area (518 hectares), covering most of the retention licence and haul road corridor on the lower valley sides to valley floor. At Lamb Creek this habitat is characterised by little to no overstory aside from scattered trees or patches of mixed shrubs often regenerating from fire. *Eucalyptus leucophloia* often occurs on the slopes, *Eucalyptus gamophylla* on the valley floor and lower slopes and *Corymbia hamersleyana* grades into drainage. Within the survey area the stony plain typically has low habitat complexity with microhabitats restricted to infrequent rocky outcrops and limited shade provided by vegetation.

Stony plain habitat is a common habitat in the Pilbara, particularly in the Boolgeeda Land System. Aerial photography and helicopter visuals confirm that this broad habitat occurs outside of the survey area. There are some species of conservation significance that may utilise this habitat, primarily as foraging or dispersal. However, they are not restricted to this habitat type. The stony plain habitat is ranked as low significance (Table 4.5, Appendix IV).

4.5.2 Hill crests/hill slopes

Hillcrests and hillslopes are the rocky crest and slopes of the large hills and ranges. This habitat typically has a low habitat complexity due to low diversity of microhabitat and minimum shading from vegetation and landform dependent on surrounding topography and outcropping.

At Lamb Creek this habitat is confined to the higher elevation areas (centre and south-east corner of the retention licence) and falls within the Newman Land and Boolgeeda Land System. There are no high elevation south facing slopes and outcropping with cracks and crevices predominately occurs in the adjacent gorge, gully and rocky breakaway habitat. This broad habitat can contain areas of outcropping, outwash (minor drainage) and breakaway that were too small to map in detail.

Hill crests and hill slopes formed the second most extensive habitat within the survey area, covering 319 hectares. Vegetation is characterised by a *Triodia hummock* grassland with scattered *Eucalyptus leucophloia* trees and mallee, and acacia and grevillea shrubs.

Aerial photography, helicopter visuals, and ground-truthing for camera trapping confirmed that this habitat extends outside of the retention licence, to the south of the haul road corridor. In a regional context, rocky spinifex dominated hillcrests and hillslopes habitats of the Pilbara are common.

Conservation significant species are likely to disperse and forage within these habitats due to the proximity of the gorge, gully and rocky breakaway habitat, therefore, this habitat is ranked as moderate significance (Table 4.5, Appendix IV).

4.5.3 Gorge, gully and rocky breakaway

Gorges are deeply incised, with vertical cliff faces, while gullies are more open and shallower. Breakaways refer to rugged slopes with vertical fall on the edge of a hill or range. This habitat can support caves and

semi-permanent rock pools and has a moderate to high habitat complexity largely dependent on landform and aspect.

At Lamb Creek this habitat is confined to the higher elevation areas within the retention licence and falls within the Newman Land System. This habitat bisects the hillcrest/hillslopes of the higher elevation areas and contains caves, deep cracks/crevices, and shaded microhabitats from both vegetation and landform shadow. The more open, shallow gullies contain have lower habitat complexity with microhabitats occurring within the rocky substrate and partial shade provided by vegetation and landform. The deepest gorge on the retention licence has northern-facing slope and there are no south facing gorges or deep gullies.

This habitat occurs as two deep gorges and two smaller gorges in the centre and south-east corner of the retention licence and is typically vegetated with spinifex hummock grassland with mixed shrubland patches or ficus occurring in shaded locations and occasional *Eucalyptus leucophloia*. The gorge, gully and rocky breakaway habitat does not occur on the haul road corridor.

The gorge, gully and rocky breakaway habitat is one of the smallest habitats in the survey area (54.7 hectares) due to its narrow features. Aerial photography and helicopter visuals and ground-truthing for camera trapping confirmed that this habitat extends outside of the retention licence, bisecting the higher elevation areas adjacent to the proposed haul road corridor. In a regional context, the gorges, gully and rocky breakaway habitats of the Pilbara are restricted to the Chichester and Hamersley IBRA subregions but are well represented. Locally, this habitat occurs at Mining Area C (Biologic 2017) and within Karijini National Park.

The gorge, gully and rocky breakaway habitat are considered important for conservation significant fauna, including Matters of National Environmental Significance species. The gorge, gully and rocky breakaway habitat is ranked as high significance (Table 4.5, Appendix IV).

4.5.4 Medium drainage

Medium drainage is defined as the narrow gravelly drainage channels that become wider on the lower plains of the valley. This drainage is made up of minor tributaries that feed into the major creek lines of the catchment. Medium drainage is often fringed by *Corymbia hamersleyana*. Medium drainage habitat typically exhibits a moderate habitat diversity with some tree hollows and woody debris (logs and leaf litter) and typically does not contain semi-permanent/ permanent pools or the large fringing river gums.

At Lamb Creek this habitat occurs on the valley floor of the retention licence as wide loamy drainage channels to undefined drainage (gravelly) containing occasional emergent *Corymbia hamersleyana* over patches of low mixed shrubs over buffel grass and tussock grass dominated understory on low relief. Contains very occasional mulga stands in loamy soils as the habitat transitions into mulga/corymbia plain habitat.

The medium drainage habitat provides higher protection than the surrounding stony plain habitat due to partial shading from vegetation and some leaf litter and woody debris, however it was noted in 2020 and 2021 that detritus and litter within this habitat was sparse or in piles without accumulated soil - indicating recent fast flow and little opportunity for soil and fine detritus to accumulate. This habitat typically has deeper loamier soils than the surrounding stony plain, therefore greater potential to retain moisture.

The medium drainage habitat although small in area (113 hectares) due to narrow features is relatively common throughout the Pilbara. Aerial photography and helicopter visuals confirm that this habitat occurs outside of the survey area aligning with the Lamb Creek that feeds into Marillana creek.

The medium drainage habitat provides foraging and dispersal opportunities for conservation significant fauna including Matters of National Environmental Significance species. The medium drainage habitat is ranked as moderate significance (Table 4.5, Appendix IV).

4.5.5 Minor drainage

Minor drainage represents the small drainage channels that originate from the hillcrest/ hillslope habitats and bisect the stony plain habitat. Minor drainage typically exhibits a low-moderate habitat complexity, with some shading from vegetation but low soil moisture levels, low accumulated litter, and generally gravelly soils.

At Lamb Creek this habitat occurs throughout the survey area and represents the smaller drainage channels and shallow gullies. Typically, vegetation can be denser than the surrounding habitat of stony plain or hill slopes and hill crests, consisting of mixed open shrubland to shrubland often over tussock grass and herbs with occasional fringing trees (scattered *Eucalyptus leucophloia, Corymbia hamersleyana or Eucalyptus gamophylla*. The substrate can be sandy in places but generally consists of a skeletal loam gravel or stone. This broad habitat although small in area (211 hectares) is relatively common throughout the Pilbara. Aerial photography and helicopter visuals confirm that this habitat occurs outside of the survey area.

There are some species of conservation significance that may utilise this habitat, primarily as foraging or dispersal, however, they are not restricted to this habitat type. The minor drainage line habitat is ranked as moderate significance (Table 4.5, Appendix IV).

4.5.6 Tussock grassland plain

The tussock grassland plain habitat is defined as tussock grassland dominated drainage plain (hardpan) containing open mulga woodland stands or scattered mulga individuals on brown sandy clay loam to loams with surface mantles of very few to few pebbles of ironstone.

This habitat occurs at the southern end of the haul road corridor within the Wannamunna and Boolgeeda land systems. This habitat receives run-on from adjacent hills and surrounding stony plain and much of the drainage is undefined. The tussock grassland broad habitat is not widespread throughout the Pilbara, compared with the adjacent spinifex stony plain and hillcrest/hillslope habitats and aligns broadly with the groves landform unit of the Boolgeeda land system, the hardpan plains landform unit of the Wannamunna land system and 'valley floor mulga' as described by Kendrick (2001).

Aerial photography suggests that this habitat continues south east from the survey area parallel to the Great Northern Highway, aligning with the mulga habitat found at Area C (Biologic 2017), approximately three kilometres to the south-south west of the survey area.

Mulga (species in the *Acacia aneura* complex) is widespread across arid and semi-arid regions of Western Australia, covering approximately 37 percent of the surface area of Western Australia (Fox 1980). Grove-intergrove Mulga communities of the eastern Hamersley range were considered as "ecosystems at risk" by (Kendrick 2001) because it is thought that sensitivity to disturbance is greatest at the northern limit of

mulga's distribution (Fox 1980), related to the dominant summer rainfall pattern of the Pilbara (Fox 1980, Kendrick 2001, Maslin & Reid 2012).

Kendrick (2001) lists a number of 'ecosystems at risk' including grove/inter-grove mulga of the eastern Hamersley range, and 'valley floor mulga' within the Hamersley IBRA subregion. Given the lack of detail provided by Kendrick, it is not possible to determine if the habitats containing mulga vegetation at Lamb Creek match the mulga ecosystems at risk. However, vegetation types B, C, D and E (Rapallo 2021b) do contain *Acacia aptaneura* within the upper storey on stony or clay plains and floodplains, which broadly aligns with the broad description of 'valley floor mulga'.

Regionally, (Biota 2014) consider "valley floor mulga" to extend over a range of approximately 350 kilometres through the southern half of the Pilbara (Biota, unpublished data, cited in Biota 2014) and Onshore (2017) conclude that mulga vegetation of *Acacia catenulata* subsp. *occidentalis* and *Acacia aptaneura* that aligns with valley floor mulga' on the MAC Development Envelope is common on plains between Newman and Roy Hill (approximate range 150 kilometres).

Onshore (2017) concluded that seven other vegetation associations within BHP Billiton Iron Ore's consolidated vegetation mapping database support *Acacia catenulata* subsp. o*ccidentalis* and *Acacia aptaneura* as dominant upper storey components, and are considered to be closely affiliated with the mulga communities recorded on the lower stony plains of the MAC development area. As such Onshore (2017) does not considered the mulga communities within the MAC Development Area to be locally endemic or unique.

Neither the vegetation association nor related ecosystem of "valley floor mulga" has been nominated as a PEC by DBCA since identified as an ecosystem at risk by Kendrick (2001b) suggesting a low level of perceived conservation significance.

The tussock grassland plain habitat provides foraging and dispersal opportunities for conservation significant fauna including Matters of National Environmental Significance species. The tussock grassland plain habitat is ranked as moderate significance (Table 4.5, Appendix IV).

4.5.7 Mulga/corymbia plain

The mulga/corymbia plain habitat is defined as level plain subject to sheet flow containing mulga woodland patches adjacent to run-on zones of stonier plain.

At Lamb Creek this habitat occurs on the valley floor adjacent to medium drainage primarily in the retention licence and also in the northern section of the haul road corridor. Vegetation is broadly open mulga shrubland patches over spinifex or tussock grassland surrounded by run - on zones of stonier plain of open spinifex/tussock grassland under very open mulga/ *Corymbia deserticola* shrubland. Soils are loams to sandy clay loam.

The mulga/corymbia plain habitat exhibits a moderate habitat complexity. Mulga stands provide shade; however, the stands are not extensive or thick, therefore the shade is patchy as is the accumulated litter and associated patches of moister soil. Within the mulga patches this habitat provides loamier soil for burrowing species, however the substrate in adjacent run-on areas is predominantly hard and stony.

This habitat aligns broadly with the stony lower plains and narrow drainage floors, channels land landform unit of the Boolgeeda land system (van Vreeswyk et al. 2004) and 'valley floor mulga' as described by Kendrick (2001).

Boolgeeda is a common system in shallow valleys below hill systems such as the Newman and Rocklea land system (van Vreeswyk et al. 2004). Aerial photography and helicopter visuals suggest that this habitat occurs outside of the survey area however, ground truthing has not verified the extent of individual mulga patches beyond 50 metres south of the survey area. Valley floor mulga is discussed in detail in section 4.5.6.

Disruption to sheet flow could impact this habitat. The mulga/corymbia plain habitat provides foraging and dispersal opportunities for conservation significant fauna including Matters of National Environmental Significance species . The mulga/corymbia plain habitat is ranked as moderate significance (Table 4.5, Appendix IV).

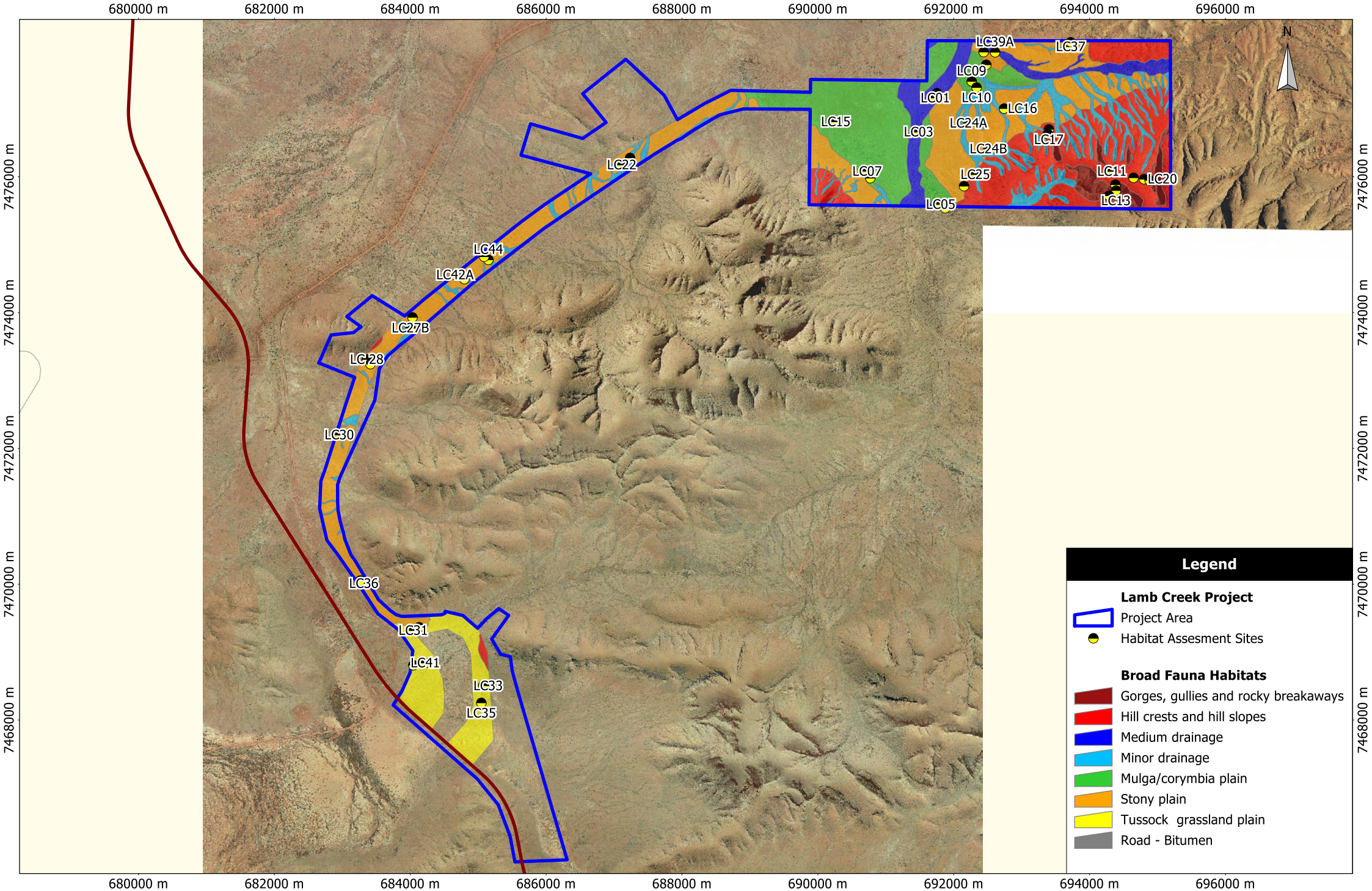
4.5.8 Disturbance

Some habitats have been disturbed via selective clearing for tracks, drill pads and laydown associated with exploration activities, particularly within the stony plain habitat of the retention licence. The majority of the survey area has been burnt over recent years, with some parts burnt several times (NAFI 2021) resulting in a mosaic of different post fire ages. See section 2.5.

4.6 Habitat Features

Water sources are a limiting factor for many ecosystems ((James *et al.* 1995), particularly within arid-zone ecosystems such as the Pilbara ((Burbidge *et al*. 2010, Doughty *et al.* 2011) and often represent areas of comparatively high ecological productivity (Murray *et al.* 2003). Continuous sources of food and moisture, and water for amphibians provides opportunities to forage and breed (James *et al.* 1995). To date there have not been permanent or semi-permanent pools recorded from the Lamb Creek project area, despite extensive use of helicopter in 2012, 2020 and 2021 for baseline surveys.

Caves can be important features within a landscape, particularly in arid zone systems, often providing stable microclimates, shelter and protection (Medellin et al. 2017). Ghost bat occurrence, or evidence of occurrence, has been recorded at five known caves on or proximal to the survey area (section 4.4.2). Cave photographs are located in Appendix VIII.



Rapallo environmental

Mineral Resources Limited
Lamb Creek Project

Lamb Creek Iron Ore Project
Detailed Vertebrate Fauna Survey

Original Size: A4 Scale: 1:70,000
Datum: MGA94 Zone 50
0 2 km

Figure 4.4

Habitats of the survey area

4.7 Survey adequacy and limitations

The following sections address level of assessment, survey completeness and survey limitations. The field survey was completed in April 2020 and aligned with the following Environmental Protection Authority (EPA) guidance statements:

- *Technical Guidance – Terrestrial Fauna Surveys* (EPA 2016c)
- *Technical Guidance – Sampling methods for terrestrial vertebrate fauna* (EPA 2016b).

These guidance statements have been superseded by the current technical guidance (EPA 2020), which was published post field work (June 2020).

4.7.1 Level of assessment and survey timing

A single-phase detailed vertebrate fauna survey was conducted over 13 days, from 16 to 28 April 2020. Supplementary habitat assessment and bat call recordings occurred during the wet season between 16 and 25 February 2021. The survey level and timing were as per client request aligning with the end of the EPA (2016b, 2020) recommended survey period for reptiles in the Eremaean botanical province. The recommended survey period for birds and amphibians in the Eremaean province is after rain (EPA 2016b, 2020). As described in section 2.1, rainfall in January 2020 was above average, but below average for February and March 2020 (BOM 2020), and there was no rainfall during the survey. At the time of the survey, the area appeared to be very dry.

The primary focus of the detailed terrestrial vertebrata fauna survey was to identify the faunal assemblages present in the survey area. For this reason, conducting the survey post summer rainfall, when faunal activity is typically high was appropriate. The field survey occurred post-mating season for Northern quoll (Hernandez-Santin, *et al.* 2019), however, the cameras deployed as part of this survey were additional survey effort to the detailed survey rather than constituting a targeted survey as per the Commonwealth guidelines for Northern quoll (DoE 2016). A targeted conservation significant fauna survey (including northern quoll and ghost bat) was beyond the scope.

4.7.2 Survey completeness

Species accumulation curves for trappable fauna and birds are presented in section 4.2.5. Species richness estimators indicate that the survey recorded 61% of the estimated trappable fauna, and 76% of the estimated birds. This is reflected in the shape of the species accumulation curves, which by the end of the survey had not started to approach an asymptote. Additional trapping surveys would likely improve the known species richness of the survey area; however, further short-term trapping surveys are unlikely to yield additional conservation significant species.

4.7.3 Survey limitations

In accordance with EPA (2016c, 2020) technical guidance, an assessment of the limitations of the survey is presented in Table 4.6.

Table 4.6 Limitations of the fauna survey of the Lamb creek survey project area

Aspect	Limitation	Discussion
Scope and intensity	No	Scope and intensity of the survey were suitable to achieve the aims of a level 2 fauna survey as outlined in EPA (2016a).

Aspect	Limitation	Discussion
Availability of contextual information at a regional and local scale	No	Extensive surveying has been undertaken in the Pilbara region including an extensive body of work over BHP Mining Area C which is located directly adjacent and south of the survey area over similar land systems.
Competency/experience of the team carrying out the survey, including experience in bioregion surveyed	No	All members of the survey team have experience in conducting fauna surveys in arid Western Australia.
Proportion of fauna recorded and/or collected, any identification issues	Partial	Approximately 43% of vertebrate fauna identified in the desktop assessment were recorded during the field survey. Although the desktop assessment is likely to overestimate the number of species occurring within the survey area, appropriate sampling was conducted to adequately sample all fauna groups. Apart from SRE specimens, all observed fauna was identified at the point of observation during the field surveys. All recorded bat calls were analysed, and species identified by an external expert. The survey recorded 128 species of vertebrate fauna, including 63 bird species, 20 mammal species, 44 reptile species, and one frog species. However, in comparison with the 2012 survey, the 2020 fauna assemblage was subdued, which was likely related to low rainfall and recent fires. In addition, the 2012 survey included nocturnal spotlighting which often produces additional fauna that are not captured in traps or diurnal surveys, while in 2020 nocturnal surveys were not possible due to client safety requirements. The species accumulation curves for trappable fauna and birds indicated that additional trapping effort is likely to detect further species within the Lamb Creek survey area. The survey comprised a single-season detailed fauna survey, and was not a targeted survey for conservation significant fauna including ghost bat, northern quoll, and Pilbara olive python. The latter two species were not detected in 2020 but known to be present at Lamb Creek in 2012. These species are cryptic and take sufficient effort to detect. Targeted surveys in accordance with national guidelines (DEWHA 2010, 2011) may detect these species within the project area but this was outside the scope. The method used to sample northern quoll broadly aligned with an initial reconnaissance survey under DotEE (2016), but this was not the purpose of the survey which was designed as a detailed fauna survey. Not all critical habitat as per (DotEE 2016) was ground truthed. The camera transects deployed aimed to collect supplementary data to feed into a targeted survey. SM4 deployment completed in 2020 and 2021 did not comprise a targeted survey for ghost bat as per DEWHA (2010). This is not a limitation of this survey as it was a detailed vertebrate fauna survey and a targeted ghost bat survey was outside the scope.
Was the appropriate area fully surveyed (effort and extent)	Partial (survey area) Yes (project area)	The entire survey area (but not the project area) was covered through the use of helicopters which enabled access to all areas. Approximately 555 hectares (25%) of the current project area has not been covered by fauna surveys. Spotlighting was not conducted due to client safety restrictions. Often nocturnal surveys detect additional species including owls

Aspect	Limitation	Discussion
		and nightjars, reptile or mammal species that are not typically captured in traps, and species like frogs which most frequently call at night. The survey was completed as a single-phase detailed vertebrate fauna survey, and not a targeted conservation significant fauna survey.
Access restrictions within the survey area	No	All survey areas were accessible by helicopter.
Survey timing, rainfall, season of survey	Partial	The survey was completed in late April, which falls within the EPA (EPA 2016b) recommended timing to survey reptiles in the Eremaean botanical province. The recommended survey time for birds and frogs is immediately after rainfall events. Rainfall in the two-month preceding the survey was low compared to the annual average and conditions over most of the project area were dry. This is a factor of the survey being single-season only. A single-season survey is unlikely to sample all fauna species present, either because they are infrequently encountered, or because they are not present year-round.
Disturbances that may have affected the results of the survey (e.g. fire, flooding, clearing)	No	The survey area experienced fires in recent years, and the vegetation over most of the survey area was regenerating and relatively sparse compared to unburnt conditions. This is likely to have influenced the overall diversity and abundance of species, however where possible trap sites were positioned in pockets of unburnt habitat within the burn mosaic.

5 Conclusion

Five species of vertebrate fauna listed as conservation significant under either the Western Australian *Biodiversity Conservation Act 2016* (BC Act) or the federal *Environment Protection and Biodiversity Conservation Act 1950* (EPBC Act) or ranked as a priority species by the Department of Biodiversity Conversation and Attractions (DBCA) have been recorded from or proximal to the Lamb Creek project area to date.

- Northern quoll (*Dasyurus hallucatus*) listed Endangered under both the EPBC Act and BC Act – Confirmed, recorded in 2012.
- Ghost bat (*Macroderma gigas*) listed Vulnerable under both the EPBC Act and the BC Act - Confirmed, recorded in 2012 and 2020.
- Western pebble-mound mouse (*Pseudomys chapmani*) DBCA Priority 4 – Confirmed, mounds recorded throughout the survey area in 2012 and 2020.
- Fork-tailed Swift (*Apus pacificus*) listed migratory and marine under the EPBC Act – Confirmed, recorded in 2012.
- Pilbara olive python (*Liasis olivaceus barroni*) listed Vulnerable under both the EPBC Act and the BC Act – Confirmed, recorded in 2012.

The desktop review identified 29 species of conservation significance (excluding species listed solely as EPBC Marine) for which records, or potential habitat exist within 50 kilometres of the project area.

Five species identified in the desktop were recorded during the 2012 and 2020-2021 surveys, as discussed above. Three species were considered likely to occur within the survey area. These were Peregrine falcon (*Falco peregrinus* – listed Other Specially Protected Fauna under the BC Act), Gane's blind snake (*Anilios ganei* –DBCA Priority 1) and Pilbara barking gecko (*Underwoodisaurus seorsus* - DBCA Priority 2).

Four species of conservation significance were regarded as possibly occurring within the survey area these were Night parrot (*Pezoporus occidentalis* – listed Critically Endangered under the BC Act and Endangered under the EPBC Act), Grey falcon (*Falco hypoleucos* – listed Vulnerable under both the EPBC Act and the BC Act), Letter-winged Kite (*Elanus scriptus* – DBCA Priority 1), and the Short-tailed mouse (*Leggadina lakedownensis* – DBCA Priority 4).

Night parrot was not detected via acoustic recorder in 2020. Much of the spinifex across the survey area has been frequently burnt and habitats of the survey area do not include mosaics with samphire and chenopod shrublands, salt lake margin, or paleochannel.

The remaining seventeen species identified by the desktop assessment were considered unlikely to occur within the survey area.

Within the survey area, the gorge, gully, and rocky breakaway habitat was considered to be of high significance for vertebrate fauna as this habitat support species of conservation significance (including nationally listed threatened species) or contains core habitats for such species. Five habitats were ranked as of moderate significance (Hillcrest/hillslope, Mulga/Corymbia plain, Minor drainage, Tussock grassland plain, Medium drainage) and the remaining habitat (Stony plain) was ranked as low significance, as it is widespread in the surrounding region and species of conservation significance are exclusively dependent on this habitat.

To date there have not been permanent or semi-permanent pools recorded from the Lamb Creek project area, despite extensive use of helicopter in 2012, 2020 and 2021 for baseline surveys.

There are five known caves on or proximal to the survey area in which Ghost bat occurrence, or evidence of occurrence, has been recorded. Cave 1 is provisionally assigned as a Category 2 roost while caves 2, and 3 are provisionally Category 3. Caves 4 and 5 are known Category 3 and 2 respectively and occur nearby to a number of other caves, shelters and overhangs. Caves that are confirmed as Category 2 and groupings of caves that surround them are critical Ghost bat habitat.

Cave 1 and 3 are located in the R47/19, within respectively 325 meters and 600 meters from footprint V3 (mining pit, stock piles, infrastructure). Caves 4 and 5 were located adjacent to L47/736 within 200 meters of footprint V3 (haul road).

6 References

Anstee, S.D. and Armstrong, K.N. (2001) The effect of familiarity and mound condition in translocations of the western pebble-mound mouse, Pseudomys chapmani, in the Pilbara region of Western Australia. Wildlife Research **28**, 135-140.

Armstrong, K.N. (2010) Assessing the short-term effect of minerals exploration drilling on colonies of bats of conservation significance: A case study near Marble bar, Western Australia. Journal of the Royal Society of Western Australia.

Armstrong, K.N. and Anstee, S.D. (2000) The Ghost Bat in the Pilbara: 100 years on. Australian Mammalogy **22**, 93–101.

Atlas of Living Australia (2021) Atlas of Living Australia. http://www.ala.org.au/

Australasian Bat Society (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.

Bat Call WA (2021) Lamb Creek, Pilbara WA. Acoustic survey of bat and Night Parrot activity, April 2020. and February 2021. Report prepared for Rapallo.

Beard, J.S. (1975) Vegetation Survey of Western Australia, Pilbara 1:1 000 000. Map and Explanatory Notes to Sheet 7. Published by University of Western Australia Press., Perth.

Beard, J.S. (1990) Plant life of Western Australia. Kangaroo Press, Kenthurst, N.S.W.

Beard, J.S. (2018) Pre-European Vegetation - Western Australia (NVIS Compliant version 20110715). ArcView shapefiles published by the Department of Primary Industry and Regional Development. The major sources of data in this database are the published and unpublished mapping of J.S. Beard at 1:250,000 scale.

Biologic (2011) Area C and Surrounds Fauna Survey. Unpublished report for BHP Billiton Pty Ltd.

Biologic (2012) Southern Flank Vertebrate Fauna Survey. Unpublished report for BHP Billiton Pty Ltd.

Biologic (2013) Mudlark Vertebrate Fauna Survey. Unpublished report for BHP Billiton Pty Ltd.

Biologic (2016a) South Flank Targeted Fauna Survey. Unpublished report prepared for BHP Billiton Iron Ore.

Biologic (2016b) Mining Area C - Southern Flank. Environmental Impact Assessment for Ghost Bat (Macroderma gigas). BHP Billiton Iron Ore Ltd.

Biologic (2017) Proposed Mining Area C Development Envelope Vertebrate Fauna Desktop Assessment. Report prepared for BHP Iron Ore Pty Ltd. February 2017.

Biota Environmental Sciences (2014) Baby Hope Downs Flora and Vegetation Survey.

Birdlife Australia (2019) Working List of Australian Birds v3. August 2019.

Birdlife Australia (2020a) Birdata. https://birdata.birdlife.org.au/

Birdlife Australia (2020b) Birds in Backyards. Black-shouldered Kite. https://www.birdsinbackyards.net/species/Elanus-scriptus. Accessed 2020.

Braithwaite, R.W. and Griffiths, A.D. (1994) Demographic variation and range contraction in the northern quoll, *Dasyurus hallucatus* (Marsupialia: Dasyuridae). Wildlife Research **21**, 203–217.

Bullen, R.D. and McKenzie, N.L. (2002) Differentiating Western Australian Nyctophilus (Chiroptera: Vespertilionidae) echolocation calls. Australian Mammalogy **23**, 89–93.

Burbidge, A.H., Johnstone, R.E. and Pearson, D.J. (2010) Birds in a vast arid upland: avian biogeographical patterns in the Pilbara region of Western Australia. Records of the Western Australian Museum, Supplement **78**, 247–270.

Bureau of Meteorology (2020) Climate Data Online. http://www.bom.gov.au/climate/data/index.shtml

Bureau of Meteorology (2021) Climate data online. Australian Government Bureau of Meteorology. http://www.bom.gov.au/climate/data/

Caccetta, W. (2018) Night parrot photographed twice in secret location. National Indigenous Times.

Cogger, H.G. (2018) Reptiles and Amphibians of Australia. Updated seventh edition, October 2018. CSIRO Publishing.

Colwell, R.K. (2013) EstimateS: Statistical estimation of species richness and shared species from samples. Version 9.1.0. Persistent URL <purl.oclc.org/estimates>.

Colwell, R.K., Chao, A., Gotelli, N.J., Lin, S.Y., Mao, C.X., Chazdon, R.L. and Longino, J.T. (2012) Models and estimators linking individual-based and sample-based rarefaction, extrapolation and comparison of assemblages. Journal of Plant Ecology **5**, 3–21.

CSIRO Australia (2018) Australian Soil Resource Information System (ASRIS). http://www.asris.csiro.au/themes/Atlas.html

Davis and Metcalf (2008) The Night Parrot (Pezoporus occidentalis) in northern Western Australia: a recent sighting from the Pilbara region. Emu **108**, 233–236.

Department of Agriculture and Food, Western Australia (2021) Western Australian Organism List (WAOL). Last updated 8 March 2021. www.agric.wa.gov.au/organisms

Department of Agriculture Water and the Environment (2020) Protected Matters Search Tool. http://www.environment.gov.au/epbc/protected -matters-search-tool.

Department of Agriculture Water and the Environment (2021) Protected Matters Search Tool. http://www.environment.gov.au/epbc/protected-matters-search-tool

Department of Agriculture, Water and the Environment (2021) Species Profile and Threats Database (SPRAT). Published by the Australian Govenment, Department of Agriculture, Water and the Environment. www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Department of Biodiversity Conservation and Attractions (2019) 2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of March 2019. Government of Western Australia, Department of Biodiversity, Conservation and Attractions, Perth.

Department of Biodiversity Conservation and Attractions (2020a) Threatened and Priority Fauna Database (custom search). Government of Western Australia. Government of Western Australia.

Department of Biodiversity Conservation and Attractions (2020b) NatureMap: Mapping Western Australia's Biodiversity. https://naturemap.dbca.wa.gov.au/

Department of Biodiversity Conservation and Attractions (2021a) Threatened Ecological Communities Database (custom search). Government of Western Australia.

Department of Biodiversity Conservation and Attractions (2021b) Priority Ecological Communities for Western Australia - Version 32. Species and Communities Program, 15 July 2021.

Department of Environment Regulation (2014) A Guide to the Assessment of Applications to Clear Native Vegetation.

Department of Sustainability, Environment, Water, Population and Communities (2011) Environment Protection and Biodiversity Conservation Act 1999 referral guidelines for the endangered northern quoll, *Dasyurus hallucatus*., EPBC Act policy statement 3.25. Australian Government, Canberra, A.C.T.

Department of the Environment and Energy (2012) Australia's bioregions (IBRA), Version 7. http://www.environment.gov.au/land/nrs/science/ibra

Department of the Environment and Energy (2016) EPBC Act referral guideline for the endangered northern quoll Dasyurus hallucatus. Canberra, Australian Capital Territory:

Department of Water and Environmental Regulation (2020) Clearing Permit System and Map Viewer. https://cps.dwer.wa.gov.au

DEWHA (2010) Survey Guidelines for Australia's Threatened Bats;

Doughty, P. and Oliver, P.M. (2011) A new species of Underwoodisaurus (Squamata: Gekkota: Carphodactylidae) from the Pilbara region of Western Australia. Zootaxa **3010**, 20–30.

Doughty, P., Rolfe, J.K., Burbidge, A.H., Pearson, D.J. and Kendrick, P.G. (2011) Herpetological assemblages of the Pilbara biogeographic region, Western Australia: ecological associations, biogeographic patterns and conservation. Records of the Western Australian Museum, 315–341.

DPaW (2017) Department of Parks and Wildlife. Interim guideline for the preliminary surveys of Night Parrot (Pezoporus occidentalis) in Western Australia. Kensington, Western Australia.

Dutson, G., Garnett, S. and Gole, C. (2009) Australia's Important Bird Areas. Key Sites for bird conservation. Bird Australia (RAOU) Conservation Statement No. 15.

ecologia Environment (1998) Mining Area C Biological Survey. Unpublished report for BHP Billiton Pty Ltd.

ecologia Environment (2004a) Packsaddle Range Biological Survey. Unpublished report for BHP Billiton Pty Ltd.

ecologia Environment (2004b) Area C: Deposits D, E and F Biological Survey. Unpublished report for BHP Billiton Pty Ltd.

ecologia Environment (2005) Pilbara Leaf-nosed Bat, (Rhinonicteris aurantius) and Ghost Bat, (Macroderma gigas) monitoring survey at Nimingarra and Cattle Gorge 2005. Unpublished report for BHP, Western Australia, Perth.

ENV Australia (2007) Area C R-deposit Fauna Assessment. Unpublished report for BHP Billiton Pty Ltd.

ENV Australia (2008) Area C Southern Flank Deposit Fauna Assessment. Unpublished report for BHP Billiton Pty Ltd.

Environmental Protection Authority (2000) Position Statement No. 2: Clearing of Native vegetation, with particular Reference to the Agricultural Area. Environmental Protection Authority, Government of Western Australia.

Environmental Protection Authority (2016a) Environmental Factor Guideline: Flora and Vegetation. EPA, Perth, Western Australia.

Environmental Protection Authority (2016b) Technical Guidance - Sampling methods for terrestrial vertebrate fauna. December 2016. EPA, Perth, Western Australia.

Environmental Protection Authority (2016c) Technical Guidance - Terrestrial Fauna Surveys. December 2016. EPA, Perth, Western Australia.

Environmental Protection Authority (2020) Technical Guidance - Terrestrial vertebrate fauna surveys for environmental impact assessment. June 2020.

Fox, J.E.D. (1980) Effects of fire on the mulga (Acacia aneura) community (Annual Report No. 3), Mulga Research Centre Ann. Rept. 3 (1979). Mulga Research Centre.

Gardiner, S.J. (2003) Impacts of Mining and Mine Closure on Water Quality and the Nature of Shallow Aquifer, Yandi Iron Ore Mine (Master's Thesis).

Garnett, S.T., Szabo, J.K. and Dutson, G. (2011) The Action Plan for Australian Birds 2010. *CSIRO Publishing/Birds Australia, Melbourne.*

Gibson, L.A. and McKenzie, N.L. (2009) Environmental associations of small ground -dwelling mammals in the Pilbara region, Western Australia. Records of the Western Australian Museum Supplement **78**, 91–122.

Gotelli, N.J. and Colwell, R.K. (2011) Estimating species richness, in: Magurran, A., MgGill, B. (Eds.), Biological Diversity: Frontiers in Measurement and Assessment. Oxford University Press, Oxford, UK, pp. 39–54.

Halpern Glick Maunsell (1999) Marillana Creek Western Access Corridor - Biological Assessment. Unpublished report for BHP Iron Ore Pty Ltd.

Hamilton, N.A., Onus, M., Withnell, B. and Withnell, K. (2017) Recent sightings of the Night Parrot Pezoporus occidentalis from Matuwa (Lorna Glen) and Milrose Station in Western Australia. Australian Field Ornithology 71–75.

Harewood, G. (2018) Night Parrot Survey Report. Lake Disapointment Potash Project. Reward Minerals Ltd.

Hernandez-Santin, L., Dunlop, J., Goldizen, A. and Fisher, D. (2019) Demography of the northern quoll (Dasyurus hallucatus) in the most arid part of its range. Journal of Mammalogy **100**, 1191–1198.

Hill and Ward (2010) National Recovery Plan for the Northern Quoll Dasyurus hallucatus.

Ison, S. (2017) Hear the night parrot audio captured by Busselton locals. Busselton Dunsborough Times. https://www.bdtimes.com.au/news/regional/night-parrot-recording-a-coup-for-club-ng-b88641203z

Jackett, N., Greatwich, B., Swann, G. and Boyle, A. (2017) A nesting record and vocalisations of the Night Parrot Pezoporus occidentalis from the East Murchison, Western Australia. Australian Field Ornithology, 34, 144-150.

James, C., Landsberg, J. and Morton, S. (1995) Ecological functioning in arid Australia and research to assist conservation of biodiversity. Pacific Conservation Biology **2**, 126–142.

Jenkins, A.R. (2000) Hunting mode and success of African Peregrines Falco peregrinus minor, does nesting habitat quality affect foraging efficiency? Ibis **142**, 235–246.

Jenkins, A.R. and Hockey, P.A.R. (2001) Prey availability influences habitat tolerance: an explanation for the rarity of Peregrine Falcons in the tropics. Ecography **24**, 359–367.

Johnstone, R.E. and Storr, G.M. (1998) Handbook of Western Australian birds. Volume I: Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth, W.A.

Johnstone, R.E. and Storr, G.M. (2004) Handbook of Western Australian birds. Volume II: Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth, W.A.

Kendrick, P. (2001) Pilbara 3 (PIL3 - Hamersley subregion), in: Cowan, M., Graham, G., McKenzie, N. (Eds.), A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002. Department of Conservation and Land Management.

Lee, A.K. (1995) The Action Plan for Australian Rodents. Australian Department of the Environment and Heritage., Canberra, Australia.

Maslin, B.R. and Reid, J.E. (2012) A taxonomic revision of Mulga (*Acacia aneura* and its close relatives: Fabaceae) in Western Australia. Nuytsia **22**, 129–267.

McDougall, A., Porter, G., Cupitt, R., Joseph, L. and Burbidge, A. (2009) Another piece in an Australian ornithological puzzle - a second night parrot is found dead in Queensland. Emu - Austral Ornithology, **109**, 198–203.

McGilp, J. (1931) Geopsittacus occidentalis, Night-Parrot. South Australian Ornithologist, 11, 68-70.

McKenzie, N.L. and Bullen, R.D. (2003) Identifying Little Sandy Desert bat species from their echolocation calls. Australian Mammalogy **25**, 73–80.

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.

Medellin, R.A., Wiederholt, R. and Lopez-Hoffman, L. (2017) Conservation relevance of bat caves for biodiversity and ecosystem services. Biological Conservation **211 (Part B)**, 45–50.

Menkhorst, P. and Knight, F. (2010) A Field Guide to the Mammals of Australia. Third Edition. 18 November 2010. Oxford University Press, Australia.

Michelmore, K. and Birch, L. (2020) Night parrot located by KJ rangers on Martu country in the Pilbara. ABC Pilbara.

Moore, H.A., Michael, D.R., Ritchie, E.G., Dunlop, J.A., Valentine, L.E., Hobbs, R.J. and Nimmo, D.G. (2021) A rocky heart in a spinifex sea: occurrence of an endangered marsupial predator is multiscale dependent in naturally fragmented landscapes. Landscape Ecology.

Murphy, S., Silcock, J.L., Murphy, R., Reid, J. and Austin, J. (2017) Movements and habitat use of the night parrot Pezoporus occidentalis in south-western Queensland. Austral Ecology, 42(7), 858-868. doi:https://doi.org/10.1111/aec.12508.

Murray, B.B.R., Zeppel, M.J., Hose, G.C. and Eamus, D. (2003) Groundwater-dependent ecosystems in Australia: It's more than just water for rivers. Ecological Management & Restoration **4**, 110–113.

NAFI (2021) North Australia & Rangelands Fire Information. https://firenorth.org.au/nafi3/

Oakwood, M. (2002) Spatial and social organization of a carnivorous marsupial Dasyurus hallucatus (Marsupialia: Dasyuridae). Journal of Zoology **257**, 237–248.

Onshore Environmental (2017) Mining Area C Southern Flank Flora and Vegetation Impact Assessment. Report prepared for BHP Billiton Iron Ore.

Outback Ecology Services (2008) Area C Mining Operation Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits. Unpublished report for BHP Billiton Iron Ore Pty Ltd.

Pearson (1993) Distribution, status and conservation of Pythons in Western Australia, in: D. Lunney, D. Ayers (Eds.), Herpetology in Australia, a Diverse Discipline. Surrey Beatty & Sons, pp. 383–395.

Rapallo Environmental (2012a) Level 2 Vertebrate Fauna Survey and Targeted Northern Quoll Survey of the Lamb Creek Project Area. Report prepared for Process Minerals International.

Rapallo Environmental (2012b) Level 2 Flora and Vegetation Survey of Lamb Creek Project Area. Report prepared for Process Minerals International.

Rapallo Environmental (2021a) Memo J020247 – Review of the Lamb Creek haul road corridor extrapolated vegetation mapping.

Rapallo Environmental (2021b) Detailed flora and vegetation survey of the Great Northern Highway intersection area of the Lamb Creek project. Report prepared for Mineral Resources Limited, 29 October 2021.

Rapallo Environmental (2022) Baseline Short-range Endemic Invertebrate Survey of the Lamb Creek Iron Ore Project. Report No. J020969. Prepared for Mineral Resources Limited, January 2022.

Ratcliffe, D.A. (1993) The Peregrine Falcon, 2nd ed. T & AD Poyser Ltd, London.

Richards, G.C., Hand, S., Armstrong, K.N. and Hall, L.S. (2008) Ghost Bat. In S. Van Dyck & R. Strahan (Eds.)., Mammals of Australia 3rd Edition. ed. Sydney: Reed New Holland.

Shepherd, D., Beeston, G. and Hopkins, A. (2002) Native Vegetation in Western Australia: Extent, type, and status. Resource Management Technical Report 249. Department of Agriculture, South Perth, Western Australia.

Specialised Zoological (2008) Area C bat survey.

Thackway, R. and Cresswell, I. (Eds.) (1995) An interim biogeographic regionalisation for Australia : a framework for setting priorities in the National Reserves System Cooperative Program / edited by R Thackway and I D Cresswell. Australian Nature Conservation Agency, Reserve Systems Unit, Canberra.

Thorne, A.M. and Tyler, I.M. (1997) Roy Hill 1:250,000 Map Sheet SF50-12. Geological Survey of Western Australia.

Tidemann, C.R., Priddel, D.M., Nelson, J.E. and Pettigrew, J.D. (1985) Foraging behaviour of the Australian Ghost Bat, Macroderma gigas (Microchiroptera: Megadermatidae). Australian Journal of Zoology. **33**, 705–713.

Turpin, J. and Bamford, M. (2014) A new population of the northern quoll (Dasyurus hallucatus) on the edge of the Little Sandy Desert, Western Australia. Australian Mammalogy **37**, 86–91.

Tyler, M.J. and Doughty, P. (2009) Field guide to frogs of Western Australia. Western Australian Museum, Welshpool, W.A. :

Van Dyck, S., Gynther, I. and Baker, A. (2013) Field Companion to The Mammals of Australia. New Holland Publishers.

Van Dyck, S. and Strahan, R. (2008) The mammals of Australia. New Holland Publishers, Sydney.

Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P. (2004) Inventory and condition survey of the Pilbara region, Western Australia. Department of Agriculture and Food, Western Australia, Perth, W.A.

Vavrek, M.V. (2011) fossil: Palaeoecological and palaeogeographical analysis tools. Palaeontologia Electronica **14**, 16p.

Western Australian Land Information Authority (2018) Soil Landscape Mapping - Rangelands (DPIRD-063). Land system mapping for the pastoral area of Western Australia (Version April 2018).

Western Australian Museum (2012) Preservation and Lodgement of Terrestrial Invertebrate Specimens. Version 8 (June 2012).

Western Australian Museum (2018) Frog Watch. Alcoa Frog Watch. Western Australian Museum. http://museum.wa.gov.au/explore/frogwatch

Western Australian Museum (2019) Checklist of the Terrestrial Vertebrate Fauna of Western Australia. Updated October 2019.

Wilson, H. (1937) Notes on the Night Parrot, with references to recent occurrences. 37, 79-87.

Wilson, S. and Swan, G. (2017) Complete Guide to Reptiles of Australia. 5th Edition. New Holland Publishers, Chatswood, NSW.

Woinarski, J.C.Z., Legge, S., Fitzsimons, J.A., Traill, B.J., Burbidge, A.A., Fisher, A. and Ziembicki, M. (2011) The disappearing mammal fauna of northern Australia: context, cause, and response. Conservation Letters **4**, 192–201.

Woinarski, J.C.Z., Oakwood, M., Winter, J., Burnett, S., Milne, D., Foster, P., Myles, H. and Holmes, B. (2008) Surviving the toads: patterns of persistence of the northern quoll Dasyurus hallucatus in Queensland. Department of Natural Resources, Environment and the Arts, Darwin.

7 Appendices

No	Title
Appendix I	Likelihood of occurrence matrix: Vertebrate fauna
Appendix II	Conservation codes
Appendix III	Site coordinates, camera trap and SM4 deployment details
Appendix IV	Significance assessment criteria: Habitat
Appendix V	Fauna desktop results: All fauna
Appendix VI	Fauna desktop results: Conservation significant vertebrate fauna
Appendix VII	Field Records
Appendix VIII	SM4 Analysis
Appendix IX	Fauna habitat sites

Appendix I Likelihood of occurrence matrix: Vertebrate fauna

Species records relative to survey area	Habitat suitability			
	High (breeding and foraging)	Medium (foraging habitat)	Low (dispersal habitat)	Unsuitable [6]
Records within 10 km [1]	Highly Likely	Likely	Likely	Possible
Records within 50 km [2]	Likely	Possible	Possible	Unlikely
Records within 100 km [3]	Possible	Possible	Possible	Unlikely
Records within 200 km [4]	Possible	Unlikely	Unlikely	Unlikely
No records within 200 km [5]	Unlikely	Unlikely	Unlikely	Highly unlikely

Footnotes for highly cryptic or poorly known species for which there are few records, and for under-surveyed areas:
1 – Survey area occurs within currently known range and species has high dispersal capability.
2 – Survey area occurs within currently known range and species has low dispersal capability.
3 – Survey area occurs on margin of currently known range and species has high dispersal capability.
4 – Survey area occurs outside of currently known range and species has high dispersal capability.
5 – Survey area occurs outside of currently known range and species has low dispersal capability.
Footnotes with habitat suitability:
6 – Depending on a species' ecology, 'unsuitable' can either mean 'not preferred' or 'not containing resources', or it can be 'prohibitive' (i.e. absence of water for aquatic species). This distinction affects the final likelihood score in this column.

Appendix II Conservation codes

Threatened species under the Commonwealth EPBC Act

Threatened fauna and flora may be listed under Section 178 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in any one of the following categories:

EX Extinct

EW Extinct in the wild

CR Critically endangered

EN Endangered

VU Vulnerable

CD Conservation dependent

Migratory and Marine species under the Commonwealth EPBC Act

Migratory and Marine species are not listed as Threatened but are protected for other reason. Only Migratory species are considered Matters of National Environmental Significance (MNES) while Marine species are not.

MI Migratory

MA Marine

Migratory species listed under international agreements to which Australia is a party are protected under section 209 of the EPBC Act and are considered MNES. Listed migratory species are those listed in the:

- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
- China-Australia Migratory Bird Agreement (CAMBA)
- Japan-Australia Migratory Bird Agreement (JAMBA)
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)

Marine species are those listed under s248 of the EPBC Act. Marine species are not considered MNES.

Conservation codes for Western Australian flora and fauna under the Western Australian *Biodiversity Conservation Act 2016*

Threatened, Extinct and Specially Protected fauna or flora are species which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such.

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 *Biodiversity Conservation Act 2016*.

Categories of Threatened, Extinct and Specially Protected fauna and flora are:

Threatened species

Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the *Biodiversity Conservation Act 2016* (BC Act).

Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for Threatened Fauna.

Threatened flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the *Wildlife Conservation (Rare Flora) Notice 2018* for Threatened Flora.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

CR Critically endangered species

Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines.

Published under **schedule 1** of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for critically endangered fauna or the *Wildlife Conservation (Rare Flora) Notice 201*8 for critically endangered flora.

EN Endangered species

Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under **schedule 2** of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for endangered fauna or the *Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora*.

VU Vulnerable species

Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines.

Published under **schedule 3** of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for vulnerable fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for vulnerable flora.

Extinct species

Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.

EX Extinct species

Species where "there is no reasonable doubt that the last member of the species has died", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act).

Published as presumed extinct under **schedule 4** of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for extinct fauna or the *Wildlife Conservation (Rare Flora) Notice 2018 for extinct flora*.

EW Extinct in the wild species

Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act).

Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.

Specially protected species

MI Migratory species

Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act).

Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program.

Migratory species listed under the BC Act are a subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species. Published as migratory birds protected under an international agreement under **schedule 5** of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.

CD **Species of conservation interest (conservation dependent fauna)**

Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act). Published as conservation dependent fauna under **schedule 6** of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018.*

OS **Other specially protected species**

Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act). Published as other specially protected fauna under **schedule 7** of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.

Priority species

Priority species are possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations. In this report, priority species are given the codes P1, P2, P3 and P4.

P1 **Priority 1: Poorly-known species**

Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.

P2 **Priority 2: Poorly-known species**

Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.

P3 **Priority 3: Poorly-known species**

Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

P4 **Priority 4: Rare, Near Threatened and other species in need of monitoring**

(a) **Rare**. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands.

(b) **Near Threatened**. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent.

(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Appendix III Site coordinates, camera trap and SM4 deployment details

Site Name	Site Type	Easting	Northing	Zone	Broad fauna habitat
LCS01	Trap Site	684819	7467764	50	Tussock grassland plain
LCS02	Trap Site	685084	7468479	50	Tussock grassland plain
LCS03	Trap Site	682885	7471282	50	Stony plain
LCS04	Trap Site	685943	7475368	50	Stony plain
LCS05	Trap Site	688629	7477055	50	Stony plain
LCS06	Trap Site	690247	7477147	50	Mulga/corymbia plain
LCS07	Trap Site	691349	7476300	50	Medium drainage lines
LCS08	Trap Site	692588	7476971	50	Stony plain
LCS09	Trap Site	692984	7477591	50	Medium drainage lines
LCS10	Trap Site	693039	7476648	50	Majority Hill crests and hill slope. Some minor drainage (scree slope)

Site Name	Site Type	Transect ID	Easting	Northing	Zone	Broad fauna habitat
MDCNQ01210420	Camera Transect	Transect 1	693611	7476123	50	Gorge, gully and rocky breakaway
MDCNQ02210420	Camera Transect	Transect 1	693624.1	7476107	50	Gorge, gully and rocky breakaway
MDCNQ03210420	Camera Transect	Transect 1	693628.7	7476099	50	Gorge, gully and rocky breakaway
MDCNQ04210420	Camera Transect	Transect 1	693620.9	7476084	50	Gorge, gully and rocky breakaway
MDCNQ05210420	Camera Transect	Transect 1	693609.4	7476071	50	Gorge, gully and rocky breakaway
MDCNQ06210420	Camera Transect	Transect 1	693600.4	7476057	50	Gorge, gully and rocky breakaway
MDCNQ07210420	Camera Transect	Transect 1	693605.6	7476056	50	Gorge, gully and rocky breakaway
MDCNQ07210420	Camera Transect	Transect 1	693601.1	7476056	50	Gorge, gully and rocky breakaway
MDCNQ08210420	Camera Transect	Transect 1	693591	7476034	50	Gorge, gully and rocky breakaway
MDCNQ08210420	Camera Transect	Transect 1	693589.9	7476035	50	Gorge, gully and rocky breakaway
MDCNQ09210420	Camera Transect	Transect 1	693587.4	7476026	50	Gorge, gully and rocky breakaway
MDCNQ10210420	Camera Transect	Transect 1	693587	7476013	50	Gorge, gully and rocky breakaway
MDCNQ11220420	Camera Transect	Transect 2	694542.3	7475730	50	Gorge, gully and rocky breakaway
MDCNQ12210420	Camera Transect	Transect 2	694495.3	7475731	50	Gorge, gully and rocky breakaway
MDCNQ13220420	Camera Transect	Transect 2	694414.2	7475744	50	Gorge, gully and rocky breakaway
MDCNQ14220420	Camera Transect	Transect 2	694368.2	7475770	50	Gorge, gully and rocky breakaway
MDCNQ15220420	Camera Transect	Transect 2	694319.1	7475766	50	Gorge, gully and rocky breakaway

Site Name	Site Type	Transect ID	Easting	Northing	Zone	Broad fauna habitat
MDCNQ16220420	Camera Transect	Transect 2	694238.9	7475780	50	Gorge, gully and rocky breakaway
MDCNQ17220420	Camera Transect	Transect 2	694169.5	7475772	50	Gorge, gully and rocky breakaway
MDCNQ18220420	Camera Transect	Transect 2	694101.8	7475779	50	Gorge, gully and rocky breakaway
MDCNQ19220420	Camera Transect	Transect 2	694040.9	7475778	50	Gorge, gully and rocky breakaway
MDCNQ20220420	Camera Transect	Transect 2	693998.3	7475789	50	Gorge, gully and rocky breakaway
MDCNQ21220420	Camera Transect	Transect 2	688959.4	7473331	50	Gorge, gully and rocky breakaway
MDCNQ22220420	Camera Transect	Transect 2	688921	7473319	50	Gorge, gully and rocky breakaway
MDCNQ230420	Camera Transect	Transect 3	688868.4	7473340	50	Gorge, gully and rocky breakaway
MDCNQ24220420	Camera Transect	Transect 3	688832.4	7473378	50	Gorge, gully and rocky breakaway
MDCNQ25220420	Camera Transect	Transect 3	688795.1	7473365	50	Gorge, gully and rocky breakaway
MDCNQ26220420	Camera Transect	Transect 3	688724	7473347	50	Gorge, gully and rocky breakaway
MDCNQ27220420	Camera Transect	Transect 3	688667.4	7473334	50	Gorge, gully and rocky breakaway
MDCNQ28220420	Camera Transect	Transect 3	688593.2	7473349	50	Gorge, gully and rocky breakaway
MDCNQ29220420	Camera Transect	Transect 3	688524.1	7473391	50	Gorge, gully and rocky breakaway
MDCNQ30220420	Camera Transect	Transect 3	688468.1	7473404	50	Gorge, gully and rocky breakaway
MDCNQ31230420	Camera Transect	Transect 4	687953.5	7472869	50	Gorge, gully and rocky breakaway
MDCNQ32230420	Camera Transect	Transect 4	687901.9	7472876	50	Gorge, gully and rocky breakaway
MDCNQ33230420	Camera Transect	Transect 4	687853.9	7472883	50	Gorge, gully and rocky breakaway
MDCNQ34230420	Camera Transect	Transect 4	687796.5	7472886	50	Gorge, gully and rocky breakaway
MDCNQ35230420	Camera Transect	Transect 4	687729.3	7472869	50	Gorge, gully and rocky breakaway
MDCNQ36230420	Camera Transect	Transect 4	687672.5	7472870	50	Gorge, gully and rocky breakaway
MDCNQ37230420	Camera Transect	Transect 4	687596.8	7472840	50	Gorge, gully and rocky breakaway
MDCNQ38230420	Camera Transect	Transect 4	687536.3	7472774	50	Gorge, gully and rocky breakaway
MDCNQ39230420	Camera Transect	Transect 4	687513.4	7472762	50	Gorge, gully and rocky breakaway
MDCNQ40230420	Camera Transect	Transect 4	687453.9	7472748	50	Gorge, gully and rocky breakaway

Site Name	Type	Date deployed	Survey nights	Zone	Easting	Northing	Survey Period	Comment
SM4U-6479_Site 1	Bat Detector	20/04/20	1	50	684831.3	7467776.8	2020	Vertebrate Trap Site
SM4U-6488_Site 2	Bat Detector	20/04/20	1	50	685101.9	7468474.6	2020	Vertebrate Trap Site
SM4U-6479_Site 3	Bat Detector	21/04/20	1	50	682905.3	7471293.6	2020	Vertebrate Trap Site
SM4U-6479_Site 4	Bat Detector	22/04/20	1	50	685919.3	7475392	2020	Vertebrate Trap Site
SM4U-6479_Site 5	Bat Detector	23/04/20	1	50	688642.3	7477107.3	2020	Vertebrate Trap Site
SM4U-6488_Site 6	Bat Detector	16/04/20	2	50	690293.6	7477135	2020	Vertebrate Trap Site
SM4U-6479_Site 7	Bat Detector	16/04/20	2	50	691388.9	7476256.9	2020	Vertebrate Trap Site
SM4A-4717_A3	Night Parrot	20/04/20	3	50	682915.6	7471272.9	2020	Spinifex patch
SM4U-6488_Site 8	Bat Detector	18/04/20	1	50	692623.3	7476976.7	2020	Vertebrate Trap Site
SM4U-6488_Site 9	Bat Detector	19/04/20	1	50	692959.1	7477588.3	2020	Vertebrate Trap Site
SM4U-6479_Site10	Bat Detector	18/04/20	2	50	693016.2	7476648.8	2020	Vertebrate Trap Site
SM4A-4717_A_Haul Road	Night Parrot	23/04/20	2	50	683241.5	7473176.7	2020	Spinifex patch
SM4U-6479_Gully	Bat Detector	27/04/20	0	50	688385	7475295.9	2020	Deep Gully - Failed to record
SM4U-6488_Cave 1	Bat Detector	21/04/20	4	50	693571.3	7476273.6	2020	Cave
SM4U-6488_Cave 2	Bat Detector	25/04/20	2	50	690696.5	7473764.1	2020	Cave
SM4U-6479_Cave 3	Bat Detector	24/04/20	4	50	694116.6	7476556.6	2020	Cave
SM4A-4717_A_footprint	Night Parrot	25/04/20	3	50	691745.9	7475914.2	2020	Spinifex patch in disturbed area
SM4U-4031_Cave 1	Bat Detector	20/02/21	3	50	693571	7476273	2021	Cave
SM4U-8168_Cave 3	Bat Detector	20/02/21	3	50	694116	7476556	2021	Cave
SM4U-4031_Cave 4	Bat Detector	23/02/21	2	50	683844	7469750	2021	Cave
SM4U-8168_Cave 5	Bat Detector	23/02/21	2	50	683848	7469788	2021	Cave

Appendix IV Significance assessment criteria: Habitat

Rank	Criteria
High	Fauna listed as threatened under the EPBC Act and/ or BC Act and fauna listed as Species of Special Conservation Interest or Other Specially Protected Species have been recorded breeding from this habitat type within the survey area
	Fauna listed as threatened under the EPBC Act and/ or BC Act and fauna listed as species of Special Conservation Interest or Other Specially Protected Species have been recorded foraging or sheltering from this habitat type within the survey area where the species is solely reliant on this habitat type for foraging or sheltering
	Habitat known to be suitable core habitat (breeding), for EPBC Act and/ or BC Act listed threatened fauna and/or fauna listed as species of Special Conservation Interest or Other Specially Protected Species, and there are records of this species within 40km^2
	Habitat known to be suitable core habitat (foraging or sheltering), for EPBC Act and/ or BC Act listed threatened fauna and or fauna listed as species of Special Conservation Interest or Other Specially Protected Species, and there are records of this species within 40km^2 and the species is solely reliant on this habitat type for foraging or sheltering.
	Habitat is regionally uncommon or limited in extent and known to support species listed as: ▪ Threatened fauna under the EPBC Act and/or BC Act, but it is not their core habitat (e.g. may be used periodically/ seasonally or for dispersal). ▪ DBCA listed Priority fauna which are known to be solely reliant on this habitat.
	Habitat known to support EPBC Act and/or BC Act listed Migratory fauna such as breeding grounds, or important feeding grounds such as Eighty Mile Beach (including ephemeral habitats) defined via international agreement e.g. RAMSA and also Important Bird Areas (Dutson *et al.* 2009) https://www.birdlife.org.au/documents/OTHPUB-IBA-supp.pdf
Moderate	Habitat known to regularly support EPBC Act and/or BC Act listed Migratory fauna – (not breeding grounds or important feeding grounds)
	Habitat that is regionally uncommon (e.g. occurs in small and isolated areas) and supports a particularly diverse and uncommon faunal assemblage.
	Habitat is common and widespread and known to support species listed as: Threatened fauna under the EPBC Act and/or BC Act but it is not their core habitat (e.g. may be used periodically/ seasonally or for dispersal, or foraging habitats that where the species is not solely reliant on that habitat for resources, is an occasional visitor or foraging habitat is marginal. Species of Special Conservation Interest or Other Specially Protected Species under the BC Act but it is not their core habitat (e.g. may be used periodically/ seasonally or for dispersal) or foraging habitats that where the species is not solely reliant on that habitat for resources, is an occasional visitor or foraging habitat is marginal. DBCA listed Priority fauna which are known to be solely reliant on this habitat
Low	▪ Habitat is widespread/common and does not solely support any DBCA listed Priority fauna ▪ Habitat has minimal records of EPBC Act and/or BC Act listed Migratory fauna – (not breeding grounds or important feeding grounds). Especially so if these records are > 10 years old.

Appendix V Desktop results: All vertebrate fauna species recorded within 50 km of Lamb Creek

Family	Scientific name[1)]	Common name	Status[2)]		Databases[3)]				Survey reports[4)]													
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
Birds																						
Casuariidae	*Dromaius novaehollandiae*	Emu						1								1						
Anatidae	*Dendrocygna eytoni*	Plumed Whistling-Duck						1														
Anatidae	*Malacorhynchus membranaceus*	Pink-eared Duck						1														
Anatidae	*Cygnus atratus*	Black Swan						1														
Anatidae	*Aythya australis*	Hardhead						1														
Anatidae	*Anas superciliosa*	Pacific Black Duck						1														
Anatidae	*Anas gracilis*	Grey Teal						1														
Phasianidae	*Synoicus ypsilophorus*	Brown Quail						1														
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe						1														
Podicipedidae	*Poliocephalus poliocephalus*	Hoary-headed Grebe						1														
Columbidae	**Columba livia*	Rock Dove					1															
Columbidae	*Geophaps plumifera*	Spinifex Pigeon						1	1	1		1	1	1		1	1	1	1	1		1
Columbidae	*Phaps chalcoptera*	Common Bronzewing						1	1	1	1		1			1	1	1		1		1
Columbidae	*Ocyphaps lophotes*	Crested Pigeon						1	1	1	1		1	1		1	1	1	1	1		1
Columbidae	*Geopelia cuneata*	Diamond Dove						1	1		1		1	1		1	1	1	1	1		1
Columbidae	*Geopelia placida*	Peaceful Dove						1	1		1					1	1					
Cuculidae	*Centropus phasianinus*	Pheasant Coucal						1														
Cuculidae	*Chalcites basalis*	Horsfield's Bronze-Cuckoo	MA					1	1	1	1		1	1		1		1		1		1
Cuculidae	*Chalcites osculans*	Black-eared Cuckoo	MA				1	1								1			1			
Cuculidae	*Heteroscenes pallidus*	Pallid Cuckoo	MA					1	1		1		1	1		1	1	1	1	1		1
Otididae	*Ardeotis australis*	Australian Bustard						1	1	1	1					1		1		1		1
Podargidae	*Podargus strigoides*	Tawny Frogmouth						1	1	1			1	1		1	1	1				1
Eurostopodidae	*Eurostopodus argus*	Spotted Nightjar	MA					1	1	1	1		1	1		1	1			1		1
Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar						1	1	1	1		1	1		1	1	1	1	1		1
Apodidae	*Apus pacificus*	Fork-tailed Swift	MI, MA	MI		1	2	1	1											1		1
Rallidae	*Hypotaenidia philippensis*	Buff-banded Rail						1														
Rallidae	*Fulica atra*	Eurasian Coot						1														
Burhinidae	*Burhinus grallarius*	Bush Stone-curlew						1														
Recurvirostridae	*Himantopus leucocephalus*	Pied Stilt	MA					1									1					
Charadriidae	*Charadrius ruficapillus*	Red-capped Plover	MA					1														
Charadriidae	*Charadrius veredus*	Oriental Plover	MI				2															
Charadriidae	*Elseyornis melanops*	Black-fronted Dotterel						1			1					1						

Family	Scientific name[1]	Common name	Status[2]		Databases[3]				Survey reports[4]													
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
Rostratulidae	*Rostratula australis*	Australian Painted-snipe	EN, MA	EN			2															
Scolopacidae	*Calidris acuminata*	Sharp-tailed Sandpiper	MI, MA				2															
Scolopacidae	*Calidris ferruginea*	Curlew Sandpiper	CR, MI, MA	CR			3															
Scolopacidae	*Calidris melanotos*	Pectoral Sandpiper	MI, MA				2															
Scolopacidae	*Actitis hypoleucos*	Common Sandpiper	MI, MA				2															
Scolopacidae	*Tringa nebularia*	Common Greenshank	MI, MA	IA	2	1																
Turnicidae	*Turnix velox*	Little Button-quail						1	1		1		1	1		1	1	1	1	1		1
Pelicanidae	*Pelecanus conspicillatus*	Australian Pelican						1														
Ardeidae	*Nycticorax caledonicus*	Nankeen Night-Heron						1														
Ardeidae	*Bubulcus ibis*	Cattle Egret	MA				1															
Ardeidae	*Ardea pacifica*	White-necked Heron						1														
Ardeidae	*Ardea alba*	Great Egret	MA				1	1														
Ardeidae	*Egretta novaehollandiae*	White-faced Heron						1								1						1
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked Ibis						1														
Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant						1														
Phalacrocoracidae	*Phalacrocorax sulcirostris*	Little Black Cormorant						1														
Phalacrocoracidae	*Phalacrocorax varius*	Pied Cormorant						1			1							1		1		
Anhingidae	*Anhinga novaehollandiae*	Australasian Darter						1														
Accipitridae	*Elanus axillaris*	Black-shouldered Kite						1			1						1					1
Accipitridae	*Elanus scriptus*	Letter-winged Kite		P4	1	1																
Accipitridae	*Hamirostra melanosternon*	Black-breasted Buzzard						1	1		1											1
Accipitridae	*Lophoictinia isura*	Square-tailed Kite						1														
Accipitridae	*Aquila audax*	Wedge-tailed Eagle						1	1	1	1		1	1		1	1	1				1
Accipitridae	*Hieraaetus morphnoides*	Little Eagle						1	1								1	1		1		1
Accipitridae	*Circus approximans*	Swamp Harrier						1														
Accipitridae	*Circus assimilis*	Spotted Harrier						1	1		1					1	1					1
Accipitridae	*Accipiter fasciatus*	Brown Goshawk	MA					1	1	1	1					1						1
Accipitridae	*Accipiter cirrocephalus*	Collared Sparrowhawk						1	1	1	1					1						1
Accipitridae	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	MA				1															
Accipitridae	*Haliastur sphenurus*	Whistling Kite	MA					1	1	1	1		1			1	1	1		1		1
Accipitridae	*Milvus migrans*	Black Kite						1												1		1
Tytonidae	*Tyto alba*	Barn Owl						1	1				1	1								
Strigidae	*Ninox boobook*	Southern Boobook	MA					1	1	1				1		1	1					1
Strigidae	*Ninox connivens subsp. connivens*	Barking Owl (southwest)		P3		1																

Family	Scientific name[1]	Common name	Status[2]		Databases[3]				Survey reports[4]													
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
Meropidae	*Merops ornatus*	Rainbow Bee-eater	MA				1	1	1	1	1					1	1	1	1	1		1
Alcedinidae	*Todiramphus sanctus*	Sacred Kingfisher	MA					1										1	1			
Alcedinidae	*Todiramphus pyrrhopygius*	Red-backed Kingfisher						1	1	1	1		1	1			1	1		1		1
Alcedinidae	*Dacelo leachii*	Blue-winged Kookaburra						1	1		1									1		
Falconidae	*Falco cenchroides*	Nankeen Kestrel	MA					1	1	1	1			1		1	1	1	1			1
Falconidae	*Falco longipennis*	Australian Hobby						1	1		1					1		1				1
Falconidae	*Falco berigora*	Brown Falcon						1	1	1	1		1	1		1	1	1		1		1
Falconidae	*Falco hypoleucos*	Grey Falcon	VU	VU	4	1							1					1				
Falconidae	*Falco peregrinus*	Peregrine Falcon		OS	10	1		1	1	1						1						
Cacatuidae	*Nymphicus hollandicus*	Cockatiel						1														1
Cacatuidae	*Eolophus roseicapilla*	Galah						1	1	1	1		1	1		1	1	1		1		1
Cacatuidae	*Cacatua sanguinea*	Little Corella						1			1					1	1		1			
Psittaculidae	*Psephotellus varius*	Mulga Parrot						1			1						1			1		
Psittaculidae	*Barnardius zonarius*	Australian Ringneck						1	1	1	1		1	1		1	1	1	1	1		1
Psittaculidae	*Pezoporus occidentalis*	Night Parrot	EN	CR			1															
Psittaculidae	*Neopsephotus bourkii*	Bourke's Parrot						1		1			1			1				1		
Psittaculidae	*Melopsittacus undulatus*	Budgerigar						1	1		1		1	1		1	1		1	1		1
Ptilonorhynchidae	*Ptilonorhynchus guttatus*	Western Bowerbird						1	1	1	1		1	1		1	1	1	1	1		1
Climacteridae	*Climacteris melanurus*	Black-tailed Treecreeper						1					1			1						
Maluridae	*Malurus lamberti*	Variegated Fairy-wren						1	1	1	1		1	1		1	1		1	1		1
Maluridae	*Malurus splendens*	Splendid Fairy-wren						1			1							1				
Maluridae	*Malurus leucopterus*	White-winged Fairy-wren						1	1	1	1		1	1		1	1	1		1		
Maluridae	*Malurus leucopterus subsp. leucopterus*	White-winged Fairy-wren (Dirk Hartog Island)	VU	VU		1																
Maluridae	*Stipiturus ruficeps*	Rufous-crowned Emu-wren						1	1	1	1		1	1		1						
Maluridae	*Amytornis striatus*	Striated Grasswren						1	1	1	1		1	1		1				1		
Meliphagidae	*Sugomel niger*	Black Honeyeater						1														1
Meliphagidae	*Lichmera indistincta*	Brown Honeyeater						1	1	1	1		1	1		1	1	1	1	1		1
Meliphagidae	*Melithreptus gularis*	Black-chinned Honeyeater						1	1	1			1	1		1	1					1
Meliphagidae	*Certhionyx variegatus*	Pied Honeyeater						1									1					1
Meliphagidae	*Conopophila whitei*	Grey Honeyeater						1	1	1	1									1		1
Meliphagidae	*Epthianura tricolor*	Crimson Chat						1	1		1						1	1				1
Meliphagidae	*Epthianura aurifrons*	Orange Chat						1														
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater						1	1	1	1		1	1		1	1	1		1		1
Meliphagidae	*Gavicalis virescens*	Singing Honeyeater						1	1	1	1		1	1		1	1	1	1	1		1
Meliphagidae	*Ptilotula keartlandi*	Grey-headed Honeyeater						1	1	1	1	1	1	1		1	1	1		1		1

Family	Scientific name[1]	Common name	Status[2]		Databases[3]				Survey reports[4]													
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
Meliphagidae	*Ptilotula plumula*	Grey-fronted Honeyeater						1														
Meliphagidae	*Ptilotula penicillata*	White-plumed Honeyeater						1	1	1	1					1			1	1		1
Meliphagidae	*Purnella albifrons*	White-fronted Honeyeater							1													1
Meliphagidae	*Manorina flavigula*	Yellow-throated Miner						1	1	1	1		1	1		1	1	1	1	1		1
Pardalotidae	*Pardalotus rubricatus*	Red-browed Pardalote						1	1	1	1					1	1			1		1
Pardalotidae	*Pardalotus striatus*	Striated Pardalote						1	1	1	1		1	1		1	1		1	1		
Acanthizidae	*Gerygone fusca*	Western Gerygone						1	1	1	1			1		1		1	1	1		1
Acanthizidae	*Smicrornis brevirostris*	Weebill						1	1	1	1		1	1		1	1	1	1	1		1
Acanthizidae	*Pyrrholaemus brunneus*	Redthroat						1			1											
Acanthizidae	*Aphelocephala leucopsis*	Southern Whiteface						1														
Acanthizidae	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill						1		1	1					1						
Acanthizidae	*Acanthiza apicalis*	Inland Thornbill						1	1	1	1			1		1			1	1		1
Acanthizidae	*Acanthiza robustirostris*	Slaty-backed Thornbill						1		1	1			1		1		1				
Acanthizidae	*Acanthiza uropygialis*	Chestnut-rumped Thornbill						1		1	1					1						1
Pomatostomidae	*Pomatostomus temporalis*	Grey-crowned Babbler						1	1	1	1			1		1		1		1		1
Pomatostomidae	*Pomatostomus superciliosus*	White-browed Babbler						1		1	1					1			1			
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella						1			1					1	1					
Campephagidae	*Coracina maxima*	Ground Cuckoo-shrike						1	1	1	1					1	1					1
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	MA					1	1	1	1		1	1		1	1	1	1	1		1
Campephagidae	*Lalage tricolor*	White-winged Triller						1	1	1	1		1	1		1	1	1	1	1		1
Cinclosomatidae	*Cinclosoma castaneothorax*	Chestnut-breasted Quail-thrush						1		1												
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler						1	1	1	1		1	1		1	1	1	1	1		1
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush						1	1	1	1	1	1	1		1	1	1	1	1		1
Oreoicidae	*Oreoica gutturalis*	Crested Bellbird						1	1	1	1		1	1		1	1	1	1	1		1
Psophodidae	*Psophodes occidentalis*	Chiming Wedgebill						1														
Artamidae	*Gymnorhina tibicen*	Australian Magpie						1	1	1	1		1	1		1	1	1	1	1		1
Artamidae	*Cracticus nigrogularis*	Pied Butcherbird						1	1	1	1		1	1		1	1	1	1	1		1
Artamidae	*Cracticus torquatus*	Grey Butcherbird						1	1	1	1		1	1		1	1	1		1		1
Artamidae	*Artamus personatus*	Masked Woodswallow						1								1	1		1			1
Artamidae	*Artamus cinereus*	Black-faced Woodswallow						1	1	1	1		1	1		1	1	1		1		1
Artamidae	*Artamus minor*	Little Woodswallow						1	1	1	1		1	1		1	1		1	1		1
Artamidae	*Artamus leucorynchus*	White-breasted Woodswallow																				
Rhipiduridae	*Rhipidura leucophrys*	Willie Wagtail						1	1	1	1	1	1	1		1	1	1	1	1		1
Rhipiduridae	*Rhipidura fuliginosa*	Grey Fantail						1	1	1	1			1		1	1	1				

Family	Scientific name[1]	Common name	Status[2]		Databases[3]				Survey reports[4]													
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
Corvidae	*Corvus orru*	Torresian Crow						1	1	1	1		1	1			1	1	1	1		1
Corvidae	*Corvus bennetti*	Little Crow						1								1						1
Corvidae	*Corvus coronoides*	Australian Raven																				1
Monarchidae	*Grallina cyanoleuca*	Magpie-lark	MA					1	1	1	1		1	1		1	1	1	1	1		1
Petroicidae	*Petroica goodenovii*	Red-capped Robin						1		1	1					1	1		1			
Petroicidae	*Melanodryas cucullata*	Hooded Robin						1	1	1	1		1	1		1	1	1	1	1		1
Dicaeidae	*Dicaeum hirundinaceum*	Mistletoebird						1	1	1	1		1	1		1	1					1
Estrildidae	*Emblema pictum*	Painted Finch						1	1	1	1		1	1		1	1	1		1		1
Estrildidae	*Neochmia ruficauda*	Star Finch						1					1	1								
Estrildidae	*Taeniopygia guttata*	Zebra Finch						1	1	1	1		1	1		1	1	1	1	1		1
Motacillidae	*Anthus novaeseelandiae*	Australasian Pipit	MA					1	1	1							1		1	1		
Motacillidae	*Motacilla flava*	Yellow Wagtail	MI, MA				2															
Motacillidae	*Motacilla cinerea*	Grey Wagtail	MI, MA				2															
Alaudidae	*Mirafra javanica*	Horsfield's Bushlark						1					1					1				
Locustellidae	*Cincloramphus cruralis*	Brown Songlark						1														1
Locustellidae	*Cincloramphus mathewsi*	Rufous Songlark						1	1		1		1			1	1	1		1		1
Locustellidae	*Poodytes carteri*	Spinifexbird						1	1	1	1		1	1		1	1	1		1		1
Acrocephalidae	*Acrocephalus australis*	Australian Reed-Warbler						1														
Hirundinidae	*Cheramoeca leucosterna*	White-backed Swallow						1														
Hirundinidae	*Petrochelidon ariel*	Fairy Martin						1									1			1		
Hirundinidae	*Petrochelidon nigricans*	Tree Martin						1								1	1					
Hirundinidae	*Hirundo neoxena*	Welcome Swallow	MA					1									1	1				
Hirundinidae	*Hirundo rustica*	Barn Swallow	MI, MA				2															
Mammals																						
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna							1	1	1	1				1						1
Dasyuridae	*Dasycercus blythi*	Brush-tailed Mulgara, Ampurta		P4	1	1																
	Dasykaluta rosamondae	Kaluta							1	1	1			1		1	1			1		1
	Dasyurus geoffroii	Western Quoll, Chuditch	VU	VU		1																
	Dasyurus hallucatus	Northern Quoll	EN	EN	9	1	1			1												1
	Ningaui timealeyi	Pilbara Ningaui							1	1	1			1		1				1		1
	Planigale ingrami	Long-tailed Planigale																				1
	Planigale sp. 1	(undescribed planigale species)							1	1	1			1		1	1					
	Pseudantechinus woolleyae	Woolley's Pseudantechinus							1	1												

Family	Scientific name[1)]	Common name	Status[2)]		Databases[3)]				Survey reports[4)]													
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
	Sminthopsis macroura	Froggatt's Stripe-faced Dunnart							1	1	1			1		1						1
	Sminthopsis ooldea	Ooldea Dunnart									1					1						
	Sminthopsis youngsoni	Lesser Hairy-footed Dunnart									1											
Thylacomyidae	*Macrotis lagotis*	Bilby, Dalgyte	VU	VU	2	1	1															
Macropodidae	*Osphranter robustus*	Euro, Biggada							1	1		1	1	1		1	1	1	1	1		1
	Osphranter rufus	Red Kangaroo, Marlu								1								1	1	1		
	Petrogale rothschildi	Rothschild's Rock-wallaby							1	1	1	1				1		1		1		1
Muridae	**Mus musculus*	House Mouse					1		1	1	1	1										1
	Leggadina lakedownensis	Short-tailed Mouse		P4	2	1																
	Pseudomys chapmani	Western Pebble-mound Mouse		P4	191	1			1	1	1		1	1		1	1	1	1	1		1
	Pseudomys desertor	Desert Mouse							1	1	1						1					1
	Pseudomys hermannsburgensis	Sandy Inland Mouse							1	1	1			1		1				1		1
	Zyzomys argurus	Common Rock-rat							1	1	1	1		1		1	1	1		1		1
	Zyzomys pedunculatus	Central Rock-rat	CR	CR		1																
Leporidae	**Oryctolagus cuniculus*	Rabbit					1			1	1											
Rhinonycteridae	*Rhinonicteris aurantia (Pilbara)*	Pilbara Leaf-nosed Bat	VU	VU	8	1	1			1							1					
Megadermatidae	*Macroderma gigas*	Ghost Bat	VU	VU	133	1	1		1	1	1											1
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheath-tailed Bat							1	1			1	1				1			1	1
	Taphozous georgianus	Common Sheath-tailed Bat							1	1	1		1	1	1		1	1			1	1
	Taphozous hilli	Hill's Sheath-tailed Bat							1	1	1					1						
Molossidae	*Austronomus australis*	White-striped Free-tailed Bat								1	1			1				1				
	Chaerephon jobensis	Greater Northern Free-tailed Bat							1	1	1						1	1				1
	Ozimops lumsdenae	Northern Free-tailed Bat							1	1	1		1	1			1	1			1	
	Ozimops planiceps	Southern Free-tailed Bat														1						
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat							1	1	1		1	1		1	1	1			1	1
	Nyctophilus geoffroyi	Lesser Long-eared Bat							1	1			1				1					
	Scotorepens balstoni	Inland Broad-nosed Bat														1						
	Scotorepens greyii	Little Broad-nosed Bat							1	1	1		1	1		1	1	1			1	1
	Vespadelus finlaysoni	Finlayson's Cave Bat							1	1	1		1	1	1	1	1	1			1	1
Canidae	**Canis familiaris familiaris*	Dog					1					1										
	**Vulpes vulpes*	Red Fox					1											1				

Family	Scientific name[1)]	Common name	Status[2)]		Databases[3)]				Survey reports[4)]												
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
	Canis familiaris dingo	Dingo							1	1	1		1	1		1		1	1	1		1
Felidae	**Felis catus*	Cat					1			1	1	1		1		1		1	1	1		
Equidae	**Equus asinus*	Donkey					1			1												
	**Equus caballus*	Horse					1															
Camelidae	**Camelus dromedarius*	Dromedary, Camel					1		1	1												
Bovidae	**Bos taurus*	European Cattle							1	1						1		1		1		1
Reptiles																						
Carphodactylidae	*Nephrurus cinctus*	Northern Banded Knob-tailed Gecko							1	1	1											1
	Underwoodisaurus seorsus	Pilbara Barking Gecko		P2	17	1			1	1	1		1									
Diplodactylidae	*Crenadactylus ocellatus*	South-western Clawless Gecko																				1
	Diplodactylus conspicillatus	Variable Fat-tailed Gecko																				1
	Diplodactylus pulcher	Pretty Gecko								1	1											1
	Diplodactylus savagei	Southern Pilbara Beak-faced Gecko							1		1					1		1		1		1
	Lucasium stenodactylum	Sand-plain Gecko							1	1	1			1								1
	Lucasium wombeyi	Pilbara Ground Gecko							1	1	1					1	1					1
	Oedura fimbria	Western Marbled Velvet Gecko							1	1	1		1	1		1	1	1		1		1
	Rhynchoedura ornata	Western Beaked Gecko							1	1	1									1		1
	Strophurus elderi	Jewelled Gecko							1													
	Strophurus wellingtonae	Western-shield Spiny-tailed Gecko							1	1	1		1				1	1				1
Gekkonidae	*Gehyra pilbara*	Pilbara Dtella							1							1						
	Gehyra punctata	Spotted Rock Dtella							1	1	1		1	1		1	1	1				1
	Gehyra variegata	Variegated gehyra							1	1	1			1		1	1	1				1
	Heteronotia binoei	Bynoe's Gecko							1	1	1			1		1	1			1		1
	Heteronotia spelea	Pilbara Cave Gecko							1	1	1			1			1	1				
Pygopodidae	*Delma butleri*	Spinifex Delma														1						
	Delma elegans	Pilbara Delma							1		1											1
	Delma haroldi	Neck-barred Delma												1								
	Delma nasuta	Sharp-snouted Delma							1	1	1			1								1
	Delma pax	Peace Delma							1		1			1		1				1		
	Delma tincta	Black-necked Delma							1	1	1					1				1		1
	Lialis burtonis	Burton's Snake-lizard							1	1	1						1					1
	Pygopus nigriceps	Western Hooded Scaly-foot									1							1				1

Family	Scientific name[1)]	Common name	Status[2)]		Databases[3)]				Survey reports[4)]												
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
Agamidae	*Ctenophorus caudicinctus*	Western Ring-tailed Dragon							1	1	1		1	1		1	1	1		1		1
	Ctenophorus isolepis	Yellowy Military Dragon							1	1	1			1		1		1				1
	Ctenophorus nuchalis	Central Netted Dragon									1											
	Ctenophorus reticulatus	Western Netted Dragon								1	1											
	Diporiphora amphiboluroides	Mulga Dragon								1	1					1						1
	Diporiphora valens	Southern Pilbara Tree Dragon								1	1			1								1
	Gowidon longirostris	Long-nosed Dragon							1	1	1		1	1		1		1	1	1		1
	Pogona minor	Dwarf Bearded Dragon							1	1	1		1	1		1			1			1
	Tympanocryptis cephalus	Coastal pebble-mimic dragons									1											
Scincidae	*Carlia munda*	Striped Rainbow Skink							1	1	1		1	1		1	1			1		1
	Carlia triacantha	Desert Rainbow Skink							1	1												
	Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink								1	1											
	Cryptoblepharus ustulatus	Russet Snake-eyed Skink							1	1	1											1
	Ctenotus duricola	Eastern Pilbara Lined Ctenotus							1		1		1	1		1						1
	Ctenotus hanloni	Nimble Ctenotus									1					1						
	Ctenotus helenae	Dusky Ctenotus							1	1	1			1			1	1				1
	Ctenotus leonhardii	Common Desert Ctenotus														1						
	Ctenotus pantherinus	Leopard Ctenotus							1	1	1		1	1		1	1			1		1
	Ctenotus piankai	Coarse Sands Ctenotus														1						
	Ctenotus rubicundus	Ruddy Ctenotus							1		1		1	1		1						1
	Ctenotus rutilans	Rusty-shouldered Ctenotus								1						1		1				1
	Ctenotus saxatilis	Rock Ctenotus							1	1	1		1	1		1	1	1		1		1
	Ctenotus schomburgkii	Barred Wedge-snouted Ctenotus								1	1			1		1						1
	Ctenotus serventyi	North-western Sandy-loam Ctenotus							1													
	Ctenotus uber	Western Spotted Ctenotus									1											1
	Cyclodomorphus melanops	Spinifex Slender Blue-tongue							1	1	1					1	1			1		1
	Egernia cygnitos	Western Pilbara Spiny-tailed Skink								1	1											1
	Egernia depressa	Southern Pygmy Spiny-tailed Skink							1		1		1	1		1						
	Egernia formosa	Goldfields Crevice-skink							1	1		1				1	1	1		1		1

Family	Scientific name[1]	Common name	Status[2]		Databases[3]				Survey reports[4]													
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
	Eremiascincus pallidus	Western Narrow-banded Skink							1		1					1		1		1		
	Eremiascincus richardsonii	Broad-banded Sand Swimmer							1													
	Lerista chalybura	Pilbara blue-tailed Slider							1	1	1		1	1		1						1
	Lerista flammicauda	Pilbara Flame-tailed Slider									1											
	Lerista muelleri	Mueller's Three-toed Slider							1	1	1					1		1				1
	Lerista neander	Pilbara Robust Slider									1					1	1					
	Menetia greyii	Common Dwarf Skink							1	1	1			1		1		1				1
	Menetia surda	Western Dwarf Skink									1											
	Morethia ruficauda	Fire-tailed Skink							1	1	1		1	1		1				1		1
	Tiliqua multifasciata	Central Blue-tongue							1	1	1		1			1	1	1				1
Varanidae	*Varanus acanthurus*	Spiny-tailed Goanna							1	1	1		1	1		1				1		1
	Varanus brevicauda	Short-tailed Pygmy Goanna																		1		1
	Varanus bushi	Pilbara Mulga Goanna							1	1	1			1		1	1					1
	Varanus giganteus	Perentie							1	1		1				1		1		1		1
	Varanus gouldii	Bungarra or Sand Goanna																1				
	Varanus hamersleyensis	Southern Pilbara Rock Goanna							1	1						1	1	1				1
	Varanus panoptes	Yellow-spotted Monitor							1	1			1			1		1	1	1		1
	Varanus tristis	Racehorse Goanna							1	1		1	1				1	1		1		1
Typhlopidae	*Anilios ammodytes*	Pilbara Blind Snake															1	1				
	Anilios ganei	Gane's Blind Snake		P1	2	1			1					1				1				
	Anilios grypus	Northern Beaked Blind Snake							1									1				
	Anilios hamatus	Northern Hook-snouted Blind Snake								1								1				
Pythonidae	*Antaresia perthensis*	Pygmy Python							1	1				1		1		1				1
	Antaresia stimsoni	Stimson's Python																	1			
	Aspidites melanocephalus	Black-headed Python														1						
	Liasis olivaceus barroni	Pilbara Olive Python	VU	VU	4	1	1			1							1					1
Elapidae	*Acanthophis wellsi*	Pilbara Death Adder							1				1	1								
	Brachyurophis approximans	North-western Shovel-nosed Snake							1	1								1				
	Demansia psammophis	Yellow-faced Whipsnake							1	1				1				1				1
	Demansia rufescens	Rufous Whipsnake							1	1			1				1	1	1			
	Furina ornata	Moon Snake							1	1				1			1	1				
	Parasuta monachus	Monk Snake							1	1								1				1

Family	Scientific name[1)]	Common name	Status[2)]		Databases[3)]				Survey reports[4)]													
			EPBC	BCA	TPFa	NM	PM50	BD50	BL11	BL12	BL13	BL16	EC04a	EC04b	EC05	EC98	EV07	EV08	MA99	OE08	SZ08	Ra12
	Pseudechis australis	Mulga Snake							1	1				1								1
	Pseudonaja mengdeni	Western Brown Snake								1							1			1		1
	Pseudonaja modesta	Ringed Brown Snake							1	1								1				1
	Suta fasciata	Rosen's Snake							1							1		1				1
	Vermicella snelli	Pilbara Bandy Bandy							1													1
Amphibians																						
Pelodryadidae	*Cyclorana maini*	Sheep Frog							1	1	1					1		1		1		1
	Cyclorana occidentalis	Western Water-holding Frog																1				
	Litoria rubella	Little Red Tree Frog							1	1	1					1	1	1		1		1
Limnodynastidae	*Neobatrachus sutor*	Shoemaker Frog									1							1				
	Platyplectrum spenceri	Centralian Burrowing Frog									1											
Myobatrachidae	*Pseudophryne douglasi*	Gorge Toadlet							1													
	Uperoleia russelli	Northwest Toadlet							1													

Footnotes:
1) Scientific name:
Asterisk (*) preceding name indicates fauna species in introduced (not native) to Western Australia.
2) Status:
EPBC = Conservation listing under the federal EPBC Act: CR = Critically Endangered, EN = Endangered, VU = Vulnerable, MI = Migratory, MA = Marine
BCA = Conservation listing under the Western Australian Biodiversity Conservation Act and Priority listing by the DBCA: CR = Critically Endangered, EN = Endangered, VU = Vulnerable, MI = Migratory, OS = Other specially protected fauna, P1 to P4 = DBCA Priority 1 to 4
3) Databases:
TPFa = DBCA Threatened and Priority Fauna Database (50 km radius)
NM = DBCA NatureMap online database (40 km radius)
PM = Protected Matters database (50 km radius). Only returns species and communities listed under the EPBC Act.
BD50 = Birdlife Australia Birdata database (50 km radius)
4) Fauna survey reports:
BL11 = Biologic (2011) Area C and surrounds fauna survey
BL12 = Biologic (2012) Southern Flank vertebrate fauna survey
BL13 = Biologic (2013) Mudlark vertebrate fauna survey
BL16 = Biologic (2016) South Flank targeted fauna survey
EC04a = Ecologia (2004a) Packsaddle Range biological survey
EC04b = Ecologia (2004b) Area C: Deposits D, E, F biological survey
EC05 = Ecologia (2005) Pilbara Leaf-nosed Bat and Ghost Bat monitoring survey at Nimingarra and Cattle Gorge.
EC98 = Ecologia (1998) Mining area C biological survey
EV07 = ENV (2007) Area C: R deposit fauna assessment
EV08 = ENV (2008) Area C southern flank deposit fauna assessment
MA99 = Halpern Glick Maunsell (1999) Mining Area C western access corridor biological assessment
OE08 = Outback Ecology (2008) Area C Mining Operation Environmental Management Plan
SZ08 = Specialised Zoological (2008) Area C bat survey
Ra12 = Rapallo (2012) Lamb Creek detailed fauna survey and targeted northern quoll survey
*RA20 = Rapallo (2020) Lamb Creek - **THIS SURVEY***

Appendix VI Desktop results: Conservation significant fauna recorded within 50 km of Lamb Creek

Family	Scientific name	Common name	Status[1)]		Total records	Likelihood in Survey area
			EPBC	BCA		
Birds						
Cuculidae	*Chalcites basalis*	Horsfield's Bronze-Cuckoo	MA		10	Confirmed
Cuculidae	*Chalcites osculans*	Black-eared Cuckoo	MA		5	Likely
Cuculidae	*Heteroscenes pallidus*	Pallid Cuckoo	MA		11	Confirmed
Eurostopodidae	*Eurostopodus argus*	Spotted Nightjar	MA		10	Confirmed
Apodidae	*Apus pacificus*	Fork-tailed Swift	MI, MA	MI	11	Confirmed
Scolopacidae	*Tringa nebularia*	Common Greenshank	MI, MA	IA	3	Unlikely
Ardeidae	*Bubulcus ibis*	Cattle Egret	MA		2	Possible
Threskiornithidae	Threskiornis spinicollis	Straw-necked Ibis	MA		1	Possible
Accipitridae	*Elanus scriptus*	Letter-winged Kite		P4	2	Possible
Accipitridae	*Accipiter fasciatus*	Brown Goshawk	MA		7	Confirmed
Accipitridae	*Haliastur sphenurus*	Whistling Kite	MA		11	Confirmed
Strigidae	Ninox boobook	Southern Boobook	MA		7	Likely
Strigidae	Ninox connivens subps. connivens	Barking Owl (southwest)		P3	1	Highly unlikely
Meropidae	*Merops ornatus*	Rainbow Bee-eater	MA		13	Confirmed
Alcedinidae	Todiramphus sanctus	Sacred Kingfisher	MA		3	Possible
Falconidae	*Falco cenchroides*	Nankeen Kestrel	MA		11	Confirmed
Falconidae	*Falco hypoleucos*	Grey Falcon	VU	VU	7	Possible
Falconidae	*Falco peregrinus*	Peregrine Falcon		OS	16	Likely
Psittaculidae	*Pezoporus occidentalis*	Night Parrot	EN	CR	2	Possible
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	MA		13	Confirmed
Maluridae	Malurus leucopterus subsp. leucopterus	White-winged Fairy-wren (Dirk Hartog Island)	VU	VU	1	Highly unlikely
Monarchidae	*Grallina cyanoleuca*	Magpie-lark	MA		12	Confirmed

Family	Scientific name	Common name	Status[1)]		Total records	Likelihood in Survey area
			EPBC	BCA		
Motacillidae	Anthus novaeseelandiae	Australasian Pipit	MA		6	Possible
Hirundinidae	*Hirundo neoxena*	Welcome Swallow	MA		3	Possible
Mammals						
Dasyuridae	*Dasycercus blythi*	Brush-tailed Mulgara, Ampurta		P4	2	Unlikely
Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	EN	EN	16	Confirmed
Dasyuridae	*Dasyurus geoffroii*	Western quoll, Chuditch	VU	VU	1	Highly unlikely
Thylacomyidae	*Macrotis lagotis*	Bilby, Dalgyte	VU	VU	5	Unlikely – no sandplains
Muridae	*Leggadina lakedownensis*	Short-tailed Mouse		P4	3	Likely
Muridae	*Pseudomys chapmani*	Western Pebble-mound Mouse		P4	205	Confirmed
Muridae	*Zyzomys pedunculatus*	Central rock rat	CR	CR	1	Highly unlikely
Rhinonycteridae	*Rhinonicteris aurantia (Pilbara)*	Pilbara Leaf-nosed Bat	VU	VU	13	Unlikely
Megadermatidae	*Macroderma gigas*	Ghost Bat	VU	VU	142	Confirmed
Reptiles						
Carphodactylidae	*Underwoodisaurus seorsus*	Pilbara Barking Gecko		P2	22	Likely
Typhlopidae	*Anilios ganei*	Gane's Blind Snake		P1	6	Likely
Pythonidae	*Liasis olivaceus barroni*	Pilbara Olive Python	VU	VU	10	Confirmed

Appendix VII List of vertebrate fauna species recorded during the survey

Family	Scientific Name	Common name	Status[1)]	Systematic trap sites										Other sites[2)]		
				S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	Opp	CT	SM4
Birds																
Phasianidae	*Coturnix pectoralis*	Stubble Quail	MA					1							1	
Columbidae	*Geophaps plumifera*	Spinifex Pigeon					1							1		
Columbidae	*Ocyphaps lophotes*	Crested Pigeon		2		1						1		2		
Columbidae	*Geopelia cuneata*	Diamond Dove		2				1						2		
Columbidae	*Geopelia placida*	Peaceful Dove						1								
Cuculidae	*Chalcites osculans*	Black-eared Cuckoo	MA				1							1		
Otididae	*Ardeotis australis*	Australian Bustard												1		
Turnicidae	*Turnix velox*	Little Button-quail		2										3		
Accipitridae	*Elanus axillaris*	Black-shouldered Kite												1		
Accipitridae	*Aquila audax*	Wedge-tailed Eagle												1		
Accipitridae	*Accipiter fasciatus*	Brown Goshawk	MA			1										
Accipitridae	*Haliastur sphenurus*	Whistling Kite	MA	2		1		1						2		
Accipitridae	*Milvus migrans*	Black Kite		1												
Falconidae	*Falco cenchroides*	Nankeen Kestrel	MA			1										
Falconidae	*Falco berigora*	Brown Falcon								2	1			2		
Cacatuidae	*Nymphicus hollandicus*	Cockatiel				1					1	1		3		
Cacatuidae	*Eolophus roseicapilla*	Galah									3					
Psittacidae	*Barnardius zonarius*	Australian Ringneck				1			1		3					
Psittacidae	*Melopsittacus undulatus*	Budgerigar					1		3		2	5	2	2		
Maluridae	*Malurus lamberti*	Variegated Fairy-wren				2		1						7		

Family	Scientific Name	Common name	Status[1)]	Systematic trap sites										Other sites[2)]		
				S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	Opp	CT	SM4
Maluridae	*Malurus leucopterus*	White-winged Fairy-wren				1								2		
Meliphagidae	*Lichmera indistincta*	Brown Honeyeater				1			1					1		
Meliphagidae	*Certhionyx variegatus*	Pied Honeyeater									1			1		
Meliphagidae	*Conopophila whitei*	Grey Honeyeater		1								1				
Meliphagidae	*Epthianura tricolor*	Crimson Chat												1		
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater		2	1	3	1	2	1	4	4	3	6	4		
Meliphagidae	*Gavicalis virescens*	Singing Honeyeater		4	1	2	1	5	8	6	6	6		4		
Meliphagidae	*Ptilotula keartlandi*	Grey-headed Honeyeater		2	1	2	1	1	2	2	3		6	4		
Meliphagidae	*Ptilotula plumula*	Grey-fronted Honeyeater												1		
Meliphagidae	*Ptilotula penicillata*	White-plumed Honeyeater				2										
Meliphagidae	*Purnella albifrons*	White-fronted Honeyeater		1	1	3	2							3		
Meliphagidae	*Manorina flavigula*	Yellow-throated Miner		1										1		
Pardalotidae	*Pardalotus rubricatus*	Red-browed Pardalote									4			4		
Pardalotidae	*Pardalotus striatus*	Striated Pardalote												1		
Acanthizidae	*Gerygone fusca*	Western Gerygone		1					1		2			1		
Acanthizidae	*Smicrornis brevirostris*	Weebill			1	1		2			3	8	2	1		
Acanthizidae	*Aphelocephala leucopsis*	Southern Whiteface								1				1		
Acanthizidae	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill												1		
Acanthizidae	*Acanthiza apicalis*	Inland Thornbill				2				2	3					
Acanthizidae	*Acanthiza robustirostris*	Slaty-backed Thornbill									2					
Pomatostomidae	*Pomatostomus temporalis*	Grey-crowned Babbler		1	1			1	3	1		3		2		

Family	Scientific Name	Common name	Status[1)]	Systematic trap sites										Other sites[2)]		
				S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	Opp	CT	SM4
Campephagidae	*Coracina maxima*	Ground Cuckoo-shrike								3						
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	EPBC Marine									1		2		
Campephagidae	*Lalage tricolor*	White-winged Triller		3							1					
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler		2	1	3	1					2		7		
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush										2		4		
Oreoicidae	*Oreoica gutturalis*	Crested Bellbird		1	1	2	1	2	2	4	7	1	4	7		
Artamidae	*Gymnorhina tibicen*	Australian Magpie									4					
Artamidae	*Cracticus nigrogularis*	Pied Butcherbird		1	1	1	1				2	1	3	2		
Artamidae	*Artamus cinereus*	Black-faced Woodswallow		1			1		7			2		2		
Artamidae	*Artamus minor*	Little Woodswallow							4	1				3		
Artamidae	*Artamus leucorynchus*	White-breasted Woodswallow		1					5	5			1			
Rhipiduridae	*Rhipidura leucophrys*	Willie Wagtail		3	1			1	2		8	6		5		
Corvidae	*Corvus orru*	Torresian Crow												1	1	
Corvidae	*Corvus bennetti*	Little Crow							1					1		
Petroicidae	*Petroica goodenovii*	Red-capped Robin												1		
Petroicidae	*Melanodryas cucullata*	Hooded Robin								2	7		1	2		
Estrildidae	*Emblema pictum*	Painted Finch												1		
Estrildidae	*Taeniopygia guttata*	Zebra Finch		2				1	3	4		5	1	3		
Locustellidae	*Cincloramphus cruralis*	Brown Songlark		1										1		
Locustellidae	*Cincloramphus mathewsi*	Rufous Songlark								1				1		
Locustellidae	*Poodytes carteri*	Spinifexbird							3	2				2		

Family	Scientific Name	Common name	Status[1)]	Systematic trap sites										Other sites[2)]		
				S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	Opp	CT	SM4
Mammals																
Dasyuridae	*Dasykaluta rosamondae*	Kaluta					2		1		1				1	
Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	EN											1		
Dasyuridae	*Ningaui timealeyi*	Pilbara Ningaui			1	2	1	1								
Dasyuridae	*Sminthopsis ooldea*	Ooldea Dunnart			2			1				2				
Macropodidae	*Osphranter robustus*	Euro, Biggada												3		
Macropodidae	*Petrogale rothschildi*	Rothschild's Rock-wallaby												10		
Muridae	*Mus musculus*	House Mouse	s11										1			
Muridae	*Pseudomys chapmani*	Western Pebble-mound Mouse	P4											35		
Muridae	*Pseudomys desertor*	Desert Mouse		2								1				
Muridae	*Pseudomys hermannsburgensis*	Sandy Inland Mouse		1			2		1	1						
Megadermatidae	*Macroderma gigas*	Ghost Bat	VU													3
Emballonuridae	*Taphozous hilli*	Hill's Sheath-tailed Bat														8
Molossidae	*Chaerephon jobensis*	Greater Northern Free-tailed Bat														8
Molossidae	*Ozimops lumsdenae*	Northern Free-tailed Bat														2
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat														7
Vespertilionidae	*Scotorepens greyii*	Little Broad-nosed Bat														9
Vespertilionidae	*Vespadelus finlaysoni*	Finlayson's Cave Bat														9
Canidae	*Canis familiaris dingo*	Dingo												1		
Felidae	*Felis catus*	Cat	s11											1		

Family	Scientific Name	Common name	Status[1)]	Systematic trap sites										Other sites[2)]		
				S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	Opp	CT	SM4
Reptiles																
Carphodactylidae	*Nephrurus cinctus*	Northern Banded Knob-tailed Gecko						3		1						
Diplodactylidae	*Diplodactylus pulcher*	Pretty Gecko		1												
Diplodactylidae	*Diplodactylus savagei*	Southern Pilbara Beak-faced Gecko									2		5			
Diplodactylidae	*Lucasium wombeyi*	Pilbara Ground Gecko			1	7	10	5	4	5	2	2	1			
Diplodactylidae	*Rhynchoedura ornata*	Western Beaked Gecko		2				2	12	8		12				
Diplodactylidae	*Strophurus elderi*	Jewelled Gecko							1							
Gekkonidae	*Gehyra variegata*	Variegated gehyra		4	4				1							
Gekkonidae	*Heteronotia binoei*	Bynoe's Gecko				3	9	3	2		6	4	2			
Pygopodidae	*Delma butleri*	Spinifex Delma				1										
Pygopodidae	*Delma nasuta*	Sharp-snouted Delma									1					
Pygopodidae	*Delma pax*	Peace Delma						1			1					
Pygopodidae	*Delma tincta*	Black-necked Delma					1									
Pygopodidae	*Lialis burtonis*	Burton's Snake-lizard						1			1		1			
Agamidae	*Ctenophorus caudicinctus*	Western Ring-tailed Dragon		1	2	1	4	2	5	1	3	2	2	14		
Agamidae	*Ctenophorus isolepis*	Yellowy Military Dragon		4		1	1		1			1		3		
Agamidae	*Diporiphora amphiboluroides*	Mulga Dragon												2		
Agamidae	*Diporiphora valens*	Southern Pilbara Tree Dragon		1		4	1		1	2	2			1		
Agamidae	*Gowidon longirostris*	Long-nosed Dragon												1		

Family	Scientific Name	Common name	Status[1)]	Systematic trap sites										Other sites[2)]		
				S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	Opp	CT	SM4
Agamidae	*Pogona minor*	Dwarf Bearded Dragon		2					1							
Scincidae	*Carlia triacantha*	Desert Rainbow Skink		7	1	1	1		2							
Scincidae	*Cryptoblepharus ustulatus*	Russet Snake-eyed Skink													2	
Scincidae	*Ctenotus duricola*	Eastern Pilbara Lined Ctenotus				2					1	1				
Scincidae	*Ctenotus helenae*	Dusky Ctenotus										1				
Scincidae	*Ctenotus pantherinus*	Leopard Ctenotus		20	7	11	8	2	3	2	2	4	1	1		
Scincidae	*Ctenotus saxatilis*	Rock Ctenotus		18	10	5	3	3	7	8	11	11	6	5	4	
Scincidae	*Ctenotus schomburgkii*	Barred Wedge-snouted Ctenotus		2				1	4	2	1	2	1			
Scincidae	*Ctenotus serventyi*	North-western Sandy-loam Ctenotus										1				
Scincidae	*Cyclodomorphus melanops*	Spinifex Slender Blue-tongue						1								
Scincidae	*Egernia formosa*	Goldfields Crevice-skink													2	
Scincidae	*Eremiascincus richardsonii*	Broad-banded Sand Swimmer							1	4						
Scincidae	*Lerista jacksoni*	Jackson's Three-toed Slider				1						1				
Scincidae	*Menetia greyii*	Common Dwarf Skink											1			
Scincidae	*Morethia ruficauda*	Fire-tailed Skink				1										
Scincidae	*Proablepharus reginae*	Western soil-crevice skink				1										
Scincidae	*Tiliqua multifasciata*	Central Blue-tongue			1			1	1							
Varanidae	*Varanus acanthurus*	Spiny-tailed Goanna											1		1	

Family	Scientific Name	Common name	Status[1)]	Systematic trap sites										Other sites[2)]		
				S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	Opp	CT	SM4
Varanidae	*Varanus brevicauda*	Short-tailed Pygmy Goanna				3	2	1			1	1				
Varanidae	*Varanus bushi*	Pilbara Mulga Goanna										1				
Varanidae	*Varanus hamersleyensis*	Southern Pilbara Rock Goanna													2	
Varanidae	*Varanus tristis*	Racehorse Goanna												2		
Typhlopidae	*Anilios hamatus*	Northern Hook-snouted Blind Snake			1											
Elapidae	*Brachyurophis approximans*	North-western Shovel-nosed Snake								1	1	1				
Elapidae	*Pseudechis australis*	Mulga Snake													2	
Elapidae	*Pseudonaja modesta*	Ringed Brown Snake					1							1		
Amphibians																
Pelodryadidae	*Cyclorana maini*	Sheep Frog												1		

Footnotes:

1) Status:

VU = Vulnerable under the EPBC Act and BC Act;
P4 = DBCA Priority 4,
MA = Marine under the EPBC Act;
s11 = Introduced species (feral) listed permitted under the Western Australian Organism List (WAOL);
s22(2) = Introduced (feral) species listed as a Declared Pest under the WAOL.

2) Other sites

Opp = Opportunistic records across the survey area
CT = Recorded on camera transects
SM4 = Recorded from bat detectors deployed across the survey area

Appendix VIII Bat call analysis

Lamb Creek, Pilbara WA,

Acoustic Survey of Bat and Night Parrot Activity, April 2020, February 2021.

Prepared for Rapallo Group

Bat Call WA Pty Ltd
ABN 26 146 117 839
43 Murray Drive
Hillarys Western Australia 6025
bullen2@bigpond.com
+61 8 9402 1987
+61 488 930 735

Prepared by:
R. D. Bullen – Bat Call WA
Issue 5
10 November 2021

Document Revision History

Issue	Date	Revision History
A	7 May 2020	Initial draft for Rapallo review
1	15 May 2020	First formal issue
2	17 Nov 2020	Second issue with minor corrections
3	15 March 2021	Third issue incorporating Feb 21 data
4	6 April 2021	Fourth Issue incorporating client review comments.
5	10 November 2021	Fifth Issue incorporating further client review comments.

Summary
Bat and Night Parrot (*Pezoporus occidentalis*) presence is reported for seventeen sites at Lamb Creek, in the Pilbara, WA. Rapallo carried out an echolocation-based survey in April 2020 and February 2021. Sixteen sites were surveyed for all bats present including Ghost bat social and ultrasonic calls. Three were surveyed using acoustic detectors set to record Night Parrot and Ghost bat social calls. Bat Call WA has reviewed the recordings made and provided species lists for the bats present.

Seven species of echolocating bats were confirmed present including the Ghost bat (*Macroderma gigas*) (PGb) that is listed as vulnerable under both state and commonwealth legislation. PGb presence was detected at five caves. Multiple calls consistent with at least four diurnally roosting PGb were detected on three nights at Cave 1 in April 2020 and for 2 nights at Cave 5 in February 2021. Calls consistent with a single diurnally roosting PGb were detected on one night at Cave 4 in February 2021. Calls at times consistent with foraging visits were detected at Caves 2 and 3 in April 2020 and at Cave 3 in February 2021. This result is consistent with the known population and dispersal of PGb in the district.

No Pilbara leaf-nosed bats (*Rhinonicteris aurantia*) (PLNb) or Night Parrot calls were detected.

Habitats
The sites for the survey were chosen by Rapallo. Details of the sites are presented in table 1 and caves are described in detail in Appendix A. The bat sites included each type of habitat present in the study area including cave entrances, an incised gully, drainage lines and spinifex plains. All the Night Parrot sites are on spinifex plains with thin shrubland. The locations are shown in relation to local features in figure 1.

Timing, Moon Phase and Weather
The dry season echolocation survey was conducted between 16th to 28th April 2020. The sampling evenings were hot and dry with minimum overnight temperatures between 25 and 30^{O}C. Occasional showers fell during the survey. The moon was between third quarter and new.

The wet season echolocation survey was conducted between 20th to 24th February 2021. The sampling evenings were hot and dry with minimum overnight temperatures between 20 and 25^{O}C. No rain fell during the survey. The moon was between first quarter and full.

Survey Team
Sites were chosen and detectors placed by Rapallo ecologists. Bob Bullen of Bat Call WA completed analysis of audio and echolocation recordings.

Sampling
The bat survey consisted of completing a total of thirty-three overnight ultrasonic bat sound recordings, beginning at twilight, at sixteen locations within the survey area. A total of eight acoustic survey nights were completed at three sites for Night Parrot. The recordings were "continuous" (Hyder *et al.* 2010) made using ultrasonic SM4BAT-FS and acoustic SM4A SongMeter (both by Wildlife Acoustics Inc., USA) detectors. The audio settings used followed the manufacturer's recommendations contained in the user manuals.

For the ultrasonic recordings, once reformatted as .wav files, COOL EDIT 2000 (now available as AUDITION from Adobe Systems Inc.) was used to display each sequence for identification. Calls were identified manually. Only good quality call sequences were used. Details of calls analysed are provided in Table 2 as recommended by Australasian Bat Society (ABS 2006). Reference data for

the species identified are available in Bullen and McKenzie 2002, McKenzie and Bullen 2003 and McKenzie and Bullen 2009.

For the acoustic recordings, each was reviewed both manually and using an automatic scan technique for Night Parrot calls. Candidate calls were compared with the author's confirmed reference calls from two Western Australian arid zone locations.

Survey Limitations
The sites surveyed were accessible on foot and the detectors, using omnidirectional microphones, were set on the ground with the microphone horizontal. Species are unlikely to be under-represented as a result.

Bat species density away from cave or adit entrances is impossible to estimate from echolocation records. Bat activity is therefore substituted as an approximate guide to the relative numbers of each species using the study area.

Results of bat fauna survey
An assemblage of seven echolocating bat species was confirmed as present at the study sites including the PGb, table 4. Species activity levels were low to high, which is expected for the study area habitat and the times of year.

PLNb detections
No PLNb were detected during the survey

PGb detections
Ghost bats were detected ultrasonically at all five cave sites, table 4, figure 1. At least four diurnally roosting PGb were confirmed at Cave 1 in April 20 by the temporal pattern of their recorded calls on three nights. Both social and ultrasonic calls were recorded before dawn followed by similar numbers of calls soon after dusk that day. This was not repeated in February 2021. Calls consistent with diurnally roosting PGb were detected at Caves 4 and 5 in February. Calls consistent with foraging PGb were detected at Caves 2 and 3 on one night each in February and for two nights at cave 3 in February. These records are consistent with the PGb being present in the study area ridges. This result is consistent with the known presence of the PGb across the central Pilbara in general and on the major ridges in the district.

The five caves have been provisionally classified as roost caves of either Category 2, 3 or 4 based on the detected call pattern and the descriptions of their internal complexity, table 4 and Appendix A. Cave 1 is provisionally a Cat 2 while Caves 2, and 3 are provisionally Cat 3. Caves 4 and 5 are known Cat 3 and 2 respectively (authors unpublished data). Caves that are confirmed as Category 2 and groupings of caves that surround them are critical PGb habitat. The categories are described in detail in Appendix B.

Common bat species detections
Four common species, *Chaerephon jobensis*, *Chalinolobus gouldii*, *Taphozous hilli* and *Vespadelus finlaysoni* dominated bat presence in the area.

Taxonomy presented herein is after Reardon *et al.* (2014) and Jackson and Groves (2015).

Results of Night Parrot survey.
No Night Parrot calls were detected.

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.

Bullen R.D. and McKenzie N.L. (2002). Differentiating Western Australian Nyctophilus (Chiroptera: Vespertilionidae) echolocation calls. *Australian Mammalogy*. 23: 89-93

Hyder, B.M., Dell, J. and Cowan, M.A. (eds) (2010). *Technical guide – Terrestrial vertebrate fauna surveys for environmental impact assessment.* Technical report of the Environmental Protection Authority and the Department of Environment and Conservation.

Jackson, S. and Groves, C (2015). *Taxonomy of Australian Mammals*. CSIRO Publishing: Collingwood Vic.

McKenzie N.L. and Bullen R.D. (2003). Identifying Little Sandy Desert bat species from their echolocation calls. *Australian Mammalogy* 25: 73-80.

McKenzie, N.L. and Bullen R.D. (2009). The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Rec. West. Aust. Mus.* Supplement 78:123-155.

Reardon, T.B., McKenzie, N.L., Cooper, S.J., Appleton, B. Carthew, S. and Adams, M. (2014). A molecular and morphological investigation of species boundaries and phylogenetic relationships in Australian free-tailed bats *Mormopterus* (Chiroptera: Molossidae). *Australian Journal of Zoology*, available on-line 23 April 2014.

Table 1: Microbat site specific details. Coordinates are Zone 50K

	Date	Recording Time & SM unit	Habitat	Easting	Northing
April 2020					
Site 1	20 Apr 20	One overnight recording using SM4U-6479 recording at 384 kbps	Thin woodland	684831	7467776
Site 2	20 Apr 20	One overnight recording using SM4U-6488 recording at 384 kbps	Thin woodland	685101	7468474
Site 3	21 Apr 20	One overnight recording using SM4U-6479 recording at 384 kbps	Shrubland	682905	7471293
Site 4	22 Apr 20	One overnight recording using SM4U-6479 recording at 384 kbps	Spinifex plain	685919	7475392
Site 5	23 Apr 20	One overnight recording using SM4U-6479 recording at 384 kbps	Shrubland	688642	7477107
Site 6	16 to 17 Apr 20	Two overnight recordings using SM4U-6488 recording at 384 kbps	Shrubland	690293	7477134
Site 7	16 to 17 Apr 20	Two overnight recordings using SM4U-6479 recording at 384 kbps	Thin woodland	691388	7476256
Site 8	18 Apr 20	One overnight recording using SM4U-6488 recording at 384 kbps	Thin woodland	692623	7476976
Site 9	19 Apr 20	One overnight recording using SM4U-6488 recording at 384 kbps	Minor drainage line	692959	7477588
Site 10	18 to 19 Apr 20	Two overnight recordings using SM4U-6479 recording at 384 kbps	Minor drainage line	693016	7476648
Site Gully	27 to 28 Apr 20	Detector failed to record	Incised gully	688384	7475295
Cave 1	21 to 24 Apr 20	Four overnight recordings using SM4U-6488 recording at 384 kbps	Cave Entrance	693571	7476273
Cave 2	25 to 26 Apr 20	Two overnight recordings using SM4U-6488 recording at 384 kbps	Cave Entrance	690696	7473764
Cave 3	24 to 27 Apr 20	Four overnight recordings using SM4U-6479 recording at 384 kbps	Cave Entrance	694116	7476556
February 2021					
Cave 1	20 to 22 Feb 21	Three overnight recordings using SM4U-4031 recording at 384 kbps	Cave Entrance	693571	7476273
Cave 3	20 to 22 Feb 21	Three overnight recordings using SM4U-8168 recording at 384 kbps	Cave Entrance	694116	7476556
Cave 4	23 to 24 Feb 21	Two overnight recordings using SM4U-4031 recording at 384 kbps	Cave Entrance	683844	7469750
Cave 5	23 to 24 Feb 21	Two overnight recordings using SM4U-8168 recording at 384 kbps	Cave Entrance	683848	7469788

Table 2: Night Parrot site specific details.

	Date	Recording Time & SM2 unit	Habitat	Easting	Northing
April 2020					
Site A3	20 to 22 April	Three overnight recordings using SM4A-4717	Thin Shrubland	682915	7471272
A-Haul Road	23 to 24 April	Two overnight recordings using SM4A-4717	Spinifex plain	683241	7473176
A-Footprint	25 to 27 April	Three overnight recordings using SM4A-4717	Spinifex plain	691745	7475914

Note 1: Coordinates are Zone 50K

Table 3: Summary of Echolocation call characteristics for microbat species present.

Genus species Authority	Common name	Typical F_{peak} kHz Note 1	Ave. Q Note 1	Typical Duration msec	Typical Call Shape
Chaerephon jobensis (Miller 1902)	Northern free-tailed bat	22	5	8 - 15	Shallow FM
Chalinolobus gouldii (Grey 1841)	Gould's wattled bat	32	10	7 - 11	FM
Macroderma gigas (Dobson 1880)	Ghost bat	20 – 52 variable	2 – 20 variable	variable	Complex FM
Ozimops lumsdenae Reardon *et al*.2014	Northern free-tailed bat	26	10	8 - 13	Shallow FM
Scotorepens greyii (Gray 1843)	Little broad-nosed bat	38	10	7 - 13	FM
Taphozous hilli Thomas 1915	Hills sheath-tailed bat	26	14	9 - 18	CF– shallow FM
Vespadelus finlaysoni (Kitchener, Jones and Caputi 1987)	Inland cave bat	55	14	4 - 8	FM

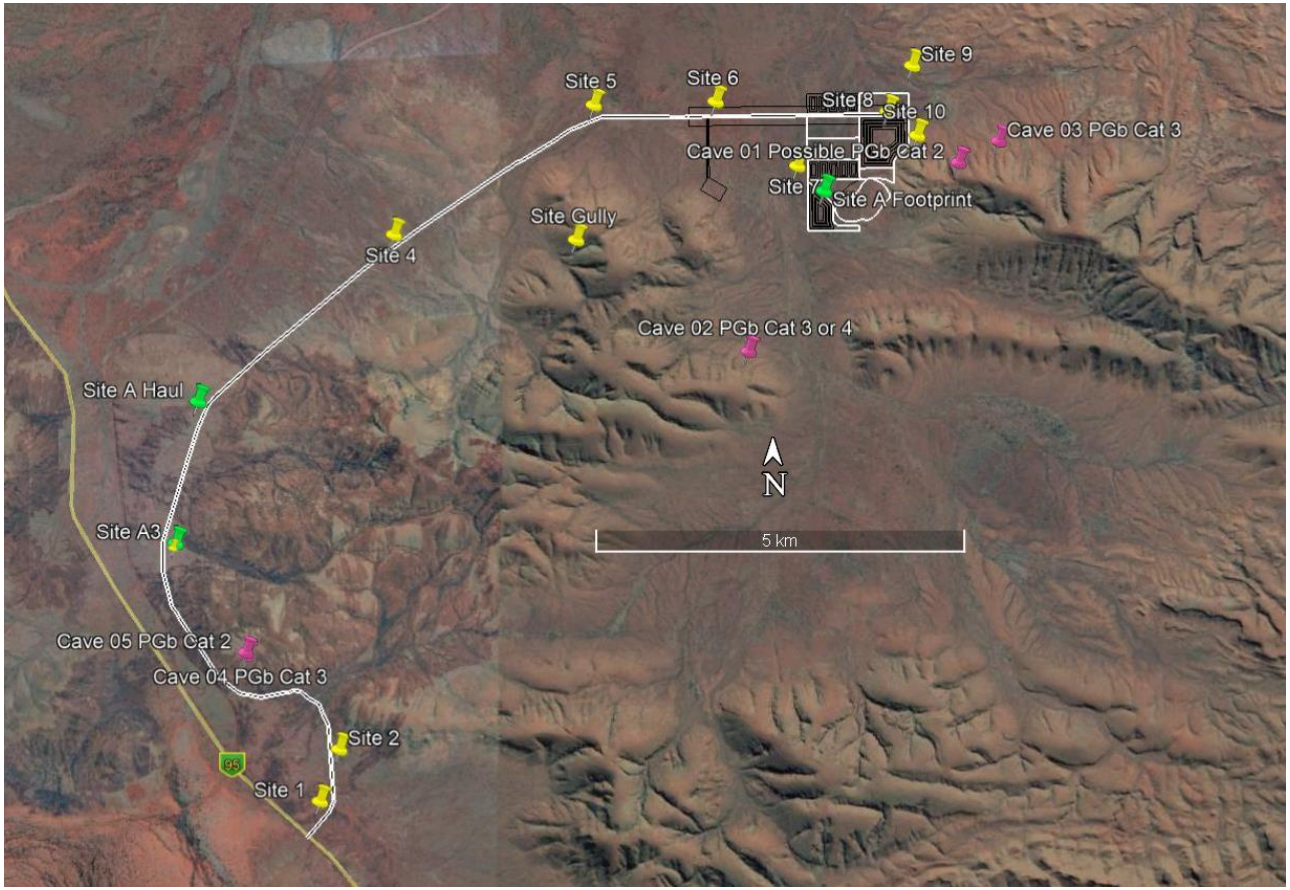
Note 1: Fpeak and Q are defined in McKenzie and Bullen 2003, 2009.
Note 2: Taxonomy follows Jackson and Groves (2015). *O. lumsdenae* was recently *Mormopterus beccarii*.

Table 4: Survey microbat lists presented by site.

Site	*Chaerephon jobensis*	*Chalinolobus gouldii*	*Macroderma gigas*	*Ozimops lumsdenae*	*Scotorepens greyii*	*Taphozous hilli*	*Vespadelus finlaysoni*
April 2020							
Site 1					Yes		Yes
Site 2	Yes				Yes		Yes
Site 3							Yes
Site 4	Yes	Yes			Yes	Yes	Yes
Site 5					Yes	Yes	
Site 7	Yes	Yes			Yes	Yes	Yes
Site 8	Yes	Yes		Yes		Yes	
Site 9	Yes	Yes			Yes		
Site 10	Yes	Yes		Yes	Yes	Yes	Yes
Cave 1	Yes	Yes	Multiple calls consistent with diurnal roosting over multiple days		Yes	Yes	Yes
Cave 2	Yes		Multiple calls consistent with nocturnal foraging on one night			Yes	Yes
Cave 3		Yes	1 call consistent with nocturnal foraging on one night		Yes	Yes	Yes
February 21							
Cave 1	Yes	Yes			Yes	Yes	Yes
Cave 3	Yes		Multiple calls consistent with nocturnal foraging on two nights			Yes	Yes
Cave 4			Multiple calls consistent with diurnal roosting			Yes	Yes
Cave 5	Yes		Multiple calls consistent with diurnal roosting			Yes	Yes

Note: Both *Taphozous* species were detected. The majority of calls were *T. georgianus. T hilli* calls were also present at some sites

Figure 1. Survey sites in relation to features in the study area. The white and black areas are the proposed impact area and the haul road to the GNH. Pink pins denote sites where PGb ultrasonic calls and opportunistic observations were recorded. Yellow pins denote sites where microbat calls were recorded but no PLNb or PGb were detected. Green pins denote sites where acoustic detectors were placed to record Night Parrot and Ghost bat social calls.



Appendix 1. Cave Descriptions.

Descriptions and images provided by Rapallo.

	MGA Zone 50 K		Description	Photograph
	Easting (mE)	Northing (mE)		
Cave 1 **Cat 2.** PGb diurnal roosting detected. 5 PGb observed April 2020 No PGb detected Feb 21	693571	7476273	**Entrance:** 4 m wide x 1.5 m high **Orientation:** South **Internal:** 2 chambers over 10 m deep. **Conditions:** Ghost Bats roosting diurnally in April 20 and middens present.	

	MGA Zone 50 K		Description	Photograph
	Easting (mE)	Northing (mE)		
Cave 2 **Cat 3.** PGb nocturnal visit detected April 2020.	690696	7473764	**Entrance:** 3.5 m wide x 2 m high **Orientation:** East **Internal:** Single chamber 10 m deep. **Conditions:** PGb nocturnal visit detected but no middens present.	

	MGA Zone 50 K		Description	Photograph
	Easting (mE)	Northing (mE)		
Cave 3 **Cat 3.** PGb nocturnal visits detected April 2020 and Feb 21.	694116	7675556	**Entrance:** 4 m wide x 1.5 m high **Orientation:** West **Internal:** Single chamber with a 4 m high dome. **Conditions:** PGb nocturnal visit detected but no middens present.	

	MGA Zone 50 K		Description	Photograph
	Easting (mE)	Northing (mE)		
Cave 4 **Cat 3.** Feb 21. PGb nocturnal visits detected. Possible diurnal roosting	683844	7469750	**Entrance:** 3 m high x 3.5 m wide. **Orientation:** West **Internal:** Inner chamber approx. 2 m high. **Conditions:** Large deep cave with high roof. Inner chamber approx. 2 m high.	

	MGA Zone 50 K		Description	Photograph
	Easting (mE)	Northing (mE)		
Cave 5 **Cat 2.** Feb 21. PGb diurnal roosting detected.	683848	7469788	**Entrance:** 7 m wide x 6 m high. **Orientation:** East **Conditions:** Large deep cave with high roof and complex interior. PGb diurnal roosting detected.	

Appendix B: Ghost bat Cave Habitat Classifications

Each Ghost bat roost cave identified can be categorised according to the following definitions based on usage. These definitions are based on contemporary observations and unpublished data and have been developed from the earlier cave definitions contained in TSSC 2016 and other publications.

Category 1 diurnal roost caves with permanent Ghost bat occupancy.

There are a number of documented permanent roost caves and underground mines in northern Australia, e.g. Tunnel Creek in the Kimberley and Kohinoor adit in the NT. These tend to have large but variable populations, e.g. Kohinoor's colony has grown from 300+ in 1981 to ~1,500 in 1990 and then reduced to 550 in 2013 (Woinarski *et al*. 2014). In the Pilbara, other than a number of historical underground mines e.g. Comet, Klondyke Queen, Lalla Rookh and Bamboo Creek which do have large populations of over 100 Ghost bats, very few such roosts in natural caves are documented. Those natural caves that may be permanently occupied have been observed with variable populations present. One example is a significant cave with a complex surrounding gully in the Robe Valley south-west of Pannawonica that has had Ghost bats present on most, if not all, survey visits. The colony size at this cave has varied from a few to over 70 recorded in April 2017 (Bat Call 2017). Where permanent presence at category 1 sites is proven, they must all be assumed to be maternity caves. These are considered as critical habitat essential for the persistence of the Ghost bat in the Pilbara.

Category 2 diurnal roost caves with regular occupancy.

There are a number of Pilbara caves and adits where Ghost bats have regular, but not continuous, presence over long periods. These tend to be deep caves with ceiling heights in rear chambers of at least 1.5 m allowing multiple roosting opportunities for Ghost bats out of reach of predators. The longest continuous monitoring programs have been at Rio Tinto's West Angelas project and at BHPs Mining Area C and South Flank projects. At all three locations there are a number of caves with roosting Ghost bats records but none of these have had either permanent presence or consistently high numbers present. Numbers have varied between zero and five with very occasional counts of 20 or more (author's unpublished data). Based on recent monitoring of caves using ultrasonic call detectors, these caves have Ghost bats present for 25 to 75% of nights for mid to long periods but then may be abandoned for periods. There is insufficient data at present to see if there are any seasonal trends in these occupancy rates. These caves typically have a

number of other caves, shelters and overhangs within a few hundred meters. Together they make up an "apartment block" grouping (TSSC 2016, Bat Call 2017) that supports the ongoing presence of the bats.

Recent analysis at West Angelas based on genetic sampling at five monitored caves in 2015 and 2017 (Ottwell *et al*. 2018) suggests that some Ghost bats tend to use particular caves regularly over a season or year, but others move between caves in the same period. Their analysis identifies 34 unique individuals at caves over those two years and indicated that the "genetic effective population size" was twelve. Two of the five caves have been shown by the long-term observations to have regular occupancy (Biologic 2016). In all surveys undertaken, Ghost bats have been either roosting in low numbers or there was evidence of recent roosting at the former and, with the exception of one survey, at the latter. The genetic analysis also supports this conclusion with presence of multiple bats over the two years of that study at these caves. Similar occupancy patterns have been recorded at several caves at the BHP projects. There are an increasing number of observations becoming available of pregnant Ghost bats or Ghost bats carrying pups at some of these caves, plus others (e.g. Silvergrass East cave SG-1, Hamersley Iron 1999) although again there is insufficient data to identify any trends other than to say that any cave that has regular occupancy must be assumed to be capable of supporting one or more reproducing females and their offspring. These caves are considered as critical habitat essential for the persistence of the Ghost bat in the Pilbara.

Category 3 roost caves with occasional occupancy.

There are a large number of caves and adits where Ghost bats roost occasionally or rarely in small numbers of one to a few. Many are located nearby higher category roosts, but many are also in isolated locations. Surveys in recent years have identified numerous caves that have Ghost bats scats or small food middens present but either no evidence of roosting bats or with rarely repeated presence observations, e.g. five of the seven monitored caves at West Angelas (Biologic 2016) show such a pattern with occasional Ghost bats present and/or intermittent evidence of recent occupancy. Reproducing females have been reported from at least two caves at West Angelas that ongoing observations indicate fall into this category, but no firm evidence exists that such caves are necessary for successful reproduction. Individually, these are not considered as critical habitat but when they are located nearby one or more category 1 or 2 caves, and are part of an "apartment block" of disturbance refuges or nocturnal feeding sites, they are important for the persistence of the Ghost bat in the local area and the cave grouping becomes critical. Due

to the number of caves across the Hamersley Ranges and the Eastern Pilbara, isolated category 3 caves may only be considered important for the long-range dispersal of the species.

Category 4 nocturnal roost caves, opportunistic usage.

Numerous observations suggest that the majority of caves and adits in the Pilbara are used in at least an opportunistic manner by itinerant Ghost bats. This may be anything from a single foraging visit to a longer visit with a resting period or possibly a feeding session. Evidence of such visits is the widespread presence of small numbers of scats found or occasional echolocation calls recorded during surveys. These visits may or may not be repeated depending whether the bat is passing through a district or is a more permanent resident nearby. These are not considered as critical habitat but when they are located close to higher category caves and are part of an apartment block of refuges, the cave grouping is important for the persistence of the Ghost bat in the local area. Due to the number of caves across the Hamersley Ranges and the Eastern Pilbara, isolated category 4 caves are not considered important for the species.

Appendix A References

Bat Call (2017). Robe Valley Mesa A to Mesa 2405A, impact of mining on Ghost bat presence and activity, April 2017, including assessment of caves on Mesas F and G. Unpublished report for Rio Tinto dated 10 July 2017.

Biologic (2016). West Angelas Iron Ore Mine – Deposit B and F Ghost bat monitoring 2015. Unpublished report prepared for Rio Tinto dated January 2016.

Hamersley Iron (1999). Nammuldi/Silvergrass Exploration Project. Biological Survey Report November 1998 - May 1999. Hamersley Iron Pty. Ltd.

Ottwell, K, McArthur, S., Van Leeuwen, S. and Byrne, M. (2018). Cave use by Ghost Bat (*Macroderma gigas*) at the West Angelas mine site. WA Department of Biodiversity and Attractions report dated January 2018.

Threatened Species Scientific Committee (2016). Conservation advice, *Macroderma gigas*, Ghost bat. Australian Government Department of Environment, dated 5 May 2016.

Woinarski, J.C., Burbidge, A.A. and Harrison, P.L. (2014). The action plan for Australian mammals, 2012. CSIRO Publishing: Collingwood, Australia.

Appendix IX Habitat assessment data

Appendix IX Habitat assessment data

Date	Site Name	Habitat	Slope	Shading	Soil	Soil Colour	Soil Comments	Rocks	Litter Depth	Litter Distribution	Large Fallen Logs	Fire History	Disturbance	Drainage	Main_Veget Form	Easting	Northing	Zone
17/02/2021	LC01	Medium Drainage	Negligible	Minimal Shading from topography, Shade only under corymbias	Loam	Red Brown	Some piles of soil but not deep even under trees	Negligible	0-2cm	Patchy Under Trees	None	Within 5 years	Buffel grass	Creek Wide	Open Woodland	691730.6	7477159.8	50
17/02/2021	LC02	Medium Drainage	Negligible	Some shade from vegetation not heavy	Loam	Red Brown			2-5 cm	Patchy Under Trees		Long Unburnt	Buffel grass	Creek Wide	Open Woodland	691751.39	7477231.6	50
17/02/2021	LC03	Medium Drainage	Gentle	Some shading from vegetation	Loam	Red Brown			Gr20cm	Patchy Under Trees	Some	Long Unburnt	Creek choked with buffel grass	Creek Wide	Open Woodland	691483.75	7476658.5	50
17/02/2021	LC04	Mulga/corymbia plain	Negligible	Some shading from patchy vegetation (mulgas)	Sandy Clay Loam	Red Brown	Mostly hard soil except right against trees	Small Rocks	2-5 cm	Patchy Under Trees	Some	Within 5 years	Buffel grass	Sheet flow		691578.66	7476651	50
18/02/2021	LC05	Mulga/corymbia plain	Negligible	Some shading from patchy vegetation (mulgas)	Sandy Clay Loam	Red Brown	Patches of soil mostly shallow 0-5cm		2-5 cm	Patchy Under Trees		Within 10 years	Buffel grass	Sheet flow	Open Woodland	691809.64	7475592	50
18/02/2021	LC06	Mulga/corymbia plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown		Small Rocks	2-5 cm	Patchy Under Trees		Within 10 years	Buffel grass	Sheet flow	Open Woodland	691874.62	7475537.1	50
19/02/2021	LC07	Mulga/corymbia plain	Negligible	Average shading from vegetation	Sandy Clay Loam	Red Brown	Skeletal hard soil between mulga patches	Small Rocks	2-5 cm	Patchy Under Trees	Some	Within 5 years		Sheet flow	Open Shrubland	690726.58	7476079.3	50
19/02/2021	LC08	Mulga/corymbia plain	Negligible	Some shading from patchy vegetation	Loam	Red Brown	Loamy. The mulga patch tending to sandy clay loam out of the patch	Pebbles	5-10 cm	Patchy Under Trees	Some	Within 10 years		Sheet flow	Open Woodland	690772.62	7475978.9	50
19/02/2021	LC09	Mulga/corymbia plain	Negligible	Some shading from patchy vegetation	Loam	Red Brown		Surface sprinkle	2-5 cm	Patchy Under Trees	Some	Within 10 years	Buffel grass	Sheet flow	Open Woodland	692264.79	7477404.7	50
20/02/2021	LC10	Mulga/corymbia plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown		Surface sprinkle	5-10 cm	Patchy Under Trees		Within 10 years	Buffel grass	Sheet flow	Open Woodland	692336.31	7477314.8	50
20/02/2021	LC11	Hillcrest/ hillslope	Gentle	Minimal Shading from topography	No Soil	Red Brown	Skeletal under rocks	Gravel	Negligible		None	Within 10 years		Negligible		694331.16	7476078.3	50
20/02/2021	LC12	Shallow Open Gully	Steep	Some shade from topography	Sandy Clay Loam	Dark Brown			Gr20cm	Patchy against rocks	None	Long Unburnt		gully	Spinifex Grassland	694379.69	7475884.1	50
20/02/2021	LC13	Deep Gully	Steep	Some shade from topography	No Soil	Red Brown	Patches of soil (sandy clay loam) against rocks, not deep	Large Rocks	5-10 cm	Patches of litter under trees and against rocks	None	Long Unburnt		gully	Spinifex Grassland	694389.26	7475797.2	50
20/02/2021	LC14	Shallow Open Gully	Steep	Some shade from topography	No Soil	Red Brown	Patches of soil (sandy clay loam) against rocks, not deep	Large Rocks	5-10 cm	Patches of litter under trees and against rocks	None	Long Unburnt		gully	Spinifex Grassland	694288.2	7475719.9	50
21/02/2021	LC15	Mulga/corymbia plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown	Some soil against trees but not deep	Small Rocks	2-5 cm	Patchy Under Trees	Some	Within 5 years		Sheet flow	Open Shrubland	690264.72	7476809.2	50

Date	Site Name	Habitat	Slope	Shading	Soil	Soil Colour	Soil Comments	Rocks	Litter Depth	Litter Distribution	Large Fallen Logs	Fire History	Disturbance	Drainage	Main_Veget Form	Easting	Northing	Zone
21/02/2021	LC16	Stony Plain	Negligible	Minimal Shading from topography	Clay_loam	Red Brown	Skeletal under rocks	Small Rocks on surface	0-2cm	Patchy Under Trees	None	Within 5 years		Negligible	Spinifex Grassland	692741.5	7477004	50
21/02/2021	LC17	Hillcrest/ hillslope	Gentle	Minimal Shading from topography	Clay_loam	Red Brown	Skeletal	Small Rocks	Negligible		None	Within 10 years		Negligible	Spinifex Grassland	693400.78	7476697.5	50
21/02/2021	LC18	Minor Drainage	Moderate	Minimal Shading from topography	No Soil	Red Brown	Very little soil mostly creek gravel	Gravel	0-2cm			Within 10 years		Creek Narrow	Open Shrubland	693385.61	7476629.3	50
21/02/2021	LC19	Hillcrest/ hillslope	Gentle	Minimal Shading from topography	Clay_loam	Red Brown		Small Rocks, Soil is present under rocks but skeletal	Negligible			Within 5 years		Negligible	Spinifex Grassland	694647.79	7475985.4	50
21/02/2021	LC20	Shallow Open Gully	Moderate	Some shade from topography	Sandy Clay Loam	Dark Brown		Large Rocks	2-5 cm	Patches of litter under trees and against rocks	None	Long Unburnt		gully	Spinifex Grassland	694800.9	7475965.1	50
21/02/2021	LC 21	Deep Gully	Moderate	Some shade from topography	Sandy Clay Loam	Dark Brown		Small Rocks	5-10 cm	Patches of litter in the twist and turns of gullies or gorges	None	Long Unburnt		gully		694883.35	7475947.5	50
22/02/2021	LC22	Stony Plain	Gentle	Minimal Shading from topography	Sandy Clay Loam	Red Brown	Skeletal under rocks	Small Rocks	0-2cm	Patchy Under Trees	None	Within 5 years		Negligible	Spinifex Grassland	687114.4	7476173.8	50
22/02/2021	LC23	Minor Drainage	Gentle	Minimal Shading from topography and vegetation	Sandy Clay Loam	Red Brown	Little bit deeper under trees; patches of loamier soil in places	Gravel	0-2cm	Patchy Under Trees	None	Within 5 years		Creek Narrow	Other	687235.88	7476276.6	50
22/02/2021	LC24B	Stony Plain	Negligible	Minimal Shading from topography and vegetation	Loam	Red Orange		Pebbles	5-10 cm	Patchy Under Trees	None	Within 5 years	Edge of laydown and road	Sheet flow	Open Woodland	692511.24	7476409.2	50
22/02/2021	LC24A	Stony Plain	Negligible	Minimal Shading from topography and vegetation	Loam	Red Orange		Pebbles	5-10 cm	Patchy Under Trees	None	Within 5 years	Next to laydown and road	Sheet flow	Open Woodland	692218.17	7476788.5	50
22/02/2021	LC25	Minor Drainage	Gentle	Minimal Shading from topography and vegetation	No Soil	Red Brown	Skeletal Clay loam under rocks	Small Rocks	0-2cm	Patchy Under Trees	Some	Within 5 years	Exploration disturbance	Creek Narrow	Open Shrubland	692318.72	7476031.6	50
22/02/2021	LC26	Hillcrest/ hillslope	Gentle	Minimal Shading from topography and vegetation	Loam	Red Brown	Skeletal under rocks	Small Rocks	Negligible		None	Within 5 years	Exploration	Negligible	Open Shrubland	692152.09	7475861.3	50
22/02/2021	LC27B	Stony Plain	Gentle	Minimal Shading from topography and vegetation	Sandy Clay Loam	Red Brown	Soil under rocks	Small Rocks	0-2cm	Patchy Under Trees	None	Within 10 years		Negligible	Spinifex Grassland	684003.25	7473771.8	50
22/02/2021	LC27A	Minor Drainage	Gentle	Some shading from vegetation	Sandy Clay Loam	Red Brown	Patches of deeper soil in creekbed but still not that deep	Surface sprinkle	0-2cm	Patchy Under Trees	None	Within 10 years		Creek Narrow	Other	684032.84	7473928.5	50
23/02/2021	LC 28	Stony Plain	Gentle	Minimal Shading from topography and vegetation	Sandy Clay Loam	Red Brown		Surface sprinkle	5-10 cm	Patchy Under Trees	Some	Within 10 years		Creek Narrow	Shrubland	683361.54	7473308.9	50
23/02/2021	LC 29A	Stony Plain	Gentle	Minimal Shading from topography and vegetation	Sandy Clay Loam	Red Brown		Small Rocks	0-2cm	Patchy Under Trees	Some	Within 5 years		Negligible	Spinifex Grassland	683413.49	7473241	50
23/02/2021	LC30	Stony Plain	Gentle	Minimal Shading from topography and vegetation	Sandy Clay Loam	Red Brown		Small Rocks	Negligible	Even	None	Long Unburnt		Negligible	Spinifex Grassland	682956.21	7472197.5	50

Date	Site Name	Habitat	Slope	Shading	Soil	Soil Colour	Soil Comments	Rocks	Litter Depth	Litter Distribution	Large Fallen Logs	Fire History	Disturbance	Drainage	Main_Veget Form	Easting	Northing	Zone
24/02/2021	LC31	Tussock grassland plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown	Quite dry	Surface sprinkle	2-5 cm	Patchy Under Trees	None	Within 10 years			Open Woodland/ grassland	684046.02	7469318.5	50
24/02/2021	LC32	Tussock grassland plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown	Quite dry	Surface sprinkle	2-5 cm	Patchy Under Trees	None	Within 10 years			Open Woodland/ grassland	684130.16	7469366	50
24/02/2021	LC33	Tussock grassland plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown			2-5 cm	Patchy Under Trees	Some	Within 10 years	Buffel grass	Creek Wide	Open Woodland/ grassland	685147.6	7468502.9	50
24/02/2021	LC34	Tussock grassland plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown			2-5 cm	Patchy Under Trees	None	Within 10 years	Buffel grass	Creek Wide	Open Woodland/ grassland	685073.66	7468505.3	50
24/02/2021	LC35	Tussock grassland plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown			2-5 cm	Patchy Under Trees	None	Within 10 years	Buffel grass	Creek Wide	Open Woodland/ grassland	685046.68	7468252.4	50
24/02/2021	LC36	Minor Drainage	Gentle	Minimal Shading from topography and vegetation	No Soil	Red Brown		Gravel	0-2cm	Patchy Under Trees	None	Within 5 years		Creek Narrow	Open Shrubland	683317.24	7470009.9	50
24/02/2021	LC37A	Stony Plain	Gentle	Minimal Shading from topography and vegetation	Sandy Clay Loam	Red Brown		Small Rocks	0-2cm	Patchy Under Trees	None	Within 5 years				683263.51	7470052.9	50
25/02/2021	LC37	Minor Drainage	Gentle	Minimal Shading from topography and vegetation	No Soil	Red Brown		Gravel	Negligible		None	Within 5 years		Creek Wide	Open Shrubland	693722.6	7477914.9	50
25/02/2021	LC38	Hillcrest/ hillslope	Negligible	Minimal Shading from topography and vegetation	Loam	Red Orange		Small Rocks	Negligible	Patchy Under Trees	None	Within 5 years			Spinifex Grassland	693720.91	7477981.9	50
25/02/2021	LC39A	Medium Drainage	Gentle	Some shading from patchy vegetation	Loam	Red Brown			Gr20cm	Patchy Under Trees	Some	Long Unburnt	Creek choked with buffel grass	Creek Wide	Open Woodland	692608.6	7477833.7	50
25/02/2021	LC39	Medium Drainage	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown		Surface sprinkle	5-10 cm	Patchy Under Trees		Within 10 years		Sheet flow	Open Woodland	692440.57	7477837.2	50
25/02/2021	LC40	Stony Plain	Gentle	Minimal Shading from topography and vegetation	Loam	Red Brown	Skeletal under rocks	Small Rocks	Negligible		None	Within 5 years	Exploration rehab	Negligible	Spinifex Grassland	692479.53	7477649.2	50
25/02/2021	LC41	Tussock grassland plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown			2-5 cm	Patchy Under Trees	None	Within 10 years	Buffel grass	Sheet flow	Open Woodland/ grassland	684223.16	7468840.2	50
25/02/2021	LC42	Tussock grassland plain	Negligible	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown			2-5 cm	Patchy Under Trees	None	Within 10 years	Buffel grass	Creek Wide	Open Woodland/ grassland	684045.25	7468807.2	50
22/02/2021	LC42A	Minor Drainage	Gentle	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown	Patches of deeper soil in creekbed but still not that deep	Surface sprinkle	0-2cm	Patchy Under Trees	None	Within 10 years		Creek Narrow	Other	684659.52	7474554.3	50
23/02/2021	LC44	Minor Drainage	Gentle	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown		Surface sprinkle	2-5 cm	Patchy Under Trees	None	Within 10 years		Creek Narrow	Shrubland	685150.51	7474776.6	50
22/02/2021	LC43	Minor Drainage	Gentle	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown	Patches of deeper soil in creekbed but still not that deep	Surface sprinkle	0-2cm	Patchy Under Trees	None	Within 10 years		Creek Narrow	Other	684796.95	7474492.7	50
23/02/2021	LC45	Minor Drainage	Gentle	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown		Surface sprinkle	2-5 cm	Patchy Under Trees	None	Within 10 years		Creek Narrow	Shrubland	685087.82	7474822.8	50
23/02/2021	LC29B	Minor Drainage	Gentle	Some shading from patchy vegetation	Sandy Clay Loam	Red Brown		Surface sprinkle	2-5 cm	Patchy Under Trees	None	Within 10 years		Creek Narrow	Shrubland	683019.84	7472195.7	50